AIS-135

AUTOMOTIVE INDUSTRY STANDARD

Fire Detection and Alarm System (FDAS) & Fire Detection and Suppression Systems (FDSS) for Buses - Requirements

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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT and HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT and HIGHWAYS)
GOVERNMENT OF INDIA

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Status chart of the Standard to be used by the Purchaser for updating the record

Sr.	Corrigenda	Amendment	Revision	Date	Remark	Misc.

General Remarks:

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work on the preparation of the standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, the Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, will publish this standard.

Considering that:

- There is a sense of urgency as evidenced by the formulation of Fire Detection & Suppression System requirements and specified in Urban Bus Specification II for implementing the required fire safety technologies;
- There are no mandatory regulations exist internationally for Fire Detection and/or Suppression Systems;
- The document (ECE/TRANS/WP29/2015/88) from which reference have been drawn for preparing the standard has been voted for implementation in the WP 29 session – 167th session dated November 2015. Further discussions on this standard are ongoing in UNECE which will be monitored & suitably drawn into this standard at an appropriate time.
- a significant majority of the bus fire accidents on Indian roads originate from the engine bay of the vehicle.

This Committee has decided to create rules in progression adapted from this document as follows:

Part I: Regulations for Detection & Alarm Systems for fires originating from engine compartment of buses

Part II: Regulations for Detection & Suppression of fires originating from engine compartment of buses

Till such time as relevant portions of the standard are brought into force for the vehicles scoped therein, institutional and private procurers of such buses would have the option to specify FDAS or FDSS complying with this standard as part of their procurement requirements.

It is to be recorded the UNECE WP.29 has voted and accepted the UNECE regulations on this subject. However the final version of UNECE regulation reflecting the decision is yet to be made available. Such changes in the UNECE document will be monitored and suitably implemented in this standard.

Composition of the panel and Automotive Industry Standards Committee (AISC) responsible for preparation of this standard are given in Annex IX and X.

Fire Detection and Alarm System (FDAS) & Fire Detection and Suppression Systems (FDSS) for Buses – Requirements

1.0 SCOPE

1.1 This standard specifies the guidelines for detection and suppression systems for fires that may originate from engine compartment of buses.

1.2 This standard applies to

1.2.1 Part I – Fire Detection and Alarm Systems (FDAS)

Approval of Fire Detection and Alarm Systems (FDAS) which are fitted to Buses.

1.2.2 Part II – Fire Detection and Suppression Systems (FDSS)

Approval of Fire Detection and Suppression Systems (FDSS) which are fitted to Buses.

1.3 Buses fitted with FDAS & FDSS shall comply with the recommendatory requirements of this standard, if required.

1.4 The requirements of this standard shall not be applicable for Electric Powertrain Vehicles (EVs).

2.0 REFERENCES

2.1 AIS-052 (Rev. 1) - Code of Practice for Bus Body Design and Approval.

2.2 UN R 107-06 (Rev.6/Corr.1, 8th December 2014) – Uniform provisions concerning the approval of category: M2 or M3 vehicles with regard to their general construction.

2.3 IS 2175 Specification for Heat Sensitive Fire Detectors for use in Automatic Fire Alarm System.

2.4 I.S. 6278, Part 3 (2013) (Israel Standard) - Automatic Fire Extinguishing Systems in Bus Engine Compartments: Installation and Maintenance.

2.5 FM 3210:2007 Heat Detectors for Automatic Fire Alarm Signaling.

2.6 UL 521 Heat Detectors for Fire Protective Signaling Systems.

PART I

Requirements for Buses with regard to Fire Detection & Alarm System (FDAS)

1.0. DEFINITIONS

For the purpose of Part I of this standard,

1.1. Automatic Fire Detection and Alarm System - A system comprising of components and sub-systems required for automatically detecting a fire and initiating an automatic alarm.

1.2. 'Engine compartment' means the compartment in which the engine is installed and / or in which a combustion heater may be installed.

1.3. Fault Signal - A distinctive audible and visual signal indicating occurrence of a fault within the FDAS / FDSS system (for example, break in electric circuit, short circuit or fault in power supply, mechanical damage in detector or elsewhere in system).

1.4. Alarm Signal - A signal is an audio and visual signal initiated by a fire alarm-initiating device, such as a manual fire alarm box, automatic fire detector, water flow switch, or other device in which activation is indicative of the presence of a fire or fire signature.

1.5. Fire detection system type for the purpose of type approval as a component means a category of systems which does not essentially differ in the following aspects:

a) Detection system;
b) detector;
c) triggering device at end of detector;
d) ECU.

1.6. Heat Detector - A heat detector is a sensor that senses either abnormally high temperature or rate of temperature rise, or both.

2.0. APPLICATION FOR CMVR APPROVAL

2.1. Application for CMVR type approval for a vehicle type in respect of the fire detection and alarm system (FDAS).

2.1.1. The application for approval of:

(a) A vehicle type or;
(b) A separate technical unit type or;
(c) A vehicle type fitted with bodywork type already approved as a separate technical unit or;
(d) A component type with regard to its constructional features shall be submitted by the manufacturer or by his duly accredited representative.

2.1.2. It shall be accompanied by the documents containing the information specified in Annex I & III as applicable.

2.1.2.1. Detailed description of the vehicle type with regard to the arrangement

and design of the control or of the unit on which the fire detection and alarm system acts.

2.1.3 A vehicle representative of the type to be approved shall be submitted to the test agency.

2.1.4 A vehicle not comprising all the components proper to the type may be accepted provided that it can be shown by the applicant to the satisfaction of the test agency that the absence of the components omitted has no effect on the results of the verifications, so far as the requirements of this standard are concerned.

2.1.5 In case of application for approval of a type of vehicle, the manufacturer shall also provide the following documents,:

2.1.5.1. Information regarding the installed fire detection & alarm system (FDAS):

2.1.5.1.1 In case of a fire detection & alarm system (FDAS) approved as a component, a copy of the analysis on regarding the installation of the FDAS (see Annex IV) or

2.1.5.1.2 In case of a fire detection & alarm system (FDAS) installed in a specific engine compartment, an analysis on regarding the installation of the FDAS (see Annex VI)

3.0 MODIFICATION AND EXTENSION OF APPROVAL OF A VEHICLE OR BODYWORK TYPE

3.1 Every modification of the vehicle, bodywork type or fire detection & alarm system shall be notified to the test agency which approved the type. That test agency may then determine that: (see Annex VIII)

Either that the modifications made are unlikely to have an appreciable adverse effect and that, in any case, the vehicle, bodywork or fire detection system still complies with the requirements; Or require a further test of compliance from the manufacturer.

4.0. GENERAL REQUIREMENTS

4.1 Vehicles shall be equipped with fire detection & alarm system detecting fires in the engine compartment based on sensors that senses either abnormally high temperature or rate of temperature rise, or both.

4.2 Upon detection in engine compartment, the system referred in clause no 4.1, shall provide the driver with both an acoustic and a visual signal, and activate the hazard warning signal. The placement of the visual alarm shall be such that it is visible unobstructed while viewed from the driver seat.

4.3 The detection & alarm system shall be operational irrespective of whether engine has been started and the vehicle's attitude.

4.4 The installation of the fire detection & alarm system shall comply with the following requirements;

4.4.1. The fire detection & alarm system shall be installed according to the system manufacturer's installation manual.

4.4.2 An analysis shall be conducted prior to the installation in order to determine the location of fire detectors and alarm system. Potential fire hazards within the engine compartment shall be identified such that the fire detectors shall be positioned to cover the fire hazard. The system shall also be ensured to work properly regardless of the vehicle's altitude, road conditions etc.,

4.4.3 Fire hazards to be taken into account in the analysis shall at least consist of the following: Components whose surface may reach temperatures above the auto-ignition temperature for fluids, gases or substances that are present within the compartment and electrical components and cables with a current or voltage high enough for an ignition to occur as well as hoses and containers with flammable liquid or gas (in particular if those are pressurized). The analysis shall be fully documented.

PART II

Approval of Buses with regard to Fire Detection & Suppression System (FDSS)

1.0. DEFINITIONS

For the purpose of Part II of this standard,

1.1 Fire Detection and Suppression System is a FDAS (Fire Detection & Alarm System) with additional facility to automatically trigger fire extinguishing system capable of extinguishing fire in engine compartment.

