

Certification rules  
regarding

# Fire suppression systems in engine compartments of buses and coaches



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## Abstract

Products can be certified for P-marking by SP Technical Research Institute of Sweden. Issue of a certificate is subject to establishment that the product meets the requirements of relevant standards, regulations etc., and that the manufacturer operates an approved inspection regime and quality control system.

This document sets out the certification rules for fire suppression systems in engine compartments of buses and coaches. The rules include details of the technical requirements with respect to fire suppression performance, together with requirements relating to continuous inspection.

The specific product requirements are based on the test method SP 4912 and the standards listed in section 3. In case of deviation from the requirement in the standards this is highlighted in section 3. The products are divided into different fire technical classes as in the referred standards and are also specified in section 3.

Continuous inspection involves primarily the manufacturer's FPC (Factory Production Control), together with surveillance inspection by SP. Surveillance inspection is carried out by SP through visits to the manufacturing premises. During these visits, SP are concerned with ensuring that the manufacturer's FPC is adequate and operating as intended. In addition, samples of the finished products may be taken for testing.

**Key words:** Certification, P-marking, fire suppression systems in engine compartments of buses and coaches, Quality control, SP method 4912

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## Preface

This document sets out the rules for certification of fully automatic fire suppression systems in engine compartments of buses and coaches.

The requirements concerning surveillance as set out in Sections 4 and 5, have been drawn up by SP. The technical requirements as set out in Section 3 are based on internationally accepted standards. Certification, as described in Section 2, is performed by SP Certification.

Continuous inspection involves inspection by the manufacturer and surveillance inspection by SP. Surveillance inspection is carried out through visits to the manufacturer, and involves assessment of the manufacturer's FPC. In addition, samples of the finished products may be taken for testing in order to verify that the manufacturer's FPC is operating as intended.

The certification rules are based on current standards, but may be revised in future, e.g. to harmonise them with future European or international standards. Revision may also be necessary if new regulations are introduced or if a need for such revision is shown by the results of experience of application of the rules. If clarification or complementation of the rules becomes necessary, an appropriate PM document will be issued, and will also be incorporated in future issues of the rules.

Borås, October 2012

**SP Technical Research Institute of Sweden  
Certification**



Lennart Månsson


# 1. Introduction

## 1.1 General

Certification involves confirmation by an independent third party that a product fulfils requirements set out in standards or some other form of specification. Certification by SP is performed by SP Certification, a department that is completely separate from the testing and inspection departments. It answers to a certification board, whose members are drawn from across the range of industry areas involved. The board can appoint expert groups for various product areas, e.g. as technical working parties. Certification of products by SP is performed in accordance with EN 45011 (ISO Guide 65).

The requirements that must be fulfilled are set out in special certification rules (SPCR), developed for each product sector. Before certification starts, the certification rules must - except in those cases where the rules are based entirely on regulations issued by public authorities - have been discussed with interested parties and then have been approved by SP's certification board. This procedure ensures that certification is based on rules that have been thoroughly considered, are relevant and are firmly based.

Products which, after an initial assessment - including but not limited to testing, show that they fulfil specified requirements can be certified by SP. This certification is confirmed by issue of a certificate, one of the rights of which is usually permission (under licence) to use a certification symbol. Ongoing inspection/surveillance, consisting of the manufacturer's FPC procedures and SP's surveillance inspection, ensures that the requirements relating to the product continue to be fulfilled during the validity period of the certificate.

SP certifies for several different certification schemes. SP's own certification approval symbol, the -symbol, applies only to SP's own certification system.

## 1.2 Scope

These certification rules apply for fire suppression systems for installation in engine compartments of buses and coaches.

## **2. Conditions for certification of fire suppression systems in engine compartments of buses and coaches**

### **2.1 General**

Certification consists of an initial assessment of the product and of its manufacturer's FPC procedures. When the certification requirements have been fulfilled, a certificate is issued. Provided that the product continues to fulfil the requirements and that the continuous inspection procedures are operating as intended, the certificate stays valid during its validity period.

Other terms and conditions are set out in Section 6.

