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FIRE REGULATION IN RAILWAYS
WORLD OVERVIEW
We have devoted lots of energy to set up this document and probably all the updates are not in – hope however it will help you to catch the big picture of the complex fire standards and regulation.
1 FRANCE

The actual classification used by French regulations for the classification of fire behaviour of materials/component is described in:
- NF F 16-101: "Rolling stock I. Fire behaviour I. Materials selection" [87]
- NF F 16-102: "Rolling stock I. Fire behaviour I. Materials selection I. Application for electrical equipment" [88]

This classification regards substantially three vehicles categories:
- √ A1: all rolling rock, including their drivers' cabins, which travel frequently though tunnels
- √ A2: urban and suburban rolling rocks which travel infrequently through tunnels,
- √ B: mainline rolling rock, including locomotives, which travel infrequently through tunnels.

These standards provide the classification of the material by "reaction to fire" and "smoke" (combination of smoke opacity and toxicity). The product of the above parameters gives the "risk index".

1.1 Reaction to fire test

-For wide specimens, the "reaction to fire" tests classify the material/product into one of six categories: from M0 to M5 and are obtained from combination of the parameters measured. Theses reaction to fire tests comes form the buildings standards.

The principal test used in this standard is the "Epiradia" tester. According to NF P 92501 [90] both for rigid and flexible materials more than 5 mm thickness are evaluated. NF P 92503 [91] is used for flexible materials with thickness up to 5 mm. If dripping is noted in the above tests, NF P 92504 [92] and NF P 92505 [93] tests (rate of flame speed) are used.

A complementary test for floor covering is the radiant panel test NF P 92506 [94] which is used only if in the primary test (NF P 92501 and NF P 92503) the material does not obtain the M1 or M2 classification. The NF P 925010 test (calorific potential [95]) is used to give materials classified in M1 class (below NF P 92501) the M0 class (if the heat of combustion is less than 2500 kJ/kg).

-For small specimens which are not able to be assessed with the M rating,, two tests are used: Oxygen index (NF EN ISO 4589-2 [96]) and glow wire test (NF EN 60695-2-10 [81]). These tests classify the materials into five classes: from I0 to NC (I5). The same tests are used for the electrical materials as described in NF F 16 102.

<table>
<thead>
<tr>
<th>Class</th>
<th>Result of test</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOI</td>
<td>Glow wire</td>
</tr>
<tr>
<td>I0</td>
<td>&gt;= 70, No ignition at 960°C</td>
</tr>
<tr>
<td>I1</td>
<td>&gt;= 45, No ignition at 960°C</td>
</tr>
<tr>
<td>I2</td>
<td>&gt;= 32, No ignition at 850°C</td>
</tr>
<tr>
<td>I3</td>
<td>&gt;= 28, Ignition does not persist at 850°C after glow wire is withdrawn</td>
</tr>
<tr>
<td>I4</td>
<td>&gt;= 20</td>
</tr>
<tr>
<td>NC</td>
<td>&lt; 20, Non classified</td>
</tr>
</tbody>
</table>

Table 1: small specimens reaction classes
-For wires
The wires are assessed according to the NF C 32-070 [119] standard testy method based on the horizontal flame spread along a wire.

1.2 Smoke parameters

Concerning "smoke" parameter, as described in the standard, this is obtained from the combination of "smoke emission"and "toxicity index".

The first one is evaluated by the NF X 10 702 (Smoke Density Chamber [97]) and the second one with NF X 70-100 [68]. The Assessment of smoke toxicity is focused on CO, CO₂, HCl, HBr, HF, HCN, and SO₂. The NOₓ, acrolein and formaldehyde derivatives will be probably integrated in the requirements in a near future. The toxic analysis can be realised with the ionic chromatography (Figure 2).

Each of the gas concentrations is divided by an "acceptable- value and then summed to determine the toxicity index called ITC according to the below formula:

\[
\text{ITC : } 100 \times \sum \left( \frac{t_i}{C_{ci}} \right) \tag{3}
\]

**Table 2: reference value of gaseous species**

<table>
<thead>
<tr>
<th>Gaseous species</th>
<th>CCi (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>1750</td>
</tr>
<tr>
<td>CO₂</td>
<td>90 000</td>
</tr>
<tr>
<td>HCl</td>
<td>150</td>
</tr>
<tr>
<td>HBr</td>
<td>170</td>
</tr>
<tr>
<td>HCN</td>
<td>55</td>
</tr>
<tr>
<td>HF</td>
<td>17</td>
</tr>
<tr>
<td>SO₂</td>
<td>260</td>
</tr>
</tbody>
</table>

The smoke emission index is a combination of the maximum optical density (Dm) and the summation of optical density up to 4 min VOF4. These two parameters Dm and VOF4 are assessed during the smoke chamber test.

