



Our know-how makes your success



TS 45 545: does new standard mean new materials?

2011/11/16

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- ❑ **TS 45 545: does new standard mean new materials?**
- ❑ **New changes are ongoing in the railway industry**, due to the new Interoperability of the Trans-European High-Speed Rail System Directive, which aims to standardize the regulation in order to guarantee the same level of security whatever the location in the EU.
- ❑ These new trends imply key changes in the material development approaches that involve product with a low kinetic of degradation.
- ❑ This implies the use of new fire-retardant chemistry and opens the space for a new generation of solutions, which has been achieved in thermoset resins, although there is still work to be done for other polymeric applications.

- ☐ Introduction
- ☐ CEN TS 45545- part 1
- ☐ CEN TS 45545-part 2
 - FIRST : fire assessment
 - Case studies (inner wall, circuit breaker)
 - Complete seat test
- ☐ Bold ideas
 - Key drivers
 - Grouping rules
 - Assemblies
- ☐ Conclusion

❑ **1999** : COFRAC 77-1, 2 & 3 accreditation



❑ **2003** : CERTIFER (SNCF/RATP) recognition



❑ **2006** : ISO 5659-2 test (TS 45545-2) accreditation

❑ **2010** : French Home Office recognition (M-ranking, Procès-Verbal)

❑ **September 2011** : *Complete seat test accreditation – Appendix A&B (TS 45545-2)*

❑ **Short term** : Full equipped and ready for the new European Standard for railway applications

Free market

- Free flow of goods and people in the world
- Mass transport

Interoperability

- **Council Directive 9648EC (23/07/96)**
on the interoperability of the Trans-European high-speed rail system
- **Directive 200116EC (19/03/01)** of the European Parliament and of the Council on the interoperability of the Trans-European conventional rail system

STI / standards

- ***STI*** : Main requirements for sub-systems
- ***Standards*** : CEN, CENELEC and ETSI

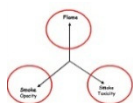
Fire safety
standard

- ***TS 45545 (parts 1 to 7)***
: fire safety requirements

☐ *Essential Requirements*

- **Safety**
- Reliability and availability
- Health
- Environmental protection
- Technical compatibility

Part 1 General



Part 2 Requirements for fire behaviour of materials

Part 3 Fire resistance requirements for fire barriers
Rejected, revision and partitions



Insulation
I

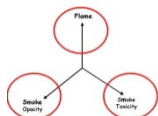


Integrity
E



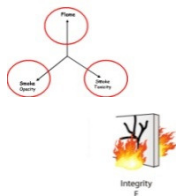
Load Bearing
R

Part 4 Fire safety requirements for rolling stock design



Part 5 Fire safety requirements for electrical equipment

Part 6 Fire control and management systems



Part 7 Fire safety requirements for flammable liquid and flammable gas installations

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- ❑ This Part of TS 45545 covers
 - Principal definitions
 - 4 Operation categories
 - 4 Design categories
 - Fire safety objectives
 - General requirements for fire protection measures and their evaluation of conformity

- ❑ **1 Vehicles that are not designed or equipped to run on underground** sections, tunnels and/or elevated structures and which may be stopped with minimum delay, after which immediate side evacuation to a place of ultimate safety is possible.
 - Length between tunnel > train length
 - Tunnel length < 10% total travel length

- ❑ **2: Vehicles that are designed or equipped to run on underground sections,** tunnels and/or elevated structures, with side evacuation available and where there are stations or emergency stations that offer a place of ultimate safety to passengers, reachable **within a short running time.**
 - Tunnel length < 5 km
 - Travel time < 4 min

- ❑ **3: Vehicles that are designed or equipped to run on underground sections,** tunnels and/or elevated structures, with side evacuation available and where there are stations or emergency stations that offer a place of ultimate safety to passengers, reachable within a long running time.
 - Tunnel length < 20 km
 - Travel time < 15 min

- ❑ 4: Vehicles that are designed or equipped to run on underground sections, tunnels and/or elevated structures, without side evacuation available and where there are stations or emergency stations that offer a place of ultimate safety to passengers, reachable within a short running time.
 - Travel time < 4 min



- ☐ A: Vehicles forming part of an automatic train having no emergency trained staff on board
- ☐ D: Double decked vehicles
- ☐ S: Sleeping and couchette vehicles
- ☐ N: All other vehicles (standard vehicles)

- Hazard levels are the combination between the operation category and design category

Design Category \ Operation Category	N : Standard vehicles	A : Automatic vehicles having no emergency trained staff on board	D : Double decked vehicle ¹⁾	S : Sleeping and couchette cars Double decked or single deck
1	HL1	HL1	HL1	HL2
2	HL2	HL2	HL2	HL2
3	HL2	HL2	HL2	HL3
4	HL3	HL3	HL3	HL3

- HL1= Tramway



- HL2= TGV, TER, RER... 90% of the market



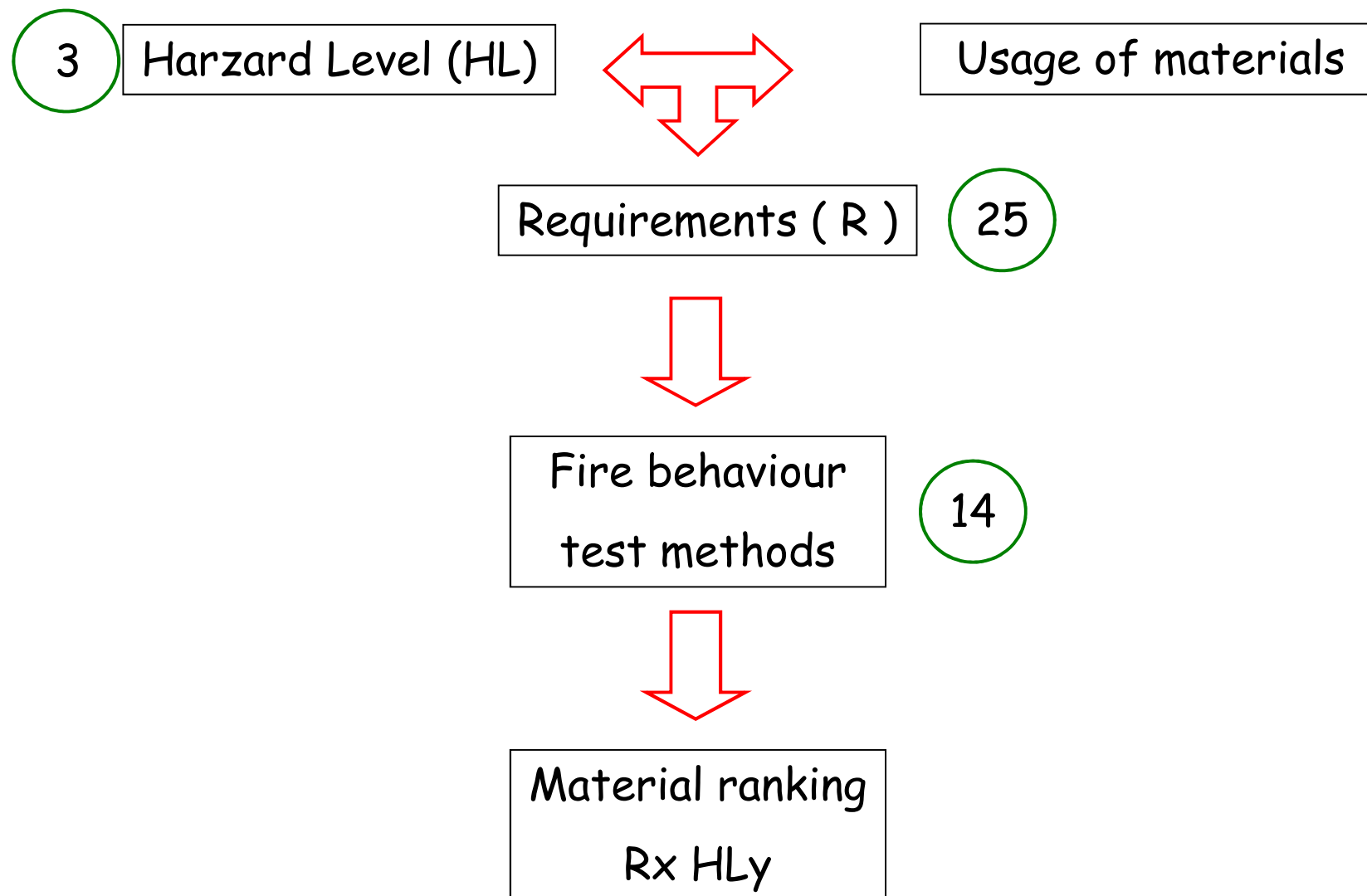
- HL3= Subway, Tube, Sleeping and couchette cars



