

Behaviour of M2 & M3 general construction in case of Fire Event (BMFE)

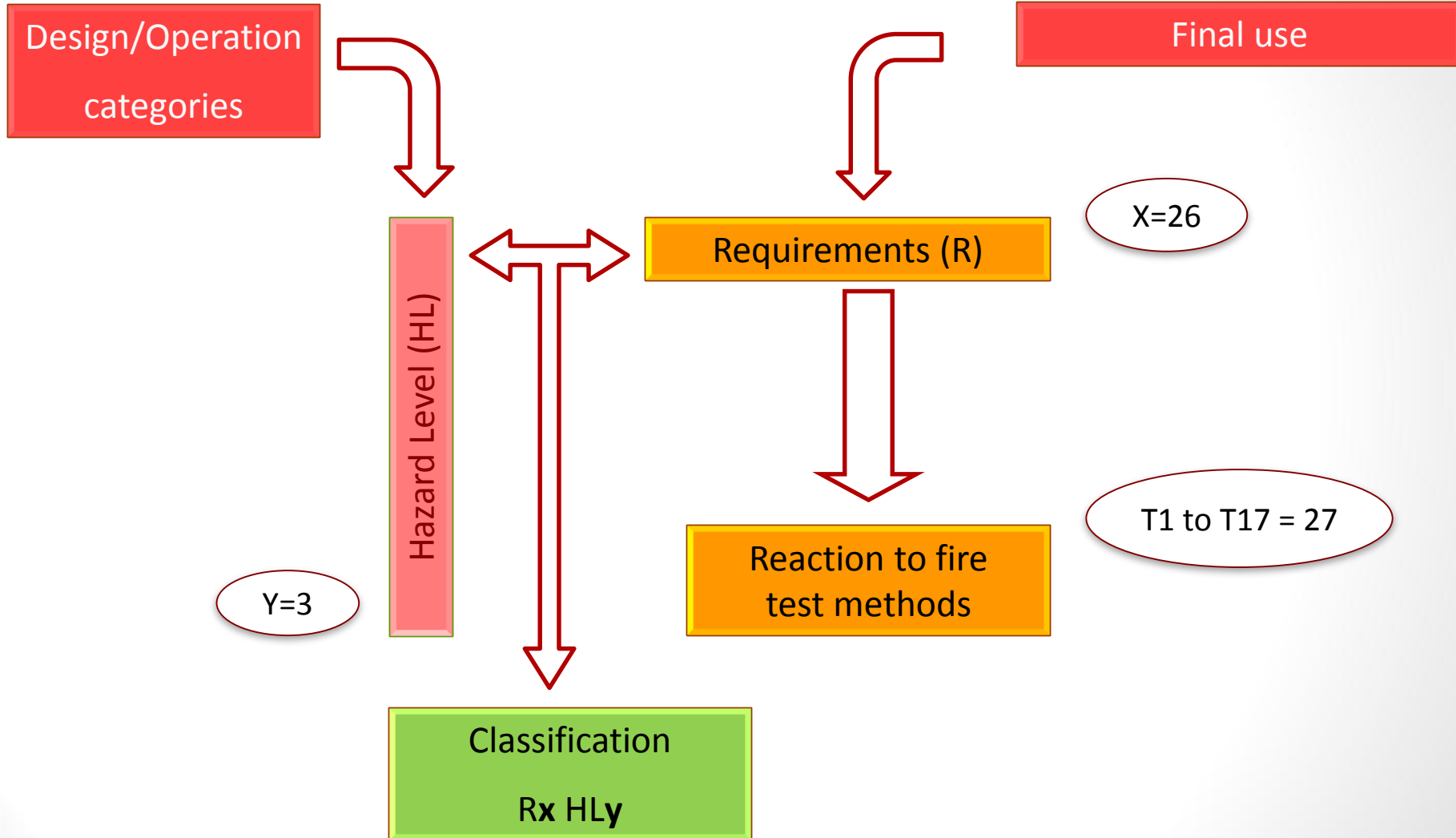
Smoke density and toxicity of materials

First approach : evaluation of R118 compliant materials according to EN 45545-2 – requirement R22

