Federation of European Rigid Polyurethane Foam Associations

Research program
"FIGRA project"

Valuation of fire grow
FIGRA – mARHE – FIGRA t*
EN 13823 – EN 11925-2 – EN 13501-1

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Foreword

Scope of this research, effected for BING, was to verify the reliability of the evaluations obtained by SBI on some building products. I have always been convinced that FIGRA, as it is calculated, i.e. not considering thermal attack conditions and ventilation (intended as number of changes of air in the apparatus per hour), using analysers at limits of their sensitivity etc.. etc…- is conceptually wrong.

To emphasise the effect of the initial fire growth, attributing the maximum importance to the only initial slope of the curve, without seriously considering the fire power, leads to the evident result to consider the fire from a newspaper ball of 100 gr. so important to consider a product, having similar curve, at maximum danger levels.
To do a "military" comparison, to receive a small shot at 1000 km/h speed would be much more harmful than to receive a cannon shot of 50 kg running at only 900 km/h. Try to believe.
Joking a part, the SBI, in the present version and with this FIGRA calculation system, obtains aberrant results. We will see how it is possible, **in part, to find a remedy using other calculation systems**, easy to be applied to the curves already produced up today: it is given that, since curves are obtained with an apparatus and in not realistic testing conditions, we work on data that wouldn't be used to evaluate the fire behaviour of a product.

To consider only the first 10 minutes of testing will be even a good gift for those products that need some times to let grow the fire, and it will be useful in those cases when the firemen start to extinguish the fire within 600 seconds. Our firemen, that are really very clever (and more, I think the cleverest I know), generally arrive on place in these times only if the fire has the kindness to occur very near their centres.

It seems to me a real nonsense, if we want to take in consideration the heat release, it is necessary to do it seriously and without tricks. And if a material produces an initial flame, at low power and short duration, I believe this product should be honestly considered a medium or even few dangerous product.

We will keep on working, in Ad hoc 44 of CEN TC 127 to improve SBI and to change this situation: using also this data, thank to BING and to Companies that have taken part in the program.

The curves you will find in the work, and the index produced by each curve, speak: if data will be used so as it is now required, we will have many good products of class ONE that for many years have never caused problems to be rejected and to be by force replaced by other products that – at least for costs of certifications and analysis- will be much more expensive

Our ideas –mines and of my researchers- about SBI are well known, and I can be quiet: everybody in the world on this side and on the other side of ocean, know I didn't agree.

But I'm sorry, very sorry to have attended the works.

Silvio Messa
Head of Research Team
LSFire Laboratories

Introduction

SBI (Single Burning Item EN 13823) is the European main test for Construction insulating products.
Within a range that includes Euroclasses A1 and A2 (for non combustible material) and which goes down to F for unclassified material, this test method makes possible to place products in the range between Euroclasses B and D (B being the highest level that can be assigned using this method).
To pass EN 11925-2 (ignitability) method, which is very similar to the German DIN 4102 test for B2 classification, is a necessary condition for admittance to the SBI test and also gives Euroclass E classification (15 seconds).
Panels that are to be tested using SBI are assembled in a corner configuration made up of two “wings” of 1×1.5 and 0.5×1.5 metres.
To put things simply, this apparatus measures the power, given in kW, released by the combustion of the sample during the test period. The energy is therefore measured directly in proportion to the consumption of oxygen recorded during the combustion reaction (Oxygen Depletion).
Power vs time curve represents RHR (Rate of Heat Release).

There are four test phases:

1. During the first 120s both burners are kept switched off and the paramagnetic detector records the quantity of oxygen present in the apparatus with no combustion present.
2. From the 120th to the 300th second the secondary burner remains on but its flame does not touch the specimen. This makes possible to evaluate the energy consumption produced by the burning propane only. This value will be taken away from the final combustion curve of the material and, in this way, the energy of the pure specimen will be calculated without the contribution of the burner.
3. The real test takes place from the 300th to the 1500th second. The propane directed towards the secondary burner is deviated to the main burner, and the pilot flame ignites the gas. The extraction system above the corner of the testing apparatus collects the combustion products, and convey them to the exhaustion duct where detectors record the variations of all the analysed parameters.
4. The burner is switched off after 20 minutes (normal test duration); five more minutes are left to let the measured parameters to return to their normal values.

FIGRA (Fire Growth RAte index) according to EN 13823

The FIGRA (Fire Growth Rate), namely the ratio between the immediate RHR value and the time during which this value is recorded , plays an important role in classification.
The following formula shows the mathematical calculation used to obtain the FIGRA value:

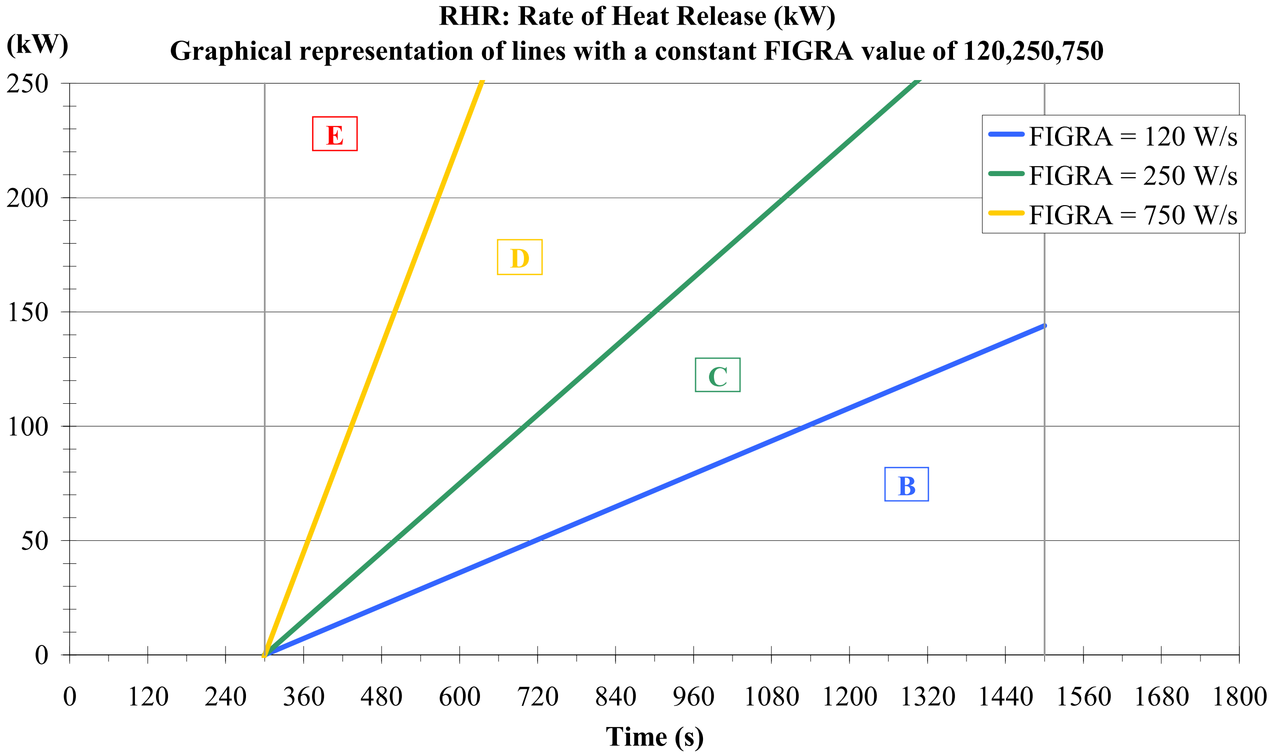
FIGRA

$$\text{FIGRA} = 1000 \times \max\left(\frac{\text{RHR}_{\text{av}}(t)}{t-300}\right) \qquad 1000\times\text{kW/s} = \text{W/s}$$

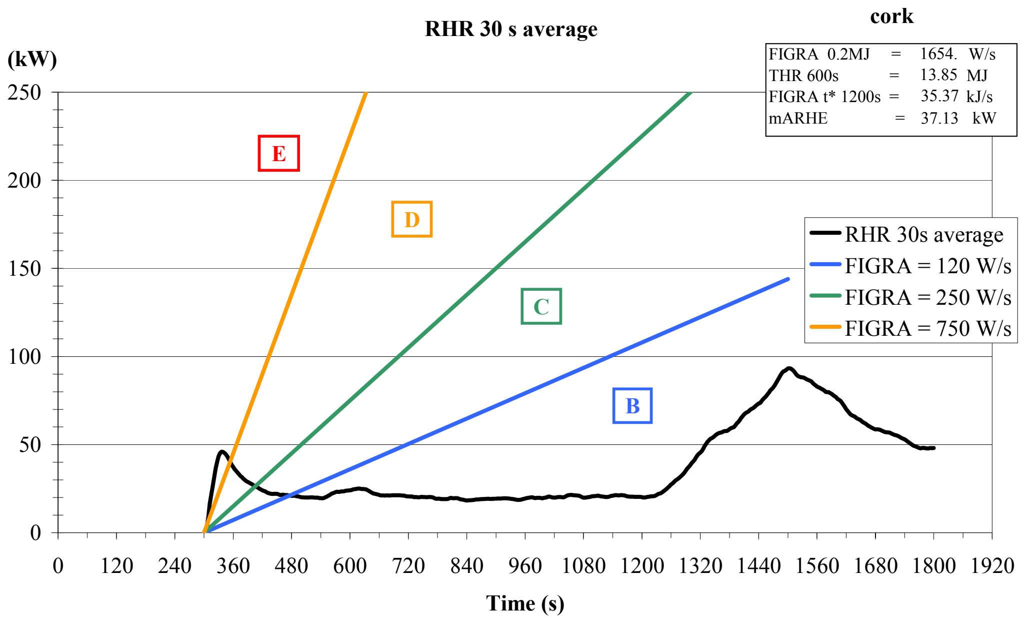
$$\text{THR}(t) = \frac{1}{1000}\sum_{300}^{t}\text{RHR}(t)\times\Delta t \qquad \text{MJ} = \text{MW}\times\text{s}$$

By varying in the formula the class limit values (indicated in the table below), we obtain lines that divide the Cartesian plane into four areas. Each one of these areas has a pertaining Euroclass, as can be seen in the first of the two following graphs:

EUROCLASS	FIGRA	THR 600s
B	Lower than 120 W/s	Lower than 7.5 MJ
C	Between 120 and 250 W/s	Between 7.5 and 15 MJ
D	Between 250 and 750 W/s	Higher than 15 MJ
E	Higher than 750 W/s	Higher than 15 MJ



As an example, the green line represents the points at which the FIGRA value is always equal to 250 W/s. If we therefore position a real combustion curve on this graph, we have an immediate graphical display of the class to which the material belongs (see graph below)



As can be seen, this material has a relatively high RHR(t)/t ratio at the start of combustion and the curve is taken to a position in the class E area, therefore determining in which sector the material belongs.

Critical aspects of the present class attribution system

The previous graph shows how the tested material obtained class E because of the initial value that was barely able to reach 50 kW, even though the peak of approx. 100 kW, which appears at around 1500s keeps the material quite easily inside the class B area.
The FIGRA value can be very high even when the RHR value remains within relatively low limits (20-30 kW), and material classification is penalised if the peak appears during the first few seconds of combustion (a value that is useful for defining the denominator in the FIGRA calculation algorithm).
A FIGRA value calculated in this manner, therefore, does not consider the energy released by the material during combustion in a reasonable way but concentrates almost exclusively on the product's ignition rate.
A 20-40 kW fire is not a serious risk especially when the highest power peak is limited through time, even if the power is reached in a short time.
The situation becomes more dangerous, however, if the fire takes just a few minutes to reach a power of 60-80 kW (or more) and the release of energy is slower but in continual growth through time.
As the test proceeds and as various materials that are commonly used in construction work are evaluated using SBI, it is easy to see that notable differences are found when organising and classifying the various combustion curves because the results are based on a parameter that leans towards the facility of ignition. Unfortunately, these differences have distorted classifications that were once considered as being valid from a fire prevention point of view.
Italian regulators, collaborating with and using the experience of the LSF, have made a proposal to CEN127 to use different algorithms than FIGRA, which is calculated using the present method. These new algorithms make possible to rank the fire reaction curves in a more logical and balanced way.
Two alternative methods (mARHE and FIGRA calculated at barycentric time – FIGRA t*) were proposed.

MAHRE (Maximum Average of Heat Emission)

This index, approved by TC 256, was created by Gary J. Duggan within the working group that co-ordinates standards in the railway sector.
The mARHE calculation method determines the average energy value generated during each combustion period in which the RHR value is measured (the integral of the RHR curve during a certain time period represents the energy developed by the specimen during that interval).
The points obtained by summing the separate areas and dividing them by the corresponding time gives the ARHE curve (average rate of heat emission), the maximum of which is, by definition, the mARHE.
This type of algorithm has the advantage of balancing the ignitability (determined by the slope of the initial peak develops) and the total energy that is developed during combustion (represented by RHR integral during the total running time of the test).

mARHE

$$ele(t) = \frac{\left(RHR(t) + RHR(t-1)\right)}{2} \times \Delta t$$ kW×s ele = the trapezoidal area for each interval

$$arhe(t) = \frac{\sum_{300}^{t} ele(t)}{t - 300}$$ kW

$$marhe = \max\left(arhe(t)\right)$$ kW

FIGRA based on barycentric time (t*1200)

The barycentre of a function is the point that divides the integral of the function into two equivalent parts in a defined interval. In our case, the barycentric time represents the time at which the material being tested releases half of its energy during the 1200 seconds (test duration). Dividing the THR (Total Heat Release, i.e. the total of the energy developed during combustion) obtained at the time (t) by the barycentric time (t*) we once again acquire a set of points that generate the barycentric time curve.
This interpretation of the RHR curve again considers both the fire development rate and the total quantity of energy developed.

FIGRA t*

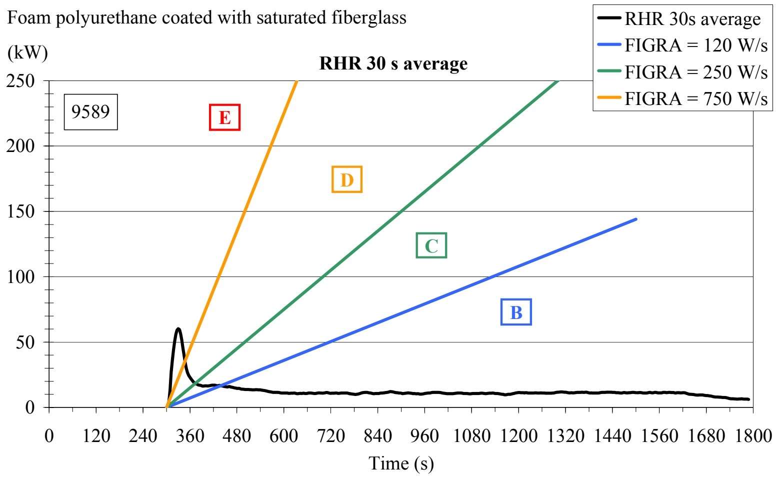
$$t^*(t) = barycentric\_time = \frac{\sum_{300}^{t}\left(RHR(t) \cdot t \cdot \Delta t\right)}{\sum_{300}^{t}\left(RHR(t) \cdot \Delta t\right)}$$ s Definition of barycentre function

$$FIGRA\_t^*(t) = 1000 \times \frac{THR(t)}{barycentric\_time}$$ 1000×MJ/s = kJ/s = kW

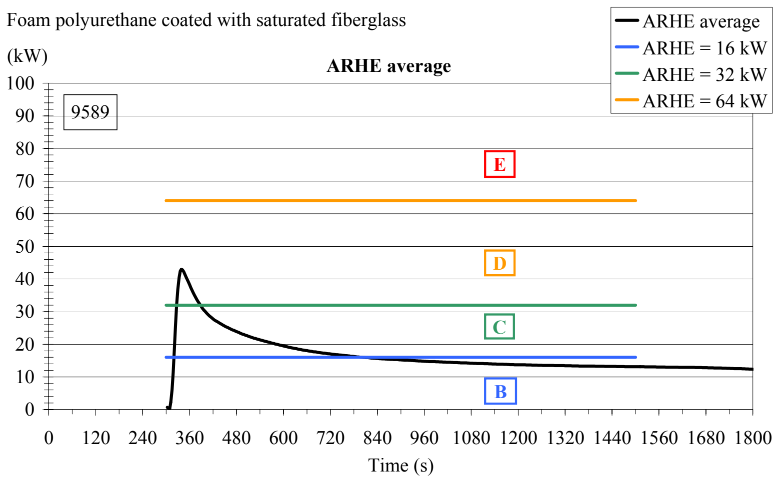
In order to simulate classification of products by using these two parameters, LSF proposed the following limit values:

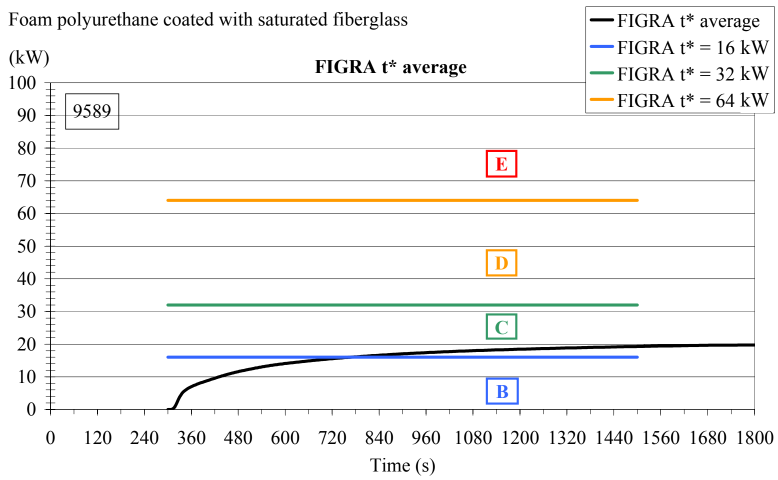
EUROCLASS	MARHE and FIGRA t*
B	Lower than 16 kW
C	Between 16 and 32 kW
D	Between 32 and 64 kW
E	Higher than 64 kW

As can be seen in the graphs below, an RHR curve evaluated using the FIGRA value, calculated in accordance with the current legislation, was compared with the possible representations and classifications obtained using the mARHE and FIGRA t* methods. The same reading key makes it possible to interprete the curves and the classifications obtained from 14 insulating products that were analysed in this project. All the relevant curves are shown in Annex B, included in this report.



FIGRA 0.2MJ	=	2471 W/s
THR 600s	=	9.15 MJ
FIGRA t* 1200s	=	19.3 kW
mARHE	=	42.9 kW





Then if the classes limit are considered according to the following table:

First proposal

CLASS	FIGRA	mARHE	FIGRA t*
	W/s	kW	kW
B	120	16	16
C	250	32	32
D	750	64	64
E			

And if the materials are ordered according to one of calculated parameters (in grey the column with growing rules), the following table is obtained:

N° material	FIGRA 0.2MJ	mARHE	FIGRA t* 1200s
	W/s	kW	kW
13	56	3	4
12	361	13	16
11	590	34	25
2	683	20	17
8	1105	21	27
9	1266	58	37
10	1279	70	69
7	1501	125	97
14	1654	34	35
4	1844	33	23
1	1918	29	12
3	2189	40	17
6	2348	52	26
5	2472	43	19

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8	1105	21	27
14	1654	34	35
9	1266	58	37
10	1279	70	69
7	1501	125	97

The cells are coloured to highlight the changing class depending on the considered parameter.