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- ❑ This Part of CEN TS 45545 covers
 - The generic material classes and the requirement classes
 - Test methods according to the generic material classes
 - Characteristic requirement of the System test
 - Requirements in principle for selection of testing and test samples

- ❑ Interior material construction



Listed products - table 4

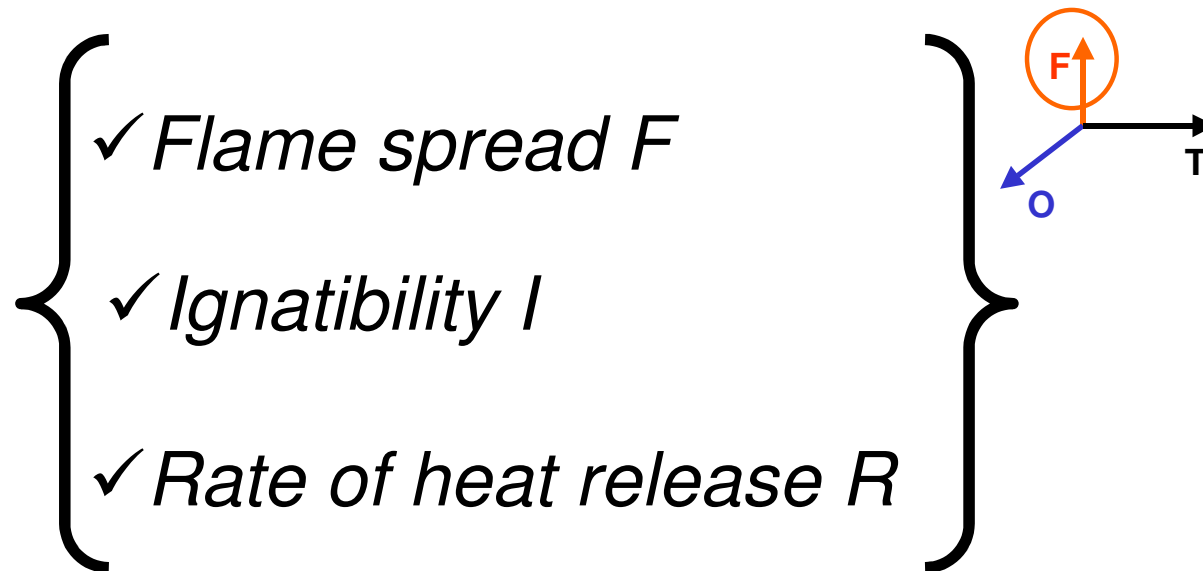
- Interior (IN)
- Exterior (EX)
- Furniture (F)
- Electrotechnical Equipment (E)
- Mechanical Equipment (M)

Non listed products - table 5

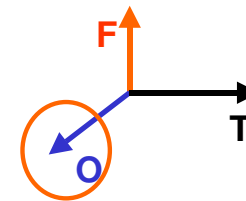
- > 0,20 m² and interior
- > 0,20 m² and exterior
- < 0,20 m² and interior
- < 0,20 m² and exterior

Grouping rules

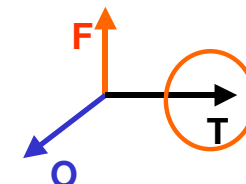
- ☐ Introduction
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✓ *Smoke S*



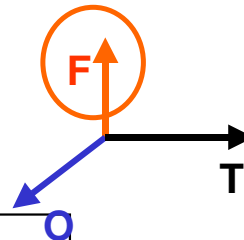
✓ *Toxicity T*



F I R S T

Material classes	Spread of flame	Ignitability*	Rate of heat release	Smoke	Toxicity
Structural surface related products	ISO 5658-2 Radial panel	ISO 5660-1 Cone calorimeter		ISO 5659-2 NBS chamber	
Furniture products	For product testing ISO 9705 Furniture calorimeter			ISO 5659-2 NBS chamber	
	---	For sample testing ISO 5660-1 Cone calorimeter		ISO 5659-2 NBS chamber	
Electro technical products	ISO 4589-2 LOI		---	ISO 5659-2 NBS chamber	
Mechanical products	ISO 4589-2 LOI		---	ISO 5659-2 NBS chamber	

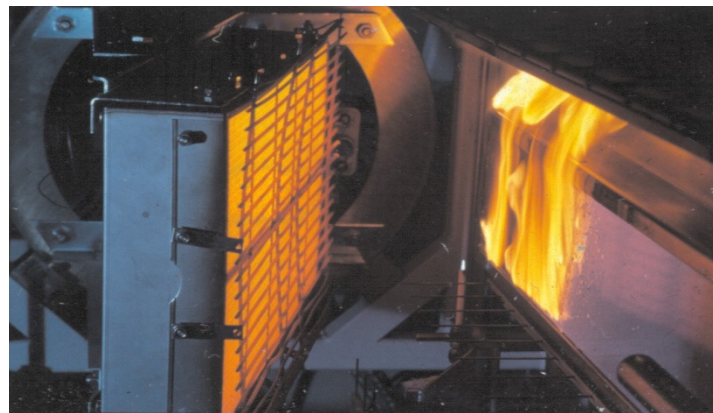
☐ Flame spread and Ignitiability :



Large surface	EN ISO 5658-2: Vertical Radiant Panel EN ISO 9239-1: Flooring radiant panel
Non listed items and EE	EN ISO 4589-2: Oxygen Index
Cables	<u>« Flame spread cable tests » :</u> EN 60332-1-2 EN 50266-2-4 EN 50305 § 9.1.1 EN 50305 § 9.1.2

EN ISO 5658-2 :

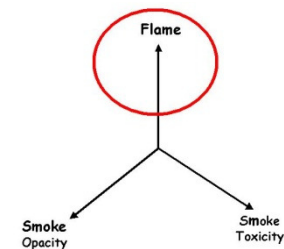
Reaction to fire tests - Spread of flame - Part 2:
Lateral spread on building products in vertical configuration



Key parameter: Flame spread

Measurement of :

- Critical Heat Flux at Extinguishment (CHF)

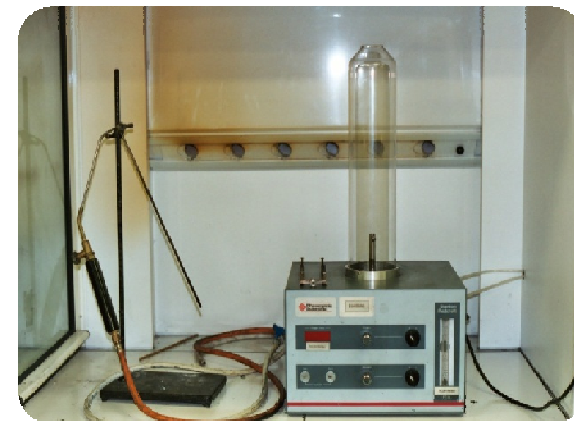


□ NF EN ISO 4589-2 (Oxygen Index) :

Key parameter : Ignitiability

Measurement of LOI :

The minimal concentration of oxygen required to just maintain the combustion of the test sample in specified conditions



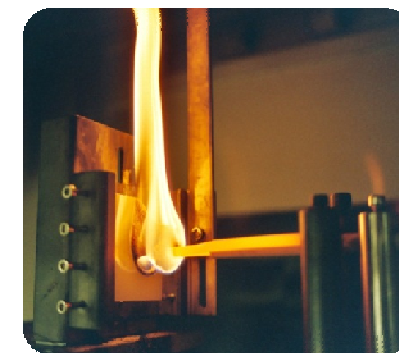
□ NF EN 60695-2-10/11 (Glow wire) :

Requirement R27 for printed board ?

