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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.

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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.

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/m³)* is the mass of an aerosol forming composition per m³ 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.

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* 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).

*** Refer to regulation II-2/10.9.1.1.1 of SOLAS chapter II-2, as adopted by resolution MSC.99(73).

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.

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.

* Refer to the Interpretations of vague expressions and other vague wording in SOLAS chapter II-2 (MSC/Circ.847).

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 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.

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;

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* 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).

.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 backup power requirements;

.9 alarms and indicators:

.1 predischarge 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. he 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 100 m^2 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 m^2 in area. In addition, closable ventilation hatches measuring at least 6 m^2 in total area should be located in the ceiling. 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 m^2 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 - 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	(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, *Gaseous 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 m^2 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 G: 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 reignition 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 reignition.

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 reignition 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 reignition 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.

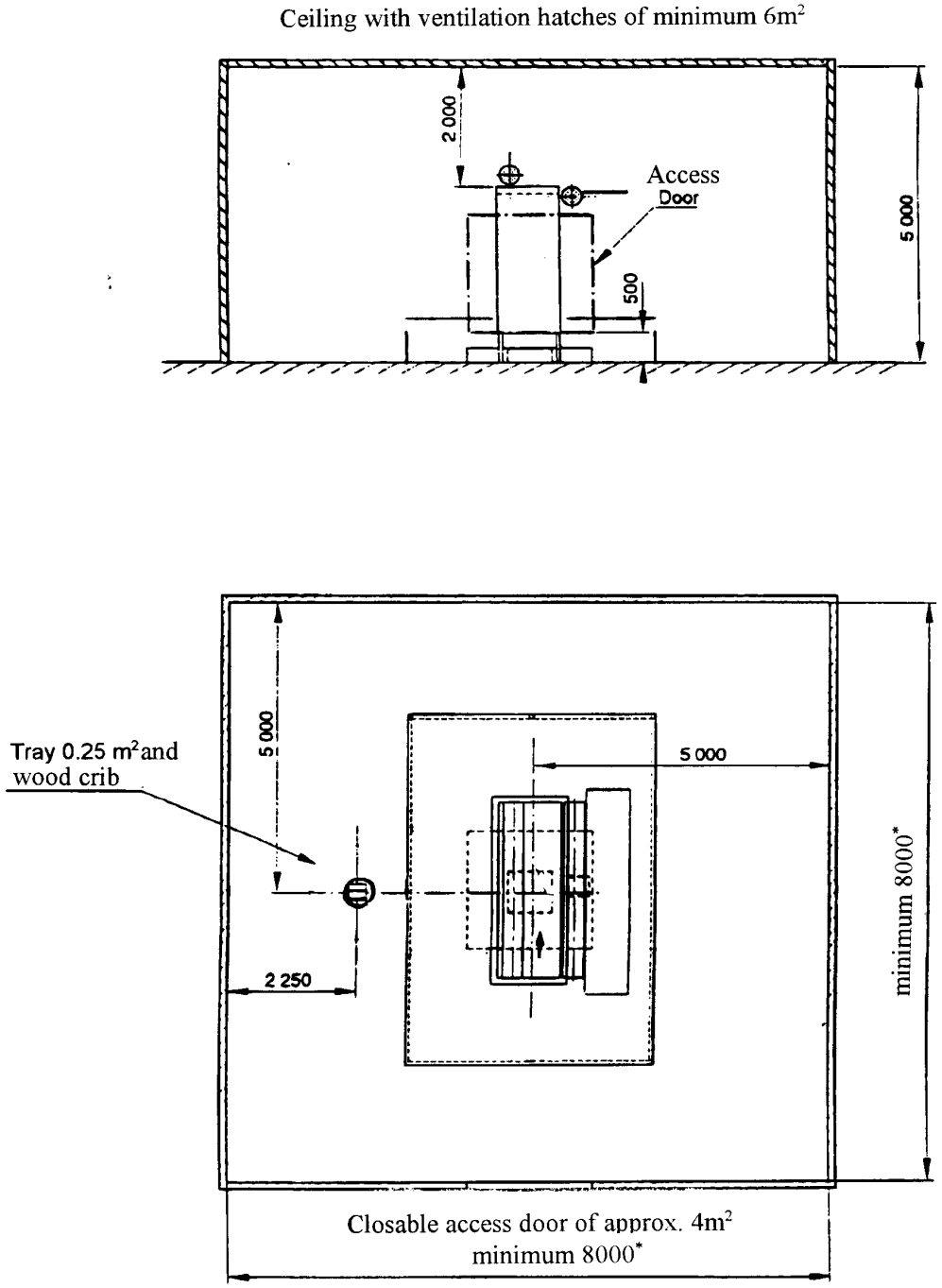

Figure 1

*The area should be 100m²

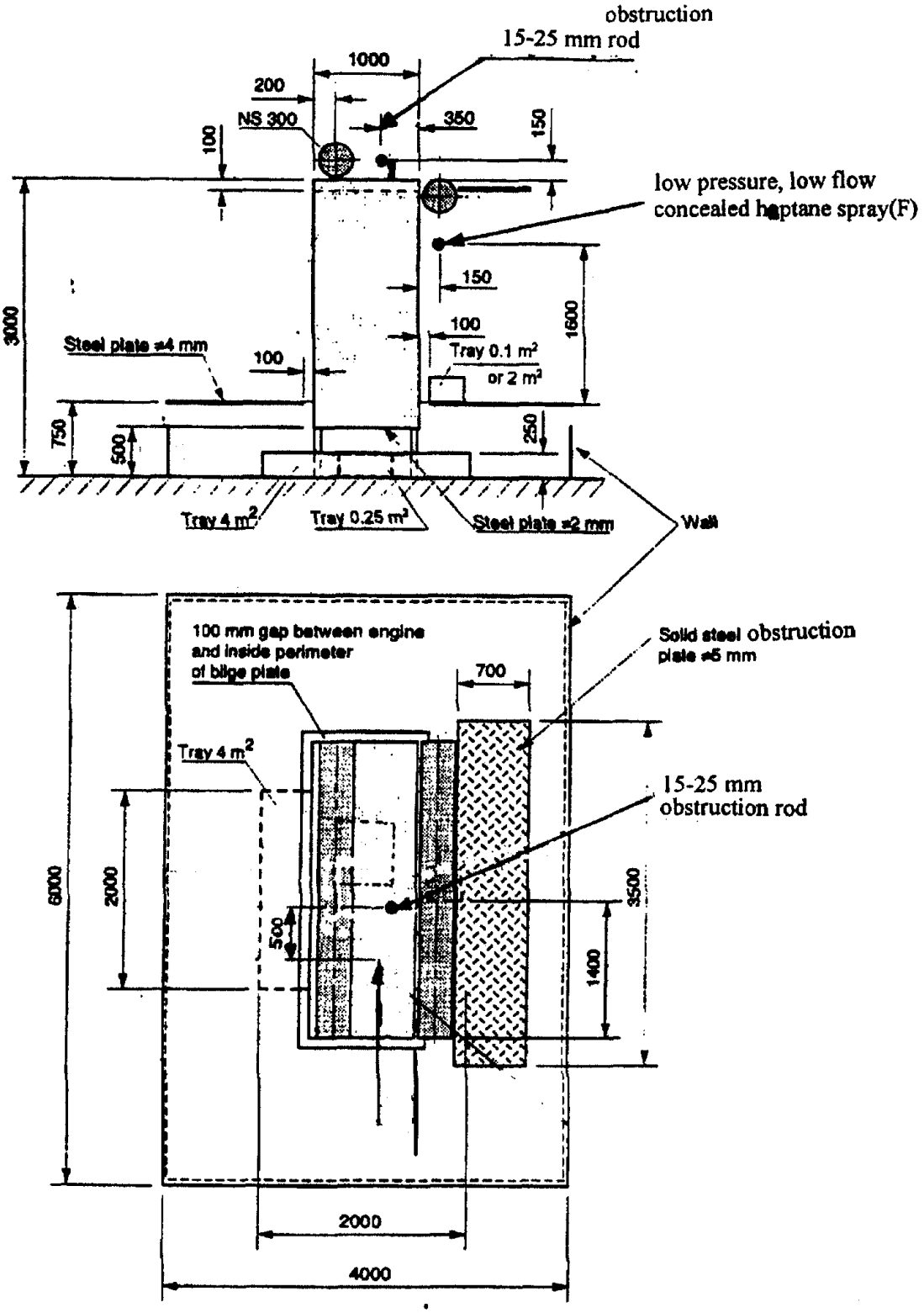
obstruction
15-25 mm rod
1000
200
NS 300
350
150
100
low pressure, low flow
concealed heptane spray(F)
150
100
1600
3000
Steel plate =4 mm
100
Tray 0.1 m²
or 2 m²
750
500
250
Tray 4 m²
Tray 0.25 m²
Steel plate =2 mm
Wall
100 mm gap between engine
and inside perimeter
of bilge plate
700
Solid steel obstruction
plate =5 mm
Tray 4 m²
15-25 mm
obstruction rod
6000
2000
500
3500
1400
2000
4000

