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Work package 8.2:
Real scale tests on railway seats

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1 ABSTRACT

The aim of the FIRESTARR project is to support CEN TC 256 WG1 and CENELEC TC9X WG3 in the drafting of part 2 (requirements for the fire behaviour of materials and components) of a seven part European standard pr EN 45545 (ref. 3).
The programme includes a series of tests to evaluate in large and real scale the fire behaviour of a representative range of furniture products used on European trains.
As indicated by statistical research on fires in trains and the description of the most frequent fire scenario in railway vehicles determined by Work Package 1 (ref. 1), the seat represents the most dangerous part of the compartment; hence, seats are the only furniture product which will be evaluated in WP8.2.
This report describes the results of these real scale tests.

2 OBJECTIVES OF WP 8.2

The objectives of WP 8.2 are as follows:

I) To perform real scale tests on furniture products using the same materials as in WP 7.2 (ref. 10).
II) To demonstrate the fire behaviour of some critical or complete parts of a coach taking into account the most probable and realistic scenario so that it will permit to validate the predictions and proposals of the previous steps. This work will also serve to provide a second validation of the choice of small-scale test methods.
III) Ignitability, spread of flame, heat release, smoke generation and toxic gas species generation are evaluated as well as the tenability limits which are directly related to fire effects on passengers (heat, toxic gases, oxygen deprivation, loss of visibility, etc.)
IV) Completion of the data base for the analysis of results in WP10.

The real scale tests have been carried out taking into account the end-use conditions of materials in a carriage. This method was chosen to represent as close as possible the conditions described by the reference scenario of WP 1 (ref. 1).

Amongst the different categories and application areas of selected products, referenced as furniture products, the main ones include seats, curtains and bedding; only seats have been tested in real scale as the most dangerous part of the compartment and representing the most probable primary ignited item in the interior of railway vehicles.

In small scale tests (ref. 7) some assemblies were defined which are intended as a combination of a block of foam covered first with a piece of an interlayer and second with a piece of fabric.
From the indication of different railway companies and taking into account the list of furniture product selected in WP 2 (ref. 2) , the selected seats are intended to represent the corresponding full-size seats actually used in European trains.
These full size seats have been evaluated in real scale tests.

3 PARTICIPANTS

The following 5 partners were involved in working group 8.2:

LSF (leader)	ITALY
FS	ITALY
LNE	FRANCE
SNCF	FRANCE
WFRC	U.K

LSF carried out all the real-scale tests on seats.

4 DESCRIPTION OF PRODUCTS TESTED

The selection of the furniture products to be tested in WP8.2 was made by statistical analysis of small scale data (ref. 7) performed in WP5 (ref. 5) and included 13 combinations/assemblies and 2 single products; so they represent 15 different types of seat.
A maximum of 8 seats has been selected using the Principal Component Analysis and Hierarchical Clustering Analysis technique for deleting outliers specimen, to judge the repeatability of several tests, to observe the correlation between small scale parameters according to the different Fire Critical Effects.
This product selection has permitted the comparison of the test methods and the discrimination of products.
The complete list of assemblies evaluated in small scale tests is described in the WP2 report (ref. 2) and the WP4.2 report (ref. 7).
The list of 8 seats tested in WP8.2 which represent the real full size products of combinations listed in WP 4 is as follows:

C01
C02
C03
C04
C05
C07
C08
C09

Full and detailed descriptions of the seats tested are given in Annex 1.

5 DESCRIPTION OF TEST METHOD AND CONDITIONS USED

Concerning the furniture products, as well as for structural materials, only one method and procedure was selected for use in Working Programme 8.2, that is the Train Compartment test (ref. 4).

5.1 Train Compartment test

5.1.1 Testing enclosure

Looking to the WP1 conclusion (ref. 1), a railway carriage Voiture VU78 with 11 compartments served by a side corridor was identified by SNCF and reproduced in the laboratory.
The compartment normally would contain eight seats with all the specifications concerning structural dimensions being well described in the WP3.2 part 2 report (ref. 4).
Moreover, it may be assumed to have a volume of approximately $9m^3$ and so be comparable to the small compartment size of $<10m^3$, which CEN/TC 256 JWG specified in their materials requirements document pr EN 45545 Part 2 (ref. 3).
The ventilation conditions in the Voiture VU78 compartment were precisely defined by SNCF and are also explained in the WP 3.2 part 2 report (ref. 4).
The compartment was sited underneath the standard ISO 9705 hood/duct system (ref. 9) and the same measurement system for fire effluents was applied to these WP8.2 test conditions.
During all the tests the flow rate in the exhaust duct system was fixed at 3.5 m^3/s.
A schematic of the apparatus for this compartment test is shown in Fig 1.

5.1.2 Procedure

Two seats were placed edge to edge inside the compartment and positioned on the right wall in the corner next to the window.
According to the fire scenario, the real and worst fire source, represented by 100g of paper cushion, is reproduced by FIRESTARR Burner "A" (see WP 3.2 part 2 report – ref. 4).
This source was applied first on seats in the corner for three minutes with the door closed and after that the burner was removed and the door opened.This in order to simulate a passenger leaving the compartment after identifying that fire occurred.
A second seat was placed by the side of the first one.

For simulating the different and most probable real situations with the seats positioned in a train compartment, 3 different stages have been defined. These are intended to reproduce the effect of a burning seat on adjacent seats:
Stage1: The seat that will be ignited is not vandalised (VL=0). The objective is to observe if there is a flame spread to the adjacent seat and facing seat measuring all reaction to fire parameters which may be related to the identified risks.
Stage2: The seat that will be ignited is vandalised (VL=2). The objective is the same as the first stage.
Stage3: The seat that will be ignited is vandalised (VL=2). The objective is to observe if there is a flame spread to the adjacent seat and the effect to the back side of a third seat placed before the first one with the same sense of direction. All reaction to fire parameters that may be related to the identified risks are measured.

An additional Stage4 was included in this procedure only for testing the combination C08 and C09 because their structural frame was the same and permitted only a different configuration of mounted seats. In this case the seats were placed as a sofa in the centre of the compartment and positioned and oriented in opposite directions with the same frame so that their seat-backs are in contact.
See the different stages scheme 1, 2 3 and 4 as illustrated below.

The procedure is intended to assess the ignitability, heat release, spread of flame, smoke opacity and toxic gases when the door is initially closed and subsequently (after 3 minutes) opened for simulating as close as possible the two main stages of a real small compartment fire scenario (limited and full ventilation).
For the determination of toxic gas species, one sampling probe is placed inside the compartment at the door position and at nose level. A second one is placed along the exhaust duct, so that it is possible to determine the toxicity hazard generated by fire smoke and to compare the results on analysis of effluents coming from the different sampling points.
In both cases the toxic gas species were detected and quantified by the FTIR Technique following the specifications and requirements coming from the SAFIR project (ref. 8).
For estimating the flow of the gases out of the door the equation defined by Rocket was used (ref. 11).
A detailed description of technical aspects about toxicity measurements is given in the WP3.4 Part 2 Report (ref. 6). A new “ad hoc” protocol was developed for FIRESTARR project requirements and so it was used for WP 8.2 testing (ref. 4).
An overview scheme of testing devices in the $9m^3$ room is shown in fig. 2.

6 TEST RESULTS

For the identification of FIRST parameters in relation to Fire Critical Effects and the determination of tenability limits, the results were grouped into 4 “main” families of data as was done for small and large scale tests:-

- Ease of ignition
- Fire Growth
- Loss of visibility
- Toxicity of smoke

These families include the following measurement:

- **Ease of ignition :**

Ign	Ignition [(1)] (yes/not),
t ign	time to reach the Ignition (s).

- **Fire Growth :**

HRR_{peak}	Heat release rate peak (kW),
t HRR_{peak}	time to Heat release rate peak (s),
THR	Total Heat released (MJ),
δm	Percentage of Total mass loss of ignited seat (%),

- **Loss of visibility :**

RSP_{peak}	Rate of Smoke Production peak (m^2/s),
t RSP_{peak}	time to Rate of Smoke Production peak (s)
TSP	Total production of light obstruction smoke (m^2)

- **Toxicity of smoke :**

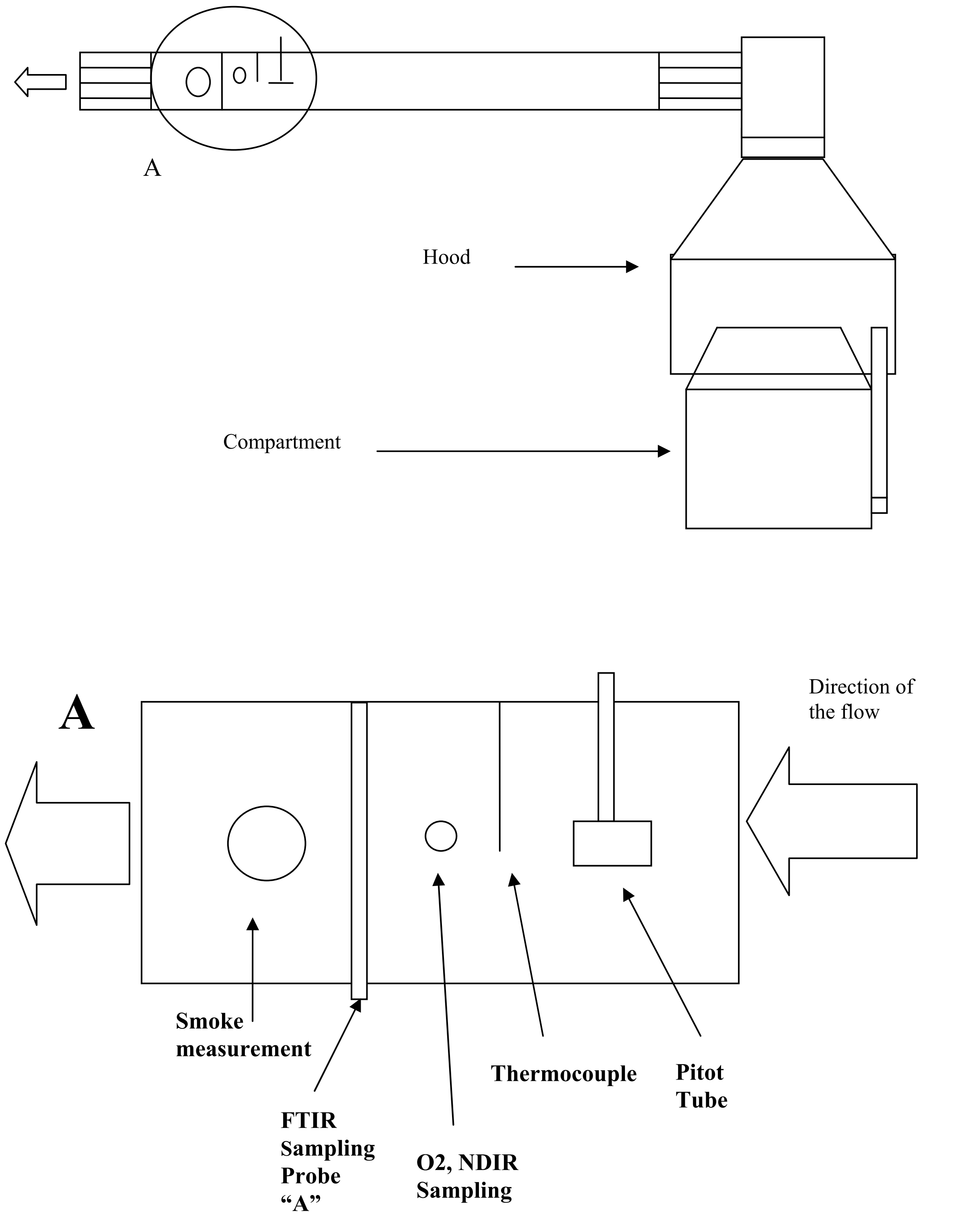
TQ	Total amount of gas produced in Duct and Door (g).

The test results for the 8 products examined in WP 8.2 are summarised in Tables 1, 2, 3, 4 and 5. The vector data on heat released and smoke production from these tests is shown in Annex 2 and parameter/information sheets in Annex 3.

[1] Ignition of the seat is indicated when the Heat release peak reach at least the value of 30 kW excluding the burner contribution, as established in Large scale tests (WP 7.2).

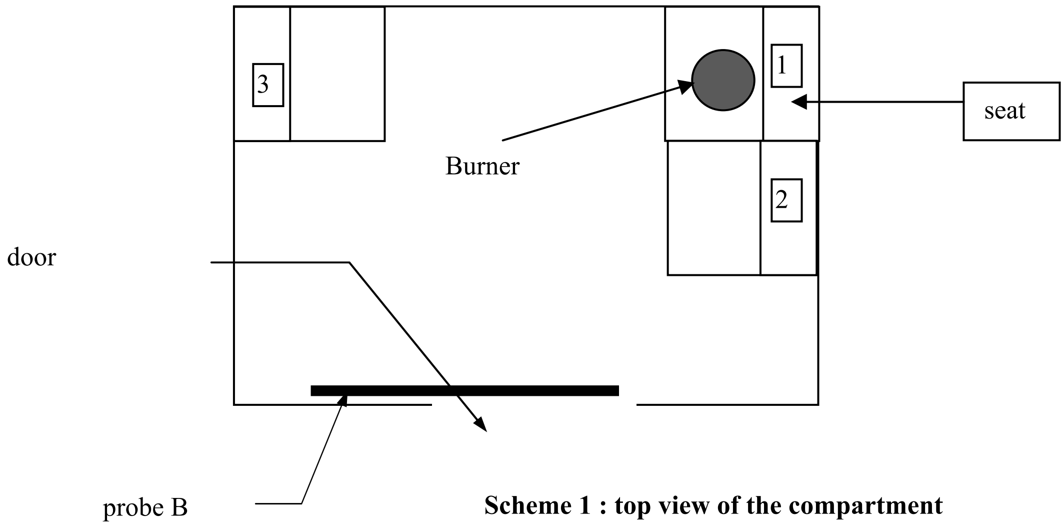
FIGURE 1

Scheme of test and set-up of measurement systems in ISO 9705 exhaust duct:



↳ stage 1 (see scheme 1) :

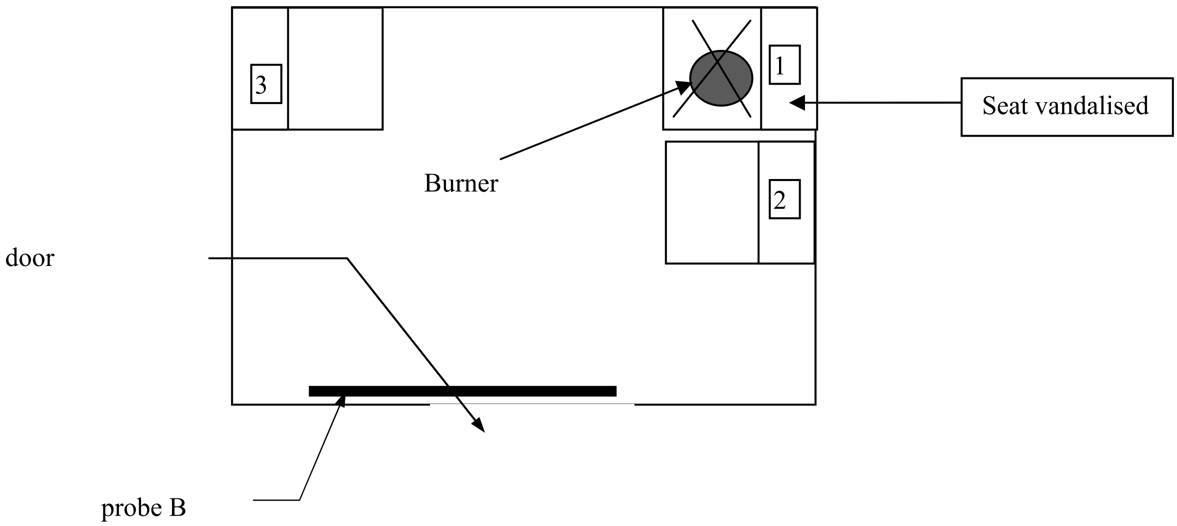
→ 3 seats not vandalised in the compartment, (see scheme 1)
→ toxic gas analysis in the exhaust duct : probe A
→ Toxic gas analysis at nose level in the door opening : Probe B
→ measurements and observation on the test