1.2 "Approval of a vehicle, or a separate technical unit or a component" means the approval of a vehicle type, or of bodywork or of a component type with regard to the constructional features specified in this Standard;"

1.3 "Fire suppression system type" for the purpose of type approval as a component means a category of systems which does not essentially differ in the following aspects:

(a) fire suppression system manufacturer;
(b) extinguishing agent;
(c) type of discharge point(s) used (e.g. type of nozzle, extinguishing agent generator or extinguishing agent discharge tube);
(d) type of propellant gas, if applicable."

2.0. APPLICATION FOR CMVR APPROVAL

2.1 The application for approval of:

(a) A vehicle type or;
(b) A separate technical unit type or;
(c) A vehicle type fitted with bodywork type already approved as a separate technical unit or;
(d) A component type with regard to its constructional features shall be submitted by the manufacturer or by his duly accredited representative.

2.2 It shall be accompanied by the documents containing the information specified in Annex II and III.

2.3 Detailed description of the vehicle type with regard to the arrangement and design of the control or of the unit on which the fire detection & suppression system acts.

2.4 A vehicle or fire detection & suppression system representative of the type to be approved shall be submitted to the test agency.

2.5 A vehicle not comprising all the components proper to the type may be accepted provided that it can be shown by the applicant to the satisfaction of the test agency that the absence of the components omitted has no effect on the results of the verifications, so far as the requirements of this standard are concerned.

2.6 In case of application for approval of a type of vehicle, the manufacturer shall also provide the following documents, if applicable:

2.6.1. Information regarding the installed fire detection & suppression system:

2.6.1.1 In case of a fire detection & suppression system (FDSS) approved as a component, a copy of the analysis on regarding the installation of the FDSS (see Annex V) or

2.6.1.2 In case of a fire detection & suppression system (FDSS) installed in a specific engine compartment, an analysis on regarding the installation of the FDSS (see Annex VII)

3.0. MODIFICATION AND EXTENSION OF APPROVAL OF A VEHICLE OR BODYWORK TYPE

3.1 Every modification of the vehicle, bodywork type or fire detection & suppression system shall be notified to the test agency which approved the type. That test agency may then determine that: (see Annex VIII)

Either that the modifications made are unlikely to have an appreciable adverse effect and that, in any case, the vehicle, bodywork or fire suppression system still complies with the requirements; Or require a further test of compliance from the manufacturer.

4.0. GENERAL REQUIREMENTS

4.1 In the case of vehicles having an internal combustion engine or a combustion heater located either to the front or rear, the engine compartment shall be equipped with a fire alarm system providing the driver with both an acoustic and a visual signal, and activating the hazard warning signal, in the event of sensing either abnormally high temperature or rate of temperature rise, or both in the engine compartment and in each compartment where a combustion heater is located.

4.2. In addition to the fire alarm system, vehicles shall be equipped with a fire suppression system in the engine compartment and each compartment where a combustion heater is located.

4.3. The fire alarm system and the fire suppression system shall be automatically activated through a fire detection system. The detection alarm system shall be designed so as to detect a temperature in the engine compartment, and in each compartment where a combustion heater is located in excess of the temperature occurring during normal operation. There shall not be any false alarm.

4.4 The fire alarm system and the fire suppression system shall be operational irrespective of whether engine has been started and the vehicle's attitude.

4.5 The installation of the fire detection & suppression system shall comply with the following requirements;

4.5.1 The fire detection & suppression system shall be installed according to the system manufacturer's installation manual.

4.5.2 An analysis shall be conducted prior to the installation in order to determine the location and direction of suppression agent discharge point(s) (e.g. nozzles, extinguishing agent generators or extinguishing agent discharge tube or other distribution points). Potential fire hazards within the engine compartment and each compartment where a combustion heater is located, shall be identified and discharge point(s) located such that the suppression agent will be distributed to cover the fire hazard when the system activates. The spray pattern and direction of discharge points as well as the throwing distance shall be ensured to cover identified fire hazards. The system shall also be ensured to work properly regardless of the vehicle's altitude, road conditions etc.,

Fire hazards to be taken into account in the analysis shall at least consist of the following: Components whose surface may reach temperatures above the auto-ignition temperature for fluids, gases or substances that are present within the compartment and electrical components and cables with a current or voltage high enough for an ignition to occur as well as hoses and containers with flammable liquid or gas (in particular if those are pressurized). The analysis shall be fully documented.

4.5.3 The suppression system shall be scaled from the tested system, based on the total gross volume of the engine and auxiliary heater compartments where the system is to be installed. When measuring the engine compartment and the auxiliary heater compartment, the gross volume of these compartments shall be measured, i.e. the volume of the engine and its components shall not be subtracted. *

The scaling of the system includes the mass of the suppression agent, all discharge points and the mass of the propellant gas container, if applicable. The system pressure shall remain the same as in the tested system. If the system includes a discharge tube for the extinguishing agent, the length of the tube shall be scaled without nozzles. It is acceptable if the suppression system has more extinguishing agent and/or more discharge points and/or a longer discharge tube for the extinguishing agent and/or more propellant gas than required according to the scaling models found below.

If the gross volume of the engine and auxiliary heater compartments exceed 4 m3, the suppression system shall be scaled up using the following scaling factor calculated in equation (1) below. If the gross volume is less than 4 m3, it is allowed to scale down the suppression system using the scaling factor given in equation (2) below. Sx denotes the scaling factor and x denotes the total gross volume including the engine and combustion heater compartments [m3].

$Sx = 0.1 \bullet x + 0.6$ …(1)
$Sx = 0.15 \bullet x + 0.4$ …(2)

The scaled number of nozzles or other discharge points, if the suppression system has more than one discharge point may be rounded to the closest whole number.

* SP Technical Research Institute of Sweden 183 (SPRC 183) provides one method for calculation of Gross volume.

ANNEX I
(See 2.1.2)

INFORMATION TO BE SUBMITTED FOR TYPE APPROVAL OF BUSES WITH REGARD TO FIRE DETECTION AND ALARM SYSTEM

S. No	Parameter	
1	Name of the Model(s)	
2	Variant(s)	
3	Vehicle category (s)	
4	Name and address of vehicle manufacturer	
5	Type of fire detector(s) used	
6	Name and address of manufacturer of the Fire detectors	
7	Test report number of the FDAS	
8	Description of the device or sketch showing location, relevant dimensions of fire detectors	
9	Devices provided additionally Acoustic or visual If visual, duration and type of optical signal	

ANNEX II

(See 2.2)

INFORMATION TO BE SUBMITTED FOR TYPE APPROVAL OF BUSES WITH REGARD TO FIRE DETECTION AND SUPPRESSION SYSTEM

S. No	Parameter	
1	Name of the Model(s)	
2	Variant(s)	
3	Vehicle category(s)	
4	Name and address of vehicle manufacturer	
5	Make and type of the fire suppression system	
6	Test report number of the FDSS	
7	Extinguishing agent (make and type):	
8	Mass of extinguishing agent:	
9	Type of discharge point(s):	
10	Length of discharge tube	
11	Number of discharge points(s):	
12	Type of propellant gas, if applicable:	
13	Pressure of propellant gas	
14	Minimum operating temperature	
15	Dimensions of pipes and fittings	
16	Detailed description, layout drawings and installation manual of the fire suppression system and its components	

ANNEX III
(See 2.2)
INFORMATION TO BE SUBMITTED FOR COMPONENT LEVEL APPROVAL OF FIRE DETECTION & ALARM SYSTEM AND FIRE DETECTION & SUPPRESSION SYSTEM

S. No	Parameter	
1	Make (trade name of manufacturer):	
2	Type and general commercial description:	
3	Name and address of manufacturer:	
4	Type of fire detector(s) used	
5	Name and address of manufacturer of the Fire detectors	
6	Description of the device or sketch showing location, relevant dimensions of fire detectors	
7	Devices provided additionally Acoustic or visual If visual, duration and type of optical signal	
8	Extinguishing agent (make and type):	
9	Mass of extinguishing agent:	
10	Type of discharge point(s):	
11	Length of discharge tube	
12	Number of discharge points(s):	
13	Type of propellant gas, if applicable:	
14	Pressure of propellant gas	
15	Minimum operating temperature	
16	Dimensions of pipes and fittings	
17	Detailed description, layout drawings and installation manual of the fire suppression system and its components	
18	Test report no. complying to FM/UL standard for each suppliers	

ANNEX IV

(See 2.1.5.1.1)

REQUIREMENTS FOR FIRE DETECTION & ALARM SYSTEM (FDAS) APPROVED AS A COMPONENT

1.0. Specifications

1.1 Fire detection & alarm system (FDAS) conforming to this standard shall comply with the requirements of, low fire load described in Appendix 3.