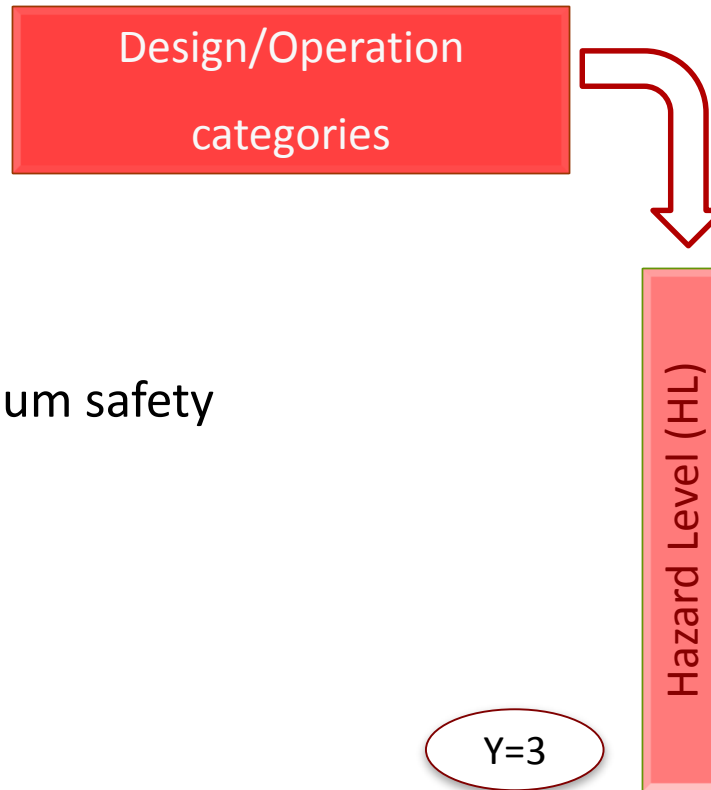
Swift overview of the EN 45545-2

- This part of the EN 45545 covers:
 - The product categories and the reaction to fire requirements for each of these categories.
 - The fire and smoke test methods depending on the necessary requirements.
 - The requirements for assemblies and non-listed products.
 - The rules and test particularities in relation with certain products and assemblies.

EN 45545 -2 : Requirements/test methods



Requirements/test methods



- How to determine the minimum safety level : HL ?
 - Rolling stock design
 - Operation category



4 operation categories: the basics

- **1:** Vehicles operated on infrastructures where the railway vehicles can be stopped with minimum delay and in an area where safety is **always immediately accessible**.
- **2:** Vehicles operated in underground sections, in tunnels and/or elevated structures, with a possible lateral exit and where there is a station or an emergency stop, accessible after a **short circulation period** and which offers a safety zone to passengers.
- **3:** Vehicles operated in underground sections, in tunnels and/or elevated structures, with a possible lateral exit and where there is a station or an emergency stop, accessible after a **long circulation period** and which offers a safety zone to passengers.
- **4:** Vehicles operated in underground sections, in tunnels and/or elevated structures, without a possible lateral exit and where there is a station or an emergency stop, accessible after a **short circulation period** and which offers a safety zone to passengers.

4 design categories

- A : vehicles constituting an automatic train that doesn't have crew members train for emergency procedures
- D : double-decker vehicles
- S : sleeper vehicles
- N : all the vehicles (standard vehicles)

The essential goals of fire safety

Classification of Hazard Levels

Operation category	Design category			
	N: standard vehicles	A: vehicles constituting an automatic train that doesn't have crew members train for emergency procedures	D: double-decker vehicles	S: sleeper vehicles
1	HL1	HL1	HL1	HL2
2	HL2	HL2	HL2	HL2
3	HL2	HL2	HL2	HL3
4	HL3	HL3	HL3	HL3

EN 45545-2 : Smoke and Toxicity evaluation

- Smoke density and toxicity measurement according to EN 45545-2 - summary:

Listed products
and
Non listed products
> 0,2m²

EN ISO 5659-2: Horizontal smoke chamber
NF EN 45545 Annexe C: Testing methods for
determination of toxic gases from railway products

25 or 50 kW/m² depending on end-use

Listed products
and
Non-listed
products
≤ 0,2m²

EN ISO 5659-2: Horizontal smoke chamber
25 kW/m²

NF X 70-100 : Toxicity in a tubular furnace
600°C

First approach

- In the frame of the BMFE working group, as a first approach, 6 materials tests have been conducted as per the EN 45545-2 R22* requirement regardless of the end-use

