Aged material testing – Report on comparative analysis aged vs. non-aged: Fire properties

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Author:	Konrad Wilkens
QA:	Anders Dragsted

DBI – Dansk Brand- og sikringsteknisk Institut

Jernholmen 12, 2650 Hvidovre · Tlf.: 36 34 90 00 · Fax: 36 34 90 01 · E-mail: dbi@dbi-net.dk · www.dbi-net.dk

Content

1 Background information

The purpose of this report is to provide a summary of the test outcomes and analysis results performed on the material sample(s) supplied by the client. With the aim of understanding how the provided samples may react to fire testing and how the effects of ageing may impact the materials fire behaviour properties.

This work was completed as part of the InnoBYG spire project "Circular insulation" which is part of a thematised call under CØ Hub.

2 The test apparatus

The test apparatus used for these studies was the Cone Calorimeter. This apparatus applies a quantified incident radiative heat flux to the samples surface. Samples are approximately 10 cm x 10 cm in area, and may vary in thickness. The method for using the Cone Calorimeter is as follows:

1. Incident heat flux is chosen
2. Sample is then placed below the shielded cone heater (which supplies the heat flux)
3. A spark ignitor is then put in place
4. The start of the test begins when the shutters are removed, and the surface of the sample is then exposed to said heat flux, and the spark ignitor activates
5. the sample will then ignite (after a certain period which is dependent on the samples composition)
6. heat release from the sample is then measured via oxygen consumption calorimetry as the combustion gases are caught and then travel through the ducting (refer Figure 1)

The cone calorimeter can measure various fire metrics including; heat release per unit area, smoke production, mass loss rate, time to ignition etc.

The Cone Calorimeter:

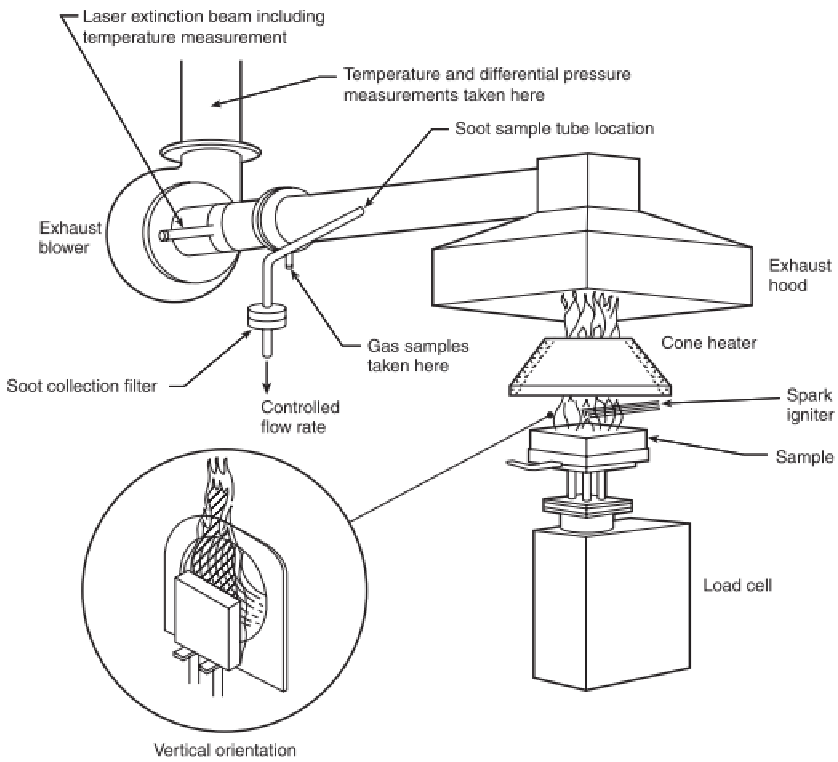

Figure 1 - Schematic of the Cone calorimeter

2.1 Materials

The materials for this project were supplied by Danish Technological Institute.

Table 1 - materials summary

Sample ID	Sample name
A	Paper fibre insulation
B	Lamb wool
C	Wood fibre insulation
D	Cork
E	Straw
F	Sea grass

Each sample material was provided for testing in two forms – a non-aged "off-the-shelf" sample and an artificially aged sample. The purpose being to investigate if the aging process, to which the materials have been exposed, showed any change in performance with regards to fire behaviour. Readers are referred to the report "Ældning af isoleringsmaterialer lavet af organiske fibre - Forslag til ældningsmetode", Teknologisk Institut, January 2019 for more detailed information on the materials and the ageing procedure.

Test inputs: The only test input chosen in this testing is the incident heat flux to the sample from the cone apparatus. This value can be varied from approximately 10-75 kW/m^2. For this test series the choice of heat flux (35 kW/m^2) was decided as the best heat flux level to begin testing. This decision was based on the requirements for the Single Burning Item (SBI) test (Euroclass classification test for these products), and in order to achieve an increased possibility of noticing differences between the aged and non-aged samples.

3 Results and Analysis

The main output from the cone calorimeter is the heat release rate per unit area (HRRPUA) which is measured in kW/m^2, this is a time dependent curve that is a measure of how much heat the sample is releasing during the combustion process. Other outputs include:

- Total Heat Release (THR) – MJ/m^2
- Peak HRR – kW/m^2
- Smoke production rate (SPR) – m^2/s
- Total smoke production (TSP)
- Smoke extinction area (SEA) – m^2/kg
- Time to ignition (t_{ig}) - s
- Mass loss rate (MLR) – g/s.m^2

These outputs shall be used to perform the comparison between the aged and non-aged samples in order to determine if the ageing process has any effect on the fire performance of these specimens.