List of the tested materials:

N°	Test code	Material description	Thick	Mounting + Fixing	Facer
1	9585	Rigid PIR foam: blowing agent normal pentane	30	Mech Fastening	Saturated Fiberglass
2	9586	Rigid PIR foam: blowing agent normal pentane	30	Mech Fastening	Aluminium foil 60 µm
3	9587	Rigid PIR foam: blowing agent normal pentane	30	Mech Fastening	Fiberglass + Mineral coating
4	9588	Rigid PIR foam: blowing agent normal pentane	80	Mech Fastening	Saturated Fiberglass
5	9589	Rigid PIR foam: blowing agent normal pentane	30	Mech Fastening	Saturated Fiberglass
6	9590	Rigid PUR foam: blowing agent water (open cells)	30	Mech Fastening	Saturated Fiberglass
7	9591	Rigid PUR foam: blowing agent Hydro Fluoro Carbon	60	Mech Fastening	Aluminium foil 40 µm
8	9592	Rigid PIR foam: blowing agent Hydro Fluoro Carbon	30	Mech Fastening	None
9	9593	Extruded Polystyrene Foam (XPS)	30	Glued	None
10	9594	Extruded Polystyrene Foam (XPS)	60	Glued	None
11	9595	Expanded Polystyrene Foam (EPS)	30	Glued	None
12	9596	Expanded Perlite (EPB)	30	Mech Fastening	None
13	9597	Mineral Wool (MW)	40	Mech Fastening	None
14	9598	Expanded Cork (ICB)	30	Mech Fastening	None

Results

1. Once again has been demonstrated that SBI test parameters for classification (FIGRA) strongly penalises those products that present a relative high ignition rate compared to a relatively low total energy release; whit the present SBI classification the total energy release is not taken into account at all.
2. The ranking of curves using FIGRA as parameter does not give a fair and balanced representation of the real behaviour of products subjected to the test. In Annex A the ranking of the curves obtained according FIGRA, mARHE and FIGRA t* shown clearly this kind of anomaly.
3. Parameters like lateral spread of flame (damaged area) and spread of flame rate, which are important for the Italian classification, are not evaluated whit the present SBI test configuration.
4. The objective of the test, i.e. the complete evaluation of a product whit regard to reaction to fire, is not reached as well the correlation whit the reference scenario (ISO 9705 room corner test)
5. Several materials, well known for their good performance in reaction to fire turn out to be penalised according this unrealistic classification method (i.e. Perlite class D). The gap between the two most important families of insulant material (inorganic and organic product) results strongly increased whit the classification system adopted for SBI. Such wide gap were not present in none of the national classification system which are considered performing well in the past.

ANNEX A

Legend of following graphs

Energy produced after 10 minutes
the mail burner ignites

Energy produced in the following 10 minutes
(ignored by classification)

Following fire grow; not considerated

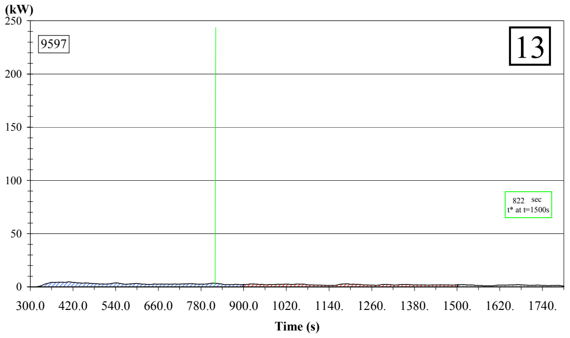
Barycentric time, it indicates when half
of energy was produced

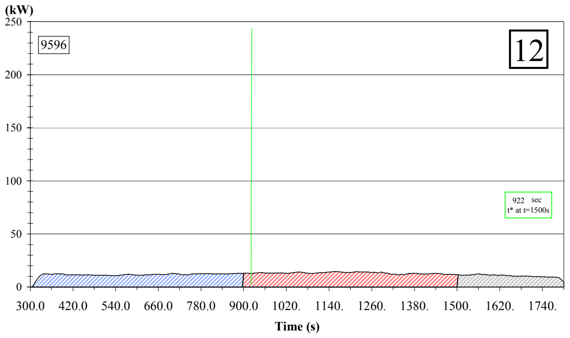
Graphs of RHR 30s, average on 3 tests

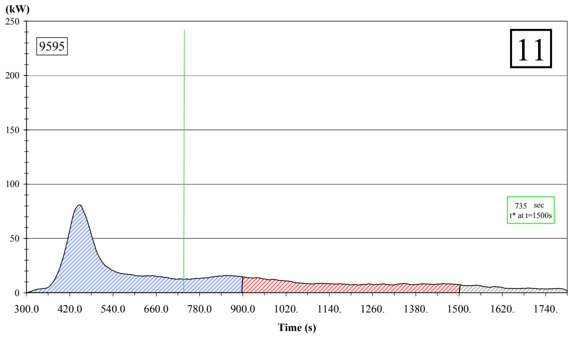
Table A

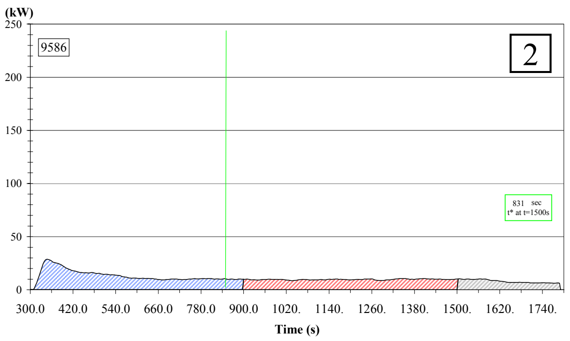
Ordering by FIGRA 0.2MJ

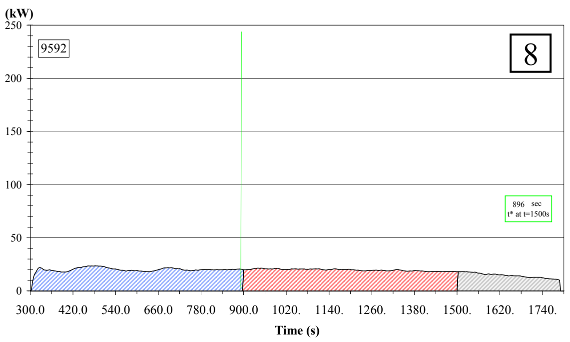
1 - FIGRA 0.2MJ increasing



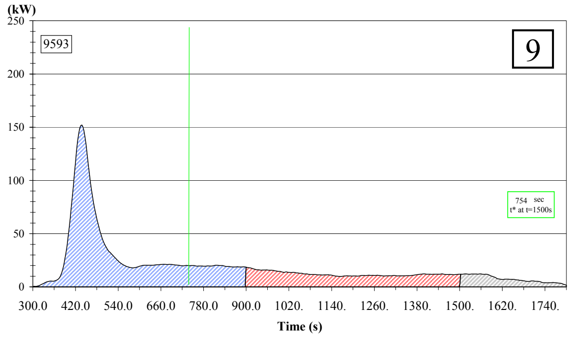


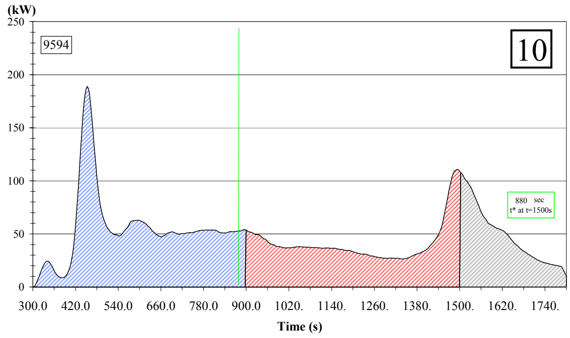


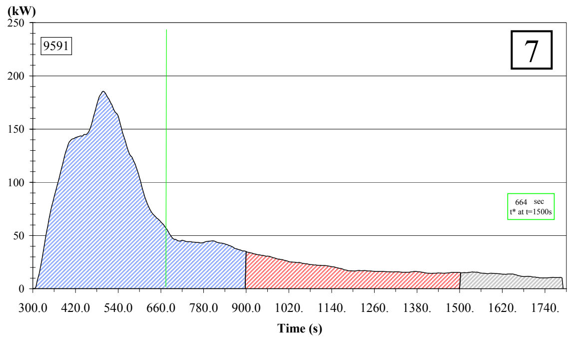


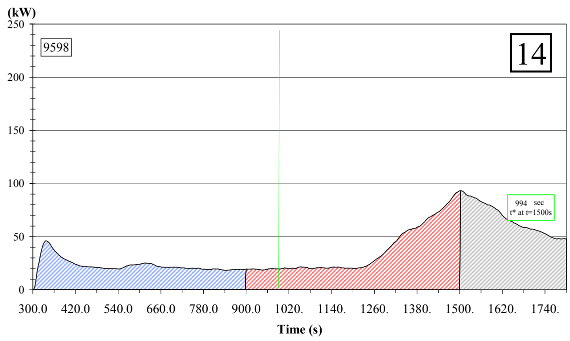


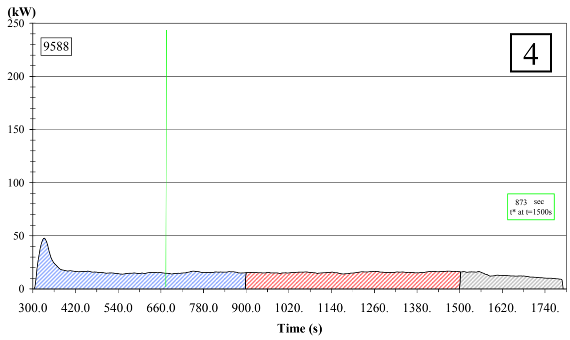
2 - FIGRA 0.2MJ increasing







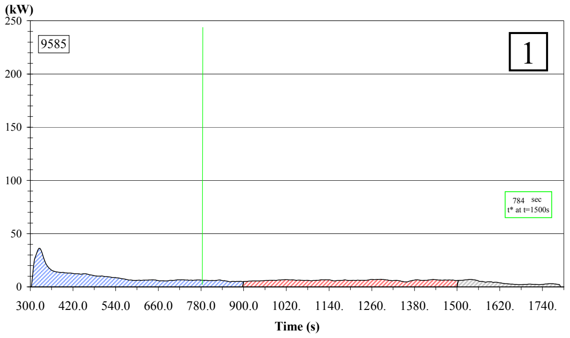


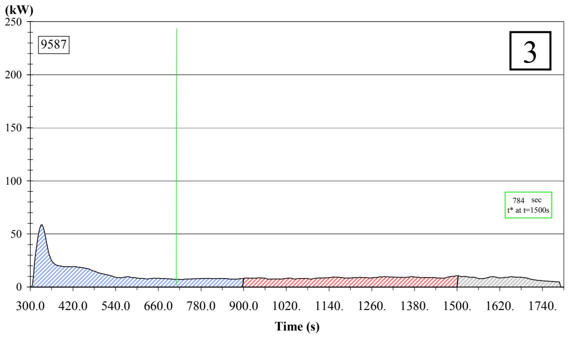


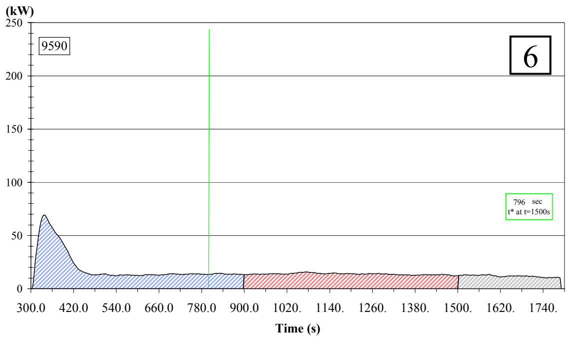
Graphs of RHR 30s, average on 3 tests

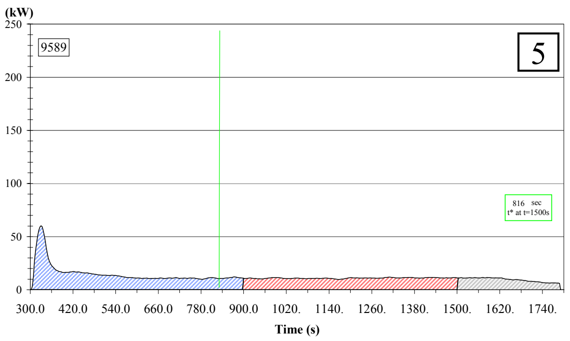
Table A

3 - FIGRA 0.2MJ increasing



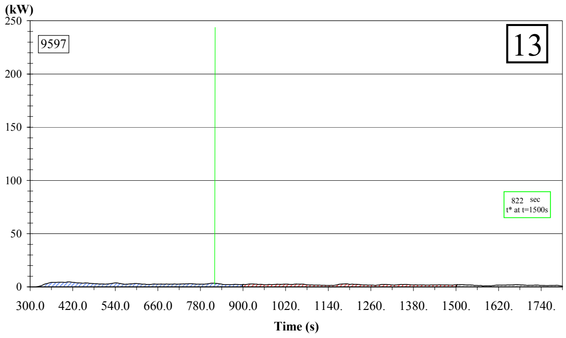


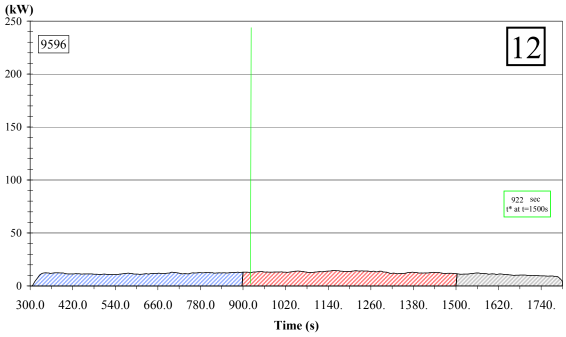


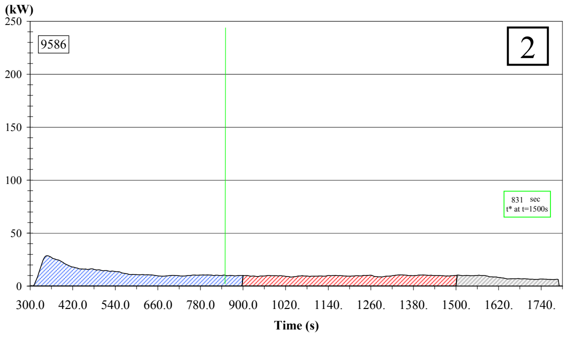


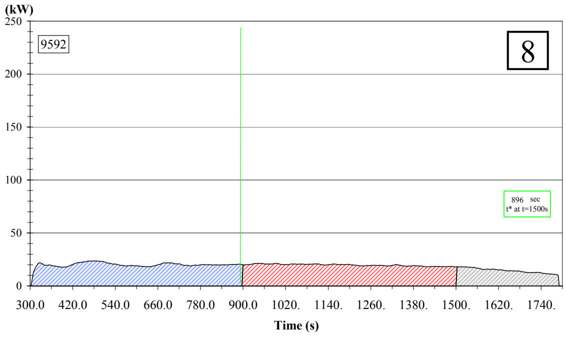
Ordering by mARHE

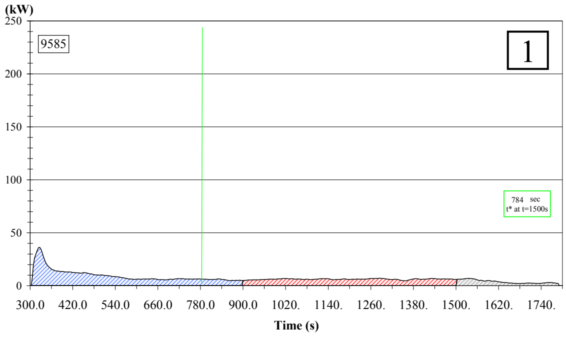
1 - mARHE increasing











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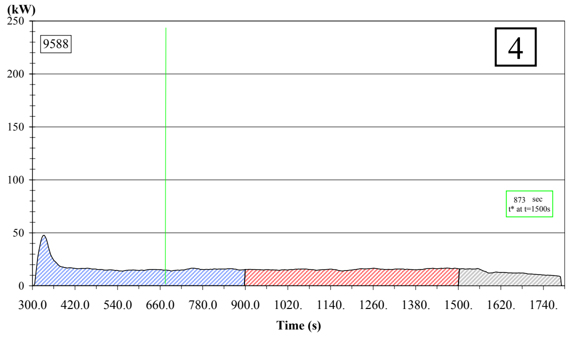
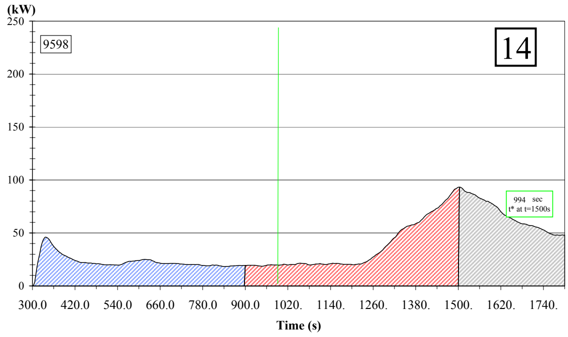
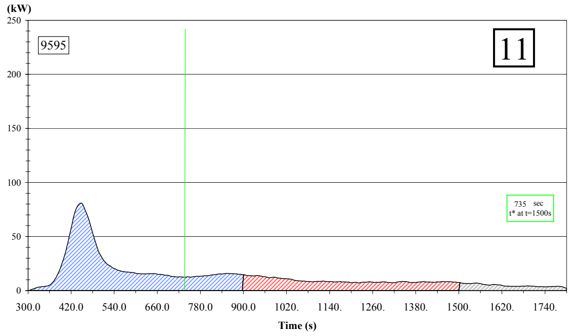
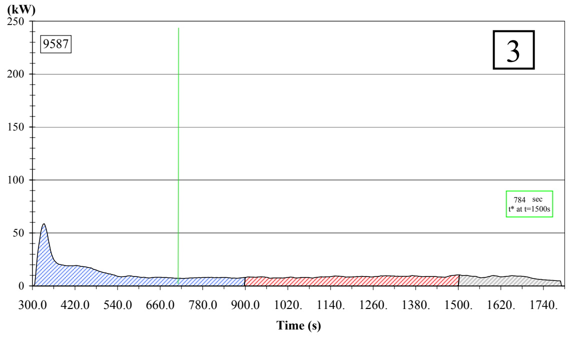








