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SP METHOD 5320

Test method for fire detection systems installed in engine compartments of heavy vehicles

Contents

1 Introduction

1.1 Scope

The test method described in this document is intended to test and rate the detection performance of fire detection systems installed in engine compartments of heavy vehicles. The test method also examines the durability of the system components.

The fire detection system is evaluated both as a complete system and in terms of components. A standardized enclosure with typical engine compartment characteristics is used to evaluate a complete system's capability to cover the entire engine compartment. In addition, heat, flame and smoke/gas detectors are tested separately for both detector performance and system durability. Durability tests are adapted for harsh vehicle conditions and are adjusted to suit both on-road applications as well as off-road applications.

1.2 Field of application

The test method is applicable to fire detection systems intended for engine compartments of heavy vehicles, including but not limited to buses, coaches, trucks, wheel loaders, tractors, mining machines and forestry machines. The engine compartment test apparatus has a gross volume of 4 m^3.The detection systems can be scaled on the basis of the test result according to section 1.5 for engine compartments within the range 2 m^3 – 6 m^3. For engine compartments larger than 6 m^3 or smaller than 2 m^3 a separate risk assessment must motivate the extension of the scaling model or the use of another scaling model. For engine compartments larger than 10 m^3, typically found in large heavy duty mobile equipment, it may be necessary to perform additional measurements of environmental conditions and detector performance tests to motivate the system size and configuration.

1.2.1 Definition of engine compartment

An engine compartment covered by this test method is any enclosure or volume containing an internal combustion engine or heater, e.g. combustion auxiliary heaters. Any separate enclosure or volume containing parts of an exhaust system or other hot surfaces in combination with possible combustible solids, liquids or gases may also be included in the engine compartment volume. The engine compartment may consist of one or several enclosures or a volume which is not confined by any walls. Section 1.5.2 defines the engine compartment gross volume used for scaling.

1.3 Disclaimer

The test results relate to the performance of the fire detection system against a variety of tests based on some of the operating conditions and fire hazards associated with engine compartments. The test method is designed to provide some information about the detection performance of the product. This information should be used as input to a risk assessment for real applications but is not intended to be the sole criterion for assessing the protection against potential fire hazards. It is the responsibility of the fire protection system provider, in collaboration with the vehicle supplier or owner, to carry out a full risk assessment for each vehicle application and accept full responsibility for the overall performance of the installed system. SP takes no responsibility for how a tested system performs in a real engine compartment fire.

1.4 Tolerances

Below tolerances shall be followed:

- ±2 seconds for time values
- ±5% for dimensions, positions, temperatures and other measurements
- Or those explicitly stated otherwise

1.5 Scaling of the fire detection system

The following scaling model can be used to install the detection system in engine compartments ranging from 2 m^3 to 6 m^3 in gross volume. The gross volume shall be calculated in accordance with 1.5.2. The reference volume of the test apparatus is 4 m^3. If the scaling range needs to be extended or if another scaling model is to be used, this shall be motivated by a risk assessment.

1.5.1 Scaling model

Equation 1 gives a scaling factor that can be used for scaling of the tested fire detection system. Scaling includes number of sensor units, length of linear sensors and number of holes for aspirating systems (the flow rate at each sampling point shall remain the same). If the detection system combines different types of sensors the scaling applies to each type individually. The number of sensor units and sampling points is rounded to closest integer.

$$S_x = 0.1x + 0.6 \tag{1}$$

Table 1. Nomenclature for equation 1.

S_x	Scaling factor for an engine compartment gross volume of x m^3
x	The gross volume of the engine compartment, [m^3]

1.5.2 Engine compartment gross volume

The gross volume is the total volume of the engine compartment, as defined in 1.2.1, without subtraction of the engine block or any other components. In case the compartment is not fully enclosed the boundaries is set to 0.5 m from the nearest component that are supposed to be protected or the outer frame of the vehicle, whichever is shortest. The gross volume is rounded to one decimal place accuracy.

2 Detection performance tests

The complete fire detection system shall be tested in accordance with 2.1-2.2. In addition, heat sensors shall be tested in accordance with 2.3, flame sensors in accordance with 2.4 and smoke/gas sensors in accordance with 2.5.

If not stated otherwise, all settings and configurations of the detector system shall be the same through all tests.