3.1 A – Paper fibre insulation

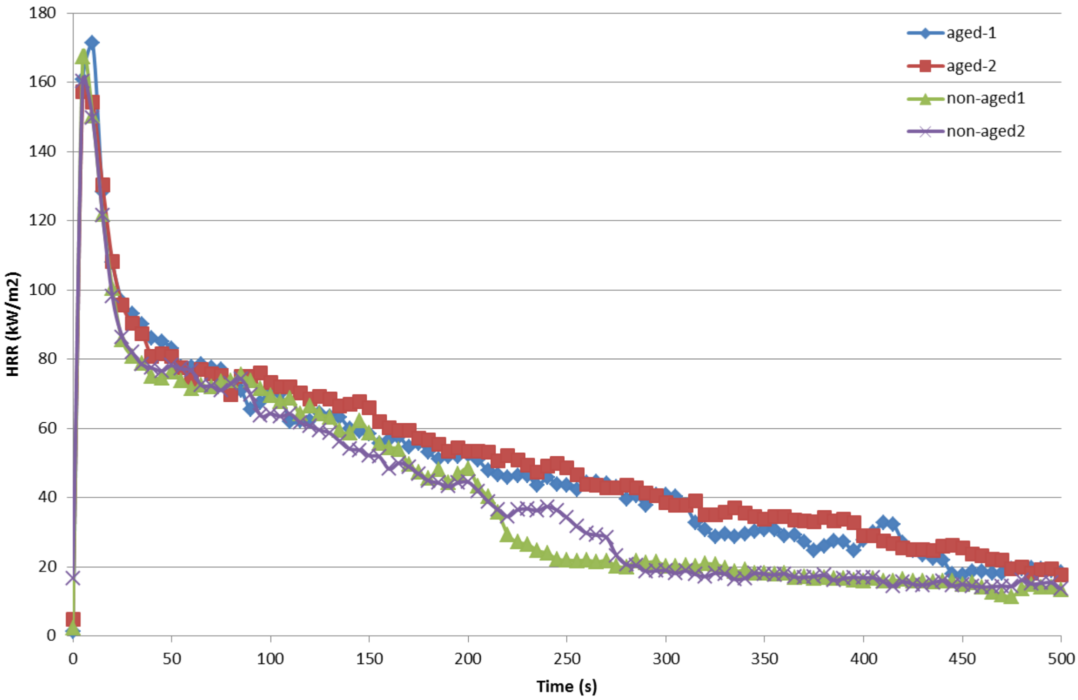

Figure 2 – HRR Results

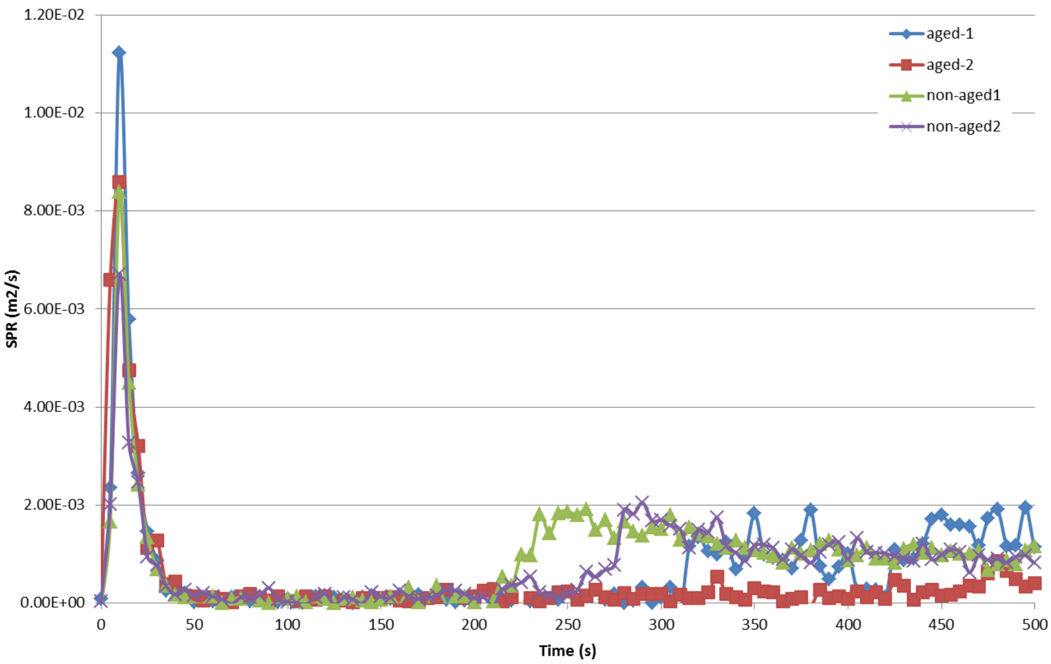

Figure 3 – Smoke Production Rate results

Table 2 – Test output summary

Material name/ID	See individual reports	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(ig) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**3.3**	**324.3**	**898.8**	**164.08**	**6.3**	**28.03**	**96.30**	**74.33**	**59.89**
1	3	344	895	171.35	10	30.13	101.44	76.12	63.67
2	4	477	890	157.20	5	31.25	98.20	77.95	65.73
3	3	222	920	167.39	5	25.34	92.34	72.69	54.95
4	3	254	890	160.37	5	25.38	93.23	70.56	55.20