1.2 The test apparatus, low test fire and general test conditions are described in Appendix 1.

2.0. Low fire load

2.1 The low fire load test shall be conducted in accordance with Appendix 3.

2.2 The detector/s will be mounted in the engine compartment in such a manner that there will be line of sight to at least one detector from any point surrounding the engine, in order to ensure optimal coverage of threats of fire liable to break out in the engine compartment.

2.3 The installation of the detectors will prevent mechanical damage that is liable to disrupt the operation thereof.

2.4 The command and control system will be mounted outside of the engine compartment, if possible.

2.5 The manual means of activation and warning will be positioned in the vicinity of the driver’s dashboard.

2.6 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

2.7 The test is considered passed if success was achieved at the first attempt or at two of three attempts in a case when first of these attempts fails.

ANNEX V
(See 2.6.1.1)

REQUIREMENTS FOR FIRE DETECTION & SUPPRESSION SYSTEM (FDSS) APPROVED AS A COMPONENT

1.0. Specifications

1.1. Fire detection & suppression system (FDSS) conforming to this standard shall comply with the requirements of high fire load, low fire load, high fire load with fan and re-ignition described in Appendix 1.

1.2. The test apparatus, test fires and general test conditions are described in Appendix 1.

2.0. High fire load

2.1 The high fire load test shall be conducted in accordance with Appendix 2.

2.2 The detector/s will be mounted in the engine compartment in such a manner that there will be line of sight to at least one detector from any point surrounding the engine, in order to ensure optimal coverage of threats of fire liable to break out in the engine compartment.

2.3 The installation of the detectors will prevent mechanical damage that is liable to disrupt the operation thereof.

2.4 The command and control system will be mounted outside of the engine compartment, if possible.

2.5 The manual means of activation and warning will be positioned in the vicinity of the driver's dashboard, in such a manner that the driver will be able to see, hear and activate them, and such will be connected to the command and control system of the extinguishing system.

2.6 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

2.7 The test shall be conducted with the extinguishing agent and the propellant gas vessel or the suppression agent generator cooled to the minimum operating temperature ("0" degrees celsius) for the fire suppression system, as declared by the manufacturer.

2.8 The fires shall be fully extinguished, either, in the minute after activation or upon end of the discharge of the suppression system.

2.9 The test is considered passed either after success at first attempt or at two of three attempts in a case when first of these attempts fails.

3.0. Low fire load

3.1 The low fire load test shall be conducted in accordance with Appendix 3.

3.2 The detector/s will be mounted in the engine compartment in such a manner that there will be line of sight to at least one detector from any point surrounding the engine, in order to ensure optimal coverage of threats of fire liable to break out in the engine compartment.

3.3 The installation of the detectors will prevent mechanical damage that is liable to disrupt the operation thereof.

3.4 The command and control system will be mounted outside of the engine compartment, if possible.

3.5 The manual means of activation and warning will be positioned in the vicinity of the driver's dashboard, in such a manner that the driver will be able to see, hear and activate them, and such will be connected to the command and control system of the extinguishing system.

3.6 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

3.7 The test shall be conducted with the extinguishing agent and the propellant gas vessel or the suppression agent generator cooled to the minimum operating temperature ("0" degrees celsius) for the fire suppression system, as declared by the manufacturer.

3.8 The fires shall be fully extinguished either in the minute after activation or upon end of the discharge of the suppression system.

3.9 The test is considered passed if success was achieved at the first attempt or at two of three attempts in a case when first of these attempts fails.

4.0. **High fire load with fan**

4.1 The high fire load test with fan shall be conducted in accordance with Appendix 4.

4.2. The detector/s will be mounted in the engine compartment in such a manner that there will be line of sight to at least one detector from any point surrounding the engine, in order to ensure optimal coverage of threats of fire liable to break out in the engine compartment.

4.3. The installation of the detectors will prevent mechanical damage that is liable to disrupt the operation thereof.

4.4 The command and control system will be mounted outside of the engine compartment, if possible.

4.5 The manual means of activation and warning will be positioned in the vicinity of the driver's dashboard, in such a manner that the driver will be able to see, hear and activate them, and such will be connected to the command and control system of the extinguishing system.

4.6 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

4.7 The test shall be conducted with the extinguishing agent and the propellant gas vessel or the suppression agent generator cooled to the minimum operating temperature ("0" degrees celsius) for the fire suppression system, as declared by the manufacturer.

4.8 The fires shall be fully extinguished either in the minute after activation or upon end of the discharge of the suppression system.

4.9 The test is considered passed if success was achieved at the first attempt or at two of three attempts in a case when first of these attempts fails.

5.0. Re-ignition test

5.1. The re-ignition test shall be conducted in accordance with Appendix 5.

5.2. The fire shall be fully extinguished and no re-ignition shall occur 45 seconds after the extinguishing of the fire.

5.3. The test is considered passed either if success was achieved at the first attempt or at two of three attempts in a case when first of these attempts fails.

ANNEX VI
(See 2.1.5.1.2)

REQUIREMENTS FOR FIRE DETECTION & ALARM SYSTEM (FDAS) INSTALLED IN A SPECIFIC ENGINE COMPARTMENT

1.0 Specifications

1.1 A specific engine compartment means engine compartments which do not differ in the following essential aspects:
(a) Engine compartments position in the vehicle;
(b) Maximum gross volume;
(c) General layout of components in the compartment (i.e. position of fire hazards determined).
For compartments where a combustion heater is placed aspects (b) and (c) apply.

1.2 The fire detection & alarm system (FDAS) conforming to this standard shall comply with the requirements of low fire load, described in Appendix 3.

1.3 The test apparatus, test fires and general test conditions are described in Appendix 1.
In order to facilitate the positioning of the fire trays within the engine and combustion heater compartment additional supports may be used and the height of the prescribed test fire may be lowered to a minimum of 40 mm.

The test conditions in Appendix 3 may be adapted for the specific engine compartment and combustion heater compartment. The adaptation shall provide an equivalent level of safety. The principles for the adaptation shall be verified by the Test Agency responsible for the tests. The principle of adaption shall be documented and added to the test report.

2.0 Low fire load

2.1 The low fire load test shall be conducted in accordance with Appendix 3.

2.2 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

2.3 The test is considered passed either after success at the first attempt or after success at the second and third attempts in case of failure at the first attempt.

ANNEX VII
(See 2.6.1.2)

REQUIREMENTS FOR FIRE DETECTION & SUPPRESSION SYSTEM (FDSS) INSTALLED IN A SPECIFIC ENGINE COMPARTMENT

1.0. Specifications

1.1. A specific engine compartment means engine compartments which do not differ in the following essential aspects:
(a) Engine compartments position in the vehicle;
(b) Maximum gross volume;
(c) General layout of components in the compartment (i.e. position of fire hazards determined).
For compartments where a combustion heater is placed aspects (b) and (c) apply.

1.2 The fire detection & suppression system (FDSS) conforming to this standard shall comply with the requirements of high fire load, low fire load, high fire load with fan (to be applied if a fan is fitted in the engine compartment and/or combustion heater compartment) and re-ignition described in Appendix 1.

1.3 The test apparatus, test fires and general test conditions are described in Appendix 1.

In order to facilitate the positioning of the fire trays within the engine and combustion heater compartment additional supports may be used and the height of the prescribed test fire may be lowered to a minimum of 40 mm.

The test conditions in Appendices 2 to 5 may be adapted for the specific engine compartment and combustion heater compartment. The adaptation shall be based on the provisions given in Part II, Clause nos. 4.5.1, 4.5.2 and 4.5.3, determining the fire hazards within the compartment and the scaling of the fire suppression system. The adaptation shall provide an equivalent level of safety. The principles for the adaptation shall be verified by the Test Agency responsible for the tests. The principle of adaption shall be documented and added to the test report.

2.0 High fire load

2.1 The high fire load test shall be conducted in accordance with Appendix 2.

2.2 The test shall be conducted with the extinguishing agent and the propellant gas vessel or the suppression agent generator cooled to the minimum operating temperature (“0” degrees celsius) for the fire suppression system, as declared by the manufacturer.