2.1 System coverage test

2.1.1 Object

The object of this test is to ensure system coverage of a complete engine compartment and to test the capability of the detectors under varying ventilation conditions in a typical engine compartment.

2.1.2 Test apparatus

The engine compartment mock-up is described in detail in SP Method 4912 ("Method for testing the suppression performance of fire suppression systems installed in engine compartments of buses and coaches"). An overview of the test apparatus can be seen in Appendix A.

2.1.3 Test fires

The test fires are described in Table A.1 in Appendix A. The fuel in the pool fires are a mixture of diesel and heptane and the amount of fuel (±10 %) is specified in Table A.3. Table A.2 specifies the pool fire trays used for the tests. Coordinates for the positions of the test fires are presented in Appendix B.

2.1.4 Test procedure

The detection system is mounted in accordance with 2.1.4.1. The 13 test fires shall be tested separately, i.e. there are 13 separate tests. If the test fire is associated with an air flow the fan shall be started 30 s before ignition of the test fire. Any doors/hatches on the mock-up that are used to facilitate ignition of the fires must be closed directly after ignition. In case any open doors/hatches affect detector performance, remote ignition shall be used with a closed engine compartment mock-up (except for the openings specified in the description of the mock-up).

2.1.4.1 Fire detection system

The fire detection system may consist of several different sensors, including combinations of different types of heat sensors, flame sensors and smoke/gas sensors. The sensors of the detector system shall be positioned at least 15 cm above or 5 cm outside the rim of the pool fire trays and on the inside of the engine compartment mock-up.

Positions, directions and lengths of the sensor elements and sensitivity settings of the detector system cannot be changed between the tests. For aspirating systems the position, number and size of sampling holes and flow rate settings must be the same for all tests.

2.1.5 Requirements

All 13 test fires must be detected within 2 min from ignition.

At least 8 of the 13 test fires must be detected by sensors fulfilling all the requirements of this document. Up to 5 of the test fires may be detected by complementary sensors/detectors, which are part of the fire detection system but do not fulfil the requirements in 2.2. Flame and smoke/gas detectors which do not meet the requirements in 2.4.3 and 2.5.2, can also be included as complementary detectors.

2.2 Response time test

2.2.1 Object

The object of this test is to compare different detector system with respect to response time for two typical fire scenarios: a slow-growing flaming fire and an instant large flaming fire. The sensor element will be positioned at a specified distance away from the fire source.

2.2.2 Test apparatus

The same test apparatus as used in the system coverage tests is used, see section 2.1.2. Top row of metal tubes in Obstruction 3, see SP Method 4912 for number reference, in the test apparatus can be removed to enable a free line of sight between detectors and the “instant large flaming fire”.

2.2.3 Test fires

Test fires coordinates are specified in Table B.2 in Appendix B.

2.2.3.1 Slow-growing flaming fire

The test fire shall be a LPG fire (min. 90% propane) with a burning area of 17 cm × 17 cm. The upper rim of the burner shall be located 6 cm below floor level of the mock-up. An aperture in the floor steel sheet shall allow the fire to enter the mock-up undisturbed. The top surface of the burner shall be horizontal and the burner shall be filled with gravel or similar to achieve an even gas flow over the entire top surface. The fire shall have a continuous growing rate of 3 kW/min, starting from zero (at any time the actual output should be within ±2 kW of the set point). End of test occur at detection or after 20 minutes.

2.2.3.2 Instant large flaming fire
The instant large flaming fire is a pool fire of size 0.3 m × 0.3 m. Fire tray specification and fuel quantity (±10 %) is specified in Table A.2 and Table A.3 in Appendix A. The fuel is a mixture of diesel and heptane. End of test occur at detection or when the fuel is consumed.

2.2.4 Test procedure
Each fire scenario is tested separately with the detector system mounted according to 2.2.4.1. There shall be no airflow and the engine compartment mock-up shall be closed during the tests, except for the openings specified in the description of the mock-up and the aperture in the floor steel sheet used for the slow-growing fire scenario.

The time interval between ignition and activation of an alarm is registered. If no activation is achieved "no detection" is registered for that fire scenario.