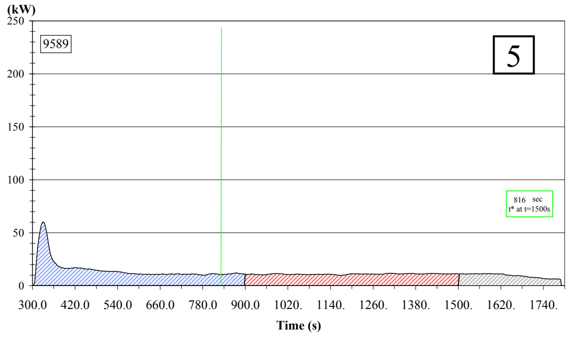
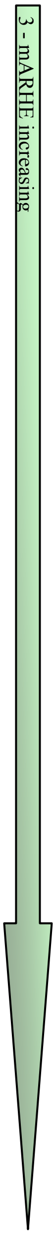
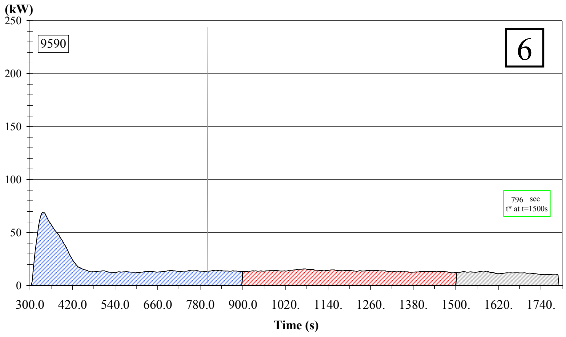
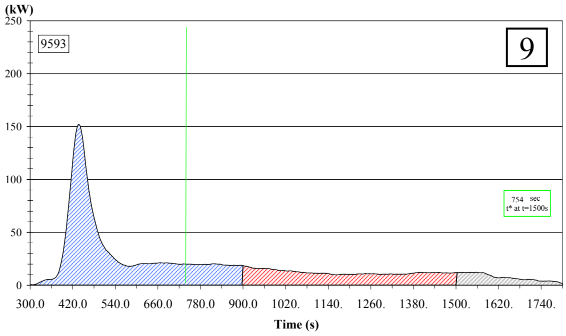
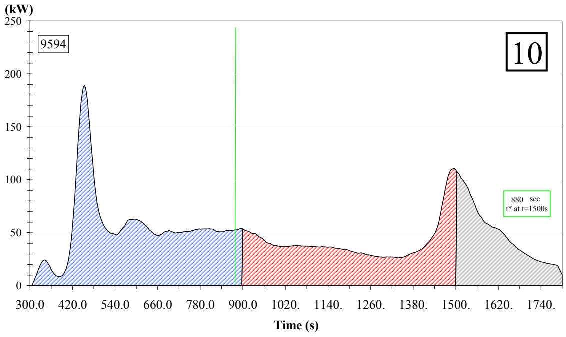


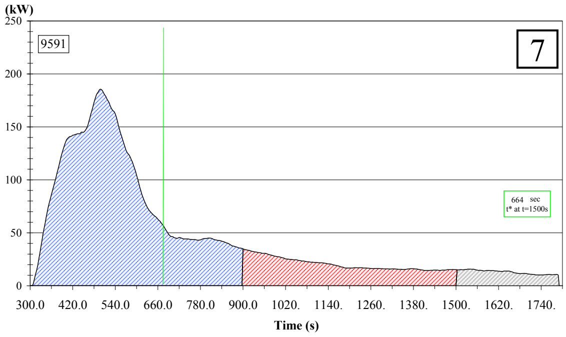
Table C


3 - mARHE increasing


(kW)
9590
6
796 sec
t* at t=1500s
Time (s)


(kW)
9593
9
754 sec
t* at t=1500s
Time (s)


(kW)
9594
10
880 sec
t* at t=1500s
Time (s)

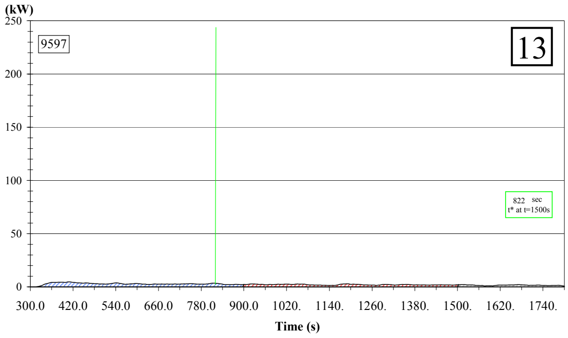

(kW)
9591
7
664 sec
t* at t=1500s
Time (s)

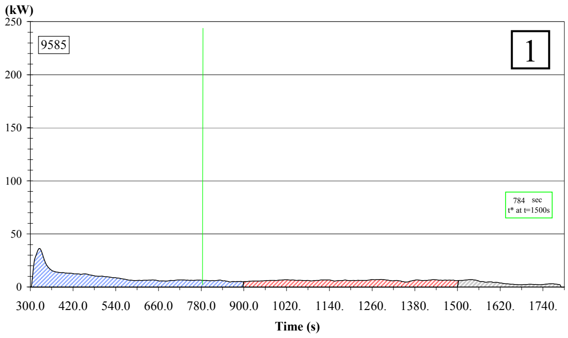
Graphs of RHR 30s, average on 3 tests

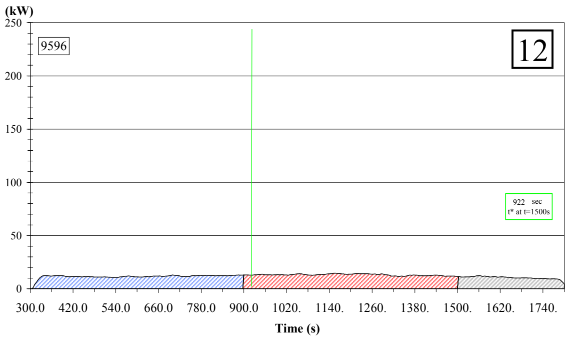
Table B

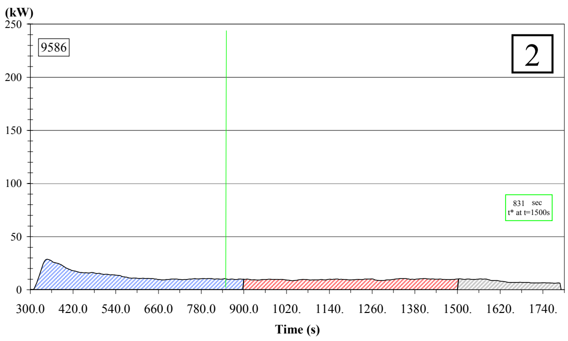
Ordering by FIGRA t* 1200s (LSF)

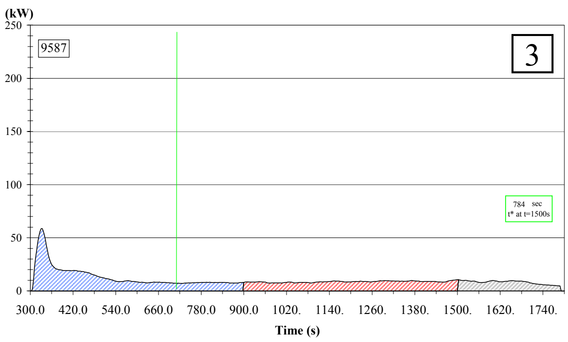
1 - FIGRA t* 1200s increasing



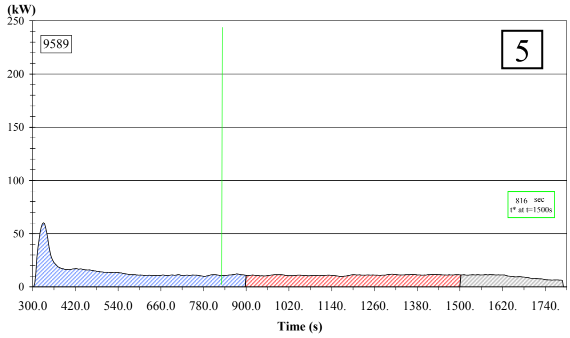


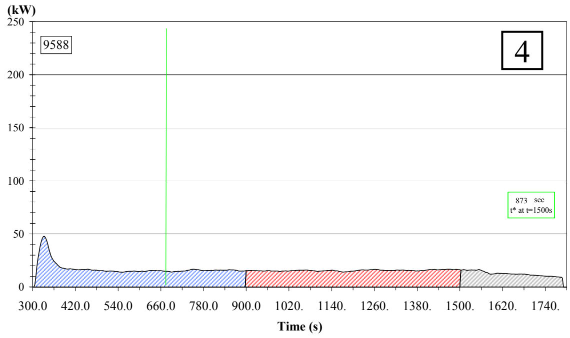


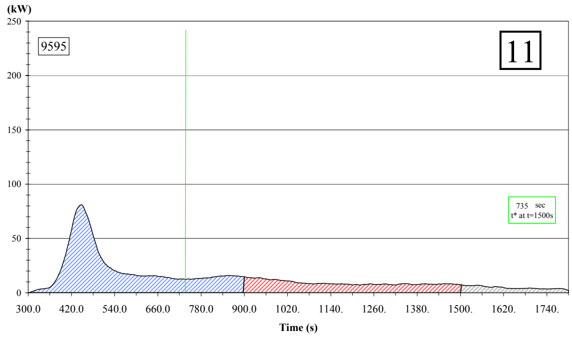


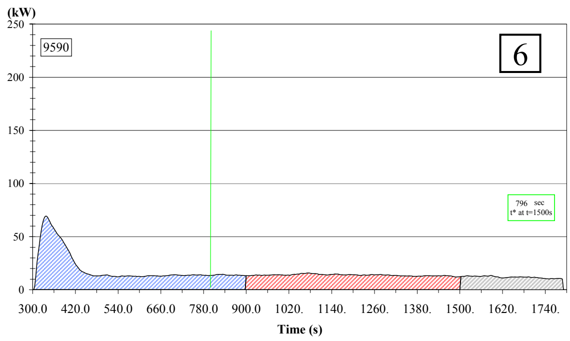


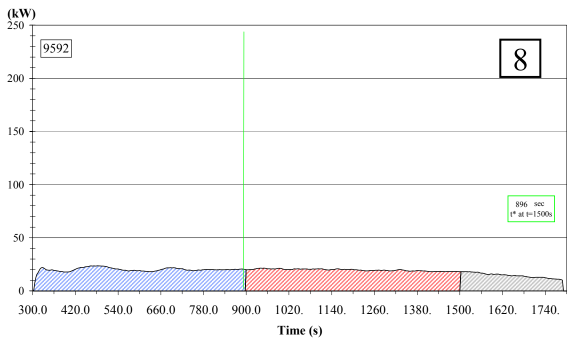
2 - FIGRA t* 1200s increasing





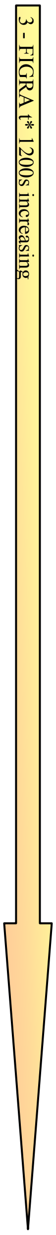


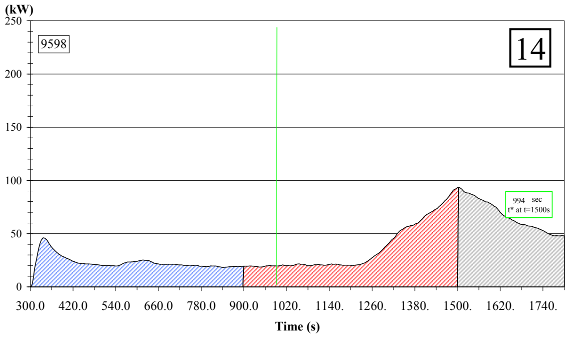


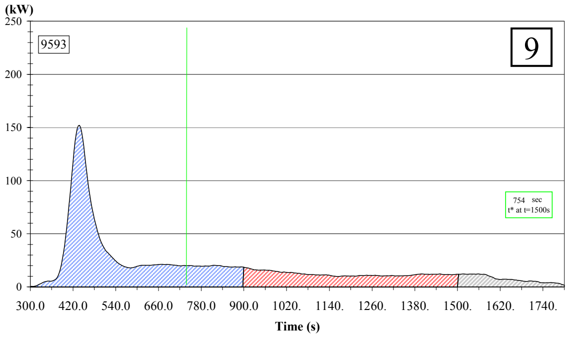


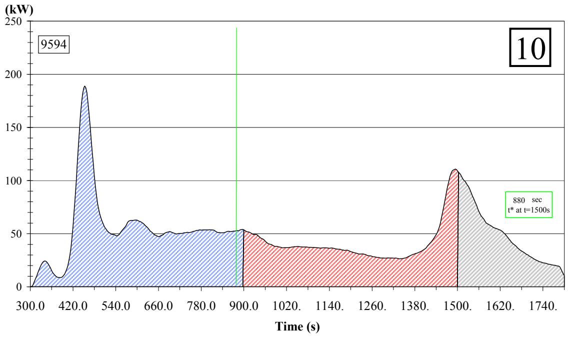
Graphs of RHR 30s, average on 3 tests

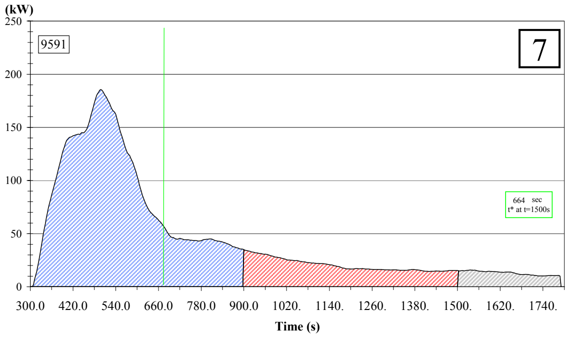
Table B





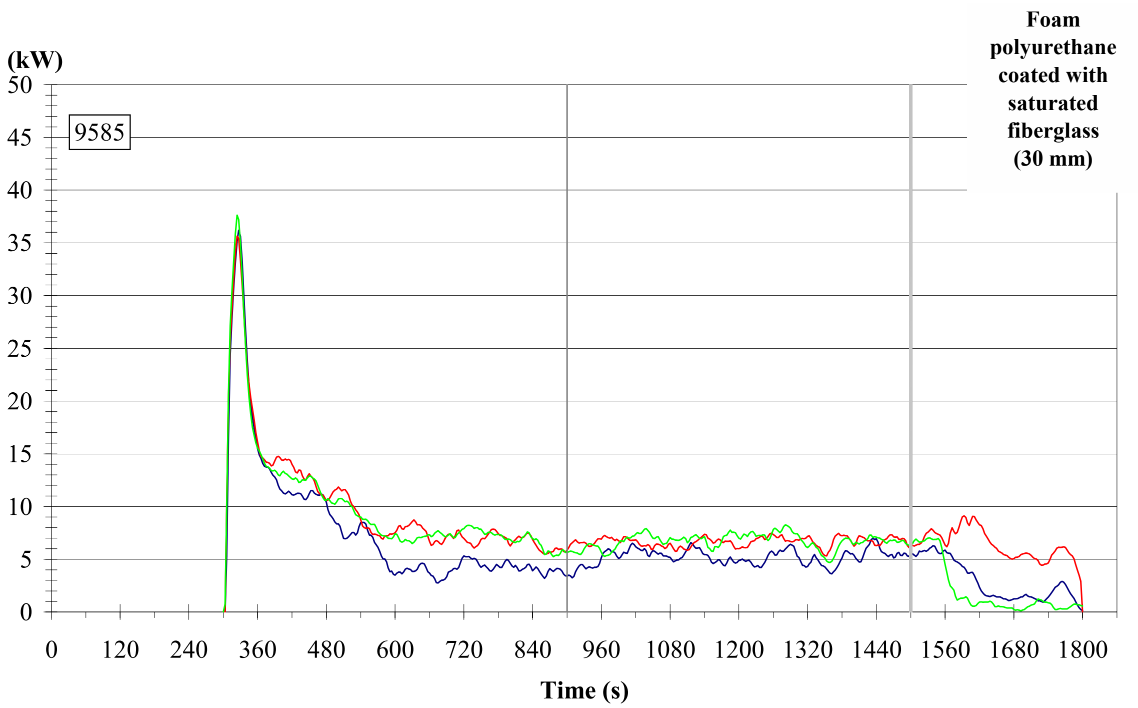


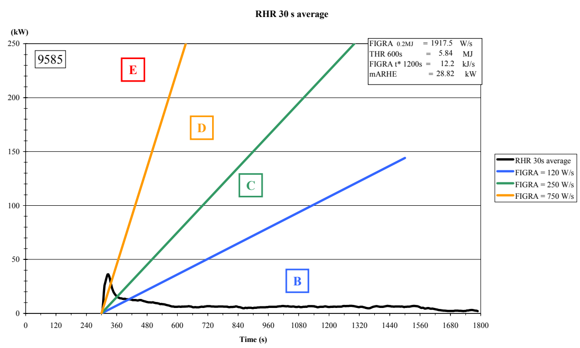


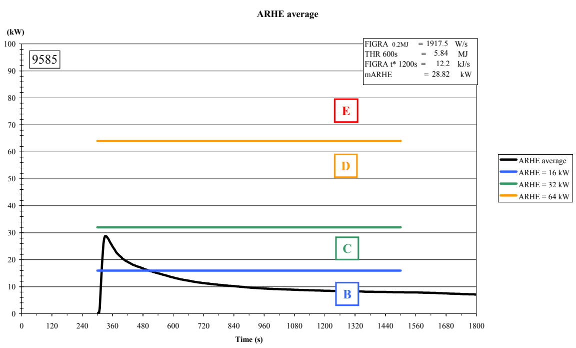


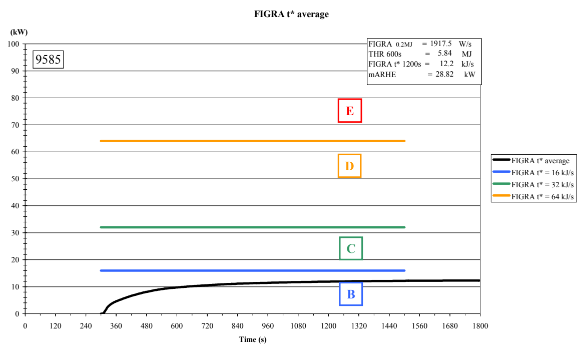
ANNEX B

Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)				
	9585-1	9585-2	9585-3	*average*
FIGRA [W/s] 0,2 MJ	1843.45	1896.92	2012.27	*1917.5*
THR600s (=RHR integral) [MJ]	4.97	6.30	6.24	*5.8*
mAHRE [kW]	27.83	28.47	30.18	*28.8*
FIGRA t* 1200s [1000·MJ/s]	10.5	13.1	13.0	*12.2*





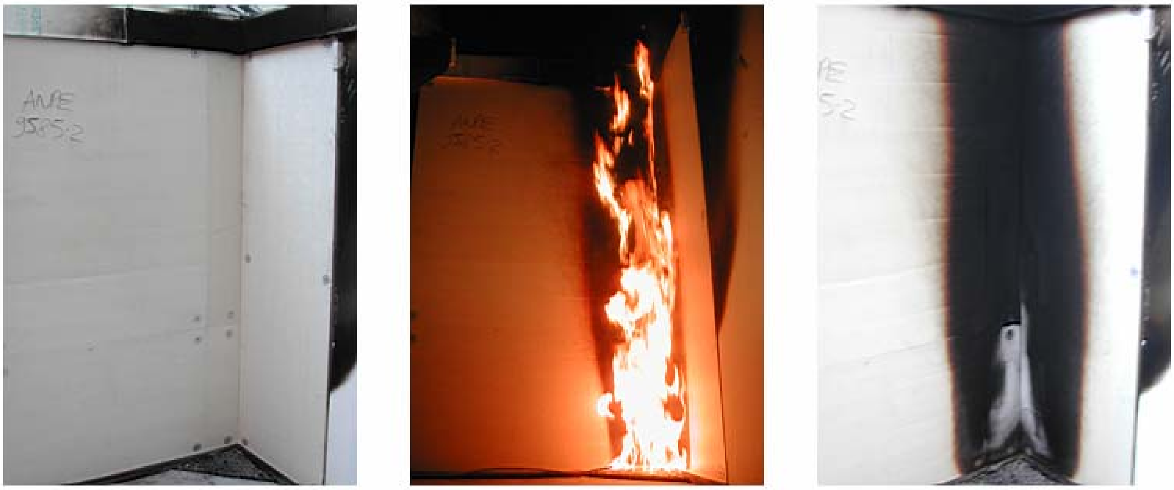




Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)