2.3 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

2.4 The fires shall be fully extinguished, either, in the minute after activation or upon end of the discharge of the suppression system.

2.5 The test is considered passed either after success at the first attempt or after success at the second and third attempts in case of failure at the first attempt.

3.0 Low fire load

3.1 The low fire load test shall be conducted in accordance with Appendix 3.

3.2 The fire shall be detected and warning signal shall be activated 10 seconds after ignition.

3.3 The fires shall be fully extinguished either in the minute after activation or upon end of the discharge of the suppression system.

3.4 The test is considered passed either after success at the first attempt or after success at the second and third attempts in case of failure at the first attempt.

4.0 High fire load with fan (if a fan is fitted in the engine and/or combustion heater compartment)

4.1 The high fire load test with fan shall be conducted in accordance with Appendix 4.

4.2 The fire shall be detected and warning signal shall be activated within 10 seconds after ignition.

4.3 The fires shall be fully extinguished either in the minute after activation or upon end of the discharge of the suppression system.

4.4 The test is considered passed either after success at the first attempt or after success at the second and third attempts in case of failure at the first attempt.

5.0. Re-ignition test

5.1 The re-ignition test shall be conducted in accordance with Appendix 5.

5.2 The fire shall be fully extinguished and no re-ignition shall occur 45 seconds after the extinguishing of the fire.

5.3 The test is considered passed either after success at the first attempt or after success at the second and third attempts in case of failure at the first attempt.

ANNEX VIII

(See 3.0 of Parts I & II)

GUIDELINES FOR DECIDING WHETHER TESTING IS NEEDED

1. In general, when changes in technical specifications of vehicle do not affect the FDAS / FDSS performance adversely, and is still within the stipulated limits, the type approval certificate can be extended. The changes in parameters that affect the FDAS / FDSS performance are listed in clause no. 2.

2. In the case of following changes, with respect to the vehicles tested, in the details submitted as per Annexures I & II, tests are necessary for establishing compliance:

1	Change in volume of engine compartment	To be tested if volume of engine compartment is increased which increases the number of nozzles derived from clause no. 4.5.3
2	Type of extinguishing agents	To be tested in case of any change
3	Change in capacity of extinguishing agent	To be tested in case of decrease in capacity
4	Dimensions of pipes & fittings of FDSS & FDAS	To be tested in case of any change
5	Pressurized cartridge system	To be tested in case of decrease in pressure of the system

3. Changes other than the above are generally considered as not affecting compliance. However it does not limit test agencies and vehicle manufacturer to investigate possibility of any other criteria, for which tests may be conducted for extension as per mutual agreement between test agencies & vehicle manufacturer.

Appendix 1

Test apparatus, test fires and general test specifications

1.0 Test apparatus

1.1. The test apparatus is to be made of steel plate. The thickness of the steel plate shall be in accordance with Table 1. Figure 1 shows the test apparatus from the front side, Figure 2 from the rear side and Figure 3 from top. The front side of the test apparatus simulates the rear side of a real engine compartment. Test apparatus shall have its own fire suppression systems which can extinguish the test fire in case the FDAS test and also in case the FDSS under test fails to suppress the test fire.

Figure 1
Coordinate system for the position of objects in test apparatus (view from front side)

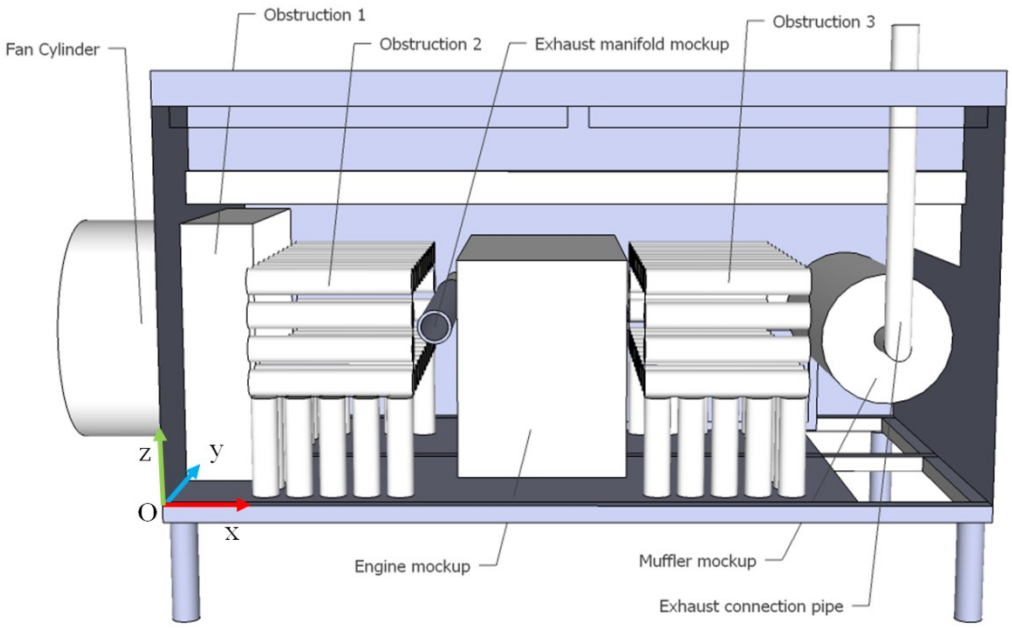


Figure 2
Test apparatus seen from the rear

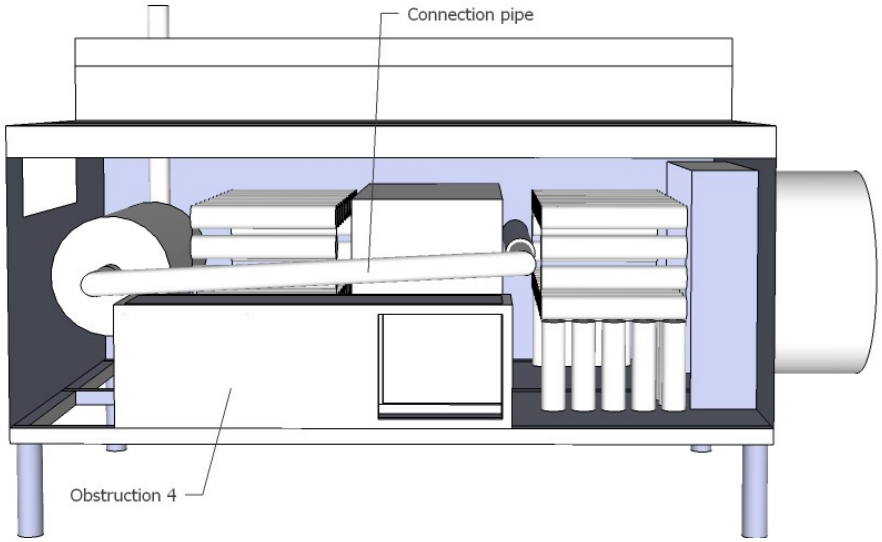


Figure 3
Test apparatus seen from Top

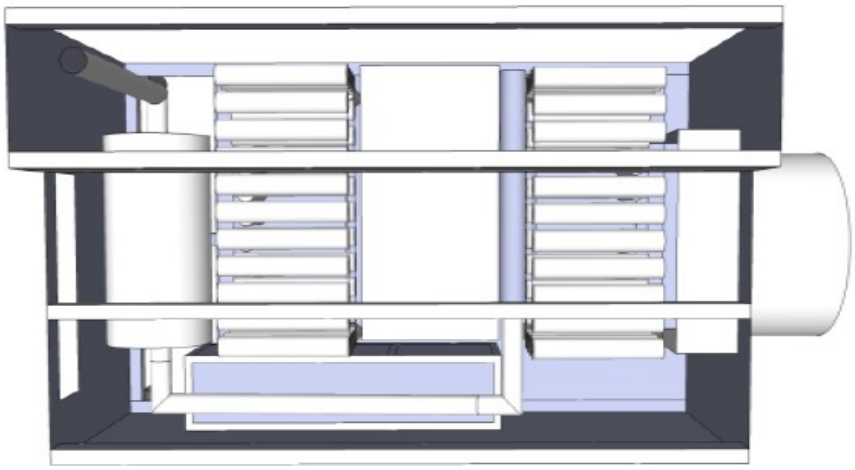


Table 1
Test apparatus objects

Objects	Plate thickness
Fan cylinder	1.5 – 2 mm
Obstructions	1.5 – 2 mm
Exhaust manifold mock-up	8 mm
Engine mock-up	2 – 3 mm
Muffler mock-up	2 – 3 mm
Exhaust pipe	2 – 3 mm
Connection pipe	2 – 3 mm
Walls, ceiling and floor	1.5 – 3 mm

1.2. Object locations

1.2.1 All objects in the test apparatus are positioned according to coordinates (x, y, z) as shown in Table 2. Origin is the position marked (O) in Figure 1. The value of the coordinates is the distance in meter from origin (see Figure 1), i.e. left-front-bottom corner.