2.2.4.1 Fire detection system
If the detection system includes different types of sensors, each sensor type shall be tested separately. The sensor shall be positioned 0.75 m or more above floor level. The sensor under test shall have the same settings and configuration as in the *System coverage test*. For example, linear sensors, where the sensitivity depends on length and position of the entire sensor, shall be of the same length as used in the *System coverage test* and uniformly spread in the mock-up. Aspirating systems shall use the same number of sampling holes positioned at the same distance from each other.

2.2.5 Requirements
The "instant large flaming fire" must generate an alarm or a pre-alarm within 20 seconds and the "slow-growing flaming fire" must generate an alarm before end of test. Detectors which do not fulfil these requirements can only be used as a complementary detector, see section 2.1.5 for more details.

2.3 Heat detection

2.3.1 Activation temperature

2.3.1.1 Object
The object of this test is to ensure that the detector performance is not altered by the durability tests. The activation temperature or response time shall be measured before and after the detector undergoes the durability tests in chapter 3.

2.3.1.2 Test procedure
The detector is mounted in a heat tunnel as described in Appendix C. The flowing air temperature is set to 30 °C below the expected activation temperature, where the detector

shall be stabilized for at least 5 minutes. The test continues with a rate of rise of air temperature of 1 °C/min until the detector activates.

If the detector activates on rate-of-rise (RoR) and does not have a fixed upper activation temperature, then a temperature ramp (specified by the detection system supplier) is applied from room temperature which is expected to generate an alarm. The time interval between start of the ramp and activation of an alarm is determined.
If the detector activates on rate-of-rise and does have a fixed upper activation temperature, then the detector supplier can decide if fixed activation temperature or RoR response time shall be determined.

2.3.1.3 Requirements
The difference between activation temperatures or RoR response times before and after the durability tests shall be within the tolerances specified by the manufacturer or within ±10%.

2.3.2 False alarm test

2.3.2.1 Object
The object of this test is to rate the ability of heat detectors to avoid false alarms due to hot surfaces in the engine compartment.

2.3.2.2 Test procedure
The detector is mounted in front of a hot surface (as described in 2.3.2.2.1), centred over the hottest area on the surface. The surface temperature shall be below 30 °C at start of test. The hottest area of the surface shall reach 650 °C within 4 min. The temperature shall then be kept constant at 650 °C.

It shall be determined if the detector positioned at a distance to the hot surface of 8 cm activates an alarm. In case of activation, a distance of 16 cm shall be tested as well. If the detector does not activate within 20 min from start of the surface heating, the test shall be ended.

2.3.2.2.1 Hot surface
The hot surface shall be a black painted metal surface in vertical position. The dimensions of the surface shall be at least 0.5 m × 0.5 m. The detector shall be centred over the surface as well as over the hottest area of the surface. The hottest area shall be 650 °C when heated and 5 cm from the hottest area the surface temperature shall at most be reduced by 10%. The hot surface and detector shall be positioned in room temperature with essentially no airflow.

2.3.2.3 Rating

The detector's resistance to hot surfaces is rated according to the following criteria:

- High resistance – no activation at a distance of 8 cm
- Medium resistance – activation at a distance of 8 cm, but no activation at a distance of 16 cm
- Low resistance – activation at a distance of 16 cm

Note: The distance criteria cannot be transferred directly to installation guidelines. If a detector is installed close to a hot surface the detector may degrade over time and be more prone to false alarms. Surrounding temperature is also most often higher in an engine compartment than during tests.

2.4 Flame detection

2.4.1 Sensitivity

2.4.1.1 Object

The object of this test is to ensure that the detector performance is not altered by the durability tests. The sensitivity shall be measured before and after the detector undergoes the durability tests in chapter 3.

2.4.1.2 Test procedure

The detector shall be positioned 1 m from the centre of the test fire (described in 2.4.1.2.1) facing the fire and on height 0.5 m above the top surface of the burner. The detector shall be stabilized before being exposed to the test fire. The exposure shall be accomplished by a sudden removal of a screen. Measures shall be taken such that the speed of removal is approximately the same between repetitions, e.g. by free fall of the screen. The lowest heat release rate of the fire that triggers an alarm within 30 s from removal of the screen shall be determined.