**requirement dedicated to small non-listed item, exposed surface < 0,2 m², interior use*

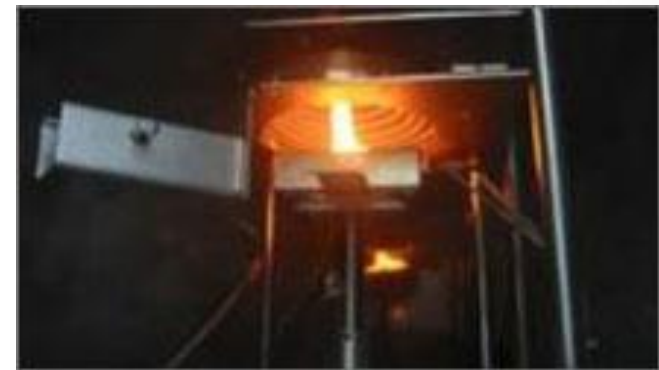
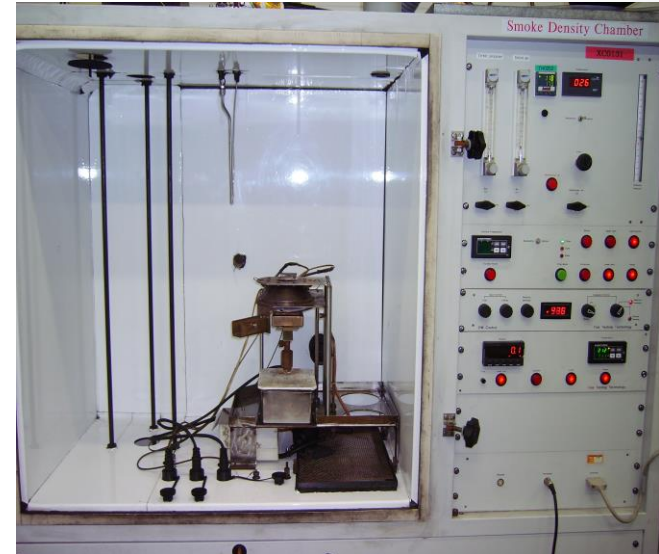
- ISO 5659-2 – smoke density :
 - Irradiation : 25 kW/m²
 - Measured parameters : Ds_{\max}
- NF X 70-100 – smoke toxicity:
 - Test conducted at 600°C
 - Measured parameters : ITC_{NLP} (CO, CO₂, HF, HBr, HCl, HCN, SO₂, NO_x)

- R22 requirement

Short name of requirement set (used for)	Test method reference	Parameter Unit	Maximum or Minimum	HL1	HL2	HL3
R22	T01 EN ISO 4589-2: OI	Oxygen content %	Minimum	28	28	32
	T10.03 EN ISO 5659-2: 25 kWm ⁻²	D_s max. dimensionless	Maximum	600	300	150
	T12 NF X 70-100-1 and -2 600 °C	CT_{NLP} dimensionless	Maximum	1,2	0,9	0,75

Smoke Density measurement

- ISO 5659-2 Smoke chamber
 - The test is carried out in a chamber of 0.5m³ in volume.
 - The specimen sits inside a small metal holder with one face left exposed (this ensures that it is a surface test only).
 - The container is then placed inside the chamber below a cone heater in a horizontal position.
 - The resulting smoke density / time curve is used to calculate the specific optical density figures
 - D_{sm} is the maximum specific optical density obtained within the 20 minutes test period.