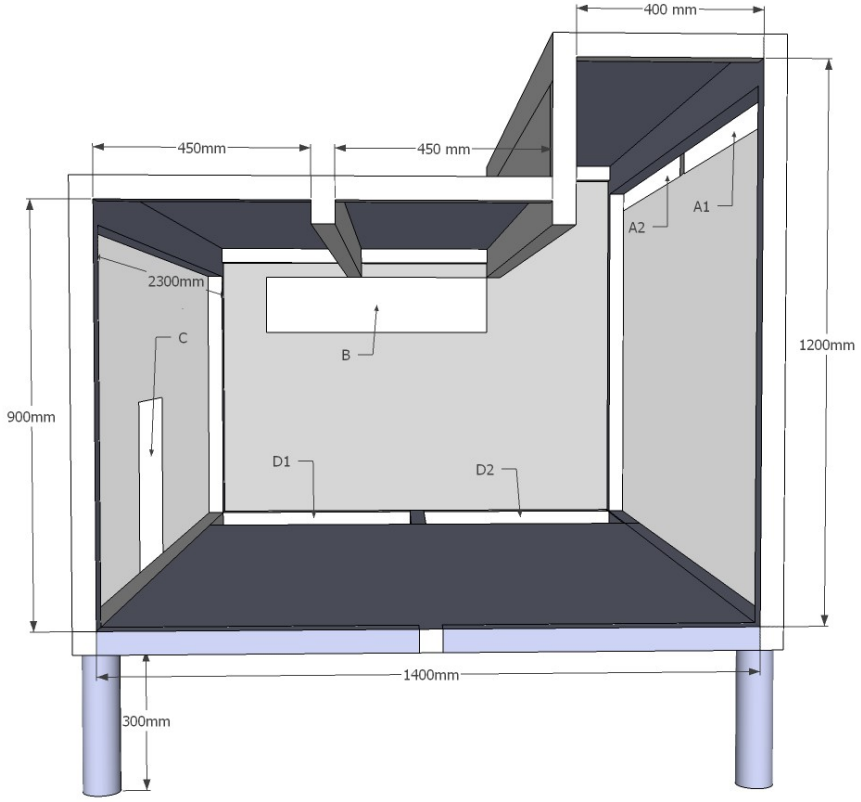
Table 2
Coordinates of objects

Objects	Coordinates [x; y; z]
Fan cylinder	[-0.60; 0.40; 0.10]
Obstruction 1	[0.0; 0.26; 0.0]
Obstruction 2	[0.26; 0.05; 0.02]
Exhaust manifold mock-up	[0.76; 0.05; 0.47]
Engine mock-up	[0.87; 0.05; 0.04]
Obstruction 3	[1.44; 0.05; 0.02]
Obstruction 4	[0.82; 1.2; 0.0]
Muffler mock-up	[2.0; 0.28; 0.23]

1.3 Framework

1.3.1 The framework of the test apparatus shall be constructed according to Figure 4. The sizes of the beams are 50 mm × 50 mm and 100 mm × 50 mm respectively. The framework shall be 300 mm above the ground.

Figure 4
Framework for the test apparatus



1.4. Apertures

1.4.1. In addition to the opening for the fan, the test apparatus includes six apertures. The dimensions and positions of the apertures are given according to the coordinates in Table 3. The positions are given by referring to two diagonally opposite corners (all apertures are rectangular in shape). The apertures are shown in Figure 4.

Table 3
Coordinates of apertures in the test apparatus

Aperture	Coordinates [x; y; z] – [x; y; z]	Area of aperture
A1	[0.03; 0.00; 1.08] – [1.18; 0.00; 1.13]	0.06 m^2
A2	[1.22; 0.00; 1.08] – [2.37; 0.00; 1.13]	0.06 m^2
B	[2.40; 0.50; 0.70] – [2.40; 1.30; 0.90]	0.16 m^2
C	[0.85; 1.50; 0.03] – [1.24; 1.50; 0.36]	0.13 m^2
D1	[2.00; 0.05; 0.00] – [2.35; 0.73; 0.00]	0.27 m^2
D2	[2.00; 0.78; 0.00] – [2.35; 1.20; 0.00]	0.26 m^2
	Total area of aperture:	0.94 m^2

1.5 Fan

1.5.1 An axial fan with a diameter of 710 mm shall be mounted on the left side of the fan cylinder. The diameter of the cylinder shall be equal to the diameter of the fan. The fan shall produce a certain rate of air flow through the cylinder according to the test scenarios in Appendices 2 to 5. A frequency converter may be used to adjust the fan speed.

1.6 Mock-up components

1.6.1 The dimensions of the engine mock-up are 1,000 mm × 650 mm × 500 mm. The dimensions of the muffler mock-up are Ø400 mm × 800 mm. The exhaust manifold mock-up shall have the inner dimensions of Ø80 mm × 900 mm. The mock-up components shall be hollowed. The exhaust manifold mock-up shall be connected to the muffler mock-up through a pipe with a diameter of 76 mm. A pipe from the muffler mock-up should also be used to carry the exhaust gases from the pre-warming system out from the test apparatus.

1.7 Thermocouples

1.7.1 The entry and exit of the detection pipe of the test rig shall be at the top of test rig only. Seven thermocouples (Tc) shall be mounted on the exhaust manifold mock-up, drilled 2 mm into the tube from the outside. Thermocouples Tc1 to Tc4 shall be located on top of the mock-up at the distances from the mock-up inlet according to Table 4. Thermocouples Tc5 to Tc7 shall be located around the mock-up at the same distance from the inlet as Tc2. The location of the thermocouples is illustrated in Figures 5 and 6.

Table 4
Distance to thermocouple from inlet of exhaust manifold mock-up

Thermocouple	Distance from inlet
Tc1	250 mm
Tc2	300 mm
Tc3	350 mm
Tc4	600 mm
Tc5	300 mm
Tc6	300 mm
Tc7	300 mm

Figure 5
Thermocouples on the exhaust manifold mock-up

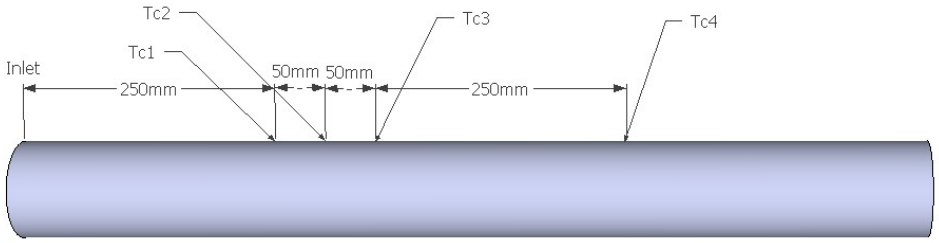
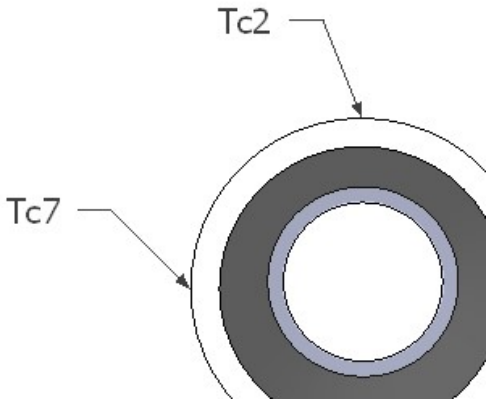


Figure 6
Thermocouples on the exhaust manifold mock-up
(the inlet of the mock-up is on the left side)



1.8 Propane burner

1.8.1 The propane burner used to pre-warm the exhaust system shall be chosen as to fulfill the requirements on achieved temperatures specified in paragraph 3.4.6.