2.4.1.2.1 Test fire

The test fire shall be a LPG fire (min. 90% propane) with a burning area of 17 cm × 17 cm. The top surface of the burner shall be horizontal and the burner shall be filled with gravel or similar to achieve an even gas flow over the entire top surface. The burner shall be placed in a corner built up by non-combustible material to achieve a stable flame directing upwards. The corner shall have a height of at least 1 m above the top surface of the burner. A drawing of the test setup fulfilling the requirements is seen in Appendix D. The fire shall be controllable to give a specified heat release rate.

2.4.1.3 Requirements

The difference between lowest detectable heat release rate before and after the durability tests shall be within the tolerances specified by the manufacturer or within 10 kW.

2.4.2 Field of view

2.4.2.1 Object

The object of this test is to determine the field of view of the flame detector for installation guidance.

2.4.2.2 Test procedure

The test fire described in 2.4.1.2.1 is set to a heat release rate 50% higher than the heat release rate determined in 2.4.1. The detector shall be positioned 1 m from the fire and on height 0.5 m above the top surface of the burner. It shall be possible to rotate the detector about a vertical axis passing through the intersection between the optical axis and the plane of the sensing element(s).

The detector shall be stabilized before exposed to the test fire. The exposure shall be accomplished by a sudden removal of a screen. Measures shall be taken such that the speed of removal is approximately the same between repetitions, e.g. by free fall of the screen. The maximum rotate angle that can be applied with activation of an alarm within 30 s from removal of the screen shall be determined. The rotate angle shall be changed in steps of 5 degrees.

The maximum rotate angle shall be determined for both clockwise and counter clockwise directions for rotations about the horizontal axis as well as the vertical axis of the sensor. If the design of the detector implies that any obstructions break the symmetry of the detector's field of view, the maximum rotate angle shall be determined also for that specific direction.

Field of view is presented in the test report.

2.4.3 General requirements

2.4.3.1 Lens supervision

The detector system shall trigger a warning signal in case the detector lens is obscured. The detector supplier defines the degree of obscuration that is acceptable.

2.5 Smoke/gas detection

2.5.1 Sensitivity

2.5.1.1 Object

The object of this test is to ensure that the detector performance is not altered by the durability tests. The sensitivity shall be measured before and after the detector undergoes the durability tests in chapter 3.

2.5.1.2 Test procedure

The detector is mounted in a smoke tunnel as described in Appendix C. The smoke shall be produced by heating dried wood sticks and the smoke obscuration level in relation to time, at the detector, shall be within the boundaries specified in Figure 1. Heating shall be kept at a level that does not generate ignition and visible flames. The wood sticks shall be pieces of pine wood, which are dried for 24 h in a ventilated oven at (105 ± 5) °C.

The time interval from when the wood sticks are disclosed for the heating element to activation of the detector shall be noted. For two comparative tests with the same detector, the obscuration level shall not differ between the tests by more than 20% or 0.05 dB/m, whichever is largest, at any time, when averaged over 10 seconds.

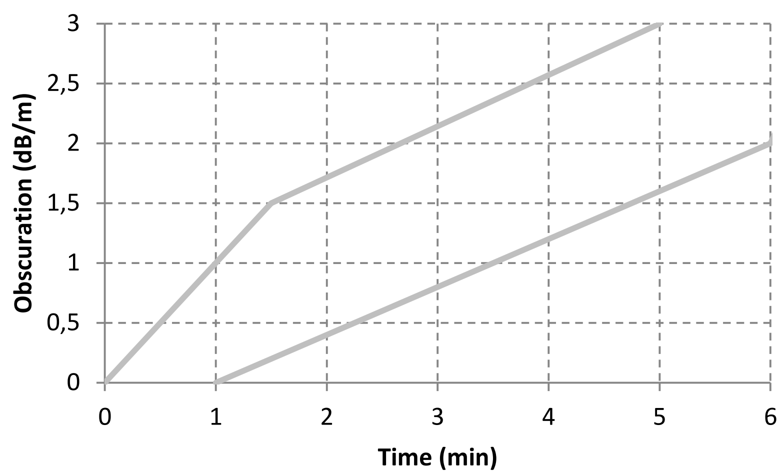

Figure 1. Boundaries of smoke obscuration level as a function of time.

2.5.1.3 Requirements

The difference between activation time before and after the durability tests shall be within the tolerances specified by the manufacturer or within 30 seconds.