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10-90}$ (g/s·m²)
Mean		**50**		**20.9**	**20.92**	**4.03**	**1910.4**	**2.36**	**2.48**
1	35	50	88.4	23.13	23.13	5.07	2043.0	2.26	2.62
2	35	50	88.4	22.38	22.38	4.50	2022.6	2.27	2.72
3	35	50	88.4	19.22	19.22	3.14	1818.8	1.95	2.29
4	35	50	88.4	18.95	18.95	3.41	1757.4	2.97	2.29

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**18.24**	**24.14**	-	**13.38**	**0.0007**	**32.00**	**11.84**	**127.91**
1	19.30	26.15	-	14.74	0.0007	36.48	11.52	132.35
2	19.93	27.36	-	15.38	0.0004	20.69	12.35	126.37
3	16.81	21.47	-	13.93	0.0008	44.15	11.66	126.54
4	16.91	21.59	-	9.47	0.0007	26.67	11.84	126.39

Test	Date	Specimen #	Line colour	Filename
1	17/12/2018	1	—	C:\CC5\DATA\18120009.CSV
2	17/12/2018	2	—	C:\CC5\DATA\18120010.CSV
3	17/12/2018	3	—	C:\CC5\DATA\18120011.CSV
4	17/12/2018	4	—	C:\CC5\DATA\18120012.CSV

