



Svalbardvej 13, DK-5700 Svendborg, Danmark, www.dafila.com

## **Fire Test Method DFL TM 70111-04 Atrium protection with sidewall water mist distribution**

### **Scope:**

The scope of DFL Method 70111-04 is to test the fire suppression performance of systems for fire protection of atriums.

The method covers water based fire protection systems, which are characterized by spraying a water based fire suppression agent from atrium walls into the atrium volume.

Examples of such systems are: Sprinkler systems with open or closed sprinkler nozzles, and water mist systems with open or closed nozzles.

The test method are suitable for absolute testing of the fire suppression systems, without comparison to other systems, as well as for comparison of fire control and fire suppression capabilities of different fire protection systems.

### **Principals:**

The test method includes the following issues:

1. System response time from fire ignition to discharge of extinguishing agent at full working pressure into the atrium volume, for two standard fire scenarios.
2. Temperature measurements measured above the fuel package.
3. Fuel losses of the fuel package after 15min. system duration time.
4. Fire spread in the fuel packages.

### **1. Fuel package: (Appendix 1)**

#### 1.1 Fuel package design:

1.1.1 The standard fuel package design consists of three sofas, a centre sofa and a side sofa on each end of the centre sofa. Each sofa having two polyether mattresses (2m x 0,8m x 0,1m) with cotton fabric covers. The mattresses and the fabric should be free from fire inhibitors. The sofas are positioned on line with 0,1m between the sofas, with the top of the backrest positioned 0,02m from a vertical back plate made of minimum 10mm thick plaster plates covered with 0,3mm thick wooden panelling on the surface facing the sofa arrangement. The wood panelling should cover the full length of the sofa arrangement and be 2,4m high.

1.1.2 The fuels should be dry and stored in a dry environment with a temperature of minimum 16°C.

#### 1.2 Assessments of fuel package loss after fire tests:

1.2.1 Mattress. After the fire tests the fabric cover is removed from the remaining polyether mattress material. For each mattress, the remaining polyether material is placed in a box having the inner measurements of 2m x 0,8m x 0,1m. Hereafter the boxes are filled with dry sand or small balls

until the box is full, while counting the volume of the material that it takes to fill the box. The material used to fill the box equals the fire loss of the mattress.

1.2.2 Wooden panelling: After fire tests the wooden panelling, while still positioned on the plaster boards, is rinsed to remove soot from the surfaces. Two vertical lines are made to show the area of the wooden panelling position behind the centre sofa, and the two areas of wooden panelling positioned behind the two side sofas. The burned or charred wooden panelling areas equals the fire loss of the three areas.

## **2. Test hall:**

2.1 The test hall should have an open volume of minimum 2500m<sup>3</sup>. The ceiling height should be minimum 12m.

2.2 The test hall should be free of draft.

## **3. Simulated Atrium set-up: (Appendix 2)**

3.1 The setup simulates an atrium.

3.2 The set-up consists of an atrium wall with the minimum length of 6m and a minimum height of the maximum installation height (H) of the hydraulic water dispatch system + 1m.

3.3 An Atrium ceiling minimum (10m x 10m) is positioned min. 2m above the atrium wall, and minimum 10m above the atrium floor. The atrium ceiling should have a width no less than 1,5 x the covering length (CL) of the system to be tested.

3.4 The distance from the test hall walls to the atrium ceiling should be no less than 1m.

## **4. Instrumentation: (Appendix 3)**

4.1 Temperature should be measured with 0,5mm wire type K-thermocouples and with a sampling time of 2 sec.

4.2 Thermocouple should be shielded against water discharge from above. The thermocouples are positioned centre in the outlet of a 1" steel pipe bend.