Key parameters : Ignitiability

Measurement of :

The ability of a material to ignite following to the contact of a heating element and to maintain a sustaining flame after the removal of this element

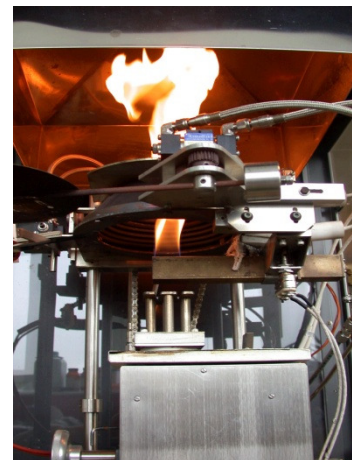


☐ Rate of Heat Release :

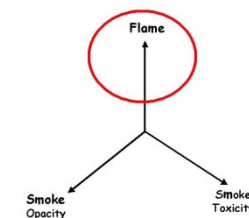
ISO 5660-1: Fire test - Reaction to fire - Part1:
Rate of heat release (Cone calorimeter method)



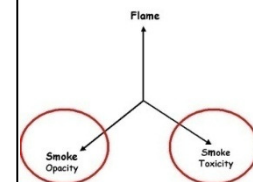
Measurement of :
- Oxygen consumption



Calculation of :
- MAHRE



☐ Smoke opacity and toxicity:



Non listed
items

and

Large surface

Opacity : EN ISO 5659-2: SDC - Horizontal apparatus

Toxicity (method 1) : CEN TS 45 545 Annex C: Testing methods for determination of toxic gases from railway products (area based method)

Non listed
items

and

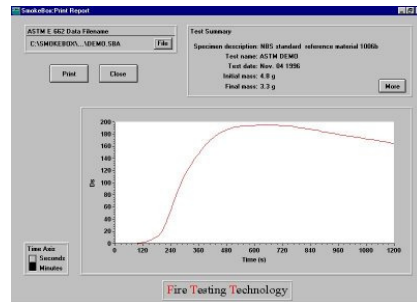
E&E materials
/cables

Opacity : EN ISO 5659-2: SDC - Horizontal apparatus

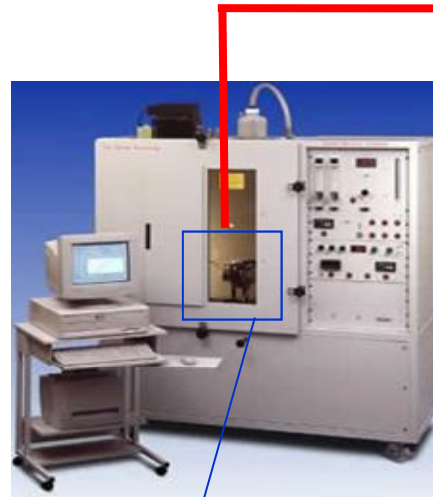
Toxicity (method 2) : NF X 70-100 : Toxicity (mass based method)

EN ISO 5659-2 / CEN TS 45 545 Annex C :

4 and 8 min sampling of gas

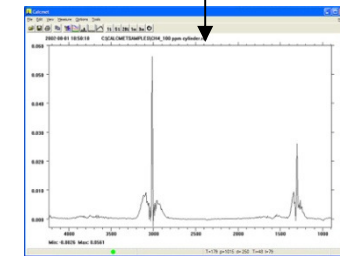
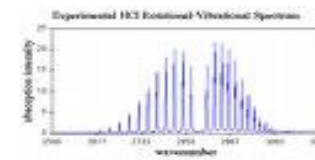


Ds (4)
Dm
VOF4



Heated sampling line

FTIR Spectroscopy

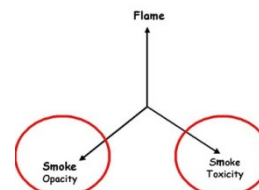


25 kw m⁻² with pilot flames

50 kW m⁻² without pilot flames



$$CIT_G = 0.0805 \times \sum_{i=1}^{i=8} \frac{c_i}{C_i}$$



□ NF X 70-100 (Tubular furnace) :

Key parameters : Toxicity

Measurement of :

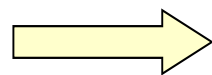
• Amount of gas emitted per g of material tested

• Targeted gas :

- CO, CO₂ (Infra-red analysis) ①
- HF, HBr, HCl, HCN, SO₂ (HPLC analysis) ②
- NO, NO_x (Chemiluminescence analysis) ③

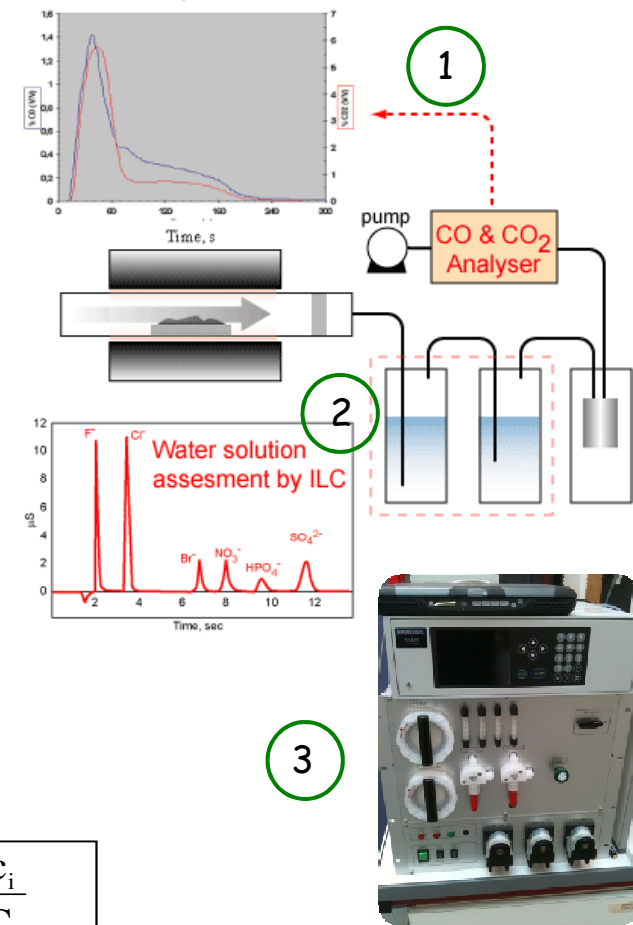
Calculation of : Conventional Toxicity Index (CIT)

Gas component	Reference concentration (mg/m ³)
CO ₂	72000
CO	1380
HBr	99
HCl	75
HCN	55
HF	25
NO _x	38
SO ₂	262



$$CIT_{MLP} = \sum_{i=1}^{i=8} \frac{c_i}{C_i}$$

POTENTIAL OF TOXICITY



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Tableau 4 — Exigences des produits listés

Article n°	Nom	Description	Exigence
IN	Intérieurs		
IN1	Composants intérieurs – surface horizontale orientée vers le bas ; surface horizontale orientée vers le haut ; surfaces dans des cavités, parois – surfaces verticales	Composants intérieurs (structure et revêtements) tels que panneaux de plafond ainsi que les trappes, boîtiers, capots, persiennes, matériaux d'isolation, et la structure de caisse dans cette zone. Composants intérieurs (structure et garnissage) tels que les parois latérales, parois frontales/parois d'extrémité, cloisons, séparation de salle, ainsi que trappes, boîtiers, capots, persiennes, dans cette zone, portes intérieures, garnissage intérieur des portes d'extrémité et portes extérieures, compartiment à bagages, fenêtres (plastique, verre feuilleté), ainsi que la structure de caisse dans cette zone; surfaces intérieures de cuisines (sauf celles des équipements de cuisine)	R1
IN2	Surface limitée	Tous les produits listés, qui répondent aux exigences conformément au 3.2.2, tableau d'expression "surface limitée"	R2
IN3	Bandes	Bandes de revêtement verticales sur paroi, diffuseur d'éclairage, vasques d'éclairage, caches lampes (les lampes elles-mêmes et les lampes de signalisation ne sont pas incluses dans ce domaine d'application)	R3



Inner wall / ceiling ...

