SPCR 183

Certification rules for

Fire suppression systems in engine compartments of buses and coaches

RISE Research Institutes of Sweden AB
Certification

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Preface

Products can be certified for P-marking by RISE Research Institutes 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 rules for certification, product requirements and requirements in respect of ongoing surveillance of 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 RISE. The technical requirements as set out in section 3 the test method SP Method 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. Certification, as described in section 2, is performed by RISE Certification.

Continuous inspection involves inspection by the manufacturer and surveillance inspection by RISE. 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 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.

This version of the rules replaces the previous version (issued under the name SP Technical Research Institute of Sweden), dated June 2013.

Disclaimer

The results relate to the performance of third party suppression systems against a variety of tests based on some of the operating conditions and fire hazards thought to be associated with transit bus / coach engine bays. The testing is designed to provide some information about the fire suppression performance of the product as part of a risk assessment for real applications but is not intended to be the sole criterion for assessing the potential fire hazard protection of the product in use. It is up to the fire protection system provider in collaboration with the bus / coach supplier or owner to carry out a full risk assessment for and of each vehicle application and accept full responsibility for the overall performance of the installed suppression system. RISE takes no responsibility for how a tested system performs in a real engine compartment fire.

Borås, September 2017

RISE Research Institutes of Sweden AB
Certification


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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 RISE is performed by RISE Certification, a department that is 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 RISE is performed in accordance with SS-EN ISO/IEC 17065.

Products which, after an initial evaluation - which includes testing and other aspects - show that they fulfil specified requirements can be certified by RISE. 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 RISE surveillance inspection, ensures that the requirements relating to the product continue to be fulfilled during the validity period of the certificate.

1.2 Scope

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

These certification rules consists of the following activities:

1. Evaluation of the product(s).
2. Initial assessment of the manufacturers FPC followed by yearly audits of the FPC.

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

2.1 The certification process

2.1.1 General

The certification consists of an evaluation of the products performances and of its manufacturer's FPC procedures. When the requirements are fulfilled, and a written agreement between the manufacturer and RISE about the extent of the surveillance inspection is signed, a certificate can be issued. The certificate is valid provided that the products continue to fulfil the requirements and that the ongoing inspection continues to operate correctly. Certified products may be marked with RISE P-mark.

- Technical requirements, requirement for the continuous inspection and marking requirements are described in chapter 3
- Requirements regarding the manufacturer´s FPC and the surveillance inspection is described in chapters 4 and 5.
- Other terms and conditions are set out in section 6.

2.1.2 Application

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

- technical data as specified in Annex 1
- a description of the manufacturer's FPC procedures
- proposal for marking, as set out in section 3.4

2.1.3 Review of application

When reviewing the application, RISE checks that the application is complete and that the application can be handled within RISE certification scope. The review may mean that the RISE cannot accept the assignment, which is then communicated to the customer with a justification.
If the application is adopted, this is communicated to the customer through an order confirmation being sent to the customer. An evaluation plan is prepared, if it does not already exist. When a standard is followed, this largely represents the evaluation plan. If a subcontractor must be engaged, this is communicated to the customer. The customer is entitled to object to the selected subcontractor.

2.1.4 Test samples

The customer is encouraged to send test samples to the extent that the evaluation plan requires. The number of samples are normally stated in the applied standard. When the certification shall cover a range of sizes, testing of samples in different sizes can be necessary.

2.1.5 Evaluation

During the evaluation process, the product is checked to ensure it has been manufactured in accordance with the technical data, and that it meets the requirements that the standard or specification requires. The evaluation process includes tests and examinations that are carried out to the extent that the specification requirements and/or evaluation plan specifies. In some cases,

previous test results can be used for evaluation. The requirements for these tests include that they should have been carried out by an accredited independent testing laboratory. The evaluation includes a review of labelling and information to the user etc. In cases where the product and/or documentation shows deficiencies, i.e. does not meet the requirements, the evaluation may be cancelled.

The evaluation process also includes an initial assessment of the manufacturers FPC.

If the results of the evaluation show that the product and documentation meet the requirements of the specification, the process proceeds to review and decision.

2.1.6 Review and decision

The evaluation work is reviewed, and following successful results, the process proceeds to the decision phase. When a decision on certification has been taken, a certificate is issued and delivered to the customer.

2.1.7 Period of validity

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.

2.2 Changes to certified products

Note that no changes may be made to the certified product, without this being assessed and approved by RISE. The manufacturer must therefore notify RISE of any planned change to the certified product. Along with this notification, a description of the changes along with the addition of the technical data is attached. RISE will then assess what measures need to be made in order for the certificate to remain in force after such changes have been made. The assessment may result in additional tests having to be performed. In this case, the manufacturer must be notified thereof and may then also be given a price quotation for this. If the result of the change means that the certificate is still valid, the certificate is revised with the new data.

2.3 Extension of validity period for the certificate issued.

At the end of the validity period, the period may be extended for a maximum of five years at a time. Applications for renewal are to be made in writing, at least 6 months before the end of the validity period. For the application, an assessment is made of the measures required for the extension. If no changes are made to the regulations, specifications, etc. the certificate can be extended without any further action, provided, of course, that the product is unchanged relative to the original certification or the latest revision. The applicant must certify that no changes have been made. Another requirement is that the surveillance inspections has been prformed as scheduled and with approved results.

If after all changes are made to the product, or are planned, the application must be supplemented with details about this. This may result in additional assessments and/or tests needing to be performed. In this case, the manufacturer must be notified thereof and may then also be given a price quotation for this.