## **5. Fire test set-ups: (Appendix 4)**

### 5.1 Fire test set-up 1: Fuel package up against the atrium wall:

5.1.1 The wood panelling is positioned on the atrium wall. The sofa group is positioned up against the wood panelling.

5.1.2 The thermocouple is positioned 3m above the ignition point on the centre sofa.

### 5.2 Fire test set-up 2: Fuel package positioned at half coverage spacing:

5.2.1 The wood panelling covered plaster wall is positioned with the wood panelling facing the atrium wall in a distance of 0,5 x coverage length of the suppression system to be tested.

The sofa group is positioned with the backrests 0,02m from the wood panelling.

5.2.2 The thermocouple is positioned 3m above the ignition point on the centre sofa.

### 5.3 Fire test set-up 3: Fuel package positioned at full system coverage distance:

5.3.1 The wood panelling covered plaster wall is positioned with the wood panelling facing the atrium wall in a distance of the coverage length of the suppression system to be tested. The sofa group is positioned with the backrests 0,02m from the wood panelling.

5.3.2 The thermocouple is positioned 3m above the ignition point on the centre sofa.

## **6. Ignition source:**

6.1 The fires are ignited with a 0,06m x 0,06m x 0,075m porous fibreboard cube soaked with 120ml heptane and rapped in thin plastic foil.

6.2 The ignition source is positioned in centre of the centre sofa in the corner between the backrest mattress and the seat mattress.

## **7. Systems to be tested:**

7.1 Suppression systems to be tested should be checked to be in accordance with the specifications of the client.

7.2 The systems should be installed in accordance with the client's specifications.

7.3 No changes or adjustments to the system should be performed during the test scenario, with the exceptions of cleaning of nozzles and filters, and repairs to the system.

## **8. Environmental conditions:**

8.1 The temperature in the test hall should be  $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$  at the start of each fire test.

8.2 The test hall should be free from draft during the fire tests.

## **9. Water pressures:**

9.1 Fire tests are conducted at minimum water pressure prescribed by the client for the system to be tested. Tests should also be conducted at maximum system water pressure if spray tests shows reductions in spray lengths when water pressures increase.

9.2 Water pressures are measured at the inlet to the installed nozzle pipe.

## **10. Water flow rate:**

10.1 Water flow rate is measured at a position between the water supply and the inlet to the system to be tested.

### **11. Tolerances:**

ISO Standard 6182-1 Feb. 1994 edition 4:

Length  $\pm 2\%$  of nominal value  
Volume  $\pm 5\%$  of nominal value  
Pressure  $\pm 3\%$  of nominal value  
Temperature  $\pm 5\%$  of nominal value

### **12. Observations:**

Before, during and after each test the following observations should be made:

Time of ignition

Activation of system

Time when water is discharged from the system

Time to when the system is shot off.

Damages to the fuel package. To be measured and to be vision recorded.

Temperature recordings. To be sampled at least once every 2 sec.

Water flow rates. To be sampled at least once every 2 sec.

Water pressures. To be sampled at least once every 2 sec.

Number of active nozzles. Time of water discharge to be recorded for each nozzle.

Vision recording of the fire scenarios.

### **13. Procedure 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:  
Description and operating details of each device and all accessory equipment, including identification of extinguishing system components or accessory equipment by part or model no. etc.
- Nozzle design recommendation and limitations.
- Type and pressure rating of pipe, tubing and fittings to be used.
- Equivalent length values of valves, fittings and system components in the system.
- Discharge nozzle limitations, including maximum dimensional and area coverage, minimum and maximum installation height limitations, and nozzle permitted location in the protected volume.
- Range of filling capacities for each size container for systems applying cylinders.
- Details for the proper installation of each device, including all component equipment.
- Reference to the specific types of detection, activation and control panels (if applicable) to be connected to the system, and the installation of such systems, and settings and orientations of detectors.
- Operating pressure range of the system.

- Method of sizing pipe and tubing.
- Recommended orientation of nozzles, tees and the flows through tees etc.
- Maximum differences in operating (flowing) pressure between the hydraulically closest and most remote nozzle or parts of the system.
- Types and limitations of the type of atriums for which the system are suitable. Geometry limitations. Building material limitations. Interior construction and design limitations. Fire load limitations.