1.9 Obstructions

1.9.1. Obstruction 1 has the dimensions of 900 mm × 840 mm × 230 mm, as shown in Figure 7. Obstructions 2 and 3 consist of horizontal and vertical obstruction tubes as shown in Figure 8. The horizontal obstruction tubes are closed and hollow, with a diameter of 80 mm and a length of 480 mm. The vertical tubes are hollow and open in the bottom, with a diameter of 80 mm and a length of 230 mm. The open distance between every tube is 20 mm. Obstruction 4 is a box measuring 1,250 mm × 300 mm × 390 mm as shown in Figure 9.

Figure 7
Obstruction 1

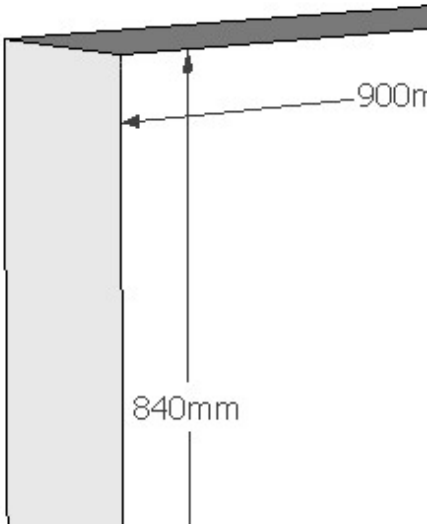


Figure 8
Obstruction 2 and 3

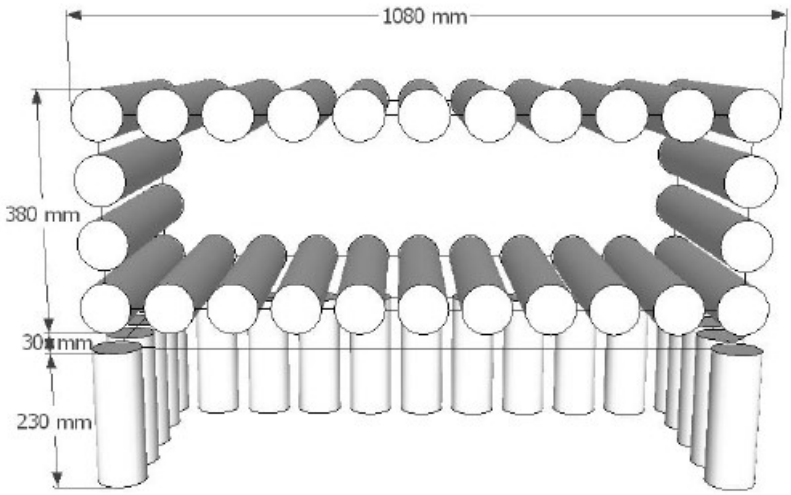
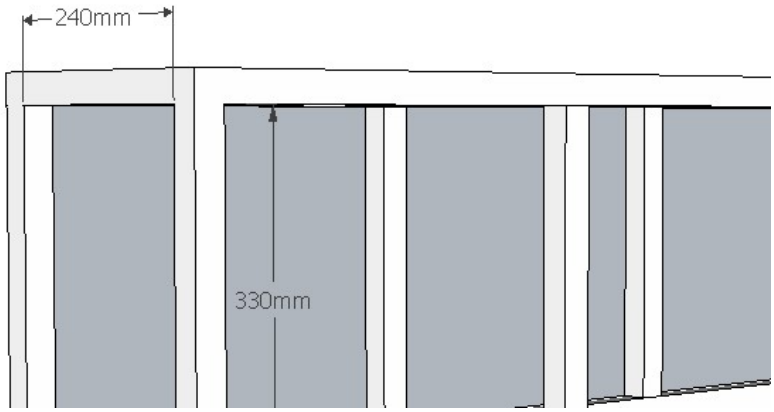


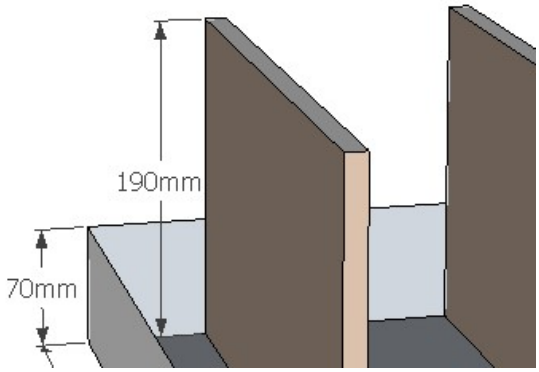
Figure 9
Obstruction 4



1.10. Pool Fire trays

1.10.1 The square pool fire trays with fibreboards and the rectangular pool fire trays shall be positioned in its orientation according to the test scenarios in Appendices 2 to 4. Figure 10 shows the dimensions for test fire #2. The test fire shall be positioned perpendicular to the long edge of the test apparatus.

Figure 10
Distances for test fire #2



2.0 Test fires

2.1. The test fires in Table 5 are to be used in the different test scenarios described in Appendices 2 to 5. Diesel oil (commercial fuel oil or light diesel oil), heptane (C_7H_{16}) and engine oil 15W-40 with a flash point COC of 230 °C and viscosity at 40 °C of 107 mm^2/s shall be used as test fuels.

Table 5
Test fires

Test fire	Description	Fuel	Approximate peak Heat Release Rate 60 sec after ignition
#1	Pool fire 300 mm × 300 mm	Diesel oil and heptane	60 kW
#2	Pool fire 300 mm × 300 mm and 2 fibreboards	Diesel oil and heptane	110 kW
#3	Pool fire 200 mm × 300 mm	Diesel oil and heptane	40 kW
#4	Pool fire Ø 150 mm	Diesel oil and heptane	7 kW
#5	Spray fire (450 kPa, 0.73 kg/min ±10%)	Diesel oil	520 kW
#6	Spray fire (450 kPa, 0.19 kg/min ±10%)	Diesel oil	140 kW
#7	Dripping oil fire (40 droplets/min ±10)	Engine oil	5 kW

2.2 Three different types of pool fire trays are applied in Table 5: square, rectangular and circular. Detailed descriptions of these trays are given in Table 6.

Table 6
Specification of pool fire trays

Dimensions	Rim height	Nominal thickness	Used for test fire
300 mm × 300 mm	70 mm	1.5 mm	#1, #2
200 mm × 300 mm	70 mm	2 mm	#3
Ø 150 mm	100 mm	1.5 mm	#4

2.3 The amount of water, diesel and heptane used in the tests should be in accordance with Table 7.

Table 7
Amount of fuel used in pool fire trays

Dimensions	Water	Diesel	Heptane	Used for test fire
300 mm × 300 mm	1.0 l	0.5 l	0.2 l	#1, #2,
200 mm × 300 mm	0.5 l	0.5 l	0.2 l	#3
Ø 150 mm	0.2 l	0.2 l	0.1 l	#4

2.4. Test fire #2 consists of a heptane pool and two diesel soaked fibreboards with a dry density of 3.5 kg/m3. The dimensions of the fibreboards shall be 12 mm × 295 mm × 190 mm. The fibreboards shall consist of at least 90 per cent raw material from wood. The moisture content in the boards before they are soaked in diesel oil shall not exceed 7 per cent.

The fibreboards shall be completely immersed in diesel oil for at least 10 minutes prior to the test and mounted vertically in the pool fire tray not more than 10 minutes before the start of the test.

2.5 Test fire #5 and #6 consist of diesel oil spray fires while Test fire #7 consists of a dripping oil fire (by hot surface ignition).

The spray nozzle for test fire #5 shall be a Lechler 460.368.30 or an equivalent. The spray nozzle for test fire #6 shall be a Lechler 212.245.11 or an equivalent. The spray nozzle for test fire #7 shall be a Danfoss 0.60X80H or an equivalent.