Scheme 1 : top view of the compartment

↳ stage 2 : (see scheme 2)

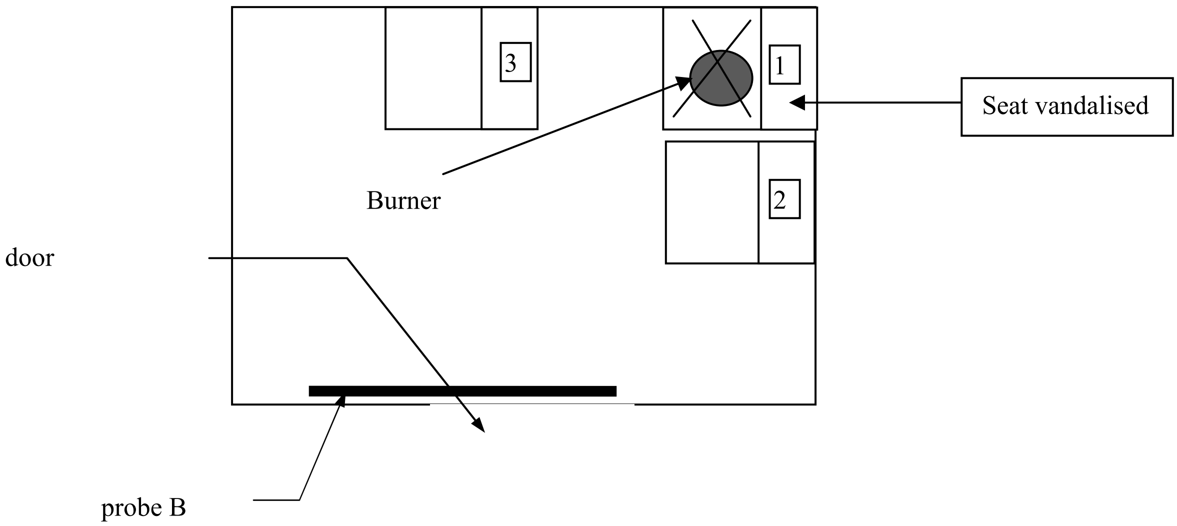
→ 3 seats with one vandalised (n°1) in the compartment
→ toxic gas analysis in the exhaust duct : probe A
→ Toxic gas analysis at nose level in the door opening : Probe B
→ measurements and observation on the test



Scheme 2 : top view of the compartment

↳ stage 3 : (see scheme 3)

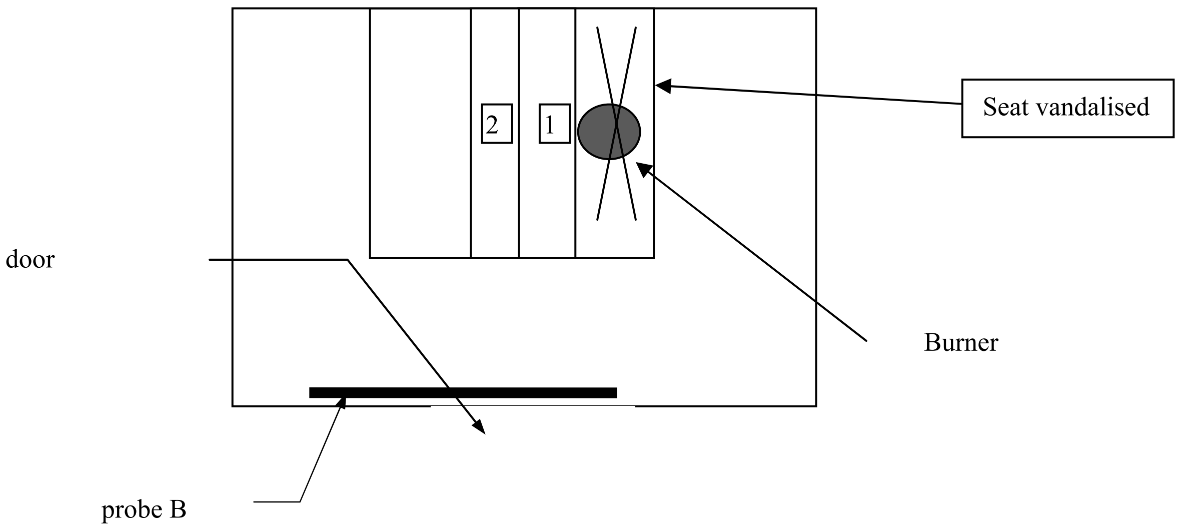
- → 3 seats with one vandalised (n°1) in the compartment
- → toxic gas analysis in the exhaust duct : probe A
- → Toxic gas analysis at nose level in the door opening : Probe B
- → measurements and observation on the test



Scheme 3 : top view of the compartment

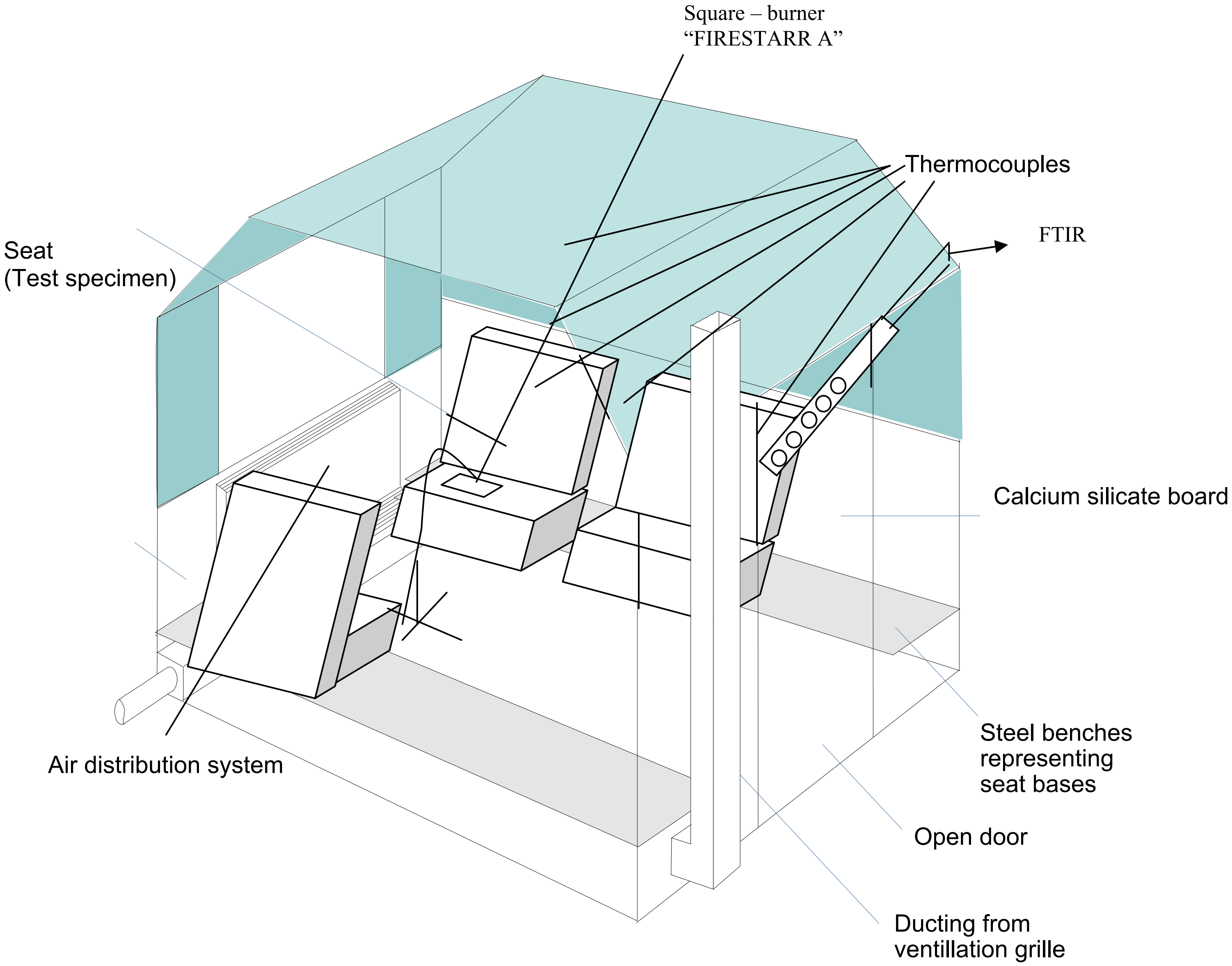
↳ stage 4 : (see scheme 4)

- → 2 seats as sofa configuration with one vandalised (n°1) in the compartment
- → toxic gas analysis in the exhaust duct : probe A
- → Toxic gas analysis at nose level in the door opening : Probe B
- → measurements and observation on the test



Scheme 4 : top view of the compartment

FIGURE 2



Square – burner
"FIRESTARR A"
Thermocouples
FTIR
Seat
(Test specimen)
Calcium silicate board
Steel benches
representing
seat bases
Air distribution system
Open door
Ducting from
ventillation grille

6.1 Tables of results

TABLE 1 : EASE OF IGNITION

Combination nr.	Stage nr.	Ignition(1) (yes / no)	Time to reach the Ignition (1) (s)
C01	1	No	NR
	2	Yes	205
	3	Yes	195
C02	1	Yes	245
	2	Yes	150
	3	Yes	135
C03	1	Yes	240
	2	Yes	140
C04	1	No	NR
	2	Yes	130
	3	Yes	150
C05	1	No	NR
	2	Yes	220
C07	1	No	NR
	2	Yes	200
C08	1	Yes	255
	2	No	NR
	4	Yes	205
C09	1	Yes	245
	2	Yes	205
	4	Yes	240

NR: Not reached

TABLE 2: FIRE GROWTH

Combination nr.	Stage nr.	HRR_{peak} (2) (kW)	Time to HRR_{peak} (2) (s)	THR (MJ)	δm* (%)
C01	1	28.6	230	4.3	0.9
	2	214.2	250	24.5	10.8
	3	231.0	230	27.8	12.0
C02	1	327.6	880	87.7	16.8
	2	321.8	325	197.1	18.8
	3	317.5	255	108.2	16.8
C03	1	40.5	255	1.7	0.7
	2	341.8	365	85.0	21.1
C04	1	29.6	260	2.8	0.2
	2	229.5	370	97.8	25.1
	3	249.4	325	79.7	25.1
C05	1	20.3	260	4.6	1.0
	2	273.4	715	80.2	25.8
C07	1	23.6	235	1.3	5.1
	2	222.8	465	78.3	25.6
C08	1	35.2	270	4.0	1.2
	2	29.0	480	1.6	0.7
	4	67.0	210	3.2	
C09	1	80.3	260	4.6	1.7
	2	91.9	215	5.3	1.1
	4	37.6	250	2.1	

(2) : All Heat release data are reported excluding the burner contribution.
(*) : Ignited seat, Percentuage of mass loss.

TABLE 3: LOSS OF VISIBILITY

Combination nr.	Stage nr.	RSP_{peak} (m^2/s)	Time to RSP_{peak} (s)	TSP (m^2)
C01	1	0.74	195	53
	2	5.30	215	1196
	3	7.44	200	1229
C02	1	7.41	860	2381
	2	7.97	300	6928
	3	11.16	195	2508
C03	1	3.77	220	241
	2	11.38	340	2855
C04	1	0.14	225	16
	2	3.45	240	1481
	3	4.09	285	1312
C05	1	0.21	225	30
	2	5.80	605	1706
C07	1	1.67	200	162
	2	11.06	200	4055
C08	1	1.03	235	61
	2	0.92	445	53
	4	1.63	185	51
C09	1	2.32	225	150
	2	2.65	185	73
	4	1.16	220	80

TABLE 4 : TOXICITY OF SMOKE

Quantitative analysis of toxic gases measured by FTIR in the dorr and duct sampling points.

Combination nr.	Stage nr.	CO		CO_2		HCN		HCl		HBr		SO_2		NOx		C_3H_4O		HCOH	
		Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g	Door TQ g	Duct TQ g
C01	1	0.207	2.938	22.197	142.171	0.042	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	33.143	167.473	1753.847	1898.914	9.029	6.484	20.066	0.017	0.003	0.0003	16.252	19.109	ND	ND	ND	ND	ND	ND
	3	32.396	157.836	1270.497	1689.593	7.423	9.838	10.668	0.013	0.004	0.0004	13.125	30.075	ND	ND	ND	ND	ND	ND
C02	1	61.890	321.215	3613.866	4559.867	27.281	19.169	229.466	120.045	0.001	0.0002	41.851	66.624	15.599	ND	ND	ND	ND	ND
	2	110.425	570.329	4648.082	8724.264	38.597	25.873	459.563	183.026	0.002	0.0004	62.691	118.034	35.717	ND	ND	ND	ND	ND
	3	55.233	442.060	2099.203	5990.303	33.655	27.764	263.778	221.066	0.004	0.0005	47.722	113.649	34.729	ND	ND	ND	ND	ND
C03	1	0.384	19.725	21.072	188.480	0.058	ND	2.357	45.715	ND	0.0004	0.279	ND	0.156	ND	ND	ND	ND	ND
	2	79.446	452.738	1654.588	4600.180	18.548	23.113	390.354	291.465	0.002	0.0005	20.738	ND	10.555	ND	ND	ND	ND	ND
C04	1	0.004	0.664	55.439	110.452	0.022	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	86.048	255.793	3604.823	4533.893	15.145	12.260	48.952	0.013	0.003	0.0003	41.216	ND	28.587	ND	ND	ND	ND	ND
	3	67.719	230.128	2444.015	4193.774	13.298	10.115	74.645	0.020	0.003	0.0004	33.329	ND	34.243	ND	ND	ND	ND	ND
C05	1	0.045	0.474	6.429	134.229	0.046	ND	0.129	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	44.500	214.340	1591.155	3086.658	18.556	29.256	42.488	61.405	0.004	0.0005	17.915	52.167	18.138	ND	ND	ND	ND	ND
C07	1	0.208	5.503	9.362	66.137	0.020	ND	0.468	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	78.818	451.452	1973.863	3574.720	27.368	28.647	193.379	110.785	0.0064	0.0005	31.500	ND	ND	ND	ND	ND	ND	ND
C08	1	0.057	4.346	29.978	121.397	0.049	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	0.156	0.970	27.516	100.057	0.125	ND	0.0018	ND	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4	0.145	0.689	82.473	126.424	0.108	ND	0.0015	ND	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
C09	1	0.189	1.372	153.214	155.880	0.203	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	0.151	0.496	44.245	131.266	0.125	ND	0.0033	ND	0.0002	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4	0.052	0.174	33.760	109.786	0.037	ND	0.0014	ND	0.0001	ND	ND	ND	ND	ND	ND	ND	ND	ND

TQ : Total amount (quantity) of gas produced ; **ND** : No detected or below the minimum detection limits.

7 Conclusions

In not-vandalised condition the ignitability results show that half of seats have reached the ignition and for ignited seats the differences between "time to reach the ignition" data do not seems to discriminate them.
In stage 2 configuration we have only one seat which is not ignited and for other items, the results in terms of "time to reach the ignition" can be divided in two levels: around 140s (during the ignition period) and around 210s (after 30s the burner has been removed).
In stage 3 and 4 the behaviour of stage 2 is confirmed because the ignition conditions are exactly the same and different configurations have not influence in the first phase of fire.