The toxicity results are combined with the smoke emission results. And, at least, these three indices are added to form a smoke index: according to the formula 4:

\[
\text{IF} = \frac{\text{Dm}}{100} + \frac{\text{VOF}}{30} + \frac{\text{ITC}}{2} \tag{4}
\]
According to NF 16101, the combination of these two parameters gives the "smoke value" with classes from F0 to F5.

Table 3: F rating according IF values

<table>
<thead>
<tr>
<th>IF value</th>
<th>F rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>F0</td>
</tr>
<tr>
<td>&lt; 20</td>
<td>F1</td>
</tr>
<tr>
<td>&lt; 40</td>
<td>F2</td>
</tr>
<tr>
<td>&lt; 80</td>
<td>F3</td>
</tr>
<tr>
<td>&lt; 120</td>
<td>F4</td>
</tr>
<tr>
<td>&gt; 120</td>
<td>F5</td>
</tr>
</tbody>
</table>

The Smoke Density Chamber (ASTM E 662 in USA [34]) illustrated in is used widely in testing of transportation.

This apparatus measures smoke generation from small, solid specimens exposed to a radiant flux level of 25 kW/m² in a flaming (piloted ignition) or non-flaming mode. The smoke produced by the burning specimen in the chamber is measured by a light source–photometer combination. The attenuation of the light beam by the smoke is a measure of the optical density or quantity of smoke that a material will generate under the given conditions of the test.
Figure 1: the NF X 10-702 smoke box apparatus (USA : ASTM E 662)
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Figure 2: the NF X 70-100 tubular furnace test method
The French standard gives a complete set of allowable pass criteria by using 18 matrices. Each grid is available for a specific material/component with three classes:

- Acceptable,
- Acceptable with agreement of user,
- Not acceptable.

In general, the higher the F category, the lower the limit on flammability which is allowed.

**Figure 3: M and F requirements versus category**

<table>
<thead>
<tr>
<th></th>
<th>A1</th>
<th>A2</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>M0F0</td>
<td>M0F0</td>
<td>M1F1</td>
</tr>
<tr>
<td>Wall</td>
<td>M1F1</td>
<td>M1F1</td>
<td>M2F1</td>
</tr>
<tr>
<td>Curtain</td>
<td>M1F1</td>
<td>M1F1</td>
<td>M1F1</td>
</tr>
<tr>
<td>Light</td>
<td>M1F1</td>
<td>M1F1</td>
<td>M1F2</td>
</tr>
<tr>
<td>Seat (each component)</td>
<td>M1F1</td>
<td>M1F1</td>
<td>M1F2</td>
</tr>
<tr>
<td>Flooring</td>
<td>M1F1</td>
<td>M2F1</td>
<td>M2F1</td>
</tr>
<tr>
<td>Interior Wires</td>
<td>AF1</td>
<td>AF1</td>
<td>BF2</td>
</tr>
<tr>
<td>Exterior Wires</td>
<td>BF1</td>
<td>BF2</td>
<td>CF3</td>
</tr>
<tr>
<td>Exterior material</td>
<td>M2F1</td>
<td>M2F2</td>
<td>M3F3</td>
</tr>
<tr>
<td>Bed furniture</td>
<td>M1F1</td>
<td>M1F1</td>
<td>M1F1</td>
</tr>
</tbody>
</table>

**Figure 4: light diffusers requirement for A1 category, matrice n°4**

<table>
<thead>
<tr>
<th></th>
<th>I 0</th>
<th>I 1</th>
<th>I 2</th>
<th>I 3</th>
<th>I 4</th>
<th>NC</th>
</tr>
</thead>
<tbody>
<tr>
<td>M 0</td>
<td>A</td>
<td>A</td>
<td>AA</td>
<td>AA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>M 1</td>
<td>A</td>
<td>A</td>
<td>AA</td>
<td>AA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>M 2</td>
<td>A</td>
<td>A</td>
<td>AA</td>
<td>AA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>M 3</td>
<td>A</td>
<td>A</td>
<td>AA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>M 4</td>
<td>A</td>
<td>A</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
<td>NC</td>
</tr>
</tbody>
</table>

A: acceptable, NA: non acceptable, AA: Acceptable with agreement of user

The NF F 16-101 regulation is effective since 76 end its achievement clearly shows a decrease of railways vehicle fires.