### **2.2 Application for certification**

Applications for certification shall be submitted in writing, and shall be accompanied by:

- technical data (test reports, product description), as set out in Section 2.3.1;
- a description of the manufacturer's FPC procedures, as set out in Section 2.3.2; *and*
- proposal for marking, as set out in Section 2.3.3.

All documents shall be presented in two sets. After the certification process, one of the sets will be sent back to the applicant, signed by SP. A special application form is available.

### **2.3 Requirements**

#### **2.3.1 Initial assessment**

The initial assessment involves examination of the submitted documents for compliance with the requirements of these rules. When assessment is complete and when the applicant's material is deemed to fulfil the requirements, SP will visit the manufacturer to check that he possesses the necessary facilities and organisation to perform the continuous inspection as required and described. If SP decides that this is the case, it will sign a contract with the manufacturer concerning continuous inspection in accordance with Section 2.3.2 below, after which a certificate will be issued.

#### **2.3.2 Requirement for continuous inspection**

Continuous inspection shall ensure that certified products continue to fulfil the requirements in these certification rules. It shall consist of the manufacturer's FPC, as described in Section 4, complemented by surveillance inspection, performed by SP, as described in Section 5.

The extent of the surveillance inspection shall be agreed and set out in a written agreement between the manufacturer/importer and SP.

### 2.3.3 Marking

Products entitled to display SP's certification symbol shall also show the number of the certificate, product name or other identification, fire technical class, actual standard and serial number or equivalent of the product. Marking shall be legible and durable, and shall be applied in conjunction to the engine compartment. Alternative designs of the certification symbol, the P-mark, are shown below.



SP's certification symbol (P-mark) in alternative designs

### 2.4 Validity of the certificate

The validity of the certificate is normally five years. Depending on the content of reports from surveillance inspection, and other factors, the validity time may be extended after application from the holder of the certificate.

### 2.5 Changes to the certified product

Before changing the design, materials or construction of the product, the holder of the certificate shall notify SP of the intended changes. SP will decide whether the changes can be approved, which will normally be notified by letter.



### **3. Technical requirements**

#### **3.1 Type testing and performance requirements**

##### **3.1.1 Fire test in accordance with SP Method 4912**

The basic fire test for testing fire suppression systems in engine compartments of buses and coaches is SP Method 4912. In order to obtain the P-mark, a minimum rating of 7 must be achieved after fire test in accordance with SP Method 4912. Moreover, following requirements must be fulfilled:

- 45 seconds re-ignition protection
- the most severe low fire load test passed shall be performed with reduced mass of extinguishing agent (ordinary mass of agent divided by 1.2)
- passed minimum operating temperature test

More information about the requirements is found in SP Method 4912. The results of the fire tests, which tests that have been passed and failed (if any), the duration of re-ignition protection and so verified minimal operating temperature will be part of the information in the P-mark certificate.

### 3.1.2 Component tests

To achieve a P-mark certificate the included components in the fire suppression system need to be verified and tested through international standards as specified below by independent accredited testing laboratories.

The hereafter listed component tests are to be considered as additional requirements in relation to local legal requirements as well as requirements imposed by the vehicle manufacturer. It is the responsibility of a suppression system manufacturer to assure compliance of its suppression system components with legal requirements and vehicle manufacturer requirements.<sup>1</sup>

The P-mark certification requirements can be found in the tables below. It is acceptable for new components to be used for subsequent tests. By representative sample of a suppression system it is meant a fully charged, operable and manually dischargeable fire suppression system unit which consists of the same components (mounting brackets inclusively) as the system tested in accordance with SP Method 4912.