Fire growth results show that for stage 1, taking into account only ignited seats, the HRR peak values are for two combinations just more than 30 kW (established ignition level), one give about 80 kW and one around 330 kW. Their times to reach the peak are comprised between 4 and 5 minutes for the first three cases above and above 10 minutes for the last one.
These differences are found again for THR and δm data which point out for C02 seat higher values and so a longer combustion time comparing with C03, C08 and C09 .
Some anoumalous results are given by THR data: for example, C01 that is not ignited has a value higher than C03 that is ignited.
The analysis of stages 2, 3 and 4 behaviours for ignited seats shows similar results: concerning HRR peak values, one seat doesn't reach 100kW, 3 seats give results comprised between 200 and 300 kW and 3 seats are over 300 kW; looking to "time to HRR peak" data, 2 combinations give results between 200 and 300s, 3 seats between 300 and 400s and 2 seats over 400s.
Some differences between stages 2, 3 and 4 are obtained by C02 and C08, where the times to reach the HRR peak are substantially lower in stages 3 and 4 than in stage 2.
THR data give three different ranges of performance: ones less than 30 MJ (C01, C08, C09), ones between 75 and 100 MJ (C03, C04, C05, C07) and ones more than 100 MJ (C02) which give a very different behaviour in the stages 2 and 3.
For δm parameter three main groups of results are identified: the first one is less than 2% (C08 and C08), the second one is between 10 and 20 % (C01 and C02) and third one is more than 20% of mass lost (C03, C04, C05, C07).

Concerning "loss of visibility" results for not-vandalised seat (stage 1), the RSP peak gives three different ranges: < 1 m^2/s (C01, C04, C05), 1 to 5 m^2/s (C03, C07, C08, C09), > 5 m^2/s (C02).
The time to RSP peak data are not discriminating the smoke results for stage 1 (all around 220s) except C02 seat which give 860s. The total smoke produced parameter identify three ranges of performance: ones less than 100 m^2 (C01, C04, C05, C08), another one between 100 and 1000 m^2 (C03, C07, C09) and more than 1000 m^2 (C02).
In stages 2, 3 and 4 RSP parameter gives three level of data: C04, C08 and C09 are below 5 m^2/s; C01, C02 (stage2) and C05 are between 5 and 10 m^2/s; C02 (stage3), C03 and C07 gives values more than 10 m^2/s. The times to reach the RSP peak are all around 200s except C02 (stage 2), C03, C04 (stage 3) which are near 300s and C05 and C08 (stage 2) over 400 s.
The TSP stratification identify a group of seats which produce values less than 2000 m^2 (C01, C04, C05, C08, C09), C02 (stage 3) and C03 which gives data less than 4000 m^2, the worst behaviour by C02 (stage 2) and C07 which produce TSP > 4000 m^2. Anyway, it is necessary to put in evidence that C08 and C09 seats gives a very low amount of smoke in comparison with others.

The analysis of parameters is made looking exclusively the experimental results with the aim to verify the possibility of stratification for identifying different performance levels.
Anyway the definition of a new classification system based on small or large scale tests will take into account only the significant parameters which are linked with fire critical effects and identified by statistical analysis (WP5).

8 REFERENCES

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6. Firestarr WP3/LNE/00003: Work package 3.4 Part 2 report – Selection of test methods for toxicity evaluation in large and real scale

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8. SAFIR Final report: 1999 Smoke gas analysis by Fourier transform infrared spectroscopy

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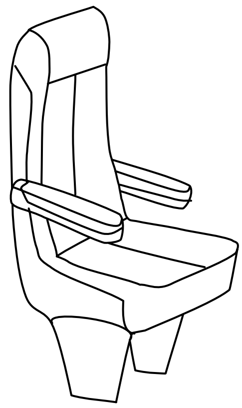
11. D.Drysdale, An Indroduction to Fire Dynamics, John Wiley and Sons Ltd, UK (1994), p. 291

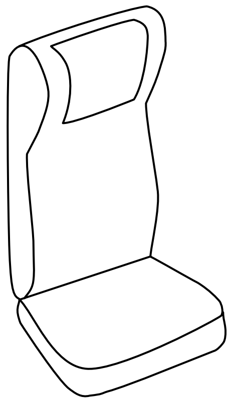
ANNEX 1 : Description of seats tested

Description of the seats tested in WP 8.2:



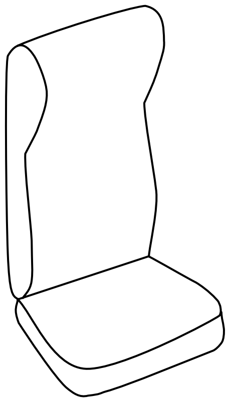
Seat “C01”

	Colour	Thickness (mm)	Density
Fabric	Blue with light blue vertical lines and sometimes a short light green horizontal line	1.5 mm	700g/m^2 fabric+interliner glued 550g/m^2 fabric and glue
Foam	Very light yellow	Seat+back max 9 cm	0.07g/cm^3
Interliner	Gray-green cloth (glued to fabric)	0.5 mm	150g/m^2
Under the seat	White plastic with large mesh	0.6 mm	575g/m^2
Shell	metallic		



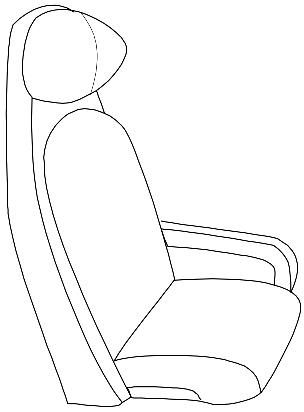
Seat “C02”

	Colour	Thickness (mm)	Density
Fabric	Pink and purple, diagonal lines (~45°), width ~3 mm	1.0 mm	450g/m^2
Foam	Yellow with outside more orange	Seat: max 10 cm Back: max 8 cm	Seat: 0.12g/cm^3 Back: 0.13g/cm^3
Interliner	Large white mesh tied to the foam	0.8 mm	320g/m^2
Under the seat	White plastic with large mesh	0.6 mm	575g/m^2
Shell	metallic		



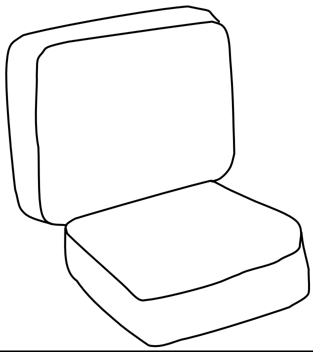
Seat “C03”

	Colour	Thickness (mm	Density
Fabric	Light brown false skin	0.8 mm	710g/m^2
Foam	Yellow	Seat: max 11 cm Back: max 7 cm Behind the back: max 3 cm	Seat+back: 0.10g/cm^3 Behind the back: 0.18g/cm^3
Interliner	Large white mesh, tied to the foam	0.9 mm	Seat (glue): 275g/m^2 Back (glue): 475g/m^2
Under the seat	White plastic with large mesh, tied to the foam	0.7 mm	550g/m^2
Shell	metallic		



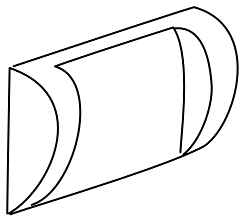
Seat “C04”

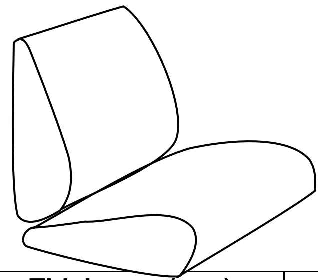
	Colour	Thickness (mm)	Density
Fabric	Blue with random green lines (hard to cut)	1.7 mm	9.5g/m^2
Foam	Light yellow. Metallic structure inside		Impossible to establish
Interliner	Grey cloth (glued to foam)		
Shell	metallic		



Seat “C05”

	Colour	Thickness (mm)	Density
Fabric	Orange with lighter vertical lines	3.4 – 1.1 mm	600g/m^2
Foam	White – light yellow	Seat: max 9.5 Back: max 13.0	0.18g/cm^3
Interliner	Seat: black cloth (glued to fabric) Back: nothing	Seat: 4 mm	Seat: 240g/m^2
Shell	Metallic under the seat and 2mm plastic board under the back		





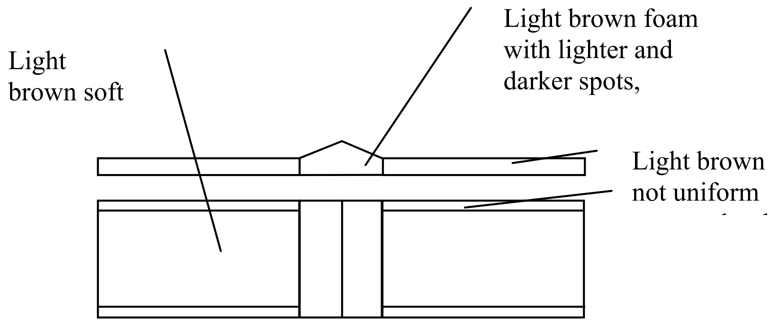
Seat “C07”

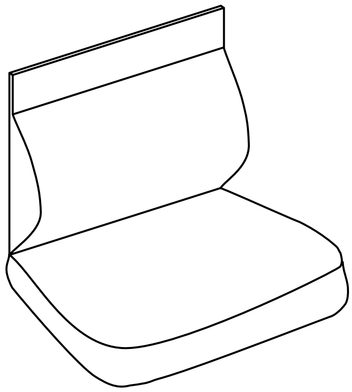
	Colour	**Thickness (mm)**	**Density**
Fabric	Dark brown false skin	1.2 mm	875g/m^2
Foam	Seat: white Back: yellow	Seat: max 13 cm Back: max 8 cm	Seat: 0.12g/cm^3 Back: 0.09g/cm^3
Interliner	Seat: grey-green felt with lighter and darker spots glued to foam Back: white glued to foam	Seat: 2.0 mm Back: 5.0 – 2.25 cm	Seat: 710g/m^2 Back: 1190g/m^2

Arm	Dark brown false skin (no interliner) Foam: White – light yellow	Fabric: 1.2 mm	Fabric: 875g/m^2 Foam: 0.19g/cm
Headrest	Dark brown false skin (no interliner) Foam: White – light yellow	Fabric: 1.2 mm	Fabric: 875g/m^2 Foam: 0.14g/cm^3
Shell	metallic		

Light brown foam with lighter and darker spots, harder 0.74g/cm^3
Light brown not uniform foam, harder 0.25g/cm^3

Seat “C08” / “C09”





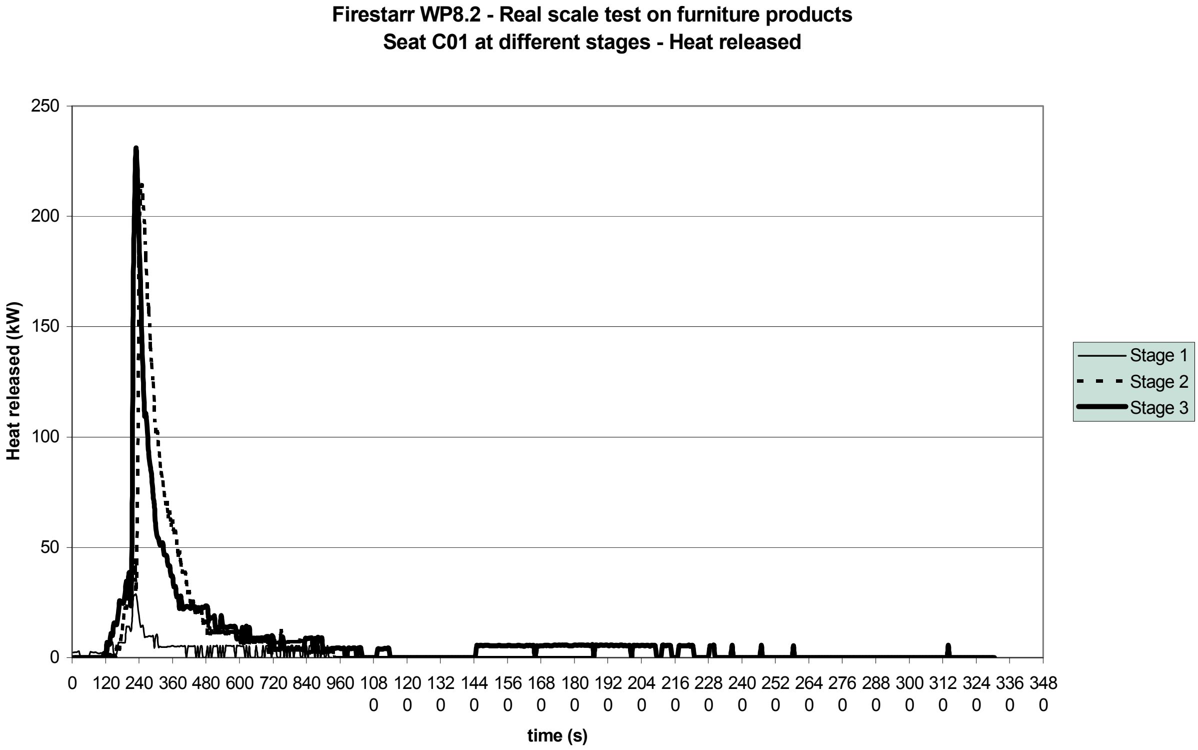
Seat “C08”

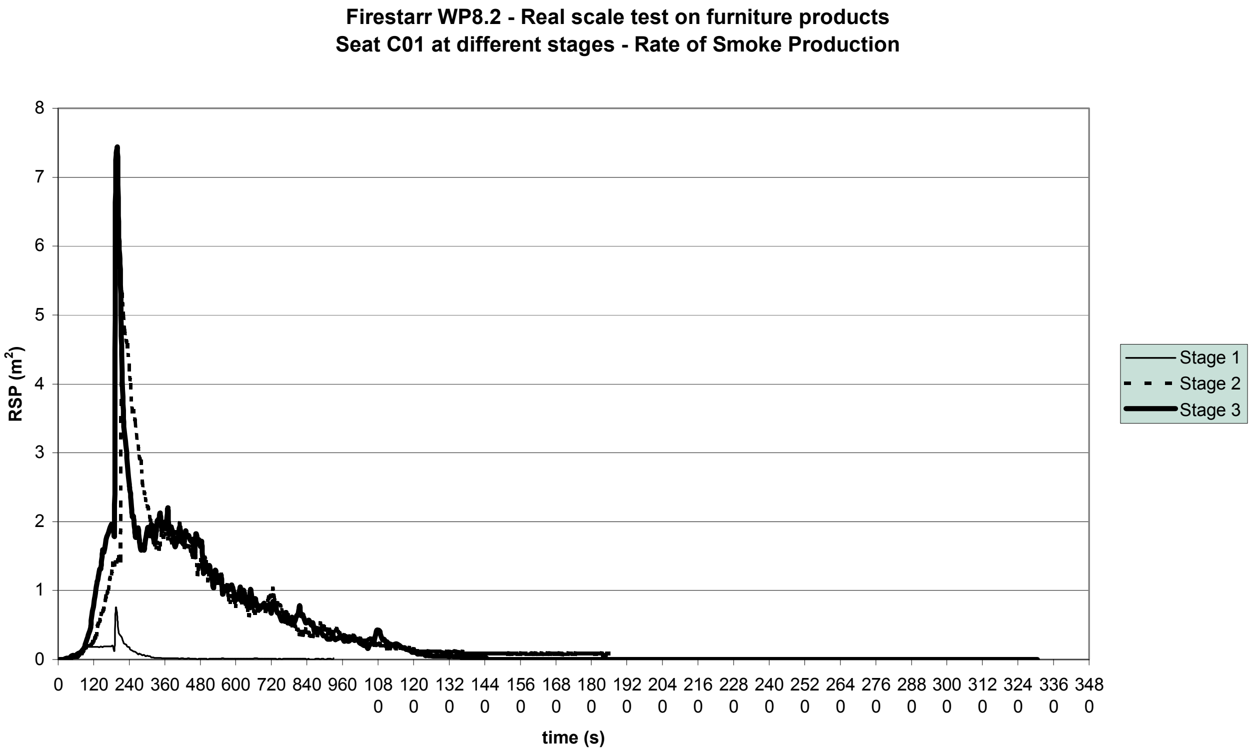
	Colour	Thickness (mm)	Density
Fabric	Pink velvet with diagonal blue lines	1.1 mm	380g/m^2
Foam	Seat+back: grey Upper part of the back: black.	Seat: max 12 cm Back: max 11 cm Upper part of the back:13 mm	Seat+back:0.09g /cm^3 Upper part of the back: 0.07g/cm^3
Interliner	Nothing		
Headrest	Fabric: grey plastic with diagonal lines of pink dots Foam: light brown soft	Fabric: 0.9 mm Foam: 3 cm	Fabric: 800g/m^2 Foam: 0.14g/cm^3
Shell	Plywood		