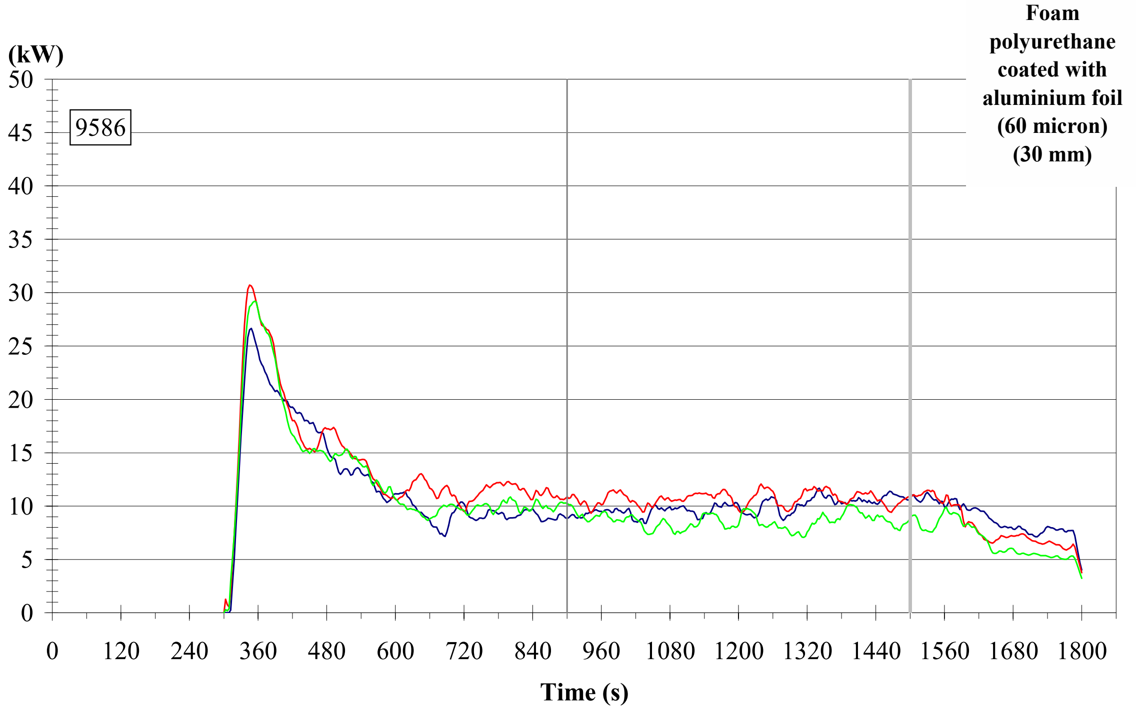
TEST 1

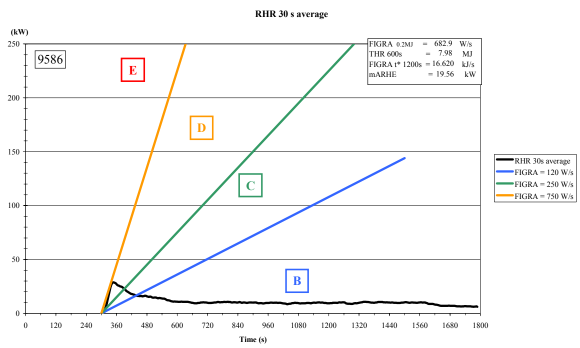
TEST 2

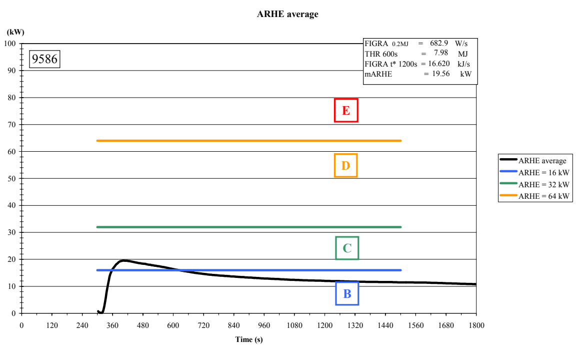


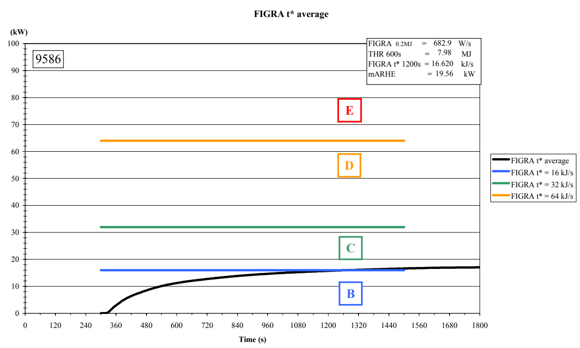
TEST 3

Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)				
	9586-1	9586-2	9586-3	*average*
FIGRA [W/s] 0,2 MJ	617.28	748.74	682.63	*682.9*
THR600s (=RHR integral) [MJ]	7.52	8.55	7.88	*8.0*
mAHRE [kW]	18.02	20.87	20.23	*19.7*
FIGRA t* 1200s [1000·MJ/s]	15.9	17.9	16.1	*16.6*





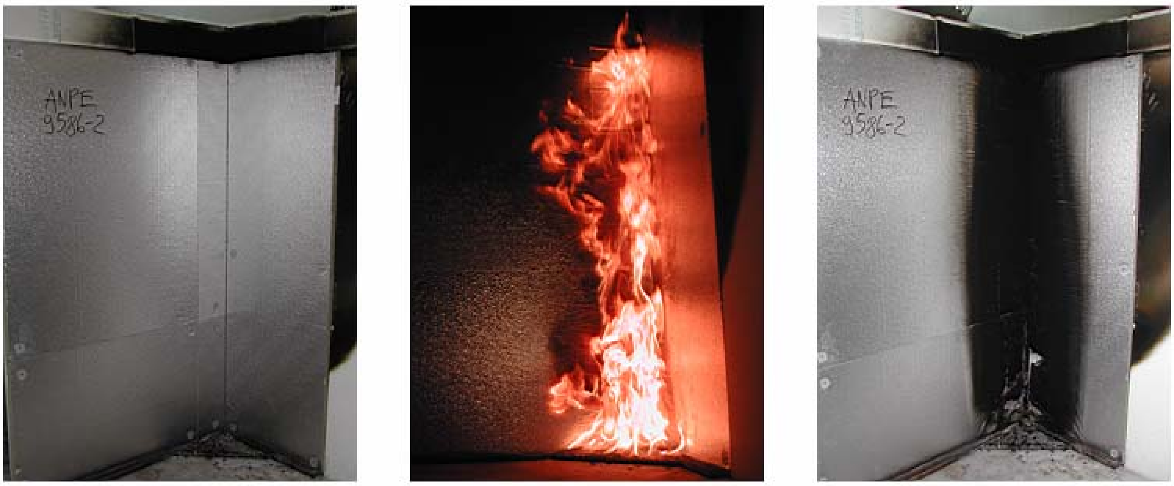




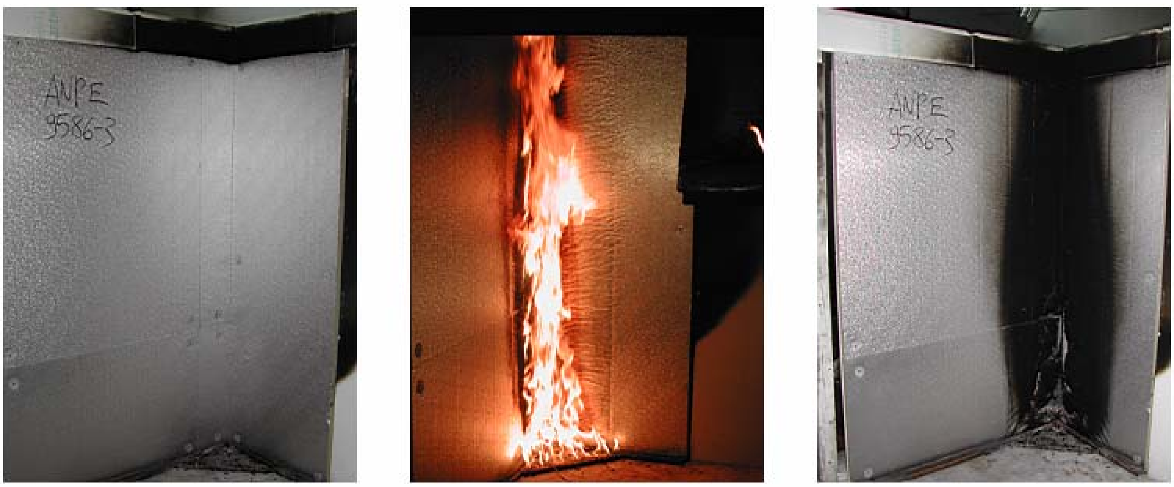
Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)

TEST 1

TEST 2

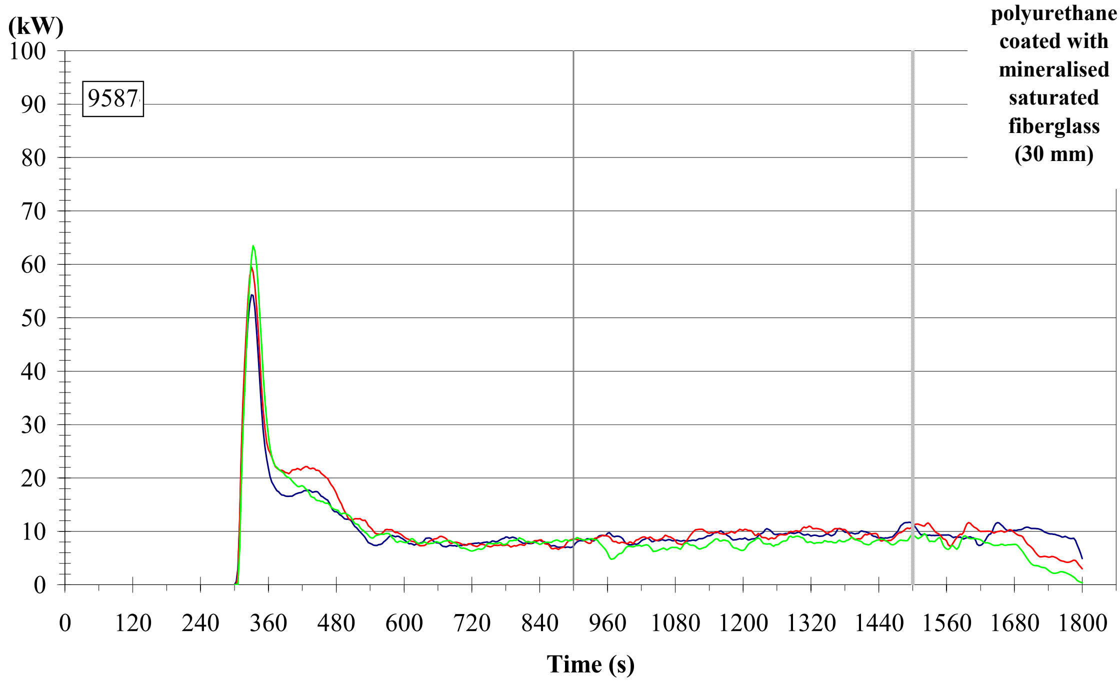


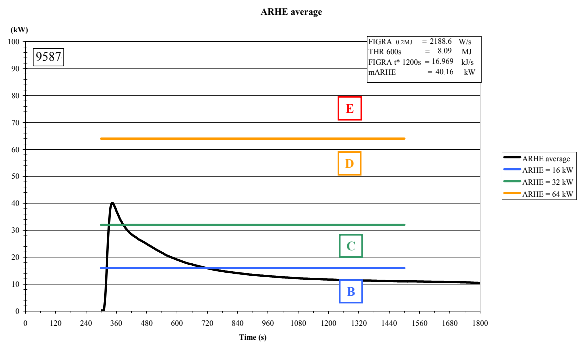
TEST 3

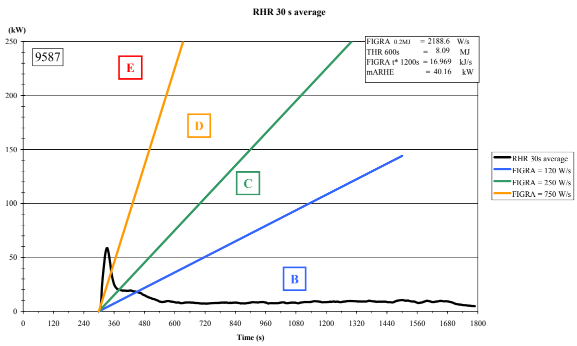


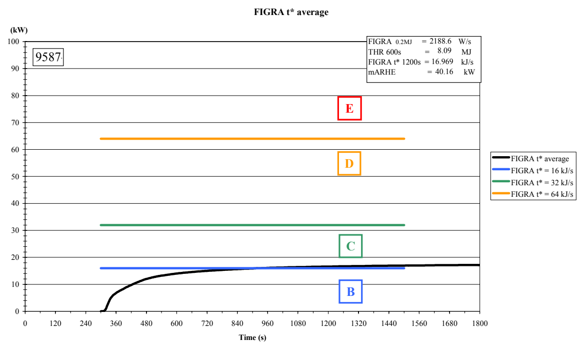
Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)				
	9587-1	9587-2	9587-3	*average*
FIGRA [W/s] 0,2 MJ	2133.77	2301.51	2130.40	*2188.6*
THR600s (=RHR integral) [MJ]	7.61	8.51	8.14	*8.1*
mAHRE [kW]	38.09	41.63	41.61	*40.4*
FIGRA t* 1200s [1000·MJ/s]	16.2	18.0	16.7	*17.0*

Foam polyurethane coated with mineralised saturated fiberglass (30 mm)







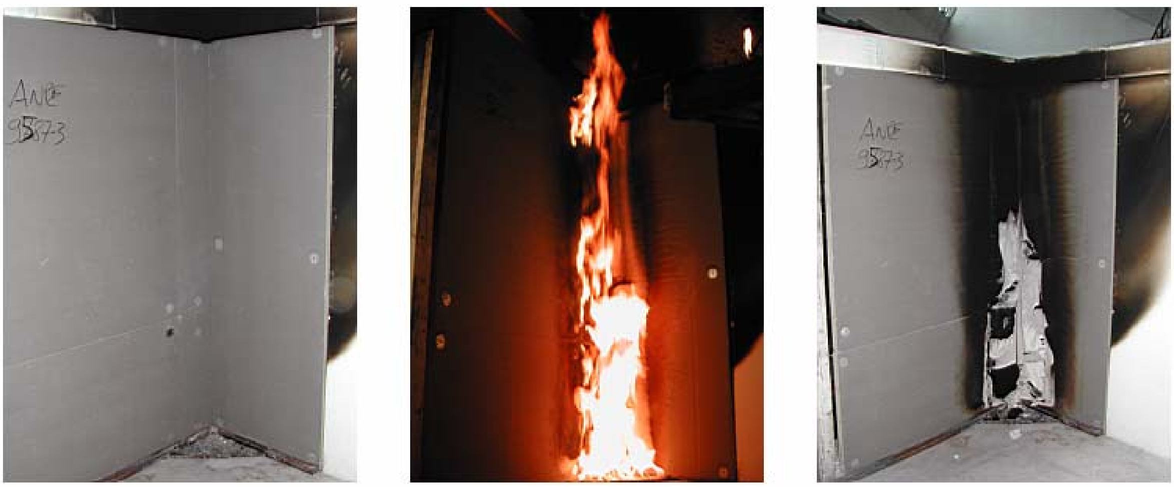


Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)

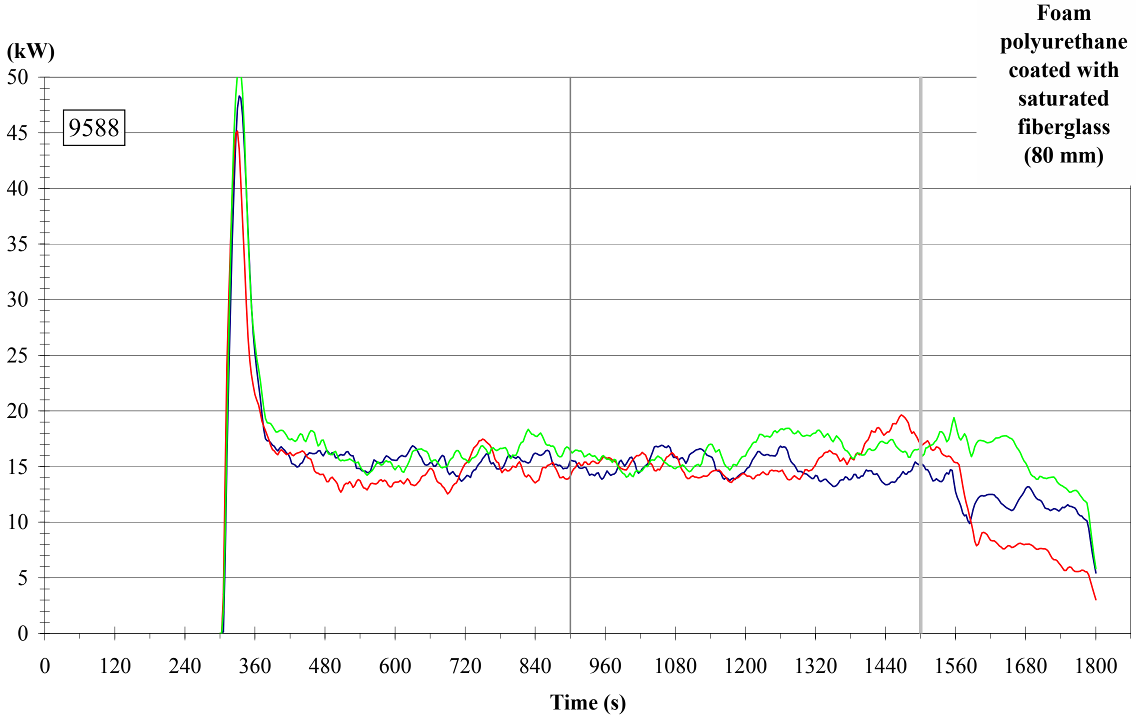
TEST 1

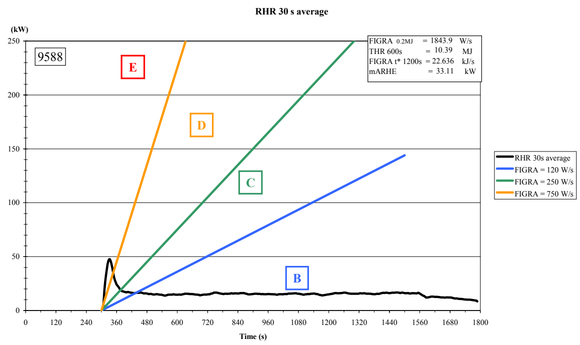
TEST 2

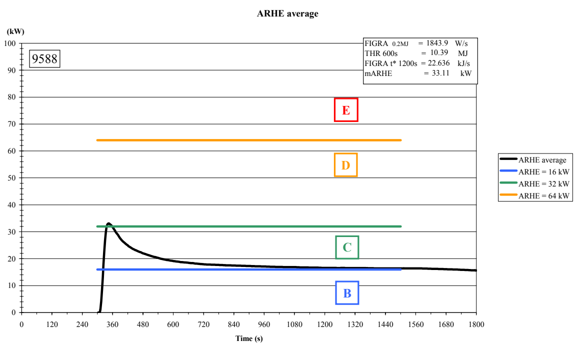
TEST 3

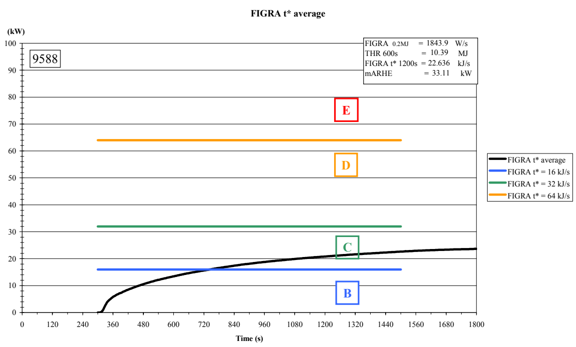


Rigid PIR foam: blowing agent normal pentane (thickness 80 mm)				
	9588-1	9588-2	9588-3	*average*
FIGRA [W/s] 0,2 MJ	1672.65	1959.98	1899.02	*1843.9*
THR600s (=RHR integral) [MJ]	10.41	9.79	10.97	*10.4*
mAHRE [kW]	32.15	32.88	34.86	*33.3*
FIGRA t* 1200s [1000·MJ/s]	22.5	21.6	23.8	*22.6*