R1 HL2 COMPLIANCE

Nom abrégé de la série d'exigences (utilisé pour)	Référence de méthode d'essai	Paramètres Unités	Définition des exigences	HL1	HL2	HL3
R1 (IN1 ; IN4 ; IN5 ; IN6A ; IN7 ; IN8 ; IN10B ; IN12 ; IN13 ; IN15 ; F7B ; E3 ; E2A ; 4.4.1 ; 5.3.4)	T02 ISO 5658-2	CFE kWm ⁻²	Minimum	20 a	20 a	20 a
	T03.01 ISO 5660-1 : 50 kWm ⁻²	MARHE kWm ⁻²	Maximum	a -	90	60
	T10.01 EN ISO 5659-2 : 50 kWm ⁻²	D ₂ (4) non dimensionné	Maximum	600	300	150
	T10.02 EN ISO 5659-2 : 50 kWm ⁻²	VOF4 Minutes	Maximum	1200	600	300
	T11.01 EN ISO 5659-2 : 50 kWm ⁻²	ITC _G non dimensionné	Maximum	1,2	0,9	0,75

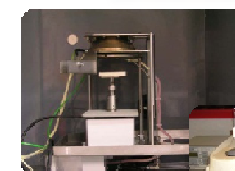
F



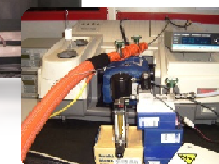
R



S



T



Article n°	Nom	Description	Exigence
E	Equipements électrotechniques		
E4C	Matériaux de barrière anti-arc	Barrière anti-arc voir définition Partie 5	R6
E5	Liquide isolant inflammable	Liquide isolant inflammable	R13
E6	Dispositifs du système d'alimentation électrique extérieur	Protecteurs de surtension; isolateurs; commutateurs; disjoncteurs principaux	R24
E7A	Dispositifs du système d'alimentation électrique à haute tension Considérés comme étant intérieurs	Isolateurs; transformateurs de courant et de tension, disjoncteurs principaux Contacteurs	R23
E7B	Dispositifs du système d'alimentation électrique à haute tension Considérés comme étant extérieurs	Isolateurs; transformateurs de courant et de tension, disjoncteurs principaux Contacteurs	R24



Circuit breaker

R23/R24 HL2 COMPLIANCE

Nom abrégé de la série d'exigences	Réf. de méthode d'essai	Unités des paramètres	Définition des exigences	HL1	HL2	HL3
R23 (E7A ; E8A ; E2A, 4.4.1, 5.3.4)	T01 EN ISO 4589-2 : IO	Indice d'oxygène :%	Minimum	28	28	32
	T10.03 EN ISO 5659-2 : 25 kWm ⁻²	D_5 max non dimensionné	Maximum	600	300	150
	T12 NF X70-100-1 et-2 600°C	ITC _{NLP} non dimensionné	Maximum	1,2	0,9	0,75
R24 (E6 ; E7B ; E2B, 5.3.4 ; E8B, 4.4.1)	T01 EN ISO 4589-2 : IO	Indice d'oxygène :%	Minimum	28	28	32
	T10.03 EN ISO 5659-2 : 25 kWm ⁻²	D_5 max non dimensionné	Maximum	-	600	300
	T12 NF X70-100-1 et-2 600°C	ITC _{NLP} non dimensionné	Maximum	-	1,8	1,5

F

S

T



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Full passenger seats, appropriately vandalised, shall be tested. The seats shall include arm and head rests, back and base shell.

FIRST

Annex A : standard vandalism - How to proceed?

This small scale test determines the ability of the seat to resist vandalism with a blade prior to an arson attempt.

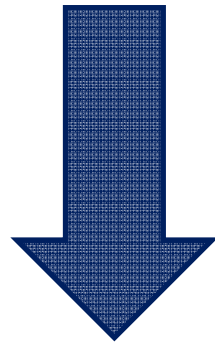
The test shall be performed by the fire laboratory before the fire test for vandalised seating (Annex B) to determine the extent of vandalism that shall be reproduced on the fire test specimens.

A representative sample is obtained from the seat having dimensions of 300 mm × 450 mm, in full thickness if lower than 50 mm, or 50 mm thick if higher than 50 mm. The edges of the test specimen shall be completely covered by the seat covering.

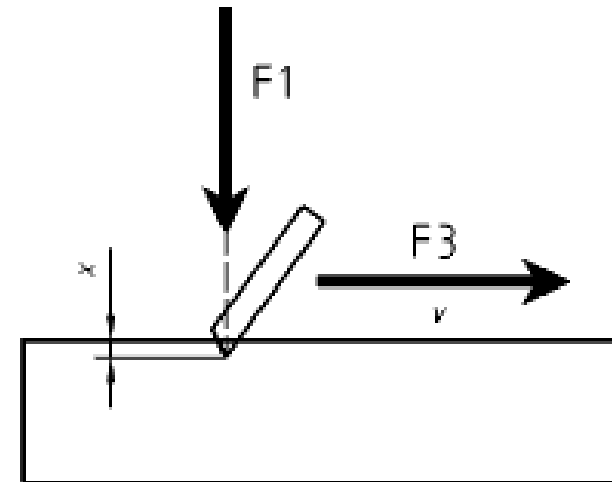
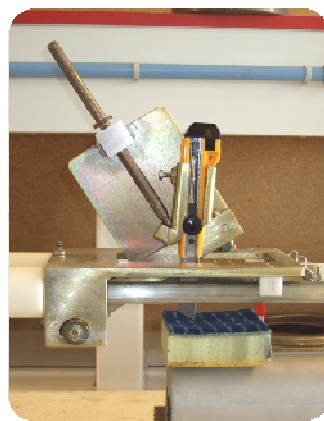
□ Annex A :

FIRST

Standard vandalism test for seat coverings



Carried out before the fire test for seating



Test time = 5s

F1 150 N

F3 150 N

X 20 mm

V 60 mm/s

FIRST

☐ Annex A :

The penetration test involves applying a vertical force F_1 onto the lever to allow the tip of the blade to penetrate the seat covering.

The lever shall be kept in this position by the blocking system.

The laceration test consists in applying a traction force onto the trolley by means of the traction device and a speed of traction of (60 ± 5) mm/s. The duration of the test shall be (5 ± 1) s.

FIRST

☐ Annex B : Extent of vandalism Annex A

Remove the specimen from the vandalism test apparatus and put the specimen on a flat surface.

Report the layers (textile, under layer, foam) that have been fully cut through to more than 50 mm laterally.

A cut of less than 50 mm is considered as non-vandalised
according to the requirements for the preparation of the test specimen

Extent of vandalism Annex A

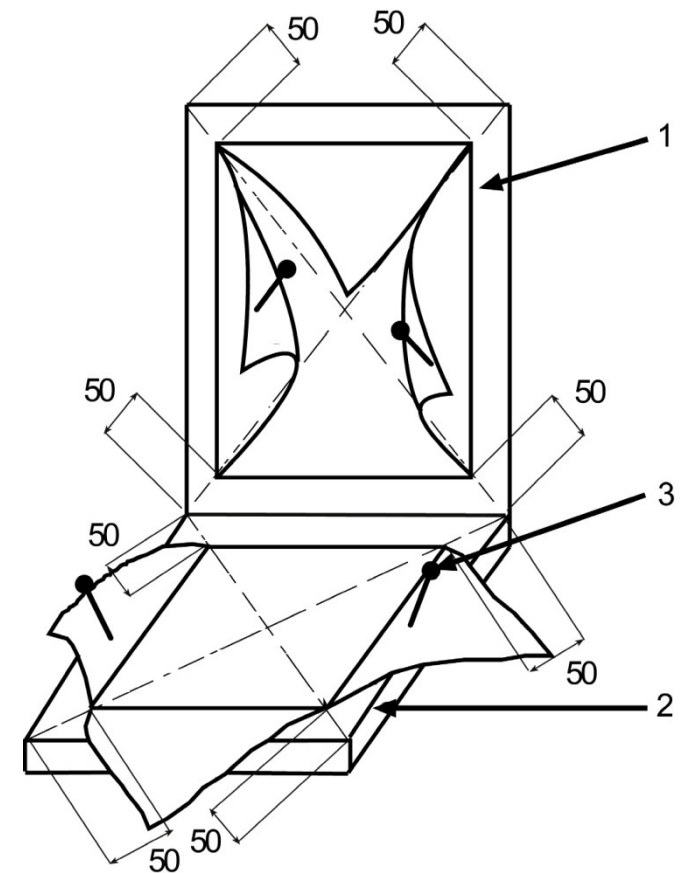
The level of vandalism determined during the test of Annex A shall be reproduced in the following way:

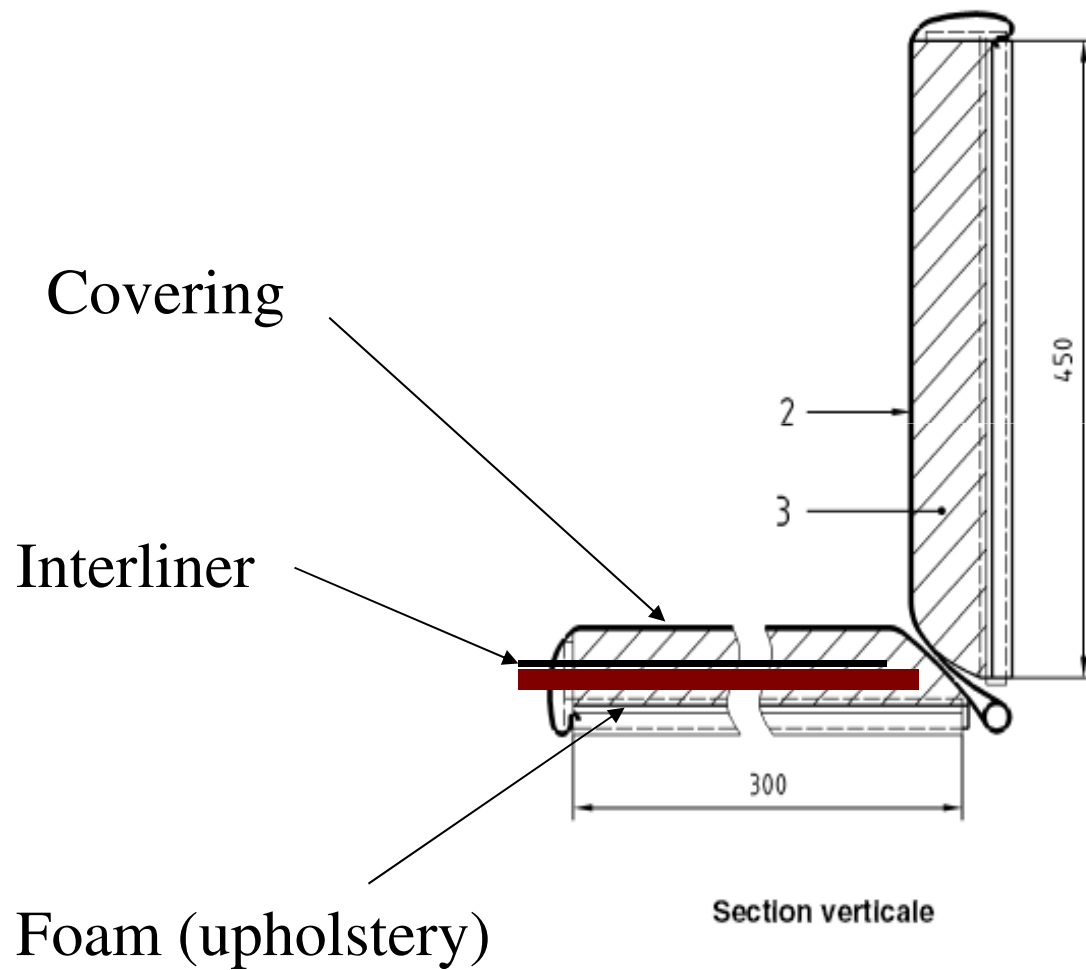
The layers that were cut or perforated for a longer distance than 50 mm shall be cut along the diagonals beginning 50 mm from the corners.

The fully cut layers shall be rolled up and pinned as shown in the figure. The rolling and pinning shall be done so that there is no interference with the burner trajectory.

To make sure that the requirements of burner position are fulfilled, the rolled up flaps shall be cut off.

FIRST



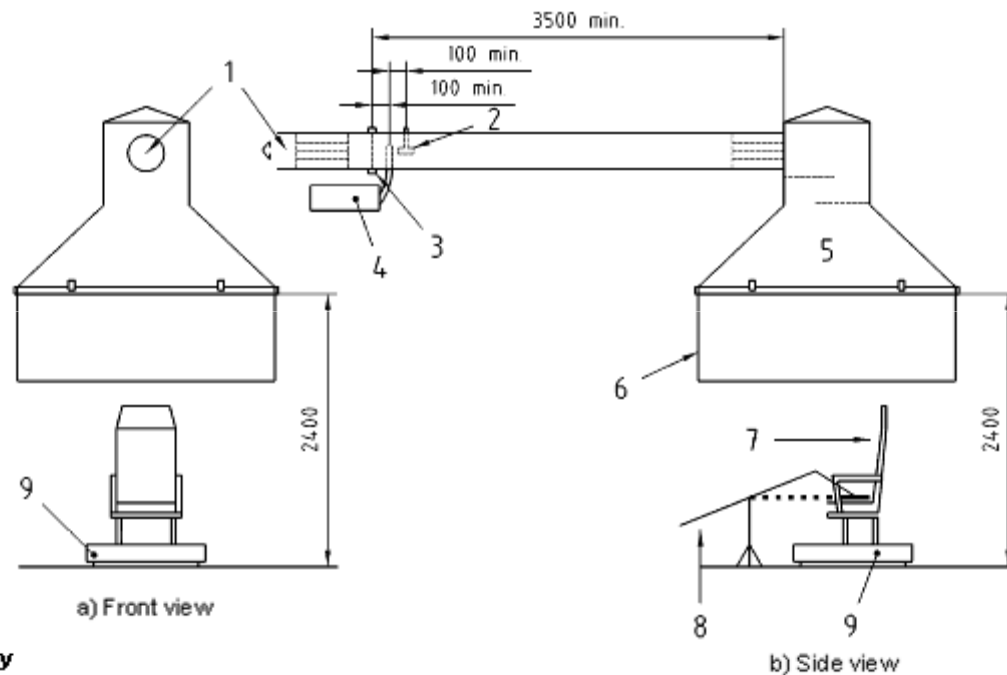


If one of the fully cut through layers is bonded to an underlayer, when the bonded layer is lifted and turned back there are several possible occurrences:

- when pulling the bonded layer back it remains integral (e.g. woven glass layer bonded to a core foam) and brings with it some additional material from the underlying layer. In this circumstance the underlying material that comes away during the process is left bonded to the pulled back layer;
- . when pulling the bonded layer back it tears easily within itself, (e.g. a weak felt bonded to a core foam) no underlying material is lifted with it and it is not possible to remove any significant area of the layer in a single action. In this circumstance the (weak) layer shall be scraped away until only well bonded material remains;
- . if it is not possible to pull back the damaged layer(s) away from the upholstery foam, leave the surfacelayer(s) as cut in the vandalism test.