|                              |  |
|------------------------------|--|
| Property                     | <b>Mechanical stress resistance</b>  |
| Component                    | Representative sample of a suppression system  |
| Applicable to type of system | All agents   |
| Standard                     | <p>ISO 16750-3:2007</p> <p>Vibration test with vibration load and duration defined by ISO 16750-3:2007 (no temperature cycling) for following mounting location:</p> <ul style="list-style-type: none"> <li>a) <i>Sprung masses, commercial vehicles</i> (4.1.2.7) if the fire suppression system is intended to be installed in a bus/coach with metallic spring suspension</li> <li>b) <i>Decoupled cab, commercial vehicles</i> (4.1.2.8) if the fire suppression system is intended to be installed in a bus/coach with air spring suspension</li> </ul> <p>The above spectrum shall if needed be extended as to include at least one resonance frequency of the representative suppression system.</p> <p>Mechanical shock test in accordance with ISO 16750 4.2.2.2 (<i>commercial vehicles, devices on rigid points of the body or frame</i>) immediately following the vibration test.</p> |
| Performance requirements     | Following these tests, the representative sample shall be discharged, show no visible signs of leaks or loosened fittings, and the mass of the extinguishing agent discharged shall not be less than 95 % of the highest mass discharged during the fire tests, based upon comparison of extinguishing agent vessel mass or sample mass before and after the test.   |

<sup>1</sup> As examples of such requirements can be mentioned *UN ECE R.10, Uniform Provisions Concerning the Approval of Vehicles with Regard to Electromagnetic Compatibility* (legal requirement in many countries, commonly required by vehicle manufacturers), *ISO 16750, Environmental conditions and testing for electrical and electronic equipment* (commonly required by vehicle manufacturers) and *The Pressure Equipment Directive (97/23/EC)* (legal requirement within European Union).

| Property                     | <b>Combined mechanical and thermal stress resistance</b>   |
|------------------------------|--|
| Component                    | Representative sample of a suppression system if the fire suppression system is intended to be mounted entirely in the engine compartment  |
| Applicable to type of system | Systems intended to be mounted entirely in the engine compartment  |
| Standard                     | ISO 16750-3:2007<br>Vibration test with vibration load and duration as specified in <b>Mechanical stress resistance</b> test, with simultaneous temperature cycling as stated by Figure 1 in ISO 16750-3:2007, 4.1.1 where $T_{min}$ and $T_{max}$ correspond to minimum and maximum operating temperatures <sup>2</sup> of the suppression system declared by the manufacturer.<br><br>Mechanical shock test in accordance with ISO 16750 4.2.2.2 ( <i>commercial vehicles, devices on rigid points of the body or frame</i> ) immediately following the combined vibration and thermal test above. |
| Performance requirements     | Following these tests, the representative sample shall be discharged, show no visible signs of leaks or loosened fittings, and the mass of the extinguishing agent discharged shall not be less than 95 % of the highest mass discharged during the fire tests, based upon comparison of extinguishing agent vessel mass or sample mass before and after the test.   |

| Property                     | <b>Corrosion resistance</b>   |
|------------------------------|---|
| Component                    | Representative sample of a suppression system.  |
| Applicable to type of system | All agents  |
| Standard                     | Test method A in ISO 21207, 6 weeks exposure.   |
| Performance requirements     | Following this test, the representative sample shall be discharged, and the mass of the extinguishing agent discharged shall not be less than 95 % of the highest mass discharged during the fire tests, based upon comparison of extinguishing agent vessel mass or sample mass prior to and after the test. |

<sup>2</sup> The on-board temperature conditions may easily exceed the suppression system operating temperature range specified by the manufacturer. For example, ISO 16750 presents, among others, [-40 °C; 140 °C] and [-40 °C; 90 °C] as reasonable temperature ranges for environmental testing of electric/electronic equipment for engine and luggage compartments, respectively (for further details see ISO 16750:4). Of course, the general temperature requirements on fixed components on vehicles that are designed to be used world-wide may not represent local climatic conditions for a certain vehicle suppression system, especially with respect to realistic minimal temperatures. Thus, considering suppression system operating temperature range in relation to climate and vehicle thermal characteristics must be part of a risk assessment (see 3.2 Risk assessment).

## **3.2 Risk assessment**

A risk assessment shall be made prior to equipment being placed into service. Its main purpose is to demonstrate that the system design corresponds to the P-mark test reports. In particular, the identified fire hazards of the specific engine compartment shall be taken into account. To this end, recommendations and specifications found in Annex 1 shall be used.

A risk assessment shall further be made when variations in design, use condition and environment, could change the fire risk potential or system performance. In practice this could mean that a risk assessment would have to be carried out for each new engine compartment configuration.