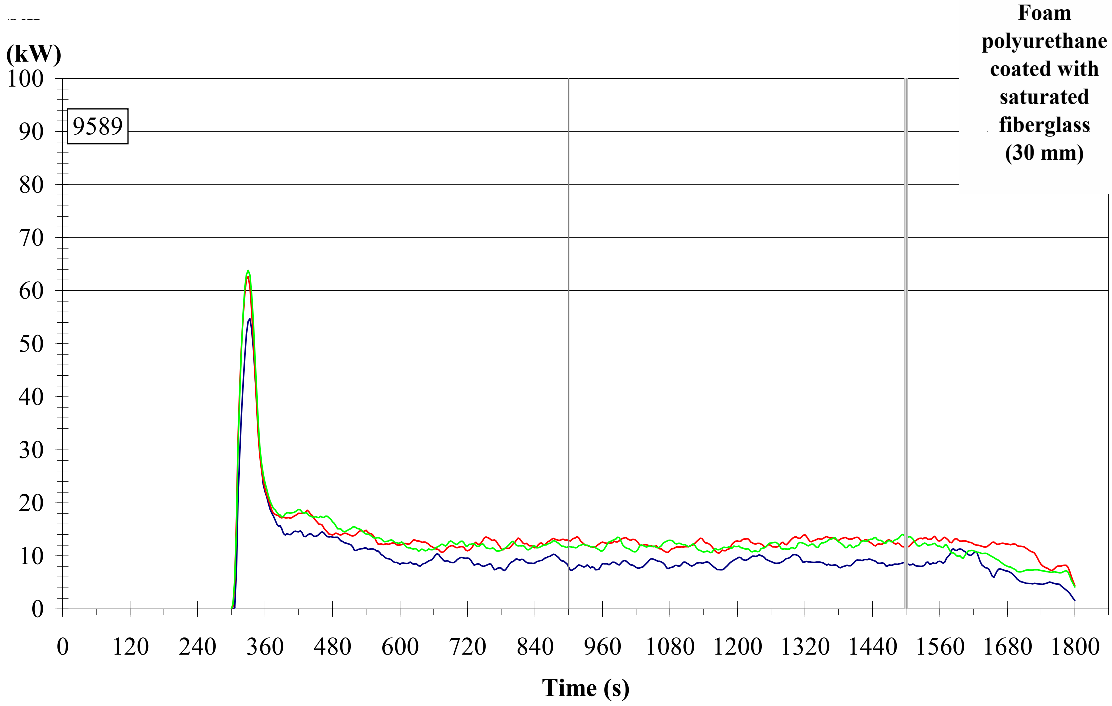
Rigid PIR foam: blowing agent normal pentane (thickness 80 mm)

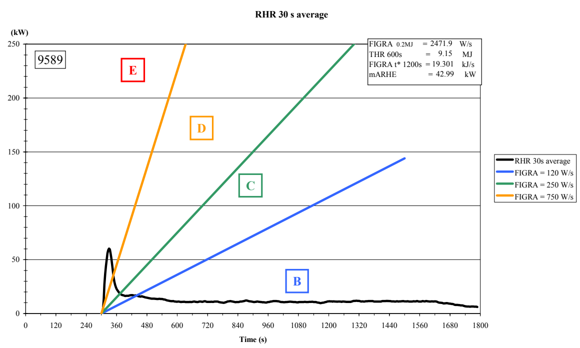
TEST 1

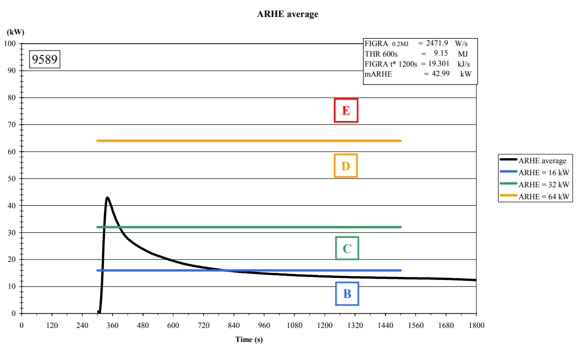
TEST 2

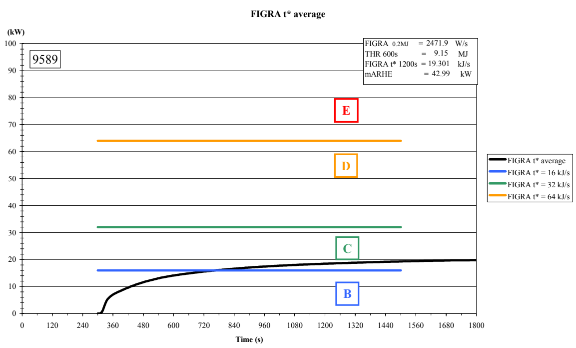
TEST 3

Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)				
	9589-1	9589-2	9589-3	*average*
FIGRA [W/s] 0,2 MJ	2009.59	2722.17	2683.91	*2471.9*
THR600s (=RHR integral) [MJ]	7.83	9.75	9.87	*9.1*
mAHRE [kW]	37.05	45.72	46.66	*43.1*
FIGRA t* 1200s [1000·MJ/s]	16.3	20.8	20.8	*19.3*









Rigid PIR foam: blowing agent normal pentane (thickness 30 mm)

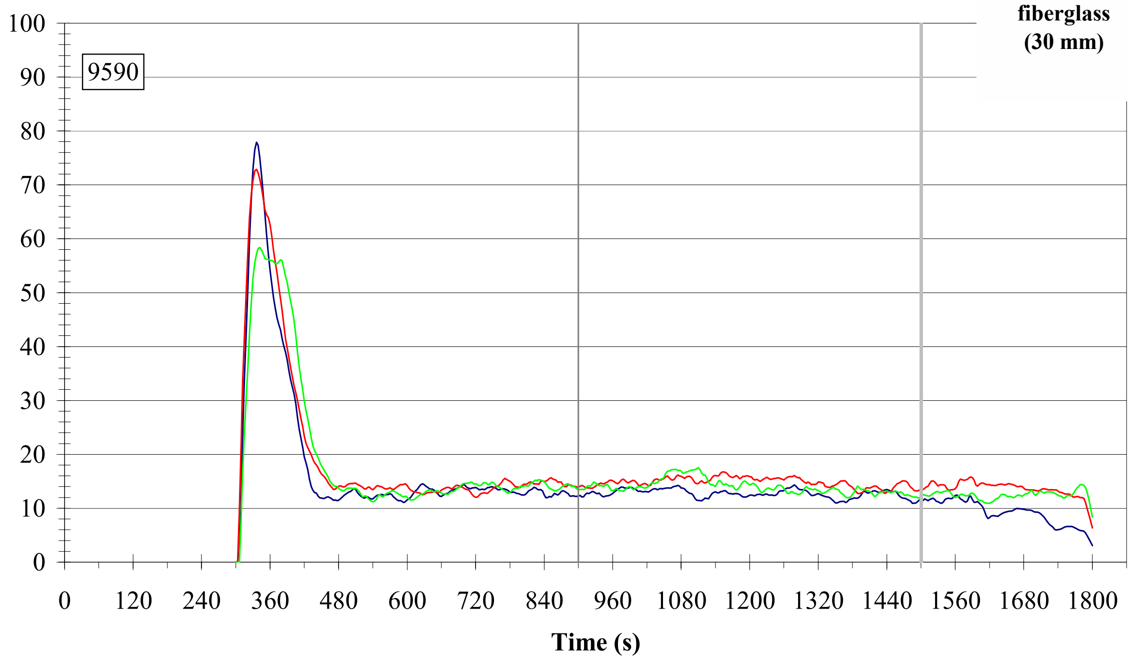
TEST 1

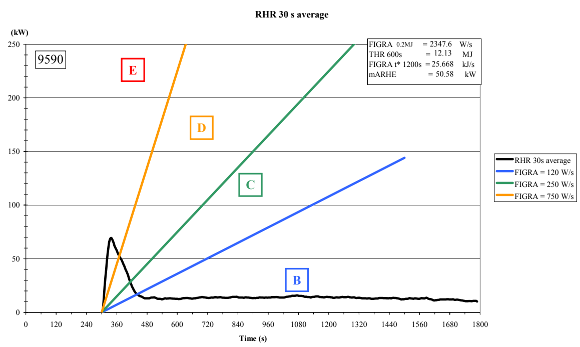
TEST 2

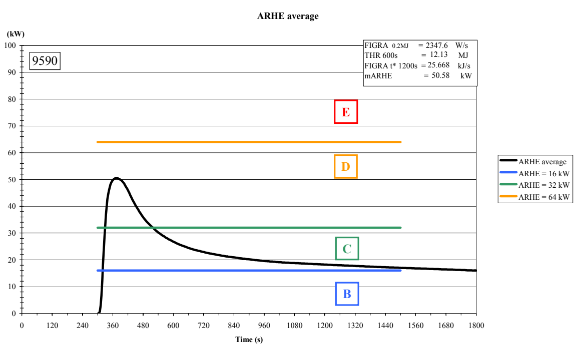
TEST 3

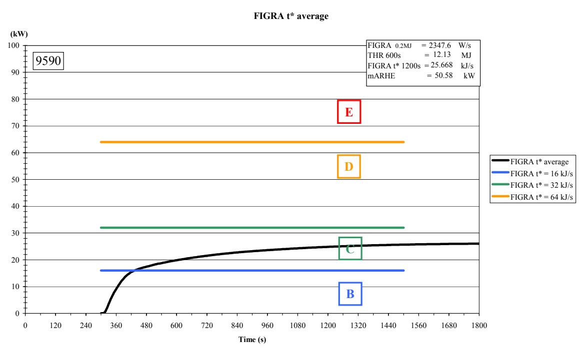
Rigid PUR foam: blowing agent water (open cells) (thickness 30 mm)				
	9590-1	9590-2	9590-3	*average*
FIGRA [W/s] 0,2 MJ	2488.33	2777.33	1777.21	*2347.6*
THR600s (=RHR integral) [MJ]	11.55	12.68	12.15	*12.1*
mAHRE [kW]	52.81	56.30	46.37	*51.8*
FIGRA t* 1200s [1000·MJ/s]	24.3	27.0	25.7	*25.7*

PUR coated with saturated fiberglass (30 mm)



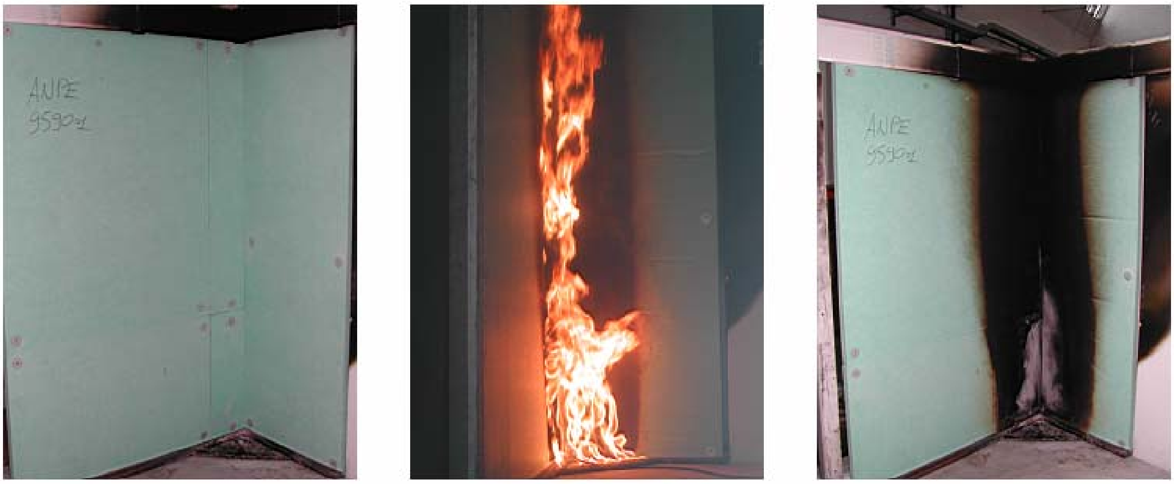






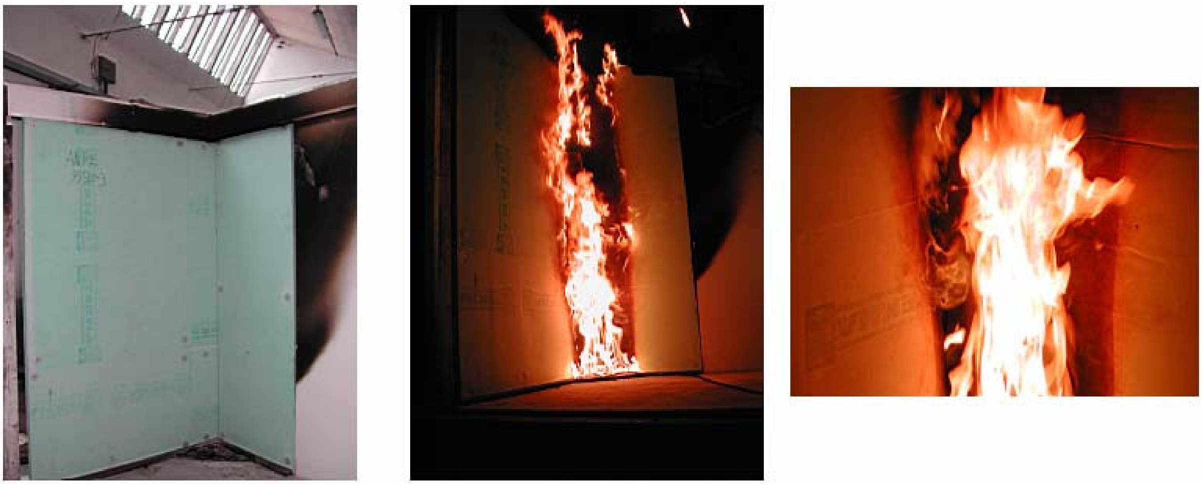
Rigid PUR foam: blowing agent water (open cells) (thickness 30 mm)

TEST 1

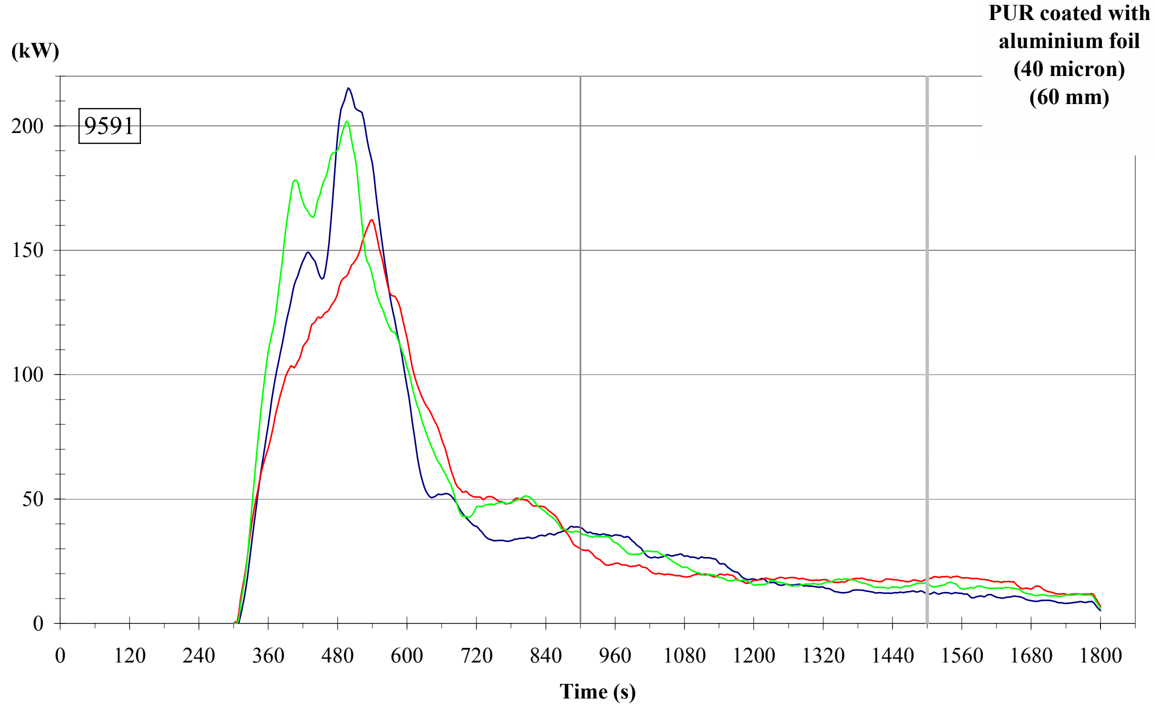


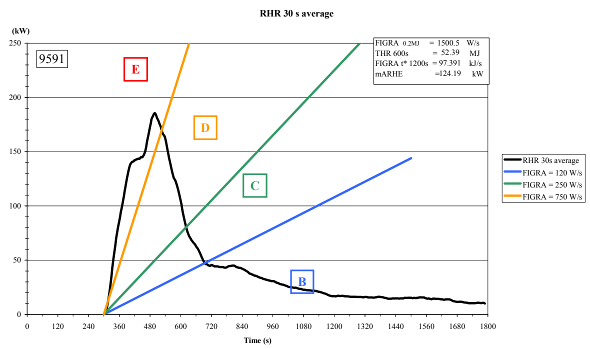
TEST 2

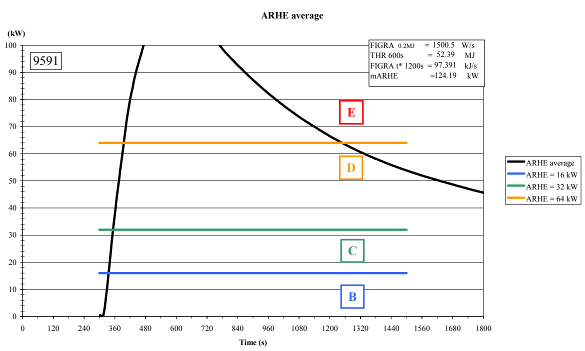
TEST 3

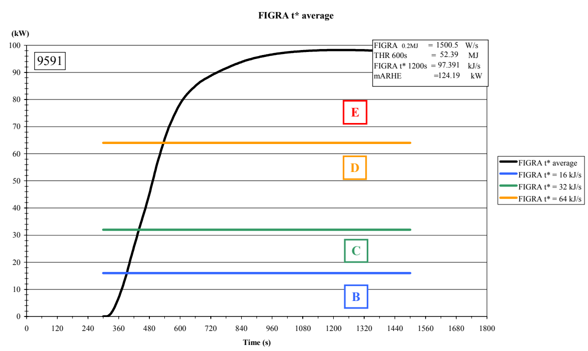


Rigid PUR foam: blowing agent Hydro Fluoro Carbon (thickness 60 mm)				
	9591-1	9591-2	9591-3	*average*
FIGRA [W/s] 0,2 MJ	1366.54	1300.45	1834.64	*1500.5*
THR600s (=RHR integral) [MJ]	51.51	49.43	56.23	*52.4*
mAHRE [kW]	130.37	107.86	137.66	*125.3*
FIGRA t* 1200s [1000·MJ/s]	97.4	89.5	105.2	*97.4*









