

FSS CODE

International Code for Fire Safety Systems



FSS CODE FSS CODE FSS CODE FSS CODE FSS CODE FSS CODE

IMO



INTERNATIONAL
MARITIME
ORGANIZATION

International Code for Fire Safety Systems (FSS Code)

Resolution MSC.98(73)



INTERNATIONAL
MARITIME
ORGANIZATION
London, 2001

Foreword

The International Code for Fire Safety Systems (FSS Code) was adopted by the Maritime Safety Committee (MSC) at its seventy-third session (December 2000) by resolution MSC.98(73) in order to provide international standards for the fire safety systems and equipment required by chapter II-2 of the 1974 SOLAS Convention. The Code is made mandatory under SOLAS by amendments to the Convention adopted by the MSC at the same session (resolution MSC.99(73)). The amendments are expected to enter into force on 1 July 2002.

In order to make this publication as comprehensive as possible for the use by equipment and systems manufacturers, shipowners and operators, shipyards, classification societies and Administrations, all related fire safety standards and guidelines adopted by either the Assembly or the MSC and referred to in the FSS Code have been incorporated, as appropriate, in this publication for the guidance and convenience of users.

Contents

	<i>Page</i>
Preamble.....	1
CHAPTER 1 - GENERAL	
1 Application.....	1
2 Definitions.....	2
3 Use of equivalents and modern technology.....	2
4 Use of toxic extinguishing media.....	2
CHAPTER 2 - INTERNATIONAL SHORE CONNECTIONS	
1 Application.....	2
2 Engineering specifications.....	2
CHAPTER 3 - PERSONNEL PROTECTION	
1 Application.....	3
2 Engineering specifications.....	3
CHAPTER 4 - FIRE EXTINGUISHERS	
1 Application.....	5
2 Type approval.....	6
3 Engineering specifications.....	6
CHAPTER 5 - FIXED GAS FIRE-EXTINGUISHING SYSTEMS	
1 Application.....	6
2 Engineering specifications.....	7
CHAPTER 6 - FIXED FOAM FIRE-EXTINGUISHING SYSTEMS	
1 Application.....	10
2 Engineering specifications.....	10
CHAPTER 7 - FIXED PRESSURE WATER-SPRAYING AND WATER-MIST FIRE-EXTINGUISHING SYSTEMS	
1 Application.....	12
2 Engineering specifications.....	13

**CHAPTER 8 - AUTOMATIC SPRINKLER, FIRE DETECTION
AND FIRE ALARM SYSTEMS**

1	Application.....	14
2	Engineering specifications.....	14

**CHAPTER 9 - FIXED FIRE DETECTION AND FIRE
ALARM SYSTEMS**

1	Application.....	19
2	Engineering specifications.....	19

**CHAPTER 10 - SAMPLE EXTRACTION SMOKE
DETECTION SYSTEMS**

1	Application.....	23
2	Engineering specifications.....	23

CHAPTER 11 - LOW-LOCATION LIGHTING SYSTEMS

1	Application.....	25
2	Engineering specifications.....	25

CHAPTER 12 - FIXED EMERGENCY FIRE PUMPS

1	Application.....	26
2	Engineering specifications.....	26

CHAPTER 13 - ARRANGEMENT OF MEANS OF ESCAPE

1	Application.....	27
2	Passenger ships.....	27
3	Cargo ships.....	35

CHAPTER 14 - FIXED DECK FOAM SYSTEMS

1	Application.....	35
2	Engineering specifications.....	35

CHAPTER 15 - INERT GAS SYSTEMS

1	Application.....	37
2	Engineering specifications.....	37

**FIRE SAFETY STANDARDS AND GUIDELINES REFERRED
TO IN THE CODE**

Resolution A.602(15): Revised guidelines for marine portable fire extinguishers)	47
Resolution A.752(18): Guidelines for the evaluation, testing and application of low-location lighting on passenger ships.	57
Resolution A.800(19): Revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation 11-2/12	63
MSC/Circ.582 and Corr.I: Guidelines for the performance and testing criteria, and surveys of low-expansion foam concentrates for fixed fire-extinguishing systems.	121
MSC/Circ.668: Alternative arrangements for halon fire-extinguishing systems in machinery spaces and pump-rooms.	137
MSC/Circ.670: Guidelines for the performance and testing criteria, and surveys of high-expansion foam concentrates for fixed fire-extinguishing systems.	181
MSC/Circ.677: Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers.	189
MSC/Circ.728: Revised test method for equivalent water-based fire-extinguishing systems for machinery spaces of category A and cargo pump-rooms contained in MSC/Circ.668.	207
MSC/Circ.731: Revised factors to be taken into consideration when designing cargo tank venting and gas-freeing arrangements	209
MSC/Circ.777: Indication of the assembly station in passenger ships.	213
MSC/Circ.798: Guidelines for performance and testing criteria and surveys of medium-expansion concentrates for fixed fire-extinguishing systems.	215
MSC/Circ.848: Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms.	225
MSC/Circ.1007: Guidelines for the approval of fixed aerosol fire-extinguishing systems equivalent to fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces.	241
MSC/Circ.1009: Amendments to the Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers (MSC/Circ.677).	259
Resolution MSC.98(73): Adoption of the International Code for Fire Safety Systems.	261

The International Code for Fire Safety Systems (FSS Code)

Preamble*

1 The purpose of this Code is to provide international standards of specific engineering specifications for fire safety systems required by chapter II-2 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended.

2 On or after 1 July 2002, this Code will be mandatory for fire safety systems required by the 1974 SOLAS Convention, as amended. Any future amendment to the Code must be adopted and brought into force in accordance with the procedure laid down in article VIII of the Convention.

Chapter 1 *General*

1 Application

1.1 This Code is applicable to fire safety systems as referred to in chapter II-2 of the International Convention for the Safety of Life at Sea, 1974, as amended.

1.2 Unless expressly provided otherwise, this Code is applicable for the fire safety systems of ships the keels of which are laid or which are at a similar stage of construction on or after 1 July 2002.

* The International Code for Fire Safety Systems comprises the annex to resolution MSC.98(73), the text of which is reproduced at the end of this publication.

2 Definitions

2.1 *Administration* means the Government of the State whose flag the ship is entitled to fly.

2.2 *Convention* means the International Convention for the Safety of Life at Sea, 1974, as amended.

2.3 *Fire Safety Systems Code* means the International Code for Fire Safety Systems as defined in chapter II-2 of the International Convention for the Safety of Life at Sea, 1974, as amended.

2.4 For the purpose of this Code, definitions provided in chapter II-2 of the Convention also apply.

3 Use of equivalents and modern technology

In order to allow modern technology and development of fire safety systems, the Administration may approve fire safety systems which are not specified in this Code if the requirements of part F of chapter II-2 of the Convention are fulfilled.

4 Use of toxic extinguishing media

The use of a fire-extinguishing medium which, in the opinion of the Administration, either by itself or under expected conditions of use gives off toxic gases, liquids and other substances in such quantities as to endanger persons shall not be permitted.

Chapter 2

International shore connections

1 Application

This chapter details the specifications for international shore connections as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 Standard dimensions

Standard dimensions of flanges for the international shore connection shall be in accordance with the following table:

Table 2.1 - Standard dimensions for international shore connections

Description	Dimension
Outside diameter	178 mm
Inside diameter	64 mm
Bolt circle diameter	132 mm
Slots in flange	4 holes, 19 mm in diameter spaced equidistantly on a bolt circle of the above diameter, slotted to the flange periphery
Flangethickness	14.5 mm minimum
Bolts and nuts	4, each of 16 mm diameter, 50 mm in length

2.2 *Materials and accessories*

International shore connections shall be of steel or other equivalent material and shall be designed for 1 N/mm² services. The flange shall have a flat face on one side and, on the other side, it shall be permanently attached to a coupling that will fit the ship's hydrant and hose. The connection shall be kept aboard the ship together with a gasket of any material suitable for 1 N/mm² services, together with four bolts of 16 mm diameter and 50 mm in length, four 16 mm nuts and eight washers.

Chapter 3

Personnel protection

1 **Application**

This chapter details the specifications for personnel protection as required by chapter II-2 of the Convention.

2 **Engineering specifications**

2.1 *Fire-fighter's outfit*

A fire-fighter's outfit shall consist of a set of personal equipment and a breathing apparatus.

2.1.1 Personal equipment

Personal equipment shall consist of the following:

- .1 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 shall be water-resistant;
- .2 boots of rubber or other electrically non-conducting material;
- .3 rigid helmet providing effective protection against impact;
- .4 electric safety lamp (hand lantern) of an approved type with a minimum burning period of 3 h. Electric safety lamps on tankers and those intended to be used in hazardous areas shall be of an explosion-proof type; and
- .5 axe with a handle provided with high-voltage insulation.

2.1.2 Breathing apparatus

Breathing apparatus shall be a self-contained compressed air-operated breathing apparatus for which the volume of air contained in the cylinders shall be at least 1,200 l, or other self-contained breathing apparatus which shall be capable of functioning for at least 30 min. All air cylinders for breathing apparatus shall be interchangeable.

2.1.3 Lifeline

For each breathing apparatus a fireproof lifeline of at least 30 m in length shall be provided. The lifeline shall successfully pass an approval test by static load of 3.5 kN for 5 min without failure. The lifeline shall 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.

2.2 *Emergency escape breathing devices (EEBD)*

2.2.1 General

2.2.1.1 An EEBD is a supplied air or oxygen device only used for escape from a compartment that has a hazardous atmosphere and shall be of an approved type.

2.2.1.2 EEBDs shall not be used for fighting fires, entering oxygen deficient voids or tanks, or worn by firefighters. In these events, a self-contained breathing apparatus, which is specifically suited for such applications, shall be used.

2.2.2 Definitions

2.2.2.1 Face *piece* means a face covering that is designed to form a complete seal around the eyes, nose and mouth which is secured in position by a suitable means.

2.2.2.2 *Hood* means a head covering which completely covers the head, neck and may cover portions of the shoulders.

2.2.2.3 *Hazardous atmosphere* means any atmosphere that is immediately dangerous to life or health.

2.2.3 Particulars

2.2.3.1 The EEBD shall have a service duration of at least 10 min.

2.2.3.2 The EEBD shall include a hood or full face piece, as appropriate, to protect the eyes, nose and mouth during escape. Hoods and face pieces shall be constructed of flame-resistant materials and include a clear window for viewing.

2.2.3.3 An inactivated EEBD shall be capable of being carried hands-free.

2.2.3.4 An EEBD, when stored, shall be suitably protected from the environment.

2.2.3.5 Brief instructions or diagrams clearly illustrating their use shall be clearly printed on the EEBD. The donning procedures shall be quick and easy to allow for situations where there is little time to seek safety from a hazardous atmosphere.

2.2.4 Markings

Maintenance requirements, manufacturer's trademark and serial number, shelf life with accompanying manufacture date and name of the approving authority shall be printed on each EEBD. All EEBD training units shall be clearly marked.

Chapter 4

Fire extinguishers

1 Application

This chapter details the specifications for fire extinguishers as required by chapter II-2 of the Convention.

2 Type approval

All fire extinguishers shall be of approved types and designs based on the guidelines developed by the Organization.*

3 Engineering specifications

3.1 Fire extinguisher

3.1.1 Quantity of medium

3.1.1.1 Each powder or carbon dioxide extinguisher shall have a capacity of at least 5 kg and each foam extinguisher shall have a capacity of at least 9 l. The mass of all portable fire extinguishers shall not exceed 23 kg and they shall have a fire-extinguishing capability at least equivalent to that of a 9 l fluid extinguisher.

3.1.1.2 The Administration shall determine the equivalents of fire extinguishers.

3.1.2 Recharging

Only refills approved for the fire extinguisher in question shall be used for recharging.

3.2 Portable foam applicators

A portable foam applicator unit shall consist of a foam nozzle of an inductor type capable of being connected to the fire main by a fire hose, together with a portable tank containing at least 20 l of foam-forming liquid and one spare tank of foam making liquid. The nozzle shall be capable of producing effective foam suitable for extinguishing an oil fire, at the rate of at least 1.5 m³/min.

Chapter 5 *Fixed gas fire-extinguishing systems*

1 Application

This chapter details the specifications for fixed gas fire-extinguishing systems as required by chapter II-2 of the Convention.

* Refer to the Guidelines for marine portable fire extinguishers adopted by the Organization by resolution A.602(15).

2 Engineering specifications

2.1 General

2.1.1 Fire-extinguishing medium

2.1.1.1 Where the quantity of the fire-extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected.

2.1.1.2 The volume of starting air receivers, converted to free air volume, shall be added to the gross volume of the machinery space when calculating the necessary quantity of the fire-extinguishing medium. Alternatively, a discharge pipe from the safety valves may be fitted and led directly to the open air.

2.1.1.3 Means shall be provided for the crew to safely check the quantity of the fire-extinguishing medium in the containers.

2.1.1.4 Containers for the storage of fire-extinguishing medium and associated pressure components shall be designed to pressure codes of practice to the satisfaction of the Administration having regard to their locations and maximum ambient temperatures expected in service.

2.1.2 Installation requirements

2.1.2.1 The piping for the distribution of fire-extinguishing medium shall be arranged and discharge nozzles so positioned that a uniform distribution of the medium is obtained.

2.1.2.2 Except as otherwise permitted by the Administration, pressure containers required for the storage of the fire-extinguishing medium, other than steam, shall be located outside the protected spaces in accordance with regulation II-2/10.4.3 of the Convention.

2.1.2.3 Spare parts for the system shall be stored on board and be to the satisfaction of the Administration.

2.1.3 System control requirements

2.1.3.1 The necessary pipes for conveying fire-extinguishing medium into the protected spaces shall be provided with control valves so marked as to indicate clearly the spaces to which the pipes are led. Suitable provisions shall be made to prevent inadvertent release of the medium into the space. Where a cargo space fitted with a gas fire-extinguishing system is used as a passenger space, the gas connection shall be blanked during such use. The pipes may pass through accommodation areas provided that they are of substantial thickness and that their tightness is verified with a pressure test, after their installation, at a pressure head not less than 5 N/mm². In

addition, pipes passing through accommodation areas shall be joined only by welding and shall not be fitted with drains or other openings within such spaces. The pipes shall not pass through refrigerated spaces.

2.1.3.2 Means shall be provided for automatically giving audible warning of the release of fire-extinguishing medium into any ro-ro spaces and other spaces in which personnel normally work or to which they have access. The pre-discharge alarm shall be automatically activated (e.g. by opening of the release cabinet door). The alarm shall operate for the length of time needed to evacuate the space, but in no case less than 20 s before the medium is released. Conventional cargo spaces and small spaces (such as compressor rooms, paint lockers, etc.) with only a local release need not be provided with such an alarm.

2.1.3.3 The means of control of any fixed gas fire-extinguishing system shall be readily accessible, simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there shall be clear instructions relating to the operation of the system having regard to the safety of personnel.

2.1.3.4 Automatic release of fire-extinguishing medium shall not be permitted, except as permitted by the Administration.

2.2 *Carbon dioxide systems*

2.2.1 Quantity of fire-extinguishing medium

2.2.1.1 For cargo spaces the quantity of carbon dioxide available shall, unless otherwise provided, be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space to be protected in the ship.

2.2.1.2 For machinery spaces the quantity of carbon dioxide carried shall be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either:

- .1 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 space concerned taken midway between the tank top and the lowest part of the casing; or
- .2 35% of the gross volume of the largest machinery space protected, including the casing.

2.2.1.3 The percentages specified in paragraph 2.2.1.2 above may be reduced to 35% and 30%, respectively, for cargo ships of less than 2,000 gross tonnage provided that, where two or more machinery spaces are not entirely separate, they shall be considered as forming one space.

2.2.1.4 For the purpose of this paragraph the volume of free carbon dioxide shall be calculated at $0.56 \text{ m}^3/\text{kg}$.

2.2.1.5 For machinery spaces, the fixed piping system shall be such that 85% of the gas can be discharged into the space within 2 min.

2.2.2 Controls

Carbon dioxide systems shall comply with the following requirements:

- .1 two separate controls shall be provided for releasing carbon dioxide into a protected space and to ensure the activation of the alarm. One control shall be used for opening the valve of the piping which conveys the gas into the protected space and a second control shall be used to discharge the gas from its storage containers; and
- .2 the two controls shall be located inside a release box clearly identified for the particular space. If the box containing the controls is to be locked, a key to the box shall be in a break-glass-type enclosure conspicuously located adjacent to the box.

2.3 *Requirements of steam systems*

The boiler or boilers available for supplying steam shall have an evaporation of at least 1 kg of steam per hour for each 0.75 m^3 of the gross volume of the largest space so protected. In addition to complying with the foregoing requirements, the systems in all respects shall be as determined by and to the satisfaction of the Administration.

2.4 *Systems using gaseous products of fuel combustion*

2.4.1 General

Where gas other than carbon dioxide or steam, as permitted by paragraph 2.3 is produced on the ship and is used as a fire-extinguishing medium, the system shall comply with the requirements of paragraph 2.4.2.

2.4.2 Requirements of the systems

2.4.2.1 Gaseous products

Gas shall be a gaseous product of fuel combustion in which the oxygen content, the carbon monoxide content, the corrosive elements and any solid combustible elements in a gaseous product shall have been reduced to a permissible minimum.

2.4.2.2 Capacity of fire-extinguishing systems

2.4.2.2.1 Where such gas is used as the fire-extinguishing medium in a fixed fire-extinguishing system for the protection of machinery spaces, it shall afford protection equivalent to that provided by a fixed system using carbon dioxide as the medium.

2.4.2.2.2 Where such gas is used as the fire-extinguishing medium in a fixed fire-extinguishing system for the protection of cargo spaces, a sufficient quantity of such gas shall be available to supply hourly a volume of free gas at least equal to 25% of the gross volume of the largest space protected in this way for a period of 72 h.

2.5 *Equivalent fixed gas fire-extinguishing systems for machinery spaces and cargo pump rooms*

Fixed gas fire-extinguishing systems equivalent to those specified in paragraphs 2.2 to 2.4 shall be approved by the Administration based on the guidelines developed by the Organization.*

Chapter 6

Fixed foam fire-extinguishing systems

1 Application

This chapter details the specifications for fixed foam fire-extinguishing systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 General

Fixed foam fire-extinguishing systems shall be capable of generating foam suitable for extinguishing oil fires.

* Refer to the Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms (MSC/Circ.848) and the Guidelines for the approval of fixed aerosol fire-extinguishing systems equivalent to fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces (MSC/Circ.1007).

2.2 Fixed high-expansion foam fire-extinguishing systems

2.2.1 Quantity and performance of foam concentrates

2.2.1.1 The foam concentrates of high-expansion foam fire-extinguishing systems shall be approved by the Administration based on the guidelines developed by the Organization.*

2.2.1.2 Any required fixed high-expansion foam system in machinery spaces shall be capable of rapidly discharging through fixed discharge outlets a quantity of foam sufficient to fill the greatest space to be protected at a rate of at least 1 m in depth per minute. The quantity of foam-forming liquid available shall be sufficient to produce a volume of foam equal to five times the volume of the largest space to be protected. The expansion ratio of the foam shall not exceed 1,000 to 1.

2.2.1.3 The Administration may permit alternative arrangements and discharge rates provided that it is satisfied that equivalent protection is achieved.

2.2.2 Installation requirements

2.2.2.1 Supply ducts for delivering foam, air intakes to the foam generator and the number of foam-producing units shall, in the opinion of the Administration, be such as will provide effective foam production and distribution.

2.2.2.2 The arrangement of the foam generator delivery ducting shall be such that a fire in the protected space will not affect the foam generating equipment. If the foam-generators are located adjacent to the protected space, foam delivery ducts shall be installed to allow at least 450 mm of separation between the generators and the protected space. The foam delivery ducts shall be constructed of steel having a thickness of not less than 5 mm. In addition, stainless steel dampers (single or multi-bladed) with a thickness of not less than 3 mm shall be installed at the openings in the boundary bulkheads or decks between the foam generators and the protected space. The dampers shall be automatically operated (electrically, pneumatically or hydraulically) by means of remote control of the foam generator related to them.

2.2.2.3 The foam generator, its sources of power supply, foam-forming liquid and means of controlling the system shall be readily accessible and simple to operate and shall be grouped in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

* Refer to the Guidelines for the performance and testing criteria, and surveys of high-expansion foam concentrates for fixed fire-extinguishing systems (MSC/Circ.670).

2.3 Fixed low-expansion foam fire-extinguishing systems

2.3.1 Quantity and foam concentrates

2.3.1.1 The foam concentrates of low-expansion foam fire-extinguishing systems shall be approved by the Administration based on the guidelines developed by the Organization.*

2.3.1.2 The system shall be capable of discharging through fixed discharge outlets in not more than 5 min a quantity of foam sufficient to cover to a depth of 150 mm the largest single area over which oil fuel is liable to spread. The expansion ratio of the foam shall not exceed 12 to 1.

2.3.2 Installation requirements

2.3.2.1 Means shall be provided for the effective distribution of the foam through a permanent system of piping and control valves or cocks to suitable discharge outlets, and for the foam to be effectively directed by fixed sprayers onto other main fire hazards in the protected space. The means for effective distribution of the foam shall be proven acceptable to the Administration through calculation or by testing.

2.3.2.2 The means of control of any such systems shall be readily accessible and simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in the protected space.

Chapter 7

Fixed pressure water-spraying and water-mist fire-extinguishing systems

1 Application

This chapter details the specifications for fixed pressure water-spraying and water-mist fire-extinguishing systems as required by chapter II-2 of the Convention.

* Refer to the Guidelines for the performance and testing criteria, and surveys of low-expansion foam concentrates for fixed fire-extinguishing systems (MSC/Circ.582 and Corr.1).

2 Engineering specifications

2.1 Fixed pressure water-spraying fire-extinguishing systems

2.1.1 Nozzles and pumps

2.1.1.1 Any required fixed pressure water-spraying fire-extinguishing system in machinery spaces shall be provided with spraying nozzles of an approved type.

2.1.1.2 The number and arrangement of the nozzles shall be to the satisfaction of the Administration and shall be such as to ensure an effective average distribution of water of at least $5 \text{ l/m}^2/\text{min}$ in the spaces to be protected. Where increased application rates are considered necessary, these shall be to the satisfaction of the Administration.

2.1.1.3 Precautions shall be taken to prevent the nozzles from becoming clogged by impurities in the water or corrosion of piping, nozzles, valves and pump.

2.1.1.4 The pump shall be capable of simultaneously supplying at the necessary pressure all sections of the system in any one compartment to be protected.

2.1.1.5 The pump may be driven by independent internal combustion machinery, but, if it is dependent upon power being supplied from the emergency generator fitted in compliance with the provisions of regulation II-1/42 or regulation II-1/43 of the Convention, as appropriate, the generator shall be so arranged as to start automatically in case of main power failure so that power for the pump required by paragraph 2.1.1.4 is immediately available. The independent internal combustion machinery for driving the pump shall be so situated that a fire in the protected space or spaces will not affect the air supply to the machinery.

2.1.2 Installation requirements

2.1.2.1 Nozzles shall be fitted above bilges, tank tops and other areas over which oil fuel is liable to spread and also above other specific fire hazards in the machinery spaces.

2.1.2.2 The system may be divided into sections, the distribution valves of which shall be operated from easily accessible positions outside the spaces to be protected so as not to be readily cut off by a fire in the protected space.

2.1.2.3 The pump and its controls shall be installed outside the space or spaces to be protected. It shall not be possible for a fire in the space or spaces protected by the water-spraying system to put the system out of action.

2.1.3 System control requirements

The system shall be kept charged at the necessary pressure and the pump supplying the water for the system shall be put automatically into action by a pressure drop in the system.

2.2 *Equivalent water-mist fire-extinguishing systems*

Water-mist fire-extinguishing systems for machinery spaces and cargo pump-rooms shall be approved by the Administration based on the guidelines developed by the Organization.*

Chapter 8 *Automatic sprinkler, fire detection and fire alarm systems*

1 Application

This chapter details the specifications for automatic sprinkler, fire detection and fire alarm systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 *General*

2.1.1 Type of sprinkler systems

The automatic sprinkler systems shall be of the wet pipe type, but small exposed sections may be of the dry pipe type where, in the opinion of the Administration, this is a necessary precaution. Saunas shall be fitted with a dry pipe system, with sprinkler heads having an operating temperature up to 140°C.

2.1.2 Sprinkler systems equivalent to those specified in paragraphs 2.2 to 2.4

Automatic sprinkler systems equivalent to those specified in paragraphs 2.2 to 2.4 shall be approved by the Administration based on the guidelines developed by the Organization.†

* Refer to the Alternative arrangements for halon fire-extinguishing systems in machinery spaces and pump-rooms (MSC/Circ.668) and the Revised test method for equivalent water-based fire-extinguishing systems for machinery spaces of category A and cargo pump-rooms contained in MSC/Circ.668 (MSC/Circ.728).

† Refer to the Revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation II-2/12, as adopted by the Organization by resolution A.800(19).

2.2 Sources of power supply

2.2.1 Passenger ships

There shall be not less than two sources of power supply for the sea water pump and automatic alarm and detection system. Where the sources of power for the pump are electrical, these shall be a main generator and an emergency source of power. One supply for the pump shall be taken from the main switchboard, and one from the emergency switchboard by separate feeders reserved solely for that purpose. The feeders shall be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards, and shall be run to an automatic changeover switch situated near the sprinkler pump. This switch shall permit the supply of power from the main switchboard so long as a supply is available therefrom, and be so designed that upon failure of that supply it will automatically change over to the supply from the emergency switchboard. The switches on the main switchboard and the emergency switchboard shall be clearly labelled and normally kept closed. No other switch shall be permitted in the feeders concerned. One of the sources of power supply for the alarm and detection system shall be an emergency source. Where one of the sources of power for the pump is an internal combustion engine it shall, in addition to complying with the provisions of paragraph 2.4.3, be so situated that a fire in any protected space will not affect the air supply to the machinery.

2.2.2 Cargo ships

There shall not be less than two sources of power supply for the seawater pump and automatic alarm and detection system. If the pump is electrically driven, it shall be connected to the main source of electrical power, which shall be capable of being supplied by at least two generators. The feeders shall be so arranged as to avoid galleys, machinery spaces and other enclosed spaces of high fire risk except in so far as it is necessary to reach the appropriate switchboards. One of the sources of power supply for the alarm and detection system shall be an emergency source. Where one of the sources of power for the pump is an internal combustion engine, it shall, in addition to complying with the provisions of paragraph 2.4.3, be so situated that a fire in any protected space will not affect the air supply to the machinery.

2.3 Component requirements

2.3.1 Sprinklers

2.3.1.1 The sprinklers shall be resistant to corrosion by the marine atmosphere. In accommodation and service spaces the sprinklers shall come into operation within the temperature range from 68°C to 79°C, 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 above the maximum deckhead temperature.

2.3.1.2 A quantity of spare sprinkler heads shall be provided for all types and ratings installed on the ship as follows:

Total number of heads	Required number of spares
< 300	6
300 to 1000	12
> 1000	24

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

2.3.2 Pressure tanks

2.3.2.1 A pressure tank having a volume equal to at least twice that of the charge of water specified in this paragraph shall be provided. The tank shall contain a standing charge of fresh water, equivalent to the amount of water which would be discharged in 1 min by the pump referred to in paragraph 2.3.3.2, and the arrangements shall provide for maintaining an air pressure in the tank such as to ensure that where 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. Suitable means of replenishing the air under pressure and of replenishing the fresh water charge in the tank shall be provided. A glass gauge shall be provided to indicate the correct level of the water in the tank.

2.3.2.2 Means shall be provided to prevent the passage of seawater into the tank.

2.3.3 Sprinkler pumps

2.3.3.1 An independent power pump shall be provided solely for the purpose of continuing automatically the discharge of water from the sprinklers. The pump shall 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.

2.3.3.2 The pump and the piping system shall 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 at the application rate specified in para-

graph 2.5.2.3. The hydraulic capability of the system shall be confirmed by the review of hydraulic calculations, followed by a test of the system, if deemed necessary by the Administration.

2.3.3.3 The pump shall have fitted on the delivery side a test valve with a short open-ended discharge pipe. The effective area through the valve and pipe shall be adequate to permit the release of the required pump output while maintaining the pressure in the system specified in paragraph 2.3.2.1.

2.4 *Installation requirements*

2.4.1 General

Any parts of the system which may be subjected to freezing temperatures in service shall be suitably protected against freezing.

2.4.2 Piping arrangements

2.4.2.1 Sprinklers shall be grouped into separate sections, each of which shall contain not more than 200 sprinklers. In passenger ships, any section of sprinklers shall not serve more than two decks and shall not be situated in more than one main vertical zone. However, the Administration may permit such a section of sprinklers to serve more than two decks or be situated in more than one main vertical zone, if it is satisfied that the protection of the ship against fire will not thereby be reduced.

2.4.2.2 Each section of sprinklers shall be capable of being isolated by one stop-valve only. The stop-valve in each section shall be readily accessible in a location outside of the associated section or in cabinets within stairway enclosures. The valve's location shall be clearly and permanently indicated. Means shall be provided to prevent the operation of the stop-valves by any unauthorized person.

2.4.2.3 A test valve shall 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 for each section shall be situated near the stop-valve for that section.

2.4.2.4 The sprinkler system shall have a connection from the ship's fire main by way of a lockable screw-down non-return valve at the connection which will prevent a backflow from the sprinkler system to the fire main.

2.4.2.5 A gauge indicating the pressure in the system shall be provided at each section stop-valve and at a central station.

2.4.2.6 The sea inlet to the pump shall wherever possible be in the space containing the pump and shall be so arranged that when the ship is afloat it will not be necessary to shut off the supply of seawater to the pump for any purpose other than the inspection or repair of the pump.

2.4.3 Location of systems

The sprinkler pump and tank shall be situated in a position reasonably remote from any machinery space of category A and shall not be situated in any space required to be protected by the sprinkler system.

2.5 System control requirements

2.5.1 Ready availability

2.5.1.1 Any required automatic sprinkler, fire detection and fire alarm system shall be capable of immediate operation at all times and no action by the crew shall be necessary to set it in operation.

2.5.1.2 The automatic sprinkler system shall be kept charged at the necessary pressure and shall have provision for a continuous supply of water as required in this chapter.

2.5.2 Alarm and indication

2.5.2.1 Each section of sprinklers shall include means for giving a visual and audible alarm signal automatically at one or more indicating units whenever any sprinkler comes into operation. Such alarm systems shall be such as to indicate if any fault occurs in the system. Such units shall indicate in which section served by the system a fire has occurred and shall be centralized on the navigation bridge or in the continuously-manned central control station and, in addition, visible and audible alarms from the unit shall also be placed in a position other than on the aforementioned spaces to ensure that the indication of fire is immediately received by the crew.

2.5.2.2 Switches shall be provided at one of the indicating positions referred to in paragraph 2.5.2.1 which will enable the alarm and the indicators for each section of sprinklers to be tested.

2.5.2.3 Sprinklers shall be placed in an overhead position and spaced in a suitable pattern to maintain an average application rate of not less than $5 \text{ l/m}^2/\text{min}$ over the nominal area covered by the sprinklers. However, the Administration may permit the use of sprinklers providing such an alternative amount of water suitably distributed as has been shown to the satisfaction of the Administration to be not less effective.

2.5.2.4 A list or plan shall 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 shall be available.

2.5.3 Testing

Means shall be provided for testing the automatic operation of the pump on reduction of pressure in the system.

Chapter 9

Fixed fire detection and fire alarm systems

1 Application

This chapter details the specifications for fixed fire detection and fire alarm systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 General requirements

2.1.1 Any required fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times.

2.1.2 The fixed fire detection and fire alarm system shall not be used for any other purpose, except that closing of fire doors and similar functions may be permitted at the control panel.

2.1.3 The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

2.1.4 Zone address identification capability

Fixed fire detection and fire alarm systems with a zone address identification capability shall be so arranged that:

- .1 means are provided to ensure that any fault (e.g. power break, short circuit, earth, etc.) occurring in the loop will not render the whole loop ineffective;
- .2 all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (e.g. electrical, electronic, informatics, etc.);
- .3 the first initiated fire alarm will not prevent any other detector from initiating further fire alarms; and
- .4 no loop will pass through a space twice. When this is not practical (e.g. for large public spaces), the part of the loop which by necessity passes through the space for a second time shall be installed at the maximum possible distance from the other parts of the loop.

2.2 Sources of power supply

There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which shall be an emergency source. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders

shall run to an automatic change-over switch situated in, or adjacent to, the control panel for the fire detection system.

2.3 *Component requirements*

2.3.1 *Detectors*

2.3.1.1 Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Administration provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

2.3.1.2 Smoke detectors required in stairways, corridors and escape routes within accommodation spaces shall be certified to operate before the smoke density exceeds 12.5% obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Administration having regard to the avoidance of detector insensitivity or oversensitivity.

2.3.1.3 Heat detectors shall be certified to operate before the temperature exceeds 78°C, but not until the temperature exceeds 54°C, when the temperature is raised to those limits at a rate less than 1°C per minute. At higher rates of temperature rise, the heat detector shall operate within temperature limits to the satisfaction of the Administration having regard to the avoidance of detector insensitivity or oversensitivity.

2.3.1.4 The operation temperature of heat detectors in drying rooms and similar spaces of a normal high ambient temperature may be up to 130°C, and up to 140°C in saunas.

2.4.2

2.3.1.5 All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

2.4 *Installation requirements*

2.4.1 *Sections*

2.4.1.1 Detectors and manually operated call points shall be grouped into sections.

2.4.1.2 A section of fire detectors which covers a control station, a service space or an accommodation space shall not include a machinery space of category A. For fixed fire detection and fire alarm systems with remotely and individually identifiable fire detectors, a loop covering sections of fire detectors in accommodation, service spaces and control

Heat

stations shall not include sections of fire detectors in machinery spaces of category A.

2.4.1.3 Where the fixed fire detection and fire alarm system does not include means of remotely identifying each detector individually, no section covering more than one deck within accommodation spaces, service spaces and control stations shall normally be permitted except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section shall be limited as determined by the Administration. In no case shall more than 50 enclosed spaces be permitted in any section. If the system is fitted with remotely and individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces.

2.4.1.4 In passenger ships, if there is no fixed fire detection and fire alarm system capable of remotely and individually identifying each detector, a section of detectors shall not serve spaces on both sides of the ship nor on more than one deck and neither shall it be situated in more than one main vertical zone except that the same section of detectors may serve spaces on more than one deck if those spaces are located in the fore or aft end of the ship or if they protect common spaces on different decks (e.g. fan rooms, galleys, public spaces, etc.). In ships of less than 20 m in breadth, the same section of detectors may serve spaces on both sides of the ship. In passenger ships fitted with individually identifiable fire detectors, a section may serve spaces on both sides of the ship and on several decks, but shall not be situated in more than one main vertical zone.

2.4.2 Position of detectors

2.4.2.1 Detectors shall be located for optimum performance. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely shall be avoided. Detectors which are located on the overhead shall be a minimum distance of 0.5 m away from bulkheads, except in corridors, lockers and stairways.

2.4.2.2 The maximum spacing of detectors shall be in accordance with the table below:

Table 9.1 - Spacing of detectors

Type of detector	Maximum floor area per detector	Maximum distance apart between centres	Maximum distance away from bulkheads
Heat	37 m ²	9 m	4.5 m
Smoke	74 m ²	11 m	5.5 m

The Administration may require or permit different spacing to that specified in the above table if based upon test data which demonstrate the characteristics of the detectors.

2.4.3 Arrangement of electric wiring

2.4.3.1 Electrical wiring which forms part of the system shall be so arranged as to avoid galleys, machinery spaces of category A and other enclosed spaces of high fire risk except where it is necessary to provide for fire detection or fire alarms in such spaces or to connect to the appropriate power supply.

2.4.3.2 A loop of fire detection systems with a zone address identification capability shall not be damaged at more than one point by a fire.

2.5 System control requirements

2.5.1 Visual and audible fire signals*

2.5.1.1 The activation of any detector or manually operated call point shall initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within 2 min, an audible alarm shall be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A. This alarm sounder system need not be an integral part of the detection system.

2.5.1.2 The control panel shall be located on the navigation bridge or in the continuously manned central control station.

2.5.1.3 Indicating units shall, as a minimum, denote the section in which a detector has been activated or manually operated call point has been operated. At least one unit shall be so located that it is easily accessible to responsible members of the crew at all times. One indicating unit shall be located on the navigation bridge if the control panel is located in the main fire control station.

2.5.1.4 Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

2.5.1.5 Power supplies and electric circuits necessary for the operation of the system shall be monitored for loss of power or fault conditions as appropriate. Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel which shall be distinct from a fire signal.

* Refer to the Code on Alarms and Indicators as adopted by the Organization by resolution A.830(19).

2.1.5
operat
comp

2.1.6 tai
the ope

2.2 0,

density '

2.5.2 Testing

Suitable instructions and component spares for testing and maintenance shall be provided.

Chapter 10

Sample extraction smoke detection systems

1 Application

This chapter details the specifications for sample extraction smoke detection systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 *General requirements*

2.1.1 Wherever in the text of this chapter the word "system" appears, it shall mean "sample extraction smoke detection system".

2.1.2 Any required system shall be capable of continuous operation at all times except that systems operating on a sequential scanning principle may be accepted, provided that the interval between scanning the same position twice gives an overall response time to the satisfaction of the Administration.

2.1.3 The system shall be designed, constructed and installed so as to prevent the leakage of any toxic or flammable substances or fire-extinguishing media into any accommodation and service space, control station or machinery space.

2.1.4 The system and equipment shall be suitably designed to withstand supply voltage variations and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships and to avoid the possibility of ignition of a flammable gas-air mixture.

2.1.5 The system shall be of a type that can be tested for correct operation and restored to normal surveillance without the renewal of any component.

2.1.6 An alternative power supply for the electrical equipment used in the operation of the system shall be provided.

2.2 *Component requirements*

2.2.1 The sensing unit shall be certified to operate before the smoke density within the sensing chamber exceeds 6.65% obscuration per metre.

2.2.2 Duplicate sample extraction fans shall be provided. The fans shall be of sufficient capacity to operate under normal ventilation conditions in the protected area and shall give an overall response time to the satisfaction of the Administration.

2.2.3 The control panel shall permit observation of smoke in the individual sampling pipe.

2.2.4 Means shall be provided to monitor the airflow through the sampling pipes so designed as to ensure that, as far as practicable, equal quantities are extracted from each interconnected accumulator.

2.2.5 Sampling pipes shall be a minimum of 12 mm internal diameter except when used in conjunction with fixed gas fire-extinguishing systems when the minimum size of pipe shall be sufficient to permit the fire-extinguishing gas to be discharged within the appropriate time.

2.2.6 Sampling pipes shall be provided with an arrangement for periodically purging with compressed air.

2.3 *Installation requirements*

2.3.1 Smoke accumulators

2.3.1.1 At least one smoke accumulator shall be located in every enclosed space for which smoke detection is required. However, where a space is designed to carry oil or refrigerated cargo alternatively with cargoes for which a smoke sampling system is required, means may be provided to isolate the smoke accumulators in such compartments for the system. Such means shall be to the satisfaction of the Administration.

2.3.1.2 Smoke accumulators shall be located for optimum performance and shall be spaced so that no part of the overhead deck area is more than 12 m measured horizontally from an accumulator. Where systems are used in spaces which may be mechanically ventilated, the position of the smoke accumulators shall be considered having regard to the effects of ventilation.

2.3.1.3 Smoke accumulators shall be positioned where impact or physical damage is unlikely to occur.

2.3.1.4 Not more than four accumulators shall be connected to each sampling point.

2.3.1.5 Smoke accumulators from more than one enclosed space shall not be connected to the same sampling point.

2.3.2 Sampling pipes

2.3.2.1 The sampling pipe arrangements shall be such that the location of the fire can be readily identified.

2.3.2.2 Sampling pipes shall be self-draining and suitably protected from impact or damage from cargo working.

2.4 *System control requirements*

2.4.1 Visual and audible fire signals

2.4.1.1 The control panel shall be located on the navigation bridge or in the continuously manned central control station.

2.4.1.2 Clear information shall be displayed on, or adjacent to, the control panel designating the spaces covered.

2.4.1.3 The detection of smoke or other products of combustion shall initiate a visual and audible signal at the control panel and the navigation bridge or continuously manned central control station.

2.4.1.4 Power supplies necessary for the operation of the system shall be monitored for loss of power. Any loss of power shall initiate a visual and audible signal at the control panel and the navigation bridge which shall be distinct from a signal indicating smoke detection.

2.4.2 Testing

Suitable instructions and component spares shall be provided for the testing and maintenance of the system.

Chapter 11 *Low-location lighting systems*

1 Application

This chapter details the specifications for low-location lighting systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 *General requirements*

Any required low-location lighting systems shall be approved by the Administration based on the guidelines developed by the Organization,^{*} or to an international standard acceptable to the Organization.

^{*} Refer to the Guidelines for the evaluation, testing and application of low-location lighting on passenger ships, as adopted by the Organization by resolution A.752(18).

[†] Refer to the recommendations by the International Organization for Standardization, in particular, publication ISO 15370:2001 on low-location lighting on passenger ships.

Chapter 12 *Fixed emergency fire pumps*

1 Application

This chapter details the specifications for emergency fire pumps as required by chapter II-2 of the Convention. This chapter is not applicable to passenger ships of 1,000 gross tonnage and upwards. See regulation II-2/10.2.2.3.1.1 of the Convention for requirements for such ships.

2 Engineering specifications

2.1 General

The emergency fire pump shall be of a fixed independently driven power-operated pump.

2.2 Component requirements

2.2.1 Emergency fire pumps

2.2.1.1 Capacity of the pump

The capacity of the pump shall not be less than 40% of the total capacity of the fire pumps required by regulation II-2/10.2.2.4.1 of the Convention and in any case not less than the following:

- .1 for passenger ships of less than 1,000 gross tonnage and for cargo ships of 2,000 gross tonnage and upwards; and 25 m³/h
- .2 for cargo ships of less than 2,000 gross tonnage 15 m³/h.

2.2.1.2 Pressure at hydrants

When the pump is delivering the quantity of water required by paragraph 2.2.1.1, the pressure at any hydrants shall be not less than the minimum pressure required by chapter II-2 of the Convention.

2.2.1.3 Suction heads

The total suction head and the net positive suction head of the pump shall be determined having due regard to the requirements of the Convention and this chapter on the pump capacity and on the hydrant pressure under all conditions of list, trim, roll and pitch likely to be encountered in service. The ballast condition of a ship on entering or leaving a dry dock need not be considered a service condition.

2.2.2 Diesel engines and fuel tank

2.2.2.1 Starting of diesel engine

Any diesel-driven power source for the pump shall be capable of being readily started in its cold condition down to the temperature of 0°C by hand (manual) cranking. If this is impracticable, or if lower temperatures are likely to be encountered, consideration shall be given to the provision and maintenance of the heating arrangement acceptable to the Administration so that ready starting will be assured. If hand (manual) starting is impracticable, the Administration may permit other means of starting. These means shall be such as to enable the diesel-driven power source to be started at least six times within a period of 30 min and at least twice within the first 10 min.

2.2.2.2 Fuel tank capacity

Any service fuel tank shall contain sufficient fuel to enable the pump to run on full load for at least 3 h and sufficient reserves of fuel shall be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 h.

Chapter 13

Arrangement of means of escape

1 Application

This chapter details the specifications for means of escape as required by chapter II-2 of the Convention.

Passenger ships

2.1 Width of stairways

2.1.1 Basic requirements for stairway widths

Stairways shall not be less than 900 mm in clear width. The minimum clear width of stairways shall be increased by 10 mm for every one person provided for in excess of 90 persons. The total number of persons to be evacuated by such stairways shall be assumed to be two thirds of the crew and the total number of passengers in the areas served by such stairways. The width of the stairways shall not be inferior to those determined by paragraph 2.1.2.

2.1.2 Calculation method of stairway widths

2.1.2.1 Basic principles of the calculation

2.1.2.1.1 This calculation method determines the minimum stairway width at each deck level, taking into account the consecutive stairways leading into the stairway under consideration.

2.1.2.1.2 It is the intention that the calculation method shall consider evacuation from enclosed spaces within each main vertical zone individually and take into account all of the persons using the stairway enclosures in each zone, even if they enter that stairway from another vertical zone.

2.1.2.1.3 For each main vertical zone the calculation shall be completed for the night-time (case 1) and daytime (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.

2.1.2.1.4 The calculation of stairway widths shall be based upon the crew and passenger load on each deck. Occupant loads shall be rated by the designer for passenger and crew accommodation spaces, service spaces, control spaces and machinery spaces. For the purpose of the calculation the maximum capacity of a public space shall be defined by either of the following two values: the number of seats or similar arrangements, or the number obtained by assigning 2 m² of gross deck surface area to each person.

2.1.2.2 Calculation method for minimum value

2.1.2.2.1 Basic formulae

In considering the design of stairway widths for each individual case which allow for the timely flow of persons evacuating to the assembly stations from adjacent decks above and below, the following calculation methods shall be used (see figures 1 and 2):

when joining two decks: $W = (N_1 + N_2) \times 10 \text{ mm};$

when joining three decks: $W = (N_1 + N_2 + 0.5N_3) \times 10 \text{ mm};$

when joining four decks: $W = (N_1 + N_2 + 0.5N_3 + 0.25N_4) \times 10 \text{ mm};$ and

when joining five decks or more decks, the width of the stairways shall be determined by applying the above formula for four decks to the deck under consideration and to the consecutive deck,

where:

W = the required tread width between handrails of the stairway.

The calculated value of W may be reduced where available landing area S is provided in stairways at the deck level defined by subtracting P from Z , such that:

$$P = S \times 3.0 \text{ persons/m}^2; \text{ and } P_{\max} = 0.25Z$$

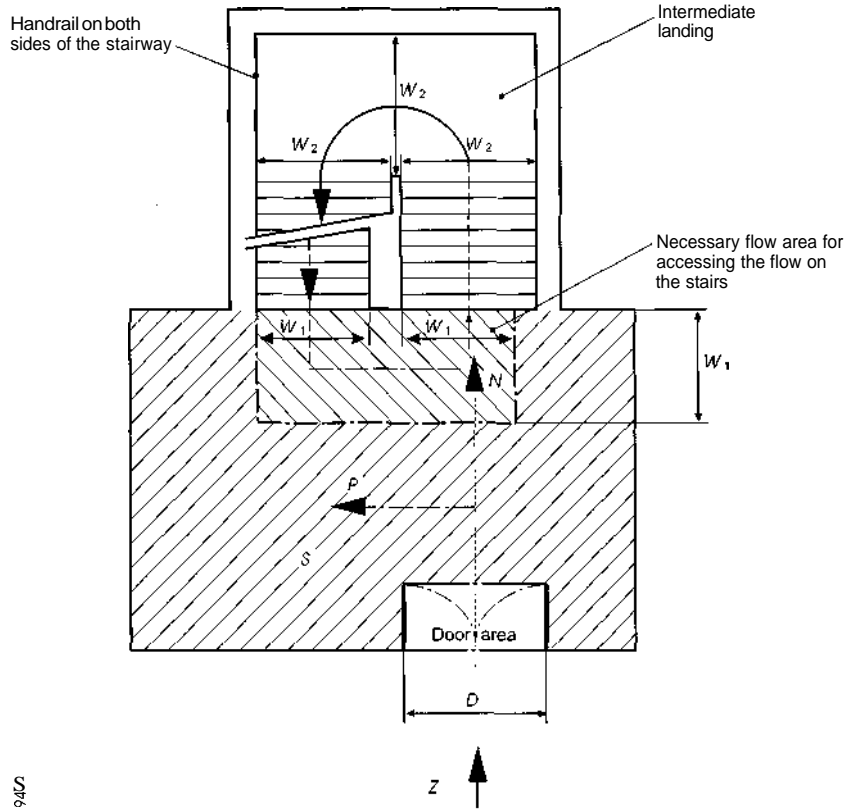
where:

- Z = the total number of persons expected to be evacuated on the deck being considered
- P = the number of persons taking temporary refuge on the stairway landing, which may be subtracted from Z to a maximum value of $P = 0.25Z$ (to be rounded down to the nearest whole number)
- S = the surface area (m^2) of the landing, minus the surface area necessary for the opening of doors and minus the surface area necessary for accessing the flow on stairs (see figure 1)
- N = the total number of persons expected to use the stairway from each consecutive deck under consideration; N_1 is for the deck with the largest number of persons using that stairway; N_2 is taken for the deck with the next highest number of persons directly entering the stairway flow such that, when sizing the stairway width as each deck level, $N_1 > N_2 > N_3 > N_4$ (see figure 2). These decks are assumed to be on or upstream (i.e. away from the embarkation deck) of the deck being considered.

2.1.2.2.2 Distribution of persons

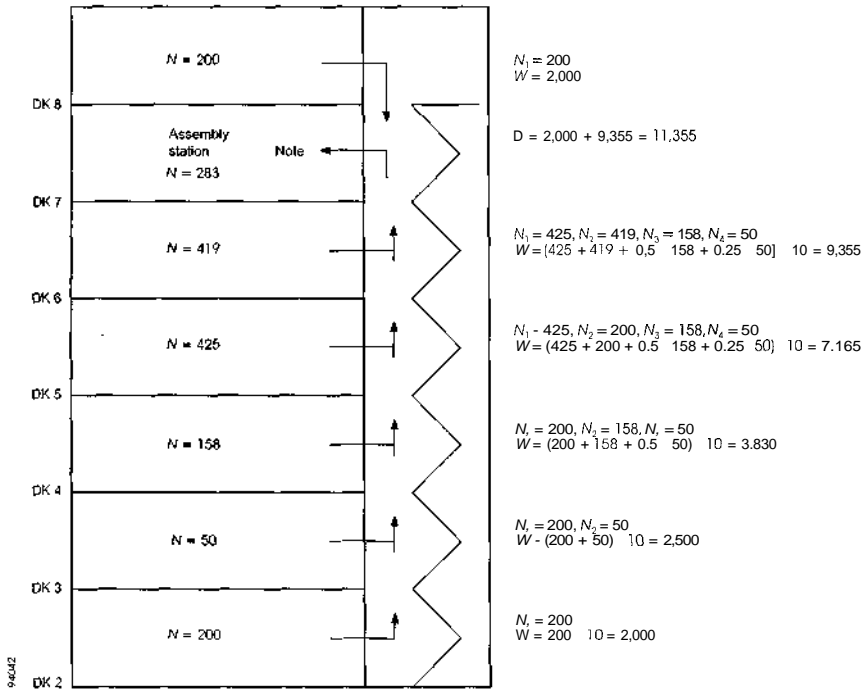
2.1.2.2.2.1 The dimension of the means of escape shall be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landings (see figure 3). Calculations shall be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken shall not be less than the largest dimension determined for each case:

- Case 1 Passengers in cabins with maximum berthing capacity fully occupied;
members of the crew in cabins occupied to $\frac{1}{2}$ of maximum berthing capacity; and service spaces occupied by $\frac{2}{3}$ of the crew.
- Case 2 Passengers in public spaces occupied to $\frac{3}{4}$ of maximum capacity;
members of the crew in public spaces occupied to $\frac{1}{3}$ of the maximum capacity;
service spaces occupied by 1 of the crew; and
crew accommodation occupied by $\frac{2}{3}$ of the crew.



- P = $S \times 3$ persons/m² = the number of persons taking refuge on the landing to a maximum of $P = 0.25Z$;
- N = $Z - P$ = the number of persons directly entering the stairway flow from a given deck;
- Z = number of persons to be evacuated from the deck considered;
- S = available landing area (m²) after subtracting the surface area necessary for movement and subtracting the space taken by the door swing area. Landing area is a sum of flow area, credit area and door area;
- D = width of exit doors to the stairway landing area (mm)

Figure 1 - Landing calculation for stairway width reduction



- Z (pers) = number of persons expected to evacuate through the stairway
- N (pers) = number of persons directly entering the stairway flow from a given deck
- W (mm) = $(N_1 + N_2 + 0.5 \times N_3 + 0.25 \times N_4) \times 10$ = calculated width of stairway
- D (mm) = width of exit doors
- $N_1 > N_2 > N_3 > N_4$ where:
- N_1 (pers) = the deck with the largest number of persons N entering directly the stairway
- N_2 (pers) = the deck with the next largest number of persons N entering directly the stairway, etc.

