

Justification and proposed draft amendments to Regulation No. 118, improvement of bus fire safety.

## **PART 1: JUSTIFICATION**

### **1 BACKGROUND**

The Norwegian and the Swedish Road Administrations have initiated a research project together with SP Swedish National Testing and Research Institute, as reported before in the GRSG. The project started in spring 2005 and is finished in 2008.

The main targets of the projects can be summarised as

- Decrease the number and consequences of bus fires
- Prevent start of fires and delay start of fires
- Inhibit fire spread and smoke development in fire incidents
- Provide more time for escape in case of fire

These targets will be accomplished through generation of an increased knowledge about fire cause and fire development in buses. The results are now used as basis for proposal of concrete measures and changes in regulations to increase the fire safety of bus travelling.

#### **1.1 PROBLEM**

It has been demonstrated earlier in GRSG<sup>1</sup> that the existing Regulation 118 does not guarantee a satisfactory fire safety level on buses. The reason for this is that the test method and criteria in Annex 6 (FMVSS 302) do not properly discriminate between materials that have a high and low fire safety performance. This shortcoming results in that fire safety performance of the interior materials and furnishings of certain bus types may be unacceptably low.

As presented earlier in GRSG<sup>2</sup> a comprehensive test series on bus materials have shown the fire quality of some bus materials to be very low, where some of the tested interiors would not be allowed for use on trains, passenger ships or in escape ways, hotels or hospitals.

All results so far are summarised in an article presented at Fire and Materials conference 2007<sup>3</sup>. The article also gives a review of U.S. research coming to similar conclusions. Recently in September 2007 a paper<sup>4</sup> was given in London at the main international fire conference Interflam 2007 where the authors concluded "...FMVSS 302 [main fire test for buses/coaches and cars] is no longer relevant to automobile fire safety and recommend improved standards based on objective criteria for fire safety...". Among the authors were several major fire researchers and organisations like National Institute of Standards and Technology (NIST) and Motor Vehicle Fire Research Institute in the US.

As a curiosity it can be noted that some materials fulfilling the requirements in Regulation 18 Annex 6 would not be allowed to be used on construction sites in Germany since they do not fulfil class B2<sup>5</sup>.

## **2 SOLUTION**

Most public transport applications, except buses, have fire safety requirements that give a satisfactory level of safety. Examples are train transport and passenger ships. Test methods to evaluate ignition, fire spread, smoke and toxic gases have been developed within ISO<sup>1</sup> and are used in the mentioned areas. Passenger ships (IMO<sup>2</sup>) uses ISO tests for evaluation of flame spread and smoke production and trains in Europe uses ISO tests for ignition, flame spread and smoke. Thus there exist established technical solutions on an international level to the fire safety problems in public transport.

The most rational way to gain an improved level of fire safety also in buses would be to draw on the experience from other similar areas, i.e. trains and passenger ships. Starting with the interiors, new fire test requirements for buses can be added to the existing requirements set out in ECE 118<sup>6</sup>. This approach will minimise the amount of research needed since the tests and criteria are established and known to give a good level of safety. More details are presented in the next section 2.1. It should be pointed out that there exist an abundance of materials that are approved according to the above mentioned test methods for trains and passenger ships.

### **2.1 Proposals for amendment of Regulation No. 118**

This chapter outlines a technical solution that will result in an acceptable fire safety level in buses and bring them to a similar level as other public transport. The alternative tests are based on sound fire safety assessments and developed on an international level. The fire requirements are based on tests with following conditions:

- Fire tests shall be internationally available and be developed on international level
- The test shall be stable, well established and based on ISO standards
- The tests shall use standard technology known to result in acceptable fire safety in enclosures

#### **2.1.1 Interior materials and furnishings.**

In addition to present requirement in Regulation 118 the following alternative tests are a suitable way forward:

For interior surfaces: ISO 5658-2 (2006)<sup>7</sup> for evaluation of ignition and flame spread. Criteria from passenger ships (IMO) or EN train standard.

For all interiors: ISO 5659-2 (2006)<sup>8</sup> for evaluation of smoke production and toxic fumes. Criteria from passenger ships (IMO) and EN train standard.

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<sup>1</sup> International Standardisation Organisation, [www.iso.org](http://www.iso.org).