3.2 B – Lamb wool

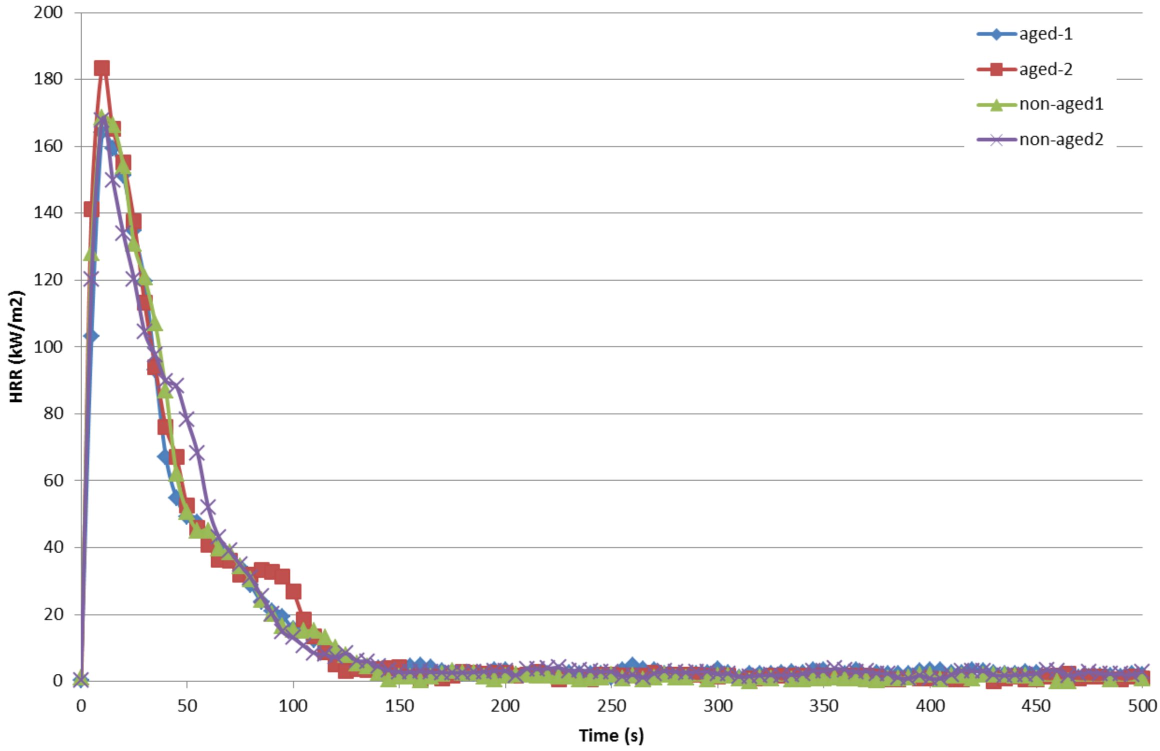

Figure 4 – HRR Results

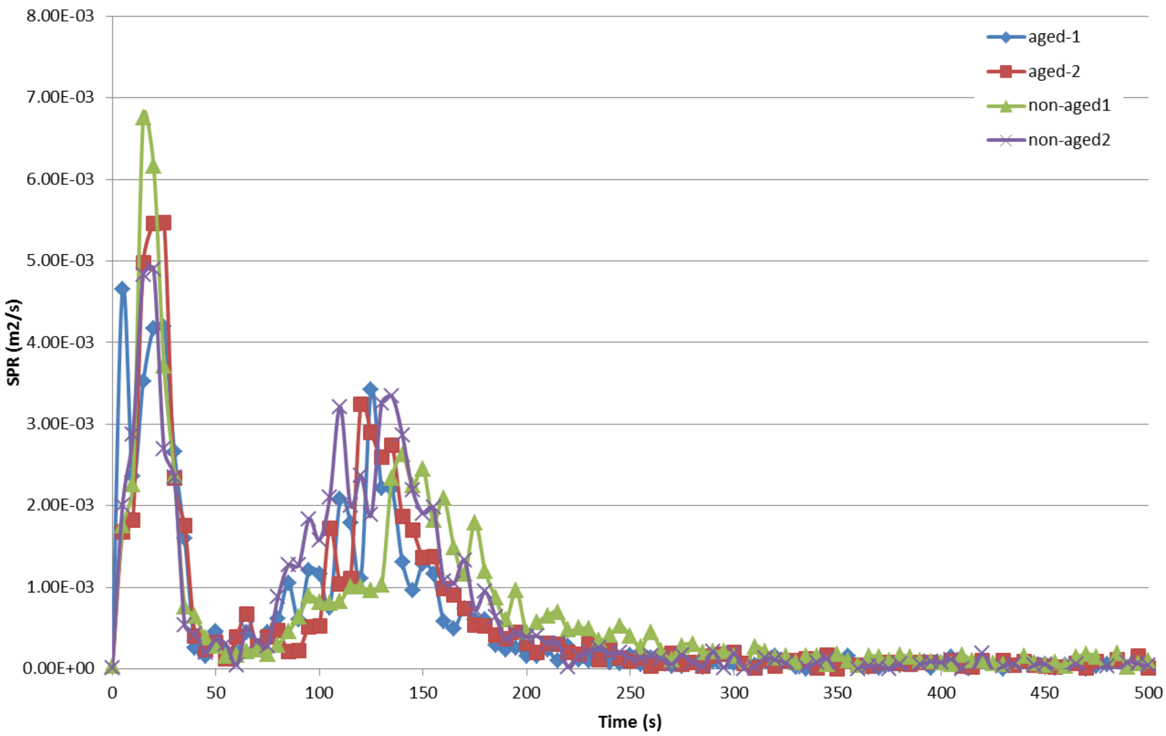

Figure 5 – Smoke Production Rate results

Table 3 – Test output summary

Material name/ID	See individual reports	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(ig) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**4.5**	**130**	**300**	**170.95**	**10**	**7.93**	**100.62**	**41.77**	**25.90**
1	5	124	300	164.13	10	7.54	96.39	40.29	25.19
2	4	140	300	183.31	10	8.25	101.61	42.77	26.34
3	4	130	300	168.56	10	8.02	101.78	41.91	25.68
4	5	126	300	167.80	10	7.90	102.68	42.09	26.38

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10\text{-}90}$ (g/s·m²)
Mean		**50**		**10.7**	**10.56**	**4.92**	**638.5**	**2.13**	**3.14**
1	35	50	88.4	10.65	10.43	5.04	609.9	2.07	2.96
2	35	50	88.4	10.7	10.70	4.94	651.3	2.14	3.16
3	35	50	88.4	10.66	10.66	4.75	668.0	2.19	3.24
4	35	50	88.4	10.67	10.45	4.92	624.8	2.12	3.22

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**8.07**	**8.57**	**-**	**12.35**	**0.0010**	**53.75**	**6.57**	**133.71**
1	7.80	8.54	-	12.36	0.0009	48.34	6.26	129.09
2	8.25	8.58	-	12.50	0.0010	51.49	6.82	142.69
3	8.02	8.30	-	11.90	0.0011	55.55	6.65	136.63
4	8.20	8.85	-	12.65	0.0011	59.62	6.55	126.42

Test	Date	Specimen #	Line colour	Filename
1	17/12/2018	1		C:\CC5\DATA\18120005.CSV
2	17/12/2018	2		C:\CC5\DATA\18120006.CSV
3	17/12/2018	3		C:\CC5\DATA\18120007.CSV
4	17/12/2018	4		C:\CC5\DATA\18120008.CSV