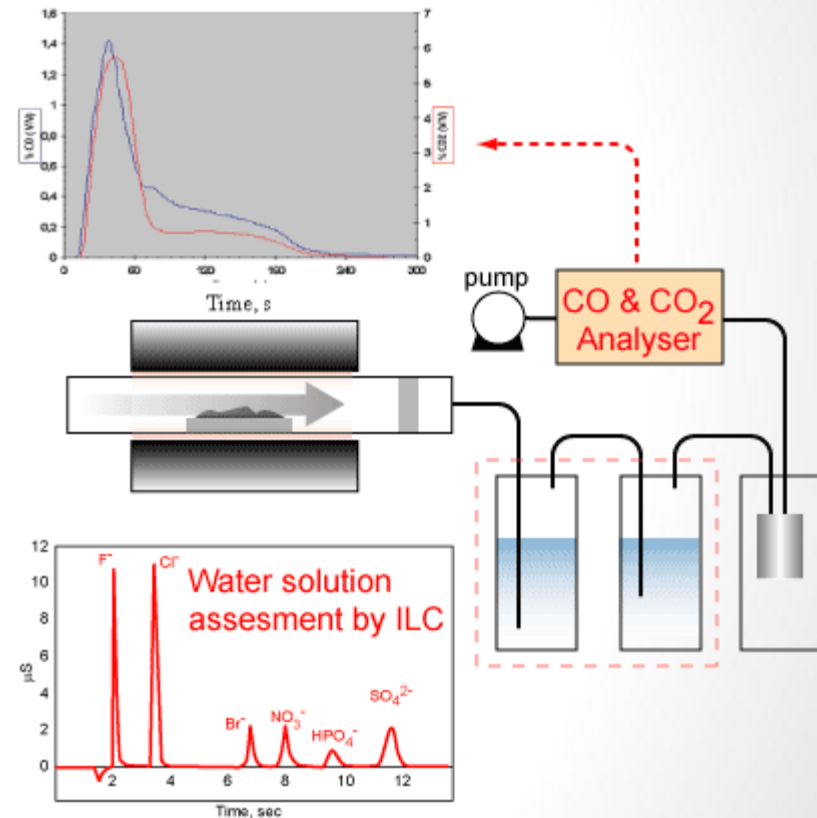


Smoke Toxicity measurement

- NF X 70-100 (tubular furnace):

Measure of the CIT_{PNL} :

- Deterioration of a quantity of material – (0,5 g) in a tubular furnace heated at 600°C
- Test duration: 20 min
- The quantity of gas per gram of tested material is determined with different test methods (HPLC, IR, chimiluminescence)
- Gases measured out : CO, CO₂, HF, HBr, HCl, HCN, SO₂, NO_x



Smoke Toxicity measurement

- Calculation of the CIT_{NLP}
 - Reference concentrations of gas constituents

$$ITC_{PNL} = 1 \frac{g}{m^3} \times \sum_{i=1}^{i=8} \frac{Y_i}{C_i}$$

The combustion of 450 g of the material and gaseous effluents which disperse in 150 m³.

Composant gazeux	Concentration de référence [mg/m ³]
CO ₂	72 000
CO	1 380
HBr	99
HCl	75
HCN	55
HF	25
NO _x	38
SO ₂	262

Reference values are based on the *IDLH* (Immediate Danger for Life and Health), recognised as a limit for personal exposure to the gas component by NIOSH (National Institute for Occupational Safety and Health) (1997 version).

Samples tested

- 6 samples declared as R118 compliant by the end-users / manufacturer have been tested:
 - Floor covering – sample A
 - Floor covering – sample B
 - Seat covering backrest – sample C
 - Thermoplastic sheet – sample D
 - Multilayers product – sample E
 - Multilayers product – sample F

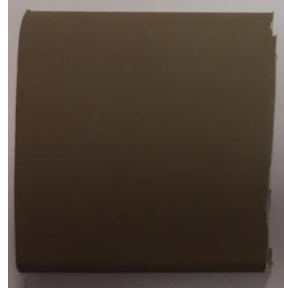
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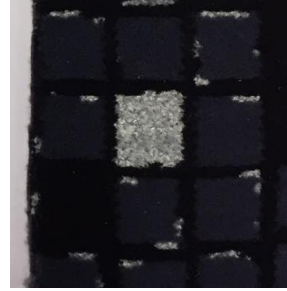
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C



D



E



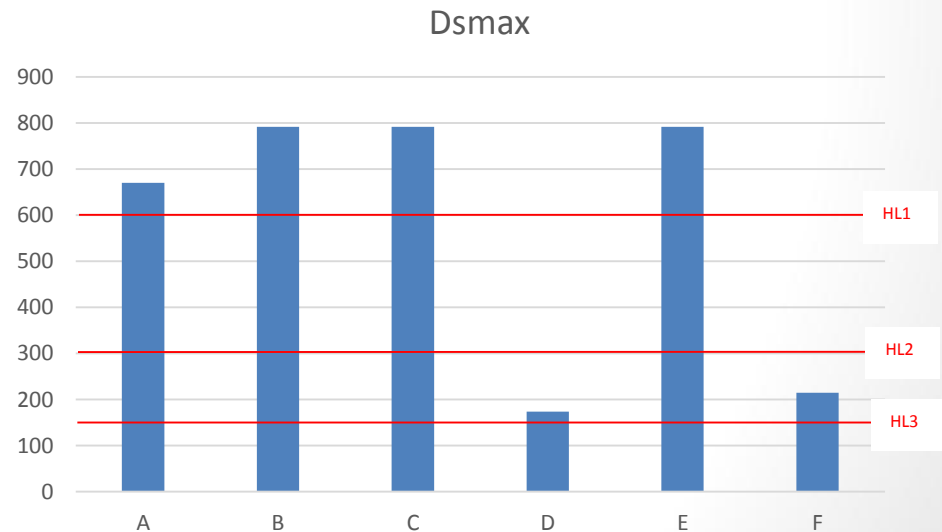
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ISO 5659-2 test results