<sup>2</sup> International Maritime Organisation, [www.imo.org](http://www.imo.org)

For seats: Complete seats are tested according to prCEN TS 45545-2<sup>9</sup> where a seat is subjected to a flaming ignition source and the resulting heat release rate is measured. The ignition source is approximately equivalent to a burning newspaper.

## **2.2 Consequences on safety and costs**

Application of the proposed fire tests will ensure a high fire safety level on buses, something which is lacking today. This will reduce the risk of future disasters substantially.

In a transition period there will be development costs to find materials that satisfy the demands for fire safety. However, as has been pointed out above there already exist an abundance of such materials for interiors of trains and ships which should be useful for bus manufacturers. In addition it is reasonable to expect that materials already in use in buses today, and with a high fire safety performance, would be approved according to the suggested new test methods. Experience from the train and ship sectors has shown that it is not a major problem to find materials with an acceptable fire safety performance.

## **2.3 Implementation in Regulation 118**

Part 2 of this document contains a proposal for draft amendments to Regulation No. 118.

## **3 References**

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<sup>1</sup> GRSG 94, SE and N presentation on Fire Safety in Buses.

<sup>2</sup> GRSG 89, 92, SE and N presentations on Fire Safety in Buses.

<sup>3</sup> Axelsson et.al, Fire Safety in Buses, Proceedings of Fire and Materials conference 2007, San Fransisco, Interscience Communications Ltd, London 2007.

<sup>4</sup> Digges et. al., "Improving Survivability in Motor Vehicle Fires", Proceedings of the Interflam 2007 conference, London, 2007.

<sup>5</sup> DIN 4102 Part 14, Fire behaviour of building materials and elements.

<sup>6</sup> E/ECE/TRANS/505, Regulation No. 118, Rev.2/Add.117, "Uniform technical prescriptions concerning the burning behaviour of materials used in the interior construction of certain categories of motor vehicles", United Nations, 20 April 2005.

<sup>7</sup> ISO 5658, Reaction to fire tests -- Spread of flame -- Part 2: Lateral spread on building and transport products in vertical configuration, International Organization for Standardisation, 2006.

<sup>8</sup> ISO 5659-2:1994, Plastics -- Smoke generation -- Part 2: Determination of optical density by a single-chamber test, International Organization for Standardisation, 2006.

<sup>9</sup> prCEN TS 45545-2 Railway applications - Fire protection of railway vehicles - Part 2: Requirements for fire behaviour of materials and components, CEN, February 2008.

## PART 2: PROPOSAL FOR DRAFT AMENDMENTS TO REGULATION. 118

### UNIFORM TECHNICAL DESCRIPTION CONCERNING THE BURNING BEHAVIOUR OF MATERIALS USED IN THE INTERIOR CONSTRUCTION OF CERTAIN CATEGORIES OF MOTOR VEHICLES

Note: The text reproduced below was prepared by the experts from Norway and Sweden based on informal documents GRSG 90-32, GRSG 93-15, GRSG 92-18. **(additions in bold style)**

#### A. PROPOSAL

Paragraph 6., amend to read:

#### 6. PART II: APPROVAL OF A COMPONENT WITH REGARD TO ITS BURNING BEHAVIOUR

##### 6.1. Definitions

For the purpose of Part II of this Regulation,

6.1.1. "Type of a component" means components which do not differ in such essential respects as:

6.1.1.1. the manufacturer's type designation,

6.1.1.2. the intended use (seat upholstery, roof lining, etc.),

6.1.1.3. the base material(s) (e. g. wool, plastic, rubber, blended materials),

6.1.1.4. the number of layers in the case of composite materials, and

6.1.1.5. other characteristics in so far as they have an appreciable effect on the performance prescribed in this Regulation.

6.1.2. "Burning rate" means the quotient of the burnt distance measured according to Annex 6 and/or Annex 8 to this Regulation and the time taken to burn this distance. It is expressed in millimetres per minute.

6.1.3. "Composite material" means a material composed of several layers of similar or different materials intimately held together at their surfaces by cementing, bonding, cladding, welding, etc. When different materials are connected together intermittently (for example, by sewing, high-frequency welding, riveting), such materials shall not be considered as composite materials.

6.1.4. "Exposed face" means the side of a material which is facing towards the passenger compartment when the material is mounted in the vehicle.

6.1.5. "Upholstery" means the combination of interior padding and surface finish material which together constitute the cushioning of the seat frame.