Note: The doors to the assembly station shall have aggregate widths of 11,355

Figure 2 - Minimum stairway width (W) calculation example

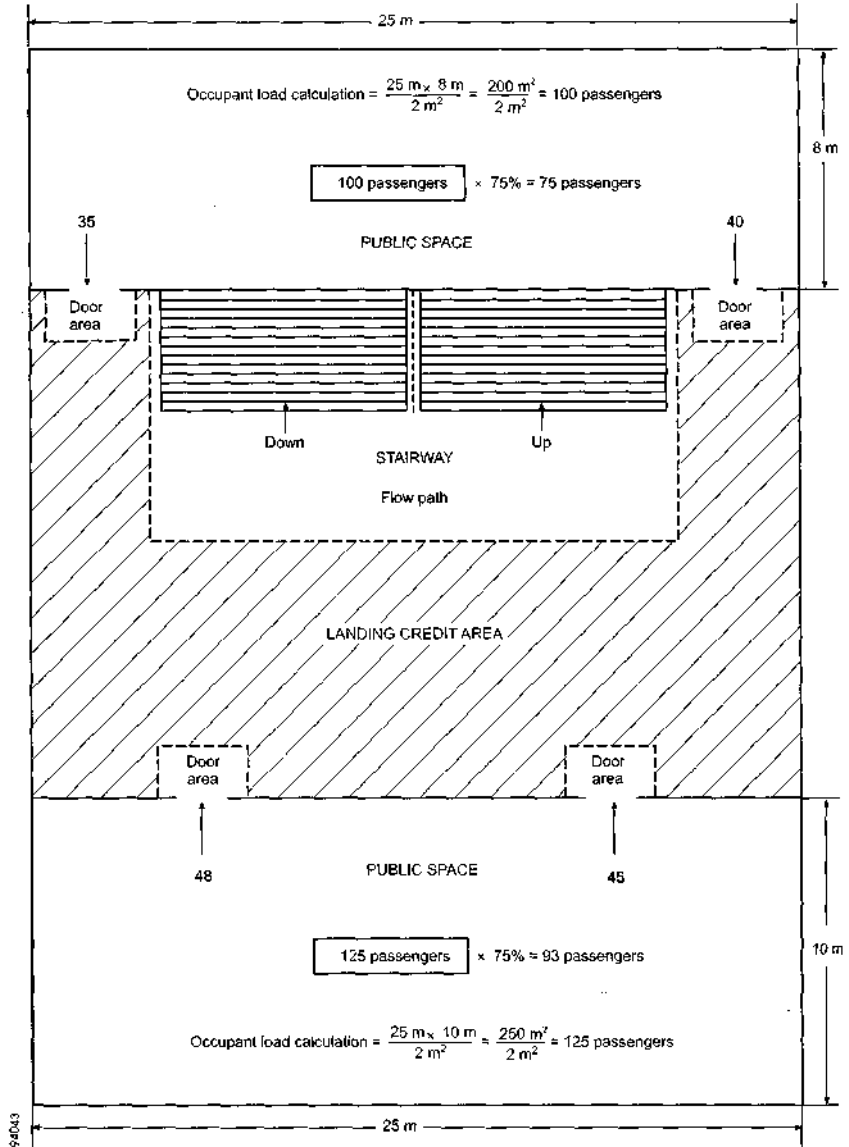


Figure 3 - Occupant loading calculation example

2.1.2.2.2 The maximum number of persons contained in a main vertical zone, including persons entering stairways from another main vertical zone, shall not be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of stairway widths only.

2.1.3 Prohibition of decrease in width in the direction to the assembly station*

The stairway shall not decrease in width in the direction of evacuation to the assembly station. Where several assembly stations are in one main vertical zone, the stairway width shall not decrease in the direction of the evacuation to the most distant assembly station.

2.2 *Details of stairways*

2.2.1 Handrails

Stairways shall be fitted with handrails on each side. The maximum clear width between handrails shall be 1,800 mm.

2.2.2 Alignment of stairways

All stairways sized for more than 90 persons shall be aligned fore and aft.

2.2.3 Vertical rise and inclination

Stairways shall not exceed 3.5 m in vertical rise without the provision of a landing and shall not have an angle of inclination greater than 45°.

2.2.4 Landings

Landings at each deck level shall be not less than 2 m² in area and shall increase by 1 m² for every 10 persons provided for in excess of 20 persons, but need not exceed 16 m², except for those landings servicing public spaces having direct access onto the stairway enclosure.

2.3 *Doorways and corridors*

2.3.1 Doorways and corridors and intermediate landings included in means of escape shall be sized in the same manner as stairways.

2.3.2 The aggregate width of stairway exit doors to the assembly station shall not be less than the aggregate width of stairways serving this deck.

Refer to the Indication of the "assembly station" in passenger ships (MSC/Circ.777).

10m



2.4 *Evacuation routes to the embarkation deck*

2.4.1 Assembly station

It shall be recognized that the evacuation routes to the embarkation deck may include an assembly station. In this case, consideration shall be given to the fire protection requirements and sizing of corridors and doors from the stairway enclosure to the assembly station and from the assembly station to the embarkation deck, noting that evacuation of persons from assembly stations to embarkation positions will be carried out in small control groups.

2.4.2 Routes from the assembly station to the survival craft embarkation position

Where the passengers and crew are held at an assembly station which is not at the survival craft embarkation position, the dimension of stairway width and doors from the assembly station to this position shall not be based on the number of persons in the controlled group. The width of these stairways and doors need not exceed 1,500 mm unless larger dimensions are required for evacuation of these spaces under normal conditions.

2.5 *Means of escape plans*

2.5.1 Means of escape plans shall be provided indicating the following:

- .1 the number of crew and passengers in all normally occupied spaces;
- .2 the number of crew and passengers expected to escape by stairway and through doorways, corridors and landings;
- .3 assembly stations and survival craft embarkation positions;
- .4 primary and secondary means of escape; and
- .5 width of stairways, doors, corridors and landing areas.

2.5.2 Means of escape plans shall be accompanied by detailed calculations for determining the width of escape stairways, doors, corridors and landing areas.

3 Cargo ships

Stairways and corridors used as means of escape shall be not less than 700 mm in clear width and shall have a handrail on one side. Stairways and corridors with a clear width of 1,800 mm and over shall have handrails on both sides. Clear width is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways should be, in general, 45°, but not greater than 50°, and in machinery spaces and small spaces not more than 60°. Doorways which give access to a stairway shall be of the same size as the stairway.

Chapter 14

Fixed deck foam systems

1 Application

This chapter details the specifications for fixed deck foam systems which are required to be provided by chapter II-2 of the Convention.

2 Engineering specifications

2.1 General

2.1.1 The arrangements for providing foam shall be capable of delivering foam to the entire *cargo* tanks deck area as well as into any *cargo* tank the deck of which has been ruptured.

2.1.2 The deck foam system shall be capable of simple and rapid operation.

2.1.3 Operation of a 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.

2.2 Component requirements

2.2.1 Foam solution and foam concentrate

2.2.1.1 The rate of supply of foam solution shall be not less than the greatest of the following:

- .1 0.6 l/min per square metre of cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship multiplied by the total longitudinal extent of the cargo tank spaces;
- .2 6 l/min per square metre of the horizontal sectional area of the single tank having the largest such area; or
- .3 3 l/min per square metre of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1,250 l/min.

2.2.1.2 Sufficient foam concentrate shall be supplied to ensure at least 20 min of foam generation in tankers fitted with an inert gas installation or 30 min of foam generation in tankers not fitted with an inert gas installation when using solution rates stipulated in paragraph 2.2.1.1, as appropriate, whichever is the greatest. The foam expansion ratio (i.e. the ratio of the volume of foam produced to the volume of the mixture of water and foam-making concentrate supplied) shall not generally exceed 12 to 1. Where systems essentially produce low expansion foam, but an expansion ratio

slightly in excess of 12 to 1, the quantity of foam solution available shall be calculated as for 12 to 1 expansion ratio systems.* When medium expansion ratio foam[†] (between 50 to 1 and 150 to 1 expansion ratio) is employed, the application rate of the foam and the capacity of a monitor installation shall be to the satisfaction of the Administration.

2.2.2 Monitors and foam applicators

2.2.2.1 Foam from the fixed foam system shall be supplied by means of monitors and foam applicators. At least 50% of the foam solution supply rate required in paragraphs 2.2.1.1.1 and 2.2.1.1.2 shall be delivered from each monitor. On tankers of less than 4,000 tonnes deadweight the Administration may not require installation of monitors but only applicators. However, in such a case the capacity of each applicator shall be at least 25% of the foam solution supply rate required in paragraphs 2.2.1.1.1 or 2.2.1.1.2.

2.2.2.2 The capacity of any monitor shall be at least 3 l/min of foam solution per square metre of deck area protected by that monitor, such area being entirely forward of the monitor. Such capacity shall be not less than 1,250 l/min.

2.2.2.3 The capacity of any applicator shall be not less than 400 l/min and the applicator throw in still air conditions shall be not less than 15 m.

2.3 *Installation requirements*

2.3.1 Main control station

The main control station for the system shall be suitably located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

2.3.2 Monitors

2.3.2.1 The number and position of monitors shall be such as to comply with paragraph 2.1.1.

2.3.2.2 The distance from the monitor to the farthest extremity of the protected area forward of that monitor shall not be more than 75% of the monitor throw in still air conditions.

2.3.2.3 A monitor and hose connection for a foam applicator shall be situated both port and starboard at the front of the poop or accommodation spaces facing the cargo tanks deck. On tankers of less

* Refer to the Guidelines for performance and testing criteria and surveys of low-expansion foam concentrates for fixed fire-extinguishing systems (MSC/Circ.582 and Corr.1).

[†] Refer to the Guidelines for performance and testing criteria, and surveys of medium-expansion concentrates for fire-extinguishing systems (MSC/Circ.798).

than 4,000 tonnes deadweight, a hose connection for a foam applicator shall *be* situated both port and starboard at the front of the poop or accommodation spaces facing the cargo tanks deck.

2.3.3 Applicators

2.3.3.1 The number of foam applicators provided shall not be less than four. The number and disposition of foam main outlets shall be such that foam from at least two applicators can be directed onto any part of the cargo tanks deck area.

2.3.3.2 Applicators shall be provided to ensure flexibility of action during fire-fighting operations and to cover areas screened from the monitors.

2.3.4 Isolation valves

Valves shall be provided in the foam main, and in the fire main when this is an integral part of the deck foam system, immediately forward of any monitor position to isolate damaged sections of those mains.

Chapter 15

Inert gas systems

1 Application

This chapter details the specifications for inert gas systems as required by chapter II-2 of the Convention.

2 Engineering specifications

2.1 *General*

2.1.1 Throughout this chapter the term cargo tank includes also slop tanks.

2.1.2 The inert gas system referred to in chapter II-2 of the Convention shall be designed, constructed and tested to the satisfaction of the Administration. It shall be so designed* and operated as to render and maintain the atmosphere of the cargo tanks non-flammable at all times, except when such tanks are required to be gas-free. In the event that the inert gas system is unable to meet the operational requirement set out above and it has been assessed that it is impracticable to effect a repair,

* Refer to the Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers (MSC/Circ.677 as amended by MSC/Circ. 1009) and the Revised factors to be taken into consideration when designing cargo tank venting and gas-freeing arrangements (MSC/Circ.731).

Chapter 15: Inert gas systems

then cargo discharge, deballasting and necessary tank cleaning shall only be resumed when the "emergency conditions" specified in the Guidelines on inert gas systems are complied with.*

2.1.3 Required functions

The system shall be capable of:

- .1 inerting empty cargo tanks by reducing the oxygen content of the atmosphere in each tank to a level at which combustion cannot be supported;
- .2 maintaining the atmosphere in any part of any cargo tank with an oxygen content not exceeding 8% by volume and at a positive pressure at all times in port and at sea except when it is necessary for such a tank to be gas-free;
- .3 eliminating the need for air to enter a tank during normal operations except when it is necessary for such a tank to be gas-free; and
- .4 purging empty cargo tanks of a hydrocarbon gas, so that subsequent gas-freeing operations will at no time create a flammable atmosphere within the tank.

2.2 Component requirements

2.2.1 Supply of inert gas

2.2.1.1 The inert gas supply may be treated flue gas from main or auxiliary boilers. The Administration may accept systems using flue gases from one or more separate gas generators or other sources or any combination thereof, provided that an equivalent standard of safety is achieved. Such systems shall, as far as practicable, comply with the requirements of this chapter. Systems using stored carbon dioxide shall not be permitted unless the Administration is satisfied that the risk of ignition from generation of static electricity by the system itself is minimized.

2.2.1.2 The system shall be capable of delivering inert gas to the cargo tanks at a rate of at least 125% of the maximum rate of discharge capacity of the ship expressed as a volume.

2.2.1.3 The system shall be capable of delivering inert gas with an oxygen content of not more than 5% by volume in the inert gas supply main to the cargo tanks at any required rate of flow.

* Refer to the Clarification of inert gas system requirements under SOLAS 1974, as amended (MSC/Circ.485) and to the Revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387.

2.2.1.4 Two fuel oil pumps shall be fitted to the inert gas generator. The Administration may permit only one fuel oil pump on condition that sufficient spares for the fuel oil pump and its prime mover are carried on board to enable any failure of the fuel oil pump and its prime mover to be rectified by the ship's crew.

2.2.2 Scrubbers

2.2.2.1 A flue gas scrubber shall be fitted which will effectively cool the volume of gas specified in paragraphs 2.2.1.2 and 2.2.1.3 and remove solids and sulphur combustion products. The cooling water arrangements shall be such that an adequate supply of water will always be available without interfering with any essential services on the ship. Provision shall also be made for an alternative supply of cooling water.

2.2.2.2 Filters or equivalent devices shall be fitted to minimize the amount of water carried over to the inert gas blowers.

2.2.2.3 The scrubber shall be located aft of all cargo tanks, cargo pump-rooms and cofferdams separating these spaces from machinery spaces of category A.

2.2.3 Blowers

2.2.3.1 At least two blowers shall be fitted and be capable of delivering to the cargo tanks at least the volume of gas required by paragraphs 2.2.1.2 and 2.2.1.3. For systems with gas generators, the Administration may permit only one blower if that system is capable of delivering the total volume of gas required by paragraphs 2.2.1.2 and 2.2.1.3 to the protected cargo tanks, provided that sufficient spares for the blower and its prime mover are carried on board to enable any failure of the blower and its prime mover to be rectified by the ship's crew.

2.2.3.2 The inert gas system shall be so designed that the maximum pressure which it can exert on any cargo tank will not exceed the test pressure of any cargo tank. Suitable shutoff arrangements shall be provided on the suction and discharge connections of each blower. Arrangements shall be provided to enable the functioning of the inert gas plant to be stabilized before commencing cargo discharge. If the blowers are to be used for gas-freeing, their air inlets shall be provided with blanking arrangements.

2.2.3.3 The blowers shall be located aft of all cargo tanks, cargo pump-rooms and cofferdams separating these spaces from machinery spaces of category A.

2.2.4 Water seals

2.2.4.1 The water seal referred to in paragraph 2.3.1.4.1 shall be capable of being supplied by two separate pumps, each of which shall be capable of maintaining an adequate supply at all times.

2.2.4.2 The arrangement of the seal and its associated fittings shall be such that it will prevent backflow of hydrocarbon vapours and will ensure the proper functioning of the seal under operating conditions.

2.2.4.3 Provision shall be made to ensure that the water seal is protected against freezing, in such a way that the integrity of the seal is not impaired by overheating.

2.2.4.4 A water loop or other approved arrangement shall also be fitted to each associated water supply and drainpipe and each venting or pressure-sensing pipe leading to gas-safe spaces. Means shall be provided to prevent such loops from being emptied by a vacuum.

2.2.4.5 The deck water seal and loop arrangements shall be capable of preventing return of hydrocarbon vapours at a pressure equal to the test pressure of the cargo tanks.

2.2.4.6 In respect of paragraph 2.4.3.1.7, the Administration shall be satisfied as to the maintenance of an adequate reserve of water at all times and the integrity of the arrangements to permit the automatic formation of the water seal when the gas flow ceases. The audible and visual alarm on the low level of water in the water seal shall operate when the inert gas is not being supplied.

2.3 *Installation requirements*

2.3.1 Safety measures in the system

2.3.1.1 Flue gas isolating valves

Flue gas isolating valves shall be fitted in the inert gas supply mains between the boiler uptakes and the flue gas scrubber. These valves shall be provided with indicators to show whether they are open or shut, and precautions shall be taken to maintain them gastight and keep the seatings clear of soot. Arrangements shall be made to ensure that boiler soot blowers cannot be operated when the corresponding flue gas valve is open.

2.3.1.2 Prevention of flue gas leakage

2.3.1.2.1 Special consideration shall be given to the design and location of scrubber and blowers with relevant piping and fittings in order to prevent flue gas leakages into enclosed spaces.

2.3.1.2.2 To permit safe maintenance, an additional water seal or other effective means of preventing flue gas leakage shall be fitted between the flue gas isolating valves and scrubber or incorporated in the gas entry to the scrubber.

2.3.1.3 Gas regulating valves

2.3.1.3.1 A gas regulating valve shall be fitted in the inert gas supply main. This valve shall be automatically controlled to close as required in paragraph 2.3.1.5. It shall also be capable of automatically regulating the flow of inert gas to the cargo tanks unless means are provided to automatically control the speed of the inert gas blowers required in paragraph 2.2.3.

2.3.1.3.2 The valve referred to in paragraph 2.3.1.3.1 shall be located at the forward bulkhead of the forward most gas-safe space* through which the inert gas supply main passes.

2.3.1.4 Non-return devices of flue gas

2.3.1.4.1 At least two non-return devices, one of which shall be a water seal, shall be fitted in the inert gas supply main, in order to prevent the return of hydrocarbon vapour to the machinery space uptakes or to any gas-safe spaces under all normal conditions of trim, list and motion of the ship. They shall be located between the automatic valve required by paragraph 2.3.1.3.1 and the aftermost connection to any cargo tank or cargo pipeline.

2.3.1.4.2 The devices referred to in paragraph 2.3.1.4.1 shall be located in the cargo area on deck.

2.3.1.4.3 The second device shall be a non-return valve or equivalent capable of preventing the return of vapours or liquids and fitted forward of the deck water seal required in paragraph 2.3.1.4.1. It shall be provided with positive means of closure. As an alternative to positive means of closure, an additional valve having such means of closure may be provided forward of the non-return valve to isolate the deck water seal from the inert gas main to the cargo tanks.

2.3.1.4.4 As an additional safeguard against the possible leakage of hydrocarbon liquids or vapours back from the deck main, means shall be provided to permit this section of the line between the valve having positive means of closure referred to in paragraph 2.3.1.4.3 and the valve referred to in paragraph 2.3.1.3 to be vented in a safe manner when the first of these valves is closed.

* A gas-safe space is a space in which the entry of hydrocarbon gases would produce hazards with regard to flammability or toxicity.

2.3.1.5 Automatic shutdown

2.3.1.5.1 Automatic shutdown of the inert gas blowers and gas regulating valve shall be arranged on predetermined limits being reached in respect of paragraphs 2.4.3.1.1, 2.4.3.1.2 and 2.4.3.1.3.

2.3.1.5.2 Automatic shutdown of the gas regulating valve shall be arranged in respect of paragraph 2.4.3.1.4.

2.3.1.6 Oxygen rich gas

In respect of paragraph 2.4.3.1.5, when the oxygen content of the inert gas exceeds 8% by volume, immediate action shall be taken to improve the gas quality. Unless the quality of the gas improves, all cargo tank operations shall be suspended so as to avoid air being drawn into the tanks and the isolation valve referred to in paragraph 2.3.1.4.3 shall be closed.

2.3.2 Inert gas lines

2.3.2.1 The inert gas main may be divided into two or more branches forward of the non-return devices required by paragraphs 2.2.4 and 2.3.1.4.

2.3.2.2 The inert gas supply main shall be fitted with branch piping leading to each cargo tank. Branch piping for inert gas shall be fitted with either stop valves or equivalent means of control for isolating each tank. Where stop valves are fitted, they shall be provided with locking arrangements, which shall be under the control of a responsible ship's officer. The control system shall provide unambiguous information of the operational status of such valves.

2.3.2.3 In combination carriers, the arrangement to isolate the slop tanks containing oil or oil residues from other tanks shall consist of blank flanges which will remain in position at all times when cargoes other than oil are being carried except as provided for in the relevant section of the Guidelines on inert gas systems.*

2.3.2.4 Means shall be provided to protect cargo tanks against the effect of overpressure or vacuum caused by thermal variations when the cargo tanks are isolated from the inert gas mains.

2.3.2.5 Piping systems shall be so designed as to prevent the accumulation of cargo or water in the pipelines under all normal conditions.

* Refer to the Revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387.

2.3.2.6 Arrangements shall be provided to enable the inert gas main to be connected to an external supply of inert gas. The arrangements shall consist of a 250 mm nominal pipe size bolted flange, isolated from the inert gas main by a valve and located forward of the non-return valve referred to in paragraph 2.3.1.4.3. The design of the flange should conform to the appropriate class in the standards adopted for the design of other external connections in the ship's cargo piping system.

2.3.2.7 If a connection is fitted between the inert gas supply main and the cargo piping system, arrangements shall be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This shall consist of two shutoff valves with an arrangement to vent the space between the valves in a safe manner or an arrangement consisting of a spool-piece with associated blanks.

2.3.2.8 The valve separating the inert gas supply main from the cargo main and which is on the cargo main side shall be a non-return valve with a positive means of closure.

2.4 *Operation and control requirements*

2.4.1 Indication devices

Means shall be provided for continuously indicating the temperature and pressure of the inert gas at the discharge side of the gas blowers, whenever the gas blowers are operating.

2.4.2 Indicating and recording devices

2.4.2.1 Instrumentation shall be fitted for continuously indicating and permanently recording when inert gas is being supplied:

- .1 the pressure of the inert gas supply mains forward of the non-return devices required by paragraph 2.3.1.4.1; and
- .2 the oxygen content of the inert gas in the inert gas supply mains on the discharge side of the gas blowers.

2.4.2.2 The devices referred to in paragraph 2.4.2.1 shall be placed in the cargo control room where provided. But where no cargo control room is provided, they shall be placed in a position easily accessible to the officer in charge of cargo operations.

2.4.2.3 In addition, meters shall be fitted:

- .1 in the navigation bridge to indicate at all times the pressure referred to in paragraph 2.4.2.1.1 and the pressure in the slop tanks of combination carriers, whenever those tanks are isolated from the inert gas supply main; and
- .2 in the machinery control room or in the machinery space to indicate the oxygen content referred to in paragraph 2.4.2.1.2.

2.4.2.4 Portable instruments for measuring oxygen and flammable vapour concentration shall be provided. In addition, suitable arrangements shall be made on each cargo tank such that the condition of the tank atmosphere can be determined using these portable instruments.

2.4.2.5 Suitable means shall be provided for the zero and span calibration of both fixed and portable gas concentration measurement instruments, referred to in paragraphs 2.4.2.1 to 2.4.2.4.

2.4.3 Audible and visual alarms

2.4.3.1 For inert gas systems of both the flue gas type and the inert gas generator type, audible and visual alarms shall be provided to indicate:

- .1 low water pressure or low water flow rate to the flue gas scrubber as referred to in paragraph 2.2.2.1;
- .2 high water level in the flue gas scrubber as referred to in paragraph 2.2.2.1;
- .3 high gas temperature as referred to in paragraph 2.4.1;
- .4 failure of the inert gas blowers referred to in paragraph 2.2.3;
- .5 oxygen content in excess of 8% by volume as referred to in paragraph 2.4.2.1.2;
- .6 failure of the power supply to the automatic control system for the gas regulating valve and to the indicating devices as referred to in paragraphs 2.3.1.3 and 2.4.2.1;
- .7 low water level in the water seal as referred to in paragraph 2.3.1.4.1;
- .8 gas pressure less than 100 mm water gauge as referred to in paragraph 2.4.2.1.1. The alarm arrangement shall be such as to ensure that the pressure in slop tanks in combination carriers can be monitored at all times; and
- .9 high gas pressure as referred to in paragraph 2.4.2.1.1.

2.4.3.2 For inert gas systems of the inert gas generator type, additional audible and visual alarms shall be provided to indicate:

- .1 insufficient fuel oil supply;
- .2 failure of the power supply to the generator; and
- .3 failure of the power supply to the automatic control system for the generator.

2.4.3.3 The alarms required in paragraphs 2.4.3.1.5, 2.4.3.1.6 and 2.4.3.1.8 shall be fitted in the machinery space and cargo control room, where provided, but in each case in such a position that they are immediately received by responsible members of the crew.

2.4.3.4 An audible alarm system independent of that required in paragraph 2.4.3.1.8 or automatic shutdown of cargo pumps shall be provided to operate on predetermined limits of low pressure in the inert gas main being reached.

2.4.4 Instruction manuals

Detailed instruction manuals shall be provided on board, covering the operations, safety and maintenance requirements and occupational health hazards relevant to the inert gas system and its application to the cargo tank system.* The manuals shall include guidance on procedures to be followed in the event of a fault or failure of the inert gas system.

* Refer to the Revised guidelines for inert gas systems (MSC/Circ.353), as amended by MSC/Circ.387.

Resolution A.602(15)
(adopted on 19 November 1987)

**Revised guidelines for marine
portable fire extinguishers**

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING FURTHER that it adopted by resolution A.518(13) the Guidelines for marine portable fire extinguishers to supplement the requirements of chapter II-2 of the International Convention for the Safety of Life at Sea, 1974, as amended, as well as chapter V of the Torremolinos International Convention for the Safety of Fishing Vessels, 1977,

RECOGNIZING the need to improve these Guidelines in the light of experience gained,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its fifty-third session,

1. ADOPTS the Revised guidelines for marine portable fire extinguishers, the text of which is annexed to the present resolution and which supersedes the *Guidelines annexed to resolution A.518(13)*;
2. RECOMMENDS Governments concerned to apply the Revised guidelines set out in the annex, in conjunction with the appropriate requirements of the above instruments.

Annex

Revised guidelines for marine portable fire extinguishers

Scope

These Guidelines have been developed to supplement the requirements for marine portable fire extinguishers* in the International Convention for the Safety of Life at Sea, 1974, and the Torremolinos International Convention for the Safety of Fishing Vessels, 1977. The Guidelines are offered to Administrations to assist them in determining appropriate design and construction parameters. The status of the guidelines is advisory. Their content is based on current practices and does not exclude the use of designs and materials other than those indicated below.

2 Definitions

2.1 An *extinguisher* is an appliance containing an extinguishing medium which can be expelled by the action of internal pressure and be directed into a fire. This pressure may be stored pressure, or be obtained by a chemical reaction, or be obtained by release of gas from a cartridge.

2.2 A *portable extinguisher* is 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.

2.3 *Extinguishing medium* is the substance contained in the extinguisher the action of which causes extinction of fire.

2.4 *Charge of an extinguisher* is the mass or volume of the extinguishing medium contained in the extinguisher. The quantity of the charge of water or foam extinguishers is normally expressed in volume (litres) and that of other types of extinguishers in mass (kilograms).

3 Classification

Extinguishers are classified according to the type of extinguishing medium they contain. At present the types of extinguishers and the uses for which they are recommended are as follows:

* Wherever in the text of these Guidelines the word "extinguisher" appears it shall be taken as meaning "marine portable fire extinguisher".

Extinguishing medium	Recommended for use on fires involving
Water	wood, paper, textiles and similar materials
Foam	wood, paper, textiles and flammable liquids
Dry powder/dry chemical (standard)	flammable liquids, electrical equipment and flammable gases
Dry powder/dry chemical (multiple or general purpose)	wood, paper, textiles, flammable liquids, electrical equipment and flammable gases
Dry powder/dry chemical (metal)	combustible metals
Carbon dioxide	flammable liquids, electrical equipment and flammable gases
Halogenated hydrocarbons (Halons)	flammable liquids, electrical equipment and flammable gases

A table is provided in the appendix which describes the general characteristics of each type of extinguisher.

4 Construction

4.1 The construction of an extinguisher should be designed and manufactured for simple and rapid operation, and ease of handling.

4.2 Extinguishers should be manufactured to a national or other recognized standard which includes a requirement that the body, and all other parts subject to internal pressure, be tested to a pressure above the maximum expected during the service life of the extinguisher. In the design of components, selection of materials and determination of maximum filling ratios and densities, consideration should be given to the temperature extremes to which extinguishers may be exposed on board ships.

4.3 The materials of construction of exposed parts and adjoining dissimilar metals should be carefully selected to function properly in the marine environment.

5 Fire classifications

Fire classifications are generally A, B, C and D. There are currently two standards, defining classes of fires according to the nature of the material undergoing combustion, as follows:

International Organization for Standardization (ISO standard 3941)*	National Fire Protection Association (NFPA 10)
<i>Class A:</i> Fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers.	<i>Class A:</i> Fires in ordinary combustible materials such as wood, cloth, paper, rubber and many plastics.
<i>Class B:</i> Fires involving liquids or liquefiable solids.	<i>Class B:</i> Fires in flammable liquids, oils, greases, tars, oil base paints, lacquers and flammable gases.
<i>Class C:</i> Fires involving gases.	<i>Class C:</i> Fires which involve energized electrical equipment where the electrical non-conductivity of the extinguishing medium is of importance. (When electrical equipment is de-energized, extinguishers for class A or B fires may be used safely.)
<i>Class D:</i> Fires involving metals.	<i>Class D:</i> Fires in combustible metals such as magnesium, titanium, zirconium, sodium, lithium, and potassium.

6 Test specifications

Construction, performance and fire-extinguishing test specifications should be to the satisfaction of the Administration.

7 Criteria for assessing compliance with regulation II-2/6.1.1 of the 1974 SOLAS Convention and regulation 8111 of the 1977 Torremolinos Convention

7.1 Regulation II-2/6.1.1 requires that extinguishers have a fire extinguishing capability at least equivalent to that of a 9 / fluid extinguisher which may be water or foam as required by the Administration. This equivalence may be demonstrated by fire test ratings determined according to an international, national or other recognized standard.

* Comité Européen de Normalisation (CEN standard-EN2) closely follows ISO standard 3941.

7.2 The size and type of extinguishers should be dependent upon the potential fire hazards in the protected spaces. Care should also be taken to ensure that the quantity of extinguishing medium released in small spaces does not endanger personnel.

8 Marking of extinguishers

Each extinguisher should be clearly marked with the following minimum information:

- .1 name of the manufacturer;
- .2 types of fire for which the extinguisher is suitable;
- .3 type and quantity of extinguishing medium;
- A approval details;
- .5 instructions for use and recharge (it is recommended that operating instructions be given in pictorial form),
- .6 year of manufacture;
- .7 temperature range over which the extinguisher will operate satisfactorily;
- 8 test pressure;

9 Periodical inspections and maintenance

9.1 Extinguishers should be subject to periodical inspections and maintenance in accordance with the manufacturer's instructions. The periods between such inspections and maintenance should not exceed the period between safety equipment surveys.

9.2 Records of inspections should be maintained. The records should show the date of inspection, the type of maintenance carried out, and whether or not a pressure test was performed.

9.3 Instructions for recharging extinguishers should be supplied by the manufacturer and be available for use on board.

Extinguishing medium used	TYPES OF EXTINGUISHER							
	Water		Chemical foam	Mechanical foam	Powder	Carbon dioxide	Halogenated hydrocarbons	
	Water, with possible salts in solution	Basic water solution	Basic water solution with foam generating substances	Water solution containing foam generating substances	Dry chemical powders	Pressurized carbon dioxide	Halogenated hydrocarbons	
Expellant charge of the extinguisher (stored pressure or cartridge as indicated):	One basic and one acid reagent; in general the basic reagent is a solution of sodium bicarbonate and the acid reagent is a solution of sulphuric or hydrochloric acid or of aluminium sulphate	Carbon dioxide or other pressurized inert gases or compressed air (storage pressure or separate cartridge)	Solution of sulphuric or hydrochloric acid or aluminium sulphate	Water solution and acid reagent (e.g. solution of aluminium sulphate)	Carbon dioxide or other pressurized inert gases or compressed air (stored pressure or separate cartridge)	Carbon dioxide or other inert gases or dry air (stored pressure or separate cartridge)		
The discharge of the extinguisher is achieved by:	Opening of the valve. Generation of carbon dioxide (chemical reaction which develops inside the extinguisher)	Opening of the valve. Action of pressurized gas (opening of the cartridge)	Opening of the valve. Generation of carbon dioxide (chemical reaction between the acid in the cartridge and the basic solution of the charge)	Opening of the valve. Generation of carbon dioxide (chemical reaction between the acid solution in the cartridge and the basic solution of the charge)	Opening of the valve. Action of pressurized gas (opening of the cartridge)	Opening of the valve. Action of pressurized gas (opening of the cartridge)	Opening of the valve of the container constituting the extinguisher	Opening of the valve of the container constituting the extinguisher

	TYPES OF EXTINGUISHER							
	Water		Chemical foam	Mechanical foam	Powder	Carbon dioxide	Halogenated hydrocarbons	
The discharged extinguishing medium consists of:	Water, with possible salts in solution	Water with salts in solution	Foam containing carbon dioxide	Foam containing the gas used	Dry chemical powders and carbon dioxide or other gas	Carbon dioxide	Halogenated hydrocarbons	
The discharged extinguishing medium causes the extinction of fire by:	Cooling of the burning materials. Water evaporation and consequent formation of a local atmosphere (water/steam) which isolates the burning products from the surrounding air	Formation of a foam layer which isolates the burning products from the surrounding air		Inhibition of the combustion process by interrupting the chemical reaction. Some separation of burning materials from surrounding air	Formation of a local inert atmosphere (carbon dioxide) which isolates the burning of materials from the surrounding air. Smothering and cooling action of carbon dioxide	Inhibition of the combustion process by interrupting the chemical reaction		
The electrical resistance of the discharged extinguishing medium is:	Very low	Very low	Very low	Low	Low	Very high. Under intense heat some powders may be electrically conductive	Very high	Very high

Operating peculiarities and limitations	TYPES OF EXTINGUISHER							
	Water			Chemical foam	Mechanical foam	Powder	Carbon dioxide	Halogenated hydrocarbons
	The jet of the extinguisher is to be directed			towards the base of the fire The extinction of the fire is achieved only when all the burning surface is covered by foam			Powder mixture subject to windage; they may therefore have limited effectiveness in the open or in ventilated spaces	Gas, subject to windage; they therefore have limited effectiveness in the open or in ventilated spaces

Disadvantages and dangers	TYPES Of EXTINGUISHER						
	Water		Chemical foam	Mechanical foam	Powder	Carbon dioxide	Halogenated hydrocarbons
		Not to be used	where there are electrical hazards		Malfunctioning of the reduced arrangements may result in dangerous overpressures	Generated powder mixtures may be suffocating. Powder can damage electrical contacts.	Carbon dioxide may be suffocating

	TYPES OF EXTINGUISHER					
	Water	Chemical foam	Mechanical foam	Powder	Carbon dioxide	Halogenated hydrocarbons
Maintenance	<p>Extinguishers with copper or copper alloy body should not be polished with products of corrosive nature which may cause wall thickness reduction. Such extinguishers should preferably be painted externally.</p> <p>The charge can freeze at temperatures of about 0°C (unless the charge is made non-freezable chemically).</p>			<p>Some types of powder may be altered by humidity; therefore, avoid the refilling of the extinguisher in humid locations.</p>		
	<p>Avoid installing the extinguisher in excessively warm locations, where the internal pressure of the carbon dioxide in the cartridge might rise to very high values</p>	<p>The charge can freeze at about -5°C. The charge can be altered by elevated temperatures (about 40°C or more). Therefore, the extinguisher should not be installed in positions where it may be exposed to high or low temperatures.</p>		<p>When a carbon dioxide container is provided, avoid the installation of the extinguisher in excessively warm locations, where the internal pressure of the carbon dioxide in the container might rise to very high values.</p>		

Resolution A.752(18)
(adopted on 4 November 1993)

**Guidelines for the evaluation, testing and
application of low-location lighting
on passenger ships**

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

RECALLING ALSO that the Maritime Safety Committee adopted, on 10 April 1992, resolution MSC.24(60) and, on 11 December 1992, resolution MSC.27(61), both of which require, *inter alia*, that, in addition to the emergency lighting required by SOLAS regulations II-1/42 and III/11.5, the means of escape, including stairways and exits, shall be marked by lighting or photoluminescent strip indicators placed not more than 0.3 m above the deck at all points of the escape route,

RECALLING FURTHER that the above resolutions require Administrations to ensure that such lighting or photoluminescent equipment has been evaluated, tested and applied in accordance with guidelines developed by the Organization,

CONSCIOUS of the need for passengers to readily identify, in case of emergencies, the route of escape when the normal emergency lighting is less effective due to smoke,

BELIEVING that passenger safety, in case of fire on board, can be greatly enhanced by the installation of a low-location lighting system, as described in the Guidelines referred to in operative paragraph 1,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-second session,

1. ADOPTS the Guidelines for the evaluation, testing and application of low-location lighting on passenger ships, set out in the annex to the present resolution;
2. INVITES Governments to implement these Guidelines at the earliest possible opportunity;

3. REQUESTS the Maritime Safety Committee to keep the Guidelines under review and to amend them as necessary in the light of experience gained in their application.

Annex

Guidelines for the evaluation, testing and application of low-location lighting on passenger ships

1 Scope

1.1 These Guidelines cover the approval, installation and maintenance of low-location lighting (LLL) required by regulations II-2/28, paragraph 1.10 and II-2/41-2, paragraph 4.7 of the 1974 SOLAS Convention, as amended, on all passenger ships carrying more than 36 passengers, to readily identify the passengers' route of escape when the normal emergency lighting is less effective due to smoke.

2 General

2.1 In addition to the emergency lighting required by regulations II-1/42 and III/11.5 of the 1974 SOLAS Convention, as amended, the means of escape, including stairways and exits, should be marked by LLL at all points of the escape route, including angles and intersections. In addition, all escape route signs and fire equipment location markings should be of photoluminescent material, or marked by lighting, or a combination of both.

2.2 The supplementary emergency lighting for ro-ro passenger ships required by regulation II-1/42-1 of the 1974 SOLAS Convention, as amended, may be accepted to form partly or wholly the LLL system provided that such a system complies with the requirements of these Guidelines.

2.3 The LLL system should function at all times for at least 60 min after its activation. Entire systems, including those that are automatically activated or continuously operating, are to be capable of being manually activated by a single action from the continuously manned central control station.

3 Definitions

3.1 *Low-location lighting (LLL)* - Electrically powered lighting or photoluminescent indicators placed at points of the escape route to readily identify all routes of escape.

3.2 *Photoluminescent (PL) system* - An LLL system which uses PL material. Photoluminescent material contains a chemical (example: zinc sulphide) that has the quality of storing energy when illuminated by visible light. The PL material emits light which becomes visible when the ambient light source is less effective. Without the light source to re-energize it, the PL material gives off the stored energy for a period of time with diminishing luminance.

3.3 *Electrically powered (EP) system* - An LLL system which requires electrical power for its operation, such as systems using incandescent bulbs, light-emitting diodes, electroluminescent strips or lamps, electrofluorescent lamps, etc.

4 Particulars

4.1 The Administration should ensure that the LLL systems meet the requirements of international standards acceptable to the Organization.*

4.2 In all passageways, the LLL should be continuous, except as interrupted by corridors and cabin doors, in order to provide a visible delineation along the escape route. Systems tested to an international standard* to demonstrate a visible delineation without being continuous should also be acceptable. The LLL should be installed at least on one side of the corridor, either on the bulkhead within 300 mm of the deck, or on the deck within 150 mm of the bulkhead. In corridors more than 2 m wide, LLL should be installed on both sides.

4.3 In dead-end corridors, LLL should have arrows placed at intervals of no more than 1 m, or equivalent direction indicators, pointing away from the dead end.

4.4 In all stairways, LLL should be installed on at least one side at a height less than 300 mm above the steps, which will make the location of each step readily identifiable to any person standing above and below that step. Low-location lighting should be installed on both sides if the width of the stairway is 2 m or more. The top and bottom of each set of stairs should be identified to show that there are no further steps.

4.5 IMO symbols should be incorporated into the LLL which directs the passengers to the muster stations required by regulation III/24 of the 1974 SOLAS Convention, as amended.

* Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied.

4.6 In all passenger cabins a placard explaining the LLL system should be installed on the inside of the cabin door. It should also have a diagram showing the location of, and the way to, the two closest exits with respect to the cabin.

4.7 Materials used in the manufacture of LLL products should not contain radioactive or toxic materials.

5 Doors

5.1 Low-location lighting should lead to the exit door handle. To prevent confusion, no other doors should be similarly marked.

5.2 Sliding fire doors and watertight doors should be marked with an LLL sign showing how the door opens.

6 Signs and markings

6.1 All escape route signs and fire equipment location marking should be of photoluminescent material or marked by lighting and fitted in the lower 300 mm of the bulkhead. The dimensions of such signs and markings are to be commensurate with the rest of the LLL system.

6.2 Low-location lighting exit signs should be provided at all exits. The signs should be located within the lower 300 mm on the side of the exit doors where the handle is located.

6.3 All signs should contrast in colour to the background (bulkhead or deck) on which they are installed.

7 Photoluminescent systems

7.1 Except where noted, PL strips should be no less than 75 mm wide. Photoluminescent strips having a width less than that stated herein should be used only if their luminance is increased proportionally to compensate for their width.

7.2 Photoluminescent materials should provide at least 15 mcd/m^2 measured 10 min after the removal of all external illuminating sources. The system should continue to provide luminance values greater than 2 mcd/m^2 for 60 min.

7.3 Any PL system materials should be provided with not less than the minimum level of ambient light necessary to charge the PL material to meet the above luminance requirements.

8 Electrically powered systems

8.1 Electrically powered systems should be connected to the emergency switchboard required by regulation II-1/42 of the 1974 SOLAS Convention, as amended, so as to be powered by the main source of electrical power under normal circumstances and also by the emergency source of electrical power when the latter is in operation. Alternatively, for existing ships only, EP systems may be connected to the main lighting system, provided independent batteries provide a backup of at least 60 min and are charged from the main lighting system. Performance of the system while powered by batteries should meet all the requirements stated herein.

8.2 Where electrically powered systems are installed, the following standards of luminance are to be applied:

- .1 the active parts of electrically powered systems should have a minimum luminance of 10 cd/m^2 ;
- .2 the point sources of miniature incandescent lamps should provide not less than 150 mcd mean spherical intensity with a spacing of not more than 100 mm between lamps;
- .3 the point sources of light-emitting-diode systems should have a minimum peak intensity of 35 mcd. The angle of half-intensity cone should be appropriate to the likely track directions of approach and viewing. Spacing between lamps should be no more than 300 mm; and
- .4 for electroluminescent systems, these should function for 60 min from the instant when the main power supply to which it was required to be connected by paragraph 8.1 is removed.

8.3 All EP systems should be arranged so that the failure of any single light, lighting strip, or battery will not result in the marking being ineffective.

8.4 Electrically powered systems should meet the relevant requirements for emergency luminaires in the current edition of publication 598-22-2 published by the International Electrotechnical Commission (IEC) when tested at a reference ambient temperature of 40°C .

8.5 Electrically powered systems should meet the requirements for vibration and electromagnetic interference in the current edition of publication 945 published by the IEC.

8.6 Electrically powered systems should provide a minimum degree of ingress protection of at least IP 55 in accordance with publication 529 published by the IEC.

9 Maintenance

9.1 All LLL systems should be visually examined and checked at least once a week and a record kept. All missing, damaged or inoperable LLL should be replaced.

9.2 All LLL systems should have their luminance tested at least once every five years. Readings should be taken on site. If the luminance for a particular reading does not meet the requirement of these guidelines, readings should be taken in at least ten locations equally spaced apart in the space. If more than 30% of the readings do not meet the requirements of these guidelines, the LLL should be replaced. If between 20% and 30% of the readings do not meet the requirements of these guidelines, the LLL should be checked again in one year or may be replaced.

Resolution A.800(19)
(adopted on 23 November 1995)

**Revised guidelines for approval of
sprinkler systems equivalent to that referred
to in SOLAS regulation II-2/12**

THE ASSEMBLY,

RECALLING Article 15(j) of the Convention on the International Maritime Organization concerning the functions of the Assembly in relation to regulations and guidelines concerning maritime safety,

NOTING the significance of the performance and reliability of the sprinkler systems approved under the provisions of regulation II-2/12 of the International Convention for the Safety of Life at Sea (SOLAS), 1974,

DESIROUS of keeping abreast of the advancement of sprinkler technology and further improving fire protection on board ships,

HAVING CONSIDERED the recommendation made by the Maritime Safety Committee at its sixty-fourth session,

1. ADOPTS the Revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation II-2/12 set out in the annex to the present resolution;
2. INVITES Governments to apply the Guidelines when approving equivalent sprinkler systems;
3. REQUESTS the Maritime Safety Committee to keep the Guidelines under review and to amend them as necessary;
4. REVOKES resolution A.755(18).

Annex

Revised guidelines for approval of sprinkler systems equivalent to that referred to in SOLAS regulation II-2/12

1 General

Equivalent sprinkler systems must have the same characteristics which have been identified as significant to the performance and reliability of automatic sprinkler systems approved under the requirements of SOLAS regulation II-2/12.

2 Definitions

2.1 *Antifreeze system:* A wet pipe sprinkler system employing automatic sprinklers attached to a piping system containing an antifreeze solution and connected to a water supply. The antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by heat from a fire.

2.2 *Deluge system:* A sprinkler system employing open sprinklers attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

2.3 *Dry pipe system:* A sprinkler system employing automatic sprinklers attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the piping system and out of the opened sprinklers.

2.4 *Preaction system:* A sprinkler system employing automatic sprinklers attached to a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same area as the sprinklers. Actuation of the detection system opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that may be open.

2.5 *Water-based extinguishing medium:* Fresh water or seawater with or without additives mixed to enhance fire-extinguishing capability.

2.6 *Wet pipe system:* A sprinkler system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

3 Principal requirements for the system

3.1 The system should be automatic in operation, with no human action necessary to set it in operation.

3.2 The system should be capable of both detecting the fire and acting to control or suppress the fire with a water-based extinguishing medium.

3.3 The sprinkler system should be capable of continuously supplying the water-based extinguishing medium for a minimum of 30 min. A pressure tank should be provided to meet the functional requirement stipulated in SOLAS regulation II-2/12.4.1.

3.4 The system should be of the wet pipe type but small exposed sections may be of the dry pipe, preaction, deluge, antifreeze or other type to the satisfaction of the Administration where this is necessary.

3.5 The system should be capable of fire control or suppression under a wide variety of fire loading, fuel arrangement, room geometry and ventilation conditions.

3.6 The system and equipment should be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging and corrosion normally encountered in ships.

3.7 The system and its components should 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 requirements given in appendices 1 and 2 to these Guidelines.

3.8 The system should be provided with both main and emergency sources of power.

3.9 The system should be provided with a redundant means of pumping or otherwise supplying a water-based extinguishing medium to the sprinkler system.

3.10 The system should be fitted with a permanent sea inlet and be capable of continuous operation using seawater.

3.11 The piping system should be sized in accordance with a hydraulic calculation technique.†

* Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied.

† Where the Hazen-Williams method is used, the following values of the friction factor C for different pipe types which may be considered should apply:

Pipe type	C
Black or galvanized mild steel	120
Copper and copper alloys	150
Stainless steel	150
Plastic	150

3.12 Sprinklers should be grouped into separate sections. Any section should not serve more than two decks of one main vertical zone.

3.13 Each section of sprinklers should be capable of being isolated by one stop valve only. The stop valve in each section should be readily accessible and its location should be clearly and permanently indicated. Means should be provided for preventing the stop valves being operated by an unauthorized person.

3.14 Sprinkler piping should not be used for any other purpose.

3.15 The sprinkler system supply components should be outside category A machinery spaces.

3.16 A means for testing the automatic operation of the system for assuring the required pressure and flow should be provided.

3.17 Each sprinkler section should be provided with a means for giving a visual and audible alarm at a continuously manned central control station within one minute of flow from one or more sprinklers, a check valve, pressure gauge, and a test connection with a means of drainage.

3.18 A sprinkler control plan should be displayed at each centrally manned control station.

3.19 Installation plans and operating manuals should be supplied to the ship and be readily available on board. A list or plan should be displayed showing the spaces covered and the location of the zone in respect of each section. Instructions for testing and maintenance should also be available on board.

3.20 Sprinklers should have fast response characteristics as defined in ISO standard 6182-1.

3.21 In accommodation and service spaces the sprinklers should have a nominal temperature rating of 57°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the nominal temperature may be increased by not more than 30°C above the maximum deckhead temperature.

3.22 Pumps and alternative supply components should be sized so as to be capable of maintaining the required flow to the hydraulically most demanding area of not less than 280 m². For application to a small ship with a total protected area of less than 280 m², the Administration may specify the appropriate area for sizing of pumps and alternative supply components.

Appendix 1

**Component manufacturing standards
for water mist nozzles**

TABLE OF CONTENTS

Introduction

Definitions

Product consistency

4 Water mist nozzle requirements

- 4.1 Dimensions
- 4.2 Nominal release temperatures
- 4.3 Operating temperatures
- 4.4 Water flow and distribution
- 4.5 Function
- 4.6 Strength of body
- 4.7 Strength of release element
- 4.8 Leak resistance and hydrostatic strength
- 4.9 Heat exposure
- 4.10 Thermal shock
- 4.11 Corrosion
- 4.12 Integrity of nozzle coatings
- 4.13 Water hammer
- 4.14 Dynamic heating
- 4.15 Resistance to heat
- 4.16 Resistance to vibration
- 4.17 Impact test
- 4.18 Lateral discharge
- 4.19 30-day leakage resistance
- 4.20 Vacuum resistance
- 4.21 Water shield
- 4.22 Clogging

5 Methods of test

- 5.1 General
- 5.2 Visual examination
- 5.3 Body strength test
- 5.4 Leak resistance and hydrostatic strength tests
- 5.5 Functional test
- 5.6 Heat-responsive element operating characteristics
- 5.7 Heat exposure tests
- 5.8 Thermal shock test for glass bulb nozzles
- 5.9 Strength tests for release elements
- 5.10 Water flow test
- 5.11 Water distribution and droplet size tests
- 5.12 Corrosion tests
- 5.13 Nozzle coating tests
- 5.14 Heat resistance test
- 5.15 Water hammer test
- 5.16 Vibration test
- 5.17 Impact test
- 5.18 Lateral discharge test
- 5.19 30-day leakage test
- 5.20 Vacuum test
- 5.21 Clogging test

6 Water mist nozzle markings

- 6.1 General
- 6.2 Nozzle housings

Figure 1 RTI and C limits for standard orientation

Figure 2 Impact test apparatus

Figure 3 Clogging test apparatus

Table 1 Nominal release temperature

Table 2 Plunge oven test conditions

Table 3 Plunge oven test conditions for conductivity determinations

Table 4 Test temperatures for coated and uncoated nozzles

Table 5 Contaminant for contaminated water cycling test

1 Introduction

1.1 This document is intended to address minimum fire protection performance, construction and marking requirements, excluding fire performance, for water mist nozzles.

1.2 Numbers in brackets following a section or subsection heading refer to the appropriate section or paragraph in the standard for automatic sprinkler systems (part 1: Requirements and methods of test for sprinklers, ISO 6182-1).

2 Definitions

2.1 *Conductivity factor (C)*: a measure of the conductance between the nozzle's heat-responsive element and the fitting expressed in units of $(m/s)^{0.5}$.

2.2 *Rated working pressure*: maximum service pressure at which a hydraulic device is intended to operate.

2.3 *Response time index (RTI)*: a measure of nozzle sensitivity expressed as $RTI = tu^{0.5}$, where t is the time constant of the heat-responsive element in units of seconds, and u is the gas velocity expressed in metres per second. RTI can be used in combination with the conductivity factor (C) to predict the response of a nozzle in fire environments defined in terms of gas temperature and velocity versus time. RTI has units of $(m \cdot s)^{0.5}$.