In the risk assessment, fire hazards and dangers related to efficient use of the extinguishment system shall be identified and documented together with a description on how each particular hazard is handled. The fire risk management process shall be fully documented for the life of the equipment (e.g. maintenance requirements) and be available to the relevant parties.

The risk assessment shall be made by personnel having documented experience for the task. The suppression system manufacturer shall either be directly involved in the risk assessment or indirectly through an organization appointed to the task by the suppression system manufacturer.

Documents demonstrating the risk assessment made shall be available at follow-up inspections.

## **3.3 Installation**

The manufacturer shall provide the installer a design manual in compliance with section 1.1 in Annex 1. The installer shall be approved/licensed by the manufacturer. After each installation the installer shall sign a declaration where he declares that the system is installed and checked according to the risk assessment and the manufacturer's design manual. The declaration shall be available at follow-up inspections.

## **4. Manufacturer's FPC**

The manufacturer shall operate FPC (Factory Production Control) procedures to ensure that products displaying the P-symbol fulfil the requirements in these certification rules. These inspection procedures shall be described in a quality manual or corresponding document, and shall fulfil the requirements set out in this section. If the manufacturer has an ISO 9001 quality system that has been certified by an accredited certification body, this can be regarded as fulfilling the following requirements in respect of organisation, management review, document control, control of nonconforming products, corrective actions, handling of finished products and complaints.

### **4.1 Organization**

The organization of the manufacturers own inspection system shall be described, with the names of those persons responsible for inspection and details of their authority to act in order to prevent sub-standard quality.

A person shall be appointed to represent the manufacturer with regards to the manufacturing inspection. This person shall have the necessary authority and responsibility to ensure that the intended quality of the certified products is achieved and maintained.

### **4.2 Management review, internal auditing**

The company management shall perform documented reviews of the company's inspection procedures at regular intervals in order to ensure the efficacy of the procedures.

### **4.3 Document control**

Only the current editions of documents concerning manufacturer's inspection shall be available to the persons concerned in the company. There shall be a list of the documents, and a distribution list for them, together with procedures for the production of new documents, alteration of existing documents and collection of documents that are no longer valid.

### **4.4 Design control**

Design management procedures shall include an instruction that any design changes shall be notified to, and approved by, SP before they can be introduced.

### **4.5 Testing and inspection**

#### **4.5.1 Reception inspection**

Reception inspection (goods inward inspection) shall be performed to the extent regarded as necessary in order to verify that incoming materials and products accord with specified requirements. If materials or goods are imported, the manufacturer's documents that certify that the materials or goods supplied fulfil the requirements set out in Section 4.5.3. shall be inspected.

#### **4.5.2 Manufacturing inspection**

Manufacturing inspection shall be performed to the extent regarded as necessary in order to ensure that products that are manufactured fulfil specified requirements.

### **4.5.3 Inspection of finished products**

Finished products shall be inspected to the extent regarded as necessary in order to ensure that they fulfil the specified requirements.

### **4.5.4 Equipment**

Equipment shall be calibrated, inspected, adjusted and maintained as appropriate.

### **4.5.5 Installation control**

If the manufacturer of the system is not the installer of the system, he shall at specified intervals perform spot checks on installed systems. Documents demonstrating the performed spot checks shall be available at follow-up inspections. See also section 3.3.

## **4.6 Control of nonconforming products**

Products that do not fulfil specified requirements shall be separated from those that do. Such products may not be sold under the same name or number etc. as certified products.

## **4.7 Corrective actions**

Any failures detected by manufacturer's FPC and/or by surveillance inspection shall be investigated by the manufacturer, and appropriate steps shall be taken to correct the situation and prevent a repetition.

## **4.8 Handling of finished products**

Damage and deterioration shall be prevented in connection with handling, storage, packing and delivery.

## **4.9 Traceability**

It shall be possible to trace products that have been supplied back to the relevant production and material batch. Which components that shall be traceable and to which extent will for each certified suppression system be specified by SP.