6.1.6. "Interior lining(s)" means material(s) that (together) constitute(s) the surface finish and substrate of a roof, wall or floor.

6.2. Specifications

6.2.1. The following materials shall undergo the test described in Annex 6 to this Regulation:

- (a) material(s) used for the upholstery of any seat and its accessories (including the driver's seat),
- (b) material(s) used for the interior lining of the roof,
- (c) material(s) used for the interior lining of the side and rear walls, including separation walls,
- (d) material(s) with thermal and/or acoustic function,
- (e) material(s) used for the interior lining of the floor,
- (f) material(s) used for the interior lining of luggage-racks, heating and ventilation pipes,
- (g) material(s) used for the light fittings

The result of the test shall be considered satisfactory if, taking the worst test results into account, the horizontal burning rate is not more than 100 mm/minute or if the flame extinguishes before reaching the last measuring point.

6.2.2. The following materials shall undergo the test described in Annex 7 to this Regulation:

- (a) material(s) used for the interior lining of the roof,
- (b) material(s) used for the interior lining of the luggage-racks, heating and ventilation pipes situated in the roof,
- (c) material(s) used for the lights situated in the luggage-racks and/or roof.

The result of the test shall be considered satisfactory if, taking the worst test results into account, no drop is formed which ignites the cotton wool.

6.2.3. The materials used for the curtains and blinds (and/or other hanging materials) shall undergo the test described in Annex 8.

The result of the test shall be considered satisfactory if, taking the worst test results into account, the vertical burning rate is not more than 100 mm/minute.

Insert new paragraphs 6.2.4. to 6.2.7., to read:

**"6.2.4. From 200x-xx-xx the the following materials shall undergo the test described in Annex 9 to this Regulation:**

- (a) material(s) used for the interior lining of the roof,
- (b) material(s) used for the interior lining of the side and rear walls, including separation walls,
- (c) material(s) with thermal and/or acoustic function,
- (d) material(s) used for the interior lining of luggage-racks, heating and ventilation pipes.

The result of the test in Annex 9 shall be considered satisfactory if the average value of CFE is less than 20 kW/m<sup>2</sup>.

**6.2.5. From 200x-xx-xx the the following materials shall undergo the test described in Annex 10 to this Regulation:**

- (a) material(s) used for the interior lining of the roof,
- (b) material(s) used for the interior lining of the side and rear walls, including separation walls,
- (c) material(s) with thermal and/or acoustic function,
- (d) material(s) used for the interior lining of the floor,
- (e) material(s) used for the interior lining of luggage-racks, heating and ventilation pipes.

The result of the test in Annex 10 shall be considered satisfactory if the average value of the maximum smoke density (Dm) does not exceed 200 in any test condition, and gas concentrations measured at each test condition are less than specified below:

CO	1450 ppm	HBr	600 ppm
HC1	600 ppm	HCN	140 ppm
HF	600 ppm	SO <sub>2</sub>	120 ppm
NOx	350 ppm		

**6.2.6. From 200x-xx-xx the material(s) used for the interior lining of the floor shall undergo the test described in Annex 11 to this Regulation.**

The result of test in Annex 11 shall be considered satisfactory if the average value of CHF is less than 6 kW/m<sup>2</sup>.

**6.2.7. From 200x-xx-xx the complete seats shall undergo the test described in Annex 12 to this Regulation.**

**The result of test in Annex 12 shall be considered satisfactory if the MARHE index is less than 50 kW."**

Paragraph 6.2.4. (former), renumber as paragraph 6.2.8. and amend to read:

**"6.2.8. Materials which are not required to undergo the tests described in Annexes 6 to 8 12 are: "**

Paragraphs 6.2.4.1. to 6.2.4.4. (former), renumber as paragraphs 6.2.8.1. to 6.2.8.4.