#### **14. Pre-burn time prior to system activation:**

14.1 For automatic activated systems the pre-burn time prior to the activation of the hydraulic suppression system the pre-burn time should for each fire tests be 2 x the system activation time as tested in accordance with §15.

14.2 For systems with manual release the pre-burn time prior to the activation of the hydraulic suppression system the pre-burn time should for all tests be 2 min.

#### **15. Test procedure: System Activation Response Tests.**

##### 15.1 Installation of detection and activation system:

15.1.1 The detection and activation system is installed in accordance with the recommendations of the client.

15.1.2 The full test scenario should be conducted with the detectors in the closest and longest recommended distances to the ignition point of the fires.

15.1.3 For systems where the client allow detectors to be installed beyond 9m ceiling height, the ceiling height of the atrium should be no less that 1m higher than the recommended installation height of the fire detectors.

15.1.4 For suppression systems accommodating double knock detection / activation systems and or activation time delays, the detection and activation systems should be system activation response tested including the mentioned features in accordance with §15.1.2 and with the maximum recommended time delay time.

##### 15. 2. Fire tests:

15.2.1 With reference to §5, the following System Activation Tests should be conducted:

15.2.1.1 System Activation Test with the fuel package position against the atrium wall.

15.2.1.2 System Activation Test with the fuel package positioned at a distance from the atrium wall of 0,5 x the coverage distance of the hydraulic fire suppression system.

15.2.1.3 System Activation Test with the fuel package position at a distance from the atrium wall similar to the maximum coverage distance of the hydraulic suppression system.

### 15.3 Fire test procedure:

15.3.1 Prior to each fire test (§ 15.2) it should be checked that the fuel package is positioned in accordance with §1.1, and the environmental conditionings are in accordance with §8. Pictures of the full set-up should be taken.

15.3.2 Prior to each fire tests it is checked that the installed detection and activation system is correctly installed in accordance with the client's recommendations, and that the activation system is switch on and in standby mode. The installation is recorded.

15.3.3 Prior to each fire test it is checked that the hydraulic system is correctly installed and in full standby mode. The installation is recorded.

15.3.3 Prior to each fire test it is checked that at least two stop watches are operating during the fire test, and that the monitoring of temperatures, water pressures, water flows and visual recordings are correctly installed and operating during the fire test. The installation and instruments are recorded.

15.3.4 30 sec. prior to the ignition of the fuel package the ignition source (§6) is positioned on the centre sofa, the plastic foil on top of the ignition cube is removed, the data logging is started, and time countdown from 30 sec to the time of ignition begins.

15.3.5 30 sec. after start of countdown the ignition cube is ignited with a match or a lighter on the free top surface.

15.3.6 The time to activation, and the time to full water discharge from all nozzles in the installed hydraulic fire suppression system is recorded.

15.3.7 The fire test duration time is 15min. after full water discharge of the first nozzle to operate. Hereafter the remaining fires are swiftly manually extinguished with water from fire hose.

15.3.8 The data sampling is stopped and logged. Pictures of the full set-up are taken. Pictures of the remaining fuel package is taken.

15.3.9 Damages to the fuel package is calculated and recorded. (§1,2)

## **16 Test procedure: Hydraulic fire suppression system:**

### 16.1 General.

16.1 The following fire tests should be conducted at minimum and maximum system water pressure with hydraulic system installation at the minimum and maximum installation height.

- Fire test with fuel package against the simulated atrium wall.
- Fire test with the fuel package positioned at the half system coverage distance to the simulated atrium wall.
- Fire test with the fuel package positioned at the maximum system coverage distance to the simulated atrium wall.

16.1.2 The fire tests should be in accordance with §1, §2, §3, §4, §5, §6, §7, §8, §9, §10, §11, §12, §13, §14 should be conducted with pre-burn times as established from fire tests conducted in accordance with §14.