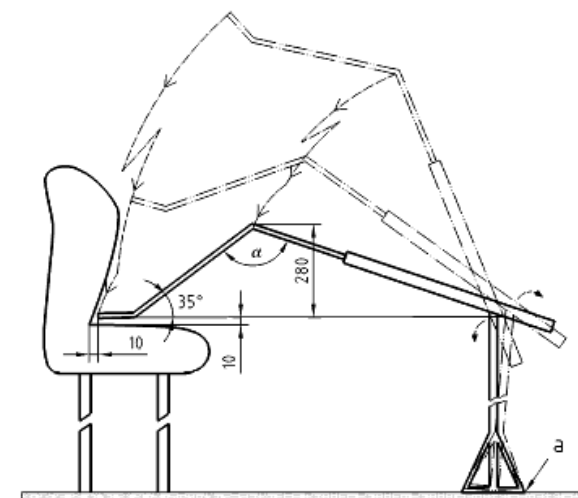
Annex B :

Fire test method for seating

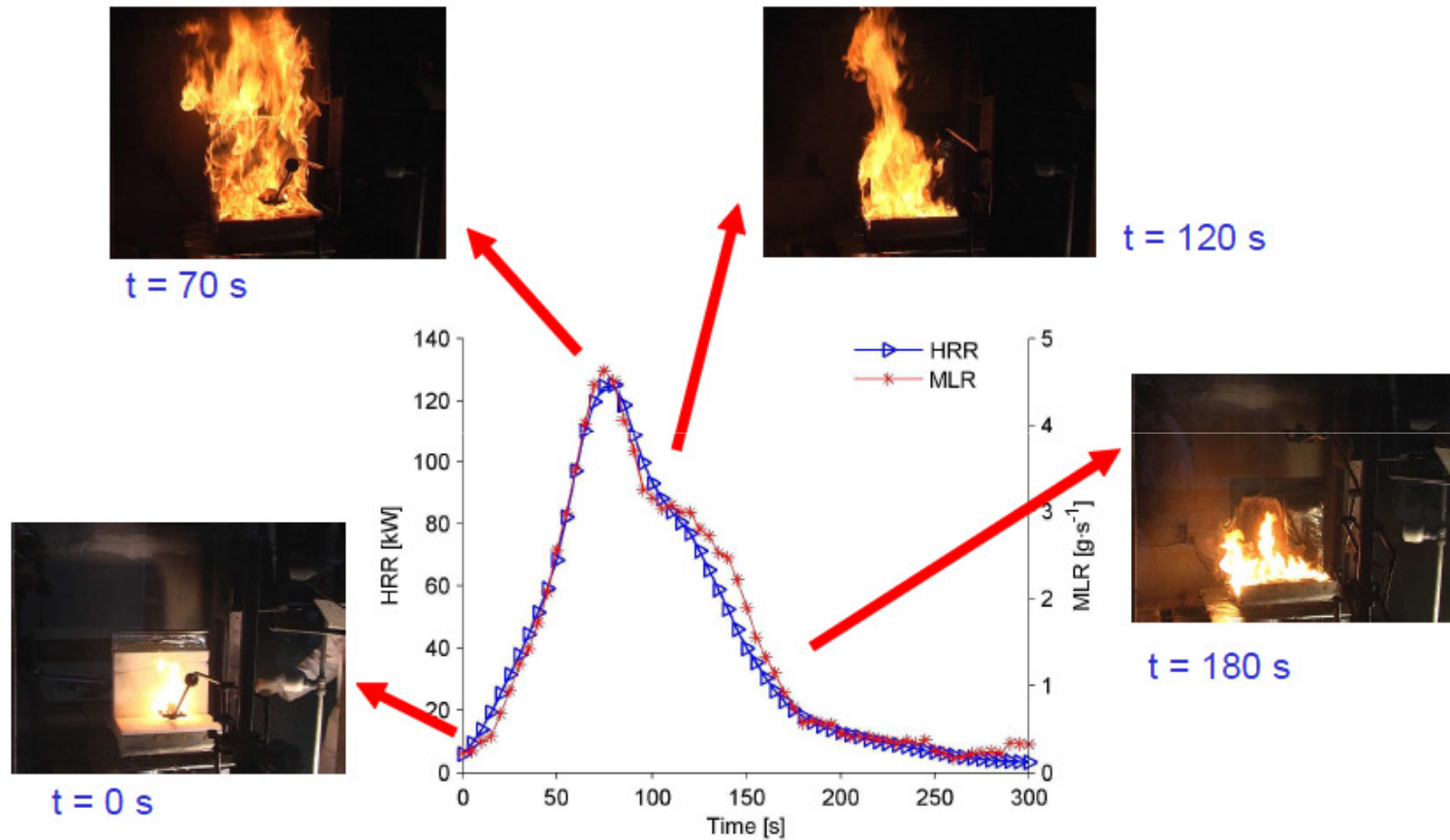


Key

- | | |
|--|---|
| 1 exhaust duct $d = 400$ mm | 6 steel plates 1 000 mm \times 3 000 mm |
| 2 pitot tube | 7 seat product |
| 3 lamp, photocell system | 8 burner |
| 4 gas analysis (O_2 , CO , CO_2) | 9 balance |
| 5 ISO 9705 Hood | |



- Heat release rate monitoring: HRR en kW



- MAHRE calculation :

$$ARHE(t_n) = \frac{\sum_{n=1}^N (t_n - t_{n-1}) X \frac{\dot{q}_n + \dot{q}_{n-1}}{2}}{t_n - t_{n-1}}$$

Example : Complete seat

F	Furniture			
F1	Complete passenger seat	Complete passenger seat including arm and head rests, separate pillows, tip up seats and driver seat accessible to the passenger	R17	Extent of vandalism see Annex A and Annex B
F1A	Upholstery for passenger seats and head rest	Upholstery for seats and head rest	R20	see Annex D
F1B	Armrest passenger seats – Upwards facing surface	Armrest – Surface on which the arm rests	R21	see Annex D
F1C	Armrest passenger seats – Vertical surface	Armrest – Inside surface (or outside surface on transverse seating) which is against the body of the seat occupant	R22	Fire integrity 6.2.1.2
F1D	Armrest passenger seats – Downwards facing surface	Armrest – Underside surface of the arm rest	R22	Fire integrity 6.2.1.2
F1E	Back shell; base shell of passenger seats	Back shell; base shell of passenger seats	R5	Fire integrity 6.2.1.2
F2	Seats in staff areas	Tested as an assembled product from upholstery, back and base shall side	R18	



Requirement R17 HL2 compliance

Short name of requirement set (used for)	Test method reference	Parameter Unit	Requirement Definition	HL1	HL2	HL3
R17 (F1)	T06 ISO 9705	MARHE KW	Maximum	75	50	20



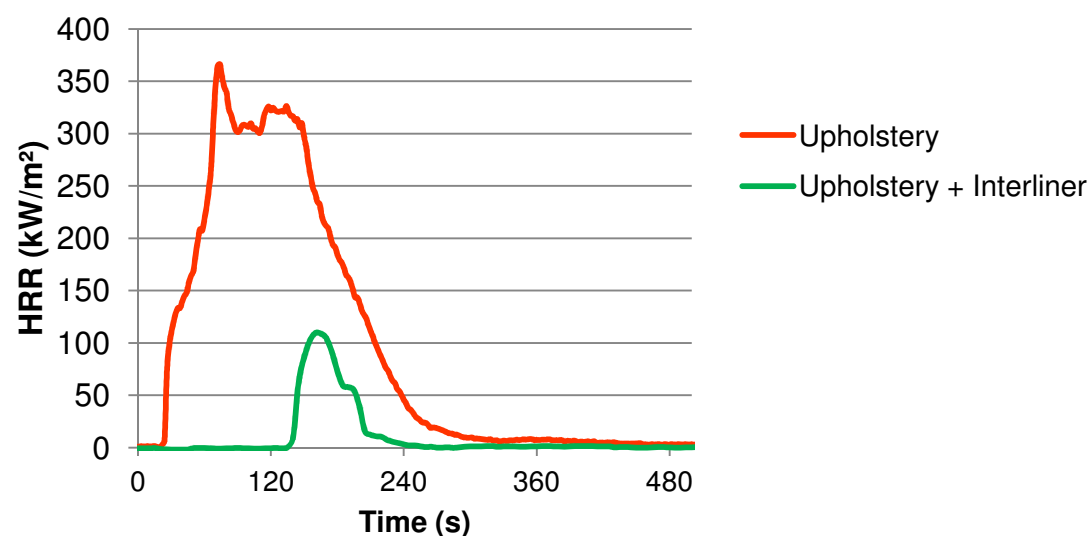
Requirement R20 HL2 compliance

Short name of requirement set (used for)	Test method reference	Parameter Unit	Requirement Definition	HL1	HL2	HL3
R20 (F1A; F3)	T03.02 ISO 5660-1: 25kWm ⁻²	MARHE kWm ⁻²	Maximum	75	50	50
	T10.03 EN ISO 5659-2: 25 kWm ⁻²	D _s max. dimensionless	Maximum	300	300	200
	T11.02 EN ISO 5659-2: 25 kWm ⁻²	CIT _G dimensionless	Maximum	1,2	0,9	0,75