## **4.10 Marking**

Products shall be marked (see Section 2.3.3) when manufacturer's inspection has shown that the requirements are fulfilled.

## **4.11 Complaints**

Complaints from customers or others in respect of certified products, marking, marketing etc., shall be documented together with details of the action taken with the documentation being kept available for inspection by SP.

## **4.12 Quality documents – keeping of records**

The manufacturer shall be able to confirm, by means of collecting and retaining relevant documents, that the products fulfil specified requirements.

Documentation of inspection and testing shall be of such an extent that the necessary traceability can be assured. Records shall contain comments when results depart from those expected, together with descriptions of actions taken in response thereof.

Archiving times shall be stated for documents relating to manufacturer's FPC.

Test and inspection records shall be kept available for inspection by SP, and shall be retained for at least ten years.

## **5. SP's surveillance inspection**

### **5.1 Execution**

Surveillance inspection will be carried out at least once a year in the form of a visit, of which prior warning will not necessarily be given, by SP to the manufacturer. The manufacturer shall provide unrestricted access to SP's representative for performance of the surveillance inspection.

On these visits, SP will inspect to determine whether the manufacturer's described inspection procedures are operating as intended, and will perform testing and inspection as described below.

If the manufacturer has a quality management system that is certified by an accredited inspection body, SP's examination of the manufacturer's own inspection procedures can normally be limited to examination of records and audit reports. Testing and inspection will be carried out as described below.

Testing and inspection may be performed to a different extent, depending on the type and results of surveillance inspection. This will be set out in the agreement on surveillance inspection.

Surveillance inspection can also be carried out on a specific object where the system has been installed.

Documents for installation will be reviewed at the time of inspection. Documented proofs of installation shall be available for inspection at any time.

### **5.2 Surveillance inspection failure**

If the manufacturer's own inspection procedures fail inspection testing and/or examination, the reasons for this failure shall be investigated. The investigation may result in a new surveillance visit, retesting or failure of the manufacturer's own inspection procedures.

### **5.3 Reporting**

The results of surveillance inspection visits shall be reported in writing to the manufacturer and - if the holder of the certificate is some party other than the manufacturer - also to the holder of the certificate.



## **6. Other terms and conditions**

### **6.1 General**

The terms and conditions in these certification rules, Sections 2 and 6, are based on principles set out in SP's Quality Manual for Certification. Sub-contractors for type-testing and surveillance inspection shall be approved by SP. "General contract terms for SP - General conditions for assignments" and "General certification rules for certification of products, CR000" are also applicable.

### **6.2 Responsibilities of the certificate holder**

The holder of the certificate is responsible for ensuring that the products covered by the certificate and which are marked with the P-symbol fulfil in all respects the requirements of the certification rules to which the certificate refers, and that the products are suited for their purposes and cannot in any other way cause damage or injury. This applies even if the holder of the certificate is not the manufacturer/importer of the product, although the agreement on surveillance inspection has been signed by the manufacturer/importer and SP.

It is the responsibility of the certificate holder to ensure that installation requirements and provisions are followed by the installer. Documented proofs of installation shall be available for inspection at any time.

### **6.3 Use of SP's P-symbol by the certificate-holder**

The holder of the certificate shall be entitled to mark the products covered by the certificate with SP's P-symbol, and shall also be entitled to use the symbol in connection with advertising or marketing of the products. Advertising shall not be performed in such a way that there is any risk of confusion between marked and unmarked products.

### **6.4 Recall of the certificate**

With immediate effect, SP can recall certificates definitively or temporarily if:

- a) the holder of the certificate has applied the P-symbol to, or used it in connection with, products that do not fulfil the requirements, *or*
- b) the holder of the certificate has applied the P-symbol to, or used it in connection with, products not covered by the certificate, *or*
- c) surveillance inspection has ceased, or has resulted in failure, *or*
- d) the holder of the certificate has in some other way failed to comply with the terms and conditions associated with the certificate, *or*
- e) the holder of the certificate has not paid fees within the prescribed time, *or*
- f) the holder of the certificate has been declared bankrupt, has gone into liquidation or has transferred the business, *or*
- g) the certificate has been found to have been issued incorrectly. However, the holder of the certificate shall be granted a reasonable time for adjusting to changed circumstances, unless there are special reasons to the contrary; *or*
- h) the product has been found to be unsuitable for its intended purpose, or can cause injury or inconvenience.

