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GUIDELINES FOR THE APPROVAL OF HIGH-EXPANSION FOAM SYSTEMS USING INSIDE AIR FOR THE PROTECTION OF MACHINERY SPACES AND CARGO PUMP-ROOMS

1 The Committee, at its eighty-fourth session (7 to 16 May 2008), having considered the proposal by the Sub-Committee on Fire Protection, at its fifty-second session, approved the Guidelines for the approval of high-expansion foam using inside air for the protection of machinery spaces and cargo pump-rooms, as set out in the annex.

2 Member Governments are invited to apply the annexed Guidelines when approving inside air foam systems for ships of which the building contract is placed on or after 1 July 2009 and bring them to the attention of ship designers, shipowners, equipment manufacturers, test laboratories and other parties concerned.

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ANNEX

GUIDELINES FOR THE APPROVAL OF HIGH-EXPANSION FOAM SYSTEMS USING INSIDE AIF FOR THE PROTECTION OF MACHINERY SPACES AND CARGO PUMP-ROOMS

1 GENERAL

These Guidelines apply to fixed high-expansion foam systems using inside air for the protection of machinery spaces in accordance with SOLAS regulation II-2/10.4.1.1, and cargo pump-rooms in accordance with SOLAS regulation II-2/10.9.1.2. These Guidelines do not apply to cargo pump-rooms of chemical tankers carrying liquid cargoes referred to in SOLAS regulation II-2/1.6.2. Fixed high-expansion foam fire-extinguishing systems using inside air should demonstrate by test that they have the capability of extinguishing a variety of fires, which may occur in a ship's engine-room. Systems complying with these Guidelines are not subject to the criteria stated in chapter 6 of the International Code for Fire Safety Systems (FSS Code).

2 DEFINITIONS

2.1 *Foam* is the extinguishing medium produced when foam solution passes through a foam generator and is mixed with air.

2.2 *Foam solution* is a solution of foam concentrate and water.

2.3 *Foam concentrate* is the liquid which, when mixed with water in the appropriate concentration forms a foam solution.

2.4 *Foam mixing rate* is the percentage of foam concentrate mixed with water forming the foam solution.

2.5 *Foam generators* are discharge devices or assemblies through which foam solution is aerated to form foam that is discharged directly into the protected space, typically consisting of a nozzle or set of nozzles and a casing. The casing is typically made of perforated steel / stainless steel plates shaped into a box that enclose the nozzle(s).

2.6 *Inside air foam system* is a fixed high-expansion foam fire-extinguishing system with foam generators located inside the protected space and drawing air from that space. A high-expansion foam system using inside air consists of both the foam generators and the foam concentrate.

2.7 *Nominal flow rate* is the foam solution flow rate expressed in *l*/min.

2.8 *Nominal application rate* is the nominal flow rate per area expressed in *l*/min/m^2.

2.9 *Nominal foam expansion ratio* is the ratio of the volume of foam to the volume of foam solution from which it was made.

2.10 *Nominal foam production* is the volume of foam produced per time unit, i.e., nominal flow rate times nominal foam expansion ratio, expressed in m^3/min.

2.11 *Nominal filling rate* is the ratio of nominal foam production to the area, i.e., expressed in m/min.

2.12 *Nominal filling time* is the ratio of the height of the protected space to the nominal filling rate, i.e., expressed in minutes.

2.13 *Design filling rate* is the minimum filling used during the approval tests in accordance with appendix 2.

3 PRINCIPAL REQUIREMENTS FOR THE SYSTEM

3.1 Principal performance:

.1 the system should be capable of manual release. Automatic release of the system should not be permitted unless appropriate operational measures or interlocks are provided to prevent the local application system from interfering with the effectiveness of the system;

.2 the system should be capable of fire extinction, and tested in accordance with appendix 2 to these Guidelines;

.3 the foam concentrates should be tested in accordance with MSC/Circ.670;

.4 the foam generators should be successfully tested in accordance with appendixes 1 and 3 to these Guidelines; and

.5 onboard procedures should be established to require personnel re-entering the protected space after a system discharge to wear breathing apparatus to protect them from oxygen deficient air and products of combustion entrained in the foam blanket.

3.2 Requirements for the system:

.1 the system should be supplied by both main and emergency sources of power and should be provided with an automatic change-over switch. The emergency power supply should be provided from outside the protected machinery space;

.2 the system and its components should be suitably designed to withstand ambient temperature changes, vibration, humidity, shock, clogging and corrosion normally encountered in machinery spaces or cargo pump-rooms in ships, and manufactured and tested to the satisfaction of the Administration in accordance with the requirements given in appendix 1 to these Guidelines. Piping, fittings and related components inside the protected spaces should be designed to withstand 925°C;

.3 system piping, components and pipe fittings in contact with the foam concentrate should be compatible with the foam concentrate and be constructed of corrosion resistant materials such as stainless steel, or equivalent. Other system piping and foam generators should be galvanized steel or equivalent;

.4 means for testing the operation of the system and assuring the required pressure and flow should be provided by pressure gauges at both inlets (water and foam liquid supply) and at the outlet of the foam proportioner. A test valve should be installed on the distribution piping downstream of the foam proportioner, along with orifices which reflect the calculated pressure drop of the system. All sections of piping should be provided with connections for flushing, draining and purging with air;

.5 the quantity of foam concentrate available should be sufficient to produce a volume of foam equal to at least five times the volume of the largest protected space at the nominal expansion ratio, but in any case not less than enough for 30 min of full operation for the largest protected space;

.6 means should be provided for the crew to safely check the quantity of foam concentrate and take periodic control samples for foam quality;

.7 operating instructions for the system should be displayed at each operating position;

.8 spare parts should be provided in accordance with the manufacturer's instruction;

.9 the design filling rate for the system should follow the results of the tests to be conducted in accordance with appendix 2 to these Guidelines, and should be adequate to completely fill the largest protected space in 10 min or less;

.10 if an internal combustion engine is used as a prime mover for the seawater pump for the system, the fuel oil tank to the prime mover should contain sufficient fuel to enable the pump to run on full load for at least 3 h and sufficient reserves of fuel should be available outside the machinery space of category A to enable the pump to be run on full load for an additional 15 h. If the fuel tank serves other internal combustion engines simultaneously, the total fuel tank capacity should be adequate for all connected engines;