3.3 C – Wood fibre insulation

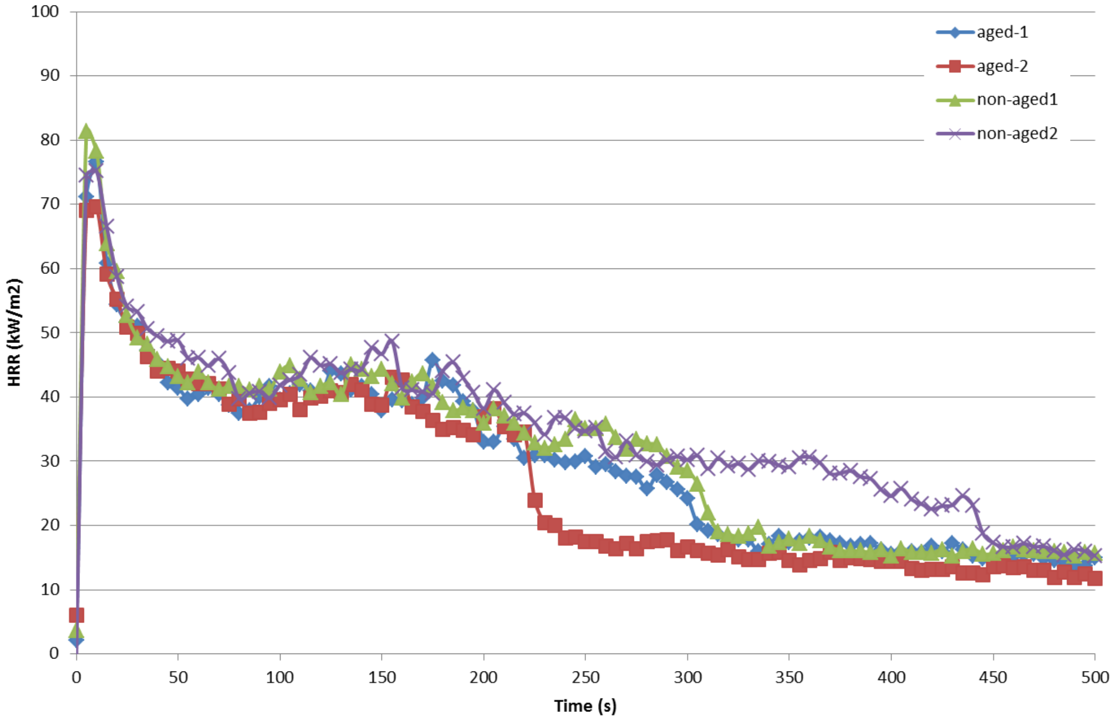

Figure 6 – HRR Results

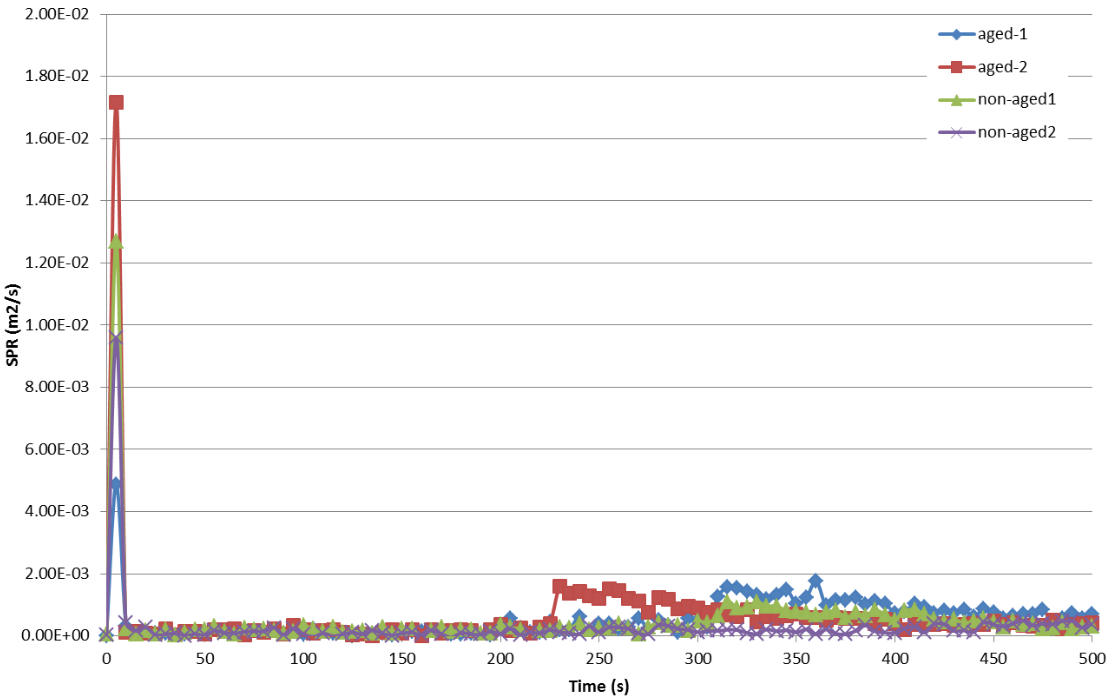

Figure 7 – Smoke Production Rate results

Table 4 – Test output summary

Sample description	See individual reports		
Material name/ID	Treefibre	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(ig) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**3.5**	**320.8**	**868.8**	**75.67**	**8.8**	**20.23**	**52.14**	**44.99**	**39.27**
1	4	305	895	76.62	10	19.88	50.61	43.97	38.52
2	3	224	810	69.56	10	16.90	50.35	43.06	35.20
3	3	309	885	81.35	5	21.02	52.82	45.68	41.01
4	4	445	885	75.17	10	23.13	54.77	47.23	42.34

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10\text{-}90}$ (g/s·m²)
Mean		**50**		**26.4**	**26.38**	**6.11**	**2292.9**	**2.63**	**2.84**
1	35	50	88.4	26.15	26.15	5.82	2300.2	2.56	2.81
2	35	50	88.4	26.39	26.39	6.85	2210.7	2.72	2.81
3	35	50	88.4	26.36	26.36	5.92	2312.3	2.60	2.80
4	35	50	88.4	26.6	26.60	5.84	2348.5	2.65	2.94

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**11.85**	**16.84**	-	**8.80**	**0.0004**	**16.83**	**6.78**	**60.66**
1	11.63	16.30	-	8.62	0.0005	21.48	6.72	59.72
2	10.67	14.66	-	7.64	0.0005	19.91	5.66	57.09
3	12.38	17.27	-	9.11	0.0004	15.74	7.05	64.46
4	12.74	19.13	-	9.84	0.0002	10.20	7.69	61.37

Test	Date	Specimen #	Line colour	Filename
1	17/12/2018			C:\CC5\DATA\18120001.CSV
2	17/12/2018	2		C:\CC5\DATA\18120002.CSV
3	17/12/2018	3		C:\CC5\DATA\18120003.CSV
4	17/12/2018	4		C:\CC5\DATA\18120004.CSV