Figure 2

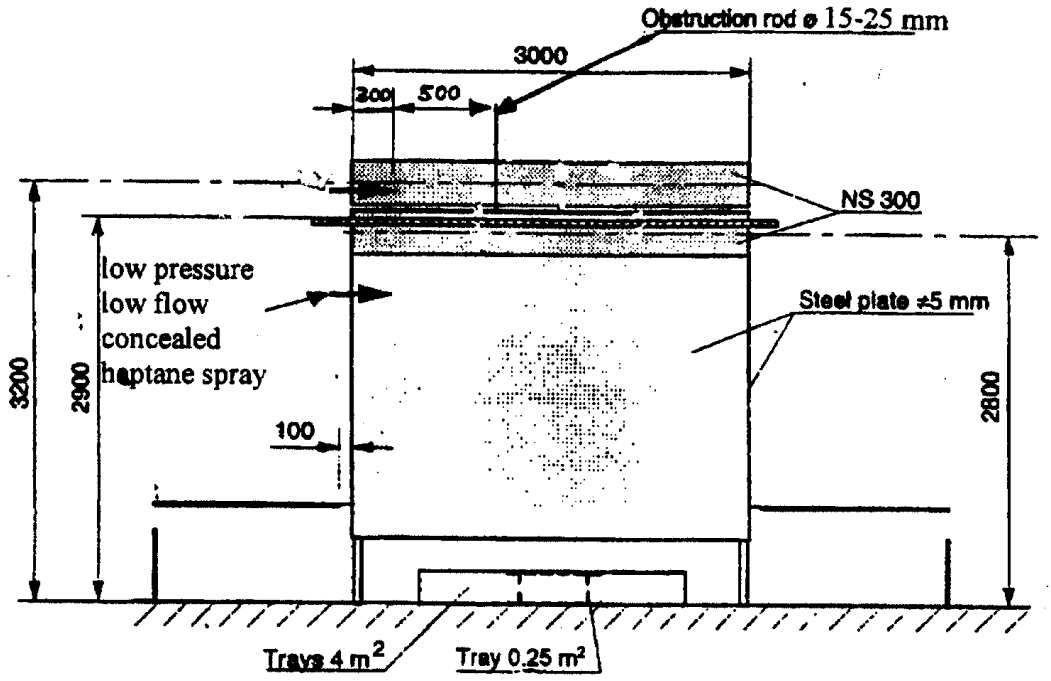
Obstruction rod ø 15-25 mm
3000
200
500
NS 300
low pressure
low flow
concealed
heptane spray
Steel plate ≠5 mm
3200
2900
2800
100
Trays 4 m²
Tray 0.25 m²

Figure 3