2.5.2 General requirements

2.5.2.1 Sensing chamber supervision

The detector system shall trigger a warning signal in case contamination of the sensing chamber or component ageing reduces the sensitivity of the detector. The detector supplier defines the degree of reduction of sensitivity that is acceptable.

Note: In case drift compensation is used it may reduce the sensitivity to slow growing fires. This shall be considered by e.g. studying the requirements on drift compensation in the European standard EN 54-7.

2.5.2.2 Filters

The detector shall have filters or equivalent protection to avoid false alarms due to considerably larger particles than fire smoke particles. This includes, for example, dust, dirt, water steam and small insects.

Aspirating systems with non-visible filters shall trigger a warning signal in case the filter is clogged, e.g. by controlling the airflow. The detector supplier defines the degree of contamination that is acceptable.

3 Detector system durability tests

A representative sample of the complete system used in the *system coverage test* shall be tested through international standards as specified below. A representative sample is meant an operable system unit which consists of the same components (mounting brackets inclusively) as the system it represent. If not stated otherwise, it is acceptable for new components to be used for every durability test. Pressurized systems are allowed to use air instead of original medium to achieve correct pressure.

The part of the complete system that can be placed in the engine compartment shall be tested in accordance with 3.1-3.2 and 3.6.

The complete system, including all associated components such as control unit and alarm indicators, shall be tested in accordance with 3.3-3.5.

The listed durability tests are to be considered as additional requirements to legal requirements and requirements imposed by the vehicle manufacturer. It is the responsibility of a detection system supplier to assure compliance with all applicable requirements.

Previously passed tests, which are in accordance with the international standards referred to here, can be valid if the tests were performed by an accredited test laboratory and it was shown that detector performance was not altered.[1]

3.1 Corrosion

3.1.1 Object

The object of this test is to ensure the ability of the detector system to withstand the corrosive effects of salt and atmospheric pollutants.

3.1.2 Test procedure

The test shall be conducted in accordance with Test method B in ISO 21207 with 3 weeks exposure.

3.1.3 Requirements

Following this test, the same sample must repeat and pass the associated performance test (2.3.1, 2.4.1 or 2.5.1). Markings and labels shall remain visible and the change of mechanical properties should not be critical for the performance of the detector, e.g. mounting brackets and fittings should remain functional.

[1] For P-mark certification in accordance with SPCR 197, each case which deviates from the requirements in this chapter must be approved by SP.

3.2 Ageing

3.2.1 Object
The object of this test is to ensure the ability of the detector system to withstand the high temperature in an engine compartment for a long time without altering its performance. The effect of combined liquid exposure is also included. This test is only mandatory for detectors containing polymers, e.g. polymer tubes or cables used as sensing elements, conductor insulations used in the engine compartment or polymer mounting brackets.

3.2.2 Test procedure
The detector shall be subjected to relevant agents they are likely to come into contact with in accordance with ISO 16750-5:2010. At least engine oil and vehicle washing chemicals shall be applied using spraying or brushing. The different agents shall be applied on relevant parts of the detector system and be physically separated from each other.

Following the liquid exposure the detector shall be subjected to air-oven ageing at temperature[2] 140 °C, for a period of 1200 hours. When applicable, the procedure in Chapter 5.13 in ISO 6722-1 shall be followed (no “winding test”). The detector shall be tested in power off mode.

3.2.3 Requirements
Following this test, the same sample must repeat and pass the associated performance test (2.3.1, 2.4.1 or 2.5.1).

Conductors shall meet the requirements in Chapter 5.13 in ISO 6722-1 (no “winding test”).

Note: A failure in terms of an alarm or too low activation temperature in 2.3.1 caused due to that heat sensitive material is affected in the same way as it is intended to, can be excepted with a notation that the detector has a low resistance to false alarms in high ambient temperatures.

3.3 Vibration with temperature variations

3.3.1 Object
The object of this test is to ensure the ability of the detector system to withstand random vibrations induced by rough-road driving with varying ambient temperatures.

[2] A lower exposure temperature may be chosen if it is compensated by a longer exposure period, such that the ageing effect remains unchanged.