2.4 *Standard orientation*: in the case of nozzles with symmetrical heat-responsive elements supported by frame arms, standard orientation is with the air flow perpendicular to both the axis of the nozzle's inlet and the plane of the frame arms. in the case of non-symmetrical heat-responsive elements, standard orientation is with the air flow perpendicular to both the inlet axis and the plane of the frame arms which produces the shortest response time.

2.5 *Worst case orientation*: the orientation which produces the longest response time with the axis of the nozzle inlet perpendicular to the air flow.

3 Product consistency

3.1 It should be the responsibility of the manufacturer to implement a quality control programme to ensure that production continuously meets the requirements in the same manner as the originally tested samples.

3.2 The load on the heat-responsive element in automatic nozzles should be set and secured by the manufacturer in such a manner so as to prevent field adjustment or replacement.

Water mist nozzle requirements

4.1 Dimensions

Nozzles should be provided with a nominal 6 mm ($\frac{1}{4}$ in) or larger nominal inlet thread or equivalent. The dimensions of all threaded connections should conform to international standards where applied. National standards may be used if international standards are not applicable.

4.2 Nominal release temperatures [6.2]*

4.2.1 The nominal release temperatures of automatic glass bulb nozzles should be as indicated in table 1.

4.2.2 The nominal release temperatures of fusible automatic element nozzles should be specified in advance by the manufacturer and verified in accordance with 4.3. Nominal release temperatures should be within the ranges specified in table 1.

4.2.3 The nominal release temperature that is to be marked on the nozzle should be that determined when the nozzle is tested in accordance with 5.6.1, taking into account the specifications of 4.3.

Table 1 - Nominal release temperature

Glass bulb nozzles		Fusible element nozzles	
Nominal release temperature (°C)	Liquid colour code	Nominal release temperature (°C)	Frame colour code ¹
57	orange	57 to 77	uncooured
68	red	80 to 107	white
79	yellow	121 to 149	blue
93 to 100	green	163 to 191	red
121 to 141	blue	204 to 246	green
163 to 182	mauve	260 to 343	orange
204 to 343	black		

¹ Not required for decorative nozzles.

4.3 Operating temperatures (see 5.6.1) [6.3]

Automatic nozzles should open within a temperature range of

$$X + (0.035X + 0.62)^{\circ}\text{C}$$

where X is the nominal release temperature.

4.5

* Figures given in square brackets refer to ISO standard 6182-1.

4.4 *Water flow and distribution*

4.4.1 Flow constant (see 5.10) [6.4.1]

4.4.1.1 The flow constant K for nozzles is given by the formula:

$$K = \frac{Q}{P^{0.5}}$$

where:

P is the pressure in bars;

Q is the flow rate in litres per minute.

4.4.1.2 The value of the flow constant K published in the manufacturer's design and installation instructions should be verified using the test method of 5.10. The average flow constant K should be within 5% of the manufacturer's value.

4.4.2 Water distribution (see 5.11)

Nozzles which have complied with the requirements of the fire test should be used to determine the effective nozzle discharge characteristics when tested in accordance with 5.11.1. These characteristics should be published in the manufacturer's design and installation instructions.

4.4.3 Water droplet size and velocity (see 5.1 1.2)

The water droplet size distribution and droplet velocity distribution should be determined in accordance with 5.11.2 for each design nozzle at the minimum and maximum operating pressures, and minimum and maximum air flow rates, when used, as part of the identification of the discharge characteristics of the nozzles which have demonstrated compliance with the fire test. The measurements should be made at two representative locations:

- .1 perpendicular to the central axis of the nozzle, exactly 1 m below the discharge orifice or discharge deflector; and
- .2 radially outward from the first location at either 0.5 m or 1 m distance, depending on the distribution pattern.

4.5 *Function* (see 5.5) [6.5]

4.5.1 When tested in accordance with 5.5, the nozzle should open and, within 5 s after the release of the heat-responsive element, should operate satisfactorily by complying with the requirements of 5.10. Any lodgement of released parts should be cleared within 60 s of release for standard-

response heat-responsive elements and within 10 s of release for fast- and special-response heat-responsive elements or the nozzle should then comply with the requirements of 5.11.

4.5.2 The nozzle discharge components should not sustain significant damage as a result of the functional test specified in 5.5 and should have the same flow constant range and water droplet size and velocity within 5% of values as previously determined in accordance with 4.4.1 and 4.4.3.

4.6 *Strength of body* (see 5.3) [6.6]

The nozzle body should not show permanent elongation of more than 0.2% between the load-bearing points after being subjected to twice the average service load as determined using the method of 5.3.1.

4.7 *Strength of release element* [6.7]

4.7.1 Glass bulbs (see 5.9.1)

The lower tolerance limit for bulb strength should be greater than two times the upper tolerance limit for the bulb design load based on calculations with a degree of confidence of 0.99 for 99% of the samples as determined in 5.9.1. Calculations will be based on the normal or gaussian distribution except where another distribution can be shown to be more applicable due to manufacturing or design factors.

4.7.2 Fusible elements (see 5.9.2)

Fusible heat-responsive elements in the ordinary temperature range should be designed to:

- .1 sustain a load of 15 times its design load corresponding to the maximum service load measured in 5.3.1 for a period of 100h; or
- .2 demonstrate the ability to sustain the design load.

4.8 *Leak resistance and hydrostatic strength* (see 5.4) [6.8]

4.8.1 A nozzle should not show any sign of leakage when tested by the method specified in 5.4.1.

4.8.2 A nozzle should not rupture, operate or release any parts when tested by the method specified in 5.4.2.

4.9 *Heat exposure* [6.9]

4.9.1 Glass bulb nozzles (see 5.7.1)

There should be no damage to the glass bulb element when the nozzle is tested by the method specified in 5.7.1.

4.9.2 All uncoated nozzles (see 5.7.2)

Nozzles should withstand exposure to increased ambient temperature without evidence of weakness or failure, when tested by the method specified in 5.7.2.

4.9.3 Coated nozzles (see 5.7.3)

In addition to meeting the requirement of 5.7.2 in an uncoated version, coated nozzles should withstand exposure to ambient temperatures without evidence of weakness or failure of the coating, when tested by the method specified in 5.7.3.

4.10 *Thermal shock* (see 5.8) [6.10]

Glass bulb nozzles should not be damaged when tested by the method specified in 5.8. Proper operation is not considered as damage.

4.11 *Corrosion* [6.11]

4.11.1 Stress corrosion (see 5.12.1 and 5.12.2)

When tested in accordance with 5.12.1, all brass nozzles should show no fractures which could affect their ability to function as intended and satisfy other requirements.

When tested in accordance with 5.12.2, stainless steel parts of water mist nozzles should show no fractures or breakage which could affect their ability to function as intended and satisfy other requirements.

4.11.2 Sulphur dioxide corrosion (see 5.12.3)

Nozzles should be sufficiently resistant to sulphur dioxide saturated with water vapour when conditioned in accordance with 5.12.3. Following exposure, five nozzles should operate when functionally tested at their minimum flowing pressure (see 4.5.1 and 4.5.2). The remaining five samples should meet the dynamic heating requirements of 4.14.2.

4.11.3 Salt spray corrosion (see 5.12.4)

Coated and uncoated nozzles should be resistant to salt spray when conditioned in accordance with 5.12.4. Following exposure, the samples should meet the dynamic heating requirements of 4.14.2.

4.11.4 Moist air exposure (see 5.12.5)

Nozzles should be sufficiently resistant to moist air exposure and should satisfy the requirements of 4.14.2 after being tested in accordance with 5.12.5.

4.12 Integrity of nozzle coatings [6.12]

4.12.1 Evaporation of wax and bitumen used for atmospheric protection of nozzles (see 5.13.1)

Waxes and bitumens used for coating nozzles should not contain volatile matters in sufficient quantities to cause shrinkage, hardening, cracking or flaking of the applied coating. The loss in mass should not exceed 5% of that of the original sample when tested by the method in 5.13.1.

4.12.2 Resistance to low temperatures (see 5.13.2)

All coatings used for nozzles should not crack or flake when subjected to low temperatures by the method in 5.13.2.

4.12.3 Resistance to high temperatures (see 4.9.3)

Coated nozzles should meet the requirements of 4.9.3.

4.13 Water hammer (see 5.15) [6.13]

Nozzles should not leak when subjected to pressure surges from 4 bar to four times the rated pressure for operating pressures up to 100 bar and two times the rated pressure for pressures greater than 100 bar. They should show no signs of mechanical damage when tested in accordance with 5.15 and should operate within the parameters of 4.5.1 at the minimum design pressure.

4.14 Dynamic heating (see 5.6.2) [6.14]

4.14.1 Automatic nozzles intended for installation in other than accommodation spaces and residential areas should comply with the requirements for RTI and C limits shown in figure 1. Automatic nozzles intended for installation in accommodation spaces or residential areas should comply with fast-response requirements for RTI and C limits shown in figure 1. Maximum and minimum RTI values for all data points calculated using C for the fast- and standard-response nozzles should fall within the appropriate category shown in figure 1. Special-response nozzles should have an average RTI value, calculated using C, between 50 and 80 with no value less than 40 or more than 100. When tested at an angular offset to the worst case orientation as described in 5.6.2, the RTI should not exceed $600 \text{ (m}\cdot\text{s)}^{0.5}$ or 250% of the value of RTI in the standard orientation, whichever is the less. The angular offset should be 15° for standard response, 20° for special response and 25° for fast response.

4.14.2 After exposure to the corrosion test described in 4.11.2, 4.11.3 and 4.11.4, nozzles should be tested in the standard orientation as described in 5.6.2.1 to determine the post-exposure RTI. All post-exposure RTI values should not exceed the limits shown in figure 1 for the appropriate category. In addition, the average RTI value should not exceed 130% of the pre-exposure average value. All post-exposure RTI values should be calculated as in 5.6.2.3 using the pre-exposure conductivity factor (C).

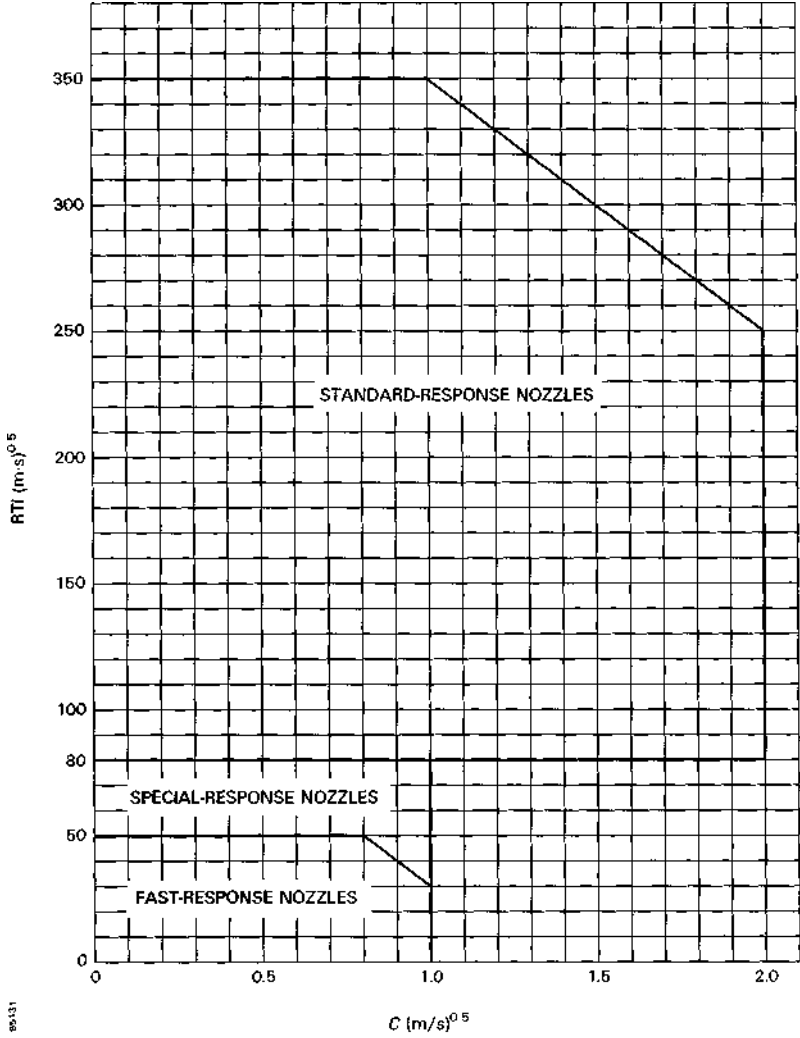


Figure 1 - RTI and C limits for standard orientation

4.15 Resistance to heat (see 5.14) [6.15]

Open nozzles should be sufficiently resistant to high temperatures when tested in accordance with 5.14. After exposure, the nozzle should not show:

- .1 visual breakage or deformation;
- .2 a change in flow constant K of more than 5%; and
- .3 no changes in the discharge characteristics of the water distribution test (see 4.4.2) exceeding 5%.

4.22

4.16 Resistance to vibration (see 5.16) [6.16]

Nozzles should be able to withstand the effects of vibration without deterioration of their performance characteristics when tested in accordance with 5.16. After the vibration test of 5.16, nozzles should show no visible deterioration and should meet the requirements of 4.5 and 4.8.

4.17 Impact test (see 5.17) [6.17]

Nozzles should have adequate strength to withstand impacts associated with handling, transport and installation without deterioration of their performance or reliability. Resistance to impact should be determined in accordance with 5.17.

4.18 Lateral discharge (see 5.18) [6.19]

Nozzles should not prevent the operation of adjacent automatic nozzles when tested in accordance with 5.18.

5.2

4.19 30-day leakage resistance (see 5.19) [6.20]

Nozzles should not leak, sustain distortion or other mechanical damage when subjected to twice the rated pressure for 30 days. Following exposure, the nozzles should satisfy the test requirements of 5.4.

4.20 Vacuum resistance (see 5.20) [6.21]

Nozzles should not exhibit distortion, mechanical damage or leakage after being subjected to the test specified in 5.20.

5.3

4.21 Water shield [6.22 and 6.23]

4.21.1 General

An automatic nozzle intended for use at intermediate levels or beneath open grating should be provided with a water shield which complies with 4.21.2 and 4.21.3.

4.21.2 Angle of protection

Water shields should provide an "angle of protection" of 45° or less for the heat-responsive element against direct impingement of run-off water from the shield caused by discharge from nozzles at higher elevations.

4.21.3 Rotation (see 5.21.2)

Rotation of the water shield should not alter the nozzle service load.

4.22 *Clogging* (see 5.21) [6.28.3]

A water mist nozzle should show no evidence of clogging during 30 min of continuous flow at rated working pressure using water that has been contaminated in accordance with 5.21.3. Following the 30 min of flow, the water flow at rated pressure of the *nozzle and strainer or filter should be within + 7 0% of the value obtained prior to conducting the clogging test.*

5 **Methods of test [7]**

5.1 *General*

The following tests should be conducted for each type of nozzle. Before testing, precise drawings of parts and the assembly should be submitted together with the appropriate specifications (using SI units). Tests should be carried out at an ambient temperature of 20 + 5°C, unless other temperatures are indicated.

5.2 *Visual examination* [7.2]

Before testing, nozzles should be examined visually with respect to the following points:

- .1 marking;
- .2 conformity of the nozzles with the manufacturer's drawings and specification; and
- .3 obvious defects.

5.3 *Body strength test* [7.3]

5.3.1 The design load should be measured on 10 automatic nozzles by securely installing each nozzle, at room temperature, in a tensile/compression test machine and applying a force equivalent to the application of the rated working pressure.

An indicator capable of reading deflection to an accuracy of 0.01 mm should be used to measure any change in length of the *nozzle* between its load-bearing points. Movement of the nozzle shank thread in the threaded bushing of the test machine should be avoided or taken into account.

The hydraulic pressure and load is then released and the heat-responsive element is then removed by a suitable method. When the nozzle is at room temperature, a second measurement should be made using the indicator.

An increasing mechanical load to the nozzle is then applied at a rate not exceeding 500 N/min, until the indicator reading at the load-bearing point initially measured returns to the initial value achieved under hydrostatic load. The mechanical load necessary to achieve this should be recorded as the service load. Calculation of the average service load should be made.

5.3.2 The applied load should then be progressively increased at a rate not exceeding 500 N/min on each of the five specimens until twice the average service load has been applied. This load should be maintained for 15+5 s.

The load should then be removed and any permanent elongation as defined in 4.6 should be recorded.

5.4 *Leak resistance and hydrostatic strength tests* (see 4.8) [7.4]

5.4.1 Twenty nozzles should be subjected to a water pressure of twice their rated working pressure, but not less than 34.5 bar. The pressure should be increased from 0 bar to the test pressure, maintained at twice rated working pressure for a period of 3 min and then decreased to 0 bar. After the pressure has returned to 0 bar, it should be increased to the minimum operating pressure specified by the manufacturer in not more than 5 s. This pressure should be maintained for 15 s and then increased to rated working pressure and maintained for 15 s.

5.4.2 Following the test of 5.4.1, the 20 nozzles should be subjected to an internal hydrostatic pressure of four times the rated working pressure. The pressure should be increased from 0 bar to four times the rated working pressure and held there for a period of 1 min. The nozzle under test should not rupture, operate or release any of its operating parts during the pressure increase nor while being maintained at four times the rated working pressure for 1 min.

5.5 *Functional test* (see 4.5) [7.5]

5.5.1 Nozzles having nominal release temperatures less than 78°C, should be heated to activation in an oven. While being heated, they should be subjected to each of the water pressures specified in 5.5.2 applied to their inlet. The temperature of the oven should be increased to 400 + 20°C in 3 min measured in close proximity to the nozzle. Nozzles having nominal release temperatures exceeding 78°C should be heated using a suitable heat source. Heating should continue until the nozzle has activated.

5.5.2 Eight nozzles should be tested in each normal mounting position and at pressures equivalent to the minimum operating pressure, the rated working pressure and the average operating pressure. The flowing pressure should be at least 75% of the initial operating pressure.

5.5.3 If lodgement occurs in the release mechanism at any operating pressure and mounting position, 24 more nozzles should be tested in that mounting position and at that pressure. The total number of nozzles for which lodgement occurs should not exceed 1 in the 32 tested at that pressure and mounting position.

5.5.4 Lodgement is considered to have occurred when one or more of the released parts lodge in the discharge assembly in such a way as to cause the water distribution to be altered after the period of time specified in 4.5.1.

5.5.5 In order to check the strength of the deflector/orifice assembly, three nozzles should be submitted to the functional test in each normal mounting position at 125% of the rated working pressure. The water should be allowed to flow at 125% of the rated working pressure for a period of 15 min.

5.6 *Heat responsive element operating characteristics*

5.6.1 Operating temperature test (see 4.3) [7.6]

Ten nozzles should be heated from room temperature to 20°C to 22°C below their nominal release temperature. The rate of increase of temperature should not exceed 20°C/min and the temperature should be maintained for 10 min. The temperature should then be increased at a rate between 0.4°C/min to 0.7°C/min until the nozzle operates.

The nominal operating temperature should be ascertained with equipment having an accuracy of +0.35% of the nominal temperature rating or + 0.25°C, whichever is greater.

The test should be conducted in a water bath for nozzles or separate glass bulbs having nominal release temperatures less than or equal to 80°C. A suitable oil should be used for higher-rated release elements. The liquid bath should be constructed in such a way that the temperature deviation within the test zone does not exceed 0.5% or 0.5°C, whichever is greater.

5.6.2 Dynamic heating tests (see 4.14)

5.6.2.1 Plunge test

Tests should be conducted to determine the standard and worst case orientations as defined in 2.4 and 2.5. Ten additional plunge tests should be performed at both of the identified orientations. The worst case orientation should be as defined in 4.14.1. The RTI should be calculated as described in 5.6.2.3 and 5.6.2.4 for each orientation, respectively. The plunge tests should

be conducted using a brass nozzle mount designed such that the mount or water temperature rise does not exceed 2°C for the duration of an individual plunge test up to a response time of 55 s. (The temperature should be measured by a thermocouple heatsinked and embedded in the mount not more than 8 mm radially outward from the root diameter of the internal thread or by a thermocouple located in the water at the centre of the nozzle inlet.) If the response time is greater than 55 s, then the mount or water temperature in degrees Celsius should not increase more than 0.036 times the response time in seconds for the duration of an individual plunge test.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 + 3 N·m. Each nozzle should be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min.

At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing. A timer accurate to + 0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

A tunnel should be utilized with air flow and temperature conditions* at the test section (nozzle location) selected from the appropriate range of conditions shown in table 2. To minimize radiation exchange between the sensing element and the boundaries confining the flow, the test section of the apparatus should be designed to limit radiation effects to within 3% of calculated RTI values.†

The range of permissible tunnel operating conditions is shown in table 2. The selected operating condition should be maintained for the duration of the test with the tolerances as specified by footnotes 1 and 2 in table 2.

5.6.2.2 Determination of conductivity factor (C) [7.6.2.2]

The conductivity factor (C) should be determined using the prolonged plunge test (see 5.6.2.2.1) or the prolonged exposure ramp test (see 5.6.2.2.2).

5.6.2.2.1 Prolonged plunge test [7.6.2.2.1]

The prolonged plunge test is an iterative process to determine C and may require up to 20 nozzle samples. A new nozzle sample must be used for each test in this section even if the sample does not operate during the prolonged plunge test.

* Tunnel conditions should be selected to limit maximum anticipated equipment error to 3%.

† A suggested method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and a polished (low emissivity) metallic test specimen.

Table 2 - Plunge oven test conditions

Normal temperature °C	Air temperature ranges ¹			Velocity ranges ²		
	Standard response °C	Special response °C	Fast response °C	Standard response m/s	Special response m/s	Fast response nozzle m/s
57 to 77	191 to 203	129 to 141	129 to 141	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
79 to 107	282 to 300	191 to 203	191 to 203	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
121 to 149	382 to 432	282 to 300	282 to 300	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
163 to 191	382 to 432	382 to 432	382 to 432	3.4 to 3.6	2.4 to 2.6	1.65 to 1.85

¹ The selected air temperature should be known and maintained constant within the test section throughout the test to an accuracy of +1 °C for the air temperature range of 129°C to 141°C within the test section and within $\pm 2^\circ\text{C}$ for all other air temperatures.

² The selected air velocity should be known and maintained constant throughout the test to an accuracy of +0.03 m/s for velocities of 1.65 to 1.85 m/s and 2.4 to 2.6 m/s and +0.04 m/s for velocities of 3.4 to 3.6 m/s.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 ± 3 N·m. Each nozzle should be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min. At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing.

A timer accurate to ± 0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

The mount temperature should be maintained at $20 \pm 0.5^\circ\text{C}$ for the duration of each test. The air velocity in the tunnel test section at the nozzle location should be maintained with $\pm 2\%$ of the selected velocity. Air temperature should be selected and maintained during the test as specified in table 3.

The range of permissible tunnel operating conditions is shown in table 3. The selected operating condition should be maintained for the duration of the test with the tolerances as specified in table 3.

Table 3 - Plunge oven test conditions for conductivity determinations

Nominal nozzle temperature °C	Oven temperature °C	Maximum variation of air temperature during test °C
57	85 to 91	± 1.0
58 to 77	124 to 130	± 1.5
78 to 107	193 to 201	± 3.0
121 to 149	287 to 295	± 4.5
163 to 191	402 to 412	± 6.0

To determine C, the nozzle should be immersed in the test stream at various air velocities for a maximum of 15 min.* Velocities should be chosen such that actuation is bracketed between two successive test velocities. That is, two velocities should be established such that at the lower velocity (u_l) actuation does not occur in the 15 min test interval. At the next higher velocity (u_h), actuation should occur within the 15 min time limit. If the nozzle does not operate at the highest velocity, an air temperature from table 3 for the next higher temperature rating should be selected.

* If the value of C is determined to be less than $0.5 \text{ (m}\cdot\text{s)}^{0.5}$, a C of $0.25 \text{ (m}\cdot\text{s)}^{0.5}$ should be assumed for calculating RTI value.

Test velocity selection should ensure that:

The test value of C is the average of the values calculated at the two velocities using the following equation:

$$C = (\Delta T_g / \Delta T_{ea} - 1) u^{0.5}$$

where:

ΔT_g = Actual gas (air) temperature minus the mount temperature (T_m) in °C;

ΔT_{ea} = Mean liquid bath operating temperature minus the mount temperature (T_m) in °C;

u = Actual air velocity in the test section in m/s.

The nozzle C value is determined by repeating the bracketing procedure three times and calculating the numerical average of the three C values. This nozzle C value is used to calculate all standard orientation RTI values for determining compliance with 4.14.1.

5.6.2.2.2 Prolonged exposure ramp test [7.6.2.2.2]

The prolonged exposure ramp test for the determination of the parameter C should be carried out in the test section of a wind tunnel and with the requirements for the temperature in the nozzle mount as described for the dynamic heating test. A preconditioning of the nozzle is not necessary.

Ten samples should be tested of each nozzle type, all nozzles positioned in standard orientation. The nozzle should be plunged into an air stream of a constant velocity of 1 m/s + 10% and an air temperature at the nominal temperature of the nozzle at the beginning of the test.

The air temperature should then be increased at a rate of 1 + 0.25 °C/min until the nozzle operates. The air temperature, velocity and mount temperature should be controlled from the initiation of the rate of rise and should be measured and recorded at nozzle operation. The C value is determined using the same equation as in 5.6.2.2.1 as the average of the 10 test values.

5.6.2.3 RTI value calculation [7.6.2.3]

The equation used to determine the RTI value is as follows:

$$RTI = \frac{-t_r(u)^{0.5}(1 + C/(u)^{0.5})}{\ln[1 - \Delta T_{ea}(1 + C/(u)^{0.5})/\Delta T_g]}$$

where:

t_r = Response time of nozzles in seconds;

u = Actual air velocity in the test section of the tunnel in m/s from table 2;

ΔT_{ea} = Mean liquid bath operating temperature of the nozzle minus the ambient temperature in °C;

ΔT_g = Actual air temperature in the test section minus the ambient temperature in °C;

C = Conductivity factor as determined in 5.6.2.2.

5.6.2.4 Determination of worst case orientation RTI

The equation used to determine the RTI for the worst case orientation is as follows:

$$RTI_{wc} = \frac{-t_{r-wc}(u)^{0.5} [1 + C(RTI_{wc}/RTI)/(u)^{0.5}]}{\ln\{1 - \Delta T_{ea} [1 + C(RTI_{wc}/RTI)/(u)^{0.5}]/\Delta T_g\}}$$

where:

t_{r-wc} = Response time of the nozzles in seconds for the worst case orientation.

All variables are known at this time as per the equation in 5.6.2.3 except RTI_{wc} (response time index for the worst case orientation) which can be solved iteratively as per the above equation.

In the case of fast-response nozzles, if a solution for the worst case orientation RTI is unattainable, plunge testing in the worst case orientation should be repeated using the plunge test conditions under Special response shown in table 2.

5.7 Heat exposure tests [7.7]

5.7.1 Glass bulb nozzles (see 4.9.1)

Glass bulb nozzles having nominal release temperatures less than or equal to 80°C should be heated in a water bath from a temperature of 20 + 5°C to 20 + 2°C below their nominal release temperature. The rate of increase of temperature should not exceed 20°C/min. High-temperature oil such as silicone oil should be used for higher-temperature-rated release elements.

This temperature should then be increased at a rate of 1°C/min to the temperature at which the gas bubble dissolves, or to a temperature 5°C lower than the nominal operating temperature, whichever is lower. The nozzle should be removed from the liquid bath and allowed to cool in air until the gas bubble has formed again. During the cooling period, the pointed end of the glass bulb (seal end) should be pointing downwards. This test should be performed four times on each of four nozzles.

5.7.2 All uncoated nozzles (see 4.9.2) [7.7.2]

Twelve uncoated nozzles should be exposed for a period of 90 days to a high ambient temperature that is 11°C below the nominal rating or at the temperature shown in table 4, whichever is lower, but not less than 49°C. If the service load is dependent on the service pressure, nozzles should be tested under the rated working pressure. After exposure, four of the

nozzles should be subjected to the tests specified in 5.4.1, four nozzles to the test of 5.5.1, two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 4.3. If a nozzle fails the applicable requirements of a test, eight additional nozzles should be tested as described above and subjected to the test in which the failure was recorded. All eight nozzles should comply with the test requirements.

5.7.3 Coated nozzles (see 4.9.3) [7.7.3]

In addition to the exposure test of 5.7.2 in an uncoated version, 12 coated nozzles should be exposed to the test of 5.7.2 using the temperatures shown in table 4 for coated nozzles.

The test should be conducted for 90 days. During this period, the sample should be removed from the oven at intervals of approximately seven days and allowed to cool for 2 h to 4 h. During this cooling period, the sample should be examined. After exposure, four of the nozzles should be subjected to the tests specified in 5.4.1, four nozzles to the test of 5.5.1, two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 4.3.

Table 4 - Test temperatures for coated and uncoated nozzles

Values in °C		
Nominal release temperature	Uncoated nozzle test temperature	Coated nozzle test temperature
57 to 60	49	49
61 to 77	52	49
78 to 107	79	66
108 to 149	121	107
150 to 191	149	149
192 to 246	191	191
247 to 302	246	246
303 to 343	302	302

5.8 Thermal shock test for glass bulb nozzles (see 4.10) [7.8]

Before starting the test, at least 24 nozzles at room temperature of 20°C to 25°C for at least 30 min should be conditioned.

The nozzles should be immersed in a bath of liquid, the temperature of which should be 10+2°C below the nominal release temperature of the nozzles. After 5 min, the nozzles should be removed from the bath and immersed immediately in another bath of liquid, with the bulb seal downwards, at a temperature of 10±1°C. Then the nozzles should be tested in accordance with 5.5.1.

5.9 *Strength tests for release elements* [7.9]

5.9.1 Glass bulbs (see 4.7.1) [7.9.1]

At least 15 samples bulbs in the lowest temperature rating of each bulb type should be positioned individually in a test fixture using the sprinkler seating parts. Each bulb should then be subjected to a uniformly increasing force at a rate not exceeding 250 N/s in the test machine until the bulb fails.

Each test should be conducted with the bulb mounted in new seating parts. The mounting device may be reinforced externally to prevent its collapse, but in a manner which does not interfere with bulb failure.

The failure load for each bulb should be recorded. Calculation of the lower tolerance limit (TL1) for bulb strength should be made. Using the values of service load recorded in 5.3.1, the upper tolerance limit (TL2) for the bulb design load should be made. Compliance with 4.7.1 should be verified.

5.9.2 Fusible elements (see 4.7.2)

5.10 *Water flow test* (see 4.4.1) [7.10]

The nozzle and a pressure gauge should be mounted on a supply pipe. The water flow should be measured at pressures ranging from the minimum operating pressure to the rated working pressure at intervals of approximately 10% of the service pressure range on two sample nozzles. In one series of tests, the pressure should be increased from zero to each value and, in the next series, the pressure should be decreased from the rated pressure to each value. The flow constant K should be averaged from each series of readings, i.e. increasing pressure and decreasing pressure. During the test, pressures should be corrected for differences in height between the gauge and the outlet orifice of the nozzle.

5.11 *Water distribution and droplet size tests*

5.11.1 Water distribution (see 4.4.2)

The tests should be conducted in a test chamber of minimum dimensions 7 m x 7 m or 300% of the maximum design area being tested, whichever is greater. For standard automatic nozzles, a single open nozzle should be installed and then four open nozzles of the same type arranged in a square, at maximum spacings specified by the manufacturer, on piping prepared for this purpose. For pilot-type nozzles, a single nozzle should be installed and then the maximum number of slave nozzles at their maximum spacings, specified in the manufacturer's design and installation instructions.

The distance between the ceiling and the distribution plate should be 50 mm for upright nozzles and 275 mm for pendent nozzles. For nozzles

t

without distribution plates, the distances should be measured from the ceiling to the highest nozzle outlet.

Recessed, flush and concealed type nozzles should be mounted in a false ceiling of dimensions not less than 6 m x 6 m and arranged symmetrically in the test chamber. The nozzles should be fitted directly into the horizontal pipework by means of "T" or elbow fittings.

The water discharge distribution in the protected area below a single nozzle and between the multiple nozzles should be collected and measured by means of square measuring containers nominally 300 mm on a side. The distance between the nozzles and the upper edge of the measuring containers should be the maximum specified by the manufacturer. The measuring containers should be positioned centrally, beneath the single nozzle and beneath the multiple nozzles.

The nozzles should be discharged both at the minimum operating and rated working pressures specified by the manufacturer and the minimum and maximum installation heights specified by the manufacturer.

The water should be collected for at least 10 min to assist in characterizing nozzle performance.

5.11.2 Water droplet size (see 4.4.3)

The mean water droplet diameters, velocities, droplet size distribution, number density and volume flux should be determined at both the minimum and maximum flow rates specified by the manufacturer. Once the data is gathered, the method of the "Standard practice for determining data criteria and processing for liquid drop size analysis" (ASTM E799-92) will be used to determine the appropriate sample size, class size widths, characteristic drop sizes and measured dispersion of the drop size distribution. This data should be taken at various points within the spray distribution as described in 4.4.3.

5.12 *Corrosion tests [7.12]*

5.12.1 Stress corrosion test for brass nozzle parts (see 4.11.1)

Five nozzles should be subjected to the following aqueous ammonia test. The inlet of each nozzle should be sealed with a non-reactive cap, e.g. plastic.

The samples should be degreased and exposed for 10 days to a moist ammonia/air mixture in a glass container of volume $0.02 + 0.01 \text{ m}^3$.

An aqueous ammonia solution, having a density of 0.94 g/cm^3 , should be maintained in the bottom of the container, approximately 40 mm below the bottom of the samples. A volume of aqueous ammonia solution corresponding to 0.01 ml/cm^3 of the volume of the container will give approximately the following atmospheric concentrations: 35% ammonia,

5% water vapour, and 60% air. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

The moist ammonia/air mixture should be maintained as closely as possible at atmospheric pressure, with the temperature maintained at $34 \pm 2^\circ\text{C}$. Provision should be made for venting the chamber via a capillary tube to avoid the build-up of pressure. Specimens should be shielded from condensate dripage.

After exposure, the nozzles should be rinsed and dried, and a detailed examination should be conducted. If a crack, delamination or failure of any operating part is observed, the nozzle(s) should be subjected to a leak-resistance test at the rated pressure for 1 min and to the functional test at the minimum flowing pressure (see 4.5.1).

Nozzles showing cracking, delamination or failure of any non-operating part should not show evidence of separation of permanently attached parts when subjected to flowing water at the rated working pressure for 30 min.

5.12.2 Stress corrosion cracking of stainless steel nozzle parts (see 4.11.1)

5.12.2.1 Five samples are to be degreased prior to being exposed to the magnesium chloride solution.

5.12.2.2 Parts used in nozzles should be placed in a 500 ml flask that is fitted with a thermometer and a wet condenser approximately 760 mm long. The flask should be filled approximately one-half full with a 42% by weight magnesium chloride solution, placed on a thermostatically controlled electrically heated mantle, and maintained at a boiling temperature of $150 \pm 1^\circ\text{C}$. The parts should be unassembled, that is, not contained in a nozzle assembly. The exposure should last for 500 h.

5.12.2.3 After the exposure period, the test samples should be removed from the boiling magnesium chloride solution and rinsed in deionized water.

5.12.2.4 The test samples should then be examined using a microscope having a magnification of 25 x for any cracking, delamination, or other degradation as a result of the test exposure. Test samples exhibiting degradation should be tested as described in 5.12.2.5 or 5.12.2.6, as applicable. Test samples not exhibiting degradation are considered acceptable without further test.

5.12.2.5 Operating parts exhibiting degradation should be further tested as follows. Five new sets of parts should be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples should be degreased and subjected to the magnesium chloride solution exposure specified in 5.12.2.2. Following the exposure, the test samples should

withstand, without leakage, a hydrostatic test pressure equal to the rated working pressure for 1 min and then be subjected to the functional test at the minimum operating pressure in accordance with 5.5.1.

5.12.2.6 Non-operating parts exhibiting degradation should be further tested as follows. Five new sets of parts should be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples should be degreased and subjected to the magnesium chloride solution exposure specified in paragraph 5.12.4.1. Following the exposure, the test samples should withstand a flowing pressure equal to the rated working pressure for 30 min without separation of permanently attached parts.

5.12.3 Sulphur dioxide corrosion test (see 4.11.2 and 4.14.2)

Ten nozzles should be subjected to the following sulphur dioxide corrosion test. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

The test equipment should consist of a 5 l vessel (instead of a 5 / vessel, other volumes up to 15 l may be used in which case the quantities of chemicals given below should be increased in proportion) made of heat-resistant glass, with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel should be electrically heated through the base and provided with a cooling coil around the side walls. A temperature sensor placed centrally 160+20 mm above the bottom of the vessel should regulate the heating so that the temperature inside the glass vessel is $45 \pm 3^\circ\text{C}$. During the test, water should flow through the cooling coil at a sufficient rate to keep the temperature of the discharge water below 30°C . This combination of heating and cooling should encourage condensation on the surfaces of the nozzles. The sample nozzles should be shielded from condensate drippage.

The nozzles to be tested should be suspended in their normal mounting position under the lid inside the vessel and subjected to a corrosive sulphur dioxide atmosphere for eight days. The corrosive atmosphere should be obtained by introducing a solution made up by dissolving 20 g of sodium thiosulfate ($\text{Na}_2\text{S}_2\text{O}_3 \cdot \text{H}_2\text{O}$) crystals in 500 ml of water.

For at least six days of the eight-day exposure period, 20 ml of dilute sulphuric acid consisting of 156 ml of normal H_2SO_4 (0.5 mol/l) diluted with 844 ml of water should be added at a constant rate. After eight days, the nozzles should be removed from the container and allowed to dry for four to seven days at a temperature not exceeding 35°C with a relative humidity not greater than 70%.

After the drying period, five nozzles should be subjected to a functional test at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.

5.12.4 Salt spray corrosion test (see 4.11.3 and 4.14.2) [7.12.3]

5.12.4.1 Nozzles intended for normal atmospheres

Ten nozzles should be exposed to a salt spray within a fog chamber. The inlet of each sample should be sealed with a non-reactive cap, e.g. plastic.

During the corrosive exposure, the inlet thread orifice should be sealed by a plastic cap after the nozzles have been filled with deionized water. The salt solution should be a 20% by mass sodium chloride solution in distilled water. The pH should be between 6.5 and 3.2 and the density between 1.126 g/ml and 1.157 g/ml when atomized at 35°C. Suitable means of controlling the atmosphere in the chamber should be provided. The specimens should be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0.43 m³ in which the exposure zone should be maintained at a temperature of 35 ± 2°C. The temperature should be recorded at least once per day, at least 7 h apart (except weekends and holidays when the chamber normally would not be opened). Salt solution should be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure between 0.7 bar (0.07 MPa) and 1.7 bar (0.17 MPa). Salt solution runoff from exposed samples should be collected and should not return to the reservoir for recirculation. The sample nozzles should be shielded from condensate drippage.

Fog should be collected from at least two points in the exposure zone to determine the rate of application and salt concentration. The fog should be such that for each 80 cm² of collection area, 1 ml to 2 ml of solution should be collected per hour over a 16 h period and the salt concentration should be 20 ± 1% by mass.

The nozzles should withstand exposure to the salt spray for a period of 10 days. After this period, the nozzles should be removed from the fog chamber and allowed to dry for four to seven days at a temperature of 20°C to 25°C in an atmosphere having a relative humidity not greater than 70%. Following the drying period, five nozzles should be submitted to the functional test at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.

5.12.4.2 Nozzles intended for corrosive atmospheres [7.12.3.2]

Five nozzles should be subjected to the tests specified in 5.12.4.1 except that the duration of the salt spray exposure should be extended from 10 days to 30 days.

5.12.5 Moist air exposure test (see 4.11.4 and 4.14.2) [7.12.4]

Ten nozzles should be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98 ± 2% and a temperature of 95 ± 4°C. The nozzles should be installed on a pipe

manifold containing deionized water. The entire manifold should be placed in the high temperature-humidity enclosure for 90 days. After this period, the nozzles should be removed from the temperature-humidity enclosure and allowed to dry for four to seven days at a temperature of $25 \pm 5^\circ\text{C}$ in an atmosphere having a relative humidity not greater than 70%. Following the drying period, five nozzles should be functionally tested at the minimum operating pressure in accordance with 5.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 4.14.2.*

5.13 *Nozzle coating tests* [7.13]

5.13.1 Evaporation test (see 4.12.1) [7.13.1]

A 50 cm^3 sample of wax or bitumen should be placed in a metal or glass cylindrical container, having a flat bottom, an internal diameter of 55 mm and an internal height of 35 mm. The container, without lid, should be placed in an automatically controlled electric, constant ambient temperature oven with air circulation. The temperature in the oven should be controlled at 16°C below the nominal release temperature of the nozzle, but at not less than 50°C . The sample should be weighed before and after a 90-day exposure to determine any loss of volatile matter. The sample should meet the requirements of 4.12.1.

5.13.2 Low-temperature test (see 4.12.2) [7.13.2]

Five nozzles, coated by normal production methods, whether with wax, bitumen or a metallic coating, should be subjected to a temperature of -10°C for a period of 24 h. On removal from the low-temperature cabinet, the *nozzles should be exposed to normal* ambient temperature for at least 30 min before examination of the coating to the requirements of 4.12.2.

5.14 *Heat resistance test* (see 4.15) [7.14]

One nozzle body should be heated in an oven at 800°C for a period of 15 min, with the nozzle in its normal installed position. The nozzle body should then be removed, holding it by the threaded inlet, and should be promptly immersed in a water bath at a temperature of approximately 15°C . It should meet the requirements of 4.15.

5.15 *Water hammer test* (see 4.13) [7.15]

Five nozzles should be connected, in their normal operating position, to the test equipment. After purging the air from the nozzles and the test equipment, 3,000 cycles of pressure varying from $4 \pm 2 \text{ bar}$ ($0.4 \pm 0.2 \text{ MPa}$)

* At the manufacturer's option, additional samples may be furnished for this test to provide early evidence of failure. The additional samples may be removed from the test chamber at 30-day intervals for testing.

to twice the rated working pressure should be generated. The pressure should be raised from 4 bar to twice the rated pressure at a rate of $60 + 10$ bar/s. At least 30 cycles of pressure per minute should be generated. The pressure should be measured with an electrical pressure transducer.

Each nozzle should be visually examined for leakage during the test. After the test, each nozzle should meet the leakage resistance requirement of 4.8.1 and the functional requirement of 4.5.1 at the minimum operating pressure.

5.16 *Vibration test* (see 4.16) [7.16]

5.16.1 Five nozzles should be fixed vertically to a vibration table. They should be subjected at room temperature to sinusoidal vibrations. The direction of vibration should be along the axis of the connecting thread.

5.16.2 The nozzles should be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 min/octave and an amplitude of 1 mm ($\frac{1}{2}$ peak-to-peak value). If one or more resonant points are detected, the nozzles, after coming to 40 Hz, should be vibrated at each of these resonant frequencies for 120 h/number of resonances. If no resonances are detected, the vibration from 5 Hz to 40 Hz should be continued for 120 h.

5.16.3 The nozzle should then be subjected to the leakage test in accordance with 4.8.1 and the functional test in accordance with 4.5.1 at the minimum operating pressure.

5.17 *Impact test* (see 4.17) [7.17]

Five nozzles should be tested by dropping a mass onto the nozzle along the axial centreline of waterway. The kinetic energy of the dropped mass at the point of impact should be equivalent to a mass equal to that of the test nozzle dropped from a height of 1 m (see figure 2). The mass should be prevented from impacting more than once upon each sample.

Following the test, a visual examination of each nozzle should show no signs of fracture, deformation or other deficiency. If none is detected, the nozzles should be subjected to the leak resistance test, described in 5.4.1. Following the leakage test, each sample should meet the functional test requirement of 5.5.1 at a pressure equal to the minimum flowing pressure.

5.18 *Lateral discharge test* (see 4.18) [7.19]

Water should be discharged from a spray nozzle at the minimum operating and rated working pressure. A second automatic nozzle located at the minimum distance specified by the manufacturer should be mounted on a pipe parallel to the pipe discharging water.

The nozzle orifices or distribution plates (if used) should be placed 550 mm, 356 mm and 152 mm below a flat smooth ceiling for three separate tests, respectively at each test pressure. The top of a square pan measuring

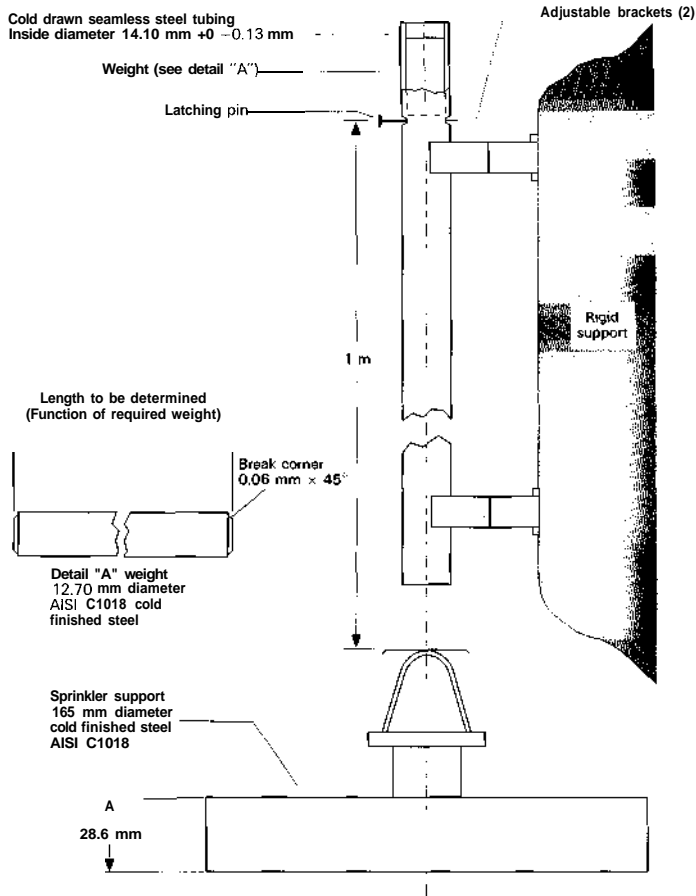


Figure 2 - Impact test apparatus

305 mm square and 102 mm deep should be positioned 152 mm below the heat-responsive element for each test. The pan should be filled with 0.47 l of heptane. After ignition, the automatic nozzle should operate before the heptane is consumed.

5.19 30-day leakage test (see 4.19) [7.20]

Five nozzles should be installed on a water-filled test line maintained under a constant pressure of twice the rated working pressure for 30 days at an ambient temperature of $20 \pm 5^\circ\text{C}$.

The nozzles should be inspected visually at least weekly for leakage. Following completion of this 30-day test, all samples should meet the leak

resistance requirements specified in 4.8 and should exhibit no evidence of distortion or other mechanical damage.

5.20 *Vacuum test* (see 4.20) [7.21]

Three nozzles should be subjected to a vacuum of 460 mm of mercury applied to a nozzle inlet for 1 min at an ambient temperature of 20 + 5°C. Following this test, each sample should be examined to verify that no distortion or mechanical damage has occurred and then should meet the leak resistance requirements specified in 5.4.1.

5.21 *Clogging test* (see 4.22) [7.28]

5.21.1 The water flow rate of an open water mist nozzle with its strainer or filter should be measured at its rated working pressure. The nozzle and strainer or filter should then be installed in the test apparatus described in figure 3 and subjected to 30 min of continuous flow at rated working pressure using contaminated water which has been prepared in accordance with 5.21.3.

5.21.2 Immediately following the 30 min of continuous flow with the contaminated water, the flow rate of the nozzle and strainer or filter should be measured at rated working pressure. No removal, cleaning or flushing of the nozzle, filter or strainer is permitted during the test.

5.21.3 The water used during the 30 min of continuous flow at rated working pressure specified in 5.21.1 should consist of 60 l of tap water into which has been mixed 1.58 kg of contaminants which sieve as described in table 5. The solution should be continuously agitated during the test.

Table 5 - Contaminant for contaminated water cycling test

Sieve designation ¹	Nominal sieve opening (mm)	Grams of contaminant (± 5%) ²		
		Pipe scale	Top soil	Sand
No. 25	0.706	-	456	200
No. 50	0.297	82	82	327
No. 100	0.150	84	6	89
No. 200	0.074	81	-	21
No. 325	0.043	153	-	3
	TOTAL	400	544	640

¹ Sieve designations correspond with those specified in the standard for wire-cloth sieves for testing purposes, ASTM E11-87, CENCO-MEINZEN sieve sizes 25 mesh, 50 mesh, 100 mesh, 200 mesh and 325 mesh, corresponding with the number designation in the table, have been found to comply with ASTM E11-87.

² The amount of contaminant may be reduced by 50% for nozzles limited to use with copper or stainless steel piping and by 90% for nozzles having a rated pressure of 50 bar or higher and limited to use with stainless steel piping.

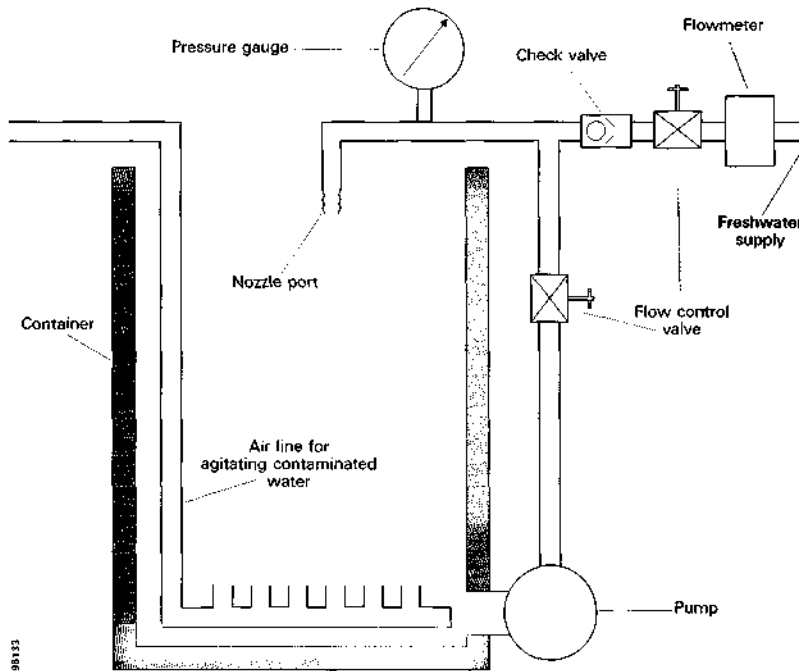


Figure 3 - Clogging test apparatus

6 Water mist nozzle markings

6.1 General

Each nozzle complying with the requirements of this standard should be permanently marked as follows:

- .1 trademark or manufacturer's name;
- .2 model identification;
- .3 manufacturer's factory identification. This is only required if the manufacturer has more than one nozzle manufacturing facility;
- .4 nominal year of manufacture* (automatic nozzles only);
- .5 nominal release temperature[†] (automatic nozzles only); and

* The year of manufacture may include the last three months of the preceding year and the first six months of the following year. Only the last two digits need be indicated.

[†] Except for coated and plated nozzles, the nominal release temperature range should be colour-coded on the nozzle to identify the nominal rating. The colour code should be visible on the yoke arms holding the distribution plate for fusible element nozzles, and should be indicated by the colour of the liquid in glass bulbs. The nominal temperature rating should be stamped or cast on the fusible element of fusible element nozzles. All nozzles should be stamped, cast, engraved or colour-coded in such a way that the nominal rating is recognizable even if the nozzle has operated. This should be in accordance with table 1.

- .6 *K* factor. This is only required if a given model nozzle is available with more than one orifice size.

In countries where colour-coding of yoke arms of glass bulb nozzles is required, the colour code for fusible element nozzles should be used.