3.4 D - Cork

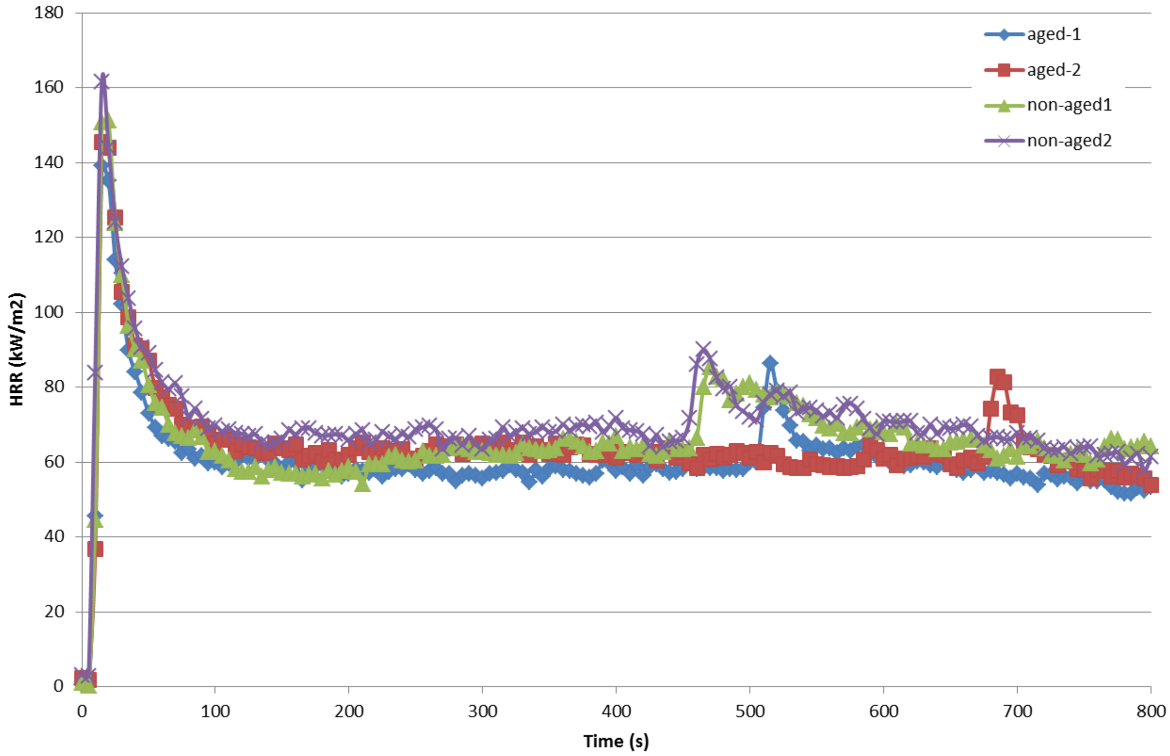

Figure 8 – HRR Results

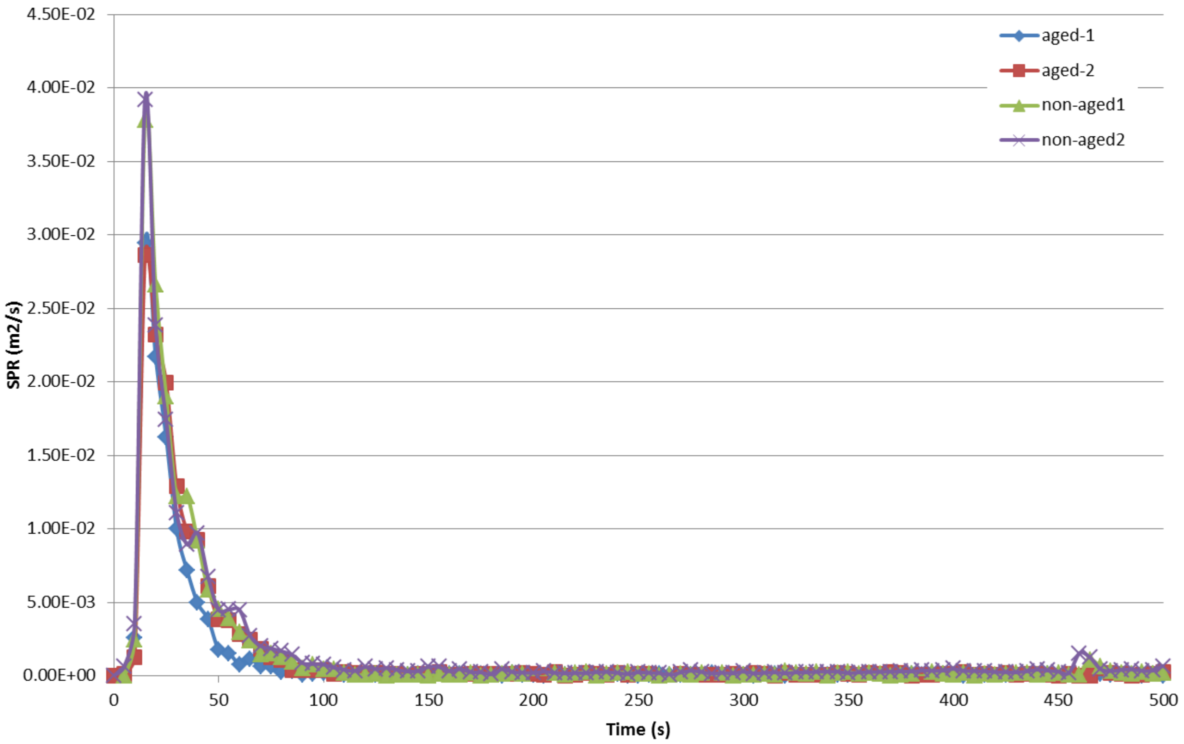

Figure 9 – Smoke Production Rate results

Table 5 – Test output summary

Material name/ID	See individual reports	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(ig) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**11**	**0**	**895**	**149.32**	**16.3**	**57.79**	**95.52**	**73.88**	**69.14**
1	11		895	139.14	15	53.54	87.08	68.83	64.18
2	12		895	145.34	15	56.58	96.33	74.96	70.25
3	11		895	151.22	20	58.98	94.67	71.19	67.15
4	10		895	161.57	15	62.08	104.01	80.54	74.99

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10\text{-}90}$ (g/s·m²)
Mean		**50**		**76.3**	**76.21**	**53.08**	**2615.7**	**2.94**	**2.88**
1	35	50	88.4	81.95	81.82	59.08	2573.3	2.89	2.84
2	35	50	88.4	79.25	79.14	56.35	2577.6	2.90	2.84
3	35	50	88.4	71.91	71.78	48.17	2670.7	3.00	2.93
4	35	50	88.4	72.18	72.09	48.74	2641.2	2.98	2.91

