New Certification Rules for Fire Detection in Vehicles

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Abstract

Detection of fires in vehicle engine compartments is challenging. High airflows, large temperature variations, dirty environment and complicated geometries make it difficult to determine the optimal type of detection technology and adequate location of sensors. A new test method has been developed for evaluation of fire detection systems meant for engine compartments of heavy vehicles. The test method considers all typical challenges normally encountered in an engine compartment, evaluating both detection system performance and durability. Certification rules connected to the new test method will ensure high quality and high performance of certified fire detection systems, increasing fire safety of vehicles.

This paper gives an outline of the new certification rules, test method and corresponding research.

Keywords: fire detection, vehicles, certification, test method

Introduction

Statistical data indicate that approximately two thirds of vehicle fires start in the engine compartment [1-3]. Furthermore, the number of fires in the engine compartment may increase in the future due to stricter regulations on noise and emission levels which result in higher operational temperatures. High temperatures, high airflows, complicated geometries, large amounts of soil, dust, and pollutants, and the wide range of surface temperatures typically occurring during normal operation of the vehicle, complicate the operation of all types of fire detectors in engine compartments. A study [4] previously performed by SP (now RISE) shows how the complex geometries and airflow in an engine compartment may affect fire detector performance. Through CFD-simulations it is shown that heat detectors are highly affected by ventilation and location and likely would not detect a fire unless its plume impinges directly on the sensor. This has also been confirmed in full scale testing [5, 6].
There are good prospects to extinguish and limit the consequences of vehicle fires if they are detected at an early stage. However, vehicle fires are most often first detected by the driver, by passengers or by other people passing by, even when fire detection systems are installed [7, 8]. Full scale experiments have shown that if a large fire breaks out in the engine compartment of a bus there might be only three minutes available for evacuation [9, 10]. Experiments and fire investigations have also shown that the time available, after the fire is detected by the driver, can be insufficient for evacuation of a complete bus [10, 11].

RISE (SP) Fire Research has put significant work into improving fire safety of heavy vehicles the last 10 years, primarily focusing on buses. A test method for suppression systems installed in the engine compartments of buses, SP Method 4912 [12, 13], was launched in 2013 and has gained a strong international sympathy. Parts of the method have been implemented in the European legislation for buses, through UNECE Regulation 107 [14]. Swedish as well as foreign bus manufacturers have expressed a desire of the standard to include a test method for fire detection systems, as an elaborate standard would create competitive neutrality keeping a high safety level. Given the obvious importance of including fire detection systems, SP initiated a project for this purpose in 2013. The main objective was to develop a test method for evaluating fire detection systems meant for engine compartments of heavy vehicles, including but not limited to buses, which now has resulted in SP Method 5320 [15]. This method will complement SP Method 4912 to increase fire safety of buses and other heavy vehicles.

Test method for fire detection in vehicle engine compartments

The requirements of the new test method should guarantee that the detection system has an acceptable performance and durability level, but the test results should also point out strengths and weaknesses of the system with respect to different fire scenarios, compartment characteristics and driving conditions. With the possibility to compare different fire detection systems, the vehicle operator or manufacturer can choose a better system if a higher safety level is desired. This will also motivate fire detection system manufacturers to improve the systems and get better test results.

It is important that the tests not wrongly favour or disqualify a certain detection technology or system configuration. The tests should therefore represent a realistic fire challenge and be conducted in a test setup which is similar to what the system would experience when installed in a heavy vehicle engine compartment. With that in mind, it is also important that the test setup and test procedure is repeatable and reproducible. This will enable a technology-neutral comparison of different fire detection systems to be available for vehicle manufacturers and operators.
The test setup includes the same engine compartment mock-up that is used for evaluation of fire suppression systems, which is implemented e.g. into UNECE Reg. 107. The mock-up is well developed and established, and represents a balanced mixture of different types of obstructions. These obstructions may play an important role for e.g. flame detectors and fire tests performed have showed that also small obstructions can prevent or delay detection. In addition, complex geometries make it difficult to determine where heat and smoke accumulate and in general there is need for several detectors to cover the complete engine compartment.

An external fan at one side of the mock-up generates a forced airflow through the engine compartment. In the test method a forced airflow of $3 \text{ m}^3/\text{s}$ simulates that the engine is running with high speed, an airflow rate of $1.5 \text{ m}^3/\text{s}$ simulates that the engine is idling or running with low speed, and no forced airflow simulates that the engine is turned off or that the vehicle has separate fan and engine compartments.