6.2 *Nozzle housings*

Recessed housings, if provided, should be marked for use with the corresponding nozzles unless the housing is a non-removable part of the nozzle.

Appendix 2

Fire test procedures for equivalent sprinkler systems in accommodation, public space and service areas on passenger ships

1 Scope

1.1 These test procedures describe a fire test method for evaluating the effectiveness of sprinkler systems equivalent to systems covered by regulation II-2/12 of the SOLAS Convention [1*] in accommodation and service areas on board ships. It should be noted that the test method is limited to the systems' effectiveness against fire and is not intended for testing of the quality and design parameters of the individual components in the system.

1.2 In order to fulfil the requirements of 3.5 of the guidelines, the system must be capable of fire control or suppression in a wide variety of fire loading, fuel arrangement, room geometry and ventilation conditions.

1.3 Products employing materials or having forms of construction differing from the requirements contained herein may be examined and tested in accordance with the intent of the requirements and, if found to be substantially equivalent, may be judged to comply with this document.

1.4 Products complying with the text of this document will not necessarily be judged to comply, if, when examined and tested, they are found to have other features which impair the level of safety contemplated by this document.

2 Hazard and occupancy classifications

For the purposes of identifying the different fire risk classifications, table 1 is given, which correlates the fire tests with the classification of occupancy defined in SOLAS regulation II-2/26 [1].

3 Definitions

3.1 *Fire suppression:* Sharply reducing the heat release rate of a fire and preventing its regrowth by means of a direct and sufficient application of water through the fire plume to the burning fuel surface [2].

3.2 *Fire control:* Limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage [2].

* Figures in square brackets in the text indicate the referenced publications listed later in this document.

Table 1 - Correlation between fire tests with the classification of occupancy defined in SOLAS regulation II-2/26.2.2

Occupancy classification	Corresponding fire test				
	Section 5 cabin	Section 5 corridor	Section 6 luxury cabin	Section 7 public spaces	Section 8 shopping and storage
(1) Control stations				X	
(2) Stairways		X ¹			
(3) Corridors		X ¹			
(6) Accommodation spaces of minor fire risk	X ²		X ³	X ⁴	
(7) Accommodation spaces of moderate fire risk	X ²		X ³	X ⁴	
(8) Accommodation spaces of greater fire risk				X	
(9) Sanitary & similar spaces	X ²		X ³	X ⁴	
(13) Store rooms, workshops, pantries, etc.					X
(14) Other spaces in which flammable liquids are stowed					X

Note: For examples of occupancies in each category, see SOLAS regulation II-2/26 [1]

¹ For corridors and stairways wider than 1.5 m, use section 7 public space fire test instead of the corridor fire test.

² For spaces up to 12 m².

³ For spaces from 12 m² up to 50 m².

⁴ For spaces over 50 m².

3.3 *Fire source:* Fire source is defined as the combustible material in which the fire is set and the combustible material covering walls and ceiling.

3.4 *Igniter.* The device used to ignite the fire source.

4 General requirements

4.1 *Nozzle positioning*

The testing organization should be responsible for assuring that the nozzles for each fire test are installed in accordance with the manufacturer's design and installation instructions. The tests should be performed at the maximum specified spacings, installation height and distances below the ceiling. In addition, if the testing organization finds it necessary, selected fire tests should also be conducted at minimum specified spacings, installation height and distances below the ceiling.

4.2 *Water pressure and flow rates*

The testing organization should be responsible for assuring that all fire tests are conducted at the operating pressure and flow rates specified by the manufacturer.

4.3 *Temperature measurements*

Temperatures should be measured as described in detail under each chapter. Chromelalumel not exceeding 0.5 mm diameter welded together and chromelalumel 0.8 mm should be used. The 0.8 mm thermocouple wires should be twisted three times, have the end remaining wire cut off and be heated with an oxyacetylene torch to melt and form a small ball. The temperatures should be measured continuously, at least once every two seconds, throughout the tests.

4.4 *Environmental conditions*

The test hall should have an ambient temperature of between 10°C and 30°C at the start of each test.

4.5 *Tolerances*

Unless otherwise stated, the following tolerances should apply:

.1	Length	+ 2% of value
.2	Volume	± 5% of value
.3	Pressure	+ 3% of value
.4	Temperature	+ 5% of value

These tolerances are in accordance with ISO standard 6182-1, February 1994 edition [4].

4.6 *Observations*

The following observations should be made during and after each test:

- .1 time of ignition;
- .2 activation time of each nozzle;
- .3 time when water flow is shut off;
- .4 damage to the fire source;
- .5 temperature recordings;
- .6 system flow rate and pressure;
- .7 total number of operating nozzles.

4.7 *Fire sources*

If the requirements for fire sources specified in the following sections of this test method cannot be fulfilled, it is the responsibility of the test laboratory to show that alternative materials used have burning characteristics similar to those of specified materials.

4.8 *Produce and documentation requirements*

A draft copy of the design, installation and operating instruction manual should be furnished for use as a guide in the testing of the fire protection system devices.

The instructions should reference the limitations of each device and should include at least the following items:

- .1 description and operating details of each device and all accessory equipment, including identification of extinguishing system components or accessory equipment by part or model number;
- .2 nozzle design recommendation and limitations for each fire type;
- .3 type and pressure rating of pipe, tubing and fittings to be used;
- .4 equivalent length values of all fittings and all system components through which water flows;
- .5 discharge nozzle limitations, including maximum dimensional and area coverage, minimum and maximum installation height limitations, and nozzle permitted location in the protected volume;
- .6 range of filling capacities for each size storage container;
- .7 details for the proper installation of each device, including all component equipment;
- .8 reference to the specific types of detection and control panels (if applicable) to be connected to the equipment;
- .9 operating pressure ranges of the system;
- .10** method of sizing pipe or tubing;

- .11 recommended orientation of tee fittings and the splitting of flows through tees;
- .12 maximum difference in operating (flowing) pressure between the hydraulically closest and most remote nozzle.

5 Cabin and corridor fire tests

5.1 Test arrangement

5.1.1 The fire tests should be conducted in a 3 m x 4 m, 2.4 m high cabin connected to the centre of a 1.5 m x 12 m long corridor, 2.4 m high with both ends open.

5.1.2 The cabin should be fitted with one doorway opening, 0.8 m wide and 2.2 m high, which provides for a 0.2 m lintel above the opening.

5.1.3 The walls of the cabin should be constructed from an inner layer of nominally 12 mm thick non-combustible wall board with a nominally 45 mm thick mineral wool liner. The walls and ceiling of the corridor and ceiling of the cabin should be constructed of nominally 12 mm thick non-combustible wall boards. The cabin should be provided with a window in the wall opposite the corridor for observation purposes during the fire tests.

5.1.4 The cabin and corridor ceiling should be covered with cellulosic acoustical panels. The acoustical panels should be nominally 12 mm to 15 mm thick and should not ignite when tested in accordance with IMO resolution A.653(16).

5.1.5 Plywood panels should be placed on the cabin and corridor walls. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s as measured in accordance with IMO resolution A.653(16).

5.2 Instrumentation

During each fire test, the following temperatures should be measured using thermocouples of diameter not exceeding 0.5 mm:

- .1 the ceiling surface temperature above the ignition source in the cabin should be measured with a thermocouple embedded in the ceiling material from above such that the thermocouple bead is flush with the ceiling surface;
- .2 the ceiling gas temperature should be measured with a thermocouple 75 ± 1 mm below the ceiling in the centre of the cabin;
- .3 the ceiling surface temperature in the centre of the corridor, directly opposite the cabin doorway, should be measured with a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling (see figure 1).

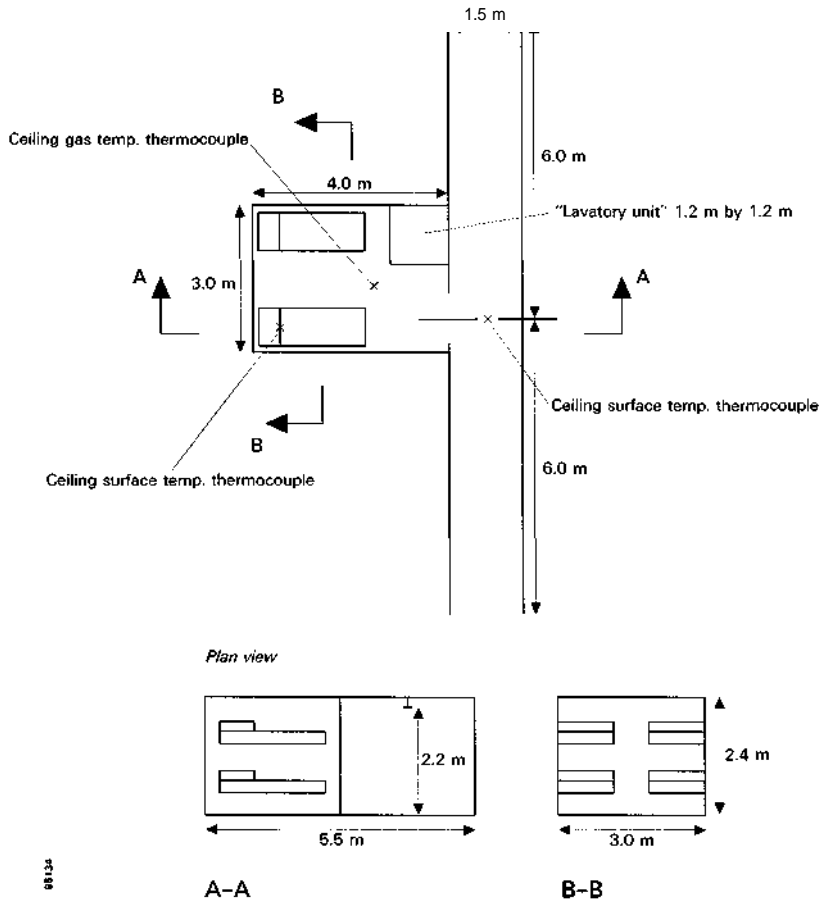
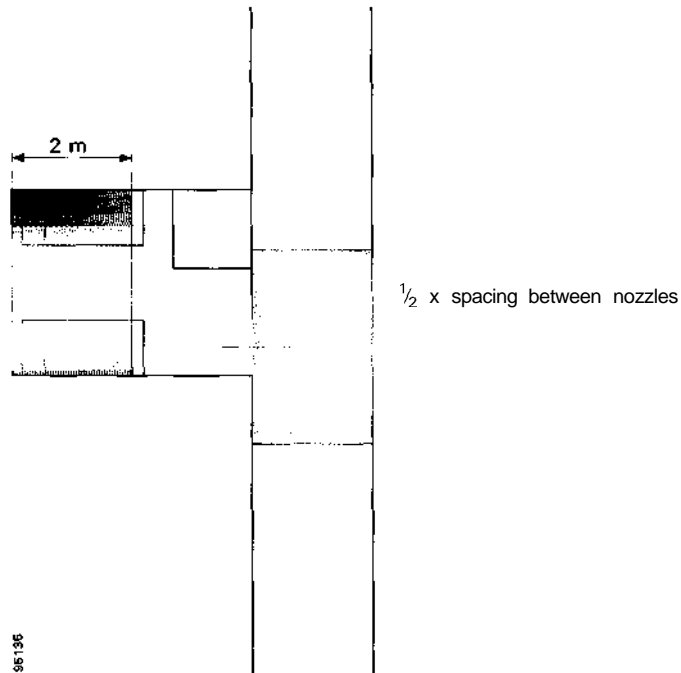


Figure 1

5.3 Nozzle positioning

The nozzles should be installed to protect the cabin and corridor in accordance with the manufacturer's design and installation instructions subject to the following:

- .1 if only one nozzle is installed in the cabin, it may not be placed in the shaded areas in figure 2; and
- .2 corridor nozzles should not be placed closer to the centreline of the cabin doorway than one half the maximum spacing recommended by the manufacturer. An exception is systems where nozzles are required to be placed outside each doorway.



Restricted area for location of nozzles

Figure 2

5.4 Fire sources

5.4.1 Cabin test fire source

Two pullman-type bunk beds having an upper and lower berth should be installed along the opposite side walls of the cabin (see figure 1). Each bunk bed should be fitted with 2.0 m by 0.8 m by 0.1 m polyether mattresses having a cotton fabric cover. Pillows measuring 0.5 m by 0.8 m by 0.1 m should be cut from the mattresses. The cut edge should be positioned towards the doorway. A third mattress should form a backrest for the lower bunk bed. The backrest should be attached in upright position in a way that prevents it from falling over (see figure 3).

The mattresses should be made of non-fire-retardant polyether and they should have a density of approximately 33 kg/m^3 . The cotton fabric should not be fire retardant treated and it should have an area weight of 140 g/m^2 to 180 g/m^2 . When tested according to ISO 5660-1 (ASTM E-1354), the polyether foam should give results as given in the table below. The frame of the bunk beds should be of steel nominally 2 mm thick.

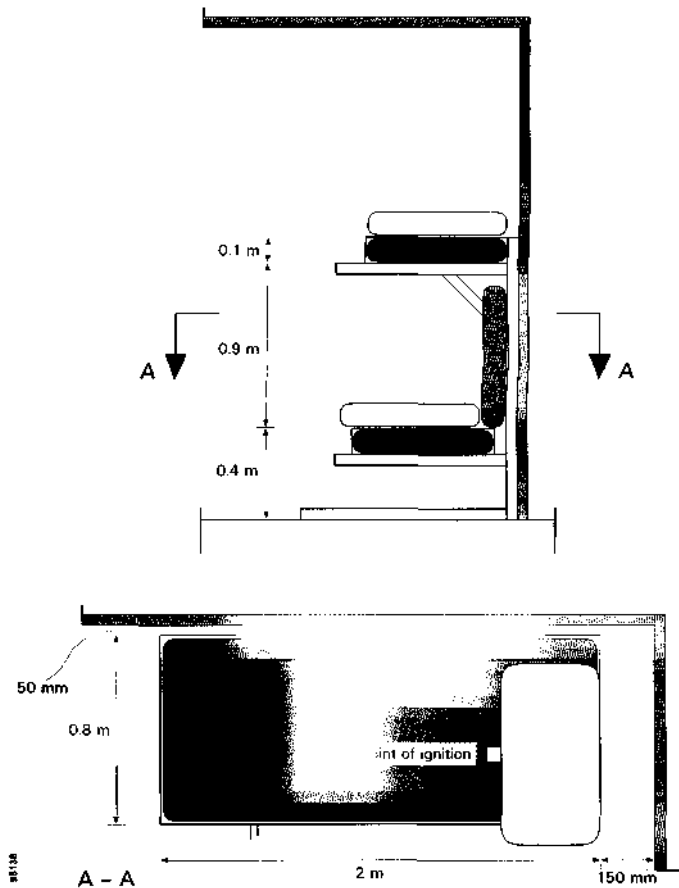


Figure 3

ISO 5660, Cone calorimeter test

Test conditions: Irradiance 35 kW/m^2 . Horizontal position.
 Sample thickness 50 mm.
 No frame retainer should be used.

Test results	Foam
Time to ignition (s)	2-6
3 minute average HRR, q_{180} (kW/m^2)	270 + 50
Effective heat of combustion (MJ/kg)	28 + 3
Total heat release (MJ/m^2)	50 + 12

5.4.2 Corridor test fire source

The corridor fire tests should be conducted using eight piled polyether mattress pieces measuring 0.4 m x 0.4 m x 0.1 m, as specified in 5.4.1, without fabric covers. The pile should be placed on a stand, 0.25 m high, and in a steel test basket to prevent the pile from falling over (see figure 4).

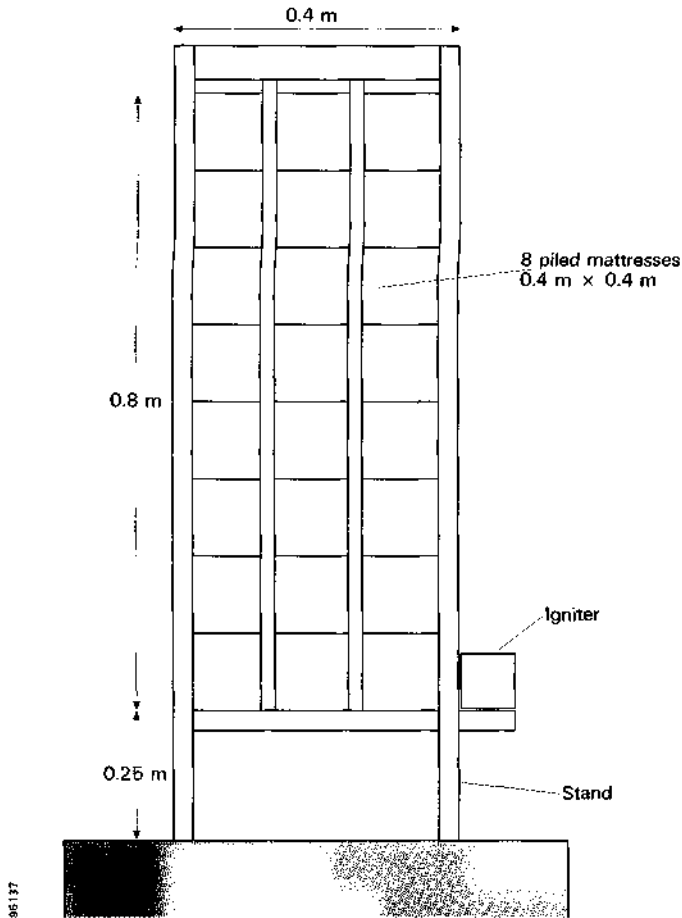


Figure 4

5.5 Test method

The following series of fire tests should be performed with automatic activation of the nozzle(s) installed in the cabin and/or corridor as indicated. Each fire should be ignited with a lighted match using an igniter

made of some porous material, e.g. pieces of insulating fibreboard. The igniter may be either square or cylindrical, 60 mm square or 75 mm in diameter. The length should be 75 mm. Prior to the test the igniter should be soaked in 120 ml of heptane and wrapped in a plastic bag and positioned as indicated for each cabin fire test. For the corridor fire tests, the igniter should be located in the centre at the base of the pile of the mattress pieces, and on one side of the test stand at the base of the pile of the mattress pieces.

- .1 Lower bunk bed test. Fire arranged in one lower bunk bed and ignited with the igniter located at the front (towards door) centreline of the pillow.
- .2 Upper bunk bed test. Fire arranged in one upper bunk bed with the igniter located at the front (towards door) centreline of the pillow.
- .3 Arsonist test. Fire arranged by spreading 1 l of white spirit evenly over one lower bunk bed and backrest 30 s prior to ignition. The igniter should be located in the lower bunk bed at the front (towards door) centreline of the pillow.
- .4 Disabled nozzle test. The nozzle(s) in the cabin should be disabled. Fire arranged in one lower bunk bed and ignited with the igniter located at the front (towards door) centreline of the pillow.

If nozzle(s) in the cabin are linked with nozzle(s) in the corridor such that a malfunction would affect them all, all cabin and corridor nozzles linked should be disabled.
- .5 Corridor test. Fire source located against the wall of the corridor under one nozzle.
- .6 Corridor test. Fire source located against the wall of the corridor between two nozzles.

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

5.6 *Acceptance criteria*

Based on the measurements, a maximum 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

Acceptance criteria for the cabin and corridor tests

		Maximum 30 s average ceiling surface temperature in the cabin (°C)	Maximum 30 s average ceiling gas temperature in the cabin (°C)	Maximum 30 s average ceiling surface temperature in the corridor (°C)	Maximum acceptable damage on mattresses (%)		Other criteria
					Lower bunk	Upper bunk	
Cabin tests	Lower bunk bed	360	320	120	40	10	No nozzles in corridor allowed to operate ³
	Upper bunk bed				N.A.	40	
	Arsonist	N.A.	N.A.	120	N.A.	N.A.	N.A.
Corridor		N.A.	N.A.	120 ¹	N.A.		Only two independent nozzles in corridor allowed to operate ⁴
Disabled nozzle		N.A.	N.A.	400 ²	N.A.		N.A.

¹ In each test, the temperature should be measured above the fire source.

² The fire is not allowed to propagate along the corridor beyond the nozzles closest to the door opening.

³ Not applicable, if cabin nozzle(s) are linked to corridor nozzle(s).

⁴ Not applicable, if corridor nozzle(s) are linked together.

N.A. Not applicable.

Note: After the test, the fire sources should be examined visually to determine compliance with the required maximum damage. The damages should be estimated using the following formula:

Damage to lower bunk bed = (damage to horizontal mattress (%) + 0.25 x damage to pillow (%) + damage to backrest (%))/2.25

Damage to upper bunk bed = (damage to horizontal mattress (%) + 0.25 x damage to pillow (%))/1.25

If it is not clearly obvious by visual examination whether the criteria are fulfilled or not, the test should be repeated.

6 Luxury cabin fire tests

6.1 Test arrangement

These fire tests should be conducted in a 2.4 m high room having equal sides and a floor area of at least 25 m², but not exceeding 80 m². The room should be fitted with two doorway openings, in cross corners opposite the fire source. Each opening should be 0.8 m wide and 2.2 m high, which provides for a 0.2 m lintel above the openings. Walls and ceilings should be made of non-combustible, nominally 12 mm thick, wall boards.

The test room ceiling should be covered 2.4 m out from the corner with cellulosic acoustical panels. The acoustical panels should be nominally 12 mm to 15 mm thick, and should not ignite when tested in accordance with IMO resolution A.653(16).

Plywood panels should be placed on two of the test room walls and extending 2.4 m out from the corner with the fire source. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s as measured in accordance with IMO resolution A.653(16) (see figure 5).

6.2 Instrumentation

During the fire tests the following temperatures should be measured. Note that the instrumentation may be different, dependent on which of two types of fire sources are used.

- .1 The ceiling material temperature above the ignition source should be measured using a 0.8 mm thermocouple embedded in the ceiling, 6.5 + 0.5 mm from the surface.
- .2 The ceiling gas temperature should be measured using a 0.8 mm thermocouple located 75 + 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.
- .3 The ceiling surface temperature above the ignition source should be measured using a thermocouple with diameter not exceeding 0.5 mm embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.

- A The ceiling gas temperature should be measured using a 0.5 mm thermocouple located 75 ± 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.

Measurements in accordance with .1 and .2 should apply when a fire source in accordance with 6.4.1 is used and .3 and .4 when a fire source in accordance with 6.4.2 is used (see figure 5).

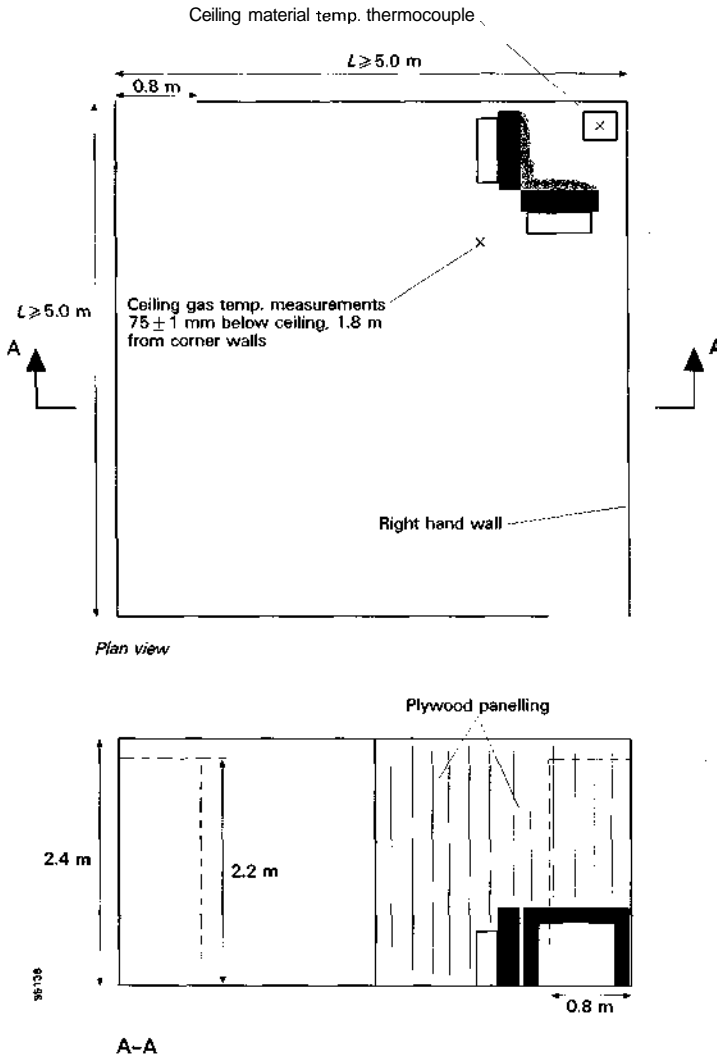


Figure 5
(shown with wood crib/simulated furniture)

6.3 *Nozzle positioning*

The distance between the outer nozzle and the walls should be one half the maximum nozzle spacing specified by the manufacturer. The distance between nozzles should be equal to the maximum spacing specified by the manufacturer.

Nozzles should be positioned with their frame arms parallel and perpendicular with the walls of the cabin, or for nozzles without frame arms, so that the lightest discharge density will be directed towards the fire area.

If non-uniform installation is selected by the manufacturer, the maximum spacing is established in the open public space scenario.

6.4 *Fire source*

The fire source should consist of a wood crib and a simulated furniture (i.e. UL 1626 Residential Sprinkler fuel package [7]) or, alternatively, an upholstered chair (i.e. FM 2030 Residential fuel package [8]).

6.4.1 Wood crib/simulated furniture description

The wood crib should weigh approximately 6 kg and should be dimensioned 0.3 m x 0.3 m x 0.3 m. The crib should consist of eight alternate layers of four trade size nominal 38 mm x 38 mm kiln-dried spruce or fir lumber 0.3 m long. The alternate layers of the lumber should be placed at right angles to the adjacent layers. The individual wood members in each layer should be evenly spaced along the length of the previous layer of wood members and stapled together.

After the wood crib is assembled, it should be conditioned at a temperature of $50 \pm 3^{\circ}\text{C}$ for not less than 16 h. Following the conditioning, the moisture content of the crib should be measured at various locations with a probe-type moisture meter. The moisture content of the crib should not exceed 5% prior to the fire test. The crib should be placed on top of a 0.3 m x 0.3 m, 0.1 m high steel test tray and positioned 25 mm from each wall.

The simulated furniture should consist of two 76 mm thick uncovered polyether foam cushions having a density of 16 kg/m^3 to 20 kg/m^3 , a compressive strength of 147 N to 160 N, measuring 0.9 m x 1.0 m, each attached to a wood support frame. The wood support frame should have a rectangular plywood face measuring approximately 810 mm x 760 mm onto which the foam cushions are applied. The cushions should be stretched and stapled onto plywood panels which extend perpendicular to the face towards the opposite end of the frame by approximately 180 mm. Each cushion should overlap the top of the wood frame by approximately 150 mm and the sides of the wood frame by approximately 180 mm.

This fuel package has an ultra-fast t^2 fire growth, a maximum heat release in excess of 2.5 MW and a growth time (time to reach 1 MW) of 80 ± 10 s (see figure 5).

6.4.2 Upholstered chair description

The fuel package consists of the following items (see figure 6):

Item	Code	No. of units	Dimensions and description
Simulated sofa end	S	1	19 mm plywood structure, open top and bottom, 610 mm x 914 mm, 610 mm high
Chair (recliner) ¹	C	1	Custom-made reclining chair approximately 760 mm x 914 mm, 990 mm high. All new materials consisting of vinyl covering with cotton backing (4.54 kg); polyurethane foam (seat 2.27 kg, 127 mm thick); polyurethane (arms, 1.36 kg, 25 mm thick); pine structure; total weight 23.8 kg, built by Old Brussels of Sturbridge, Massachusetts
End table	E	1	Table top: 19 mm particle board, 660 mm x 495 mm; table legs are softwood, i.e. pine, fir, etc., 38 mm x 38 mm, 514 mm high
Curtains	CW	4	2 panels, rod pocket panels (1,016 mm x 1,829 mm), fabric blend: 50% polyester, 50% cotton 2 panels sheer rod pocket panels (1,016 mm x 1,829 mm), (100% polyester batiste)

¹An equivalent chair may be specified as a fire source with maximum heat release rate of 1.5 MW, a Required Delivered Density of 5 mm/min, and a growth time (time to reach 1 MW assuming second power growth in time) of 75 s to 125 s.

6.5 Test method

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

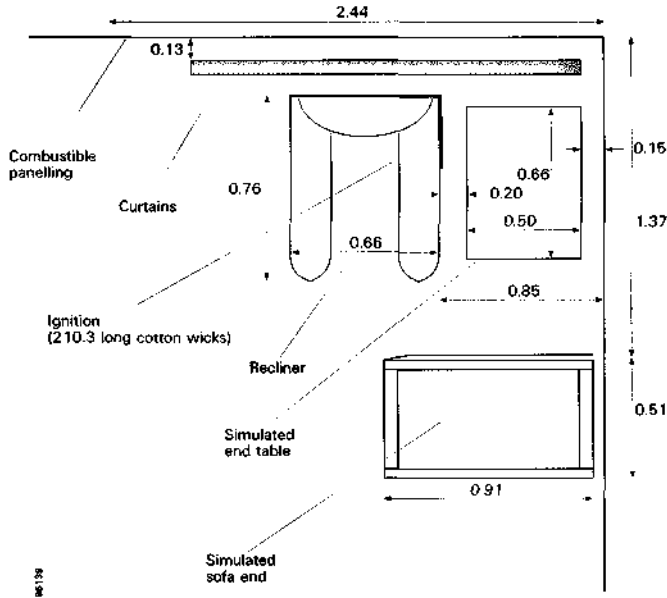


Figure 6 - Upholstered chair fuel package
(dimensions in metres)

6.5.1 Wood crib/simulated furniture

0.2 l of heptane should be placed on a 5 mm water base in the test tray positioned directly below the wood crib. Approximately 120 g total of excelsior (wood wool) should be pulled apart and loosely positioned on the floor with approximately 60 g adjacent to each section of the simulated furniture.

The heptane should be ignited and 40 s later the excelsior should also be ignited.

6.5.2 Upholstered chair

Ignition should take place using a lighted match at the centre of two horizontal axially parallel and adjacent 0.3 m long cotton wicks, each 9.3 mm in diameter, saturated with 25 cl of ethyl alcohol. The wick should be positioned at the base of the chair as described in figure 6, within 2 min prior to ignition.

6.6 Acceptance criteria

Based on the measurements, a maximum of 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

Fire source	Max. 30 s average ceiling material/ surface temperature (°C)	Max. 30 s average ceiling gas temperature (°C)
As per 6.4.1	260	320
As per 6.4.2	260	320

7 Public space fire tests

7.1 Test arrangements

The fire tests should be conducted in a well-vented building under a ceiling of at least 80 m² in area with no dimension less than 8 m. There should be at least a 1 m space between the perimeters of the ceiling and any wall of the test building. The ceiling height should be set at 2.5 m and 5.0 m respectively.

Two different tests should be conducted as per 7.1.1 and 7.1.2.

7.1.1 Open public space test

The fire source should be positioned under the centre of the open ceiling so that there is an unobstructed flow of gases across the ceiling. The ceiling should be constructed from a non-combustible material.

7.1.2 Corner public space test

The test should be conducted in a corner constructed by two at least 3.6 m wide, nominally 12 mm thick, non-combustible wall boards.

Plywood panels should be placed on the walls. The panels should be approximately 3 mm thick. The ignition time of the panel should not be more than 35 s and the flame spread time at 350 mm position should not be more than 100 s measured in accordance with IMO resolution A.653(16).

The ceiling should be covered, 3.6 m out from the corner, with cellulosic acoustical panels. The acoustical panels should be nominally 12 mm to 15 mm thick, and should not ignite when tested in accordance with IMO resolution A.653(16).

7.2 *Instrumentation*

During each fire test, the following temperatures should be measured using thermocouples with diameter not exceeding 0.5 mm.

7.2.1 Open public space test

- .1 The ceiling surface temperature above the ignition source should be measured using a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.
- .2 The ceiling gas temperature should be measured using a thermocouple located 75 ± 1 mm below the ceiling 1.8 m from ignition.

7.2.2 Corner public space test

- .1 The ceiling surface temperature above the ignition source should be measured using a thermocouple embedded in the ceiling material such that the thermocouple bead is flush with the ceiling surface.
- .2 The ceiling gas temperature should be measured using a thermocouple located 75 ± 1 mm below the ceiling within 0.2 m horizontally from the closest nozzle to the corner.

7.3 *Nozzle positioning*

For nozzles with frame arms, tests should be conducted with the frame arms positioned both perpendicular and parallel with the edges of the ceiling or corner walls. For nozzles without framed arms, the nozzles should be oriented so that the lightest discharge density will be directed towards the fire area.

7.4 *Fire sources*

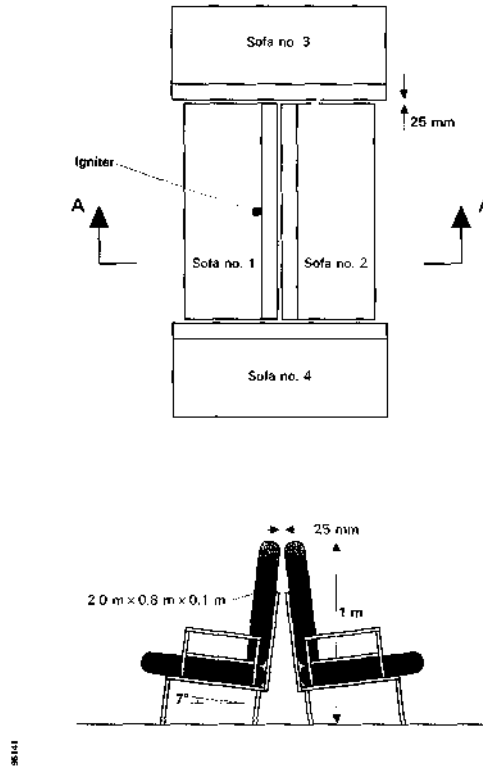
7.4.1 Open public space

The fire source should consist of four sofas made of mattresses as specified in 5.4.1 installed in steel frame sofas. The sofas should be positioned as shown in figure 7 spaced 25 mm apart.

One of the middle sofas should be ignited, centric and at the bottom of the backrest, with an igniter as described in 5.5.

7.4.2 Corner public space test

The fire source should consist of a sofa, as specified in 7.4.1, placed with the backrest 25 mm from the right hand wall and close up to the left hand wall. A target sofa should be placed along the right hand wall with the seat cushion 0.1 m from the first sofa and another target sofa should be placed



A - A Figure 7

0.5 m from it on the left hand side. The sofa should be ignited using an igniter, as described in 5.5, that should be placed at the far left of the corner sofa, at the base of the backrest, near the left hand wall (see figure 8).

7.5 Test method

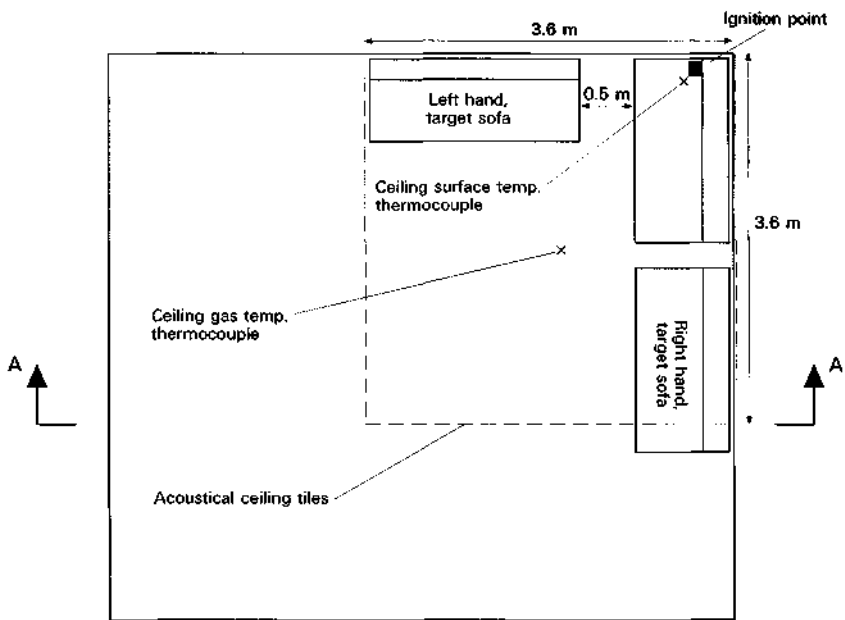
The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

7.5.1 Open public space tests

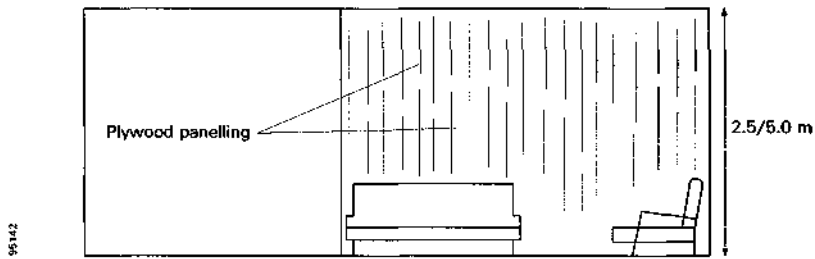
Fire tests should be conducted with the ignition centred under one, between two and below four nozzles.

7.5.2 Corner public space test

Two fire tests should be conducted with at least four nozzles arranged in a 2×2 matrix. For the second fire test, the nozzle closest to the corner should be disabled.



Plan view



A-A

Figure 8

7.6 Acceptance criteria

Based on the measurements, a maximum 30 s average value should be calculated for each measuring point which forms the temperature acceptance criteria.

7.6.1 Acceptance criteria for the public space tests

		Maximum 30 s average ceiling surface temperature	Maximum 30 s average ceiling gas temperature	Maximum acceptable damage on mattresses
Open space		360	220 ²	50/35 ¹
Corner	normal	360	220	50/35 ¹ (ignition sofa) No charring of target sofas
	disabled nozzle	N.A.	N.A.	50 (target sofas)

¹ 50% is the upper limit for any single test. 35% is the upper limit for the average of the public space tests required in 7 and 9 at each ceiling height (excluding the disabled sprinkler test).

² The gas temperature should be measured at four different positions and the evaluation of the results is based on the highest reading.

N.A. Not applicable.

8 Shopping and storage area fire tests

8.1 Test arrangements

As per 7.1 but with 2.5 m ceiling height only.

8.2 Instrumentation

No temperature measurements are required.

8.3 Nozzle positioning

As per 7.3.

8.4 Fire source

The fire source should consist of two central, 1.5 m high, solid piled stacks of cardboard boxes packed with polystyrene unexpanded plastic cups with a 0.3 m flue space. Each stack should be approximately 1.6 m long and 1.1 m to 1.2 m wide.

A suitable plastic commodity is the FMRC standard plastic commodity [9]. Similar commodities might be used if they are designed in a similar way and are proven to have the same burning characteristics and suppressability.

The fire source should be surrounded by six 1.5 m high solid piled stacks of empty cardboard boxes forming a target array to determine if the fire will

jump the aisle. The boxes should be attached to each other, for example by staples, to prevent them from falling over (see figure 9).

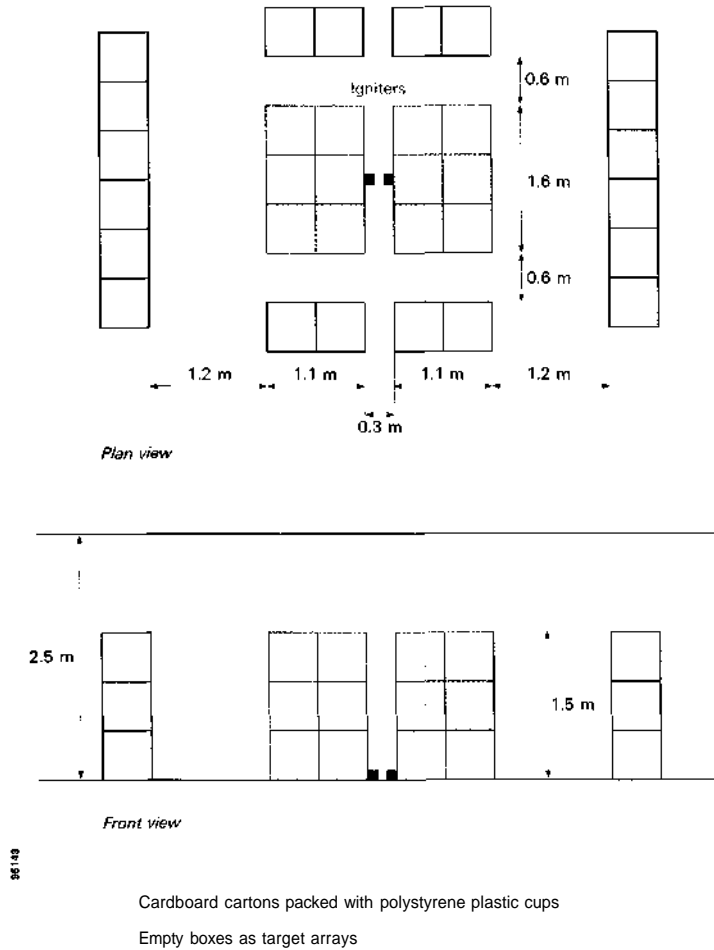


Figure 9

8.5 Test method

Fire tests should be conducted with the ignition centred under one, between two and below four nozzles.

Each fire should be ignited with a lighted match using two igniters as described in 5.5. The igniters should be located placed on the floor, each

against the base of one of the two central stacks and ignited simultaneously.

The fire tests should be conducted for 10 min after the activation of the first nozzle, and any remaining fire should be extinguished manually.

8.6 *Acceptance criteria*

- .1 No ignition or charring of the target cartons is allowed.
- .2 No more than 50% of the cartons filled with plastic cups should be consumed.

9 **Ventilation test**

One corner public space test of 7 and the corridor space test which has given the worst result among those in 5.4.2 should be repeated with the ambient air having a minimum velocity of 0.3 m/s.

The ambient air velocity in the public space tests should be measured 1 m above the floor and 1 m below the ceiling at a location 5 m out from the corner, midway between the enclosure walls. Air velocity in the corridor should be measured at the mid-height.

9.1 *Acceptance criteria*

The fire should not progress to the edge of the combustible wall or ceiling.

10 **Referenced publications**

- [1] *International Convention for the Safety of Life at Sea (SOLAS)*, International Maritime Organization, London.
- [2] Solomon, Robert E., *Automatic Sprinkler Systems Handbook*, National Fire Protection Association, Batterymarch Park, Quincy, MA, USA, 5th edition, 1991.
- [3] ANSI/UL 723, *Surface Burning Characteristics of Building Materials*.
- [4] ISO 6182/1, February 1994 edition.
- [5] ISO 5660-1, *Fire Tests - Reaction to Fire - Rate of Heat Release from Building Products (Cone Calorimeter Method)*, 1st edition, 1993.
- [6] Babrauskas, V. and Wetterlund, I., *Instructions for Cone Calorimeter Testing of Furniture Samples*, CBUF Consortium, SP-AR 1993: 65, Boras, Sweden, 1993.
- [7] *Standard for Residential Sprinklers for Fire-Protection Service*, UL 1626, Underwriters Laboratories Inc., Northbrook, IL, USA, December 28, 1990 revision.

- [8] *Approval Standard for Residential and Limited Water Supply Automatic Sprinklers*, Class 2030, Factory Mutual Research Corporation, Norwood, MA, USA, January 27, 1993.
- [9] Chicarello, Peter J. and Troup, Joan, M.A., *Fire Products Collector Jest Procedure for Determining the Commodity Classification of Ordinary Combustible Products*, Factory Mutual Research Corporation, Norwood, MA, USA, August 1990.

MSC/Circ.582
(23 April 1992)

**Guidelines for the performance and testing criteria,
and surveys of low-expansion foam concentrates
for fixed fire-extinguishing systems**

1 At its sixtieth session, the Maritime Safety Committee approved "Guidelines for the performance and testing criteria, and surveys of low-expansion foam concentrates for fixed fire-extinguishing systems".

2 Member Governments are recommended to ensure that tests for type approval and periodical control of the low-expansion foam concentrates are performed, in accordance with the attached Guidelines.

Annex

Guidelines for the performance and testing criteria
and surveys of low-expansion foam concentrates
for fixed fire-extinguishing systems

1 General

1.1 *Application*

These Guidelines apply to the foam concentrates for fixed low-expansion fire-extinguishing systems required by SOLAS 74(83) Reg. II-2/61 for oil tankers. These Guidelines also apply to foam concentrates for fixed low-expansion fire-extinguishing systems in machinery spaces according to SOLAS 74(83) regulation II-2/8.

1.2 Definitions

For the purpose of these Guidelines the following definitions apply.

- (a) Foam (*fire fighting*): an aggregate of air-filled bubbles formed from an aqueous solution of a suitable foam concentrate.
- (b) Foam *solution*: a solution of foam concentrate and water.

- (c) *Foam concentrate*: the liquid which, when mixed with water in the appropriate concentration, gives a foam solution.
- (d) *Expansion ratio*: the ratio of the volume of foam to the volume of foam solution from which it was made.
- (e) *Spreading coefficient*: a measurement of the ability of one liquid to spontaneously spread across another.
- (f) *25% (50%) drainage time*: the time for 25% (50%) of the liquid content of a foam to drain out.
- (g) *Gentle application*: application of foam to the surface of a liquid fuel via a backboard, tank wall or other surface.
- (h) *Sediment*: insoluble particles in the foam concentrate.

2 Sampling procedure

The sampling method should ensure representative samples which should be stored in filled containers.

The sample size should be:

30 / for type tests (see section 3)

2 / for periodical controls (see section 4).

3 Tests for type approval of foam concentrates

For foam concentrate type approval, the tests under paragraphs 3.1–3.11 should be performed. They should be carried out at laboratories acceptable to the Administration.

3.1 Freezing and thawing

3.1.1 Before and after temperature conditioning in accordance with 3.1.2, the foam concentrate should show no visual sign of stratification, non-homogeneity or sedimentation.

3.1.2 Freezing and thawing test

(a) Apparatus:

freezing chamber, capable of achieving temperatures required as stated in (b.1);

polyethylene tube, approximately 10 mm diameter, 400 mm long and sealed and weighted at one end, with suitable spacers attached. Figure 1 shows a typical form;

500 ml cylinder approximately 400 mm high and 65 mm diameter.

(b) Procedure:

(b.1) Set the temperature of the freezing chamber to a temperature which is 10°C below the freezing point of the sample measured in accordance with BS 5117: Section 1.3 (excluding 5.2 in the standard).

To prevent the glass measuring cylinder from breaking, due to expansion of the foam concentrate on freezing, insert the tube into the measuring cylinder, sealed end downward, weighted if necessary to avoid flotation, the spacers ensuring it remains approximately on the central axis of the cylinder.

Place the sample in the cylinder in the chest, cool and maintain at the required temperature for 24 h. At the end of this period thaw the sample for not less than 24 h and not more than 96 h in an ambient temperature of 20-25°C.

(b.2) Repeat (b.1) three times to give four cycles of freezing and thawing.

(b.3) Examine the sample for stratification and non-homogeneity

(b.4) Condition the sample for 7 days at 60°C followed by one day at room temperature.

3.2 Heat stability

An unopened 20 l container (or other standard shipping container) as supplied by the manufacturer from a production batch should be maintained for 7 days at 60°C, followed by one day at room temperature. Following this conditioning, the foam liquid after agitating/stirring will be subjected to the fire test as per 3.9, and comply with the requirements given in these guidelines.

3.3 Sedimentation

3.3.1 Any sediment in the concentrate prepared in accordance with section 2 should be dispersible through a 180 µm sieve, and the percentage volume of sediment should not be more than 0.25% when tested in accordance with 3.3.2.

3.3.2 The test should be carried out as follows:

(a) Apparatus:

graduated centrifuge tubes;

centrifuge operating at 6000 ± 100 m/s²;

180 µm sieve complying with ISO 3310-1;

plastic wash bottle.

Note: A centrifuge and tubes complying with ISO 3734 are suitable.

(b) Procedure:

Centrifuge each sample for 10 min. Determine the volume of the sediment and determine the percentage of this volume with respect to the centrifuged sample volume.

Wash the contents of the centrifuge tube onto the sieve and check that the sediment can or cannot be dispersed through the sieve by the jet from the plastic wash bottle.

Note: It is possible that the test method is not suitable for some non-Newtonian foam concentrates. In this case an alternative method, to the satisfaction of the Administration, should be used so that compliance with this requirement can be verified.

3.4 *Kinematic viscosity*

3.4.1 The test should be carried out according to ASTM D 445-86 or ISO 3104. Kinematic viscosity should not exceed 200 mm²/s.

3.4.2 The method for determining viscosity of non-Newtonian foam concentrates should be to the satisfaction of the Administration.

3.5 *pH value*

The pH of the foam concentrate prepared in accordance with section 2 should be not less than 6.0 and not more than 9.5 at (20 ± 2)°C.

3.6 *Film formation of the foam solution*

3.6.1 The spreading coefficient should be determined, using the following formula:

$$S = T_c - T_s - T_j$$

where:

S is the spreading coefficient (N/m)

T_c is the surface tension of cyclohexane (N/m)

T_s is the surface tension of the foam solution (N/m)

T_j is the interfacial tension between the foam solution and cyclohexane (N/m)

T_c , T_s and T_j should be determined according to 3.6.2.

The spreading coefficient S should be greater than 0.

3.6.2 Determination of T_c , T_s and T_i

(a) Materials:

solution of foam concentrate, at the recommended usage concentration in distilled water complying with ISO 3696.
 Note: The solution may be made up in a 100 ml volumetric flask using a pipette to measure the foam concentrate.

for T_c and γ], cyclohexane of purity not less than 99%.

(b) Procedure for surface tension:

Determine T_c at a temperature of $(20 \pm 2)^\circ\text{C}$ using the ring or plate methods of ISO 304.

(c) Procedure for interfacial tension:

After measuring the surface tension in accordance with (b), introduce a layer of cyclohexane at $(20 \pm 2)^\circ\text{C}$ onto the foam solution, being careful to avoid contact between the ring or plate and the cyclohexane. Wait (6 ± 1) min and measure T_i .

3.7 *Expansion ratio*

3.7.1 The test should be carried out according to paragraph 3.7.2, with seawater at about 20°C . Simulated seawater having the characteristics stated under 3.7.3 may be used.

The expansion ratio obtained with nozzles used on board should be consistent with the expansion ratio obtained with the nozzles during the fire test.

3.7.2 Determination of the expansion ratio

(a) Apparatus:

plastic collecting vessel of volume V , known to ± 16 ml, as shown in figure 2, equipped with a bottom discharge facility;

foam collector as shown in figure 3;

foam-making equipment with nozzle as shown in figure 4 which when tested with water has a flow rate of 11.4 // min at a nozzle pressure of (6.3 ± 0.3) bar.

(b) Procedure:

- (b.1)** Check that the pipework and hose from the foam solution tank to the nozzle is completely full of solution. Set up the nozzle horizontally directly in front of the foam collector with the front of the nozzle (3 ± 0.3) m from the top edge of the collector. Wet the vessel internally and weigh it (W_1). Set up the foam

equipment and adjust the nozzle pressure to give a flow rate of 6 l/min. Discharge the foam and adjust the height of the nozzle so that the discharge strikes the collector centrally. Keep the nozzle horizontal. Stop the foam discharge and rinse all foam from the collector. Check that the foam solution tank is full. Start discharging the foam and after (30 + 5) s to allow the discharge to stabilize, place the collecting vessel, with the discharge outlet closed, on the collector. As soon as the vessel is full, remove it from the collector, strike the foam surface level with the rim and start the clock. Weigh the vessel (W_2).

- (b.2) Calculate the expansion ϵ from the equation:

$$\sim W_2 - W_1$$

in which it is assumed that the density of the foam solution is 1.0 and where

V is the vessel volume (ml)

W_1 is the mass of the empty vessel (g)

W_2 is the mass of the full vessel (g).

- (b.3) Open the drainage facility and collect the foam solution in the measuring cylinder to measure the 25% drainage time (see paragraph 3.8.1 hereinafter).