	Upholstery	Upholstery + interliner (fire barrier)
Time to ignition (s)	17	128
peak HRR (kW / m ²)	367	109
MAHRE (kW / m²)	226	24



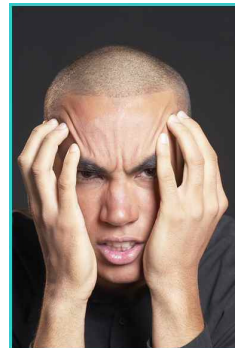
- ☐ Introduction
- ☐ CEN TS 45545- part 1
- ☐ CEN TS 45545- part 2
 - FIRST : fire assessmen
 - Case studies (inner wall, circuit breaker)
 - Complete seat test
- ☐ **Bold ideas**
 - **Key drivers**
 - Grouping rules
 - Assemblies
- ☐ Conclusion



- ❑ a homogeneous product meeting a requirement **at two different thicknesses** complies with the requirement by definition at all intermediate thicknesses;
- ❑ a test which qualifies any product or surface **shall also qualify any product or surface which differs only in colour.** A test which qualifies any product or surface shall also qualify any product or surface which differs only in the nature of the patterned surface;
- ❑ **interior and exterior coatings shall be tested in end use condition.** Where a coating is applied to aluminium or steel in the end use condition and where the thickness of the metal is greater than those defined in Table below it is sufficient to test the coating on the reference substrate defined in table below.
- ❑ Where a product has a continuous aluminium or steel surface in the end use condition and where the thickness of the metal is greater than defined in Table below, it is sufficient to test the product with the thickness given in Table below;

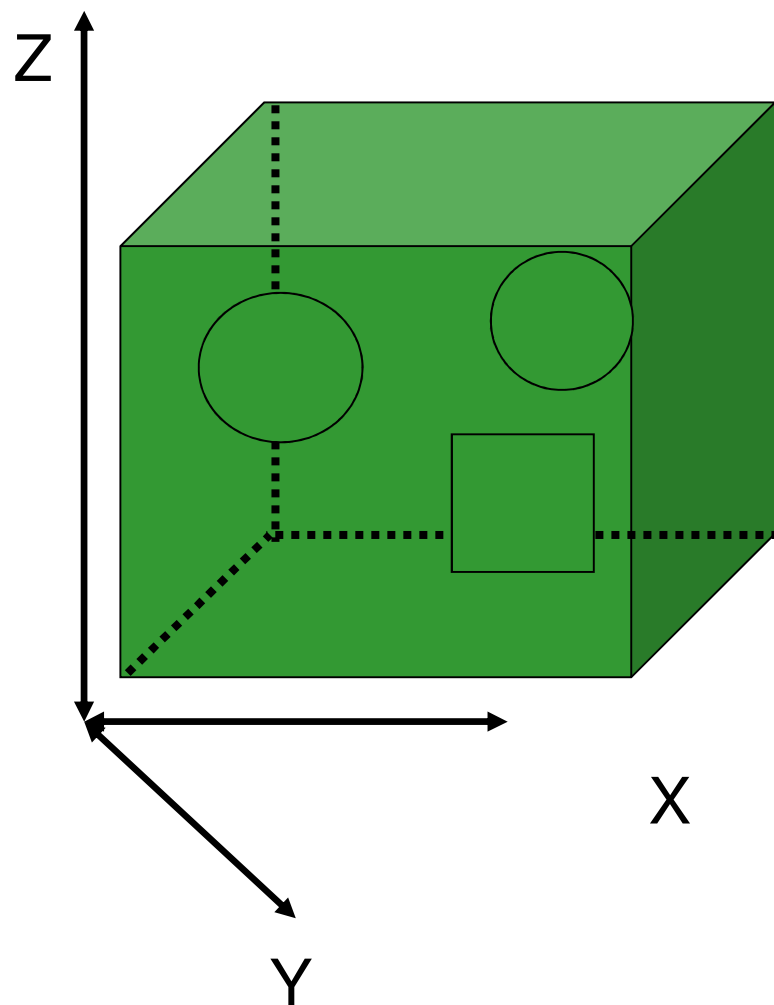
Nature	Nominal density [kg/m ³]	Thickness [mm]
Steel sheet	7 850 \pm 50	0,8 \pm 0,1
Aluminium sheet	2 700 \pm 50	1,0 \pm 0,2

- ☐ Introduction
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- ☐ CEN TS 45545- part 2
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 - Complete seat test
- ☐ **Bold ideas**
 - Key drivers
 - **Grouping rules**
 - Assemblies
- ☐ Conclusion

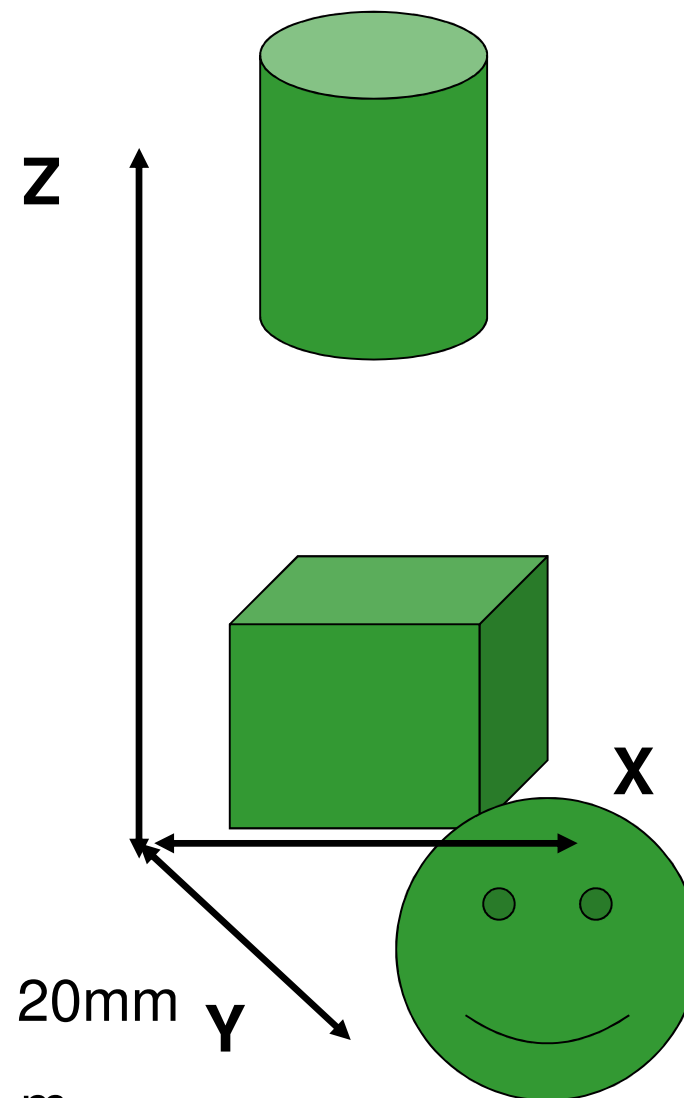


Exposed area	Location	Requirement set in Table 7
$> 0,20 \text{ m}^2$	interior	R1
$> 0,20 \text{ m}^2$	exterior	R6
$\leq 0,20 \text{ m}^2$	interior	R23
$\leq 0,20 \text{ m}^2$	exterior	R24

- ❑ Non-listed products shall be considered as grouped when
 - their horizontal distance from each other is less than 20 mm and
 - their vertical distance from each other is less than 200 mm.
 - the products are within a cubic space of side 200 mm.



$X=Y=Z=200\text{ mm}$



$X \text{ \& } Y < 20\text{ mm}$

$Z < 200\text{ m}$

- ☐ It is permitted to have up to 100 g of products with no requirements for each group.
- ☐ It is permitted to have up to 500 g of products that are compliant at least to the requirement R25 (LOI measurment) for each group.