3.3.2 Test procedure

The test shall be conducted in accordance with Test VII (Commercial vehicle, sprung masses) in ISO 16750-3:2013. The temperature cycle shall be in accordance with Figure 1 in ISO 16750-3:2013 with T_{min} = -40 °C and T_{max} = 100 °C or with T_{min} and T_{max} expressed in the specification of the detector system. Parts of the detector system that will not be placed in the engine compartment can be tested separately with a lower T_{max} specified by the manufacturer.

3.3.3 Requirements

There shall be no alarm or fault signal during the test and no visible signs of leaks, loosened fittings or other mechanical failure.

Following this test, the same sample shall be subjected to the shock test in 3.4 before repeating the associated performance test (2.3.1, 2.4.1 or 2.5.1).

3.4 Shock

3.4.1 Object

The object of this test is to ensure the ability of the detector system to withstand shocks induced by driving over a curb stone or a hole, driving off-road, or other impacts on the vehicle body and frame.

3.4.2 Test procedure

This test shall be conducted with the same sample that was subjected to the vibration test in 3.3. The test shall be conducted in accordance with Chapter 4.2.2 in ISO 16750-3:2013.

3.4.2.1 Additional test for off-road vehicles

Detection systems intended for installation on off-road vehicles shall be subjected to another 5000 shocks with acceleration 10 g and duration 20-25 ms. The system shall be mounted in its intended orientation with half-sinusoidal pulse impacts in vertical direction (2500 upwards and 2500 downwards).

3.4.3 Requirements

There shall be no alarm or fault signal during the test and no visible signs of leaks, loosened fittings or other mechanical failure.

After subjected to tests in 3.3 and 3.4, the same sample shall repeat and pass the associated performance test (2.3.1, 2.4.1 or 2.5.1).

3.5 Electromagnetic compatibility (EMC)

The detection system shall meet the requirements in UNECE Regulation No. 10 (*Uniform Provisions Concerning the Approval of Vehicles with Regard to Electromagnetic Compatibility*).

3.6 IP-classification

3.6.1 Object

The object of this requirement is to ensure that the detector system is protected against ingress of solid foreign objects and water. The degree of protection should ensure protection against high pressure water jets used for cleaning.

3.6.2 Test procedure

The test shall be conducted in accordance with ISO 20653:2013.

3.6.3 Requirements

The detector system shall fulfil the degree of protection IP6K6K/IP6K9K.

Degree of protection IP65 is allowed if the specification of the detector system explicitly states that the detector cannot be pressure washed.

4 Test report

The test report shall as a minimum include the following information:

- Name and address of the testing laboratory
- Date and identification number of the test report
- Name and address of the detector system supplier
- Date of test
- Name or other identification marks of the tested product
- Description and drawing of the test setup
- Specification, description and drawing/pictures of the detector system
- Configuration of the system used in the test (sensitivity, sampling rate, etc.)
- Identification of the test equipment and used instruments
- Deviations from the test method, if any
- Photos from the test
- Test results
- Date and signature

Appendix A: Overview of engine compartment mock-up and test fires

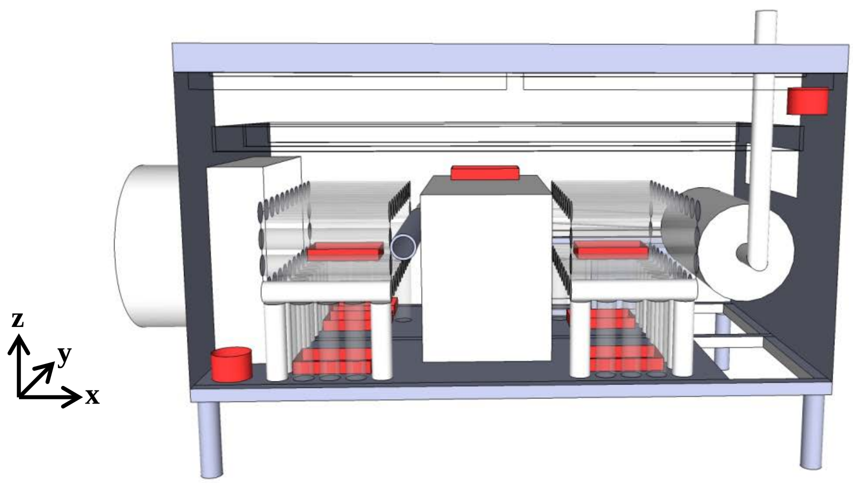

Figure A.1. Engine compartment mock-up seen from the front side. The mock-up is closed except for the two openings seen in the floor, the opening in the right sidewall, the opening for the fan and three small openings in the front and rear sidewalls. Detailed description of the mock-up is found in SP Method 4912. The locations of the pool fire trays in the "system coverage test" are highlighted in red.