3.7.3 Simulated seawater may be made up by dissolving

25.0 g Sodium chloride (NaCl)
 11.0 g Magnesium chloride ($MgCl_2 \cdot 6H_2O$)
 1.6 g Calcium chloride ($CaCl_2 \cdot 2H_2O$)
 4.0 g Sodium sulphate (Na_2SO_4)

in each litre of potable water.

3.8 *Drainage time*

3.8.1 The drainage time should be determined according to paragraph 3.7.2 (b.3), after having determined the expansion ratio.

3.8.2 The test should be carried out with seawater at about 20°C. Simulated seawater having the characteristics stated in 3.7.3 may be used.

3.8.3 Drainage time obtained with nozzles used on board should be consistent with the drainage time obtained with the nozzles during the fire test.

3.9 *Fire tests*

Fire tests should be carried out according to the following paragraphs 3.9.1-3.9.7.

Note: The fire tests of this section 3.9 are more expensive and time-consuming than the other tests of these Guidelines. It is recommended that fire tests should be carried out at the end of the test programme, so as to avoid the expense of unnecessary testing of foam concentrates which do not comply in other respects.

3.9.1 Environmental conditions

Air temperature (15 + 5)°C

Maximum wind speed 3 m/s in proximity of the fire tray

Note: If necessary, some form of wind-screen may be used.

3.9.2 Records

During the fire test, record the following:

indoor or outdoor test

air temperature

fuel temperature

water temperature

foam solution temperature

wind speed

extinction time

25% burnback time.

Note: Burnback time may either be determined visually by an experienced person or may be determined from thermal radiation measurements.

3.9.3 Foam solution

- (a) Prepare a foam solution following the recommendations from the supplier for concentration, maximum premix time, compatibility with the test equipment, avoiding contamination by other types of foam, etc.
- (b) The test should be carried out with seawater at about 20°C. Simulated seawater having the characteristics stated in 3.7.3 may be used.

3.9.4 Apparatus

(a) Fire tray:

Square fire tray with the following dimensions:

- area 4.5 m^2
- depth 200 mm
- thickness of steel wall 2.5 mm

with a vertical steel backboard $(1 + 0.05) \text{ m}$ high and $(1 + 0.05) \text{ m}$ long.

(b) Foam-making equipment:

In accordance with subparagraph 3.7.2(a).

(c) Burnback pot:

Circular burnback pot with the following dimensions:

- diameter $(300 + 5) \text{ mm}$
- height $(150 \pm 5) \text{ mm}$
- thickness of steel wall 2.5 mm.

3.9.5 Fuel

Use an aliphatic hydrocarbon mixture with physical properties according to the following specification:

- distillation range $84^\circ\text{C}-105^\circ\text{C}$
- maximum difference between initial and final boiling points 10°C
- maximum aromatic content 1%
- density at 15°C $(707.5 + 2.5) \text{ kg/m}^3$
- temperature about 20°C

Note: Typical fuels meeting this specification are n-heptane and certain solvent fractions sometimes referred to as commercial heptane.

The Administration may require additional fire tests using an additional test fuel.

3.9.8 Test procedure

- (a) Place the tray directly on the ground and ensure that it is level. Add approximately 90 l of seawater, or simulated seawater having the characteristics stated in 3.7.3, and check that the base of the tray is completely covered. Set up the foam nozzle horizontally, about 1 m above the ground in a position where the central part of the foam discharge will strike the centre axis

of the backboard, (0.35 ± 0.1) m above the rim of the tray, (gentle application). Add (144 ± 5) l of fuel, to give a nominal freeboard of 150 mm.

- (b) Ignite the tray not more than 5 min after adding the fuel and allow it to burn for a period of (60 ± 5) s after full involvement of the surface of the fuel, then start foam application.
- (c) Apply foam for (300 ± 2) s. Stop foam application and after a further (300 ± 10) s place the burnback pot, containing (2 ± 0.1) l of fuel in the centre of the tray and ignite. Record the 25% burnback time.

3.9.7 Permissible limits

- (a) extinction time: not more than 5 min;
- (b) burnback time: not less than 15 min for 25% of the surface.

3.10 Corrosiveness

The storage container shall be compatible with its foam concentrate, throughout the service life of the foam, such that the chemical and physical properties of the foam shall not deteriorate below the initial values accepted by the Administration.

3.11 Volumic mass

According to ASTM D 1298-85.

4 Periodical controls of foam concentrates stored on board

The attention of the Administration is drawn to the fact that particular installation conditions (excessive ambient temperature, incomplete filling of the tank, etc.) may lead to an abnormal ageing of the concentrates.

For the periodical control of foam concentrate the tests under paragraphs 4.1–4.5 should be performed. They should be carried out at laboratories acceptable to the Administration.

The deviations in the values obtained by these tests, in respect of those obtained during the type approval tests, should be within ranges acceptable to the Administration.

Tests under items 4.1, 4.3 and 4.4 should be carried out on samples maintained at 60°C for 24 h and subsequently cooled to the test temperature.

4.1 Sedimentation

According to paragraph 3.3.

4.2 *pH value*

According to paragraph 3.5.

4.3 *Expansion ratio.*

According to paragraph 3.7.

4.4 *Drainage time*

According to paragraph 3.8.

4.5 *Volumic mass*

According to paragraph 3 .11.

5 Intervals of periodical controls

The first periodical control of foam concentrates stored on board should be performed after a period of 3 years and, after that, every year.

A record of the age of the foam concentrates and of subsequent controls should be kept on board.

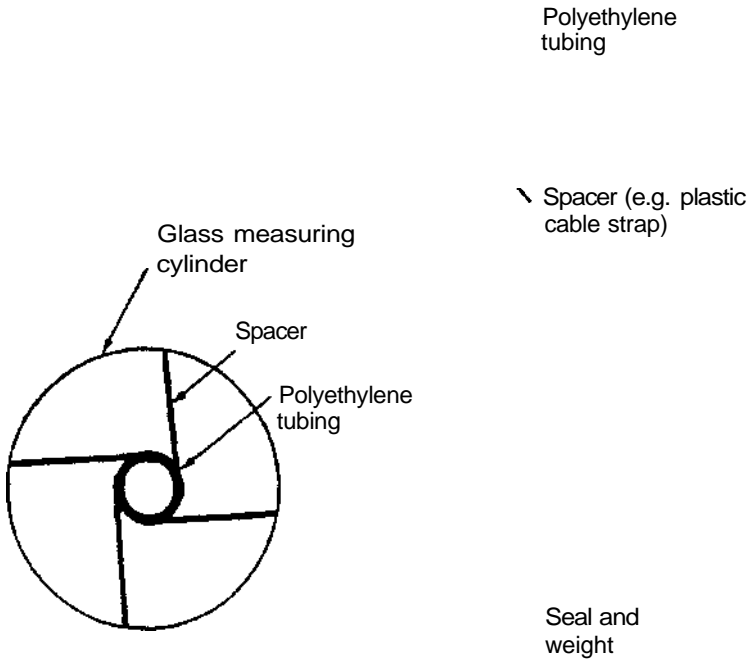
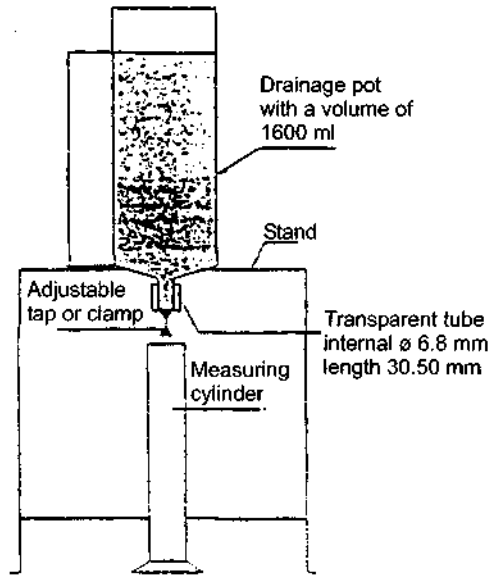


Figure 1 - Typical form of polyethylene tube



All dimensions are normal and in mm

Figure 2 - Collecting vessel for determination of expansion and drainage time

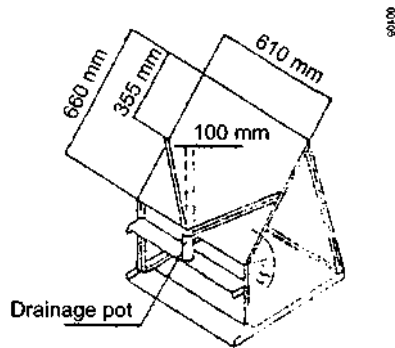


Figure 3 - Foam collector for expansion and drainage measure

Note: Suitable materials for the collection surface are stainless steel, aluminium, brass or plastics.

MSC/Circ.582/Corr.1
(10 July 2000)

**Guidelines for the performance and testing criteria
and surveys of low-expansion foam concentrates
for fixed fire-extinguishing systems**

1 The Maritime Safety Committee, at its seventy-second session (17 to 26 May 2000), approved, as proposed by the Sub-Committee on Fire Protection at its forty-fourth session, a corrigendum to MSC/Circ.582 on Guidelines for the performance and testing criteria and surveys of low-expansion foam concentrates for fixed fire-extinguishing systems, as set out in the annex.

2 Member Governments are invited to take account of the annexed modifications to the aforementioned circular and bring them to the attention of all parties concerned.

Annex

Modifications to the guidelines for the performance
and testing criteria and surveys of low-expansion foam
concentrates for fixed fire-extinguishing
systems (MSC/Circ.582)

Corrigenda

1 *In the title of MSC/Circ.582 replace the word "FROM" with "FOAM".*

2 *The following modifications are made to the text of the annex to MSC/Circ.582:*

- .1 the existing text in paragraph 3.7.1 is replaced by the following new text:*
"3.7.1 The test should be carried out according to paragraph 3.7.2 with simulated seawater at about 20°C having the characteristics stated in paragraph 3.7.3.";
- .2 in paragraph 3.7.2 (b. 1), in the fourth sentence, the flow rate of 6 l/min" ;'s replaced by "11.4 l/min";*

- .3 the existing text in paragraph 3.8.2 is replaced by the following new text:

"3.8.2 The test should be carried out with simulated seawater at about 20°C having the characteristics stated in paragraph 3.7.3.'";
- .4 the existing text in paragraph 3.9.3 (b) is replaced by the following new text:

"(b) The test should be carried out with simulated seawater at about 20°C having the characteristics stated in paragraph 3.7.3.'"; and
- .5 in paragraph 3.9.6 (a), the second sentence is replaced by the following:

"(a) Add approximately 90 l of simulated seawater having the characteristics stated in paragraph 3.7.3 and check that the base of the tray is completely covered."

MSC/Circ.668
(30 December 1994)

Alternative arrangements for halon fire-extinguishing systems in machinery spaces and pump-rooms

1 The Maritime Safety Committee, at its sixty-third session (16 to 25 May 1994), recognized the urgent necessity of providing guidelines for alternative arrangements for halon fire-extinguishing systems which are prohibited to be installed on board ships on or after 1 October 1994 in accordance with the provisions of the revised SOLAS regulation II-2/5 (resolution MSC.27(61)).

2 The Sub-Committee on Fire Protection, at its thirty-ninth session (27 June to 1 July 1994), prepared draft texts of guidelines for water-based systems, which may be installed as a replacement system for the halon fire-extinguishing system in the machinery spaces and cargo pump-rooms, and appendices to the guidelines covering component manufacturing standards and fire test procedures.

3 The Maritime Safety Committee, at its sixty-fourth session (5 to 9 December 1994), approved the Guidelines contained in the annex.

4 Member Governments are invited to apply the attached Guidelines, component manufacturing standards and fire test procedures for water-based systems in machinery spaces and cargo pump-rooms, which should, for that purpose, be approved under the provisions of SOLAS regulation I/5 (Equivalents).

Annex

Guidelines for the approval of equivalent water-based fire-extinguishing systems as referred to in SOLAS 74 for machinery spaces and cargo pump-rooms

General

1 Water-based fire-extinguishing systems for use in machinery spaces of category A and cargo pump-rooms equivalent to fire-extinguishing systems required by SOLAS regulations II-2/7 and II-2/63 should prove that

they have the same reliability which has been identified as significant for the performance of fixed pressure water-spraying systems approved under the requirements of SOLAS regulation II-2/10. In addition the system should be shown by test to have the capability of extinguishing a variety of fires that can occur in a ship's engine-room.

Definitions

2 *Antifreeze system.* A wet pipe system containing an antifreeze solution and connected to a water supply. The antifreeze solution is discharged, followed by water, immediately upon operation of nozzles.

3 *Deluge system.* A system employing open nozzles attached to a piping system connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the nozzles or opened manually. When this valve opens, water flows into the piping system and discharges from all nozzles attached thereto.

4 *Dry pipe system.* A system employing nozzles attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a nozzle) permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the piping system and out of the opened nozzle.

5 *Fire extinction.* A reduction of the heat release from the fire and a total elimination of all flames and glowing parts by means of direct and sufficient application of extinguishing media.

6 *Preaction system.* A system employing automatic nozzles attached to a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same area as the nozzles. Actuation of the detection system opens a valve that permits water to flow into the piping system and to be discharged from any nozzles that may be open.

7 *Water-based extinguishing medium* is fresh water or seawater with or without additives mixed to enhance fire-extinguishing capability.

8 *Wet pipe system.* A system employing nozzles attached to a piping system containing water and connected to a water supply so that water discharges immediately from the nozzles upon system activation.

Principal requirements for the system

9 The system should be capable of manual release.

10 The system should be capable of fire extinction, and tested to the satisfaction of the Administration in accordance with appendix B to these Guidelines.

11 The system should be available for immediate use and capable of continuously supplying water for at least 30 min 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 should have a second full fire-extinguishing capability available within a 5 min period of initial activation. A pressure tank should be provided to meet the functional requirements stipulated in SOLAS regulation II-2/12.4.1, provided that the minimum water capacity is based on the design criteria of paragraph 19 plus the filling capacity of the piping.

12 The system and its components should 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 ships. Components within the protected spaces should be designed to withstand the elevated temperatures which could occur during a fire.

13 The system and its components should 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 appropriate elements of appendices A and B to these Guidelines.

14 The nozzle location, type of nozzle and nozzle characteristics should be within the limits tested to provide fire extinction as referred to in paragraph 10.

15 The electrical components of the pressure source for the system should have a minimum rating of IP 54. The system should be supplied by both 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.

16 The system should be provided with a redundant means of pumping or otherwise supplying the water-based extinguishing medium. The system should be fitted with a permanent sea inlet and be capable of continuous operation using seawater.

17 The piping system should be sized in accordance with an hydraulic calculation technique.†

* Pending the development of international standards acceptable to the Organization, national standards as prescribed by the Administration should be applied.

Where the Hazen-Williams method is used, the following values of the friction factor C for different pipe types which may be considered should apply:

<i>Pipe type</i>	<i>C</i>
Black or galvanized mild steel	100
Copper and copper alloys	150
Stainless steel	150

18 Systems capable of supplying water at the full discharge rate for 30 min may be grouped into separate sections within a protected space. The sectioning of the system within such spaces should be approved by the Administration in each case.

19 In all cases the capacity and design of the system should be based on the complete protection of the space demanding the greatest volume of water.

20 The system operation controls should be available at easily accessible positions outside the spaces to be protected and should not be liable to be cut off by a fire in the protected spaces.

21 Pressure source components of the system should be located outside the protected spaces.

22 A means for testing the operation of the system for assuring the required pressure and flow should be provided.

23 Activation of any water distribution valve should 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 should indicate the specific valve activated.

24 Operating instructions for the system should be displayed at each operating position. The operating instructions should be in the official language of the flag State. If the language is neither English nor French, a translation into one of these languages should be included.

25 Spare parts and operating and maintenance instructions for the system should be provided as recommended by the manufacturer.

Appendix A

Component manufacturing standards of equivalent water-based fire-extinguishing systems

- 0.0 Introduction**
- 1.0 Definitions**
- 2.0 Product consistency**
- 3.0 Water mist nozzle requirements**
 - 3.1 Dimensions
 - 3.2 Nominal release temperatures
 - 3.3 Operating temperatures
 - 3.4 Water flow and distribution
 - 3.5 Function
 - 3.6 Strength of body
 - 3.7 Strength of release element
 - 3.8 Leak resistance and hydrostatic strength
 - 3.9 Heat exposure
 - 3.10 Thermal shock
 - 3.11 Corrosion
 - 3.12 Integrity of nozzle coatings
 - 3.13 Water hammer
 - 3.14 Dynamic heating
 - 3.15 Resistance to heat
 - 3.16 Resistance to vibration
 - 3.17 Impact test
 - 3.18 Lateral discharge
 - 3.19 30 day leakage
 - 3.20 Vacuum resistance
 - 3.21 Water shield
 - 3.22 Clogging
- 4.0 Methods of test**
 - 4.1 General
 - 4.2 Visual examination
 - 4.3 Body strength test
 - 4.4 Leak resistance and hydrostatic strength tests
 - 4.5 Functional test
 - 4.6 Heat responsive element operating characteristics
 - 4.6.1 Operating temperature test
 - 4.6.2 Dynamic heating tests

- 4.7 Heat exposure test
- 4.8 Thermal shock test
- 4.9 Strength test for release elements
- 4.10 Water flow test
- 4.11 Water distribution and droplet size tests
- 4.12 Corrosion tests
 - 4.12.1 Stress corrosion tests for brass nozzle parts
 - 4.12.2 Stress corrosion cracking of stainless steel nozzle parts
 - 4.12.3 Sulphur dioxide corrosion test
 - 4.12.4 Salt spray corrosion test
 - 4.12.5 Moist air exposure test
- 4.13 Nozzle coating tests
- 4.14 Heat-resistance test
- 4.15 Water-hammer test
- 4.16 Vibration test
- 4.17 Impact test
- 4.18 Lateral discharge test
- 4.19 30 day leakage test
- 4.20 Vacuum test
- 4.21 Clogging test

5.0 Water mist nozzle markings

- 5.1 General
- 5.2 Nozzle housing

List of figures

Figure number	Description
1	RTI and C limits for standard orientation
2	Impact test apparatus
3	Clogging test apparatus

List of tables

Table number	Description
1	Nominal release temperature
2	Plunge oven test conditions
3	Plunge oven test conditions for conductivity determinations
4	Test temperatures for coated and uncoated nozzles
5	Contaminant for contaminated water cycling test

Figures given in square brackets refer to ISO Standard 6182/1.

0.0 Introduction

0.1 This document is intended to address minimum fire protection performance, construction, and marking requirements, excluding fire performance, for water mist nozzles.

0.2 Numbers in brackets following a section or subsection heading refer to the appropriate section or paragraph in the Standard for automatic sprinkler systems - part 1: Requirements and methods of test for sprinklers, ISO 6182-1.

0.3 The requirements for automatically operating nozzles which involve release mechanism need not be met by nozzles of manually operating systems.

1.0 Definitions

1.1 *Conductivity factor* - A measure of the conductance between the nozzle's heat responsive element and the fitting expressed in units of $(\text{m/s})^{0.5}$.

1.2 *Rated working pressure* - Maximum service pressure at which a hydraulic device is intended to operate.

1.3 *Response time index: (RTI)* - A measure of nozzle sensitivity expressed as $\text{RTI} = tu^{0.5}$ where t is the time constant of the heat responsive element in units of seconds, and u is the gas velocity expressed in metres per second. RTI can be used in combination with the conductivity factor (C) to predict the response of a nozzle in fire environments defined in terms of gas temperature and velocity versus time. RTI has units of $(\text{m}\cdot\text{s})^{0.5}$.

1.4 *Standard orientation* - In the case of nozzles with symmetrical heat responsive elements supported by frame arms, standard orientation is with the air flow perpendicular to both the axis of the nozzle's inlet and the plane of the frame arms. In the case of nonsymmetrical heat responsive elements, standard orientation is with the air flow perpendicular to both the inlet axis and the plane of the frame arms which produces the shortest response time.

1.5 *Worst case orientation* - The orientation which produces the longest response time with the axis of the nozzle inlet perpendicular to the air flow.

2.0 Product consistency

2.1 It should be the responsibility of the manufacturer to implement a quality control programme to ensure that production continuously meets the requirements in the same manner as the originally tested samples.

2.2 The load on the heat responsive element in automatic nozzles should be set and secured by the manufacturer in such a manner so as to prevent field adjustment or replacement.

3.0 Water mist nozzle requirements

3.1 Dimensions

Nozzles should be provided with a nominal 6 mm (1 in) or larger nominal inlet thread or equivalent. The dimensions of all threaded connections should conform to international standards where applied. National standards may be used if international standards are not applicable.

3.2 Nominal release temperatures [6.2]

3.2.1 The nominal release temperatures of automatic glass bulb nozzles should be as indicated in table 1.

3.2.2 The nominal release temperatures of fusible automatic element nozzles should be specified in advance by the manufacturer and verified in accordance with 3.3. Nominal release temperatures should be within the ranges specified in table 1.

3.2.3 The nominal release temperature that is to be marked on the nozzle should be that determined when the nozzle is tested in accordance with 4.6.1, taking into account the specifications of 3.3.

3.3 Operating temperatures (see 4.6.1) [6.3]

Automatic nozzles should open within a temperature range of:

$$X + (0.035X + 0.62)^{\circ}\text{C}$$

where X is the nominal release temperature.

3.4 Water flow and distribution

3.4.1 Flow constant (see 4.10) [6.4.1]

3.4.1.1 The flow constant *K* for nozzles is given by the formula:

$$K = \frac{Q}{p^{0.5}}$$

where

P is the pressure in bars;

Q is the flow rate in litres per minute.

3.4.1.2 The value of the flow constant K published in the manufacturer's design and installation instructions should be verified using the test method of 4.10. The average flow constant K should be within +5% of the manufacturer's value.

Table 1 - Nominal release temperature

Values in degrees Celsius

Glass bulb nozzles		Fusible element nozzles	
Nominal release temperature	Liquid colour code	Nominal release temperature	Frame colour code*
57	orange	57 to 77	uncoloured
68	red	80 to 107	white
79	yellow	121 to 149	blue
93 - 100	green	163 to 191	red
121 - 141	blue	204 to 246	green
163 - 182	mauve	260 to 343	orange
204 - 343	black		

* Not required for decorative nozzles.

3.4.2 Water distribution (see 4.11)

Nozzles which have complied with the requirements of the fire test should be used to determine the effective nozzle discharge characteristics when tested in accordance with 4.11.1. These characteristics should be published in the manufacturer's design and installation instructions

3.4.3 Water droplet size and velocity (see 4.11.2)

The water droplet size distribution and droplet velocity distribution should be determined in accordance with 8.11.2 for each design nozzle at the minimum and maximum operating pressures, and minimum and maximum air flow rates (when used) as part of the identification of the discharge characteristics of the nozzles which have demonstrated compliance with the fire test. The measurements are to be made at two representative locations: 1) Perpendicular to the central axis of the nozzle, exactly 1 m below the discharge orifice or discharge deflector, and 2) Radially outward from the first location at either 0.5 m or 1 m distance, depending on the distribution pattern.

3.5 *Function* (see 4.5) [6.5]

3.5.1 When tested in accordance with 4.5, the nozzle should open and, within 5 s after the release of the heat responsive element, should operate satisfactorily by complying with the requirements of 4.10. Any lodgement of released parts should be cleared within 60 s of release for standard

response heat responsive elements and within 10 s of release for fast and special response heat responsive elements or the nozzle should then comply with the requirements of 4.1.1.

3.5.2 The nozzle discharge components should not sustain significant damage as a result of the functional test specified in 4.5.6 and should have the same flow constant range and water droplet size and velocity within 5% of values as previously determined per 3.4.1 and 3.4.3.

3.6 *Strength of body* (see 4.3) [6.6]

The nozzle body should not show permanent elongation of more than 0.2% between the load-bearing points after being subjected to twice the average service load as determined using the method of 4.3.1.

3.7 *Strength of release element* [6.7]

3.7.1 Glass bulbs (see 4.9.1)

The lower tolerance limit for bulb strength should be greater than two times the upper tolerance limit for the bulb design load based on calculations with a degree of confidence of 0.99 for 99% of the samples as determined in 4.9.1. Calculations will be based on the Normal or Gaussian Distribution except where another distribution can be shown to be more applicable due to manufacturing or design factors.

3.7.2 Fusible elements (see 4.9.2)

Fusible heat-responsive elements in the ordinary temperature range should be designed to:

sustain a load of 15 times its design load corresponding to the maximum service load measured in 4.3.1 for a period of 100 h in accordance with 4.9.2.1; or

demonstrate the ability to sustain the design load when tested in accordance with 4.9.2.2.

3.8 *Leak resistance and hydrostatic strength* (see 4.4) [6.8]

3.8.1 A nozzle should not show any sign of leakage when tested by the method specified in 4.4.1.

3.8.2 A nozzle should not rupture, operate or release any parts when tested by the method specified in 4.4.2.

3.9 Heat exposure [6.9]

3.9.1 Glass bulb nozzles (see 4.7.1)

There should be no damage to the glass bulb element when the nozzle is tested by the method specified in 4.7.1.

3.9.2 All uncoated nozzles (see 4.7.2)

Nozzles should withstand exposure to increased ambient temperature without evidence of weakness or failure, when tested by the method specified in 4.7.2.

3.9.3 Coated nozzles (see 4.7.3)

In addition to meeting the requirement of 4.7.2 in an uncoated version, coated nozzles should withstand exposure to ambient temperatures without evidence of weakness or failure of the coating, when tested by the method specified in 4.7.3.

3.10 *Thermal shock* (see 4.8) [6.10]

Glass bulb nozzles should not be damaged when tested by the method specified in 4.8. Proper operation is not considered as damage.

3.11 *Corrosion* [6.11]

3.11.1 Stress corrosion (see 4.12.1 and 4.12.2)

When tested in accordance with 4.12.1, all brass nozzles should show no fractures which could affect their ability to function as intended and satisfy other requirements.

When tested in accordance with 4.12.2, stainless steel parts of water mist nozzles should show no fractures or breakage which could affect their ability to function as intended and satisfy other requirements.

3.11.2 Sulphur dioxide corrosion (see 4.12.3)

Nozzles should be sufficiently resistant to sulphur dioxide saturated with water vapour when conditioned in accordance with 4.12.2. Following exposure, five nozzles should operate when functionally tested at their minimum flowing pressure (see 3.5.1 and 3.5.2). The remaining five samples should meet the dynamic heating requirements of 3.14.2.

3.11.3 Salt spray corrosion (see 4.12.4)

Coated and uncoated nozzles should be resistant to salt spray when conditioned in accordance with 4.12.4. Following exposure, the samples should meet the dynamic heating requirements of 3.14.2.

3.11.4 Moist air exposure (see 4.12.5)

Nozzles should be sufficiently resistant to moist air exposure and should satisfy the requirements of 3.14.2 after being tested in accordance with 4.12.5.

3.12 *Integrity of nozzle coatings* [6.12]

3.12.1 Evaporation of wax and bitumen used for atmospheric protection of nozzles (see 4.13.1)

Waxes and bitumens used for coating nozzles should not contain volatile matter in sufficient quantities to cause shrinkage, hardening, cracking or flaking of the applied coating. The loss in mass should not exceed 5% of that of the original sample when tested by the method in 4.13.1.

3.12.2 Resistance to low temperatures (see 4.13.2)

All coatings used for nozzles should not crack or flake when subjected to low temperatures by the method in 4.13.2.

3.12.3 Resistance to high temperature (see 3.9.3)

Coated nozzles should meet the requirements of 3.9.3.

3.13 *Water hammer* (see 4.15) [6.13]

Nozzles should not leak when subjected to pressure surges from 4 bar to four times the rated pressure for operating pressures up to 100 bars and two times the rated pressure for pressures greater than 100 bar. They should show no signs of mechanical damage when tested in accordance with 4.15 and shall operate within the parameters of 3.5.1 at the minimum design pressure.

3.14 *Dynamic heating* (see 4.6.2) [6.14]

3.14.1 Automatic nozzles intended for installation in other than accommodation spaces and residential areas should comply with the requirements for RTI and C limits shown in figure 1. Automatic nozzles intended for installation in accommodation spaces or residential areas should comply with fast response requirements for RTI and C limits shown in figure 1. Maximum and minimum RTI values for all data points calculated using C for the fast and standard response nozzles should fall within the appropriate category shown in figure 1. Special response nozzles should have an average RTI value, calculated using C, between 50 and 80 with no value less than 40 or more than 100. When tested at an angular offset to the worst case orientation as described in section 4.6.2, the RTI should not

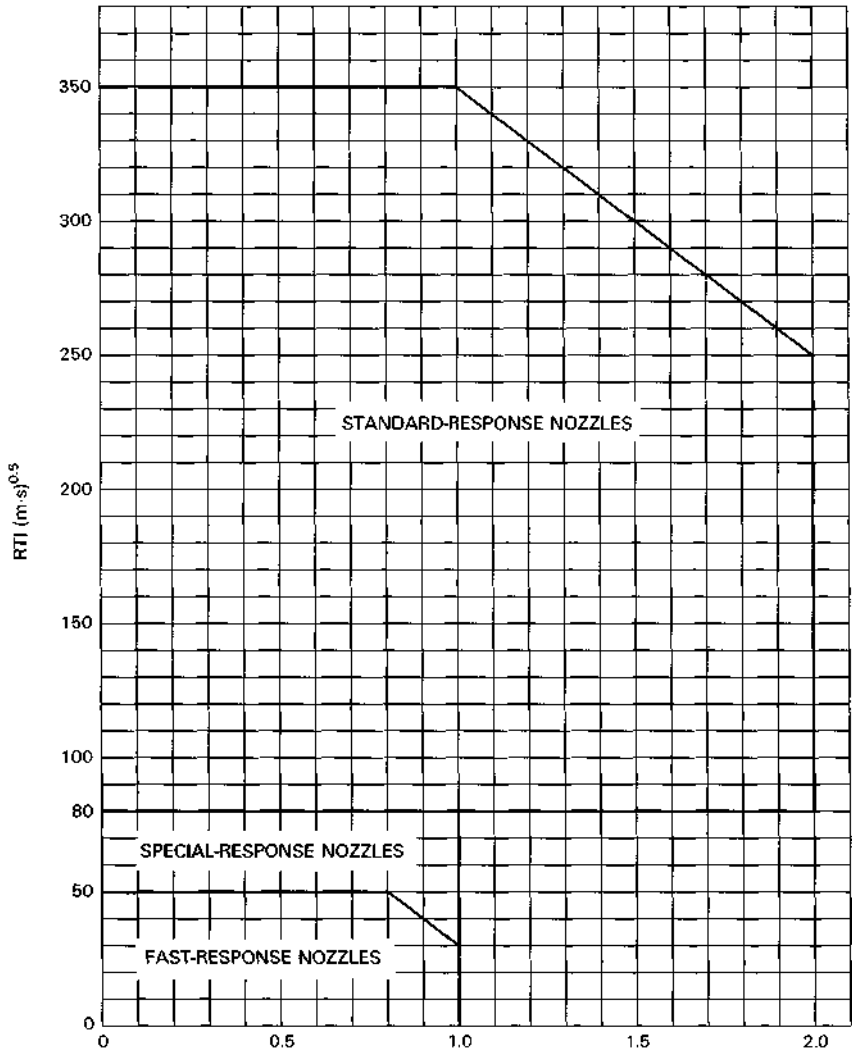


Figure 1 - RTI and C limits for standard orientation

exceed $600 \text{ (m}\cdot\text{s)}^{0.5}$ or 250% of the value of RTI in the standard orientation, whichever is less. The angular offset should be 15° for standard response, 20° for special response and 25° for fast response.

3.14.2 After exposure to the corrosion test described in sections 3.11.2, 3.11.3 and 3.11.4, nozzles should be tested in the standard orientation as described in section 4.6.2.1 to determine the post exposure RTI. All post exposure RTI values should not exceed the limits shown in figure 1 for the appropriate category. In addition, the average RTI value should not exceed 130% of the pre-exposure average value. All post exposure RTI values should be calculated as in section 4.6.2.3 using the pre-exposure conductivity factor (C).

3.15 *Resistance to heat* (see 4.14) [6.15]

Open nozzles should be sufficiently resistant to high temperatures when tested in accordance with 4.14. After exposure, the nozzle should not show 1) visual breakage or deformation 2) a change in flow constant K of more than 5% and 3) no changes in the discharge characteristics of the water distribution test (see 3.4.2) exceeding 5%.

3.16 *Resistance to vibration* (see 4.16) [6.16]

Nozzles should be able to withstand the effects of vibration without deterioration of their performance characteristics when tested in accordance with 4.16. After the vibration test of 4.16, nozzles should show no visible deterioration and should meet the requirements of 3.5 and 3.8.

3.17 *Impact test* (see 4.17) [6.17]

Nozzles should have adequate strength to withstand impacts associated with handling, transport and installation without deterioration of their performance or reliability. Resistance to impact should be determined in accordance with 4.1.

3.18 *Lateral discharge* (see 4.18) [6.19]

Nozzles should not prevent the operation of adjacent automatic nozzles when tested in accordance with 4.21.

3.19 *30-day leakage resistance* (see 4.19) [6.20]

Nozzles should not leak, sustain distortion or other mechanical damage when subjected to twice the rated pressure for 30 days. Following exposure, the nozzles should satisfy the test requirements of 4.22.

3.20 Vacuum resistance (see 4.23) [6.21]

Nozzles should not exhibit distortion, mechanical damage or leakage after being subjected to the test in 4.23.

3.21 Water shield [6.22 and 6.23]

3.21.1 General

An automatic nozzle intended for use at intermediate levels or beneath open grating should be provided with a water shield which complies with 3.21.2 and 3.21.3.

3.21.2 Angle of protection (see 4.21.1)

Water shields should provide an "angle of protection" of 45° or less for the heat responsive element against direct impingement of run-off water from the shield caused by discharge from nozzles at higher elevations. Compliance with this requirement should be determined in accordance with 4.24.1.

3.21.3 Rotation (see 4.21.2)

Rotation of the water shield should not alter the nozzle service load when evaluated in accordance with 4.24.2.

3.22 Clogging (see 4.21) [6.28.3]

A water mist nozzle should show no evidence of clogging during 30 min continuous flow at rated working pressure using water that has been contaminated in accordance with 4.21.3. Following the 30 min of flow, the water flow at rated pressure of the nozzle and strainer or filter should be within + 10% of the value obtained prior to conducting the clogging test.

4.0 Methods of test [7]

4.1 General

The following tests should be conducted for each type of nozzle. Before testing, precise drawings of parts and the assembly should be submitted together with the appropriate specifications (using SI units). Tests should be carried out at an ambient temperature of $(20 \pm 5)^{\circ}\text{C}$, unless other temperatures are indicated.

4.2 *Visual examination [7.2]*

Before testing, nozzles should be examined visually with respect to the following points:

- (a) marking;
- (b) conformity of the nozzles with the manufacturer's drawings and specification; and
- (c) obvious defects.

4.3 *Body strength test [7.3]*

4.3.1 The design load should be measured on ten automatic nozzles by securely installing each nozzle, at room temperature, in a tensile/compression test machine and applying a force equivalent to the application of the rated working pressure.

An indicator capable of reading deflection to an accuracy of 0.01 mm should be used to measure any change in length of the nozzle between its load-bearing points. Movement of the nozzle shank thread in the threaded bushing of the test machine should be avoided or taken into account.

The hydraulic pressure and load is then released and the heat responsive element is then removed by a suitable method. When the nozzle is at room temperature, a second measurement is to be made using the indicator.

An increasing mechanical load to the nozzle is then applied at a rate not exceeding 500 N/min, until the indicator reading at the load-bearing point initially measured returns to the initial value achieved under hydrostatic load. The mechanical load necessary to achieve this should be recorded as the service load. Calculate the average service load.

4.3.2 The applied load is then progressively increased at a rate not exceeding 500 N/min on each of the five specimens until twice the average service load has been applied. Maintain this load for 15+5 s.

The load is then removed and any permanent elongation as defined in 3.6 is recorded.

4.4 *Leak resistance and hydrostatic strength tests (see 3.8) [7.4]*

4.4.1 Twenty nozzles should be subjected to a water pressure of twice their rated working pressure, but not less than 34.5 bar. The pressure is increased from 0 bar to the test pressure, maintained at twice rated working pressure for a period of 3 min and then decreased to 0 bar. After the pressure has returned to 0 bar, it is increased to the minimum operating pressure specified by the manufacturer in not more than 5 s. This pressure is to be maintained for 15 s and increased to rated working pressure and maintained for 15 s.

4.4.2 Following the test of 4.4.1, the 20 nozzles should be subjected to an internal hydrostatic pressure of four times the rated working pressure. The pressure is increased from 0 bar to four times the rated working pressure and held there for a period of 1 min. The nozzle under test should not rupture, operate or release any of its operating parts during the pressure increase nor while being maintained at four times the rated working pressure for 1 min.

4.5 *Functional test* (see 3.5) [7.5]

4.5.1 Nozzles having nominal release temperatures less than 78°C, should be heated to activation in an oven. While being heated, they should be subjected to each of the water pressures specified in 4.5.3 applied to their inlet. The temperature of the oven should be increased to 400 + 20°C in 3 min measured in close proximity to the nozzle. Nozzles having nominal release temperatures exceeding 78°C should be heated using a suitable heat source. Heating should continue until the nozzle has activated.

4.5.2 Eight nozzles should be tested in each normal mounting position and at pressures equivalent to the minimum operating pressure, the rated working pressure and at the average operating pressure. The flowing pressure should be at least 75% of the initial operating pressure.

4.5.3 If lodgement occurs in the release mechanism at any operating pressure and mounting position, 24 more nozzles should be tested in that mounting position and at that pressure. The total number of nozzles for which lodgement occurs should not exceed 1 in the 32 tested at that pressure and mounting position.

4.5.4 Lodgement is considered to have occurred when one or more of the released parts lodge in the discharge assembly in such a way as to cause the water distribution to be altered after the period of time specified in 3.5.1.

4.5.5 In order to check the strength of the deflector/orifice assembly, three nozzles should be submitted to the functional test in each normal mounting position at 125% of the rated working pressure. The water should be allowed to flow at 125% of the rated working pressure for a period of 15 min.

4.6 *Heat responsive element operating characteristics*

4.6.1 Operating temperature test (see 3.3) [7.6]

Ten nozzles should be heated from room temperature to 20 to 22°C below their nominal release temperature. The rate of increase of temperature should not exceed 20°C/min and the temperature should be maintained for 10 min. The temperature should then be increased at a rate between 0.4°C/min to 0.7°C/min until the nozzle operates.

The nominal operating temperature should be ascertained with equipment having an accuracy of +0.35% of the nominal temperature rating or +0.25°C, whichever is greater.

The test should be conducted in a water bath for nozzles or separate glass bulbs having nominal release temperatures less than or equal to 80°C. A suitable oil should be used for higher-rated release elements. The liquid bath should be constructed in such a way that the temperature deviation within the test zone does not exceed 0.5%, or 0.5°C, whichever is greater.

4.6.2 Dynamic heating test (see 3.4)

4.6.2.1 Plunge test

Tests should be conducted to determine the standard and worst case orientations as defined in 1.4 and 1.5. Ten additional plunge tests should be performed at both of the identified orientations. The worst case orientation should be as defined in 3.14.1. The RTI is calculated as described in 4.6.2.3 and 4.6.2.4 for each orientation, respectively. The plunge tests are to be conducted using a brass nozzle mount designed such that the mount or water temperature rise does not exceed 2°C for the duration of an individual plunge test up to a response time of 55 s. (The temperature should be measured by a thermocouple heatsinked and embedded in the mount not more than 8 mm radially outward from the root diameter of the internal thread or by a thermocouple located in the water at the centre of the nozzle inlet.) If the response time is greater than 55 s, then the mount or water temperature in degrees Celsius should not increase more than 0.036 times the response time in seconds for the duration of an individual plunge test.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 + 3 N·m. Each nozzle is to be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min.

At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing. A timer accurate to +0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

A tunnel should be utilized with air flow and temperature conditions* at the test section (nozzle location) selected from the appropriate range of conditions shown in table 2. To minimize radiation exchange between the

* Tunnel conditions should be selected to limit maximum anticipated equipment error to 3%.

sensing element and the boundaries confining the flow, the test section of the apparatus should be designed to limit radiation effects to within +3% of calculated RTI values.*

The range of permissible tunnel operating conditions is shown in table 2. The selected operating condition should be maintained for the duration of the test with the tolerances as specified by footnotes 4 and 5 in table 2.

4.6.2.2 Determination of conductivity factor (C) [7.6.2.2]

The conductivity factor (C) should be determined using the prolonged plunge test (see 4.6.2.2.1) or the prolonged exposure ramp test (see 4.6.2.2.2).

4.6.2.2.1 Prolonged plunge test [7.6.2.2.1]

The prolonged plunge test is an iterative process to determine C and may require up to 20 nozzle samples. A new nozzle sample must be used for each test in this section even if the sample does not operate during the prolonged plunge test.

The nozzle under test should have 1 to 1.5 wraps of PTFE sealant tape applied to the nozzle threads. It should be screwed into a mount to a torque of 15 ± 3 N·m. Each nozzle is to be mounted on a tunnel test section cover and maintained in a conditioning chamber to allow the nozzle and cover to reach ambient temperature for a period of not less than 30 min. At least 25 ml of water, conditioned to ambient temperature, should be introduced into the nozzle inlet prior to testing.

A timer accurate to ± 0.01 s with suitable measuring devices to sense the time between when the nozzle is plunged into the tunnel and the time it operates should be utilized to obtain the response time.

The mount temperature should be maintained at $20 \pm 0.5^\circ\text{C}$ for the duration of each test. The air velocity in the tunnel test section at the nozzle location should be maintained with $\pm 2\%$ of the selected velocity. Air temperature should be selected and maintained during the test as specified in table 3.

The range of permissible tunnel operating conditions is shown in table 3. The selected operating condition should be maintained for the duration of the test with the tolerances as specified in table 3.

* A suggested method for determining radiation effects is by conducting comparative plunge tests on a blackened (high emissivity) metallic test specimen and a polished (low emissivity) metallic test specimen.

Table 2 - Plunge oven test conditions

Normal temperature °C	Air temperature ranges ¹			Velocity ranges ²		
	Standard response °C	Special response °C	Fast response °C	Standard response m/s	Special response m/s	Fast response nozzle m/s
57 to 77	191 to 203	129 to 141	129 to 141	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
79 to 107	282 to 300	191 to 203	191 to 203	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
121 to 149	382 to 432	282 to 300	282 to 300	2.4 to 2.6	2.4 to 2.6	1.65 to 1.85
163 to 191	382 to 432	382 to 432	382 to 432	3.4 to 3.6	2.4 to 2.6	1.65 to 1.85

¹ The selected air temperature should be known and maintained constant within the test section throughout the test to an accuracy of +1°C for the air temperature range of 129°C to 141°C within the test section and within $\pm 2^\circ\text{C}$ for all other air temperatures.

² The selected air velocity should be known and maintained constant throughout the test to an accuracy of ± 0.03 m/s for velocities of 1.65 to 1.85 m/s and 2.4 to 2.6 m/s and ± 0.04 m/s for velocities of 3.4 to 3.6 m/s.

To determine C, the nozzle is immersed in the test stream at various air velocities for a maximum of 15 min.* Velocities are chosen such that actuation is bracketed between two successive test velocities. That is, two velocities must be established such that at the lower velocity (u) actuation does not occur in the 15 min test interval. At the next higher velocity (u_h), actuation must occur within the 15 min time limit. If the nozzle does not operate at the highest velocity, select an air temperature from table 3 for the next higher temperature rating.

Table 3 - Plunge oven test conditions for conductivity determinations

Nominal nozzle temperature °C	Oven temperature °C	Maximum variation of air temperature during test °C
57	85 to 91	+1.0
58 to 77	124 to 130	±1.5
78 to 107	193 to 201	+3.0
121 to 149	287 to 295	+4.5
163 to 191	402 to 412	+6.0

Test velocity selection should insure that:

$$u^{0.5} \leq 1.1$$

The test value of C is the average of the values calculated at the two velocities using the following equation:

$$C = (\Delta T_g / \Delta T_{ea} - 1) u^{0.5}$$

where:

ΔT_g = Actual gas (air) temperature minus the mount temperature (T_m) in °C;

ΔT_{ea} = Mean liquid bath operating temperature minus the mount temperature (T_m) in °C;

u = Actual air velocity in the test section in m/s.

The nozzle C value is determined by repeating the bracketing procedure three times and calculating the numerical average of the three C values. This nozzle C value is used to calculate all standard orientation RTI values for determining compliance with 3.14.1.

* If the value of C is determined to be less than $0.5 (m \cdot s)^{0.5}$ a C of $0.25 (m \cdot s)^{0.5}$ should be assumed for calculating RTI value.

4.6.2.2.2 Prolonged exposure ramp test [7.6.2.2.2]

The prolonged exposure ramp test for the determination of the parameter C should be carried out in the test section of a wind tunnel and with the requirements for the temperature in the nozzle mount as described for the dynamic heating test. A preconditioning of the nozzle is not necessary.

Ten samples should be tested of each nozzle type, all nozzles positioned in standard orientation. The nozzle should be plunged into an air stream of a constant velocity of 1 m/s + 10% and an air temperature at the nominal temperature of the nozzle at the beginning of the test.

The air temperature should then be increased at a rate of $1 \pm 0.25^\circ\text{C}/\text{min}$ until the nozzle operates. The air temperature, velocity and mount temperature should be controlled from the initiation of the rate of rise and should be measured and recorded at nozzle operation. The C value is determined using the same equation as in 4.6.2.2.1 as the average of the ten test values.

4.6.2.3 RTI value calculation [7.6.2.3]

The equation used to determine the RTI value is as follows:

$$RTI = \frac{-t_r(u)^{0.5}(1 + C/(u)^{0.5})}{\ln[1 - \Delta T_{ea}(1 + C/(u)^{0.5})/\Delta T_g]}$$

where:

t_r = Response time of nozzles in seconds;

u = Actual air velocity in the test section of the tunnel in m/s from table 2;

ΔT_{ea} = Mean liquid bath operating temperature of the nozzle minus the ambient temperature in $^\circ\text{C}$;

ΔT_g = Actual air temperature in the test section minus the ambient temperature in $^\circ\text{C}$;

C = Conductivity factor as determined in 4.6.2.2.

4.6.2.4 Determination of worst case orientation RTI

The equation used to determine the RTI for the worst case orientation is as follows:

$$RTI_{wc} = \frac{-t_{r-wc}(u)^{0.5}[1 + C(RTI_{wc}/RTI)/(u)^{0.5}]}{\ln\{1 - \Delta T_{ea}[1 + C(RTI_{wc}/RTI)/(u)^{0.5}]/\Delta T_g\}}$$

where:

t_{r-wc} = Response time of the nozzles in seconds for the worst case orientation.

All variables are known at this time per the equation in paragraph 4.6.2.3 except RTI_{wc} (Response Time Index for the worst case orientation) which can be solved iteratively per the above equation.

In the case of fast response nozzles, if a solution for the worse case orientation RTI is unattainable, plunge testing in the worst case orientation should be repeated using the plunge test conditions under Special response shown in table 2.

4.7 Heat exposure test [7.7]

4.7.1 Glass bulb nozzles (see 3.9.1)

Glass bulb nozzles having nominal release temperatures less than or equal to 80°C should be heated in a water bath from a temperature of $(20 + 5)^\circ\text{C}$ to $(20 + 2)^\circ\text{C}$ below their nominal release temperature. The rate of increase of temperature should not exceed 20°C/min. High temperature oil, such as silicone oil, should be used for higher temperature rated release elements.

This temperature should then be increased at a rate of 1 °C/min to the temperature at which the gas bubble dissolves, or to a temperature 5°C lower than the nominal operating temperature, whichever is lower. Remove the nozzle from the liquid bath and allow it to cool in air until the gas bubble has formed again. During the cooling period, the pointed end of the glass bulb (seal end) should be pointing downwards. This test should be performed four times on each of four nozzles.

4.7.2 All uncoated nozzles (see 3.9.2) [7.7.2]

Twelve uncoated nozzles should be exposed for a period of 90 days to a high ambient temperature that is 11 °C below the nominal rating or at the temperature shown in table 4, whichever is lower, but not less than 49°C. If the service load is dependent on the service pressure, nozzles should be tested under the rated working pressure. After exposure, four of the nozzles should be subjected to the tests specified in 4.4.1, four nozzles to the test of 4.5.1, two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 3.3. If a nozzle fails the applicable requirements of a test, eight additional nozzles should be tested as described above and subjected to the test in which the failure was recorded. All eight nozzles should comply with the test requirements.

4.7.3 Coated nozzles (see 3.9.3) [7.7.3]

In addition to the exposure test of 4.7.2 in an uncoated version, 12 coated nozzles should be exposed to the test of 4.7.2 using the temperatures shown in table 4 for coated nozzles.

The test should be conducted for 90 days. During this period, the sample should be removed from the oven at intervals of approximately 7 days and allowed to cool for 2 to 4 h. During this cooling period, the sample should be examined. After exposure, four of the nozzles should be subjected to the tests specified in 4.4.1, four nozzles to the test of 4.5.1; two at the minimum operating pressure and two at the rated working pressure, and four nozzles to the requirements of 3.3.

Table 4 - Test temperatures for coated and uncoated nozzles

Values in degrees Celsius		
Nominal release temperature	Uncoated nozzle test temperature	Coated nozzle test temperature
57 to 60	49	49
61 to 77	52	49
78 to 107	79	66
108 to 149	121	107
150 to 191	149	149
192 to 246	191	191
247 to 302	246	246
303 to 343	302	302

4.8 Thermal shock test for glass bulb nozzles (see 3.10) [7.8]

Before starting the test, condition at least 24 nozzles at room temperature of 20 to 25°C for at least 30 min.

The nozzles should be immersed in a bath of liquid, the temperature of which should be 10 + 2°C below the nominal release temperature of the nozzles. After 5 min, the nozzles are to be removed from the bath and immersed immediately in another bath of liquid, with the bulb seal downwards, at a temperature of 10 + 1°C. Then test the nozzles in accordance with 4.5.1.

4.9 Strength test for release elements [7.9]

4.9.1 Glass bulbs (see 3.7.1) [7.9.1]

At least 15 sample bulbs in the lowest temperature rating of each bulb type should be positioned individually in a test fixture using the sprinkler seating parts. Each bulb should then be subjected to a uniformly increasing force at a rate not exceeding 250 N/s in the test machine until the bulb fails.

Each test should be conducted with the bulb mounted in new seating parts. The mounting device may be reinforced externally to prevent its collapse, but in a manner which does not interfere with bulb failure.

Record the failure load for each bulb. Calculate the lower tolerance limit (TL1) for bulb strength. Using the values of service load recorded in 4.3.1, calculate the upper tolerance limit (TL2) for the bulb design load. Verify compliance with 3.7.1.

4.9.2 Fusible elements (see 3.7.2)

4.10 *Water flow test* (see 3.4.1) [7.10]

The nozzle and a pressure gauge should be mounted on a supply pipe. The water flow should be measured at pressures ranging from the minimum operating pressure to the rated working pressure at intervals of approximately 10% of the service pressure range on two sample nozzles. In one series of tests, the pressure should be increased from zero to each value and, in the next series, the pressure shall be decreased from the rated pressure to each value. The flow constant K should be averaged from each series of readings, i.e., increasing pressure and decreasing pressure. During the test, pressures should be corrected for differences in height between the gauge and the outlet orifice of the nozzle.

4.11 *Water distribution and droplet size tests*

4.11.1 Water distribution (see 3.4.2)

The tests should be conducted in a test chamber of minimum dimensions 7 m x 7 m or 300% of the maximum design area being tested, whichever is greater. For standard automatic nozzles, install a single open nozzle and then four open nozzles of the same type arranged in a square, at maximum spacings specified by the manufacturer, on piping prepared for this purpose. For pilot type nozzles, install a single nozzle and then the maximum number of slave nozzles at their maximum spacings, specified in the manufacturer's design and installation instructions.