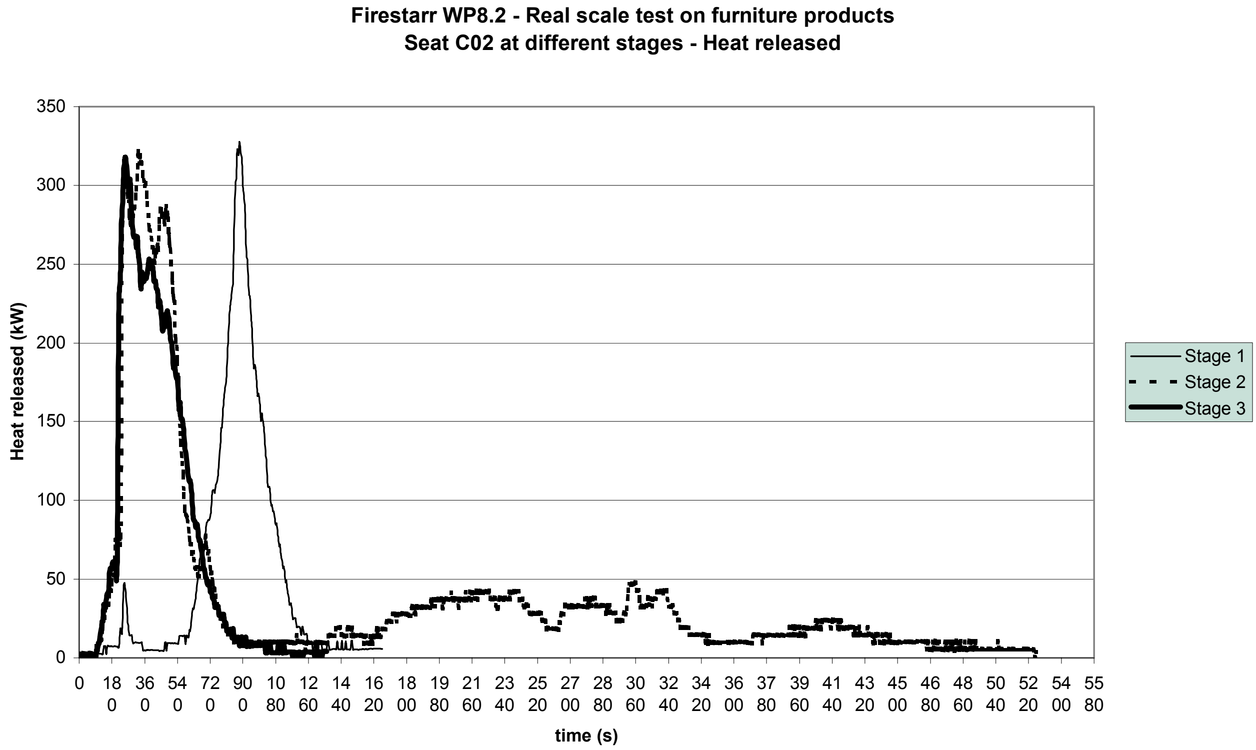
Seat “C09”

	Colour	Thickness (mm)	Density
Fabric	Blue velvet with yellow, green, violet and orange dots		550g/m^2
Foam	Grey	Seat: 11-12 cm Back: 11 cm	0.09g/cm^3
Interliner	nothing		
Headrest	Fabric: dark grey plastic Foam: light brown soft	Fabric: 0.9 mm Foam: 3 cm	Fabric: 800g/m^2 Foam: 0.14g/cm^3
Shell	Plywood		

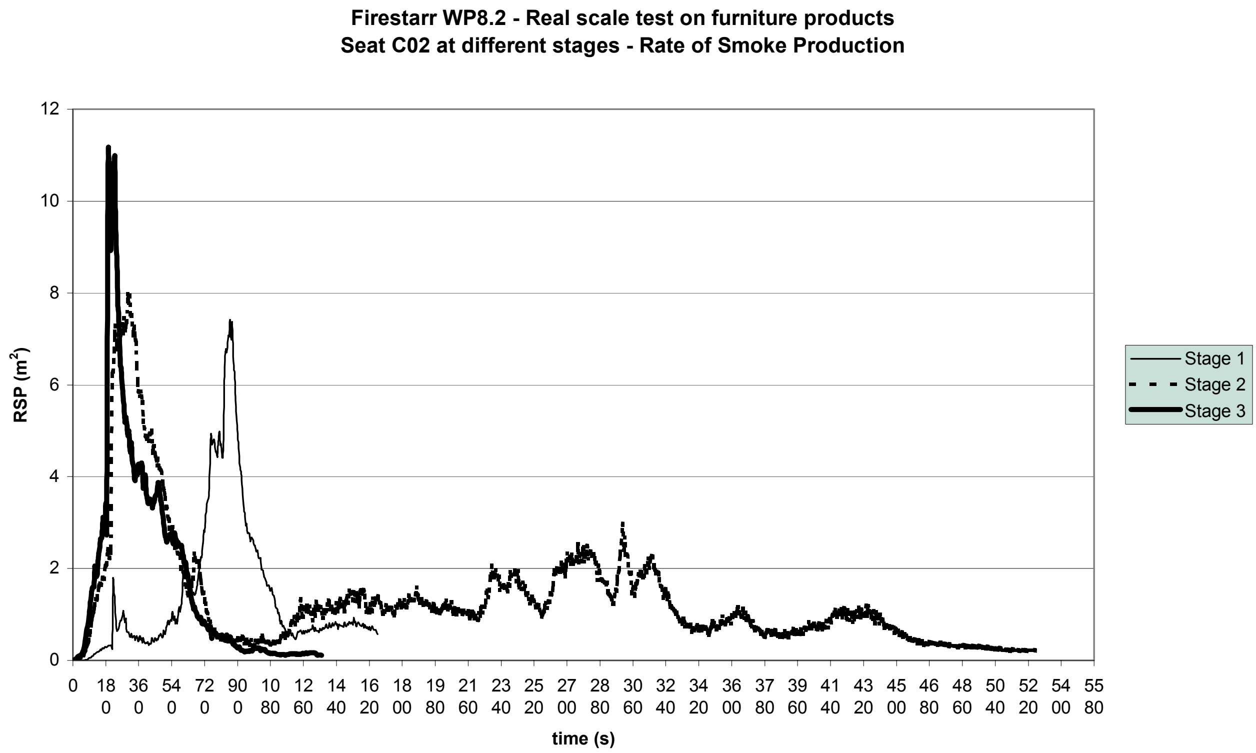
ANNEX 2 : Vector data on heat released and smoke production


Firestarr WP8.2 - Real scale test on furniture products
Seat C01 at different stages - Heat released
Heat released (kW)
time (s)
Stage 1
Stage 2
Stage 3

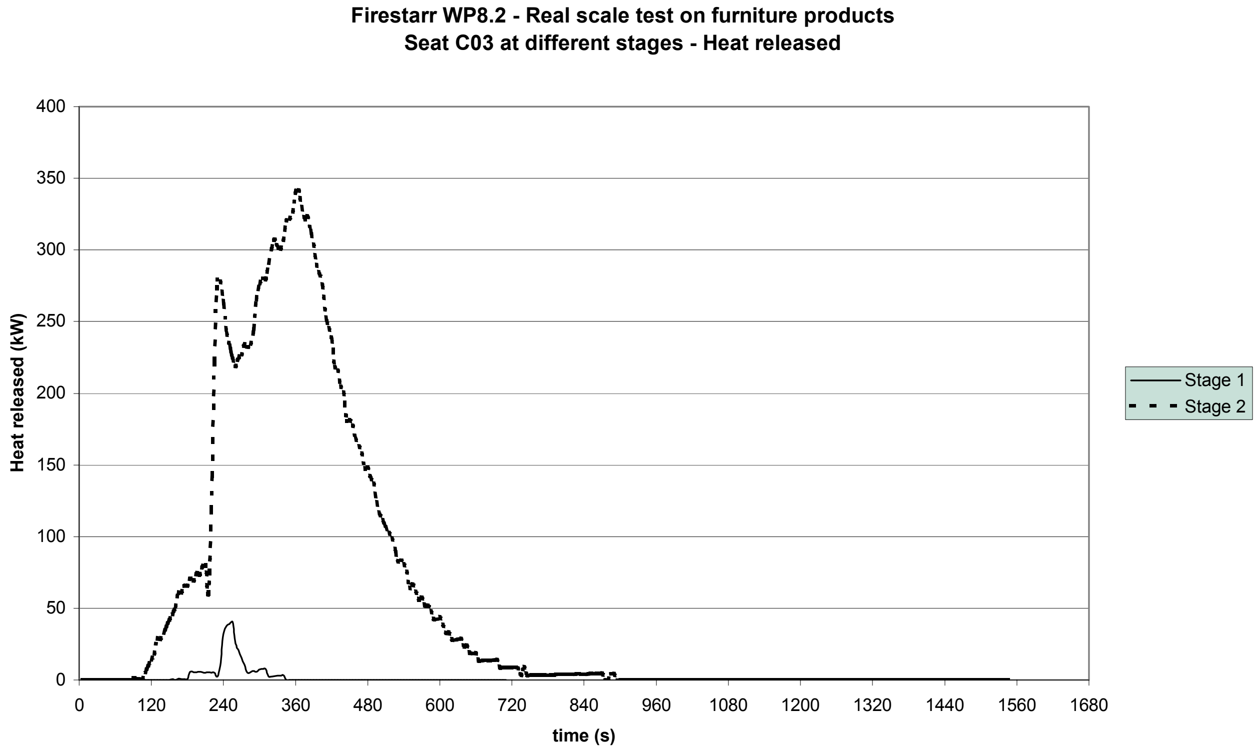

Firestarr WP8.2 - Real scale test on furniture products
Seat C01 at different stages - Rate of Smoke Production
RSP (m2)
time (s)
Stage 1
Stage 2
Stage 3

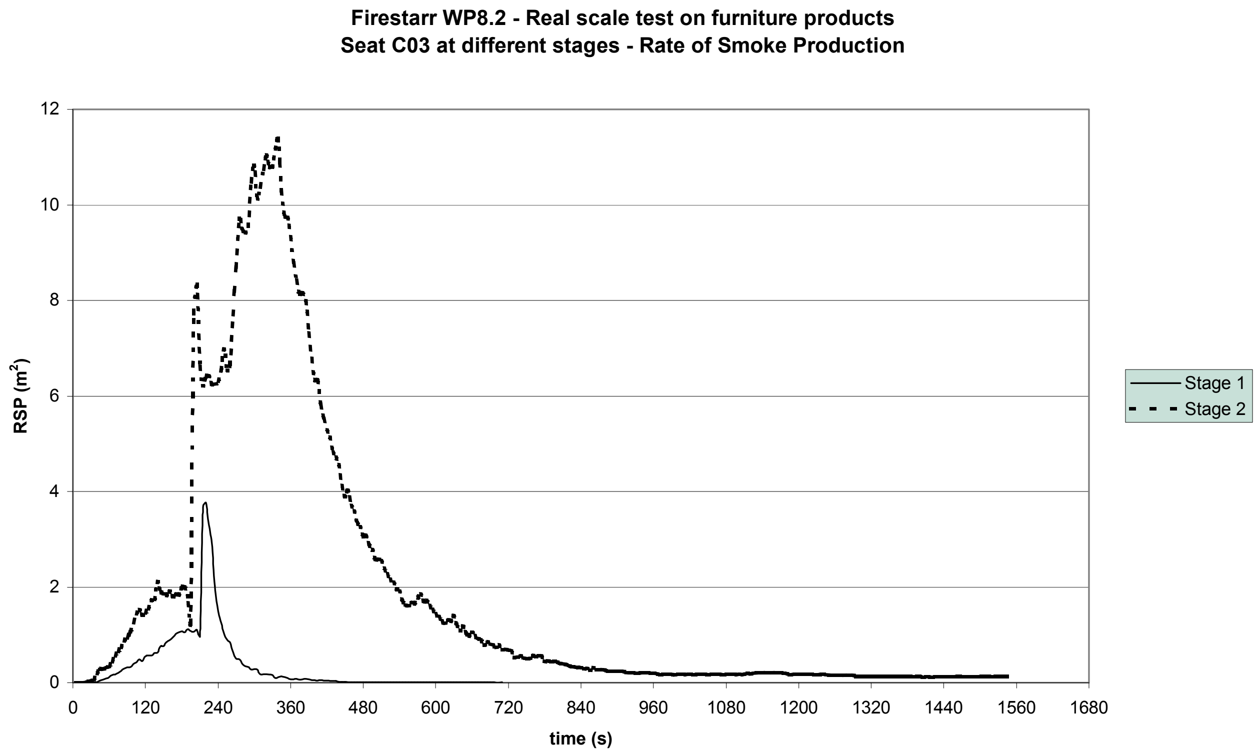


Firestarr WP8.2 - Real scale test on furniture products
Seat C02 at different stages - Heat released
Heat released (kW)
time (s)
Stage 1
Stage 2
Stage 3

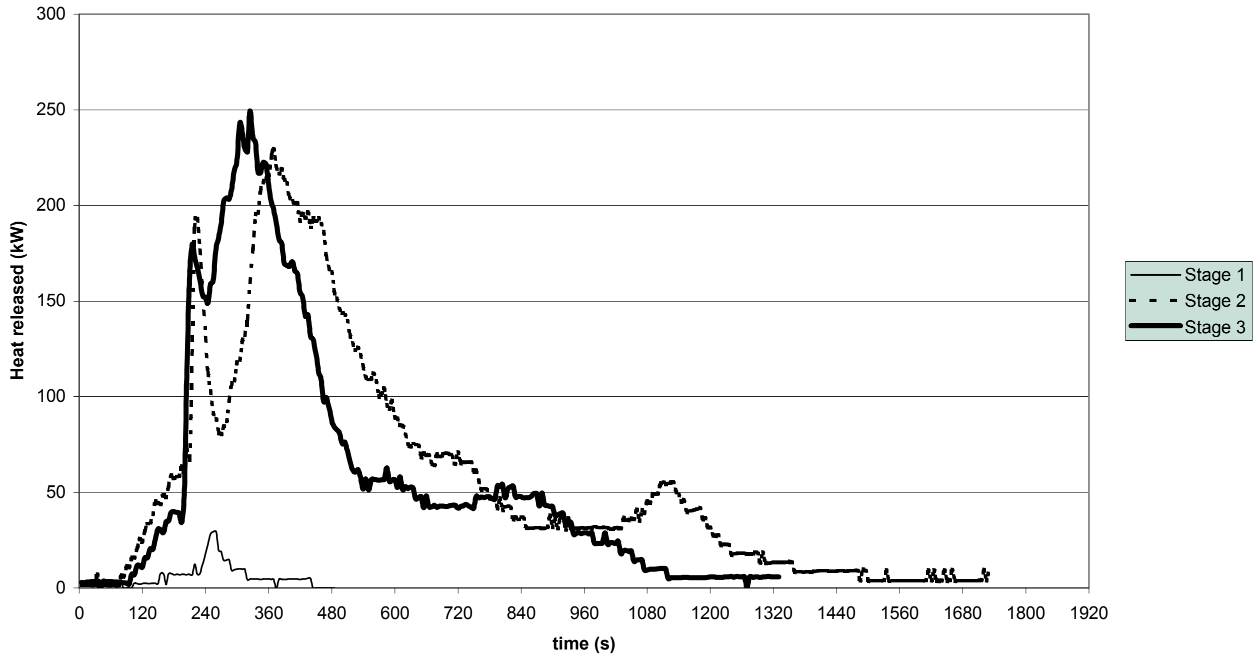


Firestarr WP8.2 - Real scale test on furniture products
Seat C02 at different stages - Rate of Smoke Production
RSP (m2)
time (s)
Stage 1
Stage 2
Stage 3