In addition to recall of the certificate, misuse of SP's P-symbol or certificate can result in legal action.

## 6.5 Obligations of the certificate-holder in the event of recall of the certificate

The holder of a certificate who has been notified that the certificate has been recalled, whether definitively or temporarily, shall:

- a) immediately cease making any reference to the certificate in advertisements or other publicity material for the product(s) concerned;
- b) ensure that SP's P-symbol is removed from all products that are in stock, if so required by SP;
- c) meet all costs associated with replacing the sub-standard products by products that fulfil the requirements in the certification rules, if so required by SP.

## 6.6 Re-issue of a certificate

The same rules apply to re-issue of a certificate that has been temporarily recalled as applied to the original issue of the certificate, as described in Section 2.3. Renewed type-testing will not be required if a period of less than one year has passed since the certificate was recalled, unless the rules for certification, or production conditions, have been changed.

## 6.7 SP's responsibility

SP is responsible for ensuring that the technical requirements in these certification rules are based on available knowledge and experience, e.g. in the form of accepted standards or corresponding specifications, and also for ensuring that the rules reflect what is generally regarded by the interested parties as a relevant quality level.

SP is responsible for ensuring that examination of certified products in accordance with these rules has been carried out with due care and in accordance with the procedures set out in SP's quality system.

SP is not responsible for certified/P-marked products (see Section 6.2), nor for their usage.

## 6.8 Secrecy

With the following exceptions, all information obtained by SP Certification will be treated as commercially confidential (secret):

- SP maintains a list of valid certificates. It contains details of the holder of the certificate, the number of the certificate, the certified products, classification (if applicable) and of the marking of products. The list is published on SP Certification's web site of certified products, [www.sp.se](http://www.sp.se).
- Certificates listed in the web site list can also be downloaded in their entirety as *pdf* files.
- SP is entitled to publish decisions relating to the recall of certificates and to misuse of certificates or marking.

## 6.9 Revision of certification rules

SP reserves the right to change the certification rules. In the event of extension of the validity of certificates issued under older rules, the holder of the certificate will be required to comply with the revised rules. However, unless special reasons to the contrary apply, the holder of the certificate shall be allowed a reasonable time for adjustment to the revised rules.

## **6.10 Fees**

Fees for initial assessment (certification), review and extension of the validity of a certificate and surveillance inspection shall be paid by the applicant / holder of the certificate.

Costs of other inspection, as set out below in Section 6.11, will be billed to the holder of the certificate only if the results of such inspection show that the requirements in the certification rules are not being fulfilled.

## **6.11 Other inspection**

SP shall be entitled, at any time and in/at any place, to carry out inspection of products displaying SP's P-symbol to ensure that the products are fulfilling the requirements in the applicable certification rules.

## **6.12 Appeals**

Appeals against SP's decisions shall be submitted in writing. Action in response to such appeals will be decided by SP's certification board.

## 7. References

BS 5117: Section 1.3:1985, Testing corrosion inhibiting, engine coolant concentrate ('antifreeze'), Determination of freezing point

EN 45011, Certification bodies - General requirements relating to certification of products. (ISO Guide 65)

EN 615:2009, Fire protection – Fire extinguishing media – Specifications for powders (other than class D powders)

EN ISO 9001:2008, Quality management systems – Requirements

ISO 16750:2006, Road vehicles – Environmental conditions and testing for electrical and electronic equipment

ISO 21207:2004, Corrosion tests in artificial atmospheres – Accelerated corrosion tests involving alternate exposure to corrosion-promoting gases, neutral salt-spray and drying

SP METHOD 2580, Foam concentrates – Quality control

SP METHOD 4912, Method for testing the suppression performance of fire suppression systems installed in engine compartments of buses and coaches