3. 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 6 must be achieved after fire test in accordance with SP Method 4912. Moreover, following requirements must be fulfilled:

- the number of passed tests must include test 1 and test 6
- the number of passed tests must include test 5 or test 7.
- 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 requirments 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.[1]
The P-mark certification requirements can be found in the tables below. If not stated otherwise, it is acceptable for new components to be used for every component test.
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. The distance between brackets used to fix the pipe is maximal distance between brackets allowed to use in real bus engine compartment installation. It is allowable to perform the component test with unpressurized system and pressurize it later, before the functional test.

[1] As exemples 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).

Component Test 1	
Property	**Thermal cycling resistance**
Component	Representative sample of a suppression system
Applicable to type of system	All systems
Standard	ISO 16750-3:2007 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[2] of the suppression system declared by the manufacturer.
Performance requirements	Following these tests, the representative sample shall be subjected to **Component Test 2**.

Component Test 2	
Property	**Mechanical stress resistance**
Component	Representative sample of a suppression system
Applicable to type of system	All systems
Standard	ISO 16750-3:2007 Vibration test with load and duration as specified in ISO 16750-3:2007 (no temperature cycling), Test VII (*Sprung masses*, *commercial vehicles*). The test profile shall be extended as to include *additional profile in case of f_n < 30 Hz* which means that curve 2 shall be followed for *X < 45* and curve 1 for *X > 45* (Figure 11 in ISO 16750-3:2007). Mechanical shock test in accordance with ISO 16750 4.2.2.2, with 20 g as acceleration (*Commercial vehicles*, *devices on rigid points of the body or frame*). This test is to be performed on the same system as vibration test.
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.

[2] 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).

Component Test 3	
Property	**Combined mechanical and thermal stress resistance**
Component	Representative sample of a suppression system
Applicable to type of system	Component Test 3 is **optional**. If performed, it replaces Component Test 1 and Component Test 2.
Standard	ISO 16750-3:2007 Mechanical test with vibration load and duration as well as mechanical shocks as specified in **Component Test 2**, with simultaneous temperature cycling as stated in **Component Test 1**.
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.

Component Test 4	
Property	**Corrosion resistance**
Component	Representative sample of a suppression system
Applicable to type of system	All systems
Standard	Test method B in ISO 21207, 3 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 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.

Component Test 5	
Property	**The extent of protection provided by an enclosure against ingress of solid foreign objects and water**
Component	Electrical and electronic equipment
Applicable to type of system	All systems
Standard	IEC 60529:1989/A1:2009/COR3:2009 The equipment upon testing shall at least fullfill the degree of protection IP65.
Performance requirements	In accordance with the standard.

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.

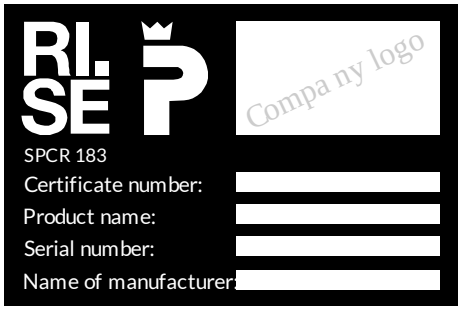
Documents demonstrating the risk assessment made shall be available at follow-up inspections.

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.

3.4 Marking

Products entitled to display RISE certification symbol shall have a marking designed as the figure below, in black colour. The marking shall be legible and durable, and shall be applied in conjunction to the engine compartment.
A template with dimensions etc. is available from RISE.



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, RISE 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 RISE.

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 RISE.

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 RISE, and shall be retained for at least ten years.

5. RISE 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 RISE to the manufacturer. The manufacturer shall provide unrestricted access to RISE representative for performance of the surveillance inspection.

On these visits, RISE will inspect to determine whether the manufacturer's described inspection procedures are operating as intended, and will perform testing and inspection as described in section 5.2.

If the manufacturer has a quality management system that is certified by an accredited inspection body, RISE examination of the manufacturer's own inspection procedures can normally be limited to examination of records and audit reports.

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

See CR000 General certification rules for certification of products

7. References

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

SS-EN ISO/IEC 17065, Certification bodies - General requirements relating to certification of products.

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

EN ISO 9001 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, dated 2017-08-14, 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

CR000 General certification rules for certification of products

Annex 1

A1. Technical descriptions

A1.1 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^3) 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 extingushing agent (including safety margin)
- Extinguishing agent[3]
- Mass of propellant gas
- Pressure of the propellant gas (at 20°C)
- Type of propellant gas
- Maximum pipe length from agent cylinder 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)

[3] 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).

A1.2 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 guidline 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.

A1.3 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

A2. 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^3 to 6 m^3 (the gross/reference volume of the test apparatus of SP Method 4912 is 4 m^3). A scaling model is presented below. If other set of rules are used for scaling, those shall be approved by RISE.

A2.1 Down-scaling

The suppression system can be scaled down for engine compartment gross volume (denoted as *x*) in the range of 2 m^3 ≤ 4 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 m^3 ≤ *x* ≤ 4 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* m^3
x	The gross volume of the engine compartment, [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.

A2.2 Up-scaling

The suppression system can be scaled up for engine compartment gross volume in the range of 4 m^3 ≤ 6 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 m^3 ≤ x ≤ 6 m^3) is calculated using following scaling factor.

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

A2.3 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 sysyem.

A2.4 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.

A3. 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.

A3.1 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.

A3.2 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.

A3.3 Length

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