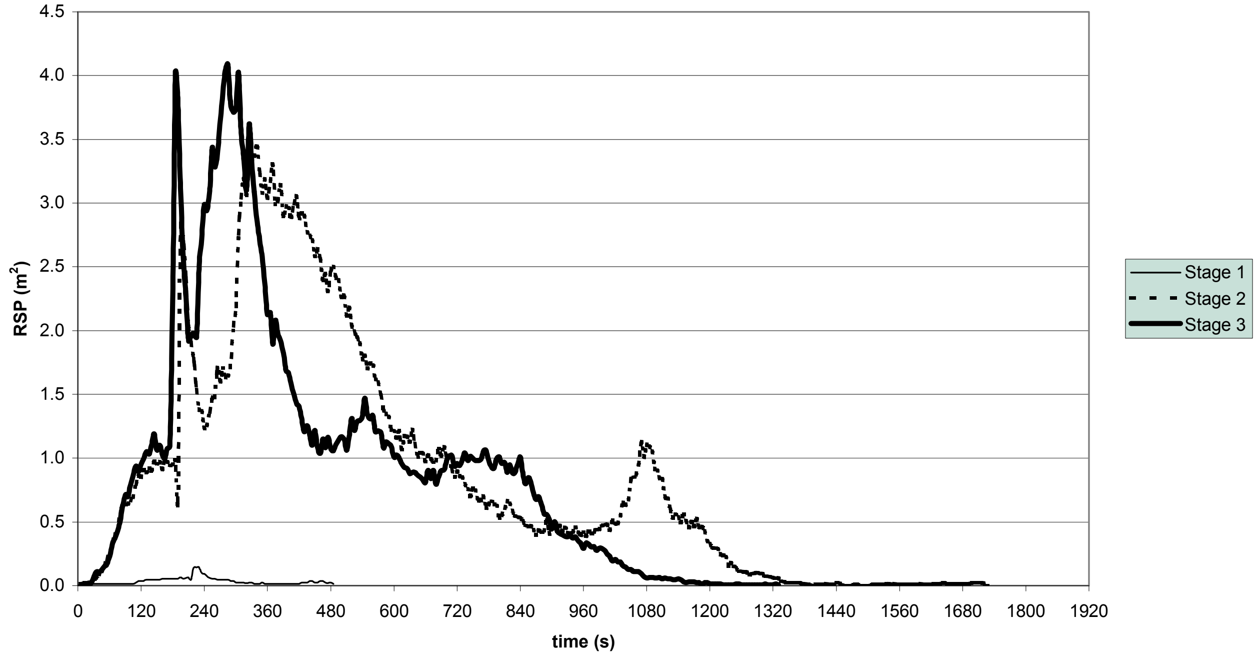

Firestarr WP8.2 - Real scale test on furniture products
Seat C03 at different stages - Heat released
Heat released (kW)
time (s)
Stage 1
Stage 2
0
50
100
150
200
250
300
350
400
0
120
240
360
480
600
720
840
960
1080
1200
1320
1440
1560
1680


Firestarr WP8.2 - Real scale test on furniture products
Seat C03 at different stages - Rate of Smoke Production
RSP (m2)
time (s)
Stage 1
Stage 2
0
2
4
6
8
10
12
0
120
240
360
480
600
720
840
960
1080
1200
1320
1440
1560
1680

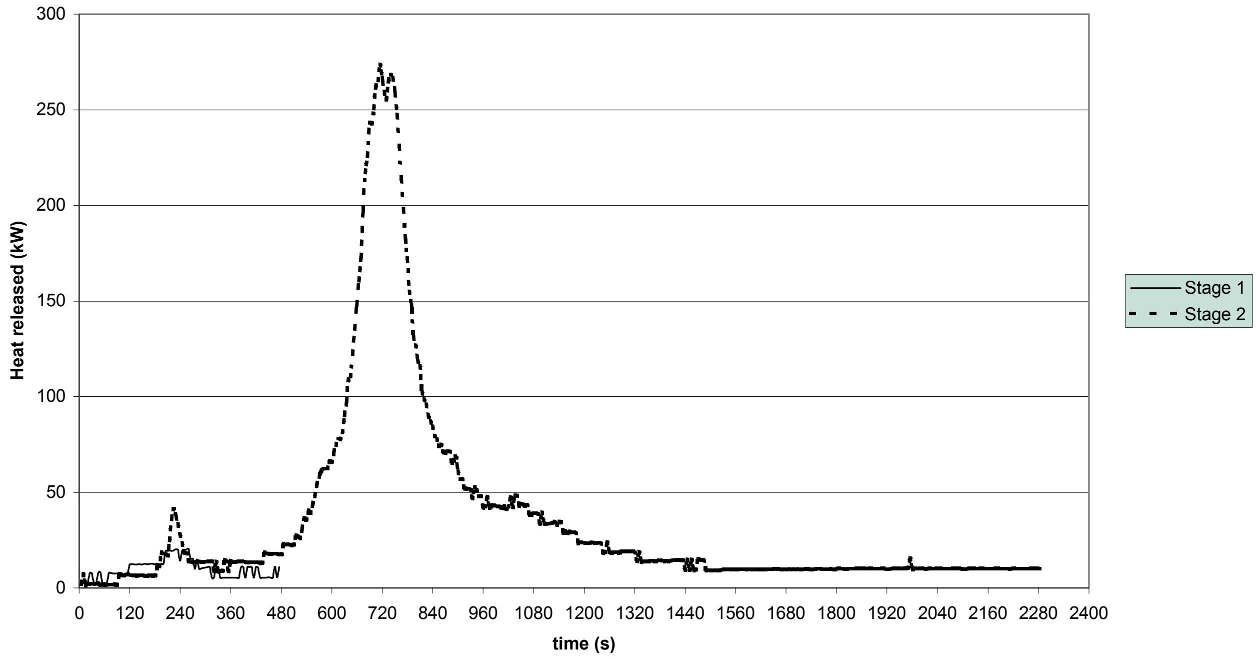
Firestarr WP8.2 - Real scale test on furniture products
Seat C04 at different stages - Heat released



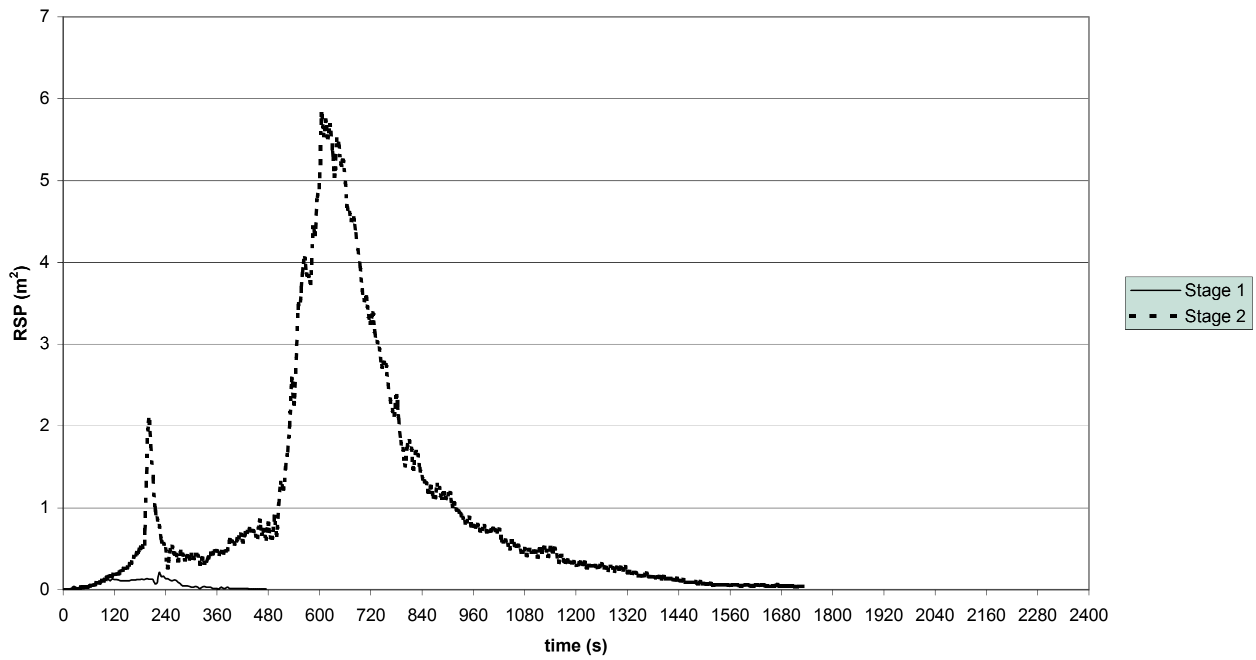
Firestarr WP8.2 - Real scale test on furniture products
Seat C04 at different stages - Rate of Smoke Production



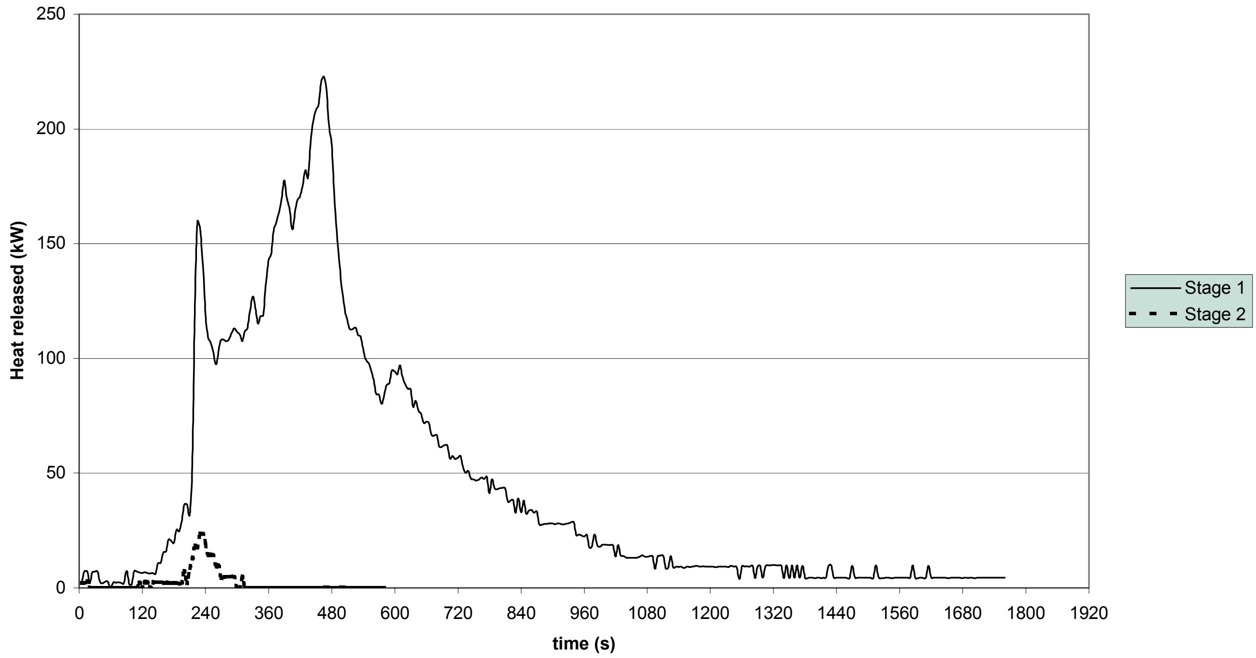
Firestarr WP8.2 - Real scale test on furniture products
Seat C05 at different stages - Heat released



Firestarr WP8.2 - Real scale test on furniture products
Seat C05 at different stages - Rate of Smoke Production

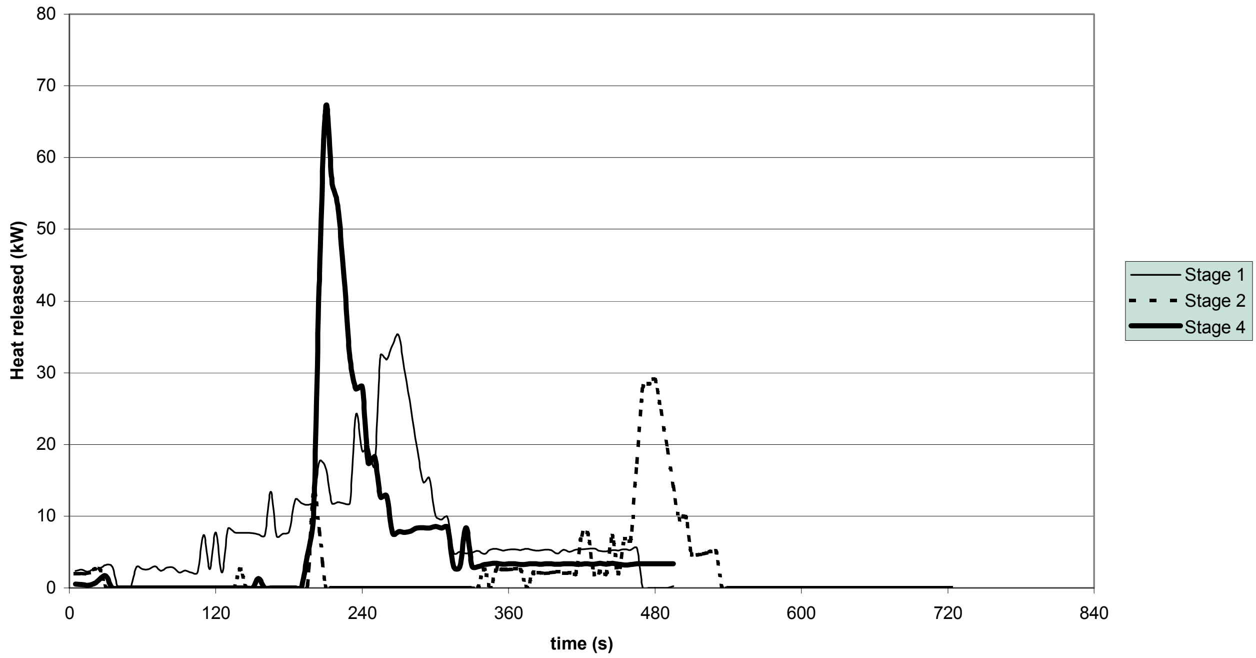


Firestarr WP8.2 - Real scale test on furniture products
Seat C07 at different stages - Heat released

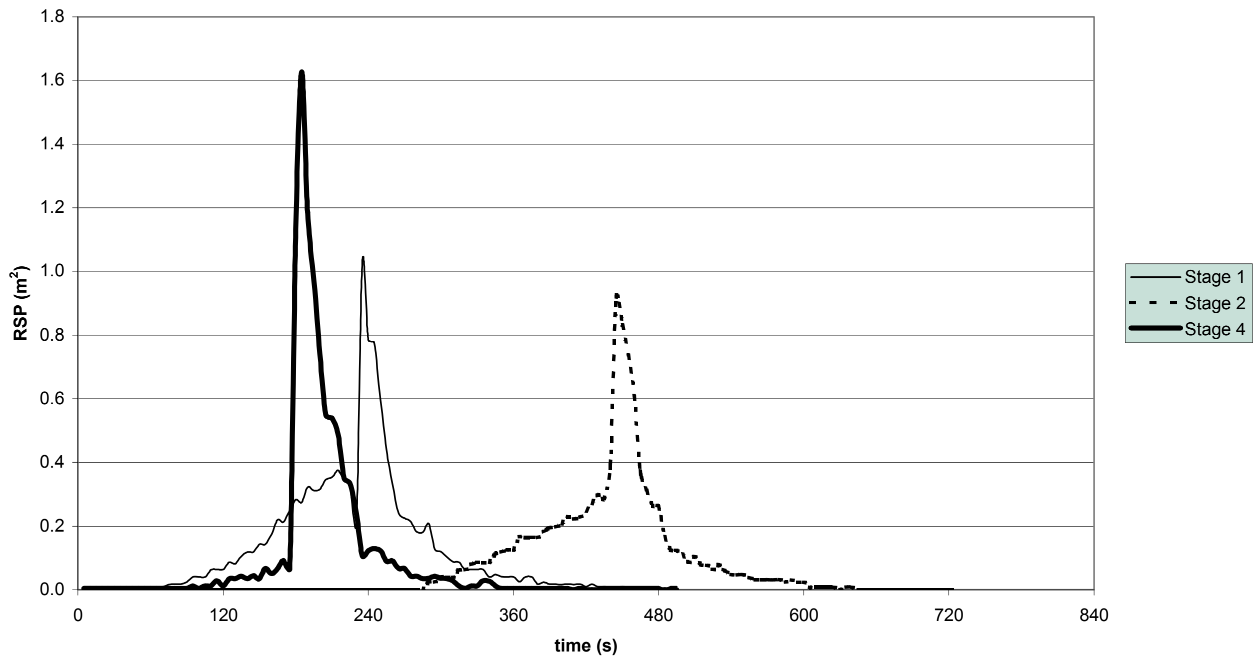


Firestarr WP8.2 - Real scale test on furniture products
Seat C07 at different stages - Rate of Smoke Production