UN ECE R10.03:2008, Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility

# Annex 1

## 1. Technical descriptions

### 1.1 Design manual

P-marking impose that the manufacturer's system design manual as a minimum fulfills design parameters of the tested system. For an engine compartment with the same gross volume as the test apparatus (4 m<sup>3</sup>) this means that the at least following variables must exactly match the tested system:

- Number of nozzles (or other discharge points used)
- Nozzle type used (if the tested system utilized more than one nozzle type, it is allowable to use them in different proportions as long as the total flow rate is assured to be the same)
- Mass of extinguishing agent (including safety margin)
- Extinguishing agent<sup>3</sup>
- Mass of propellant gas
- Pressure of the propellant gas (at 20°C)
- Type of propellant gas
- Maximum pipe length (i.e distance to the most remote nozzle)
- Dimensions of pipes and fittings (exact match)

The design manual should include a detailed description of the installation procedure and what engine parts are to be protected, for example: turbo charger, manifold, generator including electrical wiring, air conditioner, auxiliary heaters and pressurized oil and fuel lines and distribution piping.

The design manual shall also include:

- A technical description of the suppression system
- Placement of extinguishing agent and propellant gas containers
- Article number of all the included components
- The labeling and identification of high-pressure hoses, fitting and pressurized containers
- The pressure in containers and in the constituent systems
- Pressure test procedure for the piping upon completed installation if the operating pressure exceeds 30 bar
- The maximum and minimum storage and operating temperature
- A technical description of the detection system
- A schematic description showing the detection system, alarm and control unit and any shut-down devices (if applicable)

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<sup>3</sup> A sample of the agent will be taken upon testing and tested or analyzed to an extent sufficient for later comparison in connection to surveillance inspection. Standards used for these activities will be e.g. EN 615 (dry chemical), SP Method 2580 (foam concentrates) and BS 5117 (antifreezes).

## 1.2 Application guidelines based on test results

The fire tests in the test protocol are divided in the following categories: High fire load test, Low fire load test, Class A fire test, Hidden fire test, Re-ignition protection test, Minimum operating temperature test and Fire tests with fan ventilation. Based on the test result, the following deductions should be made:

High fire load test: If the high fire load test can be extinguished in the test setup, this indicates that the suppression system has the ability to suppress large fires. If these large test fires can't be extinguished special notice should be given to rapid fire detection in order to limit the potential for fire growth.

Low fire load test: If a low fire load test can be extinguished in the test setup, this indicates that the suppression system has protected larger areas in the test setup and that the system has an ability to suppress small fires. If these test fires not can be extinguished special notice should be given to the ability to distribute the agent in the whole engine compartment.

Class A fire test: If Class A fires can be extinguished in the test setup, this indicates that the suppression agent has a good ability to extinguish smaller fires in fibrous materials. If these test fires not can be extinguished special notice should be given to rapid fire detection and thereby reducing the risk of fire spread to insulation and other fibrous materials. This also implies an increased risk of re-ignition due to glowing material.

Hidden fire test: If hidden fires can be extinguished in the test setup, this indicates that the suppression system has some total flooding properties, i.e. the ability to suppress fires without direct application to the fire source. If these fires not can be extinguished particular notice should be give to hidden areas of risk. Suppression agent should be applied directly to these areas minimizing hidden and unprotected areas in the engine compartment.

Re-ignition protection: If re-ignition can be prevented, this indicates that the suppression system has an ability to prevent re-ignition of flammable liquid on hot surfaces in the engine compartment if the engine is shut down during activation of the suppression system. If re-ignition can not be prevented, special notice should be given to decreasing the risk of flammable liquid coming into contact with hot surfaces after activation of the suppression system.

Minimum operating temperature test: temperature at which the minimum operating temperature test is passed should be seen as guideline on suppression system operability limits with respect to low temperatures and should be considered within risk assessment while evaluating suitability of a particular system for local climatic conditions.

Fire tests with fan ventilation: If the fires tests with fan ventilation can be extinguished, this indicates that the suppression system has an ability to extinguish fires at high ventilation. If these fires not can be extinguished particular notice should be given to turning off the fan when the suppression system is activated. Further actions should be considered to ensure activation of the suppression system and release of the suppression agent.