.11 means should be provided for automatically giving audible and visual warning of the release of the system. The alarms should operate for the length of time needed to evacuate the space, but in no case less than 20 s;

.12 the arrangement of foam generators and piping in the protected space should not interfere with access to the installed machinery for routine maintenance activities;

.13 the system source of power supply, foam concentrate supply and means of controlling the system should be readily accessible and simple to operate, and should be arranged at positions outside the protected space not likely to be cut off by a fire in the protected space;

.14 the arrangement of foam generators should in general be designed based on the approval test results. The number of generators may be different, but the minimum design filling rate determined during approval testing should be provided by the system. A minimum of two generators should be installed in every space containing combustion engines, boilers, purifiers, and similar equipment. Small workshops and similar spaces may be covered with only one foam generator;

.15 foam generators should be uniformly distributed under the uppermost ceiling in the protected spaces including the engine casing. The number and location of foam generators should be adequate to ensure all high risk areas are protected in all parts and at all levels of the spaces. Extra foam generators may be required in obstructed locations. The foam generators should be arranged with at least 1 m free space in front of the foam outlets, unless tested with less clearance. The generators should be located behind main structures, and above and away from engines and boilers in positions where damage from an explosion is unlikely;

.16 the piping system should be sized in accordance with a hydraulic calculation technique* to ensure availability of flows and pressures required for correct performance of the system; and

.17 for spaces greater than 500 m^3, the arrangement of the protected spaces should be such that they may be ventilated as the space is being filled with foam. Procedures should be provided to ensure that upper level dampers, doors and other suitable openings are kept open in case of a fire.

3.3 Testing requirements:

.1 after installation, the pipes, valves, fittings and assembled systems should be tested to the satisfaction of the Administration, including functional testing of the power and control systems, water pumps, foam pumps, valves, remote and local release stations and alarms. Flow at the required pressure should be verified for each section using orifices fitted to the test line. In addition, all distribution piping should be blown through with air to ensure that the piping is free of obstructions; and

.2 functional tests of all foam proportioners or other foam mixing devices should be carried out to confirm that the mixing ratio tolerance is within + 30 to -0% of the nominal mixing ratio defined by the system approval. For foam proportioners using foam concentrates of Newtonian type with kinematic viscosity equal to or less than 100 cSt at 0ºC and density equal to or less than 1.1 kg/dm^3, this test can be performed with water instead of foam concentrate. Other arrangements should be tested with the actual foam concentrate.

* 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	100
Copper or copper alloys	150
Stainless steel	150

APPENDIX 1

COMPONENT MANUFACTURING STANDARDS FOR INSIDE AIR FOAM SYSTEMS

1 Foam generator nozzles for inside foam systems should be tested in accordance with the following items stipulated in appendix A of MSC/Circ.1165:

3.1 Dimensions

3.4.1 Flow constant: the value of the flow constant K should be determined by measuring the flow at the maximum operational pressure, minimum operational pressure and the middle operational pressure.

3.11.1 Stress corrosion: a representative sample extracted from the generator may be used.

3.11.2 Sulphur dioxide corrosion: visual inspection only may be carried out.

3.11.3 Salt spray corrosion: the test may be carried out at NaCl concentration of 5%. Paragraph 3.14.2 in appendix A of MSC/Circ.668 need not be applied.

3.15 Resistance to heat: where the components are made of steel, this test need not be applied.

3.17 Impact test: only, the nozzles need to be tested.

3.22 Clogging test: where the diameter of the opening of the nozzle exceeds 1.5 mm, this test need not be applied.

2 Foam generators should also be tested in accordance with the following items stipulated in standard EN 13565-1:

.1 clause 4: General construction requirements (4.1 – connections, 4.5 – corrosion resistance of metal parts, 4.8 – heat and fire resistance);

.2 clause 5: Discharge coefficients;

.3 clause 6: Quality of foam (6.2 – High-expansion components); and

.4 clause 9: Components for medium and high-expansion foam systems.

Foam generators should also be able to withstand the effects of vibration without deterioration of their performance characteristics when tested in accordance with paragraph 4.16 of appendix A of MSC/Circ.1165. After the vibration test, the generators should show no visible deterioration and should meet the requirements of clauses 5 and 9 of standard EN13565-1.

Equivalent alternative testing standards may be used as determined by the Administration.

APPENDIX 2

FIRE TEST METHOD FOR INSIDE AIR FOAM SYSTEMS

1 SCOPE

The test method is intended for evaluating the extinguishing performance of inside air high-expansion foam fire-fighting systems. System approval should be based on the nominal filling rate, water pressure and other conditions used during the specified tests.

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 FIRE TESTS

3.1 Test principles

This test procedure enables the determination of design criteria and the effectiveness of inside air high-expansion foam fire-extinguishing systems against spray and pool fires, which are obstructed by a simulated engine.

3.2 Test description

3.2.1 *Test enclosure*

3.2.1.1 The tests should be performed in a room having an ambient temperature of 20 ± 5ºC at the start of each test. Details of the test hall geometry, the ventilation conditions and environmental conditions should be given in the fire test report.

The fire-extinguishing tests of the system should be carried out using the following test compartments:

.1 Test compartment 1

The test should be performed in a 100 m^2 room with a 5 m ceiling height and ventilation through a 2 m x 2 m door opening according to figure 2. The engine mock-up should be designed according to figures 1 and 3. The door opening to the test compartment may be covered during the test at the same rate as the foam layer is building up in the compartment to avoid foam leakage through the door opening.

.2 Test compartment 2

The test should be performed in a test compartment having a volume greater than 1,200 m^3, but not greater than 3,500 m^3, and a ceiling height exceeding 7.5 m. The ventilation of the test compartment should be achieved by a 2 m x 2 m door opening at floor level (as in test compartment 1) combined with a 20 m^2 total ventilation area, distributed in the ceiling and/or along the walls, just below the ceiling. The foam generators should not be positioned near the openings. The door opening to the test compartment may be covered during the test at the same rate as the foam layer is building up in the compartment to avoid foam leakage through the door opening.

3.2.2 ***Simulated engine***

The fire test should be performed in a test apparatus consisting of:

.1 a simulated engine 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 simulated engine is fitted with two steel tubes of 0.3 m in diameter and 3 m in length, which simulate exhaust manifolds and a grating. At the top of the simulated engine a 3 m^2 tray is arranged (see figures 1 and 3); and

.2 a floor plate system of 4 m x 6 m and 0.5 m in height surrounding the simulated engine with a tray (4 m^2 in area), underneath (see figure 1).