- Smoke density measurement @ 25 Kw/m²

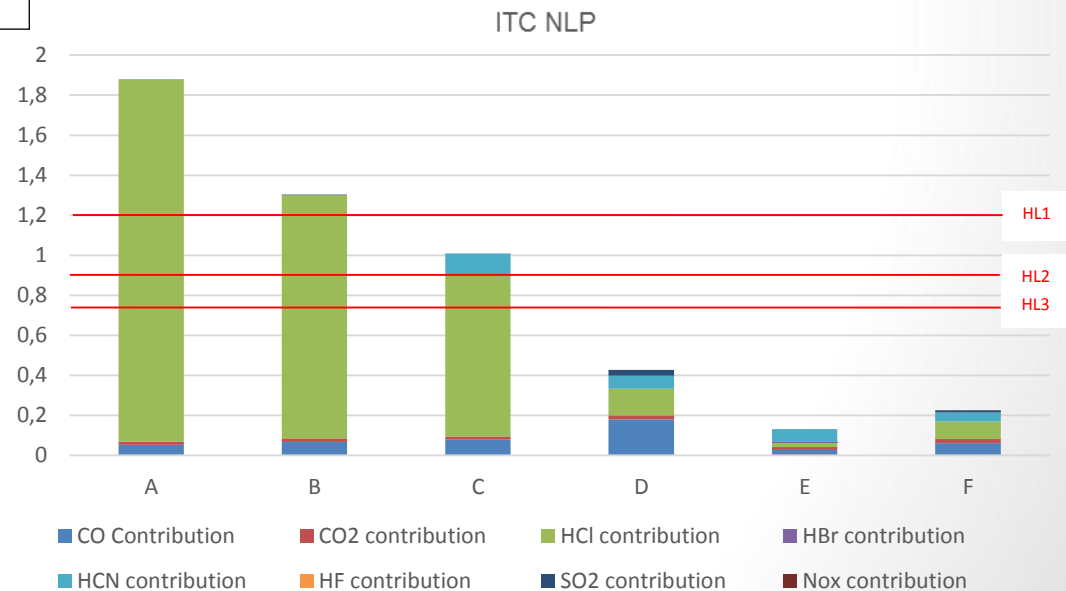
	A	B	C	D	E	F
Mass (g)	13	20	16	4	53	19
Mass loss (%)	69	74	2137	83	58	76
VOF4	1875	2488	2487	16	1427	701
Ds1.5	655	620	628	5	14	202
Ds4	545	>792	>792	4	>792	207
DS10	504	>792	>792	171	>792	198
Dsmax during the first 10 minutes of the test	670	> 792	> 792	174	> 792	215
Dsmax over the duration of the test 20 min	670	> 792	> 792	186	> 792	215



NF X 70-100 results

- Smoke toxicity measurement @600°C – ITC_{NLP} calculation

	A	B	C	D	E	F
CO (mg/g)	72,81	92,25	107,59	247,33	36,95	84,29
CO ₂ (mg/g)	1227,62	1298,81	1236,22	1554,67	1072,46	1491,62
HCl (mg/g)	135,53	91,13	60,19	9,86	1,53	6,63
HBr (mg/g)	NQ	NQ	NQ	NQ	0,6	NQ
HCN (mg/g)	NQ	NQ	6,18	3,66	3,52	2,45
HF (mg/g)	ND	ND	ND	ND	ND	ND
SO ₂ (mg/g)	0,75	0,9	NQ	7,52	NQ	2,87
NO _x	NQ	NQ	3,2	NQ	NQ	NQ
ITC NLP	1,9	1,3	1,1	0,4	0,1	0,2



Opacity / toxicity evaluation

- Smoke / Tox classification – first approach :

Short name of requirement set (used for)	Test method reference	Parameter Unit	Maximum or Minimum	HL1	HL2	HL3
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	A	B	C	D	E	F
ITC PNL	1,9	1,3	1,1	0,4	0,1	0,2
Dsmax during the first 10 minutes of the test	670	> 792	> 792	174	> 792	215
R22 - HL regardless of LOI values	Not classified	Not classified	Not classified	HL1 (and HL2)	Not classified	HL1 (and HL2)

- Opacity of smoke :
 - Relevance of the irradiance level : 25 kW/m^2 - early stage of a fire event
 - Criteria : Ds_{max} measured over 10 minutes – keeping in mind evacuation time of bus, is Ds_{90} or Ds_{240} more appropriate?
- Smoke Toxicity :
 - Is CIT model appropriate? (EU railway inspired) or should it focus on individual toxic concentrations (inspired from marine (FTP code) and Aircraft (ABD0031) models)
 - How to take into account the specificities of busses fire model?