#### 16.2 Fire test procedures for each fire test:

16.2.1 Prior to each fire test the pre-burn time before the activation of the hydraulic fire suppression system should be decided in accordance with §14, and recorded.

16.2.2 Prior to each fire test it should be checked that the fuel package is positioned in accordance with §1.1, and the environmental conditionings are in accordance with §8. Pictures of the full set-up should be taken.

16.2.3 Prior to each fire test it is checked that the hydraulic system is correctly installed and in full standby mode. The installation is recorded.

16.2.4 Prior to each fire test it is checked that at least two stop watches are operating during the fire test, and that the monitoring of temperatures, water pressures, water flows and visual recordings are correctly installed and operating during the fire test. The installation and instruments are recorded.

16.2.5 30 sec. prior to the ignition of the fuel package the ignition source (§6) is positioned on the centre sofa, the plastic foil on top of the ignition cube is removed, the data logging is started, and time countdown from 30 sec to the time of ignition begins.

16.2.6 30 sec. after start of countdown the ignition cube is ignited with a match or a lighter on the free top surface.

16.2.7 The hydraulic system is manually activated at the time as recorded in §16.2.1. The time to full water discharge from the first nozzle is recorded.

16.2.8 15min. after full water discharge of the first nozzle was observed the fire is swiftly manually extinguished with water from fire hose.

16.2.9 Hereafter the data sampling is stopped and logged, and pictures are taken of the full test set-up, and the remaining fuel package.

16.2.10 Damages to the fuel package is calculated in accordance with §1,2 and recorded.

#### **17. Acceptance criteria after end of each fire tests:**

17.1 Temperatures: Based on the measurements, a maximum 30 sec. average value should be calculated for each fire test.

17.2 For each fire test the average 30 sec. temperature should not exceed 200°C when measured 60 sec. after the system activation and to the end of the test.

## 17.3 Fire damages:

Sofa	Backrest mattress	Seat mattress	Wood panelling
Left side sofa	Max. 15%	No damage	Max 10%
Center sofa	na	Max 15%	Na
Right side sofa	Max 15%	No damage	Max 10%

**18. Comparison of test results form tests of different hydraulic suppression systems.**

18.1 Comparisons between test results of different hydraulic suppression systems should only be conducted if the systems have been tested in identical manners, using identical fuels in identical fire tests conducted to identical fire tests procedures with identical pre-burn times.

18.2 Comparisons of test results should only be conducted for single tests.

18.3 When comparing tests results on fuel losses a tolerance of  $\pm 20\%$  should be incorporated in the comparisons in the order to compensate for differences in the fire growth of the different fire tests.

18.4 When comparing temperatures a tolerance of  $\pm 5\%$  should be incorporated in the comparisons in the order to compensate for differences in measurements and fire growth of the different fire tests.

18.5 When comparing fire tests of different suppression systems the video recordings from the fire tests should be used to comment on the systems fire suppression performances.

**19 Test Report:**

The test report should as a minimum include:

- 1: Name and address of the test laboratory
- 2: Date and identification number of the test report
- 3: Name and address of the client
- 4: Purpose of the test
- 5: Method of sampling
- 6: Name and address of manufacturer and supplier of the products tested
- 7: Name and other identification marks of the products
- 8: Description of the tested products.
  - drawings
  - descriptions
  - assembly instructions
  - installation instructions
  - specifications of including materials
  - detailed drawings of test set-up
- 9: Date of supply of the products
- 10: Date of tests and laboratory leader conducting the tests.
- 11: Test methods
- 12: Drawings of each test configuration
- 13: Measured system characteristics including nozzle characteristics
- 14: Identification of the test equipment and used instruments

- 15: Test result data from each test including observations during and after the tests.
- 16: Conclusions
- 17: Deviations from the test method
- 18: Date and signature.