3.2.3 ***Test programme***

The fire test should be carried out using the following fire scenarios:

.1 combination of the following fire programmes (Test fuel: commercial fuel oil or light diesel oil):

 .1 low-pressure spray on top of the simulated engine centred with nozzle angled upward at a 45° angle to strike a 12 to 15 mm diameter rod 1 m away; and

 .2 fire in trays under (4 m^2) and on top (3 m^2) of the simulated engine;

.2 high-pressure horizontal spray fire on top of the simulated engine. (Test fuel: commercial fuel oil or light diesel oil);

.3 low pressure concealed horizontal spray fire on the side of the simulated engine with oil spray nozzle positioned 0.1 m in from the end of the simulated engine and 0.1 m^2 tray positioned 1.4 m in from the engine end at the inside of floor plate. (Test fuel: commercial fuel oil or light diesel oil); and

.4 flowing fire 0.25 kg/s from top of mock-up (Test fuel: heptane).

Fire type	**Low pressure**	**High pressure**
Spray nozzle	Wide spray angle (120° to 125°) full cone type	Standard angle (at 6 bar) full cone type
Nominal oil pressure	8 bar	150 bar
Oil flow	0.16 ± 0.01 kg/s	0.050 ±0.002 kg/s
Oil temperature	20 ± 5°C	20 ± 5°C
Nominal heat release rate	5.8 ± 0.6 MW	1.8 ± 0.2 MW

3.2.4 ***Installation requirements for tests***

3.2.4.1 Foam generators should not be installed above the simulated engine in such a way that the foam flow directly hits the test fires. The generators should also not be located near ventilation openings.

3.2.4.2 Foam generators should be installed at the uppermost level of the space. The vertical distance between the generators and test ceiling and floor should be recorded and reflected in the manufacturer's design manual.

3.2.4.3 The number and spacing of foam generators should be in accordance with the manufacturer's system design and installation manual.

3.2.4.4 The inlet water supply pressure to the foam generators should be maintained within the acceptable range determined in paragraph 3.2.5 below, throughout the tests.

3.2.5 ***Foam generator test***

Representative foam generators should be tested according to appendix 3 to these Guidelines. The results of the testing should be reflected in the manufacturer's design and installation manual.

4 TEST PROCEDURE

4.1 Preparation

4.1.1 Combination fire (paragraph 3.2.3.1 above): the 4 m^2 fire tray below the engine mock-up should be filled with at least 50 mm fuel on a water base with a freeboard of 150 ± 10 mm. The 3 m^2 fire tray on top of the engine should be filled with at least 50 mm fuel on a water base with a freeboard of 40 ± 10 mm (this requires that the notch on the side of the 3 m^2 fire tray is blocked off by an appropriate means, e.g., steel plate).

4.1.2 Low pressure concealed fire and 0.1 m^2 tray fire (paragraph 3.2.3.3 above): the 0.1 m^2 tray should be filled with at least 50 mm fuel on a water base with a freeboard of 150 ± 10 mm.

4.1.3 Flowing fire (paragraph 3.2.3.4 above): the 4 m^2 fire tray below the engine mock-up should be filled with a 50 mm water base and the 3 m^2 fire tray on top of the engine mock-up should be filled with a 40 mm water base. The fuel should be ignited when flowing down the side of the mock-up, approximately 1 m below the notch. The pre-burn time should be measured from the ignition of the fuel.

4.1.4 Fresh water may be used for practical reasons if it is shown that seawater provides the same level of performance. This should be done either by repeating the fresh water test with the longest time to extinguishment with seawater to ensure that the minimum performance requirements are still fulfilled, or to use the small scale test method in appendix 4 to these Guidelines. If the system is tested in more than one test compartment, the seawater test should be performed in test compartment 2. The temperature of the water and foam concentrate should be 20 ± 5ºC at the beginning of the test.

4.2 Measurements

The following should be measured during the test:

.1 oil flow and pressure in the oil system;

.2 foam concentrate flow and pressure, and water flow and pressure in the extinguishing system;

.3 oxygen concentration in the test compartment. The sampling point should be located 4.5 m from the centre of the engine mock-up on the exhaust pipe side and 2.5 m from floor level (the measurement may be terminated when the foam fills up to the oxygen sampling point);

.4 temperatures at the fire locations. Thermocouples should be located 1 m in front of the spray nozzles and 0.5 m above the tray fuel surface, to provide additional information about time to extinguishment; and

.5 temperatures at the foam generators. Thermocouples should be located to measure the air temperature at the foam generator air inlet, 0.1 to 0.2 m behind the water/premix nozzles.

4.3 Pre-burn

After ignition of all fuel sources, a 2 min pre-burn time is required for the tray fires, and 15 s for the spray fires and flowing heptane fires before the extinguishing agent is discharged.

4.4 Duration of test

The overall time to extinction should not exceed 15 min. The oil spray, if used should be shut off 15 s after the fire has been judged extinguished.

4.5 Observations before the fire test

Temperature of the test room, fuel and the simulated engine should be measured and recorded.

4.6 Observations during the fire test

The following observations should be recorded:

.1 start of ignition procedure;

.2 start of the test (ignition);

.3 time when the system is activated;

.4 time when foam generators begin producing foam;

.5 time when the fire is extinguished;

.6 time when the system is shut off;

.7 time when the fire is re-ignited, if any;

.8 time when the oil flow for the spray fire is shut off; and

.9 time when the test is finished.

4.7 Observations after fire test

The following should be recorded:

.1 damage to any system components; and

.2 level of fuel in the tray(s) to ensure that no limitation of fuel occurred during the test.

5 CLASSIFICATION CRITERIA

The overall time to extinction should not exceed 15 min, and at the end of discharge of foam and fuel, there should be no re-ignition or fire spread.

6 TEST REPORT

The test report should include the following items:

.1 name and address of the test laboratory;

.2 date and identification number of the test report;

.3 name and address of client, manufacturer and/or supplier of the system;

.4 purpose of the test;

.5 name or other identification marks of the product;

.6 description and specifications of the tested system and foam concentrate;

.7 date of the test;

.8 test methods;

.9 drawing of each test configuration and test compartment;

.10 identification of the test equipment and instruments used (including type and manufacturer of the foam concentration);

.11 nominal flow rate, nominal application rate and nominal filling rate;

.12 foam mixing rate;

.13 foam expansion;

.14 water supply pressure;

.15 pressure at inlet to foam generator;

.16 ventilation conditions;

.17 conclusions;

.18 deviations from the test method, if any;

.19 test results including observation and measurement before, during and after the test; and

.20 date and signature.