**Figure 5: railway vehicle fires evolution**

![Graph showing the evolution of railway vehicle fires from 1968 to 1995. The x-axis represents the years, and the y-axis represents the number of railway vehicle fires.](image-url)
Also note that real scale state has pointed out the strong decrease of fire temperature and so fire spread using material in compliance with the NF F 16-101 requirements.

**Figure 6: real scale test temperature evolution with (1) and without (2) material complying with the NF F 16-101 requirements**

2 DEUTCHLAND

The German Standard for the test procedures and classification of materials and components for the fire behaviour and fire effluents is DIN 5510 Part 2 [98].

The following parameters are defined to classify the fire behaviour of materials and components (both for external parts of car body and for internal materials):

- Combustibility,
- Smoke development,
- Dripping.

Test specimens have to meet end-use requirements.
2.1 Combustibility classification

For the combustibility classification there are five categories defined from S1 (only for small item) and S2 to S5 (all materials and components) and from SF1 to SF3 for floor coverings.

Category S1 is determined by DIN 53438 (part 1-3) [99] Testing of combustible materials; reaction to a flame of a burner; edge and surface flame action. The combustibility category from S2 to S5 is obtained using DIN 54837 [100] gas burner test. By this test smoke development and dripping will be evaluated too. The categories SF1 to SF3 for floor coverings are obtained using the test DIN 4102 with evaluation of critical radiation intensity and smoke emission.

2.2 Combustibility classification

There are two smoke development categories: SR1 and SR2 by evaluating the integral of light attenuation.

2.3 Dripping classification

For dripping category there are only two levels: ST1 and ST2

The 5510 DIN standard gives in a complete table the minimum requirements of the three parameters for each material and component depending on 4 operation categories.

<table>
<thead>
<tr>
<th>Type of product</th>
<th>Test</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>All suitable</td>
<td>Brandschacht DIN 54 837</td>
<td>S2 to S5 SR1, SR2 ST1, ST2</td>
</tr>
<tr>
<td>Floor covering</td>
<td>Radiant panel DIN EN ISO 9239-1</td>
<td>SF1 To SF3</td>
</tr>
<tr>
<td>Seats</td>
<td>Paper cushion test DIN 54 341</td>
<td>Requirements met</td>
</tr>
<tr>
<td>Small pieces</td>
<td>Small burner DIN 53438</td>
<td>S1</td>
</tr>
<tr>
<td>Cables</td>
<td>Din EN 50265-2-1 and 50266-2-1</td>
<td>A or B</td>
</tr>
</tbody>
</table>

Table 4: DIN 5510-2 classification

<table>
<thead>
<tr>
<th>Component</th>
<th>Fire protection class</th>
<th>Fire rating</th>
<th>Smoke Rating</th>
<th>Flaming droplets rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling, end walls and side walls covering</td>
<td>1</td>
<td>S2</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>2 and 4</td>
<td>S5</td>
<td>SR2</td>
<td>ST2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>S5</td>
<td>SR2</td>
<td>ST2</td>
</tr>
</tbody>
</table>
3 ENGLAND

The British classification is in accordance with BS 6853 Code of practice for fire precautions in the design and construction of passenger carrying trains[104].

This classification regards essentially three vehicles categories:

- Category Ia and Ib (underground),
- Category II (surface).

In this Standard each material (except mass loss materials and seat components) is classified by their position on the vehicle.

The most important classification regards all the materials/item with important surface (both interior and exterior of vehicle). For these are provided 3 positions:

- Horizontal prone (ceiling-like) (HP surface),
- Horizontal supine (floor-like) (HS surface),
- Vertical (wall-like) (V surface).

The fire behaviour parameters evaluated by the British Standard are:

- Ignitability,
- Spread of flame,
- Heat release (using BS476 part6),
- Smoke opacity,
- Smoke toxicity.

For the exterior and interior horizontal surfaces the above parameters are evaluated by BS 476-7 [105] (surface spread of flame); smoke density by a 27 meter cube chamber according to Annex D of the standard and smoke toxicity by the test method described in the Annex B of the above Standard.