## **20: Referenced publications**

1. IMO resolution A.800 (19)
2. ISO 5660-1, Feb.1994 edition

**Appendix 1:  
Fuel package:**

Mattress requirements:

Dimension of mattresses: 2m x 0,8m x 0,1m

Materials:

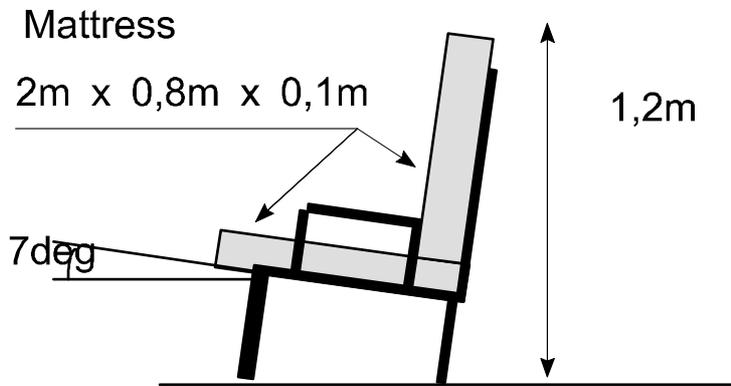
The mattresses should be made of non-fire-retarding polyether and they should have a density of  $33\text{kg/m}^3 \pm 2\text{kg/m}^3$ . The cotton fabric should not be fire retardant treated and it should have an area weight of  $0,16\text{kg/m}^2 \pm 0,02 \text{kg/m}^2$ .

When tested in accordance with ISO 5660-1 (ASTM E-1354), the polyether foam should give the following values in the ISO 5660 Cone calorimeter test:

Test conditions:	Irradiance 35 kW/m <sup>2</sup> . Horizontal position. Sample thickness 50mm	
Test results:	Time to ignition (sec.)	2-6
	3 minute average HRR, q180(kW/m <sup>2</sup> )	270 ± 70
	Effective heat of combustion (Mj/kg)	28 ± 5
	Total heat release (Mj/m <sup>2</sup> )	50 ± 15

Sofa frame design:

Frame design: square steel rods (15mm – 25mm). Material thickness: 1mm – 3mm



Wood panelling:

The panels should be  $3\text{mm} \pm 1\text{mm}$  thick. The ignition time of the panel should not be more than 35 sec and the flame spread time at 350mm position should not be more than 100 sec as measured in accordance with IMO resolution A.653(16)