7 APPLICATION OF TEST RESULTS

Systems that have been successfully tested to the provisions of paragraph 3 may be installed in different size spaces according to the following:

.1 the extinguishing system configuration and filling rate used for the test compartment 1 tests may be applied to systems for the protection of shipboard spaces of equal or less volume than 500 m^3;

.2 the extinguishing system configuration and filling rate used for the test compartment 2 tests may be applied to systems for the protection of shipboard spaces of equal or greater volumes than that of test compartment 2; and

.3 for the protection of shipboard spaces with volumes between test compartments 1 and 2, linear interpolation of the filling rates obtained for test compartments 1 and 2, respectively, should be applied. Despite the above, the filling rate used for the test compartment 2 tests may be applied to systems for the protection of small spaces within protected machinery spaces having volumes less than test compartment 2, such as workshops and similar spaces not containing combustion engines, boilers, purifiers and similar equipment.

If fresh water is used in the fire tests, any differences in expansion ratios between fresh water and simulated seawater (nominal expansion ratio measured according to standard EN13565-1, annex G, and expansion ratio measured according to "small scale test method" should be reflected in the manufacturer's installation guide. If the foam expansion ratios differ between fresh water and simulated seawater, the nominal application rate used in the fire tests should be adjusted to the level that corresponds to the nominal filling rate based on the lower expansion ratio.

Example: The fire tests were performed using fresh water with nominal filling rate of 2 m/min, corresponding to a nominal application rate of 4 *l*/min/m^2 and nominal expansion ratio with fresh water of 500. Tests according to "small scale test method" and standard EN13565-1, annex G, showed that the lowest expansion ratio is 425 with seawater. The design application rate should in this case be at least:

$$4.0^{*}(500/425) = 4.7\ l/\text{min/m}^2.$$

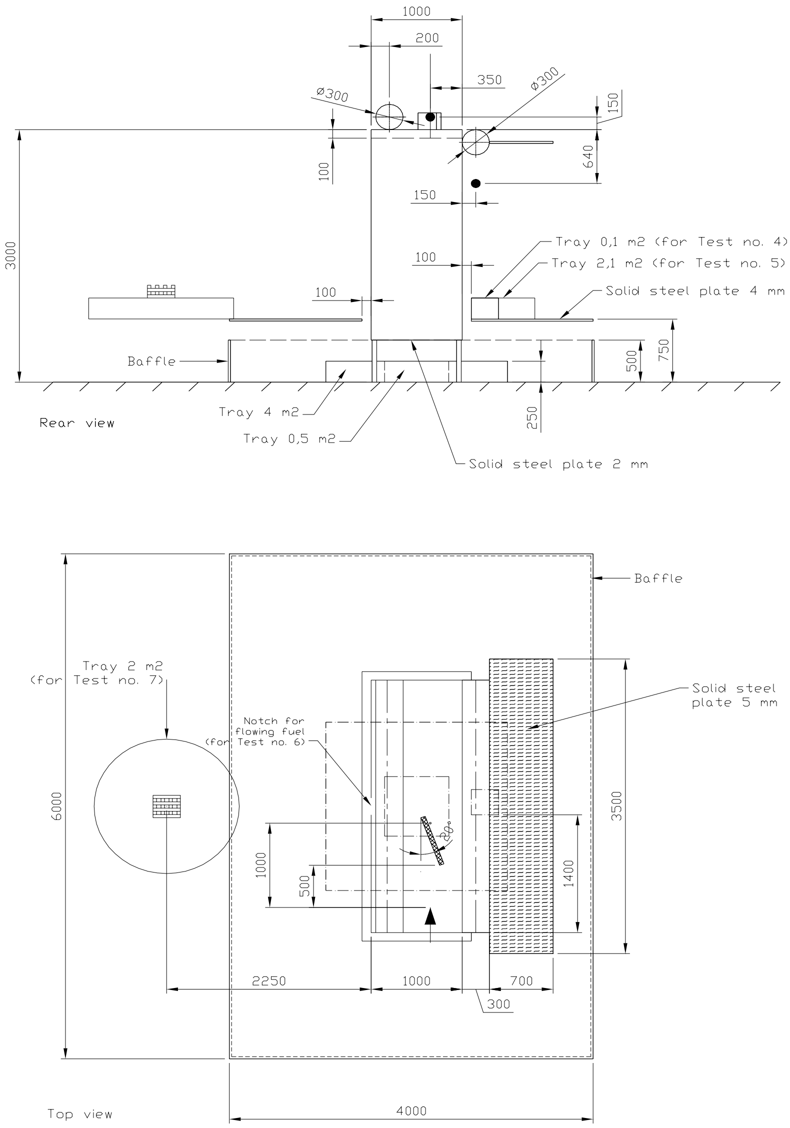


Figure 1

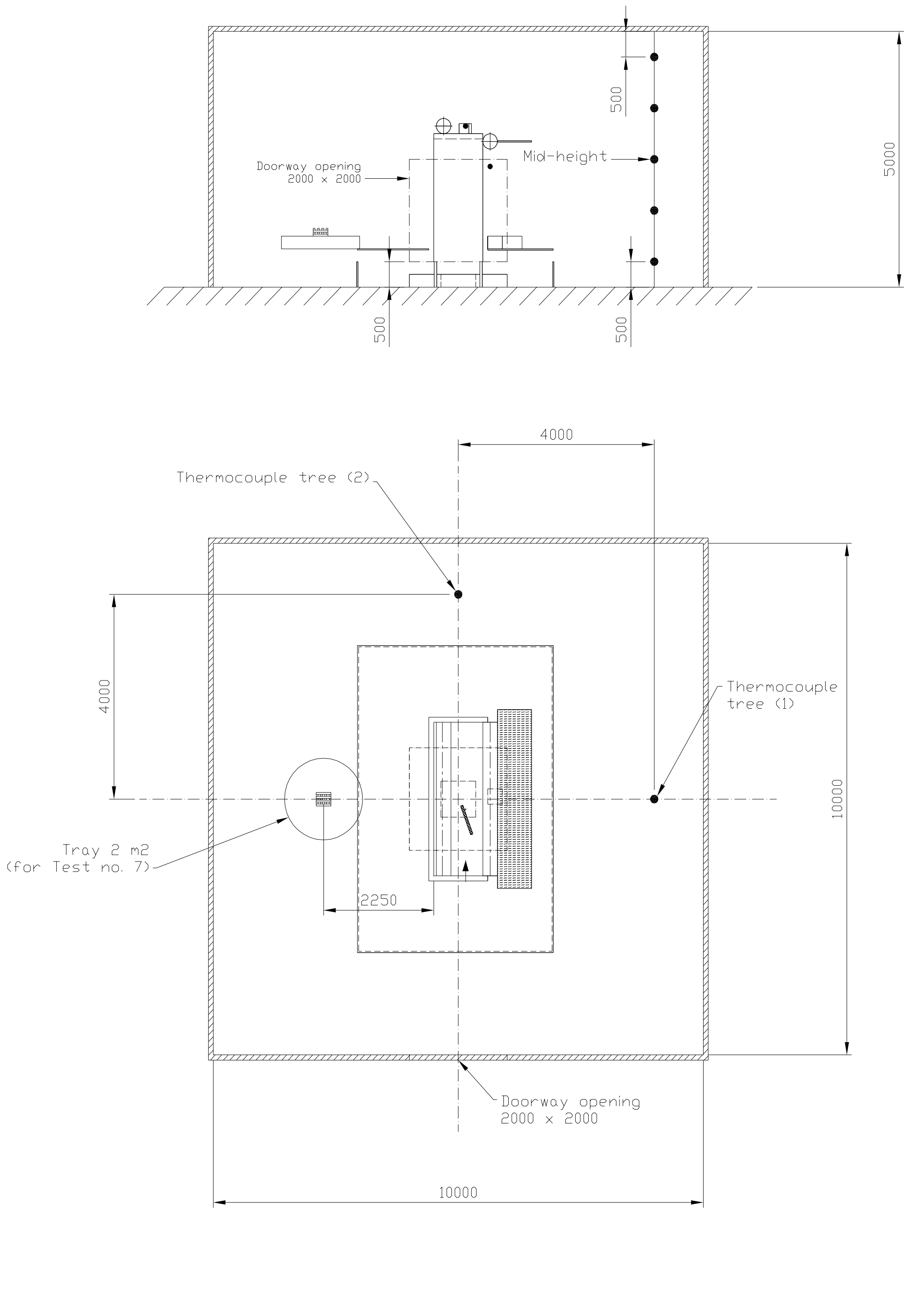
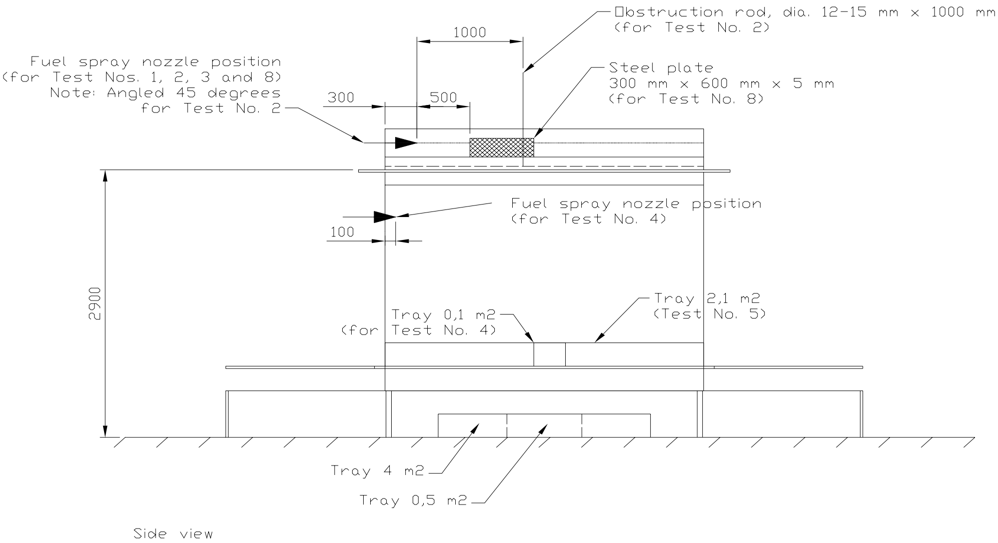

500
Mid-height
Doorway opening
2000 x 2000
5000
500
500
4000
Thermocouple tree (2)
4000
Thermocouple
tree (1)
10000
Tray 2 m2
(for Test no. 7)
2250
Doorway opening
2000 x 2000
10000

Figure 2


Obstruction rod, dia. 12-15 mm x 1000 mm
(for Test No. 2)
1000
Fuel spray nozzle position
(for Test Nos. 1, 2, 3 and 8)
Note: Angled 45 degrees
for Test No. 2
Steel plate
300 mm x 600 mm x 5 mm
(for Test No. 8)
300
500
Fuel spray nozzle position
(for Test No. 4)
100
2900
Tray 0,1 m2
(for Test No. 4)
Tray 2,1 m2
(Test No. 5)
Tray 4 m2
Tray 0,5 m2
Side view

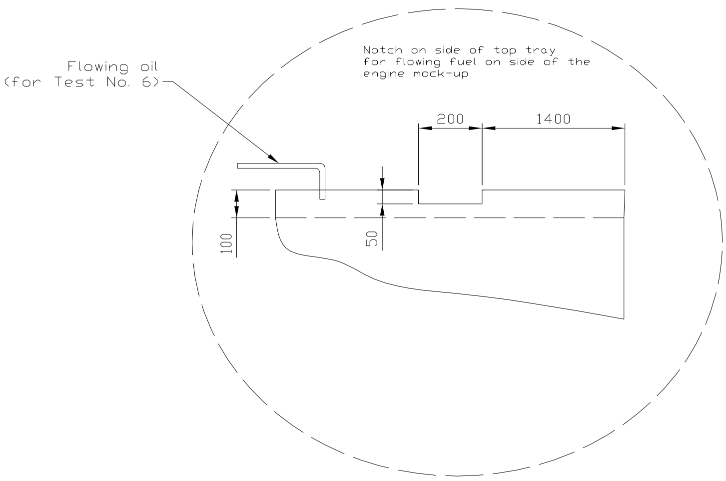

Flowing oil
(for Test No. 6)
Notch on side of top tray
for flowing fuel on side of the
engine mock-up
200
1400
100
50

Figure 3

APPENDIX 3

FOAM GENERATOR TESTS

1 Foam generator capacity test

1.1 Representative foam generators should be tested to demonstrate their nominal foam production rate over the manufacturer's specified range of inlet pressures.