Figure 7: 27 meters cube chamber

The determination of the weighted summation of toxic gas is obtained by two different methods:
✓ The first one is available for the "minor use material" and is based on the mass of the material using NF X 70-100,
✓ The second one is available to the “surfaces materials, seat and mattress” using the cone calorimeter ISO 5659-2 [19] apparatus at 25kW/m².

Table 6: BS 6853 tests

<table>
<thead>
<tr>
<th>Product</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seating</td>
<td>BS 476-6 Fire propagation box</td>
</tr>
<tr>
<td></td>
<td>BS 476-7 Surface spread of flame</td>
</tr>
<tr>
<td></td>
<td>27 m cube smoke density test</td>
</tr>
<tr>
<td></td>
<td>ISO 5659-2 Toxic fume emission</td>
</tr>
<tr>
<td>Wall and ceilings</td>
<td>BS 476-6 Fire propagation box</td>
</tr>
<tr>
<td></td>
<td>BS 476-7 Surface spread of flame</td>
</tr>
<tr>
<td></td>
<td>27 m cube smoke density test</td>
</tr>
<tr>
<td></td>
<td>ISO 5659-2 Toxic fume emission</td>
</tr>
<tr>
<td>Flooring</td>
<td>ISO 9239-1 Radiant panel test for floorings</td>
</tr>
<tr>
<td></td>
<td>27 m cube smoke density test</td>
</tr>
<tr>
<td></td>
<td>NF X 70-100 Toxic fume emission</td>
</tr>
<tr>
<td>Cables</td>
<td>BS 4066 Flammability temperature index on sheath</td>
</tr>
<tr>
<td></td>
<td>27 m cube smoke density test</td>
</tr>
<tr>
<td></td>
<td>NF X 70-100 Toxic fume emission</td>
</tr>
</tbody>
</table>

4 ITALIA

The actual classification used for Italian regulations for the fire behaviour of materials/component is described in the standard UNIFER PrE10.02.977.3 “Guidelines for fire protection of railway, tramway and guided path vehicles – Part 3 Evaluation of fire behaviour of materials – threshold values”

Similar to the French Standard, the Italian Standard provides the classification of the material/item by “reaction to fire and smoke” (combination of smoke emission and toxicity).

4.1 Reaction to fire

For the parameter “reaction to fire” (FI parameters) are provided six categories:

✓ Class 0 is evaluated by ISO 1182 “non combustibility test”
✓ Class1 to Class 5 are determined by the combination the above parameters evaluated with two tests:

- UNI 8456 [108] “reaction to fire by applying a small flame on both surfaces” and UNI 9174 [109] “reaction to fire of material attacked by flame with radiant heating”
- UNI 8457 [110] “reaction to fire of material attacked by flame on one surface” and UNI 9174 (where the sample is positioned as on the end use e.g. horizontal supine for floor materials, horizontal prone for ceiling materials or vertical for wall materials).
4.2 Smoke parameters

The “smoke” parameter is obtained identically to the French Standard, namely from combination of “smoke emission” and “toxicity index” (F value). The first one is evaluated by NF X 10-702 (Smoke density Chamber) and the second one with NF X 70-100 (toxicity test). There are three acceptable classes from F1 to F3.

For electrical materials smoke emission and smoke toxicity are separately evaluated with NF X 10-702 and IEC EN 50267[112] part 1 and 2. The classification system is done by a threshold value for “reaction to fire” and “smoke” for each listed item described in two summary tables in the standard (one for electrical components the second for all other materials/item).

5 USA

The majority of fire safety requirements for US passenger trains consist of material fire performance test criteria designed to prevent the fire or retard its growth and spread. Based on test methods that evaluate fire properties of individual materials. The FRA guidelines [59] and similar requirements for other rail applications form a prescriptive set of design specifications for material selection.
**Table 7: Federal Railways Administration 2000 requirements**