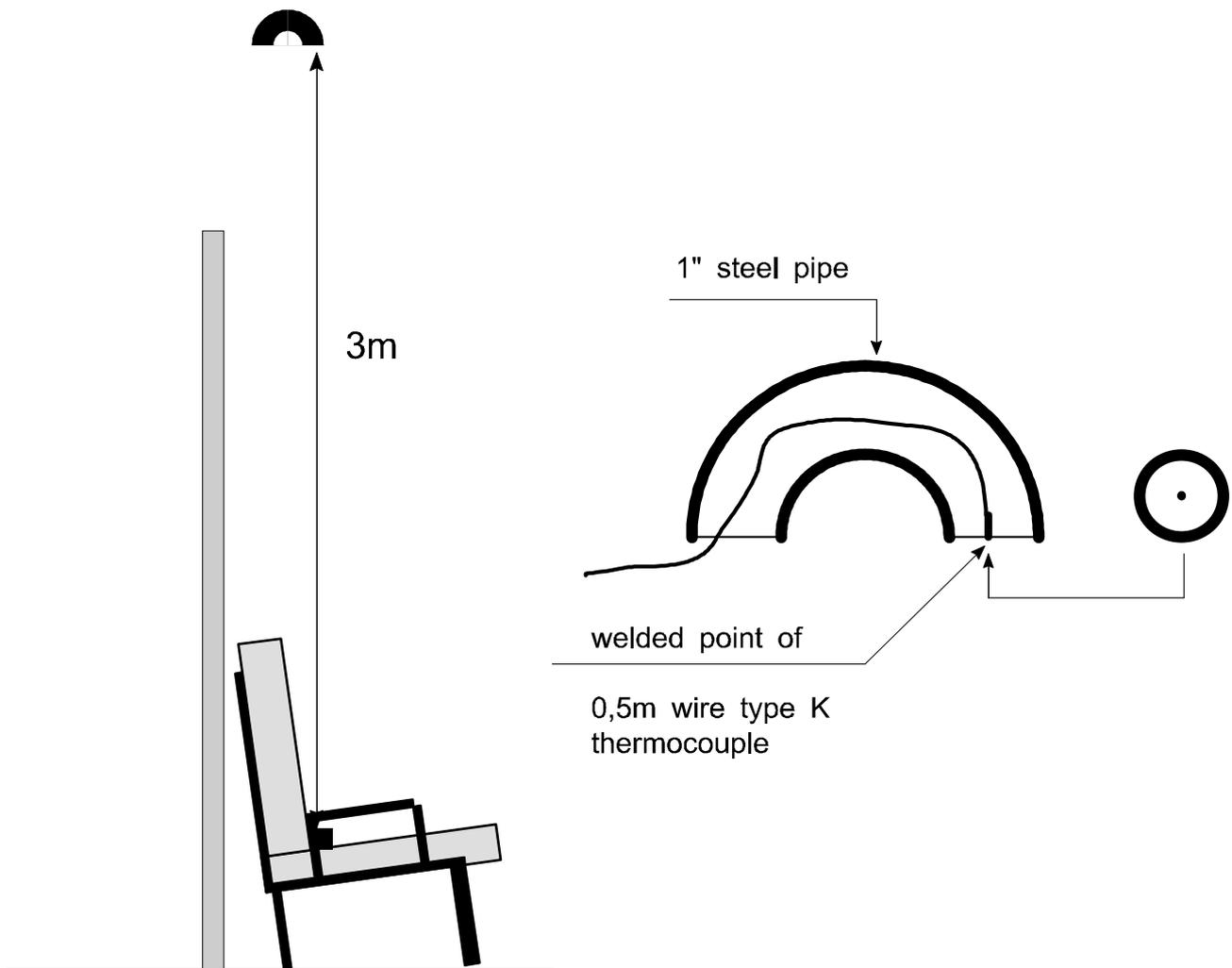


### Appendix 3 Instrumentation

Temperatures should be measured with 0,5mm wire type K-thermocouples and with a sampling time of 2 sec.

Thermocouples should be shielded against water discharge from above. The thermocouples are positioned centre in the outlet of a 1" steel pipe bend.

The thermocouples are positioned 3m above the ignition point on the centre sofa of the fuel package.



## Appendix 4

### Fire test set-ups:

#### Fire test set-up 1: Fuel package up against the atrium wall:

The 2,4m x 6m wood panelling is positioned on the atrium wall. The sofa group is positioned up against the wood panelling with a 0,02m gab between the backrest mattress and the wood panelling, and 0,1m between the sofa mattresses. The thermocouple is positioned 3m above the ignition point on the centre sofa.

#### Fire test set-up 2: Fuel package positioned at half coverage spacing:

The wood panelling covered 2,4m x 6m plaster wall is positioned with the wood panelling facing the atrium wall in a distance of 0,5 x coverage length of the suppression system to be tested. The sofa group is positioned with the backrests 0,02m from the wood panelling, and 0,1m between the sofa mattresses. The thermocouple is positioned 3m above the ignition point on the centre sofa.

#### Fire test set-up 3: Fuel package positioned at full system coverage distance:

The wood panelling covered plaster wall is positioned with the wood panelling facing the atrium wall in a distance of the coverage length of the suppression system to be tested. The sofa group is positioned with the backrests 0,02m from the wood panelling, and 0,1m between the sofa mattresses. The thermocouple is positioned 3m above the ignition point on the centre sofa.