1.2 The generator should be connected to a suitable water and foam concentrate supply through a pressure regulating device. The generator should then be operated throughout a pressure range of 50 to 150% of the nominal operating pressure in 1 bar increments.

1.3 The generator should be used to fill a fixed volume container at each tested pressure. The time to fill the container should be recorded and used to calculate the generator output in m^3/min.

1.4 The nominal foam production rate of the generator should be recorded at all test pressures.

1.5 The nominal foam production rate of the generator should be greater than or equal to the manufacturer's specified rating.

APPENDIX 4

OPTIONAL SMALL SCALE TEST METHOD FOR HIGH-EXPANSION FOAM CONCENTRATES TO BE USED WITH INSIDE AIR

1 SCOPE

This fire test method is intended for evaluating and documenting high-expansion foam properties under elevated temperatures. The data could be used for quality control of foam concentrates, as the results from the tests can be compared to results from earlier tests. Therefore, the test method can also be used during the development of new foam concentrates. The test method can also be used for evaluating the influence of using seawater compared to fresh water.

The test method is NOT intended to serve as a system verification test. Such tests need to be conducted in large-scale, using realistic fire conditions and actual foam generators, as the content of the combustion gases also might influence foam production.

> **Note 1:** A high-expansion foam system for inside air consists of both the foam generators and the foam concentrate. When measuring the foam expansion ratio of the system, the actual foam generators should be used. As the actual foam generators in practice are much larger, with higher flow rates, than the foam generator used in this small-scale test method, the method is not intended for determination of the foam expansion of the system. For determination of nominal foam expansion ratio of the system the foam concentrate, using actual foam generator, should be tested according to standard EN13565-1, annex G (or equivalent).

> **Note 2:** Presently, there are no requirements related to the results given in the test method. However, such criteria could be established in order to test if the foam concentrate has acceptable resistance to heat. The minimum criteria should specify that the foam expansion ratio should be above a certain limit under some specific test conditions in relation to "cold" foam expansion. In that case the test method could be a part of an approval. However, in order to choose sufficient requirements, additional pre-normative tests need to be undertaken.

2 DEFINITIONS

2.1 *Drainage time* is the time taken for the original premix to drain out of the generated foam.

2.2 *Expansion ratio* is the ratio of the volume of foam to the volume of the premix from which it was made.

2.3 *Foam concentrate* is the liquid which, when mixed with water in the appropriate concentration, gives a premix.

2.4 *Premix* is the solution of foam concentrate and water.

3 SAMPLING

The foam concentrate for the tests should be supplied by the manufacturer along with documentation that includes the brand name of the product, manufacturer, the manufacturing site, date of manufacture and batch number.

4 METHOD OF TEST

4.1 Principle

The foam properties of the foam concentrate should be determined using the following two evaluation parameters:

.1 the expansion ratio as a function of gas temperature; and

.2 the drainage time measured at ambient temperature.

Note: Pre-normative testing has verified that drainage time is usually very difficult to record at elevated temperatures.

Normally the foam properties should be measured both with fresh and with simulated seawater specified in standards ISO 7203-2:1995, annex F, and EN 1568-2, annex G.

4.2 Test equipment

The following test equipment is necessary for the tests:

.1 fire test compartment, as described within this document;

.2 propane gas burner, as described in standard ISO 9705;

.3 high-expansion foam generator, as described within this document;

.4 foam collector vessel for expansion and drainage measurements, as described in standards ISO 7203-2, annex F, and EN 1568-2, annex G;

.5 premix pressure vessel;

.6 air compressor;

.7 load cell; and

.8 stopwatch.

4.3 Tolerances

Unless otherwise stated, the following tolerances should apply:

.1 length: ± 2% of value;

.2 volume: ± 5% of value;

.3 time: ± 5 s; and

.4 temperature: ± 2% of value.

The tolerances are not applicable to the evaluation parameters.

5 THE FIRE TEST COMPARTMENT*

5.1 General

The fire test compartment should be constructed using 45 mm by 90 mm wood studs (or equivalent) and non-combustible wall boards, having a nominal thickness of between 10 and 15 mm. The walls and the ceiling should not be insulated.

The compartment should be fitted with a doorway opening, to allow easy access. This doorway should be sealed closed during the tests.

The compartment should be reasonably air-tight and, if considered necessary, all gaps between parts of the compartment should be sealed using high-temperature resistant sealant.

5.2 Dimensions

The inner dimensions of the compartment should be:

.1 length: 2,400 mm;

.2 width: 1,200 mm; and

.3 height: 2,400 mm.

The bottom of the walls should be positioned 150 mm above floor level, in order to provide a gap around the bottom perimeter of the compartment, to allow the inflow of fresh air.

5.3 Flame screen

The top part of the test compartment should be fitted with a flame screen, in order to prevent flames and hot combustion gases from flowing directly in to the high-expansion foam generator.

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* Refer to figures 1 and 2.

The screen should be made from a perforated (approximately 50% free area) steel sheet. It should cover the width of the test compartment and should extend 600 mm down from the ceiling.

5.4 Position of the high-expansion foam generator

The high-expansion foam generator should be positioned centrically through one of the short sides of the fire test compartment, with its centreline 200 mm below the ceiling. The cone end of the generator should be located 360 mm outside the short side of the fire test compartment.

5.5 Position of the propane gas burner

The propane gas burner should be positioned at the opposite part of the test compartment, relative to the position of the high-expansion foam generator.

The horizontal distance measured from the back and long side walls, should be 600 mm, respectively. The propane gas burner should be elevated, such that its top is 500 mm above floor level.

6 PREMIX PRESSURE VESSEL AND PIPING

A pressure vessel should be used for propelling the premix. The pressure vessel should be connected to an air compressor, via a pressure regulation valve. The outlet should be connected to the high-expansion foam generator, via a shut-off valve.