Rigid PUR foam: blowing agent Hydro Fluoro Carbon (thickness 60 mm)

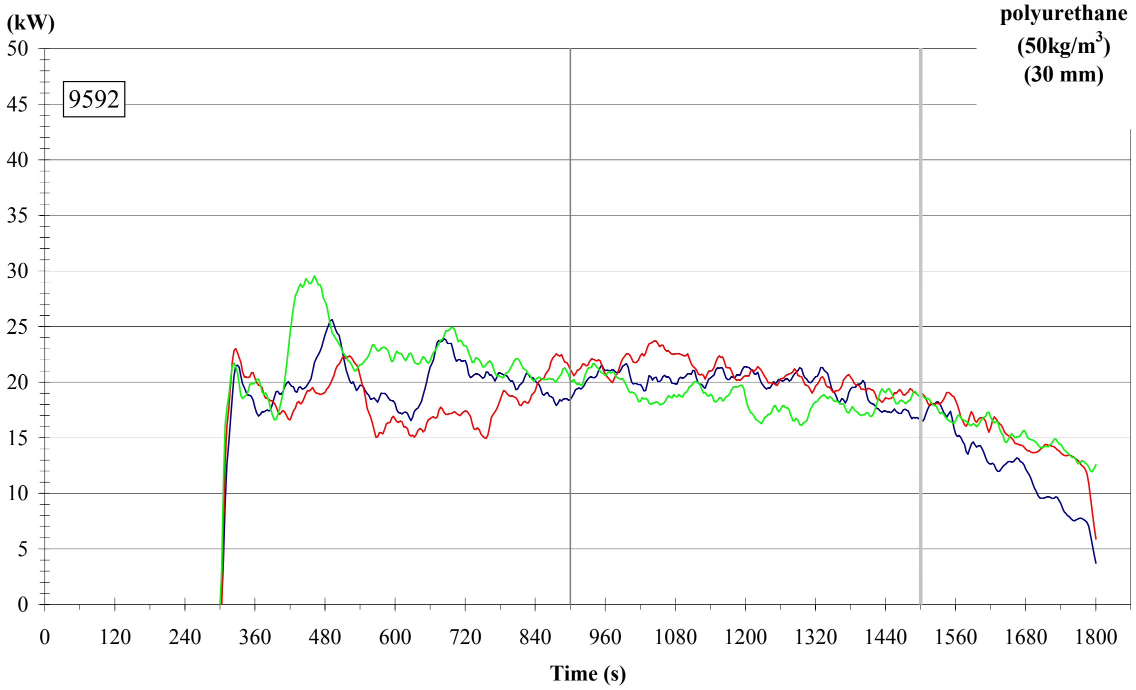
TEST 1

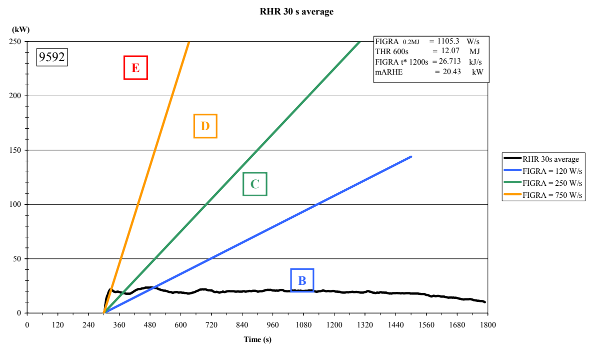
TEST 2

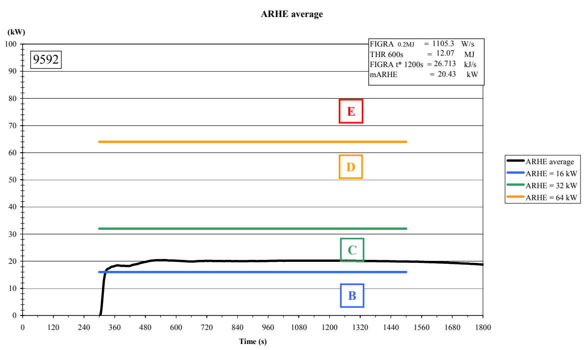
TEST 3

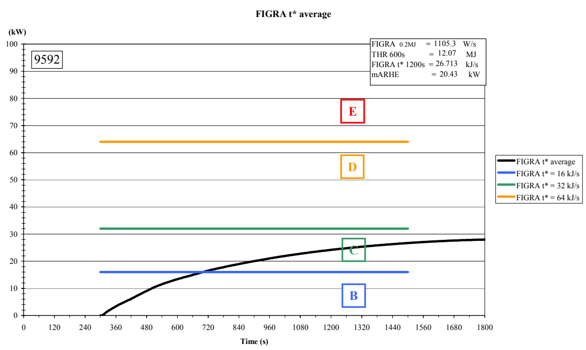
Rigid PIR foam: blowing agent Hydro Fluoro Carbon (thickness 30 mm)				
	9592-1	9592-2	9592-3	*average*
FIGRA [W/s] 0,2 MJ	883.65	1178.66	1253.58	*1105.3*
THR600s (=RHR integral) [MJ]	11.88	11.03	13.30	*12.1*
mAHRE [kW]	20.05	19.60	22.58	*20.7*
FIGRA t* 1200s [1000·MJ/s]	26.4	25.7	28.1	*26.7*

Foam polyurethane ($50 kg/m^3$) (30 mm)





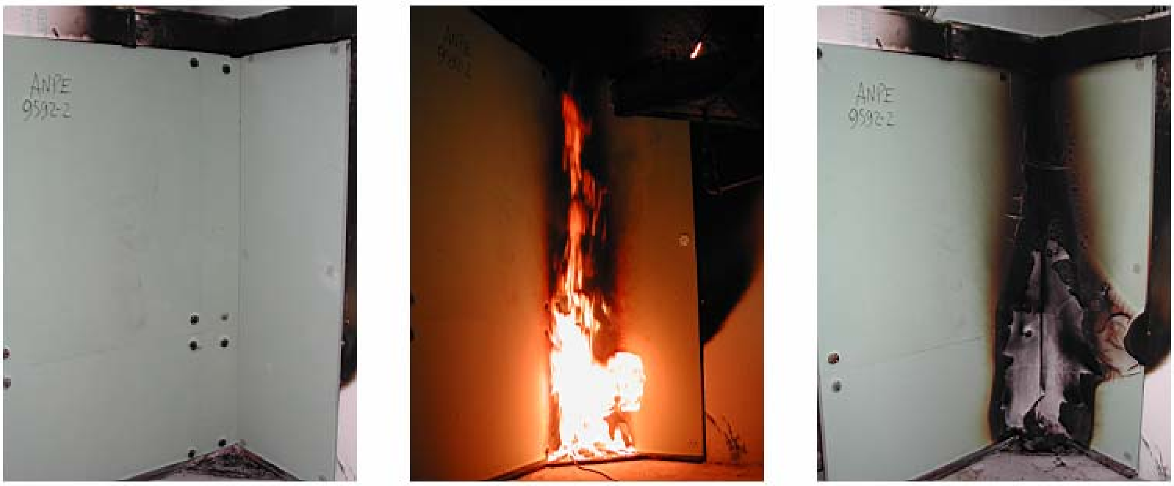




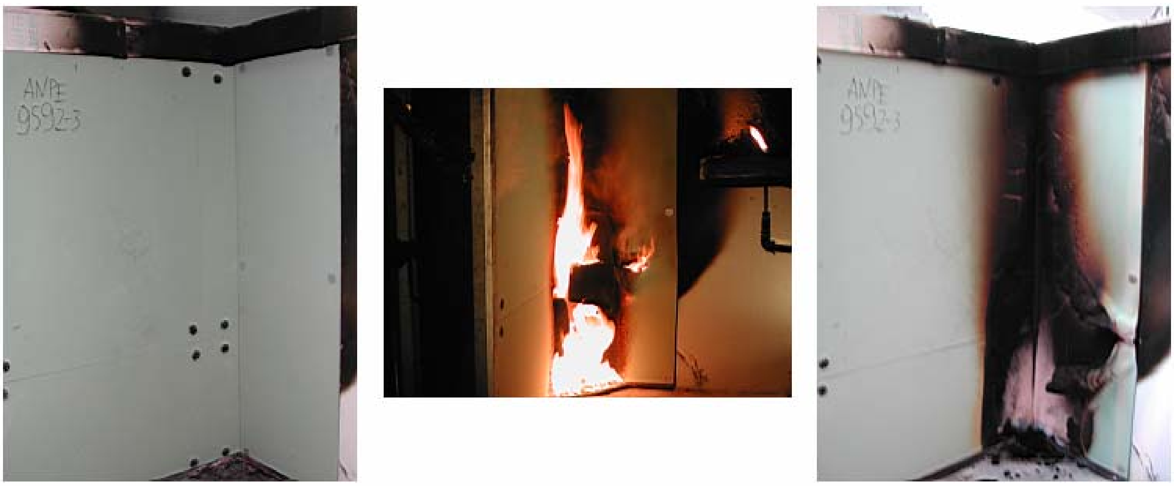
Rigid PIR foam: blowing agent Hydro Fluoro Carbon (thickness 30 mm)

TEST 1

TEST 2

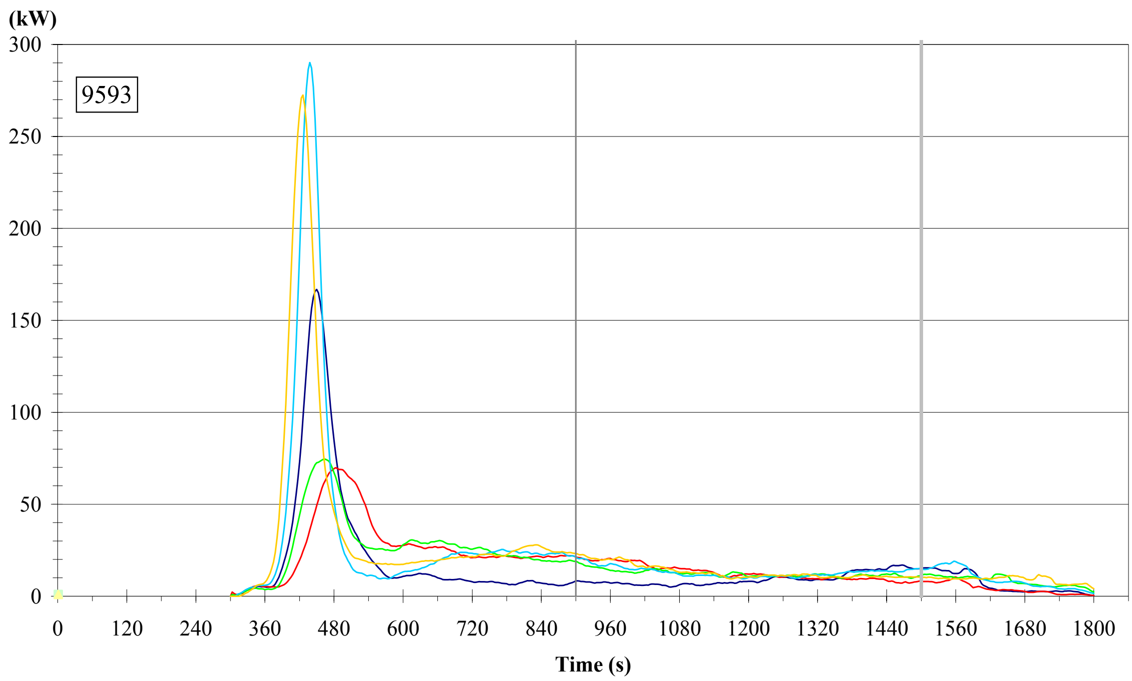


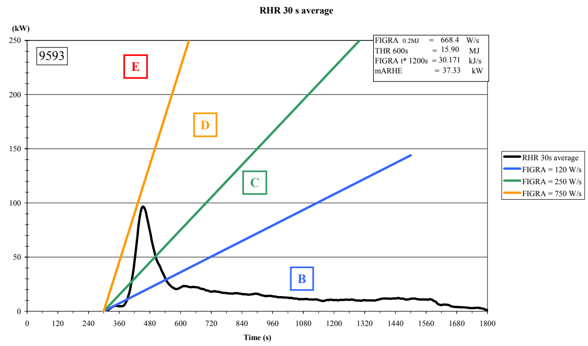
TEST 3

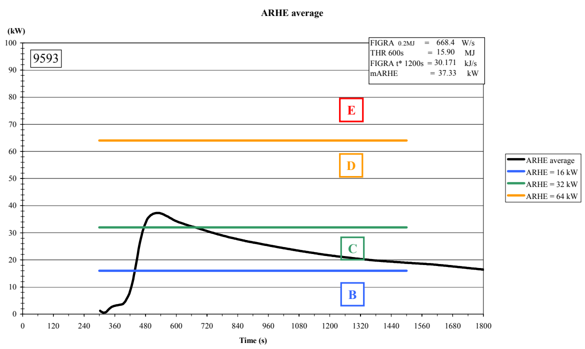


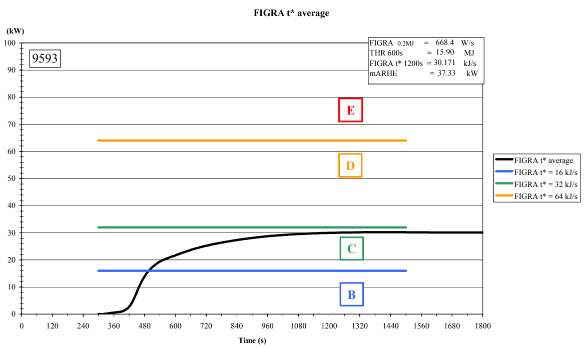
Extruded Polystyrene Foam (XPS) (thickness 30 mm)						
	9593-1	9593-2	9593-3	9593-4	9593-5	*average*
FIGRA [W/s] 0,2 MJ	1128.5	390.21	486.63	2121.6	2202.5	*1265.9*
THR600s (=RHR integral) [MJ]	15.30	16.07	16.33	23.26	24.55	*19.1*
mAHRE [kW]	53.77	30.72	31.43	84.31	87.92	*57.6*
FIGRA t* 1200s [1000·MJ/s]	29.6	30.5	30.5	44.5	47.6	*36.5*

XPS (30 mm)









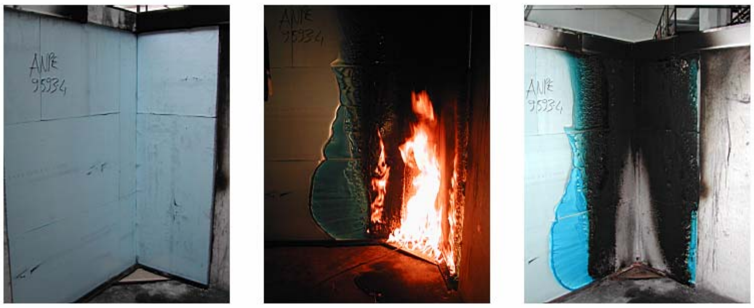
Extruded Polystyrene Foam (XPS) (thickness 30 mm)

TEST 1

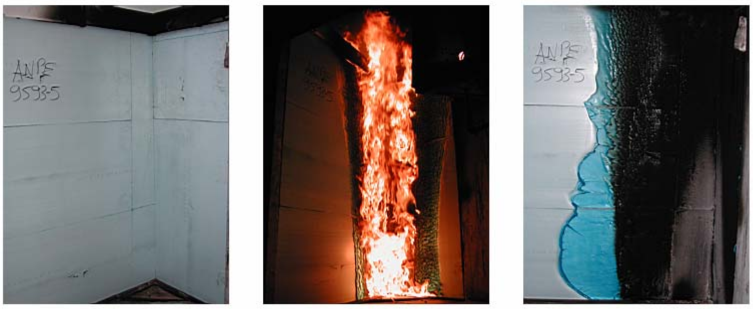
TEST 2

TEST 3

TEST 4

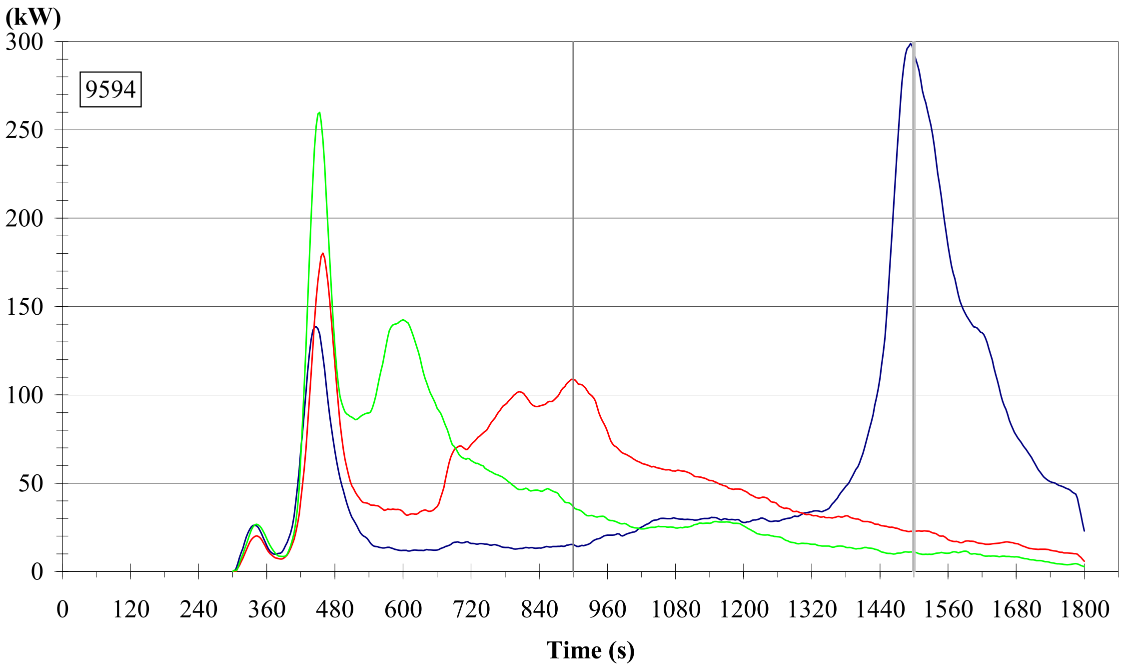


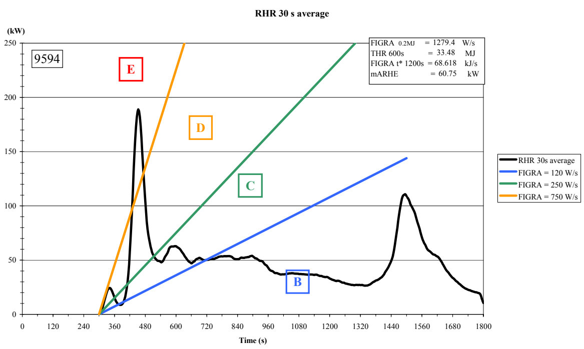
TEST 5

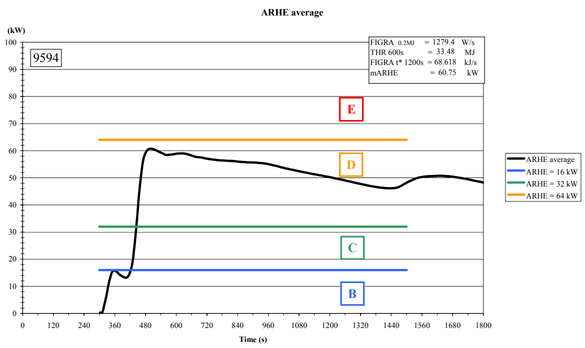


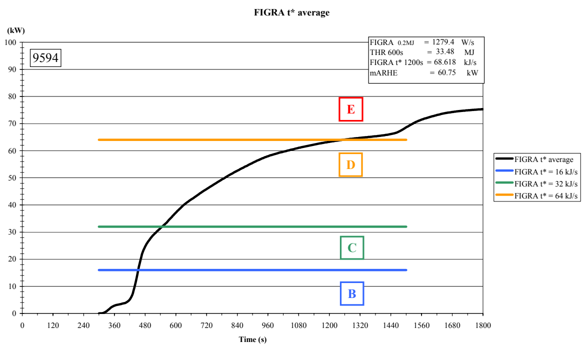
Extruded Polystyrene Foam (XPS) (thickness 60 mm)				
	9594-1	9594-2	9594-3	*average*
FIGRA [W/s] 0,2 MJ	967.13	1143.90	1727.14	*1279.4*
THR600s (=RHR integral) [MJ]	16.02	37.64	46.77	*33.5*
mAHRE [kW]	50.19	65.91	92.86	*69.7*
FIGRA t* 1200s [1000·MJ/s]	44.7	77.3	83.9	*68.6*