<table>
<thead>
<tr>
<th>Index</th>
<th>Test method</th>
<th>Performance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
<td>Cushions, mattresses</td>
<td>ASTM D-3675</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM E-662</td>
</tr>
<tr>
<td>1, 2, 3, 6, 7, 8</td>
<td>Fabrics</td>
<td>14CFR, appendix F, Part I, (vertical test)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM E-662</td>
</tr>
<tr>
<td>9, 10, 11</td>
<td>Vehicle components</td>
<td>ASTM E-162</td>
</tr>
<tr>
<td>1 and 2</td>
<td>Flexible cellular foams,</td>
<td>ASTM E-662</td>
</tr>
<tr>
<td>13 and 14</td>
<td>Floor covering</td>
<td>ASTM D-3675</td>
</tr>
<tr>
<td>2 and 15</td>
<td>Lights transmitting plastics</td>
<td>ASTM E-662</td>
</tr>
<tr>
<td>16</td>
<td>Elastomers, 16</td>
<td>ASTM E-162</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM E-662</td>
</tr>
<tr>
<td>17</td>
<td>Wire and cable</td>
<td>ASTM C1186</td>
</tr>
<tr>
<td></td>
<td>Low voltage wire and cable: Wire insulation for control and other low voltage ie less than 100 V AC and 150 V DC,</td>
<td>NEMA WC3/ICEA S-19-1981, paragraph 6.19.6; or UL44 and UL 83</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM E-662</td>
</tr>
<tr>
<td></td>
<td>Power cable: Wire insulation for control and other high voltage ie more than 100 V AC and 150 V DC</td>
<td>ANSI/IEEE Std 383</td>
</tr>
<tr>
<td>19</td>
<td>Structural components</td>
<td>Flooring 20, Other 21</td>
</tr>
</tbody>
</table>
The materials used in locomotive cabs and passenger cars shall be tested according to the methods and meet the performance criteria set forth in the following table and notes:

1. Materials tested for surface flammability shall not exhibit any flaming running or dripping.

2. The ASTM E 662-97 maximum test limits for smoke emission (specific optical density) shall be measured in either the flaming or non-flaming mode, utilizing the mode that generates the most smoke.

3. Testing of a complete seat or mattress assembly (including cushions, fabric layers, upholstery) according to ASTM E 1537-98 with application of pass/fail criteria of California Technical Bulletin 133 shall be permitted in lieu of the test methods prescribed herein, provided the assembly component units remain unchanged or new (replacement) assembly components possess equivalent fire performance properties to the original components tested. A fire hazard analysis must also be conducted that considers the operating environment within which the seat or mattress assemblies will be used in relation to the risk of vandalism, puncture, cutting, or other acts which may expose the individual components of the assemblies.

4. Testing is performed without upholstery.

5. The surface flammability and smoke emission characteristics shall be demonstrated to be permanent after dynamic testing according to ASTM D 3574-95, Test I₂ (Dynamic Fatigue Test by the Roller Shear at Constant Force) or Test I₃ (Dynamic Fatigue Test by Constant Force Pounding) both using Procedure B.

6. The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, according to FED-STD-191A Textile Test Method 5830.

7. The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry-cleaning, if appropriate, according to ASTM D 2724-87.

8. Materials that cannot be washed or dry-cleaned shall be so labelled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.

9. As a minimum, combustible component materials required to be tested include seat and mattress frames, wall and ceiling panels, seat and toilet shrouds, tray and other tables, partitions, shelves, windscreens, HVAC ducting, thermal and acoustic insulation, exterior plastic components, and interior and exterior box covers.

10. Materials used to fabricate miscellaneous, discontinuous small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that will not contribute materially to fire growth in end use configuration may be exempted from fire and smoke emission performance requirements, provided that the surface area of any individual small part is not ≥ 16 square inches (100 cm²) in end use configuration and an appropriate fire hazard analysis is conducted which addresses the location and quantity of the materials used, and the vulnerability of the materials to ignition and contribution of flame spread.

11. If the surface area of any individual small part is less than 16 square inches (100 cm²) in end use configuration, materials used to fabricate such small part shall be tested in accordance with ASTM E 1354-97, unless such small part has been shown not to contribute materially to fire growth following an appropriate fire hazard analysis as specified in Note 10. Materials tested in accordance with ASTM E 1354-97 shall meet the performance criteria of \( q_{\text{f}} / Q_{\text{max}} \leq 0.5 \). Testing shall be at 50 kW/m² applied heat flux.

12. Assessment of smoke generation by small miscellaneous, discontinuous parts may be made by utilizing the results from the ASTM E1354-97 test procedure conducted in accordance with Note 11, rather than the ASTM E 662-test procedure, if an appropriate fire hazard analysis is provided which
addresses the location and quantity of the materials used, and the vulnerability of the materials to ignition and contribution of smoke spread.

13 Carpets used as a wall or ceiling covering shall be tested as a vehicle component.

14 Floor covering shall be tested with padding in accordance with ASTM E 648-97, if the padding is used in the actual installation.