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**20.38**	**40.13**	-	**22.11**	**0.0008**	**30.90**	**6.73**	**89.94**
1	18.98	37.20	-	20.83	0.0006	22.25	5.78	83.46
2	20.67	39.20	-	21.95	0.0007	29.04	6.31	88.34
3	19.82	40.51	-	22.14	0.0008	32.02	7.25	90.31
4	22.07	43.63	-	23.50	0.0011	40.30	7.60	97.67

Test	Date	Specimen #	Line colour	Filename
1	18/12/2018	1		C:\CC5\DATA\18120018.CSV
2	18/12/2018	2		C:\CC5\DATA\18120019.CSV
3	18/12/2018	3		C:\CC5\DATA\18120020.CSV
4	18/12/2018	4		C:\CC5\DATA\18120021.CSV

3.5 E - Straw

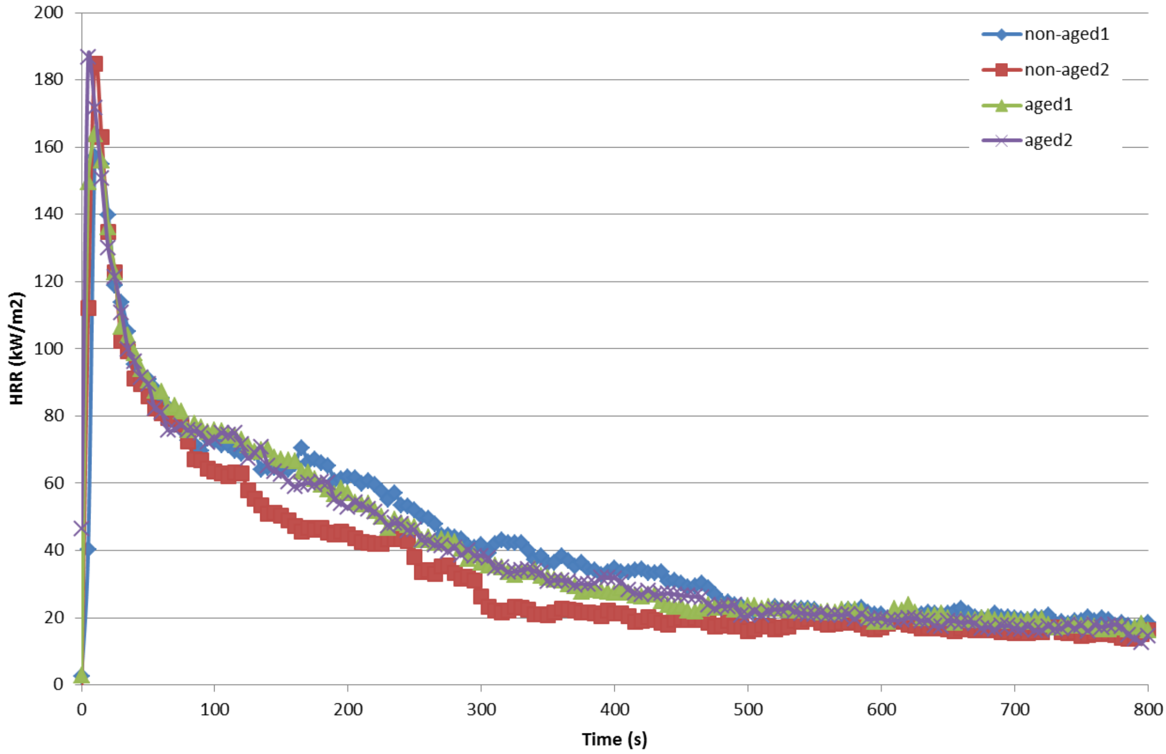

Figure 10 – HRR Results

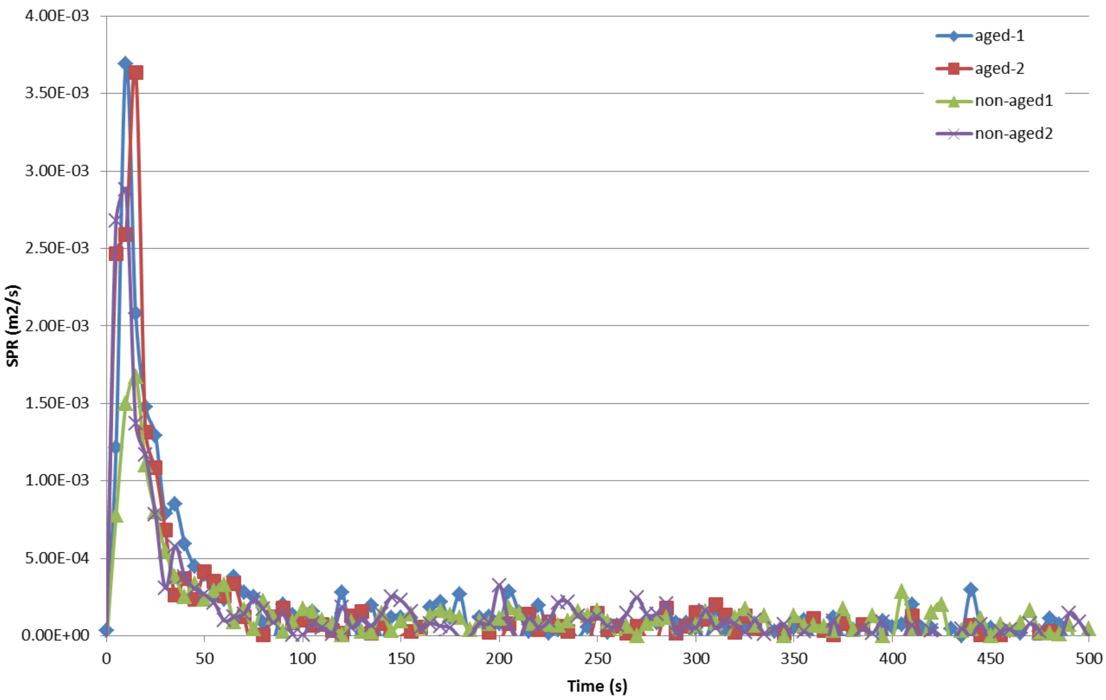

Figure 11 – Smoke Production Rate results

Table 6 – Test output summary

Material name/ID	See individual reports	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(ig) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**4.3**	**422.8**	**790**	**173.10**	**8.8**	**31.21**	**111.14**	**81.55**	**67.25**
1	7	479	890	157.01	10	35.40	106.93	81.41	69.37
2	5	303	905	184.77	10	28.84	111.05	76.04	60.94