The distance between the ceiling and the distribution plate should be 50 mm for upright nozzles and 275 mm for pendent nozzles. For nozzles without distribution plates, the distances shall be measured from the ceiling to the highest nozzle outlet.

Recessed, flush and concealed type nozzles should be mounted in a false ceiling of dimensions not less than 6 m x 6 m and arranged symmetrically in the test chamber. The nozzles should be fitted directly into the horizontal pipework by means of "T" or elbow fittings.

The water discharge distribution in the protected area below a single nozzle and between the multiple nozzles should be collected and measured by means of square measuring containers nominally 300 mm on a side. The distance between the nozzles and the upper edge of the

measuring containers should be the maximum specified by the manufacturer. The measuring containers should be positioned centrally, beneath the single nozzle and beneath the multiple nozzles.

The nozzles should be discharged both at the minimum operating and rated working pressures specified by the manufacturer and the minimum and maximum installation heights specified by the manufacturer.

The water should be collected for at least 10 min to assist in characterizing nozzle performance.

4.11.2 Water droplet size (see 3.4.3)

The mean water droplet diameters, velocities, droplet size distribution, number density and volume flux should be determined at both the minimum and maximum flow rates specified by the manufacturer. Once the data is gathered, the method of the "Standard Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis" (ASTM E799-92) will be used to determine the appropriate sample size, class size widths, characteristic drop sizes and measured dispersion of the drop size distribution. This data should be taken at various points within the spray distribution as described in 3.4.3.

4.12 *Corrosion tests* [7.12]

4.12.1 Stress corrosion test for brass nozzle parts (see 3.11.1)

Five nozzles should be subjected to the following aqueous ammonia test. The inlet of each nozzle should be sealed with a nonreactive cap, e.g., plastic.

The samples are degreased and exposed for 10 days to a moist ammonia/air mixture in a glass container of volume $0.02 + 0.01 \text{ m}^3$.

An aqueous ammonia solution, having a density of 0.94 g/cm^3 , should be maintained in the bottom of the container, approximately 40 mm below the bottom of the samples. A volume of aqueous ammonia solution corresponding to 0.01 ml per cubic centimetre of the volume of the container will give approximately the following atmospheric concentrations: 35% ammonia, 5% water vapour, and 60% air. The inlet of each sample should be sealed with a nonreactive cap, e.g., plastic.

The moist ammonia/air mixture should be maintained as closely as possible at atmospheric pressure, with the temperature maintained at $34 \pm 2^\circ\text{C}$. Provision should be made for venting the chamber via a capillary tube to avoid the build-up of pressure. Specimens should be shielded from condensate drippage.

After exposure, rinse and dry the nozzles, and conduct a detailed examination. If a crack, delamination or failure of any operating part is observed, the nozzle(s) should be subjected to a leak resistance test at the rated pressure for 1 min and to the functional test at the minimum flowing pressure (see 3.1.5).

Nozzles showing cracking, delamination or failure of any non-operating part should not show evidence of separation of permanently attached parts when subjected to flowing water at the rated working pressure for 30 min.

4.12.2 Stress-corrosion cracking of stainless steel nozzle parts (see 3.11.1)

4.12.2.1 Five samples are to be degreased prior to being exposed to the magnesium chloride solution.

4.12.2.2 Parts used in nozzles are to be placed in a 500 ml/flask that is fitted with a thermometer and a wet condenser approximately 760 mm long. The flask is to be filled approximately one-half full with a 42% by weight magnesium chloride solution, placed on a thermostatically-controlled electrically heated mantle, and maintained at a boiling temperature of $150 \pm 1^\circ\text{C}$. The parts are to be unassembled, that is, not contained in a nozzle assembly. The exposure is to last for 500 h.

4.12.2.3 After the exposure period, the test samples are to be removed from the boiling magnesium chloride solution and rinsed in deionized water.

4.12.2.4 The test samples are then to be examined using a microscope having a magnification of 25 x for any cracking, delamination, or other degradation as a result of the test exposure. Test samples exhibiting degradation are to be tested as described in 4.12.5.5 or 4.12.5.6, as applicable. Test samples not exhibiting degradation are considered acceptable without further test.

4.12.2.5 Operating parts exhibiting degradation are to be further tested as follows. Five new sets of parts are to be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples are to be degreased and subjected to the magnesium chloride solution exposure specified in paragraph 4.12.5.2. Following the exposure, the test samples should withstand, without leakage, a hydrostatic test pressure equal to the rated working pressure for 1 min then be subjected to the functional test at the minimum operating pressure in accordance with 4.5.1.

4.12.2.6 Non-operating parts exhibiting degradation are to be further tested as follows. Five new sets of parts are to be assembled in nozzle frames made of materials that do not alter the corrosive effects of the magnesium chloride solution on the stainless steel parts. These test samples

are to be degreased and subjected to the magnesium chloride solution exposure specified in paragraph 4.12.5.1. Following the exposure, the test samples should withstand a flowing pressure equal to the rated working pressure for 30 min without separation of permanently attached parts.

4.12.3 Sulphur dioxide corrosion test (see 3.11.2 and 3.14.2)

Ten nozzles should be subjected to the following sulphur dioxide corrosion test. The inlet of each sample should be sealed with a nonreactive cap, e.g., plastic.

The test equipment should consist of a 5 l vessel (instead of a 5 l vessel, other volumes up to 15 l may be used in which case the quantities of chemicals given below shall be increased in proportion) made of heat-resistant glass, with a corrosion-resistant lid of such a shape as to prevent condensate dripping on the nozzles. The vessel should be electrically heated through the base, and provided with a cooling coil around the side walls. A temperature sensor placed centrally 160 mm + 20 mm above the bottom of the vessel should regulate the heating so that the temperature inside the glass vessel is $45^{\circ}\text{C} + 3^{\circ}\text{C}$. During the test, water should flow through the cooling coil at a sufficient rate to keep the temperature of the discharge water below 30°C . This combination of heating and cooling should encourage condensation on the surfaces of the nozzles. The sample nozzles should be shielded from condensate drippage.

The nozzles to be tested should be suspended in their normal mounting position under the lid inside the vessel and subjected to a corrosive sulphur dioxide atmosphere for 8 days. The corrosive atmosphere should be obtained by introducing a solution made up by dissolving 20 g of sodium thiosulphate ($\text{Na}_2\text{S}_2\text{O}_3\cdot\text{H}_2\text{O}$) crystals in 500 ml of water.

For at least six days of the 8 day exposure period, 20 ml of dilute sulphuric acid consisting of 156 ml of normal H_2SO_4 (0.5 mol/l) diluted with 844 ml of water should be added at a constant rate. After 8 days, the nozzles should be removed from the container and allowed to dry for 4 to 7 days at a temperature not exceeding 35°C with a relative humidity not greater than 70%.

After the drying period, five nozzles should be subjected to a functional test at the minimum operating pressure in accordance with 4.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 3.14.2.

4.12.4 Salt spray corrosion test (see 3.11.3 and 3.14.2) [7.12.3]

4.12.4.1 Nozzles intended for normal atmospheres

Ten nozzles should be exposed to a salt spray within a fog chamber. The inlet of each sample should be sealed with a nonreactive cap, e.g., plastic.

During the corrosive exposure, the inlet thread orifice is to be sealed by a plastic cap after the nozzles have been filled with deionized water. The salt solution should be a 20% by mass sodium chloride solution in distilled water. The pH should be between 6.5 and 3.2 and the density between 1.126 g/ml and 1.157 g/ml when atomized at 35°C. Suitable means of controlling the atmosphere in the chamber should be provided. The specimens should be supported in their normal operating position and exposed to the salt spray (fog) in a chamber having a volume of at least 0.43 m³ in which the exposure zone shall be maintained at a temperature of 35 + 2°C. The temperature should be recorded at least once per day, at least 7 h apart (except weekends and holidays when the chamber normally would not be opened). Salt solution should be supplied from a recirculating reservoir through air-aspirating nozzles, at a pressure between 0.7 bar (0.07 MPa) and 1.7 bar (0.17 MPa). Salt solution runoff from exposed samples should be collected and should not return to the reservoir for recirculation. The sample nozzles should be shielded from condensate drippage.

Fog should be collected from at least two points in the exposure zone to determine the rate of application and salt concentration. The fog should be such that for each 80 cm² of collection area, 1 ml to 2 ml of solution should be collected per hour over a 16 h period and the salt concentration shall be 20 ± 1% by mass.

The nozzles should withstand exposure to the salt spray for a period of 10 days. After this period, the nozzles should be removed from the fog chamber and allowed to dry for 4 to 7 days at a temperature of 20 to 25°C in an atmosphere having a relative humidity not greater than 70%. Following the drying period, five nozzles should be submitted to the functional test at the minimum operating pressure in accordance with 4.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 3.14.2.

4.12.4.2 Nozzles intended for corrosive atmospheres [7.12.3.2]

Five nozzles should be subjected to the tests specified in 4.12.3.1 except that the duration of the salt spray exposure shall be extended from 10 days to 30 days.

4.12.5 Moist air exposure test (see 3.11.4 and 3.14.2) [7.12.4]

Ten nozzles should be exposed to a high temperature-humidity atmosphere consisting of a relative humidity of 98% + 2% and a temperature of 95°C + 4°C. The nozzles are to be installed on a pipe manifold containing deionized water. The entire manifold is to be placed in the high temperature-humidity enclosure for 90 days. After this period, the nozzles should be removed from the temperature-humidity enclosure and allowed to dry for 4-7 days at a temperature of 25 + 5 °C in an atmosphere

having a relative humidity of not greater than 70%. Following the drying period, five nozzles should be functionally tested at the minimum operating pressure in accordance with 4.5.1 and five nozzles should be subjected to the dynamic heating test in accordance with 3.14.2.

Note: At the manufacturer's option, additional samples may be furnished for this test to provide early evidence of failure. The additional samples may be removed from the test chamber at 30-day intervals for testing.

4.13 *Nozzle coating tests* [7.13]

4.13.1 Evaporation test (see 3.12.1) [7.13.11]

A 50 cm³ sample of wax or bitumen should be placed in a metal or glass cylindrical container, having a flat bottom, an internal diameter of 55 mm and an internal height of 35 mm. The container, without lid, should be placed in an automatically controlled electric, constant ambient temperature oven with air circulation. The temperature in the oven should be controlled at 16°C below the nominal release temperature of the nozzle, but at not less than 50°C. The sample should be weighed before and after 90 days exposure to determine any loss of volatile matter; the sample should meet the requirements of 3.12.1.

4.13.2 Low-temperature test (see 3.12.2) [7.13.2]

Five nozzles, coated by normal production methods, whether with wax, bitumen or a metallic coating, should be subjected to a temperature of -10°C for a period of 24 h. On removal from the low-temperature cabinet, the nozzles should be exposed to normal ambient temperature for at least 30 min before examination of the coating to the requirements of 3.1.12.2.

4.14 *Heat-resistance test* (see 3.15) [7.14]

One nozzle body should be heated in an oven at 800°C for a period of 15 min, with the nozzle in its normal installed position. The nozzle body should then be removed, holding it by the threaded inlet, and should be promptly immersed in a water bath at a temperature of approximately 15°C. It should meet the requirements of 3.15.

4.15 *Water-hammer test* (see 3.13) [7.15]

Five nozzles should be connected, in their normal operating position, to the test equipment. After purging the air from the nozzles and the test equipment, 3,000 cycles of pressure varying from 4 + 2 bar ((0.4 + 0.2) MPa) to twice the rated working pressure should be generated. The pressure should be raised

from 4 bar to twice the rated pressure at a rate of 60+ 10 bar/s. At least 30 cycles of pressure per min should be generated. The pressure should be measured with an electrical pressure transducer.

Visually examine each nozzle for leakage during the test. After the test, each nozzle should meet the leakage resistance requirement of 3.8.1 and the functional requirement of 3.5.1 at the minimum operating pressure.

4.16 *Vibration test* (see 3.16) [7.16]

4.16.1 Five nozzles should be fixed vertically to a vibration table. They should be subjected at room temperature to sinusoidal vibrations. The direction of vibration should be along the axis of the connecting thread.

4.16.2 The nozzles should be vibrated continuously from 5 Hz to 40 Hz at a maximum rate of 5 min/octave and an amplitude of 1 mm ($\frac{1}{2}$ peak-to-peak value). If one or more resonant points are detected, the nozzles after coming to 40 Hz, should be vibrated at each of these resonant frequencies for 120 h/number of resonances. If no resonances are detected, the vibration from 5 Hz to 40 Hz should be continued for 120 h.

4.16.3 The nozzle should then be subjected to the leakage test in accordance with 3.8.1 and the functional test in accordance with 3.5.1 at the minimum operating pressure.

4.17 *Impact test* (see 3.1 7) [7.1 7)

Five nozzles should be tested by dropping a mass onto the nozzle along the axial centreline of waterway. The kinetic energy of the dropped mass at the point of impact should be equivalent to a mass equal to that of the test nozzle dropped from a height of 1 m (see figure 2). The mass is to be prevented from impacting more than once upon each sample.

Following the test a visual examination of each nozzle shall show no signs of fracture, deformation, or other deficiency. If none is detected, the nozzles should be subjected to the leak resistance test, described in 4.4.1. Following the leakage test, each sample should meet the functional test requirement of 4.5.1 at a pressure equal to the minimum flowing pressure.

4.18 *Lateral discharge test* (see 3.18) [7.191

Water is to be discharged from a spray nozzle at the minimum operating and rated working pressure. A second automatic nozzle located at the minimum distance specified by the manufacturer is mounted on a pipe parallel to the pipe discharging water.

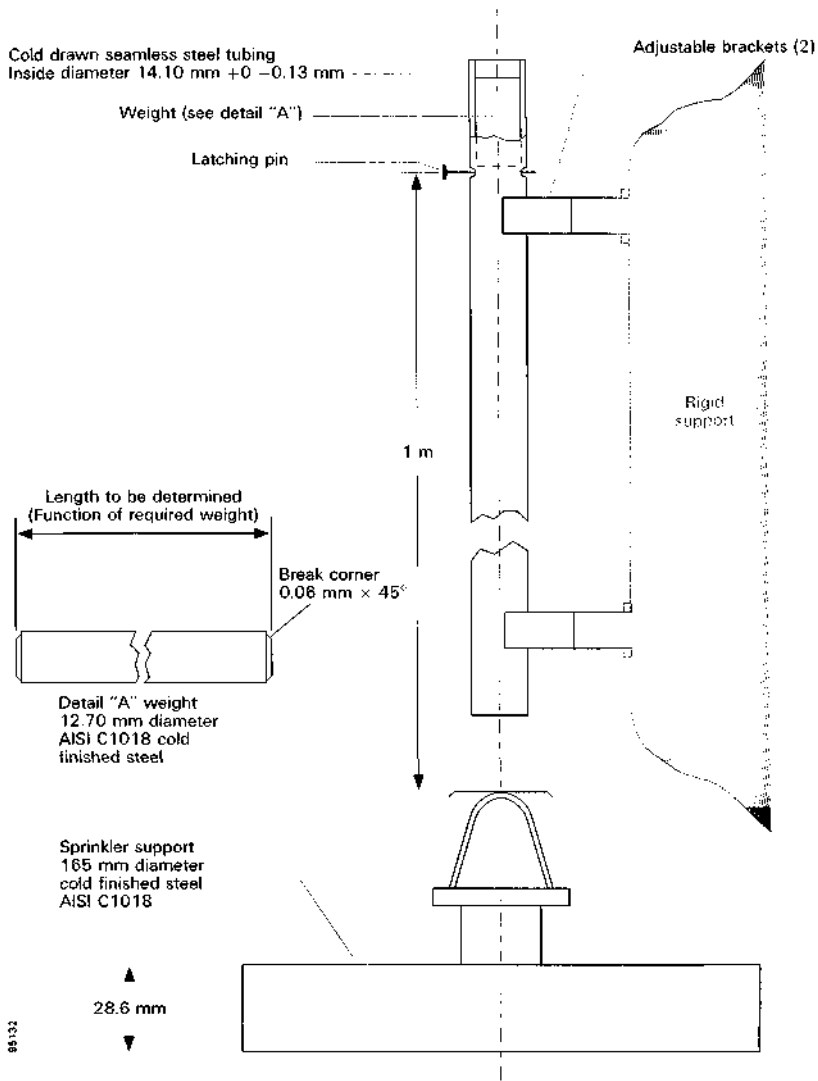


Figure 2 - Impact test apparatus

The nozzle orifices or distribution plates (if used) are to be placed 550 mm, 356 mm and 152 mm below a flat smooth ceiling for three separate tests, respectively at each test pressure. The top of a square pan measuring 305 mm square and 102 mm deep is to be positioned 152 mm below the heat responsive element for each test. The pan is filled with 0.47 l of heptane. After ignition, the automatic nozzle is to operate before the heptane is consumed.

4.19 30-day leakage test (see 3.19) [7.20]

Five nozzles are to be installed on a water filled test line maintained under a constant pressure of twice the rated working pressure for 30 days at an ambient temperature of $(20 \pm 5 \text{ }^\circ\text{C})$.

The nozzles should be inspected visually at least weekly for leakage. Following completion of this 30-day test, all samples should meet the leak resistance requirements specified in 3.2.4 and should exhibit no evidence of distortion or other mechanical damage.

4.20 Vacuum test (see 3.20) [7.21]

Three nozzles should be subjected to a vacuum of 460 mm of mercury applied to a nozzle inlet for 1 min at an ambient temperature of $(20 \pm 5^\circ\text{C})$. Following this test, each sample should be examined to verify that no distortion or mechanical damage has occurred and then should meet the leak resistance requirements specified in 4.4.1.

4.21 Clogging test (see 3.22) [7.28]

4.21.1 The water flow rate of an open water mist nozzle with its strainer or filter should be measured at its rated working pressure. The nozzle and strainer or filter should then be installed in test apparatus described in figure 3 and subjected to 30 min of continuous flow at rated working pressure using contaminated water which has been prepared in accordance with 4.21.3.

4.21.2 Immediately following the 30 min of continuous flow with the contaminated water, the flow rate of the nozzle and strainer or filter should be measured at rated working pressure. No removal, cleaning or flushing of the nozzle, filter or strainer is permitted during the test.

4.21.3 The water used during the 30 min of continuous flow at rated working pressure specified in 4.21.1 should consist of 60 l of tap water into which has been mixed 1.58 kg of contaminants which sieve as described in table 5. The solution should be continuously agitated during the test.

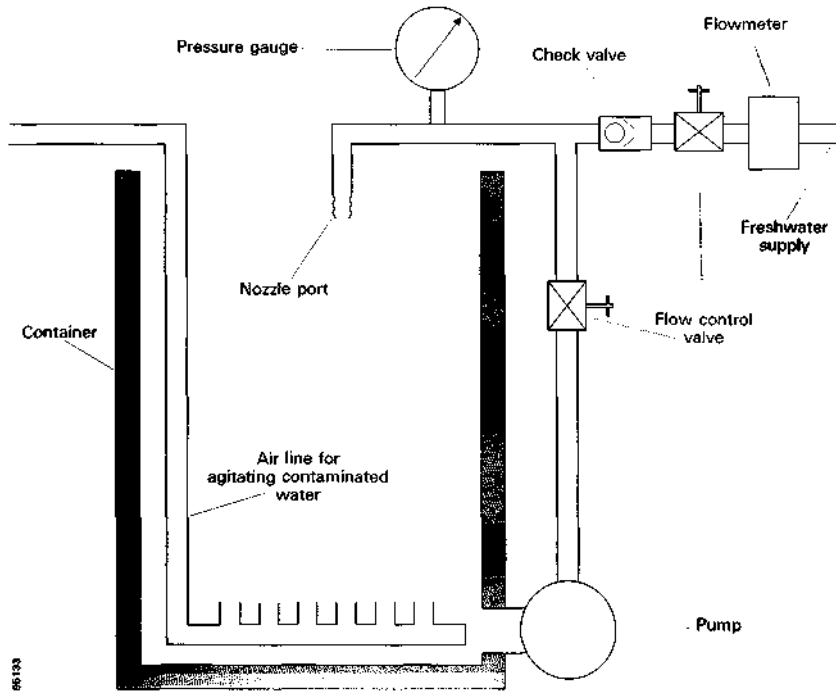


Figure 3 - Clogging test apparatus

Table 5 - Contaminant for contaminated water cycling test

Sieve designation ¹	Nominal sieve opening (mm)	Grams of contaminant ($\pm 5\%$) ²		
		Pipe scale	Top soil	Sand
No. 25	0.706	-	456	200
No. 50	0.297	82	82	327
No. 100	0.150	84	6	89
No. 200	0.074	81	-	21
No. 325	0.043	153	-	3
	TOTAL	400	544	640

¹ Sieve designations correspond with those specified in the standard for wire-cloth sieves for testing purposes, ASTM E11-87, CENCO-MEINZEN sieve sizes 25 mesh, 50 mesh, 100 mesh, 200 mesh and 325 mesh, corresponding with the number designation in the table, have been found to comply with ASTM E11-87.

² The amount of contaminant may be reduced by 50% for nozzles limited to use with copper or stainless steel piping and by 90% for nozzles having a rated pressure of 50 bar or higher and limited to use with stainless steel piping.

5 Water mist nozzle marking

5.1 General

Each nozzle complying with the requirements of this Standard should be permanently marked as follows:

- (a) trademark or manufacturer's name;
- (b) model identification;
- (c) manufacturer's factory identification - this is only required if the manufacturer has more than one nozzle manufacturing facility;
- (d) nominal year of manufacture* (automatic nozzles only);
- (e) nominal release temperature[†] (automatic nozzles only); and
- (f) *K*-factor. This is only required if a given model nozzle is available with more than 1 orifice size.

In countries where colour-coding of yoke arms of glass bulb nozzles is required, the colour code for fusible element nozzles should be used.

5.2 Nozzle housings

Recessed housings, if provided, should be marked for use with the corresponding nozzles unless the housing is a non-removable part of the nozzle

* The year of manufacture may include the last three months of the preceding year and the first six months of the following year. Only the last two digits need be indicated.

[†] Except for coated and plated nozzles, the nominal release temperature range should be colour-coded on the nozzle to identify the nominal rating. The colour code should be visible on the yoke arms holding the distribution plate for fusible element nozzles, and should be indicated by the colour of the liquid in glass bulbs. The nominal temperature rating should be stamped or cast on the fusible element of fusible element nozzles. All nozzles should be stamped, cast, engraved or colour-coded in such a way that the nominal rating is recognizable even if the nozzle has operated. This should be in accordance with table 1.

Appendix B

Interim test method for fire testing equivalent water-based fire-extinguishing systems for machinery spaces of category A and cargo pump-rooms

1 Scope

This test method is intended for evaluating the extinguishing effectiveness of water-based total flooding fire-extinguishing systems for engine-rooms of category A and cargo pump-rooms. In order to define the different engine-rooms and possible fire scenarios the engine types are divided into different classes according to table 1.

The test method covers the minimum fire-extinguishing requirement and prevention against re-ignition for fires in engine-rooms.

It was developed for systems using ceiling mounted nozzles. In the tests, the use of additional nozzles to protect specific hazards by direct application is not permitted. However, if referenced in the manufacturer's design and installation instructions, additional nozzles may be installed along the perimeter of the compartment to screen openings.

Table 1 - Classification of category A engine-room

Class	Typical engine facts	Typical net volume	Typical oil flow and pressure in fuel and lubrication systems
1	Auxiliary engine-room, small main machinery or purifier room, etc.	500 m ³	Fuel: Low pressure 0.15–0.20 kg/s 3-6 bar High pressure 0.02 kg/s 200-300 bar Lubrication oil: 3-5 bar Hydraulic oil: 150 bar
2	Main diesel machinery in medium-sized ships such as ferries	3,000 m ³	Fuel: Low pressure 0.4-0.6 kg/s at 3-8 bar High pressure 0.030 kg/s at 250 bar Lubrication oil: 3-5 bar Hydraulic oil: 150 bar
3	Main diesel machinery in large ships such as oil tankers and container ships	> 3,000 m ³	Fuel: Low pressure 0.7-1.0 kg/s at 3-8 bar High pressure 0.20 kg/s Lubrication oil: 3-5 bar Hydraulic oil: 150 bar

2 Field of application

The test method is applicable for water-based fire-extinguishing systems which will be used as alternative fire-extinguishing systems as required by SOLAS regulation II-2/7. For the installation of the system, nozzles shall be installed to protect the entire hazard volume (total flooding). The installation specification provided by the manufacturer should include maximum nozzle spacing, maximum enclosure height, distance of nozzles below ceiling, maximum enclosure volume and maximum ventilation condition.

3 Sampling

The components to be tested should be supplied by the manufacturer together with design and installation criteria, operational instructions, drawings and technical data sufficient for the identification of the components.

4 Method of test

4.1 Principle

This test procedure enables the determination of the effectiveness of different water-based extinguishing systems against spray fires, cascade fires, pool fires and class A fires which are obstructed by an engine mock-up.

4.2 Apparatus

4.2.1 Engine mock-up

The fire test should be performed in a test apparatus consisting of:

- .1 An engine mock-up of size (width x length x height) 1 m x 3 m x 3 m constructed of sheet steel with a nominal thickness of 5 mm. The mock-up is fitted with two steel tubes diameter 0.3 m and 3 m length that simulate exhaust manifolds and a grating. At the top of the mock-up, a 3 m² tray is arranged. See figure 2.
- .2 A floor plate system 4 m x 6 m x 0.5 m high surrounding the mock-up with three trays, 2, 2, and 4 m², equalling a total area of 8 m² underneath. See figure 2.

4.2.2 Test room

- .1 Class 1 - Engine-rooms

The test should be performed in 100 m² room with 5 m ceiling height and ventilation through a 2 m x 2 m door opening. Fires and engine mock-up according to tables 2, 3 and figure 1.

.2 Classes 2 and 3 - Engine-rooms

The test should be performed in a fire test hall with a minimum floor area of 300 m², and a ceiling height in excess of 10 m and without any restrictions in air supply for the test fires.

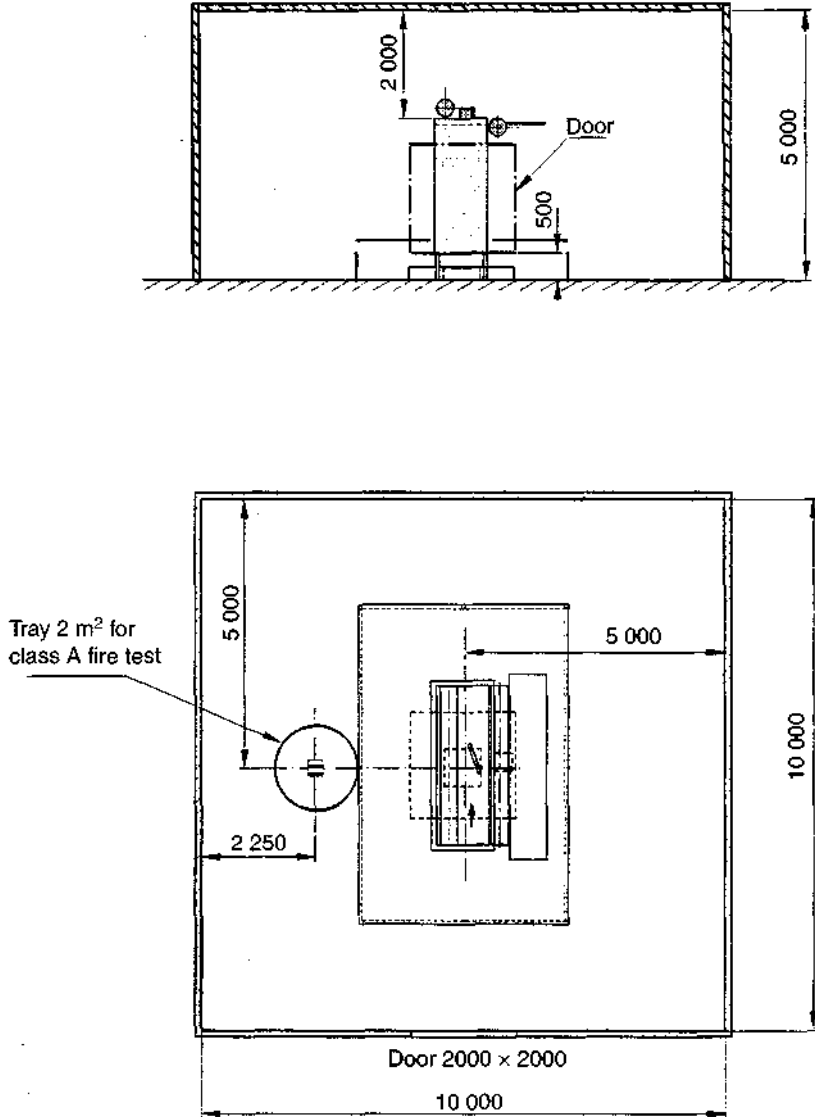


Figure 1

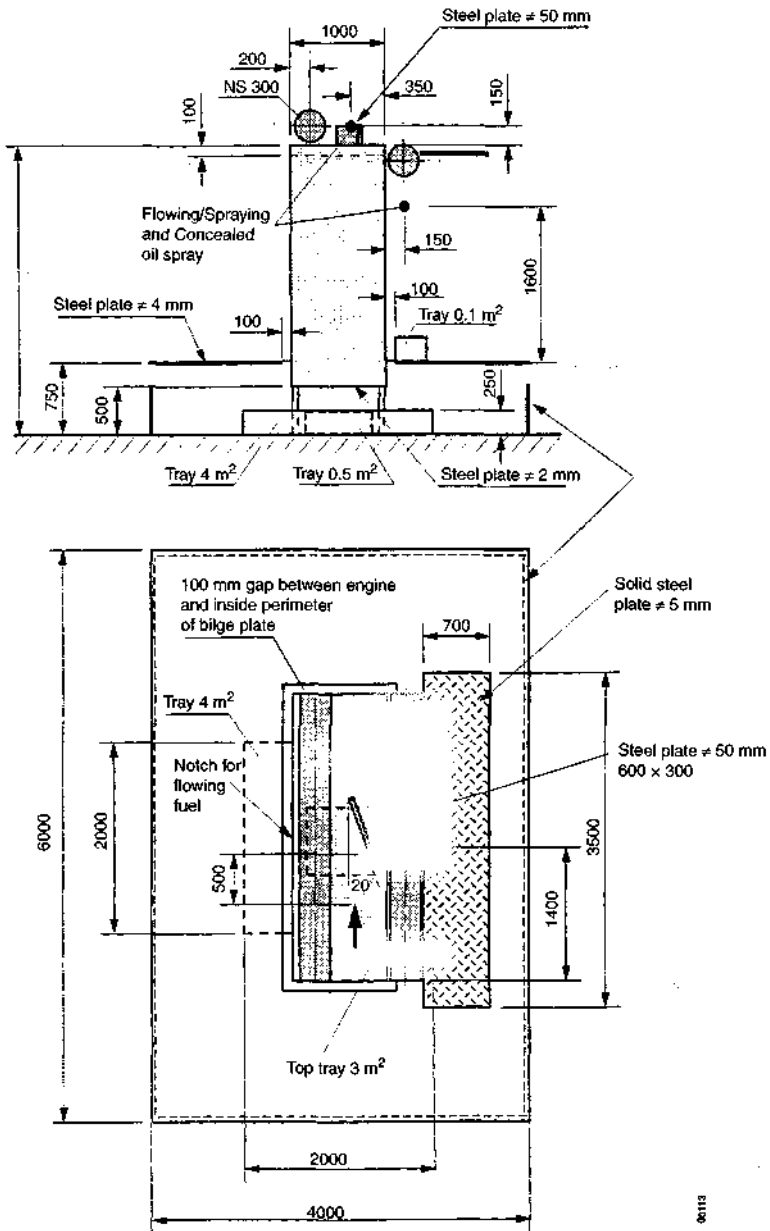
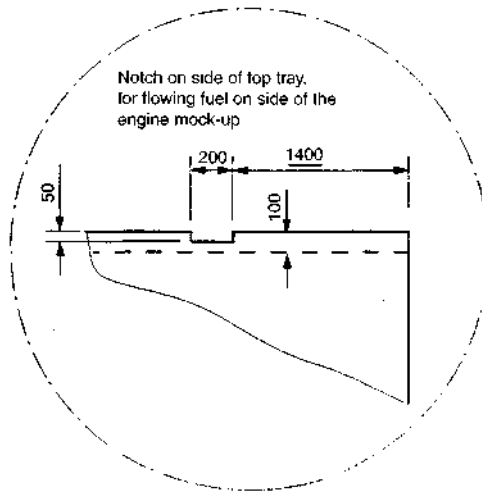
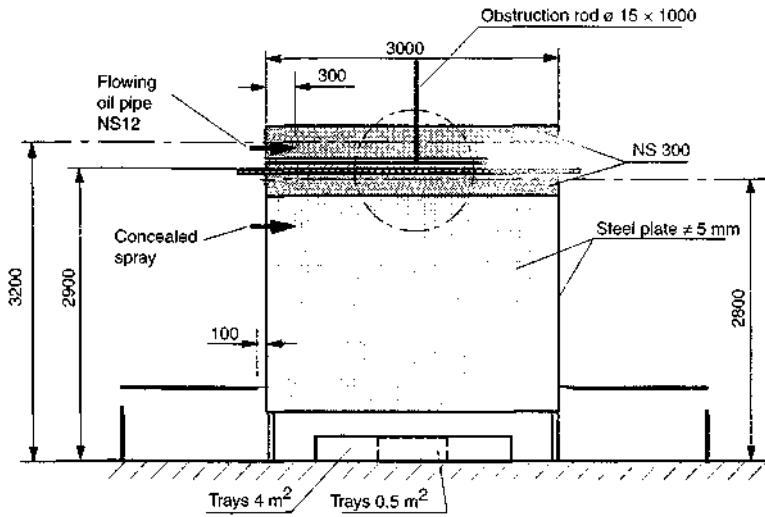


Figure 2



00114

Figure 3

Table 2 - Test programme

Test No.	Fire scenario	Test fuel
1	Low pressure horizontal spray on top of simulated engine between agent nozzles	Commercial fuel oil or light diesel oil
2	Low pressure spray on top of simulated engine centred with nozzle angled upwards at a 45° angle to strike a 12–15 mm diameter rod 1 m away	Commercial fuel oil or light diesel oil
3	Low pressure concealed horizontal spray fire on side of simulated engine with oil spray nozzle positioned 0.1 m in from the end of engine	Commercial fuel oil or light diesel oil
4	Combination of worst spray fire from tests 1 -3 and fires in trays under (4 m ²) and on top of the simulated engine (3 m ²)	Commercial fuel oil or light diesel oil
5	High-pressure horizontal spray fire on top of the simulated engine	Commercial fuel oil or light diesel oil
6	Low-pressure low flow concealed horizontal spray fire on the side of simulated engine with oil spray nozzle positioned 0.1 m in from the end of engine and 0.1 m ² tray positioned 1.4 m in from the engine end at the inside of floor plate	Commercial fuel oil or light diesel oil
7	0.5 m ² central under mock-up	Heptane
8	0.5 m ² central under mock-up	SAE 10W30 mineral based lubrication oil
9	0.1 m ² on top of bilge plate centred under exhaust plate	Heptane
10	Flowing fire 0.25 kg/s from top of mock-up. See figure 3	Heptane
11	Class A fires wood crib (see note) in 2 m ² pool fire with 30 s preburn. The test tray should be positioned 0.75 m above the floor as shown in figure 2	Heptane
12	A steel plate (30 cm x 60 cm x 5 cm) offset 20° to the spray is heated to 350°C by the top low pressure, low flow spray nozzle positioned horizontally 0.5 m from the front edge of the plate. When the plate reaches 350°C, the system is activated. Following system shutoff, no re-ignition of the spray is permitted	Heptane
13	4 m ² tray under mock-up	Commercial fuel oil or light diesel oil

Note: The wood crib is to weigh 5.4 to 5.9 kg and is to be dimensioned approximately by 305 x 305 x 305 mm. The crib is to consist of eight alternate layers of four trade size 38.1 x 38.1 mm kiln-dried spruce or fir lumber 305 mm long. The alternate layers of the lumber are to be placed at right angles to the adjacent layers. The individual wood members in each layer are to be evenly spaced along the length of the previous layer members and stapled. After the wood crib is assembled, it is to be conditioned at a temperature of 49 ± 5°C for not less than 16 h. Following the conditioning, the moisture content of the crib is to be measured with a probe type moisture meter. The moisture content of the crib should not exceed 5% prior to the fire test.

Table 3 - Oil spray fire test parameters

Category A engine-room class 1-3			
Fire type	Low pressure	Low pressure, low flow	High pressure
Spray nozzle	Wide spray angle (120 to 125°) full cone type	Wide spray angle (80°C) full cone type	Standard angle (at 6 bar) full cone type
Nominal oil pressure	8 bar	8.5 bar	150 bar
Oil flow	0.16+0.01 kg/s	0.03±0.005 kg/s	0.050+0.002 kg/s
Oil temperature	20±5°C	20±5°C	20+5°C
Nominal heat release rate	5.8+0.6 MW	1.1+0.1 MW	1.8±0.2 MW

4.3 Extinguishing system

The extinguishing system should be installed according to the manufacturer's design and installation instructions. The maximum vertical distance is limited to 5 m. For actual installation with bilges more than 0.75 m in depth, nozzles must be installed in the bilges in accordance with manufacturer's recommendations as developed from representative fire tests.

4.4 Procedure

4.4.1 Ignition

The tray/s used in the test should be filled with at least 30 mm oil on a water base. Freeboard is to be 150 + 10 mm.

4.4.2 Flow and pressure measurements (oil system)

The oil flow and pressure in the oil system should be measured before each test. The oil pressure should be measured during the test.

4.4.3 Flow and pressure measurements (extinguishing system)

Agent flow and pressure in the extinguishing system should be measured continuously on the high pressure side of a pump or equivalent equipment at intervals not exceeding 5 s during the test, alternatively, the flow can be determined by the pressure and the *K* factor of the nozzles.

4.4.4 Duration of test

After ignition of all fuel sources, a 2 min preburn time is required before the extinguishing agent is discharged for the oil tray fires and 5–15 s for the oil spray and heptane fires and 30 s for the class A fire test (test No. 11).

Extinguishing agent should be discharged for 50% of the discharge time recommended by the manufacturer or 15 min whatever is less. The oil spray, if used, should be shut off 15 s after the end of agent discharge.

4.4.5 Observations before and during the test

Before the test, the test room, fuel and mock-up temperature is to be measured.

During the test the following observations should be recorded:

- .1 the start of the ignition procedure;
- .2 the start of the test (ignition);
- .3 the time when the extinguishing system is activated;
- .4 the time when the fire is extinguished, if it is;
- .5 the time when the extinguishing system is shut off;
- .6 the time of re-ignition, if any;
- .7 the time when the oil flow for the spray fire is shut off; and
- .8 the time when the test is finished.

4.4.6 Observations after the test

- .1 Damage to any system components.
- .2 The level of oil in the tray(s) to make sure that no limitation of fuel occurred during the test.
- .3 Test room, fuel and mock-up temperature.

5 Classification criteria

At the end of discharge of water-based fire-extinguishing media and fuel at each test, there should be no re-ignition or fire spread.

6 Test report

The test report should include the following information:

- .1 name and address of the test laboratory;
- .2 date and identification number of the test report;
- .3 name and address of client;
- .4 purpose of the test;
- .5 method of sampling;
- .6 name and address of manufacturer or supplier of the product;

- .8 description of the tested product:
 - drawings,
 - descriptions,
 - assembly instructions,
 - specification of included materials,
 - detailed drawing of test set-up;
- .9 date of supply of the product;
- .10 date of test;
- .11 test method;
- .12 drawing of each test configuration;
- .13 measured nozzle characteristics;
- .14 identification of the test equipment and used instruments;
- .15 conclusions;
- .16 deviations from the test method, if any;
- .17 test results including observations during and after the test;
and
- .18 date and signature.

MSC/Circ.670
(5 January 1995)

**Guidelines for the performance and testing criteria,
and surveys of high-expansion foam concentrates
for fixed fire-extinguishing systems**

1 The Maritime Safety Committee, at its sixty-fourth session (5 to 9 December 1994), approved Guidelines for the performance and testing criteria and surveys of high-expansion foam concentrates for fixed fire-extinguishing systems, given in annex.

2 Member Governments are recommended to ensure that tests for type approval and periodical control of the high-expansion foam concentrates are performed in accordance with the annexed Guidelines.

Annex

Guidelines for the performance and testing criteria,
and surveys of high-expansion foam concentrates
for fixed fire-extinguishing systems

1 General

1.1 Application

These Guidelines apply to the foam concentrates for fixed high-expansion foam fire-extinguishing systems referred to in SOLAS regulation II-2/9.

1.2 Definitions

(As per annex to MSC/Circ.582).

2 Sampling procedure

(As per annex to MSC/Circ.582).

3 Tests for type approval of foam concentrates

(Paragraphs 3.1 to 3.5 are the same as per annex to MSC/Circ.582).

(Reference in paragraph 3 is to be modified from "3.1-3.11" to "3.1-3.10").

(Reference in paragraph 3.2 is to be modified from "3.9" to "3.8").

3.6 *Expansion ratio*

3.6.1 The test should be carried out according to paragraph 3.6.2, with seawater at about 20°C. Simulated seawater with the characteristics stated under 3.6.3 may be used. The expansion ratio obtained with the foam generators used on board should be consistent with the expansion ratio obtained with the foam generators during the fire test.

3.6.2 Determination of the expansion ratio

(a) Apparatus:

plastic collecting vessel of volume V , approximately 500 l and accurately known to ± 5 l;

high expansion foam-making equipment which when tested with water has a flow rate of 6.1 ± 0.1 l/min at a nozzle pressure of (5.0 ± 0.1) bar.

An example for a suitable apparatus is given in document ISO 7203-2.

(b) Procedure:

(b.1) Wet the vessel internally and weigh it (W_1). Set up the foam equipment and adjust the nozzle pressure to give a flow rate of 6.1 l/min. With the discharge facility closed, collect foam in the vessel. As soon as the vessel is full, stop collecting foam and strike the foam surface level with the rim. Weigh the vessel (W_2). During the filling operation, keep the discharge facility in the bottom of the vessel closed until the total weight of the foam is determined.

(b.2) Calculate the expansion λ from the equation:

$$\lambda = \frac{W_2 - W_1}{V}$$

in which it is assumed that the density of the foam solution is 1.0 kg/l and where:

V is the vessel volume, in ml;

W_1 is the mass of the empty vessel, in grams;

W_2 is the mass of the full vessel, in grams.

Assume that the density of the foam solution is 1.0 kg/l.

(b.3) Open the drainage facility and measure the 50% drainage time (see paragraph 3.7.1 hereinafter).

Determine the drainage either by having the vessel on a scale and recording the weight loss, or by collecting the drained foam solution in a measuring cylinder.

Care should be taken to ensure that there are no voids in the foam collected in the vessel.

3.6.3 Simulated seawater may be made up by dissolving:

- 25.0 g Sodium chloride (NaCl)
- 11.0 g Magnesium chloride ($MgCl_2 \cdot 6H_2O$)
- 1.6 g Calcium chloride ($CaCl_2 \cdot 2H_2O$)
- 4.0 g Sodium sulphate (Na_2SO_4)

in each litre of potable water.

3.7 *Drainage time*

3.7.1 The drainage time should be determined, after having determined the expansion ratio, according to paragraph 3.6.2(b.3).

3.7.2 The test should be carried out with seawater at about 20°C. Simulated seawater with the characteristics stated in 3.6.3 may be used.

3.7.3 Drainage time obtained with the foam generators used on board should be consistent with the drainage time obtained with the foam generators during the fire test.

3.8 *Fire tests*

Fire tests should be carried out according to the following paragraphs 3.8.1 to 3.8.7.

Note: The fire tests of section 3.8 are more expensive and time consuming than the other tests of these Guidelines. It is recommended that fire tests should be carried out at the end of the test programme, so as to avoid expense of unnecessary testing of foam concentrates which do not comply in other respects.

3.8.1 Environmental conditions

- Air temperature: (15 + 5)°C
- Maximum wind speed: 3 m/s in proximity of the fire tray

3.8.2 Records

During the fire test, record the following:

- indoor or outdoor test
- air temperature
- fuel temperature
- water temperature

foam solution temperature
wind speed
extinction time.

3.8.3 Foam solution

- (a) Prepare a foam solution, following the recommendations from the supplier for concentration, maximum premix time, compatibility with the test equipment, avoiding contamination by other types of foam, etc.
- (b) The test should be carried out with seawater at about 20°C. Simulated seawater with the characteristics stated in 3.6.3 may be used.

3.8.4 Apparatus

- (a) Fire tray:

Circular fire tray of steel with dimensions as follows:

diameter at rim: (1,480 + 15) mm

depth: (150 + 10) mm

nominal thickness of steel wall: 2.5 mm

Note: The tray has an area of approximately 1.73 m².

- (b) Foam-making equipment:

In accordance with subparagraph 3.6.2(a).

- (c) Fire screens:

Fire screens of nominal 5 mm square metal mesh to form the nominal arrangement mentioned in subparagraph 3.8.6.

3.8.5 Fuel

Use an aliphatic hydrocarbon mixture with physical properties according to the following specification

- distillation range: 84°C-105°C
- maximum difference between initial and final boiling points: 10°C
- maximum aromatic content: 1%
- density at 15°C: (707.5 + 2.5) kg/m³
- temperature: about 20°C

Note: Typical fuels meeting this specification are n-heptane and certain solvent fractions sometimes referred to as commercial heptane.

The Administration may require additional fire tests using an additional test fuel.

3.8.6 Test procedure

- (a) Place the tray directly on the ground and ensure that it is level. Add approximately 30 l of seawater, or simulated seawater with the characteristics stated in 3.6.3, and (55 ± 5) l of fuel, to give a nominal freeboard of 100 mm.
- (b) Place the net screens around the fire tray as shown in figure 2. Within 5 min ignite the fuel and allow it to burn for a period of not less than 45 s. Commence foam generation with the foam generator some distance from the fire.

(60 \pm 5) s after full involvement move the foam generator to the opening between the net screen and apply foam to the fire. Apply foam for a period of (120 ± 2) s. Record the extinction time as the period from start of foam application to extinction.

3.8.7 Permissible limits

Extinction time: not more than 120 s.

3.9 *Corrosiveness*

(As per paragraph 3.10 of annex to MSC/Circ.582).

3.10 *Volumic mass*

(As per paragraph 3.11 of annex to MSC/Circ.582).

4 **Periodical controls of foam concentrates stored on board**

(As per annex to MSC/Circ.582).

5 **Interval of periodical controls**

(As per annex to MSC/Circ.582).

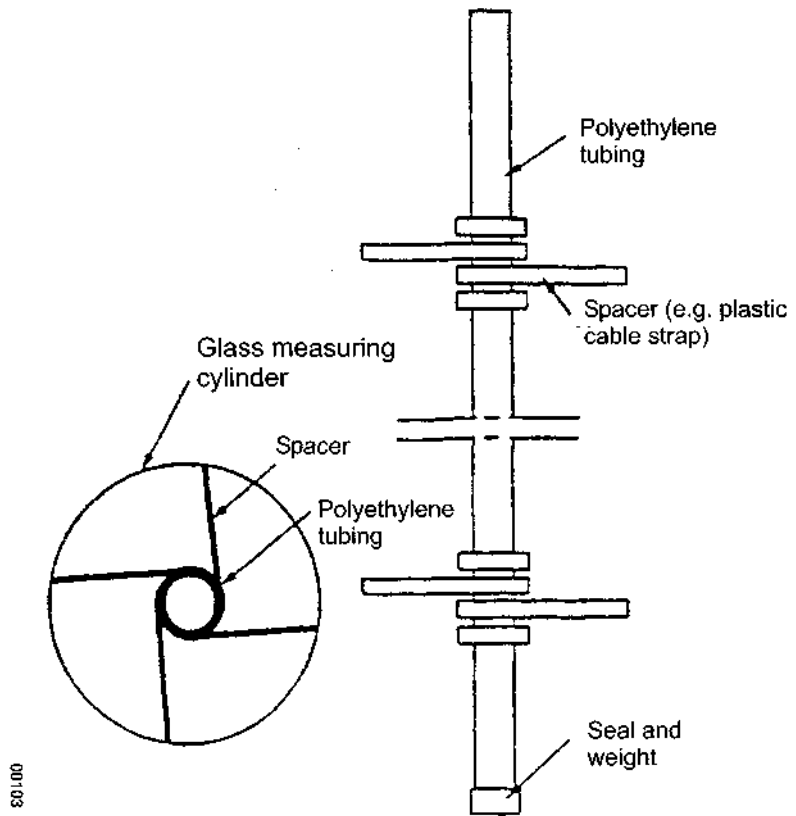
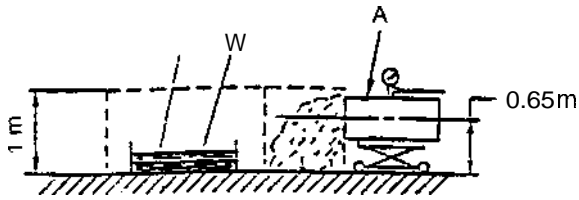
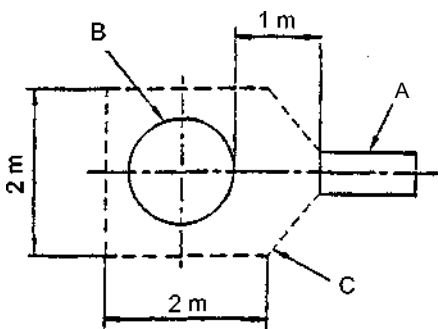


Figure 1
(as per figure 1 of annex to MSC/Circ.582)



- A- High expansion foam generator on wheeled trolley
- B - Tray
- C - Metal mesh screens
- F - Fuel
- W - Water



All dimensions are nominal in metres

Figure 2 - Fire test arrangement

MSC/Circ.677
(30 December 1994)

**Revised standards for the design, testing and locating
of devices to prevent the passage of flame
into cargo tanks in tankers**

1 By resolution A.519(13) the Maritime Safety Committee was requested by the 1983 Assembly to finalize the Standards for devices to prevent the passage of flame into cargo tanks, the Committee was developing at the time, prior to the coming into force of the 1981 SOLAS amendments.

2 The Committee, at its forty-ninth session, (2 to 6 April 1984), adopted the Standards so developed, which were attached to MSC/Circ.373.

3 The Committee agreed that the inert gas system was to be considered as equivalent to devices to prevent the passage of flame into cargo tanks only if vent outlets on ships fitted with inert gas systems were at least fitted with devices to prevent the passage of flame into cargo tanks, but that these devices need not comply with the test requirement for endurance burning. The Committee noted that, in the Standards, emphasis was laid on compliance with test specifications rather than on construction. It was then understood that, in the case of a tanker fitted with an inert gas system, the provision of flashback would suffice and a well-designed and fitted flame screen could meet this criterion. In summary, if a flame screen met the Standards, it would be accepted.

4 The Committee, at its fifty-fifth session, (11 to 22 April 1988), adopted amendments to the Standards contained in MSC/Circ.373 and disseminated them as MSC/Circ.373/Rev.1.

5 The Committee, at its sixty-fourth session, (5 to 9 December 1994), recognizing the necessity to clarify some provisions in the Revised standards, adopted further amendments thereto, which are incorporated in the text set out in the annex.

6 Member Governments are invited to give effect to the Revised standards in conjunction with the application of regulation II-2/59 of the 1974 SOLAS Convention, as amended.

Annex

**Revised standards for the design, testing and locating of
devices to prevent the passage of flame
into cargo tanks in tankers**

Contents

- 1 Introduction**
- 1.1 Purpose
- 1.2 Application
- 1.3 Definitions

- 2 Standards**
- 2.1 Principles
- 2.2 Mechanical design standards
- 2.3 Performance standards
- 2.4 Flame screens
- 2.5 Sizing, location and installation of devices

- 3 Type test procedures**
- 3.1 Principles
- 3.2 Test procedures for flame arresters located at openings to the atmosphere
- 3.3 Test procedures for high velocity vents
- 3.4 Test rig and test procedures for detonation flame arresters located in-line
- 3.5 Operational test procedures

- 4 Miscellaneous**
- 4.1 Marking of device
- 4.2 Laboratory report
- 4.3 Manufacturers' instruction manual

Introduction

1.1 Purpose

The 1981 and the 1983 amendments to the International Convention for the Safety of Life at Sea, 1974 (SOLAS) include revised requirements for fire safety measures for tankers. Regulation II-2/59 of these amendments contains provisions concerning venting, purging, gas-freeing and ventilation. regulation II-2/59.1.5 states:

"The venting system shall be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices shall comply with the requirements established by the Administration which shall contain at least the Standards adopted by the Organization."