15 For double window glazing, only the interior glazing is required to meet the materials requirements specified herein. (The exterior glazing need not meet these requirements.)

16 Elastomeric materials used for parts having a surface area ≥16 square inches (100 cm²) shall be tested in accordance with ASTM C 1166-91. As a minimum, parts required to be tested include window gaskets, door nosing, diaphragms, and roof mats.

17 Testing shall be conducted in accordance with NEMA WC 3/ICEA S-19-1981, paragraph 6.19.6; or UL 44 for thermosetting wire insulation and UL 83 for thermoplastic wire insulation.

18 Testing shall be conducted in accordance with ANSI/IEEE Standard 383-1974, section 2.5, with the additional requirement that circuit integrity shall continue for 5 minutes after the start of the test.

19 Penetrations (ducts, etc.) shall be designed to prevent fire and smoke from entering a vehicle, and representative penetrations shall be included as part of test assemblies.

20 Structural-flooring assemblies shall meet the performance criteria during a nominal test period as determined by the railroad. The nominal test period must be twice the maximum expected time period under normal circumstances for a vehicle to stop completely and safely from its maximum operating speed, plus the time necessary to evacuate all the vehicle’s occupants to a safe area. The nominal test period must not be less than 15 minutes. Only one specimen need be tested. A proportional reduction may be made in the dimensions of the specimen, provided the specimen represents a true test of the ability of the structural flooring assembly to perform as a barrier against under-vehicle fires. The fire resistance period required shall be consistent with the safe evacuation of a full load of passengers from the vehicle under worst-case conditions.

21 Portions of the vehicle body (including equipment carrying portions of a vehicle’s roof but not including floors) which separate major ignition sources, energy sources, or sources of fuel-load from vehicle interiors, shall have sufficient fire endurance as determined by a fire hazard analysis acceptable to the railroad which addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation.
The Flooring Radiant Panel test or Standard Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source - ASTM E 648 - exposes a specimen placed horizontally to a radiant source that varies across a 1 m length from a maximum of 11 kW/m² down to 1 kW/m². After ignition by a small line burner at the high radiant flux end, the distance at which the burning floor material self extinguishes is determined. This point defines the critical radiant flux (CRF) necessary to support continued flame spread. The higher the CRF, the better is the fire performance of the floor covering.

Also note that Federal requirements do not contain any settlement in term of smoke toxicity. In order to implement these requirements in term of safety increase, some train makers have set up internal standard which measure the potential smoke toxicity.

For example, Bombardier has developed a SMP 800-C test method based on BSS 7239 standard (Boeing Safety Standard, same methodology for aircraft standards). The BSS 7239 described the use of Drager Tube for the measurement of toxic gases. This technique is known to be grossly inaccurate. As a result, Bombardier has developed an absorptive sampling procedure in which 6 litres of gas are sampled, starting at 4 minutes, over a 15 minutes period. The resulting levels which are report, therefore, the cumulated concentrations over the 15 minutes period.
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## Table 8: SMP 800-C toxicity smoke requirement

<table>
<thead>
<tr>
<th>Gas</th>
<th>Symbol</th>
<th>Critical Concentration (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>CO</td>
<td>3500</td>
</tr>
<tr>
<td>Carboen Dioxyle</td>
<td>CO2</td>
<td>90000</td>
</tr>
<tr>
<td>Oxides of Nitrogen</td>
<td>NO + NO2 (Nox)</td>
<td>100</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>SO2</td>
<td>100</td>
</tr>
<tr>
<td>Hydrogen Chloride</td>
<td>HCl</td>
<td>500</td>
</tr>
<tr>
<td>Hydrogen fluoride</td>
<td>HF</td>
<td>100</td>
</tr>
<tr>
<td>Hydrogen Bromide</td>
<td>HBr</td>
<td>100</td>
</tr>
<tr>
<td>Hydrogen cyanide</td>
<td>HCN</td>
<td>100</td>
</tr>
</tbody>
</table>
6 Overview of future regulation in Europe

The European Commission has funded a 3-year research programme in 1997 to assist the work of CEN/TC256/WG1 and CENELEC/TC9X/WG3 in drafting a Part 2 (Requirements for the fire behaviour of materials and components) for a 7-part European Standard prEN 45545 Fire protection on railway vehicles[56]

The major aim of the project [122] is to develop the most representative and comprehensive test methods giving results significant enough to classify the constituent products of railway vehicles taking into account the acceptable risks for users, the vehicle design, the shape and use of the products, the functional equipment, the ventilation system and all relevant combinations of these items.