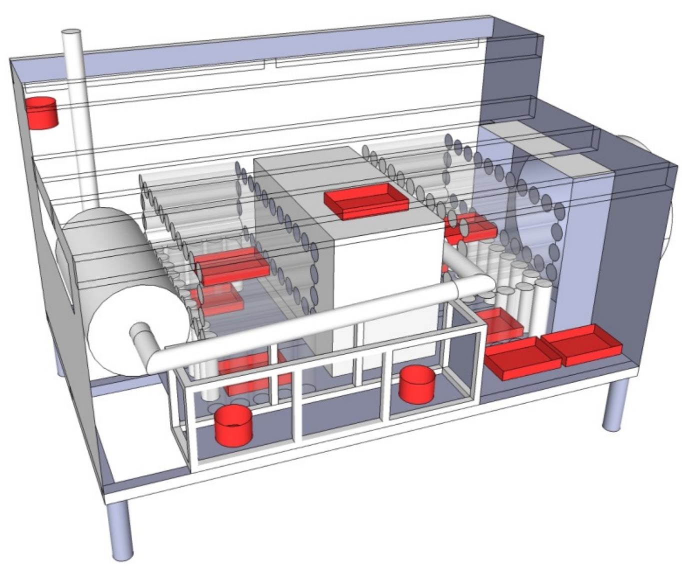

Figure A.2. Engine compartment mock-up seen from the rear side. The locations of the pool fire trays in the "system coverage test" are highlighted in red.

Table A.1. Test fires (System coverage test)

Test fire	Description	Position denotation (x-y-z)	Air flow (m^3/s)
#1	Pool fire Ø 0.15 m	right-front-top corner	0
#2	Pool fire Ø 0.15 m	central-rearmost-bottom	0
#3	Pool fire Ø 0.15 m	right-rearmost-bottom	1.5
#4	Pool fire Ø 0.15 m	left-front-bottom corner	1.5
#5	Pool fire 0.2 m × 0.3 m	left-rear-bottom	0
#6	Pool fire 0.2 m × 0.3 m	left-central-upper	0
#7	Pool fire 0.2 m × 0.3 m	left-rearmost-bottom corner	0
#8	Pool fire 0.2 m × 0.3 m	central-rear-top	0
#9	Pool fire 0.2 m × 0.3 m	right-front-bottom	0
#10	Pool fire 0.2 m × 0.3 m	right-central-upper	1.5
#11	Pool fire 0.2 m × 0.3 m	left-rearmost-bottom	1.5
#12	Pool fire 0.2 m × 0.3 m	left-front-bottom	3
#13	Pool fire 0.2 m × 0.3 m	right-rear-bottom	3

Table A.2. Specification of pool fire trays

Dimensions	Rim height	Nominal thickness
Ø 0.15 m	0.1 m	1.5 mm
0.2 m × 0.3 m	0.07 m	2 mm
0.3 m × 0.3 m	0.07 m	1.5 mm

Table A.3. Amount of diesel (commercial fuel oil or light diesel oil) and heptane (C_7H_{16}) used in pool fire trays.

Dimensions	Diesel	Heptane
Ø 0.15 m	0.2 l	0.2 l
0.2 m × 0.3 m	0.5 l	0.2 l
0.3 m × 0.3 m	0.5 l	0.3 l

Appendix B: Test fires coordinates

Coordinates refer to distances in meters in x-, y- and z-directions (Figure A.1) between left-front-bottom corner of the test apparatus and left-front-bottom corner of the fire tray. For a cylindrical tray, that is the left-front-bottom corner (as seen from the front of the test apparatus) of a rectangular cuboid in which the cylindrical object is thought to be inscribed in.

Table B.1. Test fire coordinates for *System coverage test*.