The piping to the generator should be connected to a valve arrangement making it possible to switch from water to premix.

7 THE HIGH-EXPANSION FOAM GENERATOR

The high-expansion foam generator should be a suitable type for the considered foam concentrates. For testing for evaluation of concentrates after the approval of such concentrates in combination with the system, foam generators used in the tests at the approval should be used.

8 INSTRUMENTATION, MEASUREMENTS AND MEASUREMENT EQUIPMENT

8.1 Gas temperature measurements

The gas temperature inside the test compartment should be continuously measured and recorded during the tests. The individual thermocouples should be positioned as follows:

.1 one thermocouple 150 mm behind the foam generator; and

.2 five thermocouples, respectively, at vertical distances of 100 mm, 200 mm, 300 mm, 600 mm and 1,200 mm from the ceiling. The thermocouple tree should be positioned 500 mm from the front side wall (for informative reasons only).

All thermocouples should be of type K (chromel-alumel) and made from 0.5 mm wire welded together.

8.2 Foam system and water pressure

The system pressure at the inlet to the fire test compartment should be monitored using a pressure gauge.

The pressure gauge should have an accuracy of ± 0.05 bar.

9 FIRE TEST PROCEDURES

9.1 Test conditions

The following test conditions should apply:

.1 the ambient temperature, measured inside the fire test compartment, prior to the start of a test should be 20 ± 5°C;

.2 the water temperature, measured prior to the test, should be 15 ± 5°C; and

.3 the premix temperature, measured prior to the test, should be 17.5 ± 2.5°C.

9.2 Verification of the temperature in the test compartment

Prior to any testing, the propane gas burner should be adjusted to provide the following gas temperatures, respectively, measured using the thermocouple 150 mm behind the foam generator. The approximate heat release rate (HRR) used in pre-normative testing is given as a guide (see Note below).

Ambient conditions (propane gas burner not in use)	Approximate heat release rate (HRR)
+100°C	18 kW
+150°C	28 kW
+200°C	42 kW
+300°C	90 kW

The temperature should be reached within 3 to 6 min and the temperature increase should be less than 5% per min after the desired temperature is reached. It might be necessary to adjust the HRR slightly during the temperature rise.

During the verification of the temperature, the generator should be connected to the water source. The flowing water pressure should be 6 ± 0.1 bar. The flowing water will cool down the pipes, connectors and the generator during the temperature rise and provides airflow through the generator and the test compartment.

Note: During pre-normative testing it have been concluded that the above temperatures at given heat release rates is reached within 3 to 6 min (see appendix 2 for examples).

9.3 Fire test procedures

The fire test procedure should be applied as follows:

.1 the ambient temperature, the water temperature and the premix temperature should be measured and recorded;

.2 start the water flow through the generator. The flowing water pressure should be within 10% of the nominal/design water pressure;

.3 the temperature measurements should be started;

.4 the propane gas burner should be lit by means of a torch or a match;

.5 when the desired gas temperature is reached, the valve for the water delivery should be shut and the valve for the premix should be opened;

.6 the foam system pressure should be adjusted to within 10% of the nominal/design pressure;

.7 the determination of the foam properties should be undertaken (see section 10); and

.8 the test is terminated.

The procedure should be repeated at each temperature level, as described in section 9.2.

10 DETERMINATION OF FOAM PROPERTIES

10.1 Principle

For the determination of the foam properties, it is essential that all foam and any possible unexpanded premix is collected.

10.2 Foam expansion ratio and drainage time at ambient conditions

The expansion ratio and drainage time should be measured in accordance with standards ISO 7203-2, annex F, or EN 1568-2, annex G, with the deviation that the foam generator is replaced by the foam generator as described within this document.

The expansion ratio and drainage time should be measured both with fresh and with simulated seawater specified in standards ISO 7203-2, annex F, and EN 1568-2, annex G.

10.3 Foam expansion as a function of temperature

The foam expansion should be measured by collecting the foam in the foam collector vessel during 20 s, or until it is full. The volume of the collected foam should be recorded, or the filling time. The foam expansion ratio should be calculated as follows:

$$E = \frac{V}{Qt}$$

where:

V is the volume of the collected foam;
Q is the premix flow rate from the foam generator; and
t is the time for collecting the foam.

Note: If the foam expansion is high (> 508) the vessel will be full before the 20 s has elapsed. In these cases, the time should be recorded when the vessel is full.

The expansion ratio at each temperature should be measured with both, fresh and simulated seawater specified in standards ISO 7203-2, annex F, and EN 1568-2, annex G.

The results should be presented in diagrams with expansion ratio as a function of temperature.

11 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;

.7 name or other identification marks of the product;

.8 description of the tested product;

.9 date of supply of the product;

.10 date of test;

.11 test method;

.12 identification of the test equipment and used instruments;

.13 conclusions;

.14 deviations from the test method, if any;

.15 test results including observations during and after the test; and

.16 date and signature.