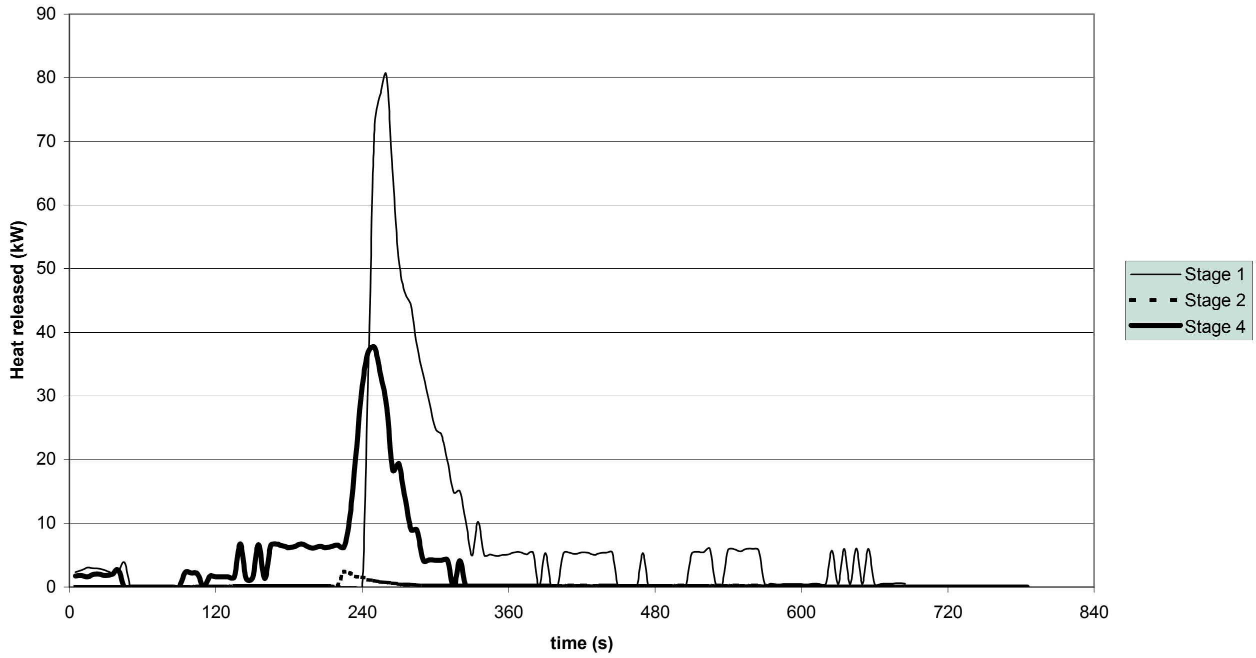
Firestarr WP8.2 - Real scale test on furniture products
Seat C08 at different stages - Heat released



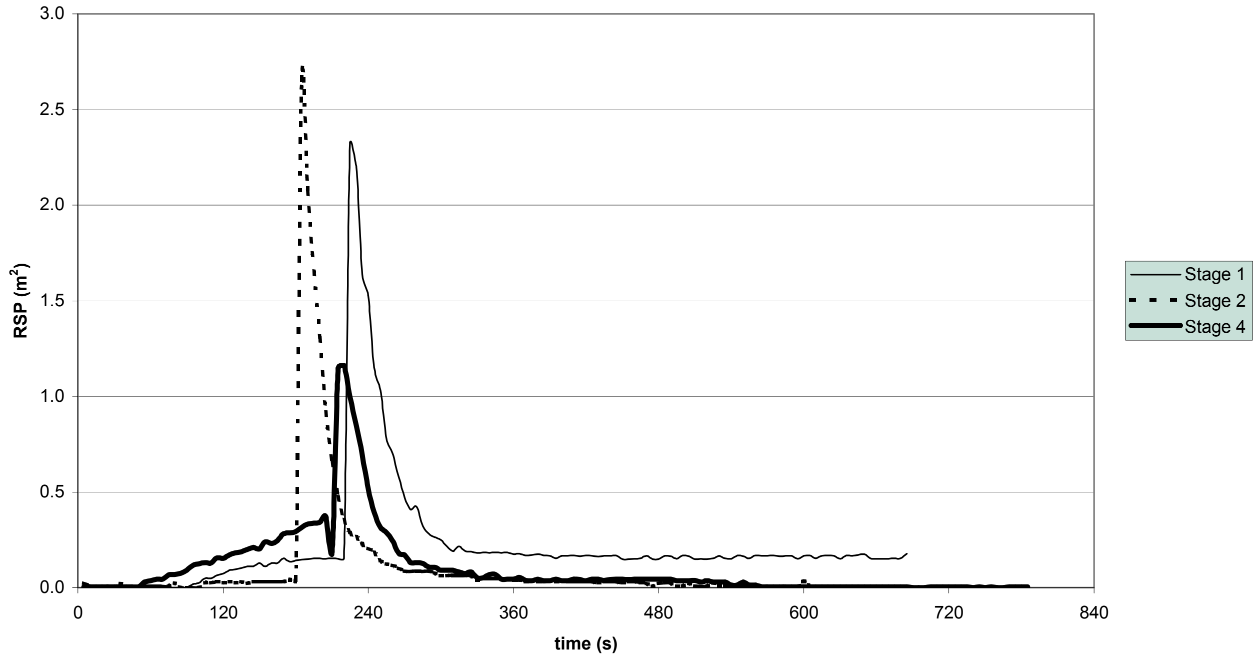
Firestarr WP8.2 - Real scale test on furniture products
Seat C08 at different stages - Rate of Smoke Production



Firestarr WP8.2 - Real scale test on furniture products
Seat C09 at different stages - Heat released



Firestarr WP8.2 - Real scale test on furniture products
Seat C09 at different stages - Rate of Smoke Production



ANNEX 3 : Parameters / informations sheets

WP 8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination 01

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	4	3	2
t afterflame of the seat tested (s)	449	1320	1740
Melting of the seat tested (yes/no)	N	Y	Y
Dripping of the seat tested (yes/no)	N	N	N
Pool fire under the seat tested (yes/no)	N	N	N
*** for the seat**			
Damaged length of the seat tested (cm)	17	41	41
Damaged width of the seat tested (cm)	37	42	42
Damaged depth of the seat tested (cm)	2	10	10
Damaged volume of the seat tested (cm3) (A)	419	17220	17220
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	57	75	75
Damaged width of the back of the seat tested (cm)	36	35-42	35-42
Damaged depth of the back of the seat tested (cm)	2	10-17	10-17
Damaged volume of the back of the seat tested (cm3) (B)	1398	39288	39288
Total volume damaged of the seat tested (A+B) (cm3)	1787	56508	56508
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	Y	
tig of the adjacent seat (s)	-	590	
t afterflame of the adjacent seat (s)	-	840	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	10	
Damaged width of the adjacent seat (cm)	-	0.5	
Damaged depth of the adjacent seat (cm)	-	0	
Damaged volume of the adjacent seat (cm3) (A')	-	-	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	70	
Damaged width of the back of the adjacent seat (cm)	-	3	
Damaged depth of the back of the adjacent seat (cm)	-	0.5	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	105	
Total volume damaged of the adjacent seat (A'+B')	-	105	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	-	
Damaged width of the facing seat (cm)	-	-	
Damaged depth of the facing seat (cm)	-	-	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			N
tig of the seat frame (s)			-
t afterflame of the seat frame (s)			-
Melting of the seat frame (yes/no)			N
Dripping of the seat frame (yes/no)			N
Pool fire under the seat frame (yes/no)			N
*** for the seat**			
Damaged length of the seat frame (cm)			-
Damaged width of the seat frame (cm)			-
Damaged depth of the seat frame (cm)			-
Damaged volume of the seat frame (cm3) (A'")			-
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			-
Damaged width of the back of the seat frame (cm)			-
Damaged depth of the back of the seat frame (cm)			-
Damaged volume of the back of the seat frame (cm3) (B'")			-
Total volume damaged of the seat frame (A'"+B'")			-
Percentage of mass loss of the seat tested (*) (%)	0.9	10.8	12

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination 02

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	4	4	2
t afterflame of the seat tested (s)	1883	5560	1650
Melting of the seat tested (yes/no)	Y	Y	Y
Dripping of the seat tested (yes/no)	Y	Y	Y
Pool fire under the seat tested (yes/no)	Y	Y	Y
*** for the seat**			
Damaged length of the seat tested (cm)	44	44	44
Damaged width of the seat tested (cm)	50	50	50
Damaged depth of the seat tested (cm)	13	13	13
Damaged volume of the seat tested (cm3) (A)	28600	28600	28600
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	85	85	85
Damaged width of the back of the seat tested (cm)	46	46	46
Damaged depth of the back of the seat tested (cm)	9	9	9
Damaged volume of the back of the seat tested (cm3) (B)	35190	35190	35190
Total volume damaged of the seat tested (A+B) (cm3)	63790	63790	63790
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	Y	Y	
tig of the adjacent seat (s)	1220	800	
t afterflame of the adjacent seat (s)	1600	5400	
Melting of the adjacent seat (yes/no)	N	Y	
Dripping of the adjacent seat (yes/no)	N	Y	
Pool fire under the adjacent tested (yes/no)	N	Y	
*** for the seat**			
Damaged length of the adjacent seat (cm)	0	44	
Damaged width of the adjacent seat (cm)	0	50	
Damaged depth of the adjacent seat (cm)	0	13	
Damaged volume of the adjacent seat (cm3) (A')	0	28600	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	50	85	
Damaged width of the back of the adjacent seat (cm)	3	46	
Damaged depth of the back of the adjacent seat (cm)	0.5	9	
Damaged volume of the back of the adjacent seat (cm3) (B')	75	35190	
Total volume damaged of the adjacent seat (A'+B')	75	63790	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	7	
Damaged width of the facing seat (cm)	-	46	
Damaged depth of the facing seat (cm)	-	0	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	
	Stage 1	**Stage 2**	**Stage 3**
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			N
tig of the seat frame (s)			-
t afterflame of the seat frame (s)			-
Melting of the seat frame (yes/no)			N
Dripping of the seat frame (yes/no)			N
Pool fire under the seat frame (yes/no)			N
*** for the seat**			
Damaged length of the seat frame (cm)			-
Damaged width of the seat frame (cm)			-
Damaged depth of the seat frame (cm)			-
Damaged volume of the seat frame (cm3) (A'")			-
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			5
Damaged width of the back of the seat frame (cm)			25
Damaged depth of the back of the seat frame (cm)			0
Damaged volume of the back of the seat frame (cm3) (B'")			-
Total volume damaged of the seat frame (A'"+B'")			-
Percentage of mass loss of the seat tested (*) (%)	16.8	18.8	16.8

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination C03

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	5	2	
t afterflame of the seat tested (s)	210	1800	
Melting of the seat tested (yes/no)	N	N	
Dripping of the seat tested (yes/no)	N	N	
Pool fire under the seat tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the seat tested (cm)	20	45	
Damaged width of the seat tested (cm)	38	44.5	
Damaged depth of the seat tested (cm)	1.5	11	
Damaged volume of the seat tested (cm3) (A)	380	22082	
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	71	76	
Damaged width of the back of the seat tested (cm)	39	43.5	
Damaged depth of the back of the seat tested (cm)	1.5	9	
Damaged volume of the back of the seat tested (cm3) (B)	1385	29754	
Total volume damaged of the seat tested (A+B) (cm3)	1767	51782	
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	Y	
tig of the adjacent seat (s)	-	-	
t afterflame of the adjacent seat (s)	-	-	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	45	
Damaged width of the adjacent seat (cm)	-	44.5	
Damaged depth of the adjacent seat (cm)	-	11	
Damaged volume of the adjacent seat (cm3) (A')	-	22082	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	76	
Damaged width of the back of the adjacent seat (cm)	-	43.5	
Damaged depth of the back of the adjacent seat (cm)	-	9	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	29754	
Total volume damaged of the adjacent seat (A'+B')	-	51782	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	3	
Damaged width of the facing seat (cm)	-	43	
Damaged depth of the facing seat (cm)	-	0	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			
tig of the seat frame (s)			
t afterflame of the seat frame (s)			
Melting of the seat frame (yes/no)			
Dripping of the seat frame (yes/no)			
Pool fire under the seat frame (yes/no)			
*** for the seat**			
Damaged length of the seat frame (cm)			
Damaged width of the seat frame (cm)			
Damaged depth of the seat frame (cm)			
Damaged volume of the seat frame (cm3) (A'")			
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			
Damaged width of the back of the seat frame (cm)			
Damaged depth of the back of the seat frame (cm)			
Damaged volume of the back of the seat frame (cm3) (B'")			
Total volume damaged of the seat frame (A'"+B'")			
Percentage of mass loss of the seat tested (*) (%)	0.7	21.1	

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination 04

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	6	3	2
t afterflame of the seat tested (s)	0	1477	940
Melting of the seat tested (yes/no)	N	Y	Y
Dripping of the seat tested (yes/no)	N	Y	Y
Pool fire under the seat tested (yes/no)	N	Y	Y
*** for the seat**			
Damaged length of the seat tested (cm)	16	37	37
Damaged width of the seat tested (cm)	33	44	44
Damaged depth of the seat tested (cm)	0.5	10	10
Damaged volume of the seat tested (cm3) (A)	88	16280	16280
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	54	56	56
Damaged width of the back of the seat tested (cm)	34	48	48
Damaged depth of the back of the seat tested (cm)	0.5	4	4
Damaged volume of the back of the seat tested (cm3) (B)	306	10752	10752
Total volume damaged of the seat tested (A+B) (cm3)	394	27032	27032
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	Y	Y	
tig of the adjacent seat (s)	720	720	
t afterflame of the adjacent seat (s)	1305	1305	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	20	
Damaged width of the adjacent seat (cm)	-	10	
Damaged depth of the adjacent seat (cm)	-	0.5	
Damaged volume of the adjacent seat (cm3) (A')	-	100	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	50	
Damaged width of the back of the adjacent seat (cm)	-	5	
Damaged depth of the back of the adjacent seat (cm)	-	0.5	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	125	
Total volume damaged of the adjacent seat (A'+B')	-	225	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	-	
Damaged width of the facing seat (cm)	-	-	
Damaged depth of the facing seat (cm)	-	-	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	
	Stage 1	**Stage 2**	**Stage 3**
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			Y
tig of the seat frame (s)			-
t afterflame of the seat frame (s)			-
Melting of the seat frame (yes/no)			Y
Dripping of the seat frame (yes/no)			Y
Pool fire under the seat frame (yes/no)			N
*** for the seat**			
Damaged length of the seat frame (cm)			-
Damaged width of the seat frame (cm)			-
Damaged depth of the seat frame (cm)			-
Damaged volume of the seat frame (cm3) (A'")			-
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			-
Damaged width of the back of the seat frame (cm)			-
Damaged depth of the back of the seat frame (cm)			-
Damaged volume of the back of the seat frame (cm3) (B'")			-
Total volume damaged of the seat frame (A'"+B'")			-
Percentage of mass loss of the seat tested (*) (%)	0.2	25.1	25.1