1.2 Application

1.2.1 These Standards are intended to cover the design, testing, locating and maintenance of "devices to prevent the passage of flame into cargo tanks" (hereafter called "devices") of tankers and combination carriers carrying crude oil and petroleum products having a flashpoint of 60°C (closed cup) or less, and a Reid vapour pressure below atmospheric pressure and other products having a similar fire hazard.

1.2.2 Oil tankers and combination carriers fitted with an inert gas system in accordance with regulation 62 should be fitted with devices which comply with these Standards, except that the tests specified in 3.2.3 and 3.3.3.2 are not required. Such devices are only to be fitted at openings unless they are tested in accordance with 3.4.

1.2.3 These Standards are intended for devices protecting cargo tanks containing crude oil, petroleum products and flammable chemicals. In the case of the carriage of chemicals, the test media referred to in section 3 can be used. However, devices for chemical tankers dedicated to the carriage of products with MESH* less than 0.9 mm should be tested with appropriate media.

1.2.4 Devices should be tested and located in accordance with these Standards.

1.2.5 Devices are installed to protect:

- .1 openings designed to relieve pressure or vacuum caused by thermal variations (regulation II-2/59.1.2.1);

Reference is made to IEC Publication 79-1.

- .2 openings designed to relieve pressure or vacuum during cargo loading, ballasting or during discharging (regulation II-2/59.1.2.2);
- .3 outlets designed for gas-freeing (regulation II-2/59.2.2.3).

1.2.6 Devices should not be capable of being bypassed or blocked open unless they are tested in the bypassed or blocked open position in accordance with section 3.

1.2.7 These Standards do not include consideration of sources of ignition such as lightning discharges since insufficient information is available to formulate equipment recommendations. All cargo handling, tank cleaning and ballasting operations should be suspended on the approach of an electrical storm.

1.2.8 These Standards are not intended to deal with the possibility of the passage of flame from one cargo tank to another on tankers with common venting systems.

1.2.9 When outlet openings of gas-freeing systems on tankers not fitted with inert gas systems are required to be protected with devices, they should comply with these Standards except that the tests specified in 3.2.3 and 3.3.3.2 are not required.

1.2.10 Certain of the tests prescribed in section 3 of these Standards are potentially hazardous, but no attempt is made in this circular to specify safety requirements for these tests.

1.3 *Definitions*

For the purpose of these Standards, the following definitions are applicable.

1.3.1 *Flame arrester* is a device to prevent the passage of flame in accordance with a specified performance standard. Its flame-arresting element is based on the principle of quenching.

1.3.2 *Flame screen* is a device utilizing wire mesh to prevent the passage of unconfined flames, in accordance with a specified performance standard.

1.3.3 *Flame speed* is the speed at which a flame propagates along a pipe or other system.

1.3.4 *Flashback* is the transmission of a flame through a device.

1.3.5 *High velocity vent* is a device to prevent the passage of flame, consisting of a mechanical valve which adjusts the opening available for flow in accordance with the pressure at the inlet of the valve in such a way that the efflux velocity cannot be less than 30 m/s.

1.3.6 *Pressure/vacuum valve** is a device designed to maintain pressure and vacuum in a closed container within preset limits.

2 Standards

2.1 Principles

2.1.1 Depending on their service and location, devices are required to protect against the propagation of:

- .1 moving flames; and/or
- .2 stationary flames from pre-mixed gases;

after ignition of gases resulting from any cause.

2.1.2 When flammable gases from outlets ignite, the following four situations may occur:

- .1 At low gas velocities, the flame may:
 - .1 flashback; or
 - .2 stabilize itself as if the outlet were a burner.
- .2 At high velocities, the flame may:
 - .1 burn at a distance above the outlet; or
 - .2 be blown out.

2.1.3 In order to prevent the passage of flame into a cargo tank, devices must be capable of performing one or more of the following functions:

- .1 permitting the gas to pass through passages without flashback and without ignition of the gases on the protected side when the device is subjected to heating for a specified period;
- .2 maintaining an efflux velocity in excess of the flame speed for the gas, irrespective of the geometric configuration of the device and without the ignition of gases on the protected side when the device is subjected to heating for a specified period; and
- .3 preventing an influx of flame when conditions of vacuum occur within the cargo tanks.

2.2 Mechanical design standards

2.2.1 The casing or housing of devices should meet similar standards of strength, heat resistance and corrosion resistance as the pipe to which they are attached.

* Pressure/vacuum valves are devices to prevent the passage of flame when designed and tested in accordance with these Standards.

2.2.2 The design of devices should allow for ease of inspection and removal of internal elements for replacement, cleaning or repair.

2.2.3 All flat joints of the housing should be machined true and should provide for a joint having an adequate metal-to-metal contact.

2.2.4 Flame arrester elements should fit in the housing in such a way that flame cannot pass between the element and the housing.

2.2.5 Resilient seals may be installed only if their design is such that if the seals are partially or completely damaged or burned, the device is still capable of effectively preventing the passage of flame.

2.2.6 Devices should allow for efficient drainage of moisture without impairing their efficiency to prevent the passage of flame.

2.2.7 The casing and element and gasket materials should be capable of withstanding the highest pressure and temperature to which the device may be exposed under both normal and specified fire test conditions.

2.2.8 End-of-line devices should be so constructed as to direct the efflux vertically upwards.

2.2.9 Fastenings essential to the operation of the device, i.e. screws, etc., should be protected against loosening.

2.2.10 Means should be provided to check that any valve lifts easily without remaining in the open position.

2.2.11 Devices in which the flame arresting effect is achieved by the valve function and which are not equipped with the flame arrester elements (e.g. high velocity valves) must have a width of the contact area of the valve seat of at least 5 mm.

2.2.12 Devices should be resistant to corrosion in accordance with 3.5.1.

2.2.13 Elements, gaskets and seals should be of material resistant to both seawater and the cargoes carried.

2.2.14 The casing or housing should be capable of passing a hydrostatic pressure test, as required in 3.5.2.

2.2.15 In-line devices should be able to withstand, without damage or permanent deformation, the internal pressure resulting from detonation when tested in accordance with section 3.4.

2.2.16 A flame arrester element should be designed to ensure quality control of manufacture to meet the characteristics of the prototype tested, in accordance with these Standards.

2.3 *Performance standards*

2.3.1 Devices should be tested in accordance with 3.5 and thereafter shown to meet the test requirements of 3.2 to 3.4, as appropriate.

2.3.2 Performance characteristics, such as the flow rates under both positive and negative pressure, operating sensitivity, flow resistance and velocity should be demonstrated by appropriate tests.

2.3.3 Devices should be designed and constructed to minimize the effect of fouling under normal operating conditions. Instructions on how to determine when cleaning is required and the method of cleaning should be provided for each device in the manufacturers' instruction manual.

2.3.4 Devices should be capable of operating in freezing conditions (such as may cause blockage by freezing cargo vapours or by icing in bad weather) and if any device is provided with heating arrangements so that its surface temperature exceeds 35°C, then it should be tested at the highest operating temperature.

2.3.5 Devices based upon maintaining a minimum velocity should be capable of opening in such a way that a velocity of 30 m/s is immediately initiated, maintaining an efflux velocity of at least 30 m/s at all flow rates and, when the gas flow is interrupted, be capable of closing in such a way that this minimum velocity is maintained until the valve is fully closed.

2.3.6 In the case of high velocity vents, the possibility of inadvertent detrimental hammering* leading to damage and/or failure should be considered, with a view to eliminating it.

2.4 *Flame screens*

2.4.1 Flame screens should be:

- .1 designed in such a manner that they cannot be inserted improperly in the opening;
- .2 securely fitted in openings so that flames cannot circumvent the screen;
- .3 able to meet the requirements of these Standards. For flame screens fitted at vacuum inlets through which vapours cannot be vented the test specified in 3.2.3 need not be complied with; and
- .4 be protected against mechanical damage.

* Hammering is rapid full stroke opening/closing, not intended by the manufacturer during normal operations.

2.5 *Sizing, location and installation of devices*

2.5.1 For determining the size of devices to avoid inadmissible pressure or vacuum in cargo tanks during loading or discharging, calculations of pressure losses should be carried out. The following parameters should be taken into account:

- .1 loading/discharge rates;
- .2 gas evolution;
- .3 pressure loss across devices, taking into account the resistance coefficient;
- .4 pressure loss in the vent piping system;
- .5 pressure at which the vent opens if a high velocity valve is used;
- .6 density of the saturated vapour/air mixture; and
- .7 to compensate for possible fouling of a flame arrester, 70% of its rated performance is to be used in the pressure drop calculation of the installation.

2.5.2 Devices should be located at the outlets to atmosphere unless tested and approved for in-line installation. Devices for in-line installation may not be fitted at the outlets to atmosphere unless they have also been tested and approved for that position.

2.5.3 End-of-line devices which are intended for exclusive use at openings of inerted cargo tanks need not be tested against endurance burning as specified in 3.2.3.

2.5.4 Where end-of-line devices are fitted with cowls, weather hoods and deflectors, etc., these attachments should be fitted for the tests described in 3.2.

2.5.5 Where detonation flame arresters are installed, as in-line devices venting to atmosphere, they should be located at a sufficient distance from the open end of the pipeline so as to preclude the possibility of a stationary flame resting on the arrester.

2.5.6 When venting to atmosphere is not performed through an end-of-line device according to 2.5.4, or a detonation flame arrester according to 2.5.5, the in-line device has to be specifically tested with the inclusion of all pipes, tees, bends, cowls, weather hoods, etc., which may be fitted between the device and atmosphere. The testing should consist of the flashback test of 3.2.2 and, if for the given installation it is possible for a stationary flame to rest on the device, the testing should also include the endurance burning test of 3.2.3.

2.5.7 Means should be provided to enable personnel to reach devices situated more than 2 m above deck to facilitate maintenance, repair and inspection.

3 Type test procedures

3.1 Principles

3.1.1 Tests should be conducted by a laboratory acceptable to the Administration.

3.1.2 Each size of each model should be submitted for type testing. However, for flame arresters testing may be limited to the smallest and the largest sizes and one additional size in between to be chosen by the Administration. Devices should have the same dimensions and most unfavourable clearances expected in the production model. If a test device is modified during the test programme, the testing should be started over again.

3.1.3 Tests described in this section using gasoline vapours (a non-leaded petroleum distillate consisting essentially of aliphatic hydrocarbon compounds with a boiling range approximating 65°C/75°C), technical hexane vapours, or technical propane, as appropriate, and referred to in this section, are suitable for all devices protecting tanks containing a flammable atmosphere of the cargoes referred to in 1.2.1. This does not preclude the use of gasoline vapours or technical hexane vapours for all tests referred to in this section.

3.1.4 After the relevant tests, the device should not show mechanical damage that affects its original performance.

3.1.5 Before the tests the following equipment as appropriate should be properly calibrated:

- .1 gas concentration meters;
- .2 thermometers;
- .3 flow meters;
- .4 pressure meters; and
- .5 time recording devices.

3.1.6 The following characteristics should be recorded, as appropriate, throughout the tests:

- .1 concentration of fuel in the gas mixture;
- .2 temperature of the test gas mixture at inflow of the device; and
- .3 flow rates of the test gas mixtures when applicable.

3.1.7 Flame passage should be observed by recording, e.g., temperature, pressure, or light emission by suitable sensors on the protected side of the device; alternatively, flame passage may be recorded on video tape.

3.2 Test procedures for flame arresters located at openings to the atmosphere

3.2.1 The test rig should consist of an apparatus producing an explosive mixture, a small tank with a diaphragm, a flanged prototype of the flame arrester, a plastic bag* and a firing source in three positions (see appendix 1).† Other test rigs may be used, provided the tests referred to in this section are achieved to the satisfaction of the Administration.

3.2.2 A flashback test should be carried out as follows:

- .1 The tank, flame arrester assembly and the plastic bag* enveloping the prototype flame arrester should be filled so that this volume contains the most easily ignitable propane/air mixture.‡ The concentration of the mixture should be verified by appropriate testing of the gas composition in the plastic bag. Where devices referred to in 2.5.6 are tested, the plastic bag should be fitted at the outlet to atmosphere. Three ignition sources should be installed along the axis of the bag, one close to the flame arrester, another as far away as possible therefrom, and the third at the midpoint between these two. These three sources should be fired in succession, twice in each of the three positions. The temperature of the test gas should be within the range of 15°C to 40°C.
- .2 If a flashback occurs, the tank diaphragm will burst and this will be audible and visible to the operator by the emission of a flame. Flame, heat and pressure sensors may be used as an alternative to a bursting diaphragm.

3.2.3 An endurance burning test should be carried out, in addition to the flashback test, for flame arresters at outlets where flows of explosive vapour are foreseeable:

- .1 The test rig as referred to in 3.2.1 may be used, without the plastic bag. The flame arrester should be so installed that the mixture emission is vertical. In this position the mixture should

* The dimensions of the plastic bag are dependent on those of the flame arrester, but for the flame arresters normally used on tankers, the plastic bag may have a circumference of 2 m, a length of 2.5 m and a wall thickness of 0.05 mm.

† In order to avoid remnants of the plastic bag from falling back on to the device being tested after ignition of the fuel/air mixture, it may be useful to mount a coarse wire frame across the device within the plastic bag. The frame should be so constructed as not to interfere with the test result.

* Reference is made to IEC Publication 79-1.

be ignited. Where devices referred to in 2.5.6 are tested, the flame arrester should be so installed as to reflect its final orientation.

- .2 Endurance burning should be achieved by using the most easily ignitable gasoline vapour/air mixture or the most easily ignitable technical hexane vapour/air mixture with the aid of a continuously operated pilot flame or a continuously operated spark igniter at the outlet. The test gas should be introduced upstream of the tank shown in appendix 2. Maintaining the concentration of the mixture as specified above, by varying the flow rate, the flame arrester should be heated until the highest obtainable temperature on the cargo tank side of the arrester is reached. Temperatures should be measured, for example, at the protected side of the flame quenching matrix of the arrester (or at the seat of the valve in case of testing high velocity vents according to 3.3). The highest obtainable temperature may be considered to have been reached when the rate of rise of temperature does not exceed 0.5°C per minute over a ten-minute period. This temperature should be maintained for a period of ten minutes, after which the flow should be stopped and the conditions observed. The temperature of the test gas should be within the range of 15°C to 40°C .

If no temperature rise occurs at all: inspect the arrester for a more adequate position of the temperature sensor, taking account of the visually registered position of the stabilized flame during the first test sequence. Positions which require the drilling of small holes into fixed parts of the arrester have to be taken into account. If all this is not successful, affix the temperature sensor at the unprotected side of the arrester in a position near to the stabilized flame.

If difficulties arise in establishing stationary temperature conditions (at elevated temperatures), the following criteria should apply: using the flow rate which produced the maximum temperature during the foregoing test sequence, endurance burning should be continued for a period of two hours from the time the above-mentioned flow rate has been established. After that period the flow should be stopped and the conditions observed. Flashback should not occur during this test.

3.2.4 When a pressure or/and vacuum valve is integrated to a flame arresting device, the flashback test has to be performed with the pressure or/and vacuum valve blocked open. If there are no additional flame

quenching elements integrated in a pressure valve, this valve has to be considered and tested as a high velocity vent valve according to paragraph 3.3.

3.3 Test procedures for high velocity vents

3.3.1 The test rig should be capable of producing the required volume flow rate. In appendices 2 and 3, drawings of suitable test rigs are shown. Other test rigs may be used, provided the tests are achieved to the satisfaction of the Administration.

3.3.2 A flow condition test should be carried out with high velocity vents using compressed air or gas at agreed flow rates. The following should be recorded:

- .1 The flow rate. Where air or a gas other than vapours of cargoes with which the vent is to be used is employed in the test, the flow rates achieved should be corrected to reflect the vapour density of such cargoes.
- .2 The pressure before the vent opens. The pressure in the test tank on which the device is located should not rise at a rate greater than $0.01 \text{ N/mm}^2/\text{min}$.
- .3 The pressure at which the vent opens.
- .4 The pressure at which the vent closes.
- .5 The efflux velocity at the outlet which should not be less than 30 m/s at any time when the valve is open.

3.3.3 The following fire safety tests should be conducted while adhering to 2.3.6 using a mixture of gasoline vapour and air or technical hexane vapour and air, which produces the most easily ignitable mixture at the point of ignition. This mixture should be ignited with the aid of a permanent pilot flame or a spark igniter at the outlet:

- .1 Flashback tests in which propane may be used instead of gasoline or hexane should be carried out with the vent in the upright position and then inclined at 10° from the vertical. For some vent designs further tests with the vent inclined in more than one direction may be necessary. In each of these tests the flow should be reduced until the vent closes and the flame is extinguished, and each should be carried out at least 50 times. The vacuum side of combined valves should be tested in accordance with 3.2.2 with the vacuum valve maintained in the open position for the duration of this test, in order to test the efficiency of the device which must be fitted.

An endurance burning test, as described in 3.2.3, should be carried out. Following this test, the main flame should be extinguished and then, with the pilot flame burning or the spark igniter discharging, small quantities of the most easily ignitable mixture should be allowed to escape for a period of ten minutes maintaining a pressure below the valve of 90% of the valves opening setting, during which time flashback should not occur. For the purposes of this test the soft seals or seats should be removed.

3.4 *Test rig and test procedures for detonation flame arresters located in-line*

3.4.1 A flame arrester should be installed at one end of a pipe of suitable length and of the same diameter as the flange of the flame arrester. On the opposed flange a pipe of a length corresponding to 10 pipe diameters should be affixed and be closed by a plastic bag* or diaphragm. The pipe should be filled with the most easily ignitable mixture of propane and air, which should then be ignited. The velocity of the flame near the flame arrester should be measured and should have a value of that for stable detonations.

3.4.2 Three detonation tests should be conducted and no flashback should occur through the device and no part of the flame arrester should be damaged or show permanent deformation.

3.4.3 A drawing of the test rig is shown in appendix 4. Other test rigs may be used provided the tests are achieved to the satisfaction of the Administration.

3.5 *Operational test procedures*

3.5.1 A corrosion test should be carried out. In this test a complete device, including a section of the pipe to which it is fitted, should be exposed to a 5% sodium chloride solution spray at a temperature of 25°C for a period of 240 hours, and allowed to dry for 48 hours. An equivalent test may be used to the satisfaction of the Administration. Following this test, all movable parts should operate properly and there should be no corrosion deposits which cannot be washed off.

3.5.2 A hydraulic pressure test should be carried out in the casing or housing of a sample device, in accordance with 2.2.1.

* The dimensions should be at least 4 m circumference, 4 m length and a material wall thickness of 0.05 mm.

4 Miscellaneous

4.1 *Marking of device*

Each device should be permanently marked, or have a permanently fixed tag made of stainless steel or other corrosion-resistant material, to indicate:

- .1 manufacturer's name or trade mark;
- .2 style, type, model or other manufacturer's designation for the device;
- .3 size of the outlet for which the device is approved;
- .4 approved location for installation, including maximum or minimum length of pipe, if any, between the device and the atmosphere;
- .5 direction of flow through the device;
- .6 indication of the test laboratory and report number; and
- .7 compliance with the requirements of MSC/Circ.373/Rev.2.

4.2 *Laboratory report*

4.2.1 The laboratory report should include:

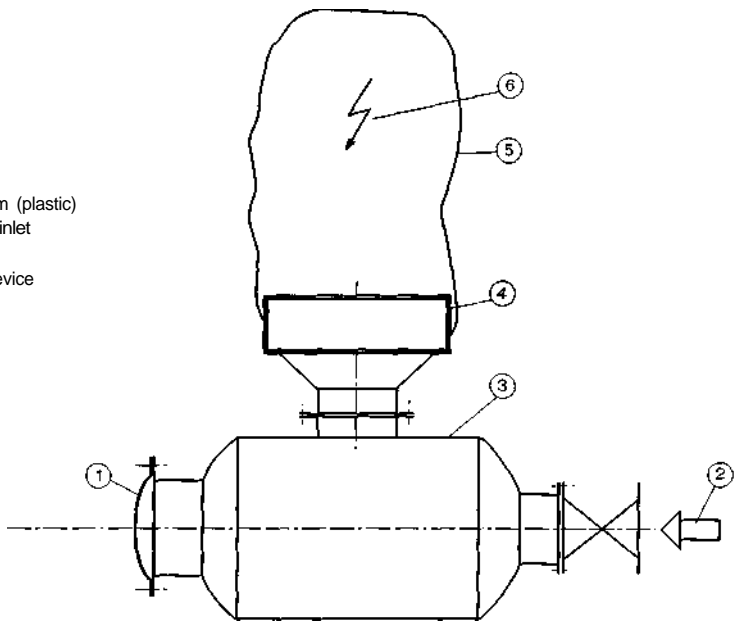
- .1 detailed drawings of the device;
- .2 types of tests conducted. Where in-line devices are tested, this information should include the maximum pressures and velocities observed in the test;
- .3 specific advice on approved attachments;
- .4 types of cargo for which the device is approved;
- .5 drawings of the test rig;
- .6 in the case of high velocity vent, the pressures at which the device opens and closes in the efflux velocity; and
- .7 all the information marked on the device in 4.1.

4.3 *Manufacturer's instruction manual*

4.3.1 The manufacturer should supply a copy of the instruction manual, which should be kept on board the tanker and which should include:

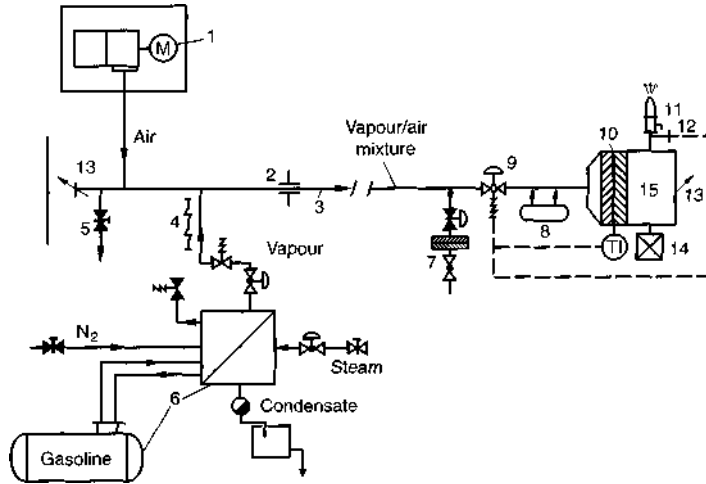
- .1 installation instructions;
- .2 operating instructions;
- .3 maintenance requirements, including cleaning (see 2.3.3);
- .4 copy of the laboratory report referred to in 4.2; and
- .5 flow test data, including flow rates under both positive and negative pressures, operating sensitivity, flow resistance and velocity, should be provided.

Appendix 1



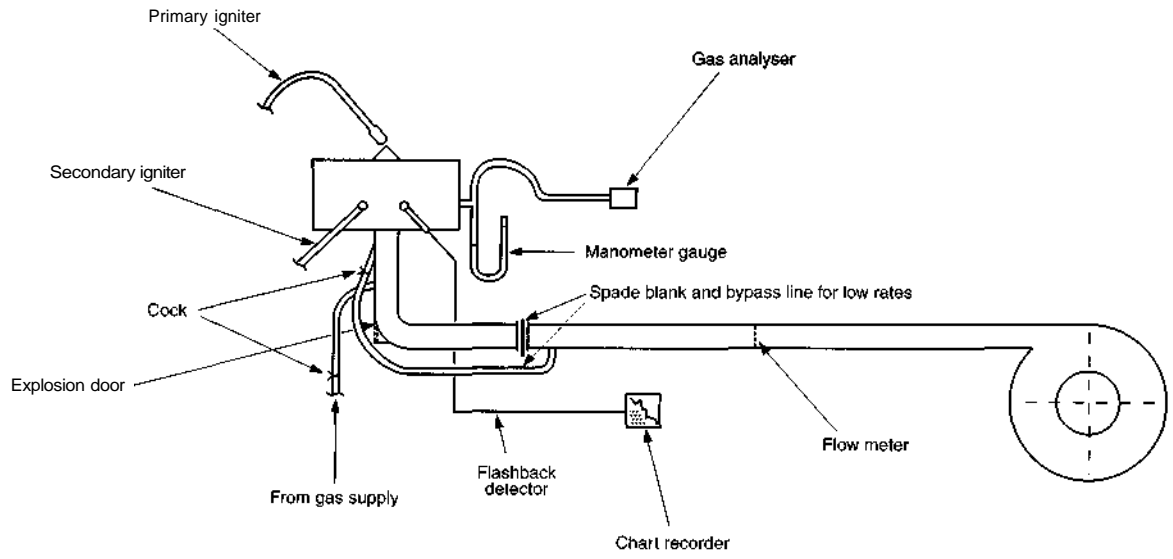
Test rig for flashback test

- 1 Bursting diaphragm (plastic)
- 2 Explosive mixture inlet
- 3 Tank
- 4 Flame-arresting device
- 5 Plastic bag
- 6 Ignition source

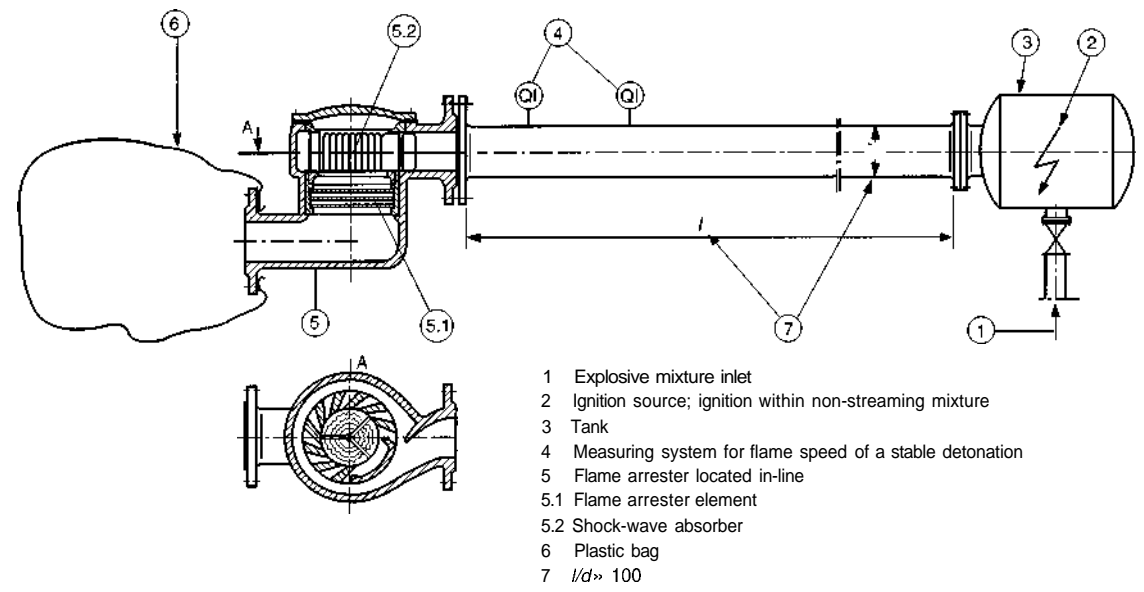


- 1 Fan with variable speed
- 2 Volume rate indicator
- 3 Pipe (500 mm diameter), length ~30 m
- 4 Heated vapour pipe
- 5 Air bypass
- 6 Evaporator and liquid storage tank
- 7 Vapour/air mixture bypass
- 8 Extinguishing agents
- 9 Control and quick-action stop valve
- 10 Explosion-arresting crimped ribbon with temperature control for the safety of the test plant
- 11 High-velocity valve to be tested
- 12 Flame detector
- 13 Bursting diaphragm
- 14 Concentration indicator
- 15 Tank

Schematic plan of the test plant for high-velocity valves (endurance burning test only)



Test rig for high-velocity vents



Test rig for flame arresters located in-line

MSC/Circ.728
(4 June 1996)

**Revised test method for equivalent water-based
fire-extinguishing systems for machinery spaces
of category A and cargo pump-rooms
contained in MSC/Circ.668**

1 The Maritime Safety Committee, at its sixty-fourth session (5 to 9 December 1994), recognizing the urgent necessity of providing guidelines for alternative arrangements for halon fire-extinguishing systems, approved guidelines for the approval of equivalent water-based fire-extinguishing systems as referred to in SOLAS 74 for machinery spaces and cargo pump-rooms as MSC/Circ.668.

2 The Sub-Committee on Fire Protection, at its fortieth session (17 to 21 July 1995), reviewed the interim test method for equivalent water-based fire-extinguishing systems contained in MSC/Circ.668, and prepared amendments to the interim test method.

3 The Committee, at its sixty-sixth session (28 May to 6 June 1996), approved the amendments prepared by the FP Sub-Committee as contained in the annex.

4 Member Governments are invited to apply the Guidelines contained in MSC/Circ.668 as amended by this circular.

Annex

Amendments to the test method for equivalent water-based
fire-extinguishing systems for machinery spaces of
category A and cargo pump-rooms contained
in MSC/Circ.668, annex, appendix B

1 *In the third paragraph of "Scope", at the end of the first sentence after "ceiling mounted nozzles" insert the phrase "for class 1 and class 2 engine-rooms and multiple level nozzles for class 3 engine-rooms, that may be utilized in conjunction with a separate bilge area protection system".*

2 *Replace the text of paragraph 4.2.2.2 by the following text:*

4.2.2.2 Class 2 - Engine-room

The tests should be performed in a room having a specified area greater than 100 m², specified height of from 5 to 7.5 m and ventilation through a 2 m x 2 m door opening, up to a total volume for the room of 3,000 m³. Fires and engine mock-up should be according to tables 2 and 3 and figure 1.

4.2.2.3 Class 3 - Engine-room

The test should be performed in a fire test hall with a minimum floor area of 300 m², and a ceiling height in excess of 10 m and without any restrictions in air supply for the test fires. Fires and engine mock-up should be according to tables 2 and 3 and figure 1."

3 *Replace the second sentence of paragraph 4.3 by the following:*

"for class 3 engine-rooms, the maximum vertical distance between levels of nozzles should be limited to 7.5 m and the lowest level of nozzles should be at a minimum height of 5 m above the floor."

4 *Replace "30 mm oil" in paragraph 4.4.1, by "50 mm fuel".*

5 *Amend table 2 as follows:*

Test No. 9, tray size should be changed from "0.1 m²" to "0.5 m²"

Below the table replace the word "note" by "notes".

Denote existing note as "1" and add a new note "2" with the following text:

"2 Tests 4, 7, 8 and 13 are not required for bilges with a separate fire protection system and are not applicable to bilges with a depth of more than 0.75 m (see section 4.3)."

MSC/Circ.731
(12 July 1996)

**Revised factors to be taken into consideration
when designing cargo tank venting and
gas-freeing arrangements**

1 The International Convention for the Safety of Life at Sea, 1974, as amended, includes requirements for fire safety measures for tankers in regulations II-2/59 and 62. These regulations contain arrangements for venting, inerting, purging, gas-freeing and ventilation.

2 The Sub-Committee on Fire Protection has considered problems associated with the design of cargo tank venting and gas-freeing arrangements and the Maritime Safety Committee, at its fifty-third session (8 to 17 September 1986), approved MSC/Circ.450 on main factors that should be considered in the design of the arrangements referred to in paragraph 1 above. That circular was revised by the Committee, at its fifty-fifth session (11 to 20 April 1988), and issued as MSC/Circ.450/Rev.1.

3 The Committee, at its sixty-sixth session (28 May to 6 June 1996), taking into account the development of MSC/Circ.677 (Revised standards for the design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers), revised the aforementioned main factors as contained in the annex.

Annex

**Revised factors to be taken into consideration
when designing cargo tank venting and
gas-freeing arrangements**

Maximum loading/discharge rate

The venting system should be designed to take into consideration the maximum permissible loading/discharge rate for each cargo tank and in the case of a combined venting system, for each group of tanks. These loading and discharge rates should also be used for the design of the inert gas system, regulation II-2/62.3.1.

Gas evolution

Regulation II-2/59.1.9.5 requires at least 25% to be added to the maximum loading rate to account for the increased volume due to gas evolution from the cargo. A higher gas evolution factor may be considered for highly volatile cargoes.

Pressure loss across devices

Data relating to pressure loss across devices to prevent the passage of flame, approved in accordance with MSC/Circ.677 and referred to in regulation II-2/59.1.5, is to be considered in the design of the venting system. Fouling of devices should be taken into account.

Pressure loss in the venting system

Pressure loss calculations of systems including pipes, valves, bends, fittings, etc., should be made to ensure that the pressure inside the cargo tanks does not exceed the pressure these tanks are designed to withstand taking into consideration .2 and .3 above. In the case where a combined venting system is used in association with loading of cargo tanks simultaneously, the combined effect of vapour pressure generated in the tanks and venting system should be considered.

Pressure at which the vents open

The initial opening pressure of the vent valves should be considered in selecting the appropriate valves for the venting system.

Prevention of hammering

In the case of high velocity vents, the possibility of inadvertent detrimental hammering leading to damage and/or failure should be considered, with a view to eliminating it.

Density of the gaseous mixture

The maximum density of the gaseous mixtures likely to be encountered in the cargo tanks having regard to the types of cargo intended to be carried and their temperature is to be considered.

Design to prevent liquid overflow

Where overflow control systems are fitted, consideration is to be given to the dynamic conditions during loading.

Location of vent outlets

Horizontal and vertical distances of the vent outlets are to be in accordance with regulation II-2/59.

Types of venting systems

Due regard is to be given to cargo segregation when considering a venting system or inert gas system common to more than one tank. Where the inert gas main is designed for venting of cargo tanks, additional means for venting of these tanks are to be in accordance with regulation II-2/62.11.3.

Vent draining arrangements

The draining arrangements for venting systems are to be designed in accordance with regulation II-2/59.1.4.

Gas-freeing

In designing a gas-freeing system in conformity with paragraphs 2.2.2 and 2.2.3 of regulation II-2/59 in order to achieve the required exit velocities, the following should be considered:

- .1 the flow characteristics of the fans to be used;
- .2 the pressure losses created by the design of a particular tank's inlets and outlets;
- .3 the pressure achievable in the fan driving medium (e.g. water or compressed air); and
- .4 the densities of the cargo vapour/air mixtures for the range of cargoes to be carried.

Others

Repairs and renewal of the venting system should conform to the original design parameters. Factors in the above paragraphs are to be taken into consideration when modifications are carried out to the venting system.

The master is to be provided with a manual containing information relating to the maximum loading and unloading rates for each tank or group of tanks established during the design of the venting system, as per paragraph 1 of this circular.

Data referred to in paragraph 4.3 of MSC/Circ.677 should be taken into consideration when renewing devices referred to in the above circular.

MSC/Circ.777
(12 December 1996)

**Indication of the assembly station
in passenger ships**

1 The Maritime Safety Committee, at its sixty-seventh session (2 to 6 December 1996), noted that the 1995 SOLAS Conference on ro-ro ferry safety, having noted a relevant recommendation made by the Panel of Experts, agreed that, for easy understanding by passengers on ro-ro passenger ships in particular, the words "assembly station" should be used to indicate "muster stations". As a consequence, the words "assembly station" were used in SOLAS regulations II-2/28-1 "Escape routes" and III/6 "Communications - Public address systems on passenger ships", as adopted by the Conference.

2 The Committee recalled that, at its sixty-sixth session (28 May to 6 June 1996), it adopted (resolution MSC.47(66)) a new SOLAS chapter III whereby the words "muster station" were retained.

3 Having noted the above discrepancy, the Committee agreed that the following footnote should be added in connection with any reference to "Assembly stations" in the amended SOLAS Convention:

“* Assembly station" has the same meaning as "muster station”.”

4 The Committee further recommended that, for the purpose of assisting passengers on passenger ships to easily understand the issue, the words "assembly station" should be used on board as appropriate.

5 Member Governments are requested to take necessary action in line with the provisions of this circular.

MSC/Circ.798
(9 June 1997)

Guidelines for performance and testing criteria and surveys of medium-expansion concentrates for fire-extinguishing systems

1 The Maritime Safety Committee, at its sixty-eighth session (28 May to 6 June 1997), approved Guidelines for performance and testing criteria and surveys of medium-expansion foam concentrates for fire-extinguishing systems, given in the annex.

2 Member Governments are recommended to ensure that tests for type approval and periodical controls of the medium-expansion foam concentrates are performed in accordance with the annexed Guidelines.

Annex

Guidelines for performance and testing criteria and surveys of medium-expansion foam concentrates for fire-extinguishing systems

1 General

1.1 Application

These Guidelines apply to the foam concentrates for medium-expansion foam fire-extinguishing systems referred to in SOLAS regulation II-2/61.

1.2 Definitions

For the purpose of these Guidelines the following definitions apply:

1.2.1 Foam (*fire fighting*): an aggregate of air filled bubbles formed from an aqueous solution of a suitable foam concentrate.

1.2.2 Foam *solution*: a solution of foam concentrate and waters.

1.2.3 Foam concentrate: the liquid which, when mixed with water in the appropriate concentration, gives a foam solution.

1.2.4 *Expansion ratio*: the ratio of the volume of foam to the volume of foam solution from which it was made.

1.2.5 *Spreading coefficient* a measurement of the ability of one liquid to spontaneously spread across another.

1.2.6 *25% (50%) drainage time*: the time for 25% (50%) of the liquid content of a foam to drain out.

1.2.7 *Gentle application*: application of foam to the surface of a liquid fuel via a backboard, tank wall or other surface.

1.2.8 *Sediment*: insoluble particles in the foam concentrate.

2 Sampling procedure

2.1 The sampling method should ensure representative samples which should be stored in filled containers.

2.2 The sample size should be:

- .1 30 / for type tests (see section 3); and
- .2 2 / for periodical controls (see section 4).

3 Tests for type approval of foam concentrates

For foam concentrate type approval, the tests under 3.1 to 3.10 should be performed. They should be carried out at laboratories acceptable to the Administration.

3.1 Freezing and thawing

3.1.1 Before and after temperature conditioning in accordance with 3.1.2, the foam concentrate should show no visual sign of stratification, non-homogeneity or sedimentation.

3.1.2 Freezing and thawing test

- .1 Apparatus:
 - .1 freezing chamber, capable of achieving temperatures required as stated in .2.1 below;
 - .2 polyethylene tube, approximately 10 mm diameter, 400 mm long and sealed and weighted at one end, with suitable spacers attached (figure 1 of MSC/Circ.582 shows a typical form); and
 - .3 500 ml cylinder approximately 400 mm high and 65 mm in diameter.

.2 Procedure:

- .1 set the temperature of the freezing chamber to a temperature which is 10°C below the freezing point of the sample measured in accordance with BS 5117: section 1.3 (excluding 5.2 in the Standard);

To prevent the glass measuring cylinder from breaking, due to expansion of the foam concentrate on freezing, insert the tube into the measuring cylinder, sealed end downward, weighted if necessary to void floatation, the spacers ensuring it remains approximately on the central axis of the cylinder.

Place the sample in the cylinder in the chest, cool and maintain at the required temperature for 24 h. At the end of this period thaw the sample for not less than 24 h and not more than 96 h in an ambient temperature range of 20°C to 25°C.

- .2 repeat .2.1 above three times to give four cycles of freezing and thawing;
- .3 examine the sample for stratification and non-homogeneity; and
- .4 condition the sample for 7 days at 60°C followed by one day at room temperature.

3.2 *Heat stability*

An unopened 20 / container (or other standard shipping container) as supplied by the manufacturer from a production batch should be maintained for 7 days at 60°C, followed by one day at room temperature. Following this conditioning, the foam liquid after agitating/stirring will be subjected to the fire test as per 3.8, and comply with the requirements given in these Guidelines.

3.3 *Sedimentation*

3.3.1 Any sediment in the concentrate prepared in accordance with section 2 should be dispersible through a 180 µm sieve, and the percentage volume of sediment should not be more than 0.25% when tested in accordance with 3.3.2.

3.3.2 The test should be carried out as follows:

- .1 Apparatus:
- .1 graduated centrifuge tubes;
 - .2 centrifuge operating at $6,000 \pm 100 \text{ m/s}^2$;
 - .3 180 µm sieve complying with ISO 3310-1; and

.4 plastic wash bottle.

Note: A centrifuge and tubes complying with ISO 3734 are suitable.

.2 Procedure:

Centrifuge each sample for 10 min. Determine the volume of the sediment and determine the percentage of this volume with respect to the centrifuged sample volume. Wash the contents of the centrifuge tube onto the sieve and check that the sediment can or cannot be dispersed through the sieve by the jet from the plastic wash bottle.

Note: It is possible that the test method is not suitable for some non-Newtonian foam concentrates. In this case an alternative method, to the satisfaction of the Administration, should be used so that compliance with this requirement can be verified.

3.4 *Kinematic viscosity*

3.4.1 The test should be carried out according to ASTM D 445-86 or ISO 3104. Kinematic viscosity should not exceed 200 mm²/s.

3.4.2 The method for determining viscosity of non-Newtonian foam concentrates should be to the satisfaction of the Administration.

3.5 *pH value*

The pH value of the foam concentrate should be not less than 6 and not more than 10 at temperature of 20 + 2°C.

3.6 *Expansion ratio*

3.6.1 The test should be carried out in accordance with 3.6.2 with seawater at about 20°C. Simulated seawater with the characteristics stated under 3.6.3 may be used. The expansion ratio obtained with the foam generators used on board should be consistent with the expansion ratio obtained with the foam generators during the fire test.

3.6.2 Determination of the expansion ratio:

.1 Apparatus:

.1 plastic collecting vessel of volume (V), approximately 200 l and accurately known to + 2 l;

(An example of suitable vessel is given in ISO 7203-2)

.2 medium-expansion foam-making equipment which when tested with water has a flow rate not less than 3 + 0.1 l/min at a nozzle pressure of 5 + 0.1 bar.

(An example of suitable apparatus is given in ISO 7203-2).

.2 Procedure:

- .1 wet the vessel internally and weight it (W_1). Set up the foam equipment and adjust the nozzle pressure of 5 + 0.1 bar. With the discharge facility closed, collect the foam in the vessel. As soon as the vessel is full, stop collecting foam and strike the foam surface level with the rim. Weigh the vessel (W_2). During the filling operation, keep the discharge facility in the bottom of the vessel closed until the total weight of the foam is determined;
- .2 calculate the expansion E from the equation:

$$E = \frac{V}{W_2 - W_1}$$

where it is assumed that the density of the foam solution is 1.0 kg/l;

V is the vessel volume, in *ml*;

W_1 is the mass of the empty vessel, in grams; and

W_2 is the mass of the full vessel, in grams;

- .3 open the drainage facility and measure the 50% drainage time (see 3.7.1 below).

Determine the drainage either by having the vessel on a scale and recording the weight loss, or by collecting the drained foam solution in a measuring cylinder.

3.6.3 Simulated seawater may be made up by dissolving:

- 25 g Sodium chloride (NaCl),
- 11 g Magnesium chloride ($MgCl_2 \cdot 6H_2O$),
- 1.6 g Calcium chloride ($CaCl_2 \cdot 2H_2O$),
- 4 g Sodium sulphate (Na_2SO_4).

3.7 Drainage time

3.7.1 The drainage time should be determined, after having determined the expansion ratio, in accordance with 3.6.2.3.

3.7.2 The test should be carried out with seawater at about 20°C. Simulated seawater with the characteristics stated in 3.6.3 may be used.

3.7.3 Drainage time obtained with the foam generators used on board should be consistent with the drainage time obtained with the foam generators during the fire test.

3.8 *Fire tests*

Fire tests should be carried out in accordance with 3.8.1 to 3.8.7 below.

Note: The fire tests of section 3.8 are more expensive and time consuming than the other tests of these Guidelines. It is recommended that fire tests should be carried out at the end of the test programme, so as to avoid expense of unnecessary testing of foam concentrates which do not comply in other respects.

3.8.1 Environmental conditions

- .1 Air temperature: $15 \pm 5^{\circ}\text{C}$.
- .2 Maximum wind speed: 3 m/s in proximity of the fire tray.

3.8.2 Records

During the fire test, the following should be recorded:

- .1 indoor or outdoor test;
- .2 air temperature;
- .3 fuel temperature;
- .4 water temperature;
- .5 foam solution temperature;
- .6 wind speed; and
- .7 extinction time.

3.8.3 Foam solution

- .1 Prepare a foam solution, following the recommendations from the supplier for concentration, maximum premix time, compatibility with the test equipment, avoiding contamination by other types of foam, etc.
- .2 The test should be carried out with seawater at about 20°C . Simulated seawater with the characteristics stated in 3.6.3 may be used.

3.8.4 Apparatus

- .1 Fire tray:

Circular fire tray of steel with dimensions as follows:

diameter at rim: 1,480 + 15 mm

depth: 150 + 10 mm

normal thickness of steel wall: 2.5 mm

Note: The tray has an area of approximately 1.73 m^2 .

- .2 Foam-making equipment:
In accordance with subparagraph 3.6.2.1.

3.8.5 Fuel

An aliphatic hydrocarbon mixture with physical properties according to the following specification should be used:

- | | | |
|----|---|-------------------------------|
| .1 | distillation range: | 84-105° |
| .2 | maximum difference between
initial and boiling points: | 10°C |
| .3 | maximum aromatic content: | 1% |
| .4 | density at 15°: | 707.5 + 2.5 kg/m ³ |
| .5 | temperature: | about 20°C. |

Note: Typical fuels meeting this specification are *n*-heptane and certain solvent fractions sometimes referred to as commercial heptane.

The Administration may require additional fire tests using an additional test fuel.

3.8.6 Test procedure

3.8.6.1 Place the tray directly on the ground and ensure that it is level. Add approximately 30 l of fresh water and 55 + 2 l of fuel, to give a nominal freeboard of 100 mm.

3.8.6.2 Not later than 5 min after adding of a fuel, ignite the fuel and allow it to burn free for a period of not less than 180 s after the full involvement. Set up the foam equipment at a height which is equal to the upper edge of the rim as it is shown at figure 1. 200 + 5 s after full involvement of the surface into the fire, apply foam along the wall of the tray for a period of 120 + 2 s. Record the extinction time as the period from start of foam application to extinction.

3.8.7 Permissible limits

Extinction time % not more than 120 s.

3.9 Corrosiveness

The storage container shall be compatible with its foam concentrate, throughout the service life of the foam, such that the chemical and physical properties of the foam shall not deteriorate below the initial values accepted by the Administration.

3.10 Volumic mass

According to ASTM D 1298-85.

4 Periodical controls of foam concentrates stored on board

The attention of the Administration is drawn to the fact that particular installation conditions (excessive ambient temperature, incomplete filling of the tank, etc.) may lead to an abnormal ageing of the concentrates.

For the periodical control of foam concentrate, the tests under 4.1 to 4.5 should be performed. They should be carried out at laboratories acceptable to the Administration.

The deviations in the values obtained by these tests, in respect of those obtained during the type approval tests, should be within ranges acceptable to the Administration.

Tests under 4.1, 4.3 and 4.4 should be carried out on samples maintained at 60°C for 24 h and subsequently cooled to the test temperature.

4.1 *Sedimentation*

According to 3.3 above.

4.2 *pH value*

According to 3.5 above.

4.3 *Expansion ratio*

According to 3.6 above.

4.4 *Drainage time*

According to 3.7 above.

4.5 *Volumic mass*

According to 3.10 above.

5 Intervals of periodical controls

5.1 The first periodical control of foam concentrates stored on board should be performed after a period of 3 years and, after that, every year.

5.2 A record of the age of the foam concentrates and of subsequent controls should be kept on board.

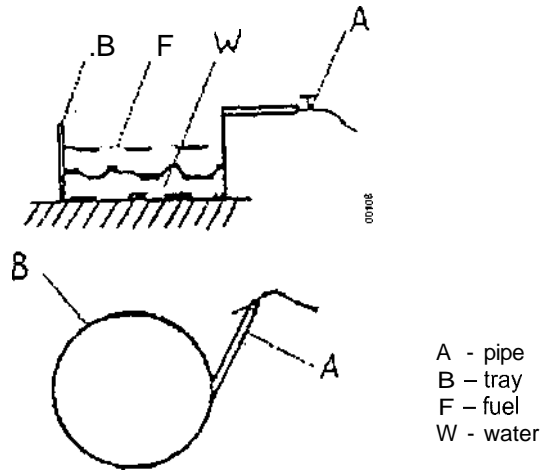


Figure 1 - Fire test arrangement of medium expansion foam

MSC/Circ.848
(8 June 1998)

Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms

1 The Maritime Safety Committee, at its sixty-seventh session (2 to 6 December 1996), approved Guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms, as MSC/Circ.776.

2 The Sub-Committee on Fire Protection, at its forty-second session (8 to 12 December 1997), recognized the need of technical improvement to the Guidelines contained in MSC/Circ.776 to assist in their proper implementation and, to that effect, prepared amendments to the Guidelines.

3 The Committee, at its sixty-ninth session (11 to 20 May 1998), approved Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms, as set out in the annex, to supersede the Guidelines attached to MSC/Circ.776.

4 Member Governments are invited to apply the annexed Guidelines when approving equivalent fixed gas fire-extinguishing systems for use in machinery spaces of category A and cargo pump-rooms.

Annex

Revised guidelines for the approval of equivalent fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces and cargo pump-rooms

General

1 Fixed gas fire-extinguishing systems for use in machinery spaces of category A and cargo pump-rooms equivalent to fire-extinguishing systems required by SOLAS regulations II-2/7 and II-2/63 should prove that they have the same reliability which has been identified as significant for the performance of fixed gas fire-extinguishing systems approved under the requirements of SOLAS regulation II-2/5. In addition, the system should be shown by test to have the capability of extinguishing a variety of fires that can occur in a ship's engine-room.

Principal requirements

2 All requirements of SOLAS regulations II-2/5.1, 5.3.1, 5.3.2 to 5.3.3, except as modified by these Guidelines, should apply.

3 The minimum extinguishing concentration should be determined by a cup burner test acceptable to the Administration. The design concentration should be at least 20% above the minimum extinguishing concentration. These concentrations should be verified by full-scale testing described in the test method, as set out in the appendix.

4 For systems using halocarbon clean agents, 95% of the design concentration should be discharged in 10 s or less. For inert gas systems, the discharge time should not exceed 120 s for 85% of the design concentration.

5 The quantity of extinguishing agent for the protected space should be calculated at the minimum expected ambient temperature using the design concentration based on the net volume of the protected space, including the casing.

5.1 The net volume of a protected space is that part of the gross volume of the space which is accessible to the free extinguishing agent gas.

5.2 When calculating the net volume of a protected space, the net volume should include the volume of the bilge, the volume of the casing and the volume of free air contained in air receivers that in the event of a fire is released into the protected space.

5.3 The objects that occupy volume in the protected space should be subtracted from the gross volume of the space. They include, but are not necessarily limited to:

- auxiliary machinery;
- boilers;
- condensers;
- evaporators;
- main engines;
- reduction gears;
- tanks; and
- trunks.

5.4 Subsequent modifications to the protected space that alter the net volume of the space shall require the quantity of extinguishing agent to be adjusted to meet the requirements of this paragraph and paragraph 6.

6 No fire suppression agent should be used which is carcinogenic, mutagenic, or teratogenic at concentrations expected during use. No agent should be used in concentrations greater than the cardiac sensitization NOAEL (No Observed Adverse Effect Level), without the use of controls as provided in SOLAS regulations II-2/5.2.5.1 and 5.2.5.2. In no case should an agent be used above its LOAEL (Lowest Observed Adverse Effects Level) nor ALC (Approximate Lethal Concentration) calculated on the net volume of the protected space at the maximum expected ambient temperature.