- ☐ no requirements apply to non-listed products with a mass of **< 10 g not in touching** contact with another non-listed product with a mass < 10 g;
- ☐ non-listed products with a total exposed area **of $\leq 0,20$ m² shall be considered compliant** if they are **within the mass limits** as stated below when grouped together;
- ☐ non-listed products fully separated by a product compliant with the fire resistancy requirement (ex E15 I15) shall not be considered as grouped.

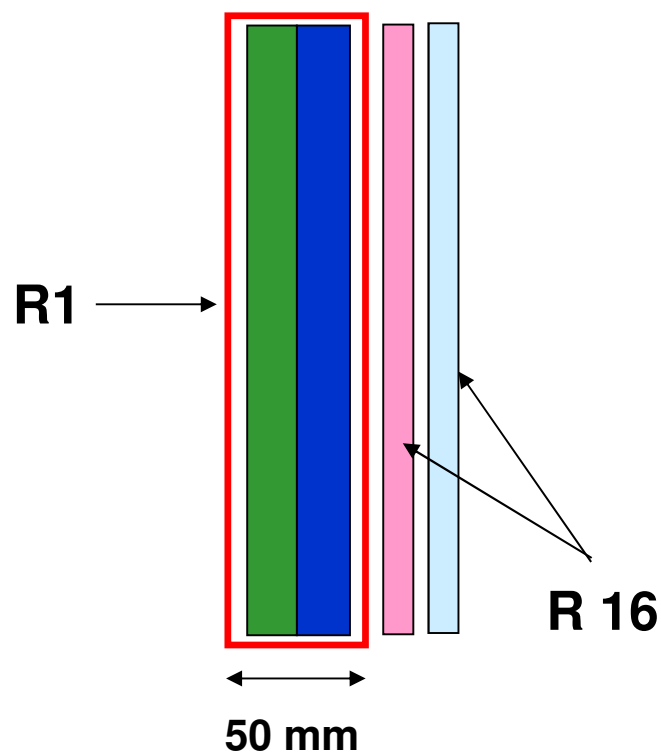
- ☐ Introduction
- ☐ CEN TS 45545- part 1
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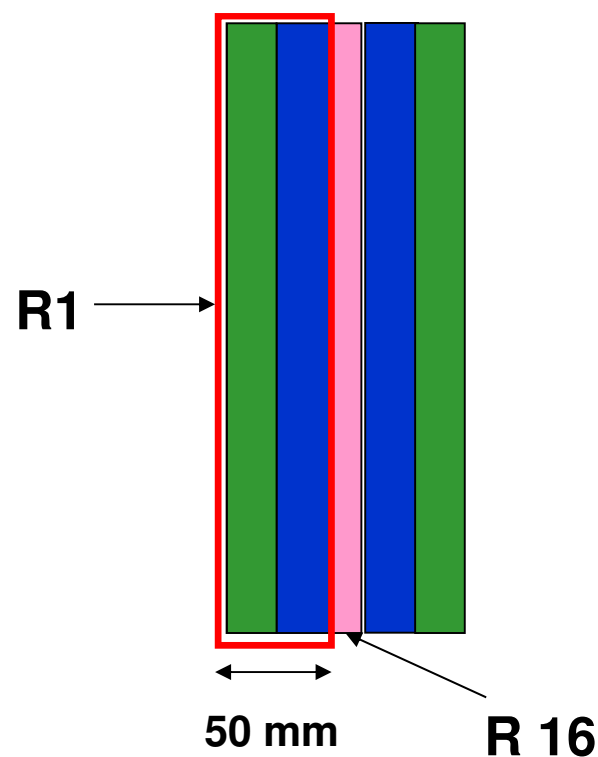
- ☐ Unit or structure composed of a combination of materials or products or both.
- ☐ **These shall be tested at their full thickness.** If the full thickness is greater than the maximum thickness that can be tested in the applicable standard, **then the thickness shall be reduced by cutting away the excess part from the rear face** of the sample that is from the face that is not exposed to the ignition source.
 - **ISO 5658-2 (lateral flame spread) : 50 mm**
- ☐ The exposed surface of the test specimen shall be the same as in the end use condition.

- Any material which is part of an assembly, but does not form part of all fire test pieces, shall be separately tested to the requirement set, R16.

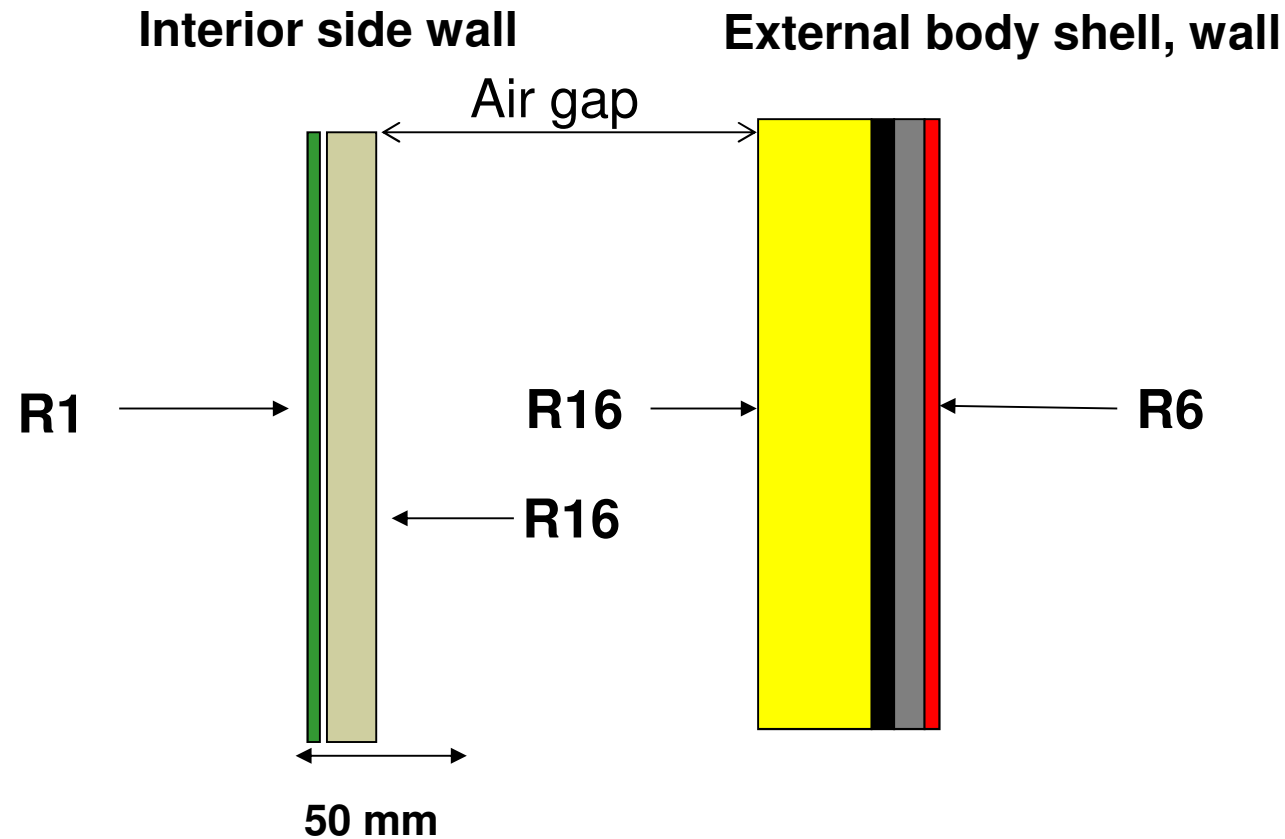
Interior side wall



Partition



- ❑ If there is an air gap, surfaces facing the air gap shall be tested to the requirement set, R16.



- ☐ Deployment by january 2009
 - Experimental standards (part 2)
- ☐ 3 years of co existence with the national regulations
 - BSS 6853 (United Kingdom)
 - NF F16-101&102 (France)
 - DIN 5510 (Germany)
 - UNI 11170 (Italia)
 - ...
- ☐ Then should be adopted after adjustments by 2012...



Questions ?