Table 9: overview of the test selected for the screening of materials

<table>
<thead>
<tr>
<th></th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ISO 5658-2 Lateral flame spread test with radiant panel source</td>
</tr>
<tr>
<td>2</td>
<td>ISO 5660-1 Cone calorimeter test for ignition time and heat release rate.</td>
</tr>
<tr>
<td>3</td>
<td>ISO 5659-2 Single chamber smoke test (cumulative conditions)</td>
</tr>
<tr>
<td>4</td>
<td>NF X 70-100 (UITP E6) Static furnace test for fire effluents</td>
</tr>
<tr>
<td>5</td>
<td>DIN 53436 Moving furnace test for fire effluents</td>
</tr>
<tr>
<td>6</td>
<td>EN ISO 9239-1 Radiant panel test for horizontal flame spread on floorings</td>
</tr>
<tr>
<td>7</td>
<td>EN 1021-4 Ignitability test for seats using burner equivalent to 100g paper</td>
</tr>
<tr>
<td>8</td>
<td>NT FIRE 032 Furniture Calorimeter Tests. Upholstered furniture : Burning behaviour + Full Scale Test</td>
</tr>
<tr>
<td>9</td>
<td>IEC 60695-2-11 Glow wire test</td>
</tr>
<tr>
<td>10</td>
<td>IEC 60695-2-4/2 Ignitability and flammability test with 500W flame source</td>
</tr>
<tr>
<td>11</td>
<td>EN ISO 11925-2 Small flame test</td>
</tr>
<tr>
<td>12</td>
<td>IEC 60695-2-30 Ignitability and flammability test with 1kW flame source.</td>
</tr>
<tr>
<td>13</td>
<td>EN 50399 Cable Calorimeter Tests</td>
</tr>
</tbody>
</table>

The FIRESTARR classification divides the materials into three important categories:

- Structural materials,
- Furniture materials,
- Electrical materials.

For each category (and in some cases for each type of component), it will provide the test method to evaluate all the parameters of the fire behaviour. Afterwards on the basis of the determined values it will classify the material/component in three categories:

- A for high performance product,
- B for medium performance product,
- C for low performance product.

The EN 45545 deployment processes has evolved and to know more about the issues, feel free to download

- Telech 6Ws EN 45545 En
- CREPIM newsletter 1 Fr
- CREPIM Newsletter 2 Fr
- CREPIM Newsletter 3 En

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[7] Fire Testing Technology, P.O. Box 116, Eadt Grinstead, West Sussex, RH19 4FP,UK


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[40] ISO 3795: road vehicles, and tractors and machinery for agriculture and forestry ï Determination of the burning behaviour of material.


[42] JAR Part 25, Appendix F, Part I, para. (a) (1) (i), Change 14

[43] FAR Part 25, Appendix F, Part I, para. (a) (1) (i), Amdt. 25-83

[44] Airbus Directives (ABD) and Procedures, Fireworthiness Requirements, ABD 0031, Pressurized Section of Fuselage, Airbus Industrie 1997, Airbus Industrie, Programmes and Processes Directorate, 31707 Blagnac CEDEX, France

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ADMINISTRATION, DEPARTMENT OF TRANSPORTATION, PART 238, PASSENGER EQUIPMENT SAFETY STANDARDS, October 1, 2000.

[60] pr EN ISO 11925-2 : Reaction to fire tests for building products part 2 : Ignitability when subjected to direct impingement of flame.

[61] UIC 546-2 Appendix 11 : Regulations relating to fire protection and fire-fighting measures in passenger-carrying railway vehicles or assimilated vehicles used on international services. Appendix 11. Test method for determining the fire-resistance of rigid thermoplastic materials.


[65] pr EN ISO 9239-1 : Reaction to fire tests for floorings Part 1 : Determination of the burning behaviour using a radiant heat source.


[68] NF X 70-100 : Fire tests Analysis of pyrolysis and combustion gases Tube furnace method.

[69] DIN 53436 : Producing thermal decomposition products from materials in an air stream and their toxicological testing.

[70] ISO 9705 : Fire tests Full scale room test for surface products.

[71] pr EN 13823 : Reaction to fire tests for building products Building products excluding floorings exposed to the thermal attack by a single burning item (SBI test).