Fig. 1 illustrates the engine compartment mock-up used in the tests. Pool fire tray positions used in the compartment coverage tests are visualised and are spread throughout the compartment. A fixed fire detection system installation shall detect each of these fires to ensure proper dimensioning of the system. However, it is important with a complementary risk analysis of the real engine compartment before installation of the detection system. The risk analysis should provide answers both on how to install the system to cover all possible fire risks and on how to scale the system based on the results from the engine compartment mock-up tests.

Fig. 1. Sketch of the engine compartment mock-up with pool fire trays positions, seen from the front side. The cylinder outside the left wall is the fan generating airflow through the compartment.
Vehicle engine compartments comprise many different fire scenarios, however, from a fire detection point of view there are especially two different scenarios that fire detection systems can respond differently to. These are smouldering fires or slow growing fires (typically electrical fires) and large flaming fires (typically spray fires or pool fires due to a fluid or gas leakage). Some detection technologies will respond quickly on one of the scenarios but have problems with the other.

Flame detectors can e.g. detect a large flaming fire in less than one second but may have problems with slow growing fires, and smoke detectors can detect a smouldering fire before there are any visible flames, but are slower than flame detectors for large fires. For both scenarios the response times of the detection system are evaluated in the test method. Fig. 2 shows a gas fire, repeatable and reproducible, which is possible to slowly ramp up from a tiny flame to a large fire.

![Fig. 2. Repeatable and reproducible fire inside the engine compartment mock-up.](image)

The test method also address nuisance alarms or false alarms caused due to hot surfaces. The external surface temperature of turbo chargers and exhaust system can be in excess of 650 °C during certain conditions. In addition of being an ignition source, the heat radiation may activate both heat and flame detectors, and oil and grease on the exhaust system may give rise to false alarm of smoke detection systems. For the latter there is however a narrow line between false alarm and early warning.
Flame detectors normally manage to differentiate between a flame and a hot surface internally, while heat detectors must be positioned far enough away from potential hot surfaces. The sensitivity for false alarms due to hot surfaces for heat detectors is evaluated by determining the maximum distance to a hot surface that may generate an alarm, see Fig. 3.

Fig. 3. Hot surface test setup. A gas burner is heating a metal surface and the detector is exposed for heat radiation from the surface at the opposite side.

Hot surfaces and high ambient temperatures may also degrade detectors over time such that they can be more prone to false alarm or cause malfunctioning. For this reason, a high temperature aging test is included in the method.

Other challenges affecting the durability of the system include vibrations, shocks, temperature variations and corrosion by liquids, salt and pollutants. The test method refers to recognized international standards used in the vehicle industry to test the durability of fire detection systems. The vibration test in the test method focus on random vibrations, with alternate frequencies and amplitudes, simulating rough-road driving and is combined with a temperature cycle to stress the system. Shocks occur more irregularly and can be induced by driving over a curb stone or a hole, driving off-road, or other impacts on the vehicle body and frame. Systems intended for off-road vehicles will, according to the new method, be subjected to more severe shock tests.

Vehicles driving on salted winter roads or by the seacoast will be subjected to salt and water with high risk of corrosion. Corrosion may also occur due to atmospheric pollutants or due to exposure of liquids
used in the engine compartment, such as engine oil, antifreeze fluid or water containing vehicle washing chemicals.

Furthermore, fire detection systems will be required to hold IP-classification for protection against dust and water, primarily to withstand high pressure water jets normally used for cleaning of engine compartments. Also EMC (electromagnetic compatibility) tests are required.

**Certification rules**

RISE Certification, a department that is completely separate from the testing and inspection departments, has published new certification rules related to the new test method for fire detection systems installed in engine compartments of heavy vehicles [16]. Certification includes performance and durability tests, requirements on risk analysis prior to installation and annual surveillance inspections. Approved certification allows the use of SP’s quality symbol, the P-mark (Fig. 4).

![Fig. 4. P-mark certification symbol.](image)

In 2017, RISE will suggest that new requirements are implemented in UNECE Regulation 107, based on the new test method. For buses today, Regulation 107 requires that the driver is provided with an acoustic and a visual signal in case of an excess temperature in the rear engine compartment. This requirement includes no performance requirements nor is it technology-neutral. The new proposal will change this, including requirements on fire tests for evaluation of fire detection systems and mandatory risk analysis before installation.

P-mark certification will, however, ensure higher safety level than proposed changes of the European legislation for buses, including durability tests of the systems and more comprehensive performance tests.

**Conclusions**

Fire detection in vehicle engine compartments is arduous and there was need for a new test method addressing this application. Many of the challenges encountered in engine compartments are not specifically tested for in conventional approval standards for fire detection systems. SP Method 5320 takes into account, for example, complex geometries cluttered with obstructions, high airflows, hot surfaces, extreme
temperature variations, corrosion and vibrations. Certification in relation to this new test method will facilitate early detection and improve fire safety of buses and other heavy vehicles.

References