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET

Combination C05

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	5	2	
t afterflame of the seat tested (s)	0	2430	
Melting of the seat tested (yes/no)	N	N	
Dripping of the seat tested (yes/no)	N	N	
Pool fire under the seat tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the seat tested (cm)	18	45	
Damaged width of the seat tested (cm)	30	46	
Damaged depth of the seat tested (cm)	1	13	
Damaged volume of the seat tested (cm3) (A)	180	26910	
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	40	58	
Damaged width of the back of the seat tested (cm)	28.5	54	
Damaged depth of the back of the seat tested (cm)	1.5	15	
Damaged volume of the back of the seat tested (cm3) (B)	570	46980	
Total volume damaged of the seat tested (A+B) (cm3)	750	73890	
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	Y	
tig of the adjacent seat (s)	-	1090	
t afterflame of the adjacent seat (s)	-	1685	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	34	
Damaged width of the adjacent seat (cm)	-	19	
Damaged depth of the adjacent seat (cm)	-	0.5	
Damaged volume of the adjacent seat (cm3) (A')	-	232	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	52	
Damaged width of the back of the adjacent seat (cm)	-	17	
Damaged depth of the back of the adjacent seat (cm)	-	0.5	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	442	
Total volume damaged of the adjacent seat (A'+B')	-	765	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	-	
Damaged width of the facing seat (cm)	-	-	
Damaged depth of the facing seat (cm)	-	-	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	
	Stage 1	**Stage 2**	**Stage 3**
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			
tig of the seat frame (s)			
t afterflame of the seat frame (s)			
Melting of the seat frame (yes/no)			
Dripping of the seat frame (yes/no)			
Pool fire under the seat frame (yes/no)			
*** for the seat**			
Damaged length of the seat frame (cm)			
Damaged width of the seat frame (cm)			
Damaged depth of the seat frame (cm)			
Damaged volume of the seat frame (cm3) (A"')			
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			
Damaged width of the back of the seat frame (cm)			
Damaged depth of the back of the seat frame (cm)			
Damaged volume of the back of the seat frame (cm3) (B"')			
Total volume damaged of the seat frame (A"'+B"')			
Percentage of mass loss of the seat tested (*) (%)	1	25.8	

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET

Combination 07

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	5	3	
t afterflame of the seat tested (s)	115	1990	
Melting of the seat tested (yes/no)	N	N	
Dripping of the seat tested (yes/no)	N	N	
Pool fire under the seat tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the seat tested (cm)	18	50	
Damaged width of the seat tested (cm)	38	59	
Damaged depth of the seat tested (cm)	0.5	16	
Damaged volume of the seat tested (cm3) (A)	114	47200	
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	36	38	
Damaged width of the back of the seat tested (cm)	38	49	
Damaged depth of the back of the seat tested (cm)	0.5	10	
Damaged volume of the back of the seat tested (cm3) (B)	228	18620	
Total volume damaged of the seat tested (A+B) (cm3)	342	65820	
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	Y	
tig of the adjacent seat (s)	-	765	
t afterflame of the adjacent seat (s)	-	1380	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	40	
Damaged width of the adjacent seat (cm)	-	35	
Damaged depth of the adjacent seat (cm)	-	0.5	
Damaged volume of the adjacent seat (cm3) (A')	-	700	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	40	
Damaged width of the back of the adjacent seat (cm)	-	20	
Damaged depth of the back of the adjacent seat (cm)	-	0.5	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	400	
Total volume damaged of the adjacent seat (A'+B')	-	1100	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	3	
Damaged width of the facing seat (cm)	-	58	
Damaged depth of the facing seat (cm)	-	0	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			
tig of the seat frame (s)			
t afterflame of the seat frame (s)			
Melting of the seat frame (yes/no)			
Dripping of the seat frame (yes/no)			
Pool fire under the seat frame (yes/no)			
*** for the seat**			
Damaged length of the seat frame (cm)			
Damaged width of the seat frame (cm)			
Damaged depth of the seat frame (cm)			
Damaged volume of the seat frame (cm3) (A''')			
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			
Damaged width of the back of the seat frame (cm)			
Damaged depth of the back of the seat frame (cm)			
Damaged volume of the back of the seat frame (cm3) (B''')			
Total volume damaged of the seat frame (A'''+B''')			
Percentage of mass loss of the seat tested (*) (%)	5.1	25.6	

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination C08

	Stage 1	Stage 2	Stage 4
Fire behaviour of the seat tested			
tig of the seat tested (s)	2	3	
t afterflame of the seat tested (s)	15	13	
Melting of the seat tested (yes/no)	N	N	
Dripping of the seat tested (yes/no)	N	N	
Pool fire under the seat tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the seat tested (cm)	21	19	
Damaged width of the seat tested (cm)	37	33	
Damaged depth of the seat tested (cm)	5	4	
Damaged volume of the seat tested (cm3) (A)	1297	836	
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	43	38	
Damaged width of the back of the seat tested (cm)	34	29	
Damaged depth of the back of the seat tested (cm)	7	8	
Damaged volume of the back of the seat tested (cm3) (B)	3411	2939	
Total volume damaged of the seat tested (A+B) (cm3)	4706	3775	
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	N	
tig of the adjacent seat (s)	-	-	
t afterflame of the adjacent seat (s)	-	-	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	-	
Damaged width of the adjacent seat (cm)	-	-	
Damaged depth of the adjacent seat (cm)	-	-	
Damaged volume of the adjacent seat (cm3) (A')	-	-	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	-	
Damaged width of the back of the adjacent seat (cm)	-	-	
Damaged depth of the back of the adjacent seat (cm)	-	-	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	-	
Total volume damaged of the adjacent seat (A'+B')	-	-	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	-	
Damaged width of the facing seat (cm)	-	-	
Damaged depth of the facing seat (cm)	-	-	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	
	Stage 1	**Stage 2**	**Stage 4**
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			
tig of the seat frame (s)			
t afterflame of the seat frame (s)			
Melting of the seat frame (yes/no)			
Dripping of the seat frame (yes/no)			
Pool fire under the seat frame (yes/no)			
*** for the seat**			
Damaged length of the seat frame (cm)			
Damaged width of the seat frame (cm)			
Damaged depth of the seat frame (cm)			
Damaged volume of the seat frame (cm3) (A'")			
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			
Damaged width of the back of the seat frame (cm)			
Damaged depth of the back of the seat frame (cm)			
Damaged volume of the back of the seat frame (cm3) (B'")			
Total volume damaged of the seat frame (A'"+B'")			
Percentage of mass loss of the seat tested (*) (%)	1.2	0.7	

WP8.2 REAL SCALE TESTS ON FURNITURE PRODUCTS : PARAMETER SHEET
Combination C09

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat tested			
tig of the seat tested (s)	3	5	
t afterflame of the seat tested (s)	95	218	
Melting of the seat tested (yes/no)	N	N	
Dripping of the seat tested (yes/no)	N	N	
Pool fire under the seat tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the seat tested (cm)	27	25	
Damaged width of the seat tested (cm)	42	46	
Damaged depth of the seat tested (cm)	7.5	11	
Damaged volume of the seat tested (cm3) (A)	28350	4217	
*** for the back of the seat**			
Damaged length of the back of the seat tested (cm)	58	56	
Damaged width of the back of the seat tested (cm)	38	50	
Damaged depth of the back of the seat tested (cm)	10	10	
Damaged volume of the back of the seat tested (cm3) (B)	7347	9333	
Total volume damaged of the seat tested (A+B) (cm3)	10182	13550	
Fire behaviour of the adjacent seat			
Ignition of the adjacent seat (yes/no)	N	N	
tig of the adjacent seat (s)	-	-	
t afterflame of the adjacent seat (s)	-	-	
Melting of the adjacent seat (yes/no)	N	N	
Dripping of the adjacent seat (yes/no)	N	N	
Pool fire under the adjacent tested (yes/no)	N	N	
*** for the seat**			
Damaged length of the adjacent seat (cm)	-	-	
Damaged width of the adjacent seat (cm)	-	-	
Damaged depth of the adjacent seat (cm)	-	-	
Damaged volume of the adjacent seat (cm3) (A')	-	-	
*** for the back of the seat**			
Damaged length of the back of the adjacent seat (cm)	-	-	
Damaged width of the back of the adjacent seat (cm)	-	-	
Damaged depth of the back of the adjacent seat (cm)	-	-	
Damaged volume of the back of the adjacent seat (cm3) (B')	-	-	
Total volume damaged of the adjacent seat (A'+B')	-	-	
Fire behaviour of the facing seat			
Ignition of the facing seat (yes/no)	N	N	
tig of the facing seat (s)	-	-	
t afterflame of the facing seat (s)	-	-	
Melting of the facing seat (yes/no)	N	N	
Dripping of the facing seat (yes/no)	N	N	
Pool fire under the facing seat (yes/no)	N	N	
*** for the seat**			
Damaged length of the facing seat (cm)	-	-	
Damaged width of the facing seat (cm)	-	-	
Damaged depth of the facing seat (cm)	-	-	
Damaged volume of the facing seat (cm3) (A")	-	-	
*** for the back of the seat**			
Damaged length of the back of the facing seat (cm)	-	-	
Damaged width of the back of thefacing seat (cm)	-	-	
Damaged depth of the back of the facing seat (cm)	-	-	
Damaged volume of the back of the facing seat (cm3) (B")	-	-	
Total volume damaged of the facing seat (A"+B")	-	-	

	Stage 1	Stage 2	Stage 3
Fire behaviour of the seat frame			
Ignition of the seat frame (yes/no)			
tig of the seat frame (s)			
t afterflame of the seat frame (s)			
Melting of the seat frame (yes/no)			
Dripping of the seat frame (yes/no)			
Pool fire under the seat frame (yes/no)			
*** for the seat**			
Damaged length of the seat frame (cm)			
Damaged width of the seat frame (cm)			
Damaged depth of the seat frame (cm)			
Damaged volume of the seat frame (cm3) (A''')			
*** for the back of the seat**			
Damaged length of the back of the seat frame (cm)			
Damaged width of the back of the seat frame (cm)			
Damaged depth of the back of the seat frame (cm)			
Damaged volume of the back of the seat frame (cm3) (B''')			
Total volume damaged of the seat frame (A'''+B''')			
Percentage of mass loss of the seat tested (*) (%)	1.7	1.1	

ANNEX 4 : Toxicity

Annex A

Toxicity : Analysis of fire effluents

A4.1 Test procedure

A4.1.1 Sampling procedure

In real scale test experiments the fire effluents are collected in the exhaust duct and in the door at a nose level of a standing person (10cm under the top of the door) and driven through a sampling line to the analysers. The principle of the sampling in the exhaust duct is shown in figure A4.1.

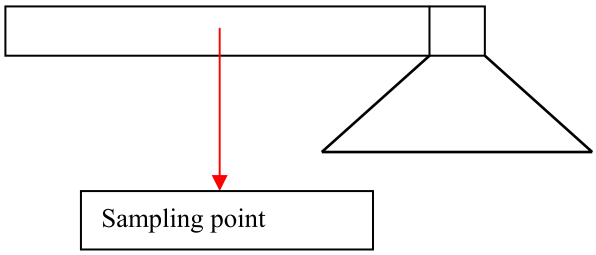


FIGURE A4.1 : SAMPLING OF FIRE EFFLUENT IN LARGE SCALE.

The sampling point is positioned in the exhaust duct at a sufficient distance from the fire to avoid the heterogeneity of the gas mixture and also to restrict the possibility of turbulence near the sampling point. In the door the probe is positioned in the door inside the compartment at 10 cm form the bottom edge of the door frame.

The probes are positioned down stream to avoid clogging. The probe could be a multi hole one or a “end hole” probe.

The fire effluents are driven to the analytical part through a heated sampling line to avoid condensation of gases. The line has to be kept as short as possible to minimise sample looses. The air flow in the sampling line is 6 to 8 L/min.

A4.1.2 Analytical methods

The gas analysis is performed using FTIR equipment in the way proposed by in the SAFIR project. The detection limits are listed in table A4.1.

Gases	Detection limit
CO	10 ppm
HCl	5 ppm
HBr	10 ppm
HCN	2 ppm
HF	2 ppm
NOx	10 ppm
SO_2	3 ppm

TABLE A4.1 : FTIR detection limit (used in WP8.2)

The sampling line and the filter(s) are washed in order to analyse the total amount of gases. The analysis of gases are performed with titration methods.

The WP3 – toxicity evaluation part 2 report gives detailed on the analytical methods and their uses.

A4.2 Test results

The results for the 8 seats tested in WP 8-2 are summarised in tables A4.2 and A4.3. An exemple of the FED versus time curves is also shown in figure A4.2.

When components were tested in small scale tests, only complete seats are tested in large scale : the seat shells are involved in the combustion process.

Remark :
- C1, C2, C3, C4 and C7 have metallic external shell
- C4 has also plastic armrests and headrests (both of them melted during the test.)
- C5 has a metallic shell under the seat and 2 mm plastic board under the back.(during tests the plastic sheet was not involved in fire).
- C8 and C9 have plywood shell for back and seat (not reached by fire).

The FED (fractional effective dose) is calculated according to ISO 13 344 standard. The calculated values and the CO/CO2 ratio are listed in table A4.3.
FED in corridor is calculated for a 40 m^3 volume which represent a corridor and 2 compartments (10 m^3) in a railway carriage. The hypothesis of a non ventilated “corridor is considered in order to simplify the calculation. (The measurement of gases used for the estimation in a corridor are performed in the duct of the NT FIRE 032 – furniture calorimeter).

Test	CO_2 (amount in g)	CO (amount in g)	HCN (amount in g)	HCl (amount in g)	HF (amount in g)	HBr (amount in g)	SO_2 (amount in g)	NOx (amount in g)	C_3H_4O (amount in g)	HCOH (amount in g)
C 1_ st1	142.17	2.94	ND	ND	ND	ND	ND	ND	ND	ND
C 1_st2	1794.25	162.65	8.16	0.01	ND	0.0004	24.59	ND	ND	ND
C 2_st1	4559.87	321.21	19.17	120.04	ND	0.0002	66.62	ND	ND	ND
C 2_st2	7357.28	506.19	26.82	202.05	ND	0.0005	115.84	ND	ND	ND
C 3_ st1	188.48	19.72	ND	45.71	ND	ND	ND	ND	ND	ND
C 3_ st2	4600.18	452.74	23.11	291.46	ND	ND	ND	ND	ND	ND
C 4_ st1	110.45	0.66	ND	ND	ND	ND	ND	ND	ND	ND
C 4_ st2	4363.83	242.96	11.19	0.02	ND	0.0004	ND	ND	ND	ND
C 5_ st1	134.23	0.47	ND	ND	ND	ND	ND	ND	ND	ND
C 5_ st2	3086.66	214.34	29.26	61.40	ND	0.0005	52.17	ND	ND	ND
C 7_ st1	66.14	5.5	ND	ND	ND	ND	ND	ND	ND	ND
C 7_ st2	3754.72	451.45190	28.65	110.78	ND	0.0005	ND	ND	ND	ND
C 8_ st1	121.40	4.35	ND	ND	ND	ND	ND	ND	ND	ND
C 8_ st2	113.25	0.83	ND	ND	ND	ND	ND	ND	ND	ND
C 9_ st1	155.88	1.37	ND	ND	ND	ND	ND	ND	ND	ND
C 9_ st2	120.53	0.33	ND	ND	ND	ND	ND	ND	ND	ND

TABLE A4.2 : amount of gases in g – measurement in the duct
ND: Not detected

Test	CO	HCN	HCl	HF	HBr	SO2	Nox	C_3H_4O	HCOH
C01	5.11	1.52	ND	ND	ND	ND	ND	ND	ND
C01 -St2	47.99	16.95	12.96	ND	ND	12.59	ND	ND	ND
C01 -st 3	47.14	15.53	7.07	ND	ND	10.67	ND	ND	ND
C02	76.23	34.21	172.21	ND	ND	23.70	15.92	ND	ND
C02-st 2	120.49	107.80	268.73	ND	ND	34.42	34.40	ND	ND
C02 -st 3	101.53	237.95	201.77	ND	ND	31.76	36.65	ND	ND
C03	24.33	2.80	23.69	ND	ND	2.72	2.64	ND	ND
C03 - st 2	166.86	160.10	304.87	ND	ND	16.18	14.07	ND	ND
C04	0.57	0.93	ND	ND	ND	ND	ND	ND	ND
C04-st 2	114.99	25.77	30.49	ND	ND	24.17	29.48	ND	ND
C04 - st 3	87.98	27.77	47.71	ND	ND	20.47	31.93	ND	ND
C05	2.17	1.28	1.07	ND	ND	ND	ND	ND	ND
C05-St2	54.61	24.89	28.28	ND	ND	9.63	15.83	ND	ND
C07	10.16	0.75	5.26	ND	ND	ND	ND	ND	ND
C07-st 2	122.21	45.07	124.56	ND	ND	18.02	ND	ND	ND
C08	2.73	1.81	ND	ND	ND	ND	ND	ND	ND
C08 - st 4	3.37	2.22	ND	ND	ND	ND	ND	ND	ND
C09	4.92	4.50	ND	ND	ND	ND	ND	ND	ND
C09-st 4	2.59	2.06	ND	ND	ND	ND	ND	ND	ND