3	3	436	895	163.96	10	34.44	113.60	85.35	70.09
4	2	473	470	186.66	5	26.14	113.00	83.40	68.58

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10-90}$ (g/s·m²)
Mean		**50**		**48.3**	**48.20**	**12.29**	**4061.6**	**4.55**	**6.70**
1	35	50	88.4	49.8	49.61	16.94	3695.7	4.14	4.45
2	35	50	88.4	49.6	49.48	20.27	3304.1	3.67	3.78
3	35	50	88.4	46.2	46.20	11.96	3873.4	4.00	4.70
4	35	50	88.4	47.5	47.50	0.00	5373.2	6.38	13.87

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**20.41**	**28.07**	**-**	**9.21**	**0.0001**	**2.64**	**5.72**	**132.63**
1	21.01	29.98	-	9.56	0.0001	2.81	6.28	111.53
2	18.44	24.32	-	8.73	0.0001	1.91	5.14	131.86
3	21.23	29.03	-	9.60	0.0001	2.74	6.59	134.76
4	20.97	28.94	-	8.95	0.0002	3.09	4.87	152.36

Test	Date	Specimen #	Line colour	Filename
1	18/12/2018	1	black	C:\CC5\DATA\18120024.CSV
2	18/12/2018	2	red	C:\CC5\DATA\18120025.CSV
3	18/12/2018	3	green	C:\CC5\DATA\18120022.CSV
4	18/12/2018	4	cyan	C:\CC5\DATA\18120023.CSV

3.6 F – Sea grass

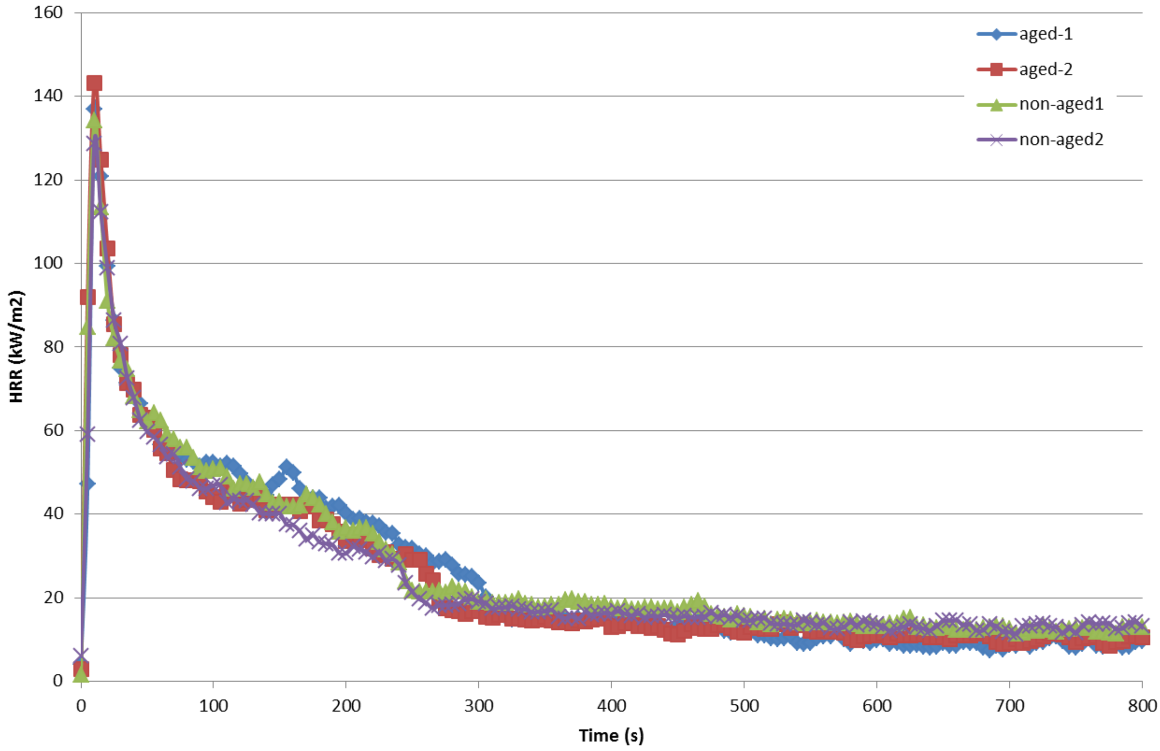

Figure 12 – HRR Results