XPS (60 mm)







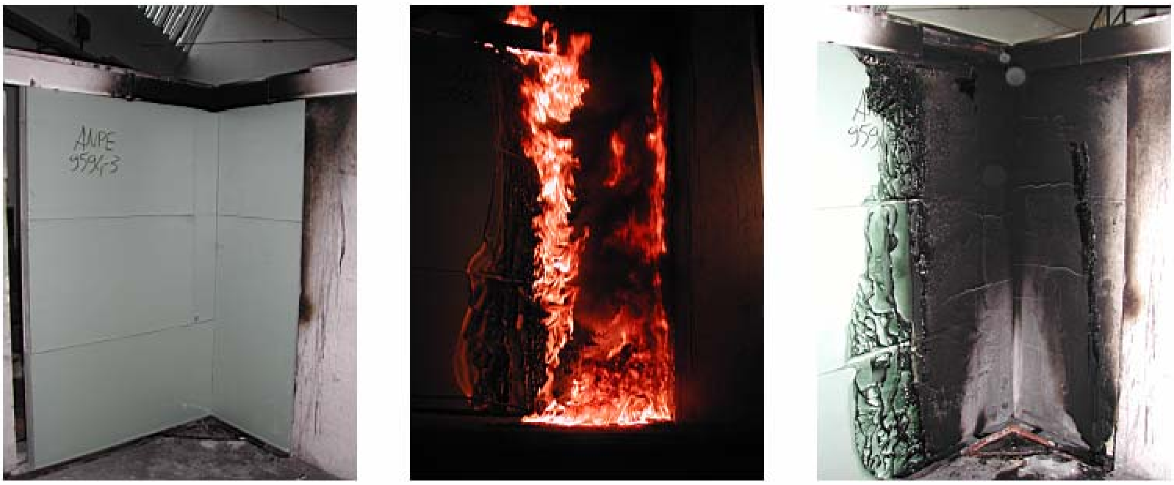


Extruded Polystyrene Foam (XPS) (thickness 60 mm)

TEST 1

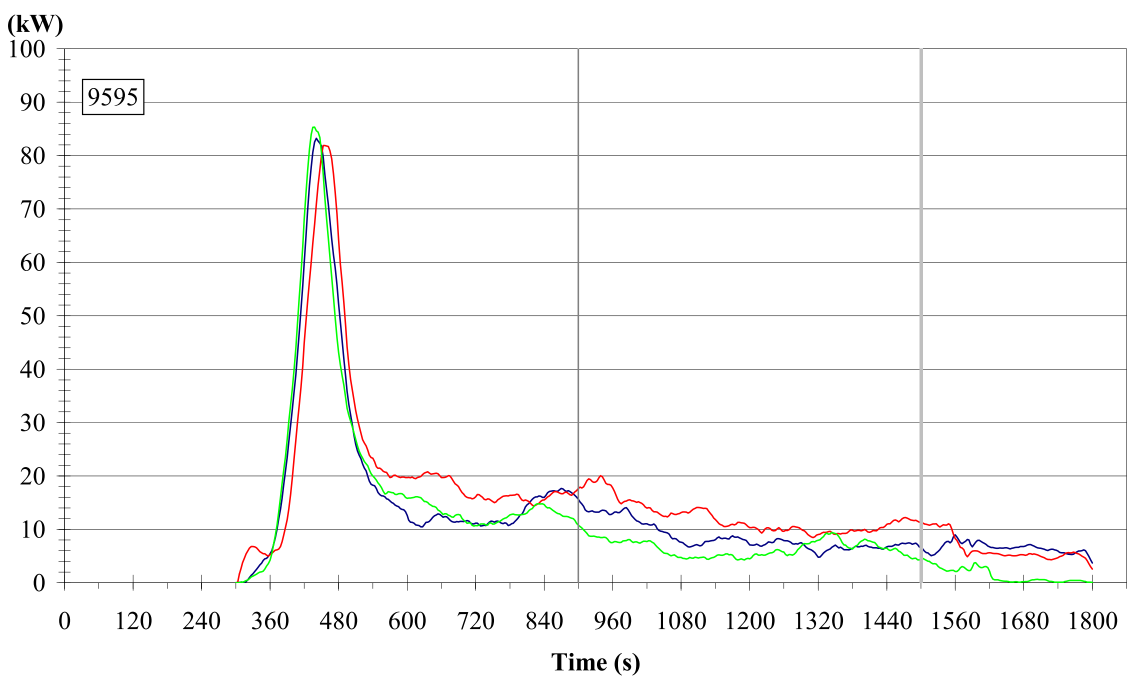
TEST 2

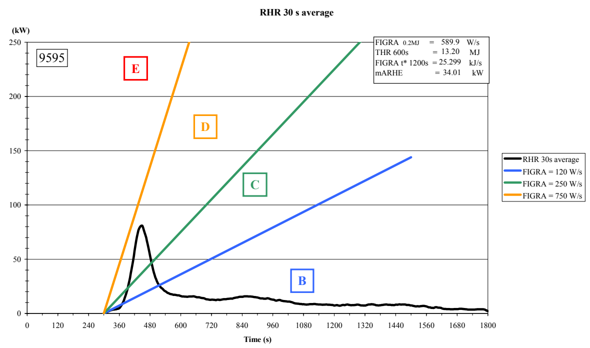
TEST 3

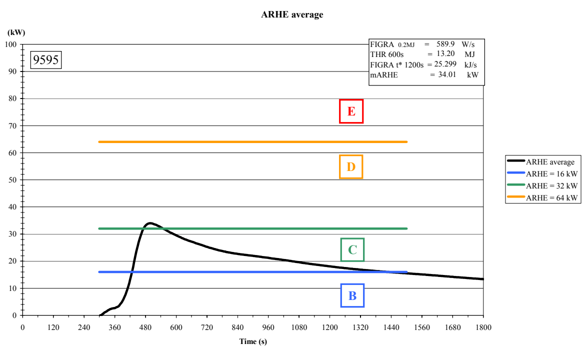


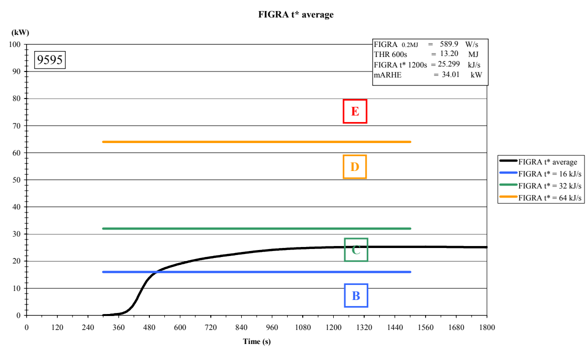
Expanded Polystyrene Foam (EPS) (thickness 30 mm)				
	9595-1	9595-2	9595-3	*average*
FIGRA [W/s] 0,2 MJ	598.11	535.14	636.40	*589.9*
THR600s (=RHR integral) [MJ]	12.68	14.15	12.79	*13.2*
mAHRE [kW]	34.55	33.18	34.47	*34.1*
FIGRA t* 1200s [1000·MJ/s]	24.4	27.7	23.8	*25.3*

EPS (30 mm)









Expanded Polystyrene Foam (EPS) (thickness 30 mm)

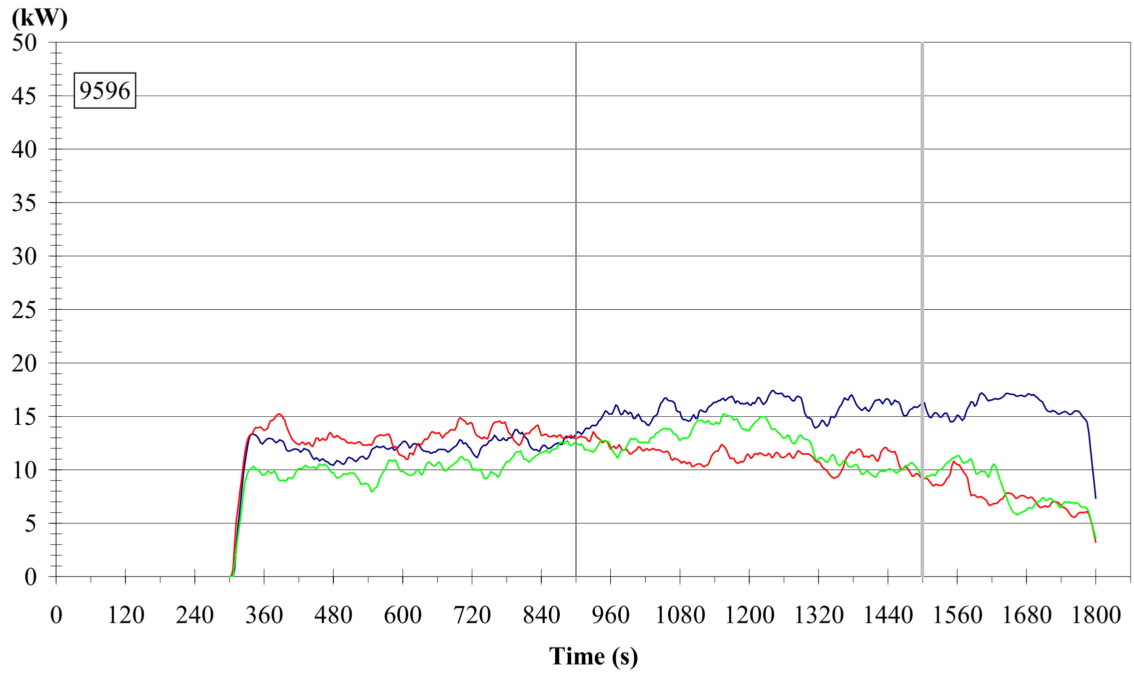
TEST 1

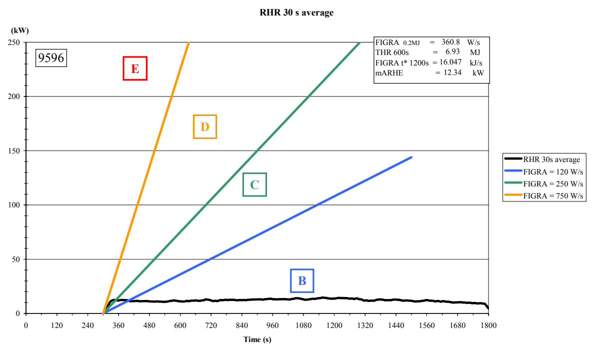
TEST 2

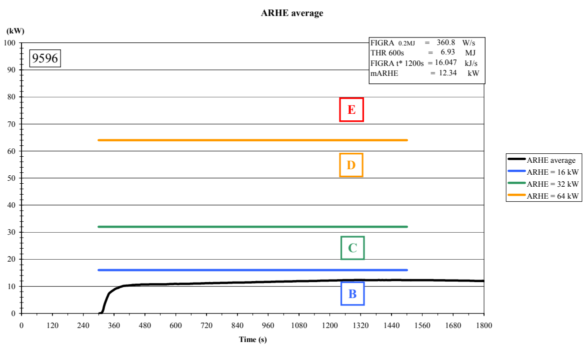
TEST 3

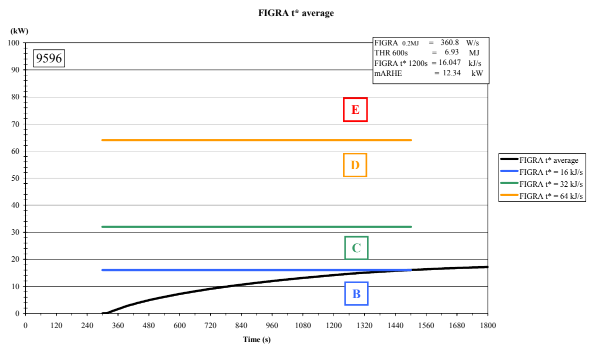
Expanded Perlite (EPB) (thickness 30 mm)				
	9596-1	9596-2	9596-3	*average*
FIGRA [W/s] 0,2 MJ	385.09	418.38	278.78	*360.8*
THR600s (=RHR integral) [MJ]	7.07	7.73	5.99	*6.9*
mAHRE [kW]	13.72	12.89	11.33	*12.6*
FIGRA t* 1200s [1000·MJ/s]	17.3	16.5	14.3	*16.0*

Perlite (30 mm)







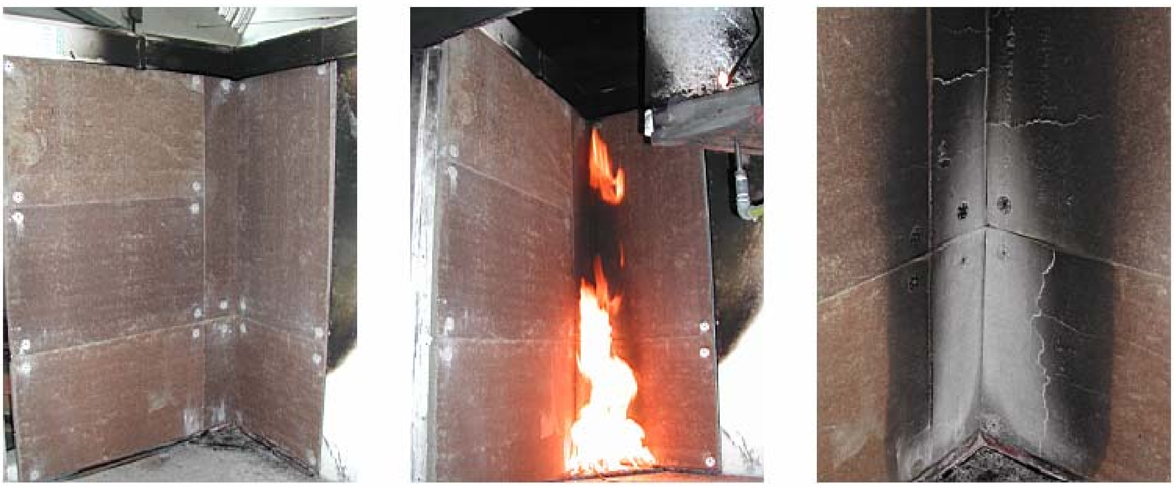


Expanded Perlite (EPB) (thickness 30 mm)

TEST 1

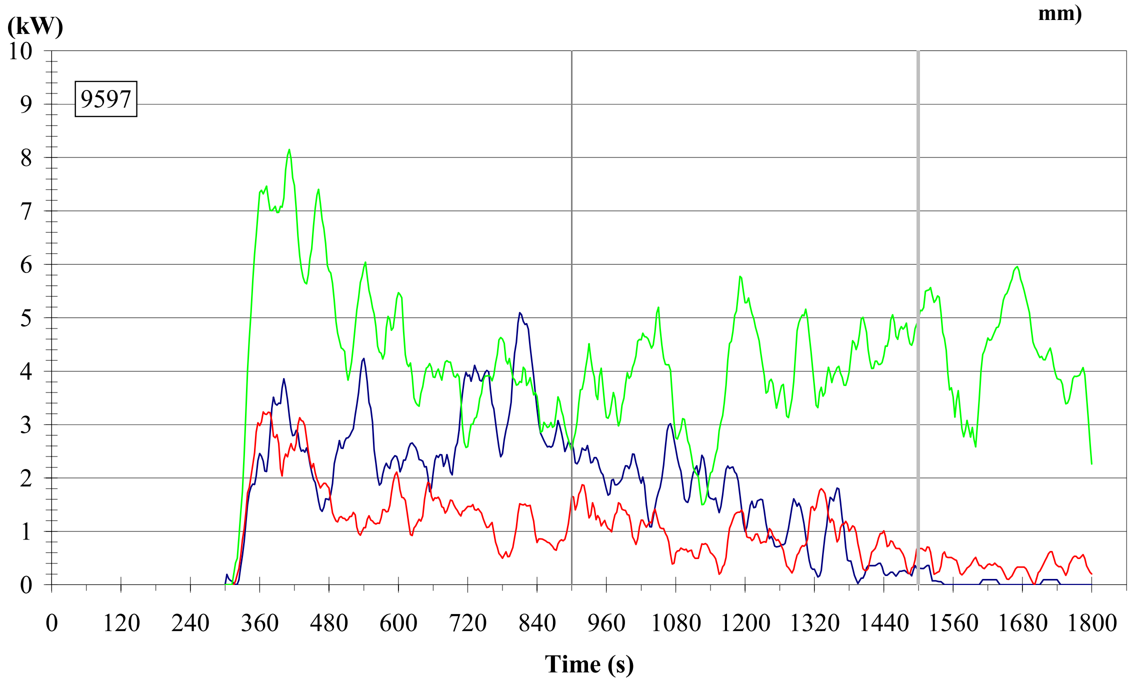
TEST 2

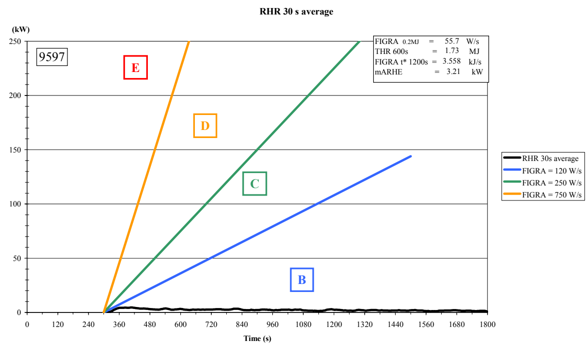
TEST 3

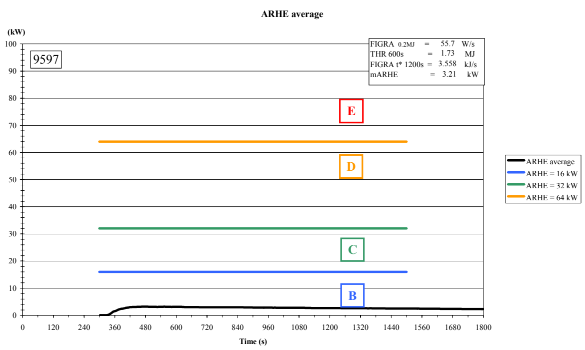


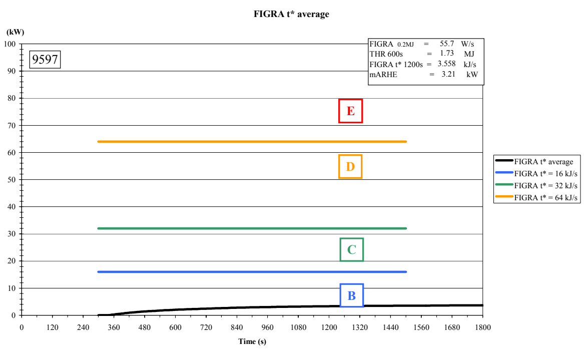
Mineral Wool (MW) (thickness 40 mm)				
	9597-1	9597-2	9597-3	*average*
FIGRA [W/s] 0,2 MJ	32.02	24.25	110.91	*55.7*
THR600s (=RHR integral) [MJ]	1.61	0.89	2.69	*1.7*
mAHRE [kW]	2.70	2.15	5.54	*3.5*
FIGRA t* 1200s [1000·MJ/s]	3.1	1.8	5.8	*3.6*