3.0 Installation of fire suppression system

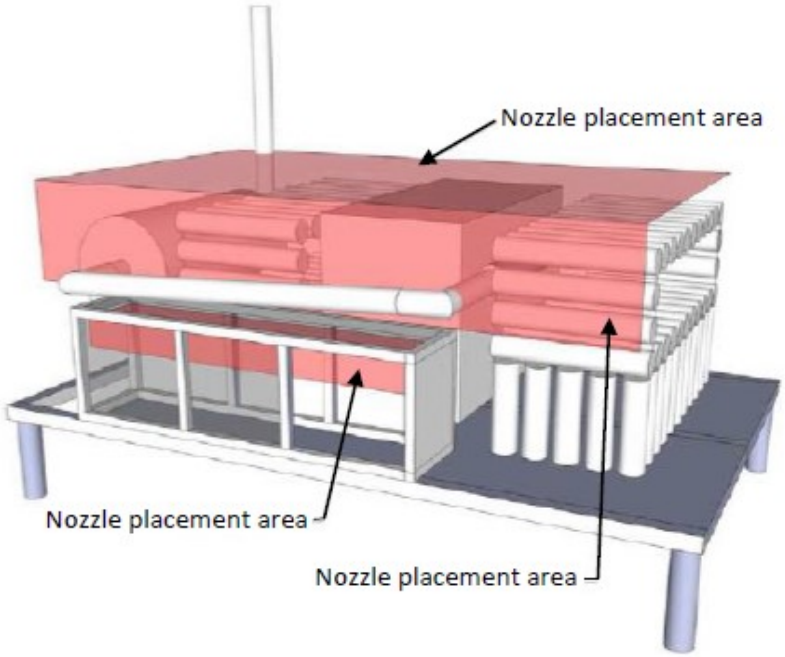
3.1 To obtain the minimum discharge rate condition, an extinguishing system is to be assembled using its maximum piping limitations with respect to the number of fittings and size and length of pipe, if relevant. The cylinder is to be used with its rated capacity and the cylinder or gas cartridge pressurized with propellant gas to the normal operating pressure, if relevant.

3.2 The fire suppression system shall be installed by the system manufacturer or supplier. It shall be the responsibility of suppliers to get heat detecting sensor approval complying with Factory Manual (FM 3210) or UL 521 standard requirements. Figure 11 shows the area where extinguishing agent discharge points such as of nozzles, extinguishing agent generators or extinguishing agent discharge tubes may be located. The discharge points shall be positioned inside the test apparatus, at two different areas:

(a) In the ceiling and at the rear wall. Discharge points positioned in the ceiling shall be positioned at a minimum of 750 mm above the floor level ($z \geq 0.75$) and outside of Obstruction 1. Nozzles positioned at the rear wall shall be positioned within 350 mm from the rear wall ($y \geq 1.15$) and minimum 450 mm from the floor level ($z \geq 0.45$). Figures 17 and 18 show the area where the nozzles may be located.

(b) Inside the small box (referred to as Obstruction 4) in the rear side of the test apparatus. Nozzles should be located in the ceiling of the box with a minimum of 290 mm from the floor ($z \geq 0.29$).

Figure 11
Nozzle positioning seen from the rear side of test apparatus



3.3 The system set-up and configuration shall be observed and documented prior to the test (e.g. amount of suppression agent and propellant gas, system pressure, number, type and location of discharge points, length of pipes and number of fittings).

Temperature shall be measured during the re-ignition tests at locations specified in Appendix 1.

3.4 Practical conduct of a test

3.4.1 The pool fire trays are to be filled with diesel and heptane on a base of water according to Table 7. If fibreboards are to be used as a fire source, the fibreboards shall be soaked in diesel oil, prior to the test, according to instructions in paragraph 2.4.

3.4.2 A pre-burn time based on the information in Appendices 2 to 5 is required. The pre-burn time is measured beginning from the time the first fire is ignited. All pool fires in the test scenarios shall be ignited within the allowed ignition-time, according to Appendices 2 to 5, using a suitable ignition source. The low fire load scenario in Appendix 3 may be performed either with one test fire at a time or the test fires combined with the suppression system showing its ability to extinguish all test fires, separately or merged.

3.4.3 A fan is used in some of the test scenarios to obtain a specific air flow rate into the test apparatus. The fan shall be engaged 30 seconds before the suppression system is activated. The fan shall remain active until the test is complete, i.e. until it is determined whether the test is passed or failed.

3.4.4. A diesel spray is used in some of the test scenarios. The diesel spray shall be activated 10 seconds prior to activation of the suppression system. The diesel spray shall remain active until the test is completed, i.e. until it is clarified if the test is passed or failed.

3.4.5 After the stipulated pre-burn time, the suppression system shall be manually or automatically activated.

3.4.6 In test for re-ignition, the exhaust manifold mock-up tube is pre-heated prior to the test with a burner. Pressurized air may be added to the flame for better combustion. The tube shall be heated from the inner side until the temperature of Tc2 is above 600 °C and Tc1 is above 570 °C and the temperatures of Tc5, Tc6 and Tc7 not are less than 520 °C. When the predefined temperatures are reached the pre-heating procedure stops. After 30 seconds the engine oil start dripping and the suppression system activates 15 seconds later. The engine oil shall ignite before activation of the suppression system. The oil should continue to drip on to the tube until it is clarified if the test is passed or failed.

4.0 Tolerances

4.1. A tolerance of ±5 per cent of the stipulated values shall apply (for time values: ±5 seconds).

Appendix 2

High fire load scenario

Table 1
Test fires in high fire load scenario

Test fire (see Table 5 in Appendix 1)	Description	Coordinates [x; y; z] (see Figure 1 in Appendix 1)
#6	Spray fire (4.5 bar, 0.19 kg/min)	[1.47; 0.73; 0.46]
#3	Pool fire 200 mm × 300 mm	[0.97; 0.85; 0.70]
#4	Pool fire Ø 150 mm	[0.97; 1.28; 0.00]
#3	Pool fire 200 mm × 300 mm	[1.54; 0.57; 0.36]
#2	Pool fire 300 mm × 300 mm and 2 Fibreboards	[1.54; 0.77; 0.36]
#3	Pool fire 200 mm × 300 mm	[1.54; 0.13; 0.00]

Note: The fan is not used

Table 2
Test procedure for high fire load scenario

Time	Action
00:00	Start igniting
00:10	Alarm should have activated*
01:20	Ignition complete
01:50	Start of Diesel spray
02:00	Manual activation of suppression system
02:30	FDSS should have suppressed the Fire

* Time in seconds after which alarm activates shall be recorded in the test report

Figure 1
Test fire positioning, view from the front side

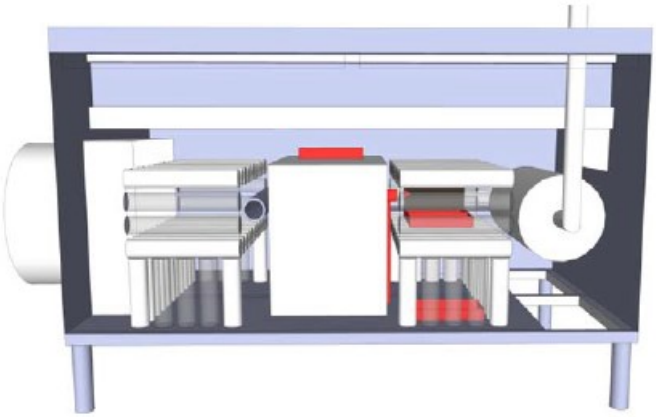
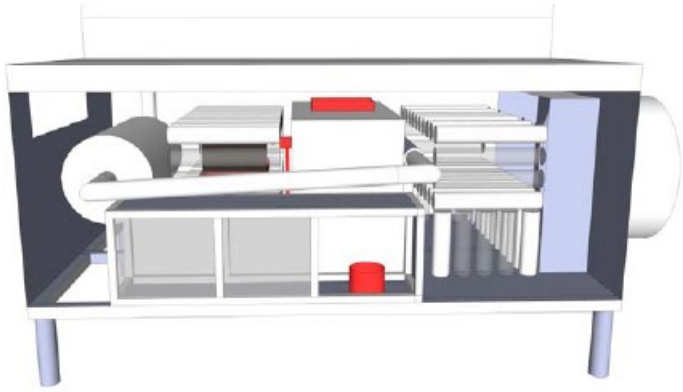


Figure 2
Test fire positioning, view from the rear side



Appendix 3

Low fire load scenario

Table 1
Test fires in low fire load scenario

Test fire (see Table 5 in Appendix 1)	Description	Coordinates [x; y; z] (see Figure 1 in Appendix 1)
#4	Pool fire Ø 150 mm	[0.02; 0.08; 0.00]
#3	Pool fire 200 mm × 300 mm	[0.37; 0.57; 0.00]
#4	Pool fire Ø 150 mm	[0.45; 1.20; 0.00]
#4	Pool fire Ø 150 mm	[0.97; 1.28; 0.00]
#4	Pool fire Ø 150 mm	[1.54; 0.57; 0.00]

Note: The fan is producing an air flow of 1.5 m3/s.