[72] EN 597-1 : Furniture Assessment of the ignitability of mattresses and upholstered bed bases Part 1 : Ignition source Smouldering cigarette


[74] pr EN 32952 - Parts 1 and 2 : Textiles Burning behaviour of bedding items Parts 1 and 2 Ignitability by smouldering cigarette.

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pr EN 32952 Part 3 and 4 : Textiles Burnign behaviour of bedding items. Parts 3 and 4 : Ignitability by a small open flame.

UIC 564-2 Annex 5 : Regulations relating to fire protection and fire-fighting measures in passenger-carrying railway vehicles or assimilated vehicles used on international services. Appendix 5 : Test method to measure the reaction to fire of covered textiles.

UIC 564-2 Annex 13 : Regulations relating to fire protection and fire-fighting measures in passenger-carrying railway vehicles or assimilated vehicles used on international services. Appendix 13 : Test method to measure the ignitability of seats.


pr EN 1021 Part 4 : Furniture Assessment of the ignitability of upholstered furniture : Part 3 : Ignition source : Flame equivalent to the flame from 100 g of newspaper.


IEC 60695-2-4/1 : Fire hazard testing : Part 2 Test Methods : Section 4 sheet 1 : 1 kW nominal pre-mixed test flame and guidance.

pr EN 50264 : Railway applications : Railway rolling stock cables having special fire performance : Standard wall.

pr EN 50266-2-4 : Cable calorimeter tests.


NF 16-201 : Railxay Rolling stock : Fire resistance test for seats

NF P 92-501 : Safety against fire : Building materials : Reaction to fire tests : Radiation test used for rigid materials, or for materials on rigid substrates (flooring and finishes) of all thicknesses, and for flexible materials thicker that 5 mm.

NF P 92-503 : Safety against fire : Building materials : Reaction to fire tests : Electrical burner test used for flexible materials.

NF P 92-504 : Safety against fire : Building materials : Reaction to fire tests : Flame persistence test and speed of flame spread.
[93] NF P 92-505 : Safety against fire i Building materials i Reaction to fire tests i Test used for thermoplastic materials i Dripping test.

[94] NF P 92-506 : Safety against fire i Building materials i Reaction to fire tests i Radiant panel test for flooring.

[95] NF P 92-510 : Safety against fire i Building materials i Reaction to fire tests i Determination of upper calorific value.


[98] DIN 5510 : Preventive Fire Protection in railway vehicles. Part 1: Levels of protection, fire preventive measures and certification, Part 2: Fire behaviour and fire side effects of materials and parts; Classifications, Demands and test methods, Part 4: Vehicle design; Safety requirements, Part 5: Electrical equipment; Safety requirements, Part 6: Auxiliary measures, emergency brake operation function; Information systems, fire alarms, fire fighting equipment; Safety requirements


[100] DIN 54837 : Testing of materials, small components and component sections for rail vehicles; Determination of burning behaviour using a gas burner.


[102] DIN 54431 : Testing of seats in railways for public traffic; determination of burning behaviour with a paper pillow ignition source.

[103] TL 918433 : Technical specifications for delivery; material combinations, passenger seats; particular demands against burning behaviour.


[105] BS 476-7 : Fire tests on building materials and structures i Part 7 : Method of test to determine the classification of the surface spread of flame of products.

[106] pr EN 2825 : Aerospace series i Burning behaviour, determination of smoke density and gas components in the smoke of materials under the influence of radiating heat and flames i Determination of smoke density.

[107] pr EN 2826 : Aerospace series i Burning behaviour, determination of smoke density and gas components in the smoke of materials under the influence of radiating heat and flames i Determination of gas components in the smoke.

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[108] UNI 8456: Combustible materials which can be hit by flame on both surfaces. Reaction to fire by applying a small flame.

[109] UNI 9174: Reaction to fire of material which can be hit by flame with radiant heating.

[110] UNI 8457: Combustible materials which can be hit by flame on one surface. Reaction to fire by applying a small flame.

[111] UNI 9175: Reaction to fire of upholstered furnitures by applying a small flame.

[112] IEC EN 50267: Common test methods for cables under fire conditions i Test on gases evolved during combustion of materials from cables

[113] IEC EN 50267: Common test methods for cables under fire conditions ii Test on gases evolved during combustion of materials from cables


[119] NF C 32-070, Insulated cables and flexible cords for installations- Classification tests on cables and cords with respect to their behaviour to fire.

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