Mineral fiber (40 mm)



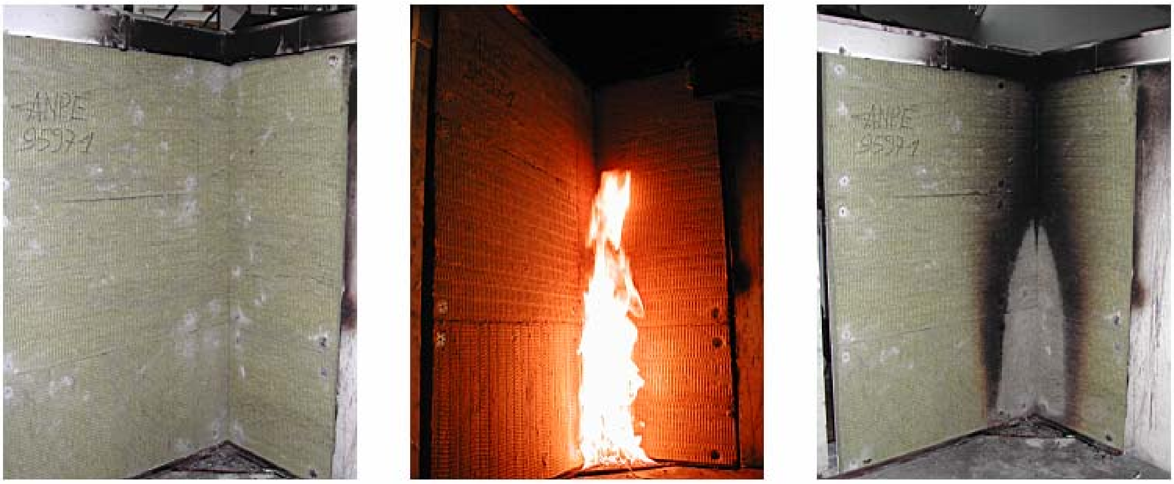




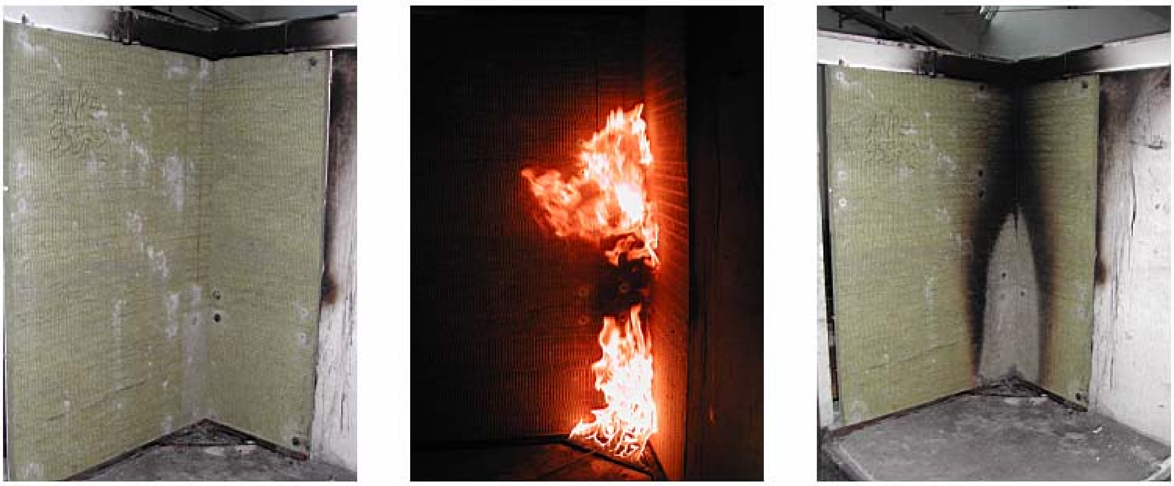


Mineral Wool (MW) (thickness 40 mm)

TEST 1



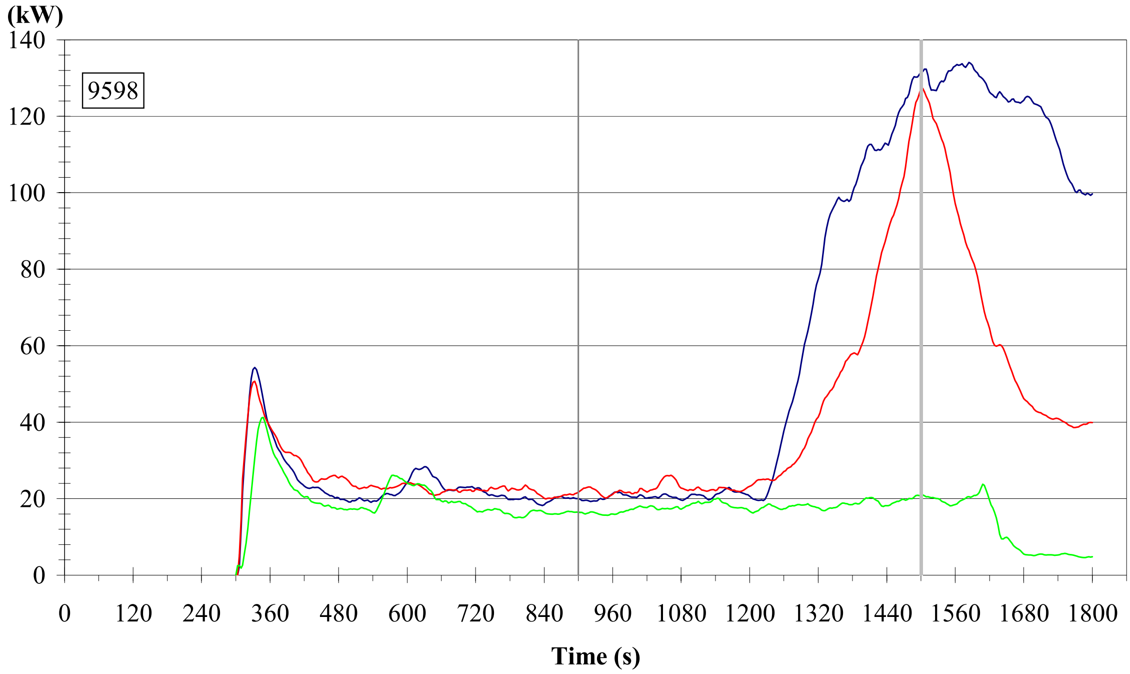
TEST 2



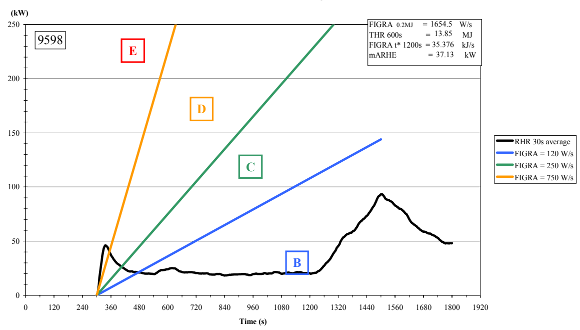
TEST 3

Expanded Cork (ICB) (thickness 30 mm)				
	9598-1	9598-2	9598-3	*average*
FIGRA [W/s] 0,2 MJ	1956.54	2030.76	976.06	*1654.5*
THR600s (=RHR integral) [MJ]	14.46	15.20	11.89	*13.9*
mAHRE [kW]	38.72	37.79	25.36	*34.0*
FIGRA t* 1200s [1000·MJ/s]	41.8	38.6	25.8	*35.4*

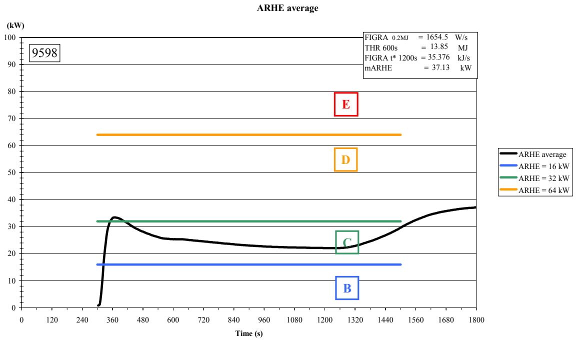
Cork (30 mm)



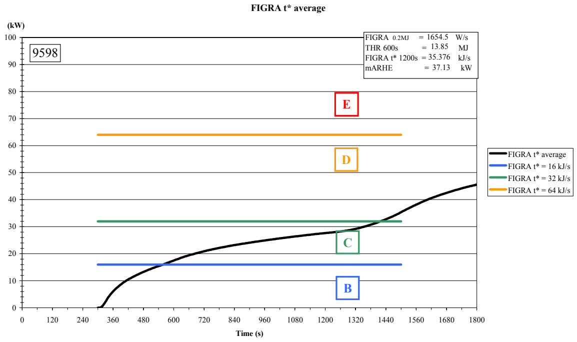
RHR 30 s average



ARHE average



FIGRA t* average

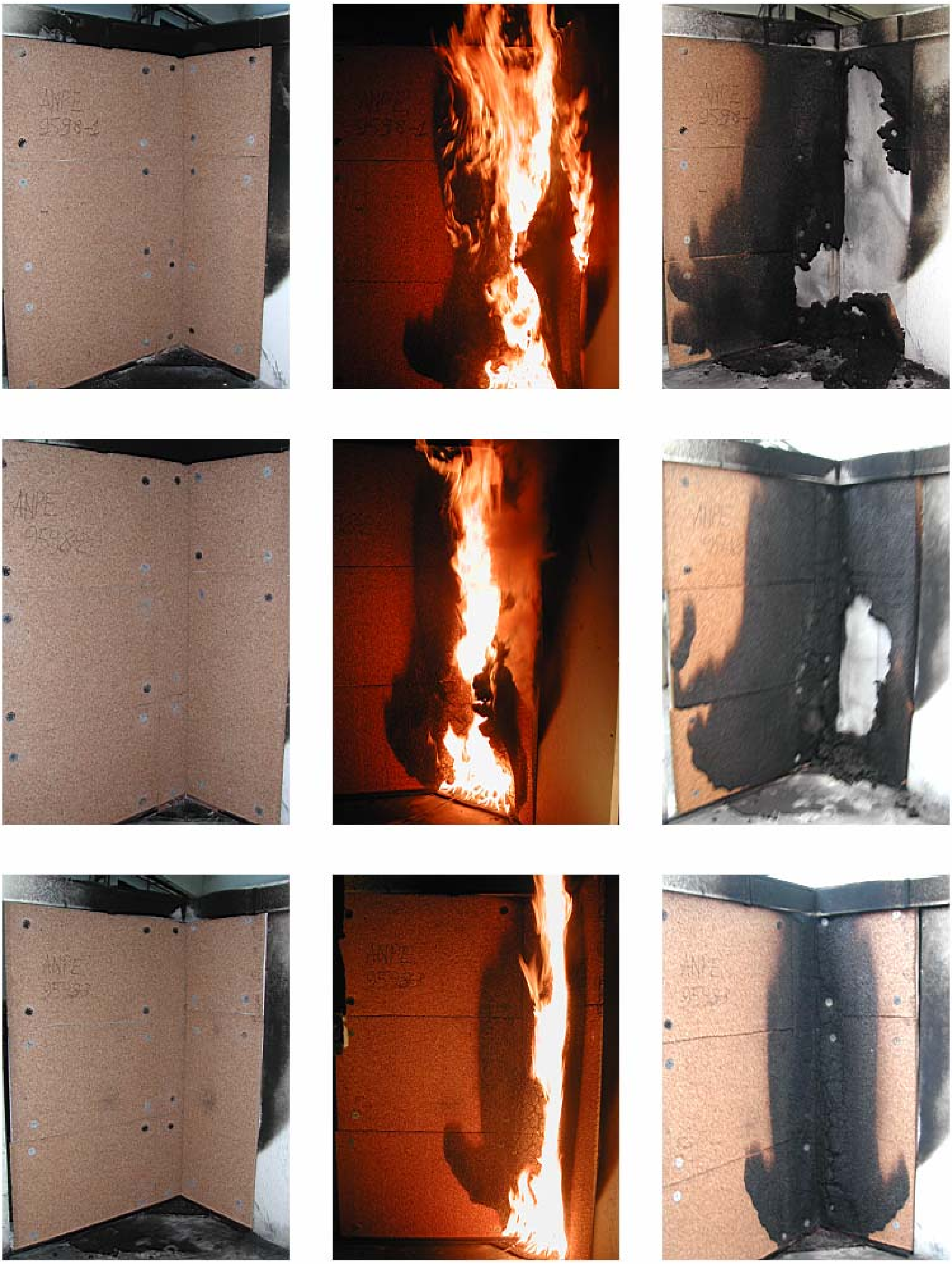


Expanded Cork (ICB) (thickness 30 mm)

TEST 1

TEST 2

TEST 3



ANNEX C

An other example showing that the classification obtained using FIGRA as defined in standard EN 13823 and used in EN 13501, doesn't allow to evaluate the real materials level of danger, is represented by two products recently tested.
In fact, if we consider the curves of the following materials:

'alfa'

and

'beta'

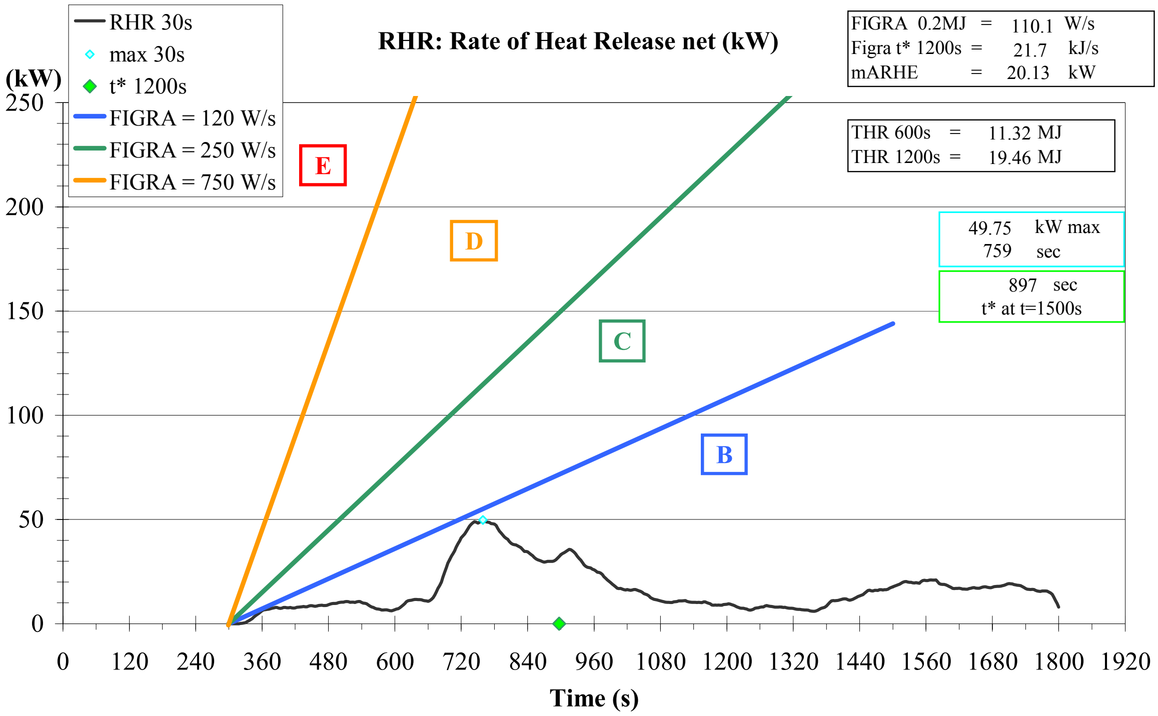
it can be observed as they have always a FIGRA in level B, but they produce a much more important fire than some products included in BING research program.

The material '**alfa**' reaches 50 kW at 759 seconds (medium power fire), sufficiently retarded from the fire starting in order to get a FIGRA lower than **120 W/s (limit for class B)**. Since the total heat released in the first 10 minutes (THR 600s) is 11,32 MJ, higher than 7,5 MJ that is the maximum limit for class B, the final euro-class is, in this case, **C**.
Even considering the other two calculation systems - mARHE and FIGRA t* - at the proposed limits, the class would always be C.

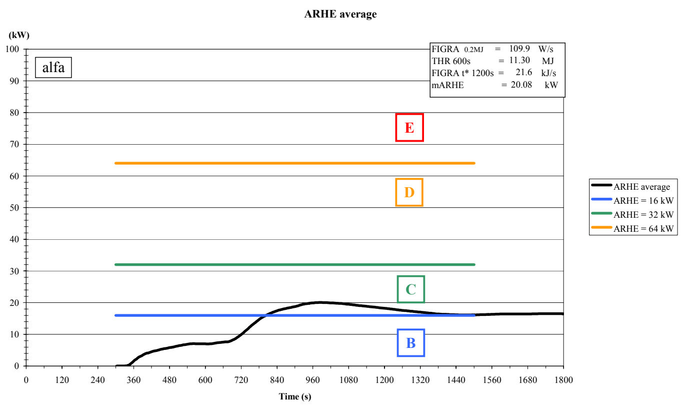
The material **'beta'** reaches a peak of 84 kW after 1080 s, and at 900 s has already reached 40 kW, but in this case the heat is mainly produced after the first 10 minutes of test, so, a big part of the heat released is not considered and FIGRA remains at low levels. Also THR 600s remains below 7,5 MJ that is the limit of class B. Then, the final classification leads to class B.

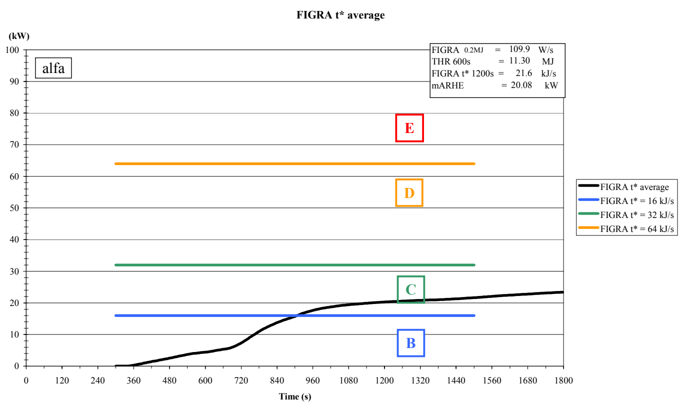
If only mAHRE or FIGRA t* calculations were considered, **the result would be a class D**, that should be much more appropriate.

alfa



Classification according to EN 13823: class C





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