### 1.3 Risk assessment

According to section 3.2 a risk assessment must be made prior to equipment being placed into service. Except for what is stated in section 3.2, the risk assessment shall also include the following information:

- Fire-risk identification within the engine compartment
- The gross volume of the engine compartment
- The protected fire risks in the engine compartment
- Installation drawings including placement of extinguisher agent container, pressure vessel, controller, piping systems, detection system, hoses, etc.
- Mass of suppression agent
- The type of nozzle (article number) and mass of nozzles
- Nozzle location and direction
- The lowest and highest approved system pressure
- System operating temperature range
- Estimation of the minimum temperature the suppression system may be activated at and calculated system pressure at this temperature
- Estimation of maximum temperature the suppression system may be activated at and calculated system pressure at this temperature
- Estimation of maximum air flow rate through the engine compartment

## 2. Up- and down-scaling of the fire suppression system

Within the context of the P-mark, after scaling up or down the mass of extinguishing agent and number of nozzles, the suppression system can be installed in engine compartments ranging from 2 m<sup>3</sup> to 6 m<sup>3</sup> (the gross/reference volume of the test apparatus of SP Method 4912 is 4 m<sup>3</sup>). A scaling model is presented below. If other set of rules are used for scaling, those shall be approved by SP.

### 2.1 Down-scaling

The suppression system can be scaled down for engine compartment gross volume (denoted as  $x$ ) in the range of  $2 \text{ m}^3 \leq 4 \text{ m}^3$  using Equation 1. A nomenclature for equations 1 and 2 can be found in Table 1. The equation gives a scaling factor that can be used for scaling the tested suppression system. This includes number of nozzles (or other discharge points used), discharge rate for the entire suppression system and minimum mass of suppression agent for an engine compartment of  $x$  cubic meters ( $2 \text{ m}^3 \leq x \leq 4 \text{ m}^3$ ). The total discharge time of the system shall as a minimum remain the same.

$$S_x = 0,15 \cdot x + 0,4 \quad (1)$$

Table 1 Nomenclature for equation 1 and 2

|       |  |
|-------|--|
| $S_x$ | Scaling factor for an engine compartment gross volume of $x \text{ m}^3$ |
| $x$   | The gross volume of the engine compartment, [ $\text{m}^3$ ]             |

When estimating discharge rate and total discharge time for a specific system, a general formula based on the test result is accepted. The down-scaled number of nozzles shall be rounded up if less than 8 nozzles are used in the test. Otherwise, the number of nozzles may be rounded to closest whole number.

### 2.2 Up-scaling

The suppression system can be scaled up for engine compartment gross volume in the range of  $4 \text{ m}^3 \leq 6 \text{ m}^3$  using Equation 2. Number of nozzles, total discharge rate and minimum mass of suppression agent for an engine compartment of  $x$  cubic meters ( $4 \text{ m}^3 \leq x \leq 6 \text{ m}^3$ ) is calculated using following scaling factor.

$$S_x = 0,1 \cdot x + 0,6 \quad (2)$$

### 2.3 Amount and pressure of propellant gas

The amount of propellant gas shall at least be such, that the filling ratio (defined as  $V_G/(V_E+V_G)$ , where  $V_E$  denotes volume extinguishing agent and  $V_G$  that of propellant gas) is the same as verified during the fire tests. The pressure of the propellant gas shall be the same as in the tested system.



## **2.4 Pipe length**

The total length of pipe and the maximum number of connections shall never exceed the length of pipe and the number of connections in the tested system.

### **3. Measurement of engine compartment gross volume**

When measuring the engine compartment the gross volume should be measured, i.e. the volume of the engine and its components should not be subtracted.

#### **3.1 Height**

The height is measured from the ceiling of engine compartment (upper boundary against the passenger compartment / cargo compartment) to the floor in the engine compartment. If there is no floor in the engine compartment, measure to the bottom of the chassis beams.

#### **3.2 Width**

The width is measured on the inside of the engine compartment from each side of the bus. If there is a full plate boundary between the engine compartment and the side of the bus, measure to the plate.

#### **3.3 Length**

The length is measured from the front of the engine to the rear of the gearbox.