Paragraph 6.2.4.5. (former), renumber as paragraphs 6.2.8.5. and amend to read:

**"6.2.8.5. elements for which it is not possible to extract a sample in the prescribed dimensions as specified in paragraph 3.1. of Annex 6, paragraph 3. of Annex 7, ~~and~~ paragraph 3.1. of Annex 8 and referenced sample sizes specified in referenced test standards in Annexes 9-12. "**

Insert new Annexes 9 to 12, to read:

### **"Annex 9**

#### **TEST TO DETERMINE LATERAL FLAME SPREAD ON TRANSPORT PRODUCTS IN VERTICAL CONFIGURATION**

- 1. General**  
The standard ISO 5658-2 (2006)1/ evaluates the lateral surface spread of flame of a material subject to thermal radiation.
- 2. Sampling and test procedure**  
The test shall follow ISO 5658-2 (2006) in all aspects concerning apparatus, calibration, sampling and test procedure.
- 3. Test results**  
Test results shall be reported according to paragraph 13 in ISO 5658-2.

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**1/ ISO 5658-2 Reaction to fire tests - spread of flame - Part 2: Lateral spread on building and transport products in vertical configuration, 2<sup>nd</sup> ed 2006-09-15, International Standardisation Organisation, Geneva, 2006.**

## Annex 10

### TESTS TO DETERMINE SMOKE GENERATION AND TOXICITY OF SMOKE GASES FROM A BURNING MATERIAL

1. **General**  
The standard ISO 5659-2 (2006) 1/ together with toxicity assessment measures the smoke and toxic gas generation from a test sample subject to thermal radiation.
2. **Test for smoke opacity**  
The test shall follow ISO 5659-2 (2006) in all aspects concerning apparatus, calibration, sampling and test procedure.
  - 2.1 **Test conditions**  
Three test specimens shall be tested subject to constant irradiation at one of the following test conditions, depending on application:
    1. for materials used for the interior lining of floors (materials (d) in 6.2.1) test at an irradiance of 25 kW/m<sup>2</sup> in the presence of pilot flame.
    2. for all other materials where smoke test is required (materials (a), (b), (c), (e) in 6.2.1) test at an irradiance of 50 kW/m<sup>2</sup> in the absence of pilot flame.
3. **Test for toxicity of smoke gases**  
A toxicity analysis shall be made during test of the second and third sample in the test condition defined in 2.1. The sampling of smoke gas shall be made continuously from the geometrical centre of the chamber during 3 minutes around the smoke maximum determined in the first test of three. The sampling flow shall not exceed 2 litres/min and suitable measures shall be taken to heat the sampling system to avoid condensation. The analysis method shall be FTIR (Fourier Transformed Infrared) and shall follow the guidelines in ISO 197022/.  
  
The results for each test shall be expressed as average of the two highest measurements during the 3 minutes.

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1/ ISO 5659-2 Plastics - Smoke generation - Part 2: Determination of optical density by a single chamber test, 2<sup>nd</sup> ed 2006-12-01, International Standardisation Organisation, Geneva, 2006.

2/ ISO 19702, Toxicity testing of fire effluents - Guidance for analysis of gases and vapours in fire effluents using FTIR gas analysis.

## **Annex 11**

### **TEST TO DETERMINE LATERAL FLAME SPREAD ON TRANSPORT PRODUCTS IN HORIZONTAL CONFIGURATION**

- 1. General**  
The standard ISO 9239-1 (2002)<sup>1/</sup> evaluates the lateral surface spread of flame of a flooring material subject to thermal radiation.
- 2. Sampling and test procedure**  
The test shall follow ISO 9239-1 (2002) in all aspects concerning apparatus, calibration, sampling and test procedure.
- 3. Test results**  
Test results shall be reported according to paragraph 9 in ISO 9239-1.

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<sup>1/</sup> ISO 9239-2, Reaction to fire tests for floorings - Part 1: Determination of the burning behaviour using a radiant heat source, International Organisation for Standardization, 2002.

## Annex 12

### TESTS TO DETERMINE THE BURNING BEHAVIOUR OF SEATS

1. **General**  
Complete seats are tested according to prCEN TS 45545-2 (2008)<sup>1/</sup> where a seat is subjected to a flaming ignition source and the resulting heat release rate is measured.
2. **Test for burning behaviour of seats**  
The test shall follow prCEN TS 45545-2 (2008) in all aspects concerning apparatus, calibration, sampling and test procedure. Only one specimen needs to be tested.
- 2.1 **Test conditions**  
The seat shall be tested in a vandalised condition according to Annex A in prCEN TS 45545-2.

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<sup>1/</sup> prCEN TS 45545-2 Railway applications - Fire protection of railway vehicles - Part 2: Requirements for fire behaviour of materials and components, CEN, February 2008. "

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