7 The system and its components should 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 ships.

8 The system and its components should be designed and installed in accordance with international standards acceptable to the Organization* and manufactured and tested to the satisfaction of the Administration. As a minimum, the design and installation standards should cover the following elements:

- .1 safety:
 - toxicity;
 - noise, nozzle discharge; and
 - decomposition products;

* Until international standards are developed, national standards acceptable to the Administration should be used. Available national standards include, e.g., Standards of Australia, the United Kingdom and NFPA 2001.

- .2 storage container design and arrangement:
 - strength requirements;
 - maximum/minimum fill density, operating temperature range;
 - pressure and weight indication;
 - pressure relief; and
 - agent identification and lethal requirements;
- .3 agent supply, quantity, quality standards;
- .4 pipe and fittings:
 - strength, material, properties, fire resistance; and
 - cleaning requirements;
- .5 valves:
 - testing requirements;
 - corrosion resistance; and
 - elastomer compatibility;
- .6 nozzles:
 - height and area testing requirements; and
 - corrosion and elevated temperature resistance;
- .7 actuation and control systems:
 - testing requirements; and
 - back-up power requirements;
- .8 alarms and indicators:
 - predischARGE alarm, agent discharge alarms as time delays;
 - abort switches;
 - supervisory circuit requirements; and
 - warning signs and audible and visual alarms should be located outside each entry to the relevant space as appropriate;
- .9 agent flow calculation:
 - approval and testing of design calculation method; and
 - fitting losses and/or equivalent length;
- .10 enclosure integrity and leakage requirements:
 - enclosure leakage;
 - openings; and

mechanical ventilation interlocks;

- .11 design concentration requirements, total flooding quantity;
- .12 discharge time; and
- .13 inspection, maintenance, and testing requirements.

9 The nozzle type, maximum nozzle spacing, maximum height and minimum nozzle pressure should be within limits tested to provide fire extinction per the proposed test method.

10 Provisions should be made to ensure that escape routes which are exposed to leakage from the protected space are not rendered hazardous during or after discharge of the agent. Control stations and other locations that require manning during a fire situation should have provisions to keep HF and HCl below 5 ppm at that location. The concentrations of other products should be kept below concentrations considered hazardous for the required duration of exposure.

11 Agent containers may be stored within a protected machinery space if the containers are distributed throughout the space and the provisions of SOLAS regulation II-2/5.3.3 are met. The arrangement of containers and electrical circuits and piping essential for the release of any system should be such that in the event of damage to any one power release line through fire or explosion in the protected space, i.e. a single fault concept, at least five-sixths of the fire-extinguishing charge as required by paragraph 5 of this annex can still be discharged having regard to the requirement for uniform distribution of medium throughout the space. The arrangements in respect of systems for spaces requiring less than six containers should be to the satisfaction of the Administration.

12 A minimum agent hold time of 15 min should be provided.

13 The release of an extinguishing agent may produce significant over and under pressurization in the protected space. Measures to limit the induced pressures to acceptable limits should be provided.

14 For all ships, the fire-extinguishing system design manual should address recommended procedures for the control of products of agent decomposition. The performance of fire-extinguishing arrangements on passenger ships should not present health hazards from decomposed extinguishing agents, e.g., on passenger ships, the decomposition products should not be discharged in the vicinity of muster (assembly) stations.

Appendix

Test method for fire testing of fixed gas fire-extinguishing systems

1 Scope

1.1 This test method is intended for evaluating the extinguishing effectiveness of fixed gas fire-extinguishing systems for the protection of machinery spaces of category A and cargo pump-rooms.

1.2 Fire-extinguishing systems presently covered in SOLAS regulation II-2/5, as amended, are excluded.

1.3 The test method covers the minimum requirements for fire extinguishing.

1.4 This test method is applicable to gases, liquefied gases and mixtures of gases. The test method is not valid for extinguishant gases mixed with compounds in solid or liquid state at ambient conditions.

1.5 The test programme has two objectives: (1) establishing the extinguishing effectiveness of a given agent at its tested concentration, and (2) establishing that the particular agent distribution system puts the agent into the enclosure in such a way as to fully flood the volume to achieve an extinguishing concentration at all points.

2 Sampling

The components to be tested should be supplied by the manufacturer together with design and installation criteria, operational instructions, drawings and technical data sufficient for the identification of the components.

3 Method of test

3.1 *Principle*

This test procedure enables the determination of the effectiveness of different gaseous agent extinguishing systems against spray fires, pool fires and class A fires.

3.2 *Apparatus*

3.2.1 Test room

The tests should be performed in a 100 m² room, with no horizontal dimension less than 8 m, with a ceiling height of 5 m. The test room should be provided with a closable access door measuring approximately 4 m² in

area. In addition, closable ventilation hatches measuring at least 6 m² in total area should be located in the ceiling.

3.2.2 Integrity of test enclosure

The test enclosure is to be nominally leak tight when doors and hatches are closed. The integrity of seals on doors, hatches, and other penetrations (e.g., instrumentation access ports) must be verified before each test.

3.2.3 Engine mock-up

- .1 An engine mock-up of size (width x length x height) 1 m x 3 m x 3 m should be constructed of sheet steel with a nominal thickness of 5 mm. The mock-up should be fitted with two steel tubes diameter 0.3 m and 3 m length that simulate exhaust manifolds and a solid steel plate. At the top of the mock-up a 3 m² tray should be arranged. See figures 1, 2 and 3.
- .2 A floor plate system 4 m x 6 m x 0.75 m high shall surround the mock-up. Provision shall be made for placement of the fuel trays, described in table 1, and located as described in table 2.

3.2.4 Instrumentation

Instrumentation for the continuous measurement and recording of test conditions should be employed. The following measurements should be made:

- .1 temperature at three vertical positions (e.g., 1, 2.5, and 4.5 m)
- .2 enclosure pressure
- .3 gas sampling and analysis, at mid-room height, for oxygen, carbon dioxide, carbon monoxide, and relevant halogen acid products, e.g., hydrogen iodide, hydrofluoric acid, hydrochloric acid
- .4 means of determining flame-out indicators
- .5 fuel nozzle pressure in the case of spray fire
- .6 fuel flow rate in the case of spray fires
- .7 discharge nozzle pressure

3.2.5 Nozzles

3.2.5.1 For test purposes, nozzles should be located within 1 m of the ceiling.

3.2.5.2 If more than one nozzle is used they should be symmetrically located.

3.2.6 Enclosure temperature

The ambient temperature of the test enclosure at the start of the test should be noted and serve as the basis for calculating the concentration that the agent would be expected to achieve at that temperature and with that agent weight applied in the test volume.

3.3 Test fires and programme

3.3.1 Fire types

The test programme, as described in table 3, should employ test fires as described in table 1.

Table 1 - Parameters of test fires

Fire	Type	Fuel	Fire size, MW	Remarks
A	76-100 mm ID Can	Heptane	0.0012 to 0.002	Tell tale
B	0.25 m ² Tray	Heptane	0.35	
C	2 m ² Tray	Diesel/Fuel oil	3	
D	4 m ² Tray	Diesel/Fuel oil	6	
E	Low pressure spray	Heptane 0.16 ± 0.01 kg/s	5.8	
F	Low pressure, low flow spray	Heptane 0.03 + 0.005 kg/s	1.1	
G	High pressure spray	Diesel/Fuel oil 0.05 ± 0.002 kg/s	1.8	
H	Wood crib	Spruce or fir	0.3	See note 2
I	0.10 m ² tray	Heptane	0.14	

Notes to table 1:

¹ Diesel/Fuel oil means light diesel or commercial fuel oil.

² The wood crib should be substantially the same as described in ISO/TC 21/SC5/WG 8 ISO Draft International Standard, *Caseous fire extinguishing systems, Part 1: General Requirements*. The crib should consist of six, trade size 50 mm x 50 mm by 450 mm long, kiln dried spruce or fir lumber having a moisture content between 9% and 13%. The members should be placed in 4 alternate layers at right angles to one another. Members should be evenly spaced forming a square structure.

Achieve ignition of the crib by burning commercial grade heptane in a square steel tray 0.25 m² in area. During the pre-burn period the crib should be placed centrally above the top of the tray a distance of 300 to 600 mm.

Table 2 - Spray fire test parameters

Fire type	Low pressure (E)	Low pressure, Low flow (F)	High pressure (G)
Spray nozzle	Wide spray angle (120 to 125°) full cone type	Wide spray angle (80°) full cone type	Standard angle (at 6 bar) full cone type
Nominal fuel pressure	8 bar	8.5 bar	150 bar
Fuel flow	0.16 + 0.01 kg/s	0.03 ± 0.005 kg/s	0.050 ± 0.002 kg/s
Fuel temperature	20 ± 5°C	20 ± 5°C	20 ± 5°C
Nominal heat release rate	5.8 ± 0.6 MW	1.1 + 0.1 MW	1.8 + 0.2 MW

3.3.2 Test programme

The fire test programme should employ test fires singly or in combination, as outlined in table 3.

Table 3 - Test Programme

Test No.	Fire Combinations (See table 1)
1	A: Tell-tales, 8 corners. See note 1.
2-a See note 2	B: 0.25 m ² heptane tray under engine mock-up E: Horizontal LP spray directed at 15–25 mm rod 0.5 m away C: HP diesel/fuel oil spray on top of engine mock-up Total fire load: 7.95 MW
2-b See note 2	B: 0.25 m ² heptane tray under mock-up I: 0.10 m ² heptane tray on deck plate located below solid steel obstruction plate Total fire load: 0.49 MW
3	C: 2 m ² diesel/fuel oil tray on deck plate located below solid steel obstruction plate H: Wood crib positioned as in figure 1 F: Low pressure, low flow horizontal spray - concealed - with impingement on inside of engine mock-up wall. Total fire load: 4.4 MW
4	D: 4 m ² Diesel tray under engine mock-up Total fire load: 6 MW

Notes to table 3:

- ¹ Tell-tale fire cans should be located as follows:
 - (a) in upper corners of enclosure 150 mm below ceiling and 50 mm from each wall;
 - (b) in corners on floors 50 mm from walls.
- ² Test 2-a is for use in evaluating extinguishing systems having discharge times of 10 s or less. Test 2-b is for use in evaluating extinguishing systems having discharge times greater than 10 s.

3.3.2.1 All applicable tests of table 3 should be conducted for every new fire extinguishant gas, or mixture of gases.

3.3.2.2 Only test 1 is required to evaluate new nozzles and related distribution system equipment (hardware) for systems employing fire extinguishants that have successfully completed the requirements of 3.3.2.1. Test 1 should be conducted to establish and verify the manufacturer's minimum nozzle design pressure.

3.4 *Extinguishing system*

3.4.1 System installation

The extinguishing system should be installed according to the manufacturer's design and installation instructions. The maximum vertical distance should be limited to 5 m.

3.4.2 Agent

3.4.2.1 Design concentration

The agent design concentration is that concentration (in volume per cent) required by the system designer for the fire protection application.

3.4.2.2 Test concentration

The concentration of agent to be used in the fire extinguishing tests should be the design concentration specified by the extinguishing system manufacturer, except for test 1 which should be conducted at 83% of the manufacturer's recommended design concentration but in no case at less than the cup burner extinguishing concentration.

3.4.2.3 Quantity of agent

The quantity of agent to be used should be determined as follows:

3.4.2.3.1 Halogenated agents

$$W = (V/S) \cdot C / (100 - C)$$

where:

W = agent mass, kg

V = volume of test enclosure, m³

S = agent vapour specific volume at temperature and pressure of the test enclosure, kg/m³

C = gaseous agent concentration, volume per cent.

3.4.2.3.2 Inert gas agents

$$Q = V[294/(273 + T)] \cdot (P/1.013) \cdot \ln[100/(100 - C)]$$

where:

Q = volume of inert gas, measured at 294 K and 1.013 bar, discharged, m³

V = volume of test enclosure, m³

T = test enclosure temperature, Celsius

P = test enclosure pressure, bar

C = gaseous agent concentration, volume per cent.

3.5 *Procedure***3.5.1** Fuel levels in trays

The trays used in the test should be filled with at least 30 mm fuel on a water base. Freeboard should be 150 + 10 mm.

3.5.2 Fuel flow and pressure measurements

For spray fires, the fuel flow and pressure should be measured before and during each test.

3.5.3 Ventilation**3.5.3.1** Pre-burn period

During the pre-burn period the test enclosure should be well ventilated. The oxygen concentration, as measured at mid-room height, shall not be less than 20 volume per cent at the time of system discharge.

3.5.3.2 End of pre-burn period

Doors, ceiling hatches, and other ventilation openings should be closed at the end of the pre-burn period.

3.5.4 Duration of test**3.5.4.1** Pre-burn time

Fires should be ignited such that the following burning times occur before the start of agent discharge:

- .1 sprays - 5 to 15 s
- .2 trays - 2 min
- .3 crib - 6 min

3.5.4.2 Discharge time:

- .1 Halogenated agents should be discharged at a rate sufficient to achieve delivery of 95% of the minimum design quantity in 10 s or less.
- .2 Inert gas agents should be discharged at a rate sufficient to achieve 85% of the minimum design quantity in 120 s or less.

3.5.4.3 Soak time

After the end of agent discharge the test enclosure should be kept closed for 15 min.

3.5.5 Measurements and observations

3.5.5.1 Before test:

- .1 temperature of test enclosure, fuel and engine mock-up;
- .2 initial weights of agent containers;
- .3 verification of integrity agent distribution system and nozzles; and
- .4 initial weight of wood crib.

3.5.5.2 During test:

- .1 start of the ignition procedure;
- .2 start of the test (ignition);
- .3 time when ventilating openings are closed;
- .4 time when the extinguishing system is activated;
- .5 time from end of agent discharge;
- .6 time when the fuel flow for the spray fire is shut off;
- .7 time when all fires are extinguished;
- .8 time of re-ignition, if any, during soak period;
- .9 time at end of soak period; and
- .10** at the start of test initiate continuous monitoring as per 3.2.4.

3.5.6 Tolerances

Unless otherwise stated, the following tolerances should apply:

- .1 length + 2% of value;
- .2 volume + 5% of value;
- .3 pressure \pm 3% of value;
- .4 temperature + 5% of value;
- .5 concentration + 5% of value.

These tolerances are in accordance with ISO standard 6182/1, February 1994 edition [4].

4 Classification criteria

4.1 Class B fires must be extinguished within 30 s of the end of agent discharge. At the end of the soak period there should be no re-ignition upon opening the enclosure.

4.2 The fuel spray should be shut off 15 s after extinguishment. At the end of the soak time, the fuel spray should be restarted for 15 s prior to reopening the door and there should be no re-ignition.

4.3 At the end of the test fuel trays must contain sufficient fuel to cover the bottom of the tray.

4.4 Wood crib weight loss must be no more than 60%.

5 Test report

The test report should include the following information:

- .1 name and address of the test laboratory;
- .2 date and identification number of the test report;
- .3 name and address of client;
- .4 purpose of the test;
- .5 method of sampling system components;
- .6 name and address of manufacturer or supplier of the product;
- .7 name or other identification marks of the product;
- .8 description of the tested product;
 - drawings
 - descriptions
 - assembly instructions
 - specification of included materials
 - detailed drawing of test set-up;
- .9 date of supply of the product;
- .10** date of test;
- .11** test method;
- .12** drawing of each test configuration;
- .13** identification of the test equipment and used instruments;
- .14** conclusions;
- .15** deviations from the test method, if any;
- .16** test results including measurements and observations during and after the test; and
- .17** date and signature.

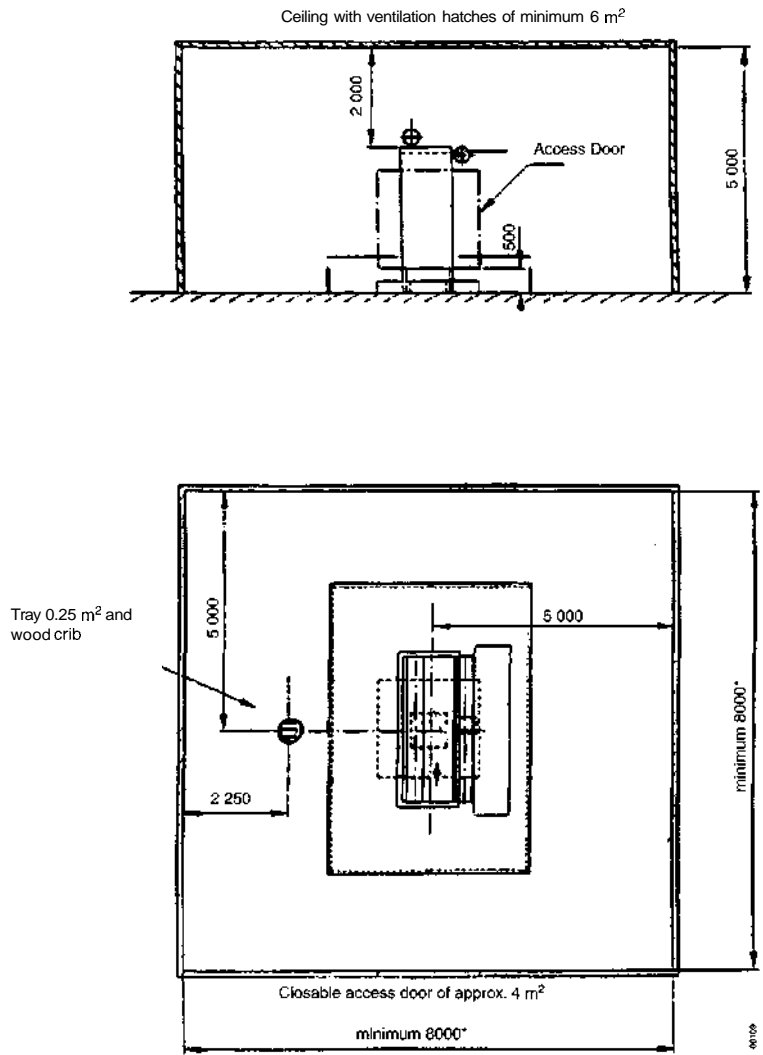
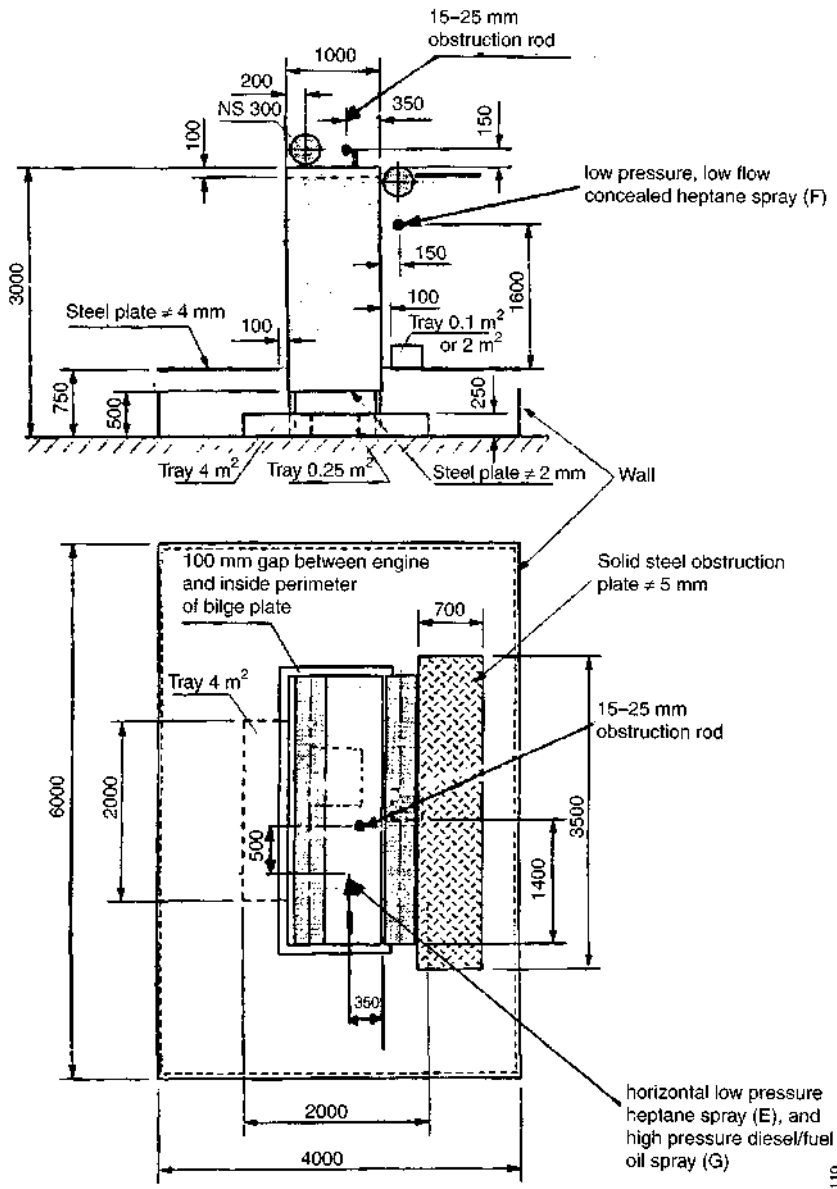


Figure 1

* The area should be 100 m².



60110

Figure 2

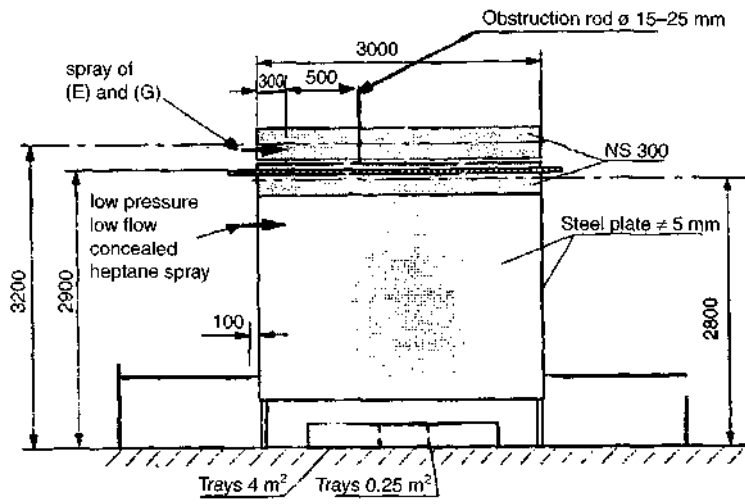


Figure 3

MSC/Circ.1007
(26 June 2001)

**Guidelines for the approval of fixed aerosol
fire-extinguishing systems equivalent to fixed
gas fire-extinguishing systems, as referred
to in SOLAS 74, for machinery spaces**

1 The Maritime Safety Committee, at its seventy-fourth session (30 May to 8 June 2001), approved Guidelines for the approval of fixed aerosol fire-extinguishing systems equivalent to fixed gas fire-extinguishing systems, as referred to in SOLAS 74, for machinery spaces, as set out in the annex.

2 Member Governments are invited to apply the annexed Guidelines when approving fixed aerosol fire-extinguishing systems for use in machinery spaces of category A.

Annex

**Guidelines for the approval of fixed aerosol
fire-extinguishing systems equivalent to fixed
gas fire-extinguishing systems, as referred
to in SOLAS 74, for machinery spaces**

General

1 Fixed aerosol fire-extinguishing systems for use in machinery spaces of category A equivalent to fire-extinguishing systems required by SOLAS regulation II-2/7* should prove that they have the same reliability which has been identified as significant for the performance of fixed gas fire-extinguishing systems approved under the requirements of SOLAS regulation II-2/5.† In addition, the system should be shown by testing according to the appendix to have the capability of extinguishing a variety of fires that can occur in machinery spaces.

* Refer to regulation II-2/10.5 of SOLAS chapter II-2, as adopted by resolution MSC.99(73).

† Refer to regulation II-2/10.4 of SOLAS chapter II-2, as adopted by resolution MSC.99(73).

2 Aerosol fire-extinguishing systems involve the release of a chemical agent to extinguish a fire by interruption of the process of the fire.

There are two methods considered for applying the aerosol agent to the protected space:

- .1 condensed aerosols are created in pyrotechnical generators through the combustion of the agent charge; and
- .2 dispersed aerosols that are not pyrotechnically generated and are stored in containers with carrier agents (such as inert gases or halocarbon agents) with the aerosol released in the space through valves, pipes and nozzles.

Definitions

3 *Aerosol* is a non ozone depleting fire-extinguishing medium consisting of either condensed aerosol or dispersed aerosol.

4 *Generator* is a device for creating a fire-extinguishing medium by pyrotechnical means.

5 *Design density* (g/m^3) is the mass of an aerosol forming composition per m^3 of the enclosure volume required to extinguish a specific type of fire, including a safety factor.

6 *Agent - medium* for the purpose of these Guidelines, these words are interchangeable.

Principal requirements

7 All requirements of SOLAS regulations II-2/5.1,* 5.3.1, 5.3.2 to 5.3.3 except as modified by these Guidelines, should apply, where applicable.

8 The minimum agent density should be determined and verified by the full-scale testing described in the test method, as set out in the appendix.

9 For aerosol systems, the discharge time should not exceed 120 s for 85% of the design density. Systems may need to discharge in a shorter time for other reasons than for fire-extinguishing performance.

10.1 The quantity of extinguishing agent for the protected space should be calculated at the minimum expected ambient temperature using the design density based on the net volume of the protected space, including the casing.

* Refer to regulation II-2/10.9.1.1.1 of SOLAS chapter II-2, as adopted by resolution MSC.99(73).

10.2 The net volume of a protected space is that part of the gross volume of the space, which is accessible to the fire-extinguishing agent.

10.3 When calculating the net volume of a protected space, the net volume should include the volume of the bilge, the volume of the casing and the volume of free air contained in air receivers that in the event of a fire may be released into the protected space.

10.4 The objects that occupy volume in the protected space should be subtracted from the gross volume of the space. They include, but are not necessarily limited to:

- .1 auxiliary machinery;
- .2 boilers;
- .3 condensers;
- .4 evaporators;
- .5 main engines;
- .6 reduction gears;
- .7 tanks; and
- .8 trunks.

10.5 Subsequent modifications to the protected space that alter the net volume of the space should require the quantity of extinguishing agent to be adjusted to meet the requirements of this paragraph and paragraphs 10.1, 10.2, 10.3, 10.4, 11.1, 11.2 and 11.3.

11.1 No fire suppression system should be used which is carcinogenic, mutagenic or teratogenic at concentrations expected during use. All systems should employ two separate controls for releasing the extinguishing medium into a protected space. Means should 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. The alarm should operate for a suitable period* before the medium is released. Unnecessary exposure to aerosol media, even at concentrations below an adverse effect level, should be avoided.

11.2 Pyrotechnically generated aerosols: Pyrotechnically generated aerosol systems for spaces that are normally occupied should be permitted in concentrations where the aerosol particulate matter does not exceed the adverse effect level as determined by a scientifically

* Refer to the Interpretations of vague expressions and other vague wording in SOLAS chapter II-2 (MSC/Circ.847).

accepted technique* and any gases produced by the pyrotechnic generator do not exceed the No Observed Adverse Effect Level (NOAEL) for the critical toxic effect as determined in a short term toxicity test.

11.3 Dispersed aerosols: Dispersed aerosol systems for spaces that are normally occupied should be permitted in concentrations where the aerosol particulate matter does not exceed the adverse effect level as determined by a scientifically accepted technique. If the carrier gas is a halocarbon, it may be used up to its NOAEL. If a halocarbon carrier gas is to be used above its NOAEL, means should be provided to limit exposure to no longer than the time specified according to a scientifically accepted physiologically based pharmacokinetic[†] (PBPK) model or its equivalent which clearly establishes safe exposure limits both in terms of extinguishing media concentration and human exposure time. If the carrier is an inert gas, means should be provided to limit exposure to no longer than 5 min for inert gas systems designed to concentrations below 43% (corresponding to an oxygen concentration of 12%, sea level equivalent of oxygen) or to limit exposure to no longer than 3 min for inert gas systems designed to concentrations between 43% and 52% (corresponding to between 12% and 10% oxygen, sea level equivalent of oxygen).

11.4 In no case should a dispersed aerosol system be used with halocarbon carrier gas concentrations above the Lowest Observed Adverse Effect Level (LOAEL) nor the Approximate Lethal Concentration (ALC) nor should a dispersed aerosol system be used with an inert gas carrier at gas concentrations above 52% calculated on the net volume of the protected space at the maximum expected ambient temperature, without the use of controls as provided in SOLAS regulations II-2/5.2.5.1 and 5.2.5.2.[‡]

12 The system and its components should be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, impact, clogging, electromagnetic compatibility and corrosion normally encountered in machinery spaces. Generators in condensed aerosol systems should be designed to prevent self-activation at a temperature below 250°C.

* Reference is made to the United States' EPA's Regional Deposited Dose Ratio Program "Methods of Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry" EPA/600/8-90/066F, October 1994.

[†] Refer to document FP 44/INF.2 (United States) - Physiologically based pharmacokinetic model to establish safe exposure criteria for halocarbon fire extinguishing agents.

[‡] Refer to regulation II-2/10.4.1.1.1 of SOLAS chapter II-2, as adopted by resolution MSC.99(73).

13 The system and its components should be designed, manufactured and installed in accordance with standards acceptable to the Organization. As a minimum, the design and installation standards should cover the following elements:

- .1 safety:
 - .1 toxicity;
 - .2 noise, generator/nozzle discharge;
 - .3 decomposition products; and
 - .4 obscuration;
- .2 storage container design and arrangement:
 - .1 strength requirements;
 - .2 maximum/minimum fill density, operating temperature range;
 - .3 pressure and weight indication;
 - .4 pressure relief; and
 - .5 agent identification, production date, installation date and hazard classification;
- .3 agent supply, quantity, quality standards, shelf life and service life of agent and igniter;
- .4 handling and disposal of generator after service life;
- .5 pipes and fittings:
 - .1 strength, material properties, fire resistance; and
 - .2 cleaning requirements;
- .6 valves:
 - .1 testing requirements; and
 - .2 elastomer compatibility;
- .7 generators/nozzles:
 - .1 height and area testing requirements; and
 - .2 elevated temperature resistance;
- .8 actuation and control systems:
 - .1 testing requirements; and
 - .2 back-up power requirements;
- .9 alarms and indicators:
 - .1 predischage alarm, agent discharge alarms and time delays;
 - .2 supervisory circuit requirements;
 - .3 warning signs, audible and visual alarms; and
 - .4 annunciation of faults;

- .10** enclosure integrity and leakage requirements:
 - .1 enclosure leakage;
 - .2 openings; and
 - .3 mechanical ventilation interlocks;
- .11** design density requirements, total flooding quantity;
- .12** agent flow calculation:
 - .1 verification and approval of design calculation method;
 - .2 fitting losses and/or equivalent length;
 - .3 discharge time;
- .13** inspection, maintenance, service and testing requirements;
and
- .14** handling and storage requirements for pyrotechnical components.

14 The generator/nozzle type, maximum generator/nozzle spacing, maximum generator/nozzle installation height and minimum generator/nozzle pressure should be within limits tested.

15 Installations should be limited to the maximum volume tested.

16 Agent containers may be stored within a protected machinery space if the containers are distributed throughout the space and the provisions of SOLAS regulation II-2/5.3.3, as applicable, are met. The arrangement of generators, containers, electrical circuits and piping essential for the release of any system should be such that in the event of damage to any one power release line through fire or explosion in the protected space (i.e. a single fault concept), at least the design density of the fire-extinguishing charge as required in paragraph 10 above can still be discharged having regard to the requirement for uniform distribution of medium throughout the space.

17 The release of an extinguishing agent may produce significant over and under pressurization in the protected space. Measures to limit the induced pressures to acceptable limits may have to be provided.

18 For all ships, the fire-extinguishing system design manual should address recommended procedures for the control of products of agent decomposition. The performance of fire-extinguishing arrangements on passenger ships should not present health hazards from decomposed extinguishing agents, (e.g., on passenger ships, the decomposition products should not be discharged in the vicinity of assembly stations).

19 Spare parts and operating and maintenance instructions for the system should be provided as recommended by the manufacturer.

Appendix

Test method for fire testing of fixed aerosol fire-extinguishing systems

1 Scope

1.1 This test method is intended for evaluating the extinguishing effectiveness of fixed aerosol fire-extinguishing systems for the protection of machinery spaces of category A.

1.2 The test method is applicable to aerosols and covers the minimum requirements for fire-extinguishing.

1.3 The test programme has two objectives:

- .1 establishing the extinguishing effectiveness of a given agent at its tested concentration; and
- .2 establishing that the particular agent distribution system puts the agent into the enclosure in such a way as to fully flood the volume to achieve an extinguishing concentration at all points.

2 Sampling

The components to be tested should be supplied by the manufacturer together with design and installation criteria, operational instructions, drawings and technical data sufficient for the identification of the components.

3 Method of test

3.1 Principle

This test procedure is intended for the determination of the effectiveness of different aerosol agent extinguishing systems against spray fires, pool fires and class A fires.

3.2 Apparatus

3.2.1 Test room

The tests should be performed in a 100 m² room, with no horizontal dimension less than 8 m, with a ceiling height of 5 m. The test room should be provided with a closable access door measuring approximately 4 m² in

area. In addition, closable ventilation hatches measuring at least 6 m² in total area should be located in the ceiling. A larger room may be employed if approvals are sought for larger volumes.

3.2.2 Integrity of test enclosure

The test enclosure should be nominally leaktight when doors and hatches are closed. The integrity of seals on doors, hatches and other penetrations (e.g., instrumentation access ports) should be verified before each test.

3.2.3 Engine mock-up

- .1 An engine mock-up of size (width x length x height) 1 m x 3 m x 3 m should be constructed of sheet steel with a nominal thickness of 5 mm. The mock-up should be fitted with two steel tubes diameter 0.3 m and 3 m length that simulate exhaust manifolds and a solid steel plate. At the top of the mock-up, a 3 m² tray should be arranged (see figures 1, 2 and 3).
- .2 A floor plate system 4 m x 6 m x 0.75 m high should surround the mock-up. Provision should be made for placement of the fuel trays, as described in table 1, and located as described in table 2.

3.2.4 Instrumentation

Instrumentation for the continuous measurement and recording of test conditions should be employed. The following measurements should be made:

- .1 temperature at three vertical positions (e.g., 1 m, 2.5 m and 4.5 m);
- .2 enclosure pressure;
- .3 gas sampling and analysis, at mid-room height, for oxygen, carbon dioxide, carbon monoxide and other relevant products;
- .4 means of determining flame-out indicators;
- .5 fuel nozzle pressure in the case of spray fires;
- .6 fuel flow rate in the case of spray fires;
- .7 discharge nozzle pressure; and
- .8 means of determining generator discharge duration.

3.2.5 Generators/nozzles

3.2.5.1 For test purposes, generators/nozzles should be located within 1 m of the ceiling.

3.2.5.2 If more than one generator/nozzle is used, they should be symmetrically located.

3.2.6 Enclosure temperature

The ambient temperature of the test enclosure at the start of the test should be noted and serve as the basis for calculating the concentration that the agent would be expected to achieve at that temperature and with that agent weight applied in the test volume.

3.3 Test fires and programme

3.3.1 Fire types

The test programme, as described in table 3, should employ test fires as described in table 1 below.

Table 1 - Parameters of test fires

Fire	Type	Fuel	Fire size, MW	Remarks
A	76 - 100mm ID can	Heptane	0.0012 to 0.002	Tell tale
B	0.25 m ² tray	Heptane	0.35	
C	2 m ² tray	Diesel/Fuel oil	3	See note 1
D	4 m ² tray	Diesel/Fuel oil	6	See note 1
E	Low pressure, low flow spray	Heptane 0.03 + 0.005 kg/s	1.1	
F	Wood crib	Spruce or fir	0.3	See note 2
G	0.10 m ² tray	Heptane	0.14	

Notes to table 1:

- ¹ Diesel/Fuel oil means light diesel or commercial fuel oil.
- ² The wood crib should be substantially the same as described in ISO Standard 14520, *Caseous fire extinguishing systems, Part 1: General Requirements* (2000). The crib should consist of six, trade size 50 mm x 50 mm by 450 mm long, kiln dried spruce or fir lumber having a moisture content between 9% and 13%. The members should be placed in 4 alternate layers at right angles to one another. Members should be evenly spaced forming a square structure.

Ignition of the crib should be achieved by burning commercial grade heptane in a square steel tray 0.25 m² in area. During the pre-burn period the crib should be placed centrally above the top of the tray a distance of 300 to 600 mm.

Table 2 - Spray fire test parameters

Fire type	Low pressure, low flow (E)
Spray nozzle	Wide spray angle (80°) full cone type
Nominal fuel pressure	8.5 bar
Fuel flow	0.03 + 0.005 kg/s
Fuel temperature	20±5°C
Nominal heat release rate	1.1 ±0.1 MW

3.3.2 Test programme

3.3.2.1 The fire test programme should employ test fires singly or in combination, as outlined in table 3 below.

Table 3 - Test programme

Test No.	Fire combinations (See table 1)
1	A: Tell-tales, 8 corners. (See note)
2	B: 0.25 m ² heptane tray under mock-up C: 0.10 m ² heptane tray on deck plate located below solid steel obstruction plate Total fire load: 0.49 MW
3	C: 2 m ² diesel/fuel oil tray on deck plate located below solid steel obstruction plate F: Wood crib positioned as in figure 1 E: Low pressure, low flow horizontal spray - concealed - with impingement on inside of engine mock-up wall. Total fire load: 4.4 MW
4	D: 4 m ² diesel tray under engine mock-up Total fire load: 6 MW

Note to *table 3*:

Tell-tale fire cans should be located as follows:

- .1 in upper corners of enclosure 150 mm below ceiling and 50 mm from each wall; and
- .2 in corners on floors 50 mm from walls.

3.3.2.2 All applicable tests of table 3 should be conducted for every new fire-extinguishing media.

3.3.2.3 Only test 1 is required to evaluate new nozzles and related distribution system equipment (hardware) for systems employing fire-extinguishing media that have successfully completed the requirements of paragraph 3.3.2.2 above. Test 1 should be conducted to establish and verify the manufacturer's minimum nozzle design pressure.

3.4 *Extinguishing system*

3.4.1 System installation

The extinguishing system should be installed according to the manufacturer's design and installation instructions. The maximum vertical distance should be limited to 5 m.

3.4.2 Agent

3.4.2.1 Design density

The agent design density is the net mass of extinguishant per unit volume (g/m^3) required by the system designer for the fire protection application.

3.4.2.2 Test density

The test density of agent to be used in the fire-extinguishing tests should be the design density specified by the manufacturer, except for test 1, which should be conducted at not more than 77% of the manufacturer's recommended design density.

3.4.2.3 Quantity of aerosol agent

The quantity of aerosol agent to be used should be determined as follows:

$$W = V \times q \text{ (g)},$$

where:

W = agent mass (g);

V = volume of test enclosure (m^3);

q = fire-extinguishing aerosol density (g/m^3).

3.5 *Procedure*

3.5.1 Fuel levels in trays

The trays used in the test should be filled with at least 30 mm fuel on a water base. Freeboard should be 150 + 10 mm.

3.5.2 Fuel flow and pressure measurements

For spray fires, the fuel flow and pressure should be measured before and during each test.

3.5.3 Ventilation

3.5.3.1 Pre-burn period

During the pre-burn period the test enclosure should be well ventilated. The oxygen concentration, as measured at mid-room height, should not be less than 20 volume per cent at the time of system discharge.

3.5.3.2 End of pre-burn period

Doors, ceiling hatches and other ventilation openings should be closed at the end of the pre-burn period.

3.5.4 Duration of test

3.5.4.1 Pre-burn time

Fires should be ignited such that the following burning times occur before the start of agent discharge:

- .1 sprays - 5 to 15 s
- .2 trays - 2 min
- .3 crib - 6 min

3.5.4.2 Discharge time

Aerosol agents should be discharged at a rate sufficient to achieve 85% of the minimum design density in 120 s or less.

3.5.4.3 Hold time

After the end of agent discharge the test enclosure should be kept closed for 15 min.

3.5.5 Measurements and observations

3.5.5.1 Before test

- .1 temperature of test enclosure, fuel and engine mock-up;
- .2 initial weights of agent containers;
- .3 verification of integrity agent distribution system and nozzles;
and
- .4 initial weight of wood crib.

3.5.5.2 During test

- .1 start of the ignition procedure;
- .2 start of the test (ignition);
- .3 time when ventilating openings are closed;
- .4 time when the extinguishing system is activated;
- .5 time from end of agent discharge;
- .6 time when the fuel flow for the spray fire is shut off;
- .7 time when all fires are extinguished;
- .8 time of re-ignition, if any, during hold time;
- .9 time at end of hold time; and
- .10 at the start of test initiate continuous monitoring as per 3.2.4.

3.5.6 Tolerances

Unless otherwise stated, the following tolerances should apply:

- .1 length + 2% of value;
- .2 volume + 5% of value;
- .3 pressure + 3% of value;
- .4 temperature + 5% of value; and
- .5 concentration + 5% of value.

These tolerances are in accordance with ISO standard 6182/1, February 1994 edition 4.

4 Classification criteria

4.1 Class B fires should be extinguished within 30 s of the end of agent discharge. At the end of the hold period there should be no re-ignition upon opening the enclosure.

4.2 The fuel spray should be shut off 15 s after extinguishments. At the end of the hold time, the fuel spray should be restarted for 15 s prior to reopening the door and there should be no re-ignition.

4.3 The ends of the test fuel trays should contain sufficient fuel to cover the bottom of the tray.

4.4 Wood crib weight loss should be no more than 60%.

4.5 A re-ignition test should be conducted after the successful extinguishments of the tell-tale fires in test 1 (Fire A) within 30 s after completion of agent discharge. The test should involve the attempted ignition of two of the tell-tale fire containers. One container should be at

the floor level and the other at the ceiling level at the diagonally opposite corner. At 10 min after extinguishment of the fires, a remotely operated electrical ignition source should be energized for at least 10 s at each container. The test should be repeated at one min intervals four more times, the last at 14 min after extinguishment. Sustained burning for 30 s or longer of any of these ignition attempts constitutes a re-ignition test failure.

5 Test report

The test report should include the following information:

- .1 name and address of the test laboratory;
- .2 date and identification number of the test report;
- .3 name and address of client;
- .4 purpose of the test;
- .5 method of sampling system components;
- .6 name and address of manufacturer or supplier of the product;
- .7 name or other identification marks of the product;
- .8 description of the tested product;
 - .1 drawings;
 - .2 descriptions;
 - .3 assembly instructions;
 - .4 specification of included materials; and
 - .5 detailed drawing of test set-up;
- .9 date of supply of the product;
- .10** date of test;
- .11** test method;
- .12** drawing of each test configuration;
- .13** identification of the test equipment and used instruments;
- .14** conclusions;
- .15** deviations from the test method, if any;
- .16** test results including measurements and observations during and after the test; and
- .17** date and signature.

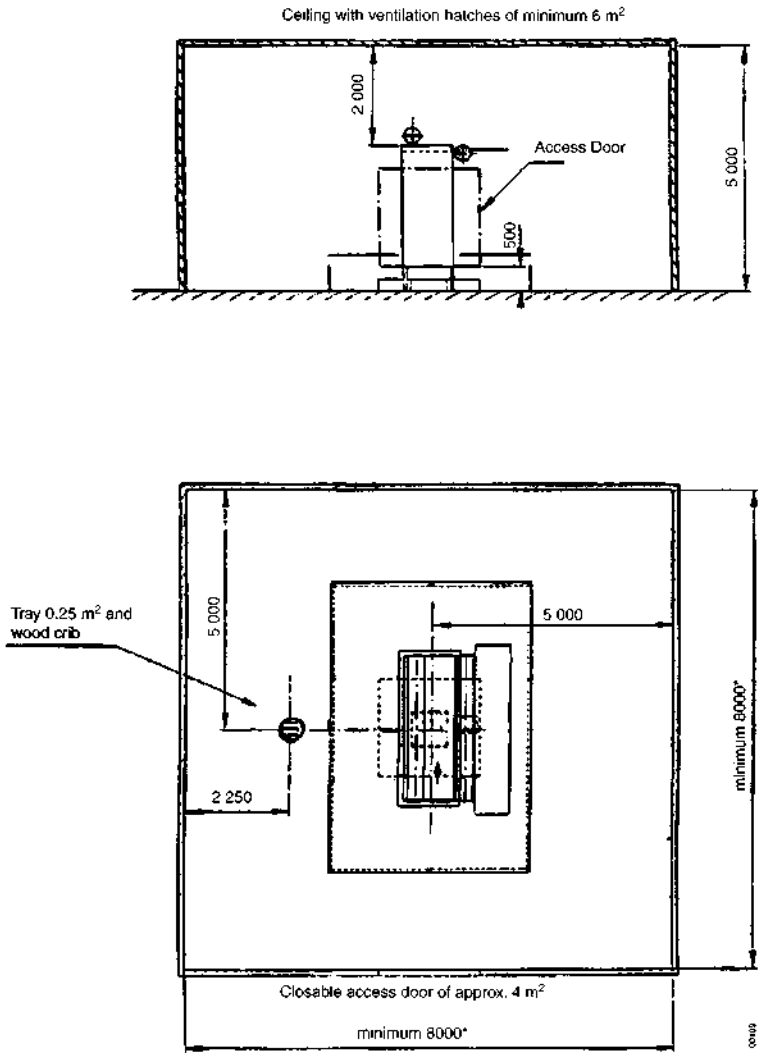


Figure 1

* The area should be 100 m².

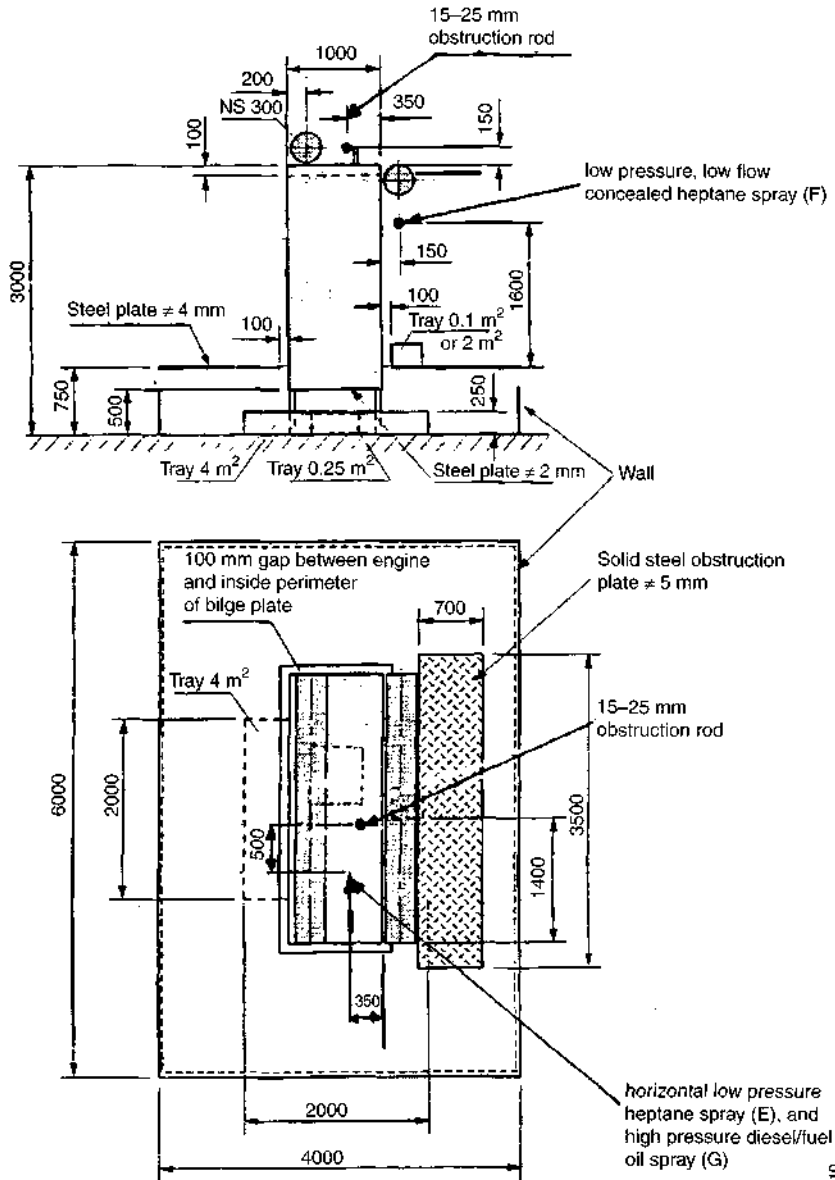


Figure 2

10

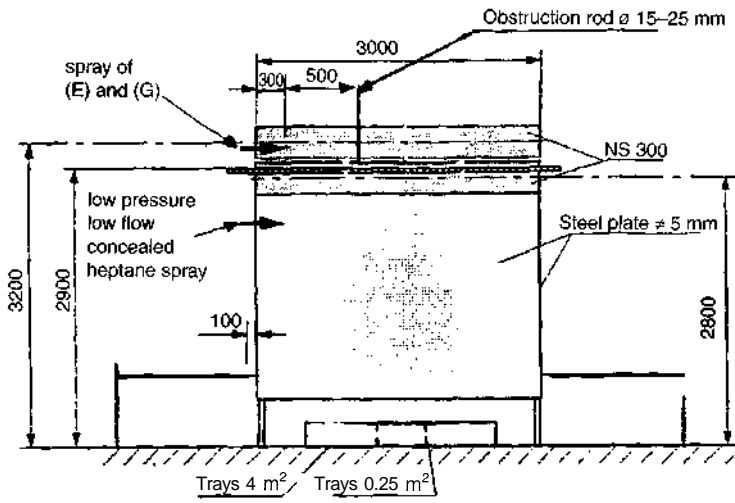


Figure 3

MSC/Circ. 1009
(8 June 2001)

**Amendments to the Revised standards for the design,
testing and locating of devices to prevent
the passage of flame into cargo tanks
in tankers (MSC/Circ.677)**

1 The Maritime Safety Committee, at its seventy-fourth session (28 May to 8 June 2001), noting that ISO standard 15364 "Ships and marine technology - Pressure/vacuum valves for cargo tanks" was completed, approved amendments to paragraph 1.2.4 of the Revised standards for design, testing and locating of devices to prevent the passage of flame into cargo tanks in tankers (MSC/Circ.677), as follows:

1.2.4 Devices should be tested and located in accordance with these standards. In addition to these standards, pressure/vacuum valves should comply with ISO standard 15364:2000 "Ships and marine technology - Pressure/vacuum valves for cargo tanks".

2 Member Governments are invited to apply the amendments to the Revised standards, in conjunction with regulation II-2/4* of the 1974 SOLAS Convention, as amended, for devices installed on or after 1 July 2002.

3 Member Governments are also invited to bring the annexed amendments to the Revised standards to the attention of ship designers, ship owners and other parties involved in the design, construction and operation of tankers.

Refers to the revised SOLAS chapter II-2, adopted by resolution MSC.99(73).

Resolution MSC.98(73)
(Adopted on 5 December 2000)

**Adoption of the International Code
for Fire Safety Systems**

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING the revision of chapter II-2 of the International Convention for the Safety of Life at Sea (SOLAS), 1974 (hereinafter referred to as the Convention),

RECOGNIZING the need to continue the mandatory application of the fire safety systems required by the revised chapter II-2 of the Convention,

NOTING resolution MSC.99(73) by which it adopted, *inter alia*, the revised chapter II-2 of the Convention to make the provisions of the International Code for Fire Safety Systems (FSS Code) mandatory under the Convention,

HAVING CONSIDERED, at its seventy-third session, the text of the proposed FSS Code,

1. ADOPTS the International Code for Fire Safety Systems (FSS Code), the text of which is set out in the annex* to the present resolution;
2. INVITES Contracting Governments to the Convention to note that the FSS Code will take effect on 1 July 2002 upon the entry into force of the revised chapter II-2 of the Convention;
3. REQUESTS the Secretary-General to transmit certified copies of this resolution and the text of the FSS Code contained in the annex to all Contracting Governments to the Convention;
4. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and the annex to all Members of the Organization which are not Contracting Governments to the Convention.

See page 1.