TABLE A4.3 : amount of gases in g – measurement in the door
ND: Not detected

Test	FED (duct)	FED (duct) corridor	time to FED =1 (duct corridor)	CO/CO2 duct	FED (door)	Time to FED =1 (door)	FED(door) corridor	time to FED =1 (door corridor)
C 1_ st1	0.00001	0.0002		0.33	0.01		0.254	
C 1_st2	0.0075	0.189		1.4	0.12546		3.139	2 MIN 40
C 1_st3	0.008	0.9326		1.5	0.252		0.933	
C 2_st1	0.046	1.151	15 MIN 30	1.09	0.391		9.84	6 MIN 30
C 2_st2	0.0624	1.573	6 MIN 30	1.01	0.994		25.041	1 MIN 30
C 2_st3	0.069	1.736	5 MIN 30	1.15	1.768	2 MIN 30	44.53	1 MIN 20
C 3_ st1	0.00007	0.002		1.65	0.047		1.18	3 MIN 30
C 3_ st2	0.057	1.443	5 MIN 40	1.54	1.199	4 MIN 40	30.204	1 MIN 30
C 4_ st1	ND	0.00005		0.008	0.006		0.144	
C 4_ st2	0.024	0.606		0.88	0.373		9.396	2 MIN
C 4_ st3	0.0212	0.534		0.86	0.398		10.018	1 MIN 40
C 5_ st1	ND	0.00004		0.06	0.0085		0.214	
C 5_ st2	0.052	1.318	12 MIN 30	1.1	0.270		6.8054	8 MIN 10
C 7_ st1	0.00002	0.0005		1.3	0.008		0.205	
C 7_ st2	0.056	1.412	7 MIN 30	1.9	0.3504		8.827	2 MIN 10
C 8_ st1	0.00001	0.0004		0.4	0.0115		0.289	
C 8_ st2	ND	0.00008		0.1	0.009		0.232	
C 8_ st4	ND	0.00006		0.1	0.014		0.353	
C 9_ st1	ND	0.0001		0.2	0.028		0.709	
C 9_ st2	0.00002	0.00004		0.1	0.022		0.551	
C 9_ st4	ND	0.00002		0.02	0.013		0.326	

TABLE A4.4 : FED and CO/CO2 ratio – Furniture products in real scale tests.
ND : Not detected

The figures A4.2 and A4.3 show the participation of the gases to the FED in term of percentage. The main contributions to FED for burning seats are CO and HCN. Other gases are also analysed but with a lower contribution to the FED value.

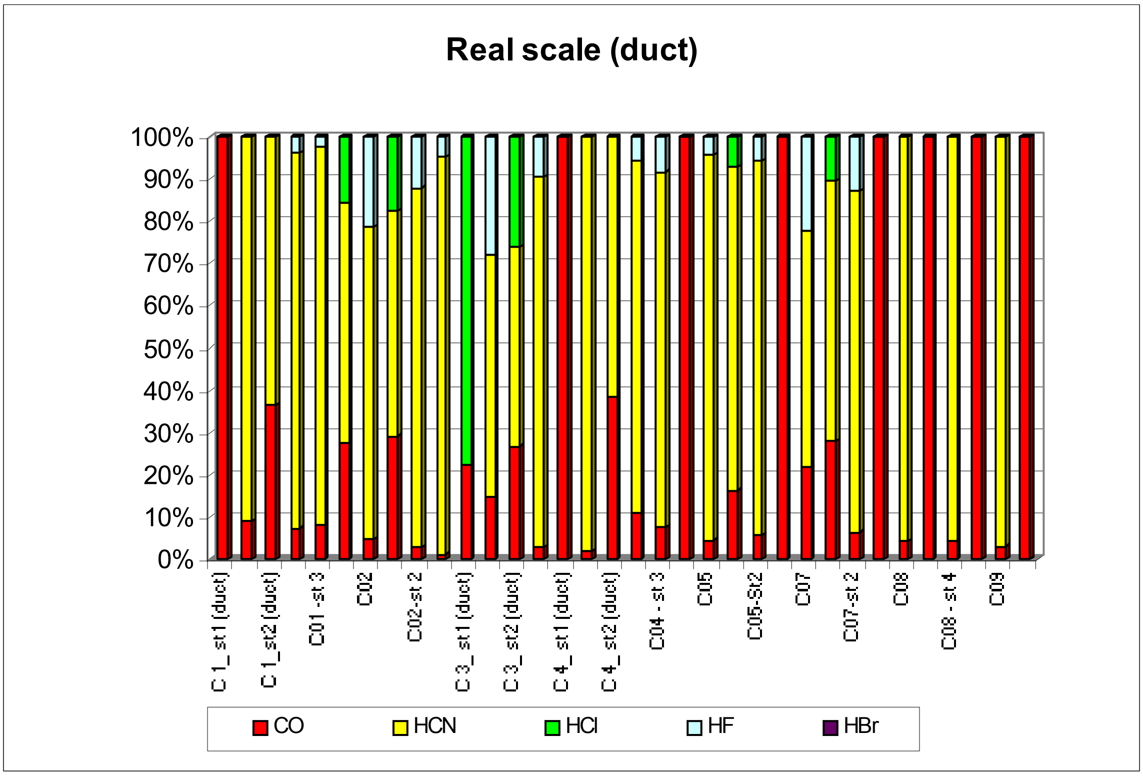


Figure A4.2 : Participation to FED – measurement in the duct.

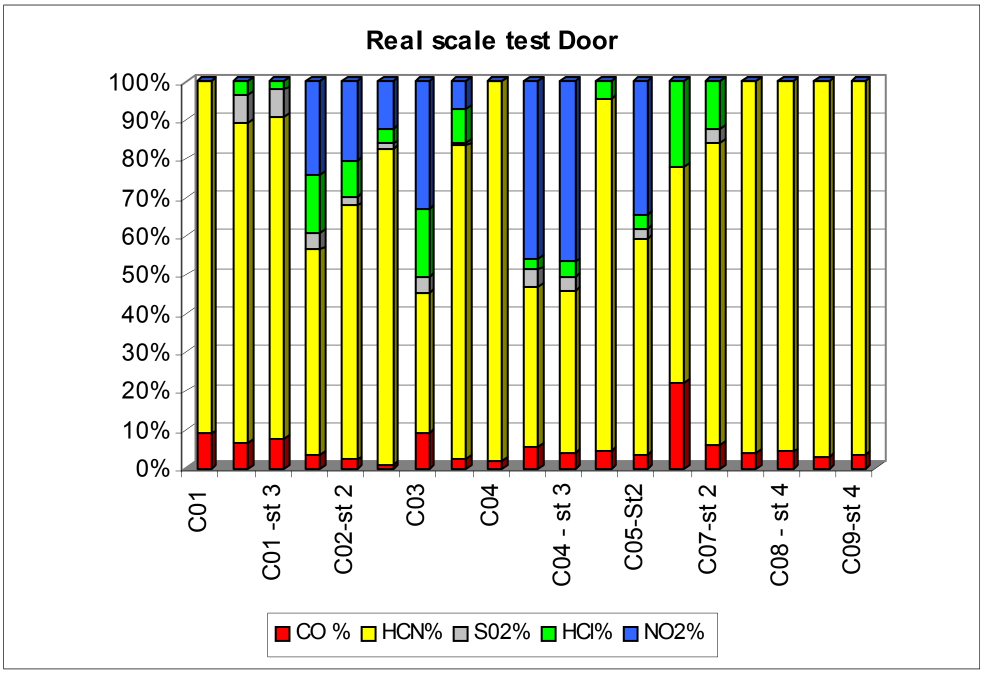


Figure A4.3 : Participation to FED – measurement in the door.

The comparison of the measurement sin the door and in the duct showed that the results obtained have some differences. Some explanation can be given :

- Condensation of gases in then duct or between the door and the sampling point in the duct,
- Dilution of gases (and then no detection because of the detection limit),
- Modification of the effluents due to fresh air mixed with the gases coming from the burning zone.

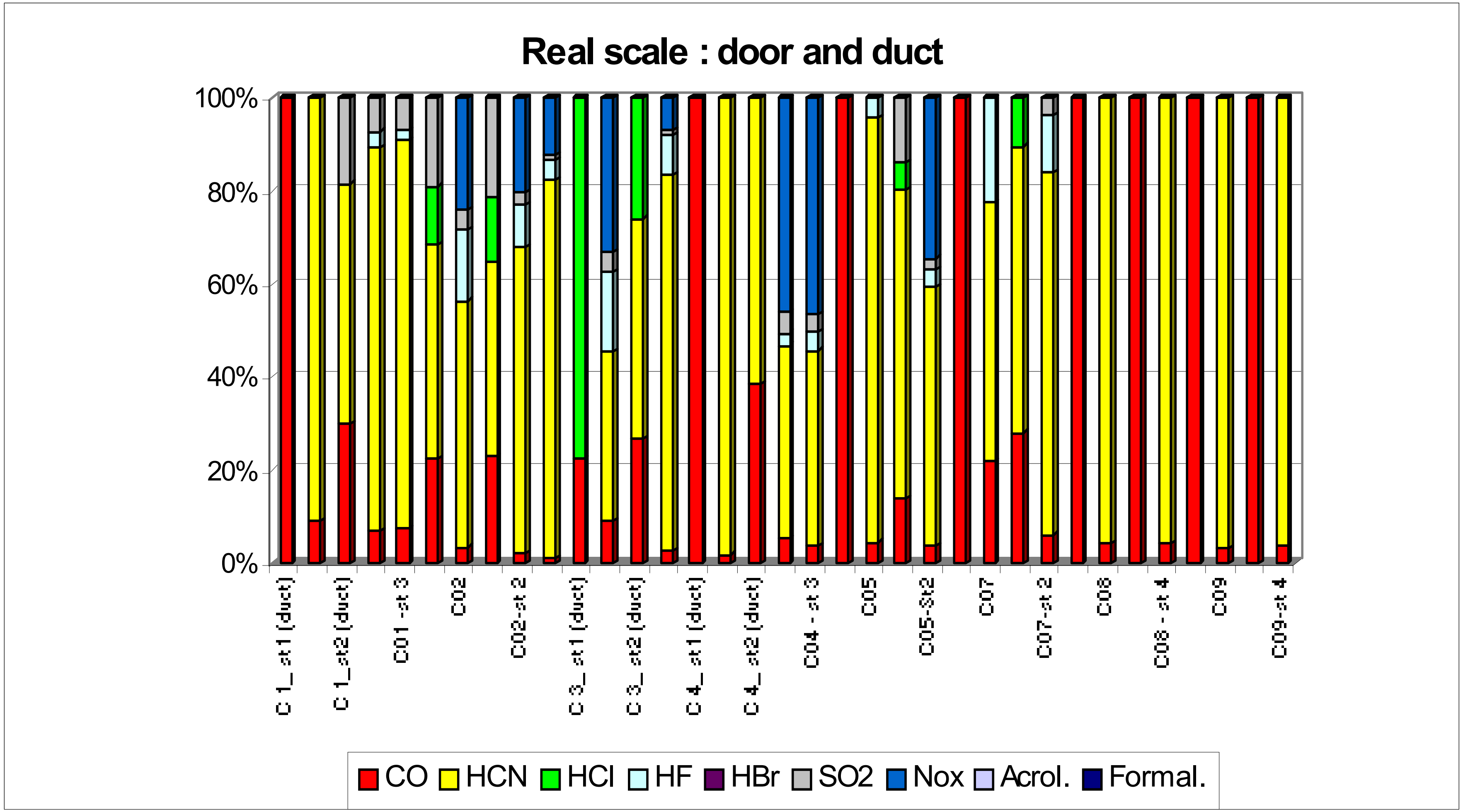


Figure A4.4 : Participation to FED in %

A3.3 Conclusion

The lethality fire critical effect can be reached for seats tested in real scale test for coming out of the 10 m3 compartment (measurement in the door) and also for more combinations in the hypothesis of gases going through the corridor.

The main conclusion is that in real scale FED =1 can be obtained for burning seats. The toxicity must be evaluated and considered for a classification of product used on railway.

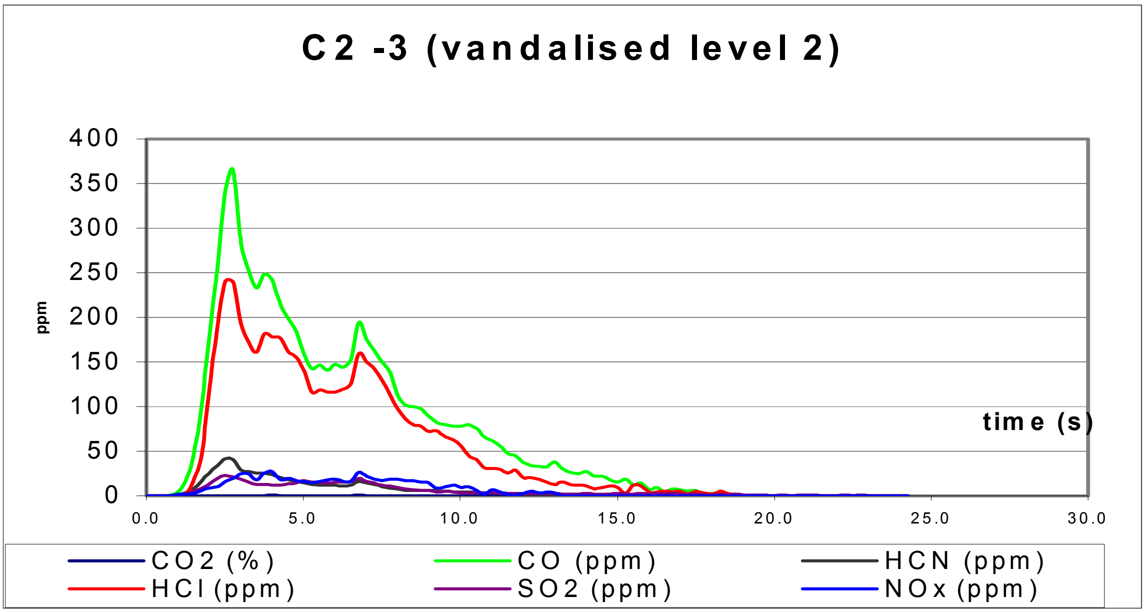
For seats that conducted to FED =1, the figure 2 show that CO is not the main contribution to the FED value. These results confirm the necessity to analyse not only CO and CO_2 but also the main toxicants: HCl, HBr, HF,HCN, SO_2, NOx (when analytical methods are available aldehyde must also be analysed because of their low LC50 values).

The FTIR method used for the purpose of this work package has been proved relevant for toxic gases analysis. The SAFIR protocol (also described in a DRAFT ISO standard) allows the direct analysis of gases and gives important information on the kinetic of evolved gases.

With measurements in the duct, the evaluation of the FCE on lethality is underestimated due to dilution, condensation or modification of the effluents due to fresh air mixed with teh effluents (secondary chemical reactions).

ANNEXE :

FIGURE A4.5 : example of kinetic curves- production of gases from burning seats.



Ranking of materials – FED increasing

Rank	Material
1	**C 1_1**
2	**C 1_2**
3	**C 2_1**
4	**C 2_2**
5	**C 4_1**
6	**C 4_2**
7	**C 9_3**
8	**C 8_1**
9	**C 5_3**
10	**C 5_2**
11	**C 8_3**
12	**C 5_1**
13	**C 8_2**
14	**C 8_4**
15	**C 9_1**
16	**C 7_1**
17	**C 7_2**
18	**C 9_4**
19	**C 9_2**
20	**C 3_1**
21	**C 5_4**
22	**C 3_2**
23	**C 1_4**
24	**C 1_3**
25	**C 3_3**
26	**C 7_4**
27	**C 4_3**
28	**C 7_3**
29	**C 4_4**
30	**C 2_3**
31	**C 2_4**

Yellow cells means FED =0