Table 2A
Test in Table 2A is intended for checking automatic activation of Suppression system.

Time	Action
00:00	Start igniting
00:10	Alarm & fire suppression should have activated automatically.*

* Time in seconds after which alarm activates shall be recorded in the test report.

Table 2B
Test in Table 2B is applicable for Low fire load scenario

Time	Action
00:00	Start igniting
00:10	Alarm should have activated*
01:00	Ignition complete
01:30	Start the Fan
02:00	Manual activation of suppression system
02:30	FDSS should have suppressed the Fire

* Time in seconds after which alarm activates shall be recorded in the test report.

Figure 1
Test fire positioning, view from the front side

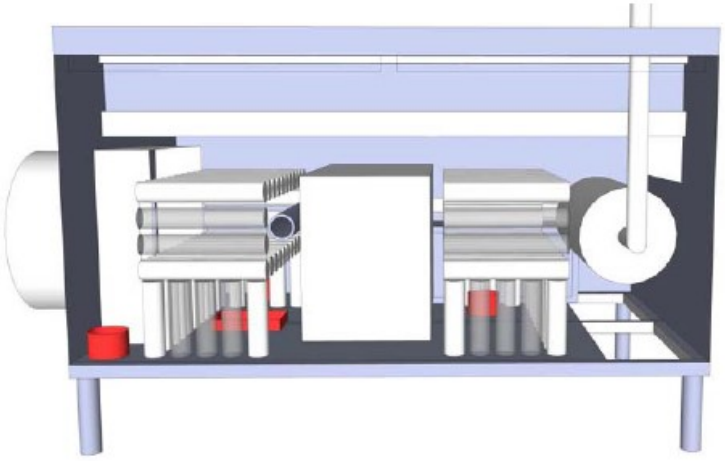
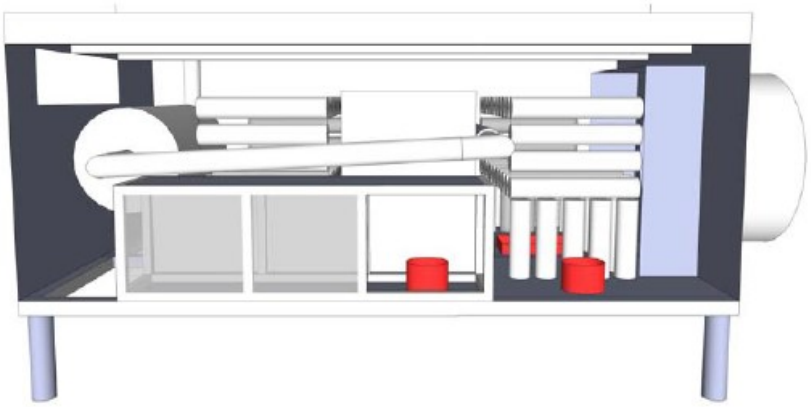


Figure 2
Test fire positioning, view from the rear side



Appendix 4

High fire load scenario with fan

Table 1
Test fires in high fire load scenario with fan

Test fire (see Table 5 in Appendix 1)	Description	Coordinates [x; y; z] (see Figure 1 in Appendix 1)
#5	Spray fire (4.5 bar, 0.73 kg/min)	[0.37; 0.70; 0.46]
#1	Pool fire 300 mm × 300 mm	[0.37; 0.47; 0.36]
#2	Pool fire 300 mm × 300 mm and 2 fibreboards	[0.37; 0.77; 0.36]
#1	Pool fire 300 mm × 300 mm	[0.37; 0.13; 0.00]
#1	Pool fire 300 mm × 300 mm	[1.54; 0.13; 0.00]

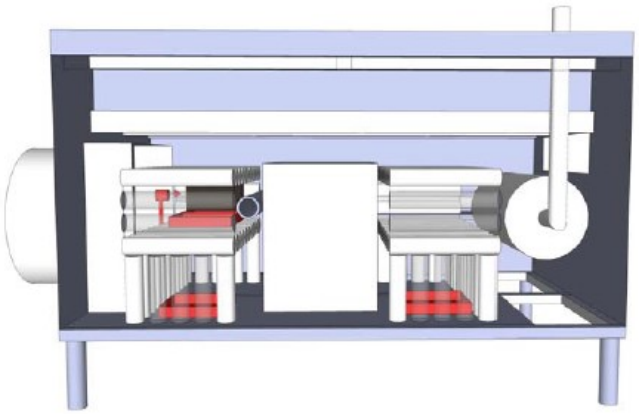
Note: The fan is producing an air flow of 1.5m^3/s.

Table 2
Test procedure for high fire load scenario with fan

Time	Action
00:00	Start igniting
00:10	Alarm should have activated*
01:00	Ignition complete
01:30	Start the Fan
01:45	Start of diesel spray
02:00	Manual activation of suppression system
02:30	FDSS should have suppressed the Fire

* Time in seconds after which alarm activates shall be recorded in the test report.

Figure 1
Test fire positioning, view from the front side



Appendix 5

Re-ignition scenario

Table 1
Test fires in re-ignition scenario

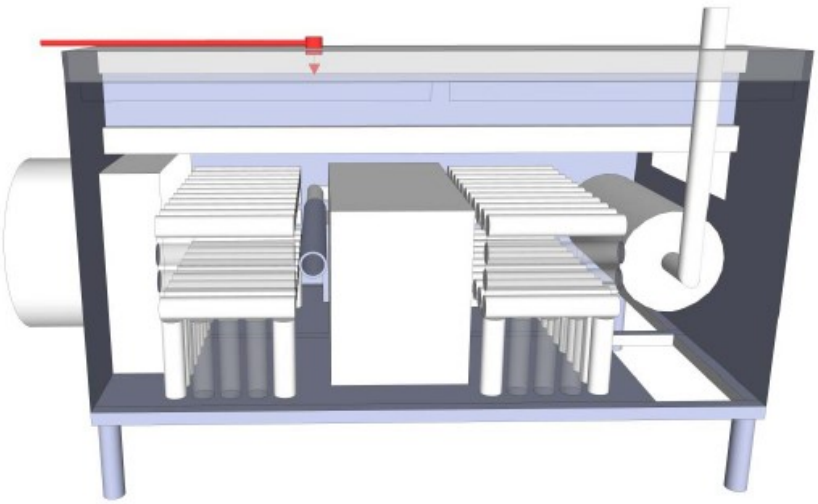
Test fire (see Table 5 in Appendix 1)	Description	Coordinates [x; y; z] (see Figure 1 in Appendix 1)
#7	Dripping oil fire (2 bar, 0.01 kg/min)	[0.82; 0.28; 1.22]

Note: The fan is not used.

Table 2
Test procedure for re-ignition scenario

Time	Action
Prior to test	Pre-heat tube
00:00	Predefined temperatures are reached
00:30	Start oil dripping
00:45	FDSS should have activated suppression system & suppressed the fire

Figure 1
Test fire positioning, view from the front side



ANNEX IX

(See Introduction)

COMPOSITION OF AISC PANEL*

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Shri V. A. Tandon	ARAI
Shri V. S. Khairatkar	ARAI
Shri V. P. Rawal	ARAI
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Shri Karthik Sarma	SIAM (Volvo Buses India Pvt. Ltd.)
Shri Saahil Saxena	SIAM (VE Commercial Vehicles Ltd.)
Shri Uday Harite	ACMA

* At the time of approval of this Automotive Industry Standard (AIS)

ANNEX X
(See Introduction)
COMMITTEE COMPOSITION *
Automotive Industry Standards Committee

Chairperson	
Mrs. Rashmi Urdhwareshe	Director The Automotive Research Association of India, Pune
Members	**Representing**
Representative from	Ministry of Road Transport and Highways (Dept. of Road Transport and Highways), New Delhi
Representative from	Ministry of Heavy Industries and Public Enterprises (Department of Heavy Industry), New Delhi
Shri S. M. Ahuja	Office of the Development Commissioner, MSME, Ministry of Micro, Small and Medium Enterprises, New Delhi
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