Fire Test Compartment

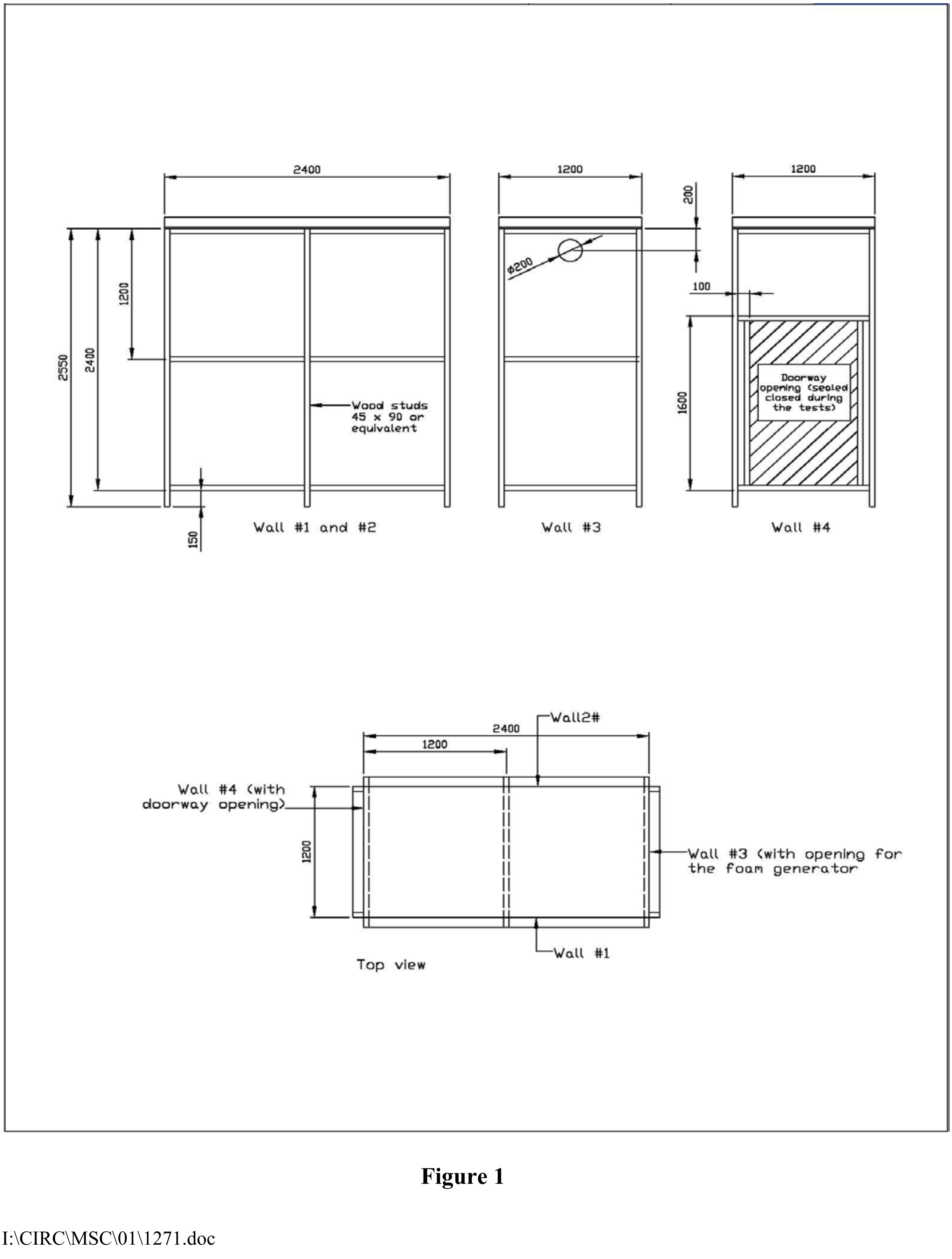

Figure 1

Interior of fire test compartment
with principal layout of the foam system

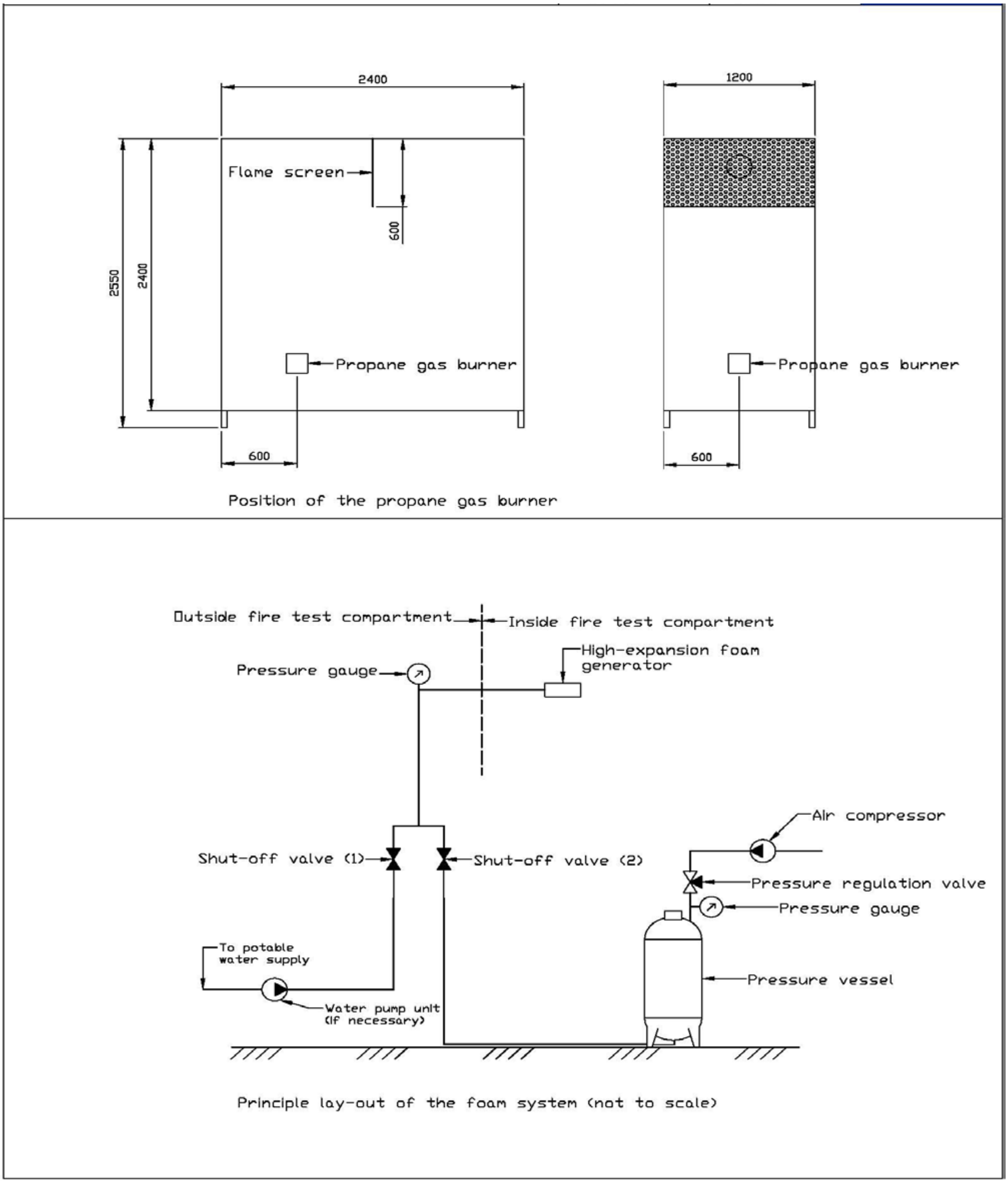

Figure 2

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