Test fire	Coordinates (x-y-z)
#1	2.23-0.08-0.92
#2	0.97-1.28-0.00
#3	1.82-1.28-0.00
#4	0.02-0.08-0.00
#5	0.37-0.87-0.00
#6	0.37-0.57-0.36
#7	0.02-1.20-0.00
#8	0.97-0.85-0.70
#9	1.54-0.13-0.00
#10	1.54-0.57-0.36
#11	0.37-1.20-0.00
#12	0.37-0.13-0.00
#13	1.54-0.87-0.00

Table B.2. Test fire coordinates for *Response time test*.

Test fire	Coordinates (x-y-z)
Slow-growing flaming fire (left-front corner of the top surface)	1.60-0.20-(-0.06)
Instant large flaming fire	1.54-0.13-0.36

Appendix C: Heat tunnel and smoke tunnel

Heat tunnel
The heat tunnel shall have a horizontal working volume, a defined part of the tunnel, where the air stream is essentially laminar, the air velocity is 1.0 ±0.1 m/s and the air temperature is within ±2 °C of nominal test conditions.

Point heat detectors shall be mounted in the centre of the working volume in a direction specified by the detector supplier. The working volume must be large enough to fully enclose the sensor element of the detector system.

Linear heat detectors shall be mounted in a straight line across the tunnel and perpendicular to the air flow. At least 0.1 m of sensor element shall be within the working volume and the total length of the sensor element shall be the same as used in the *System coverage test* (a shorter length may be used if it does not affect the activation temperature). Averaging type linear heat detectors may be installed such that the sensor element goes back and forth through the working volume. All sections of the sensor element must be in the same virtual plane perpendicular to the air flow and the distance between two sections must be at least 5 mm.

Smoke tunnel
The smoke tunnel shall have a horizontal working volume, a defined part of the tunnel, where the air stream is essentially laminar and the velocity is 0.2 ±0.04 m/s.

Point smoke detectors shall be mounted in the centre of the working volume in a direction specified by the detector supplier. The working volume must be large enough to fully enclose the sensor element of the detector system.

Aspirating smoke detectors shall have one sampling hole in the centre of the working volume in a direction specified by the detector supplier. The sensitivity, air flow rate and size of sampling hole shall be the same as used in the *System coverage test*.

The smoke obscuration level shall be measured across the working volume not more than 30 cm in front of the detector. The smoke obscuration level shall be measured in units of decibels per metre (dB/m).

Appendix D: Flame detection test setup

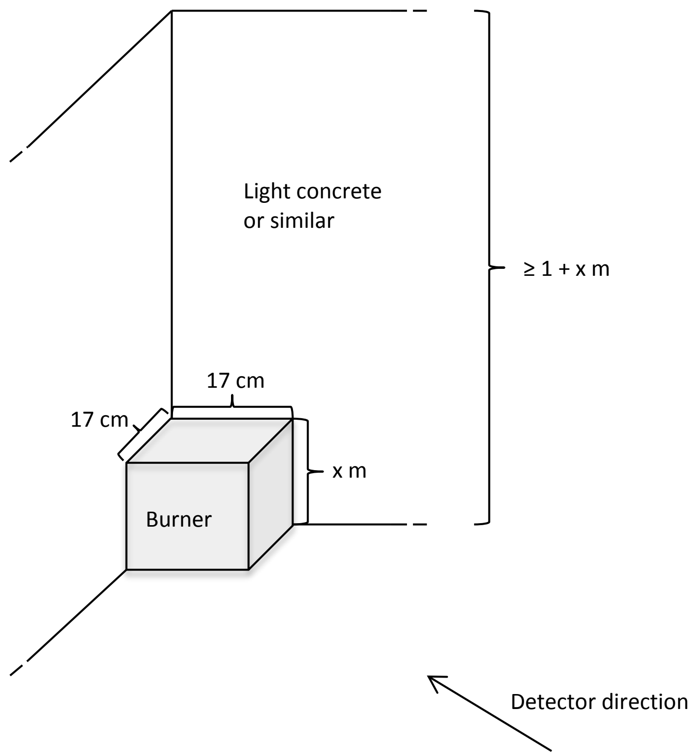

Figure D.1. Test setup fulfilling the requirements in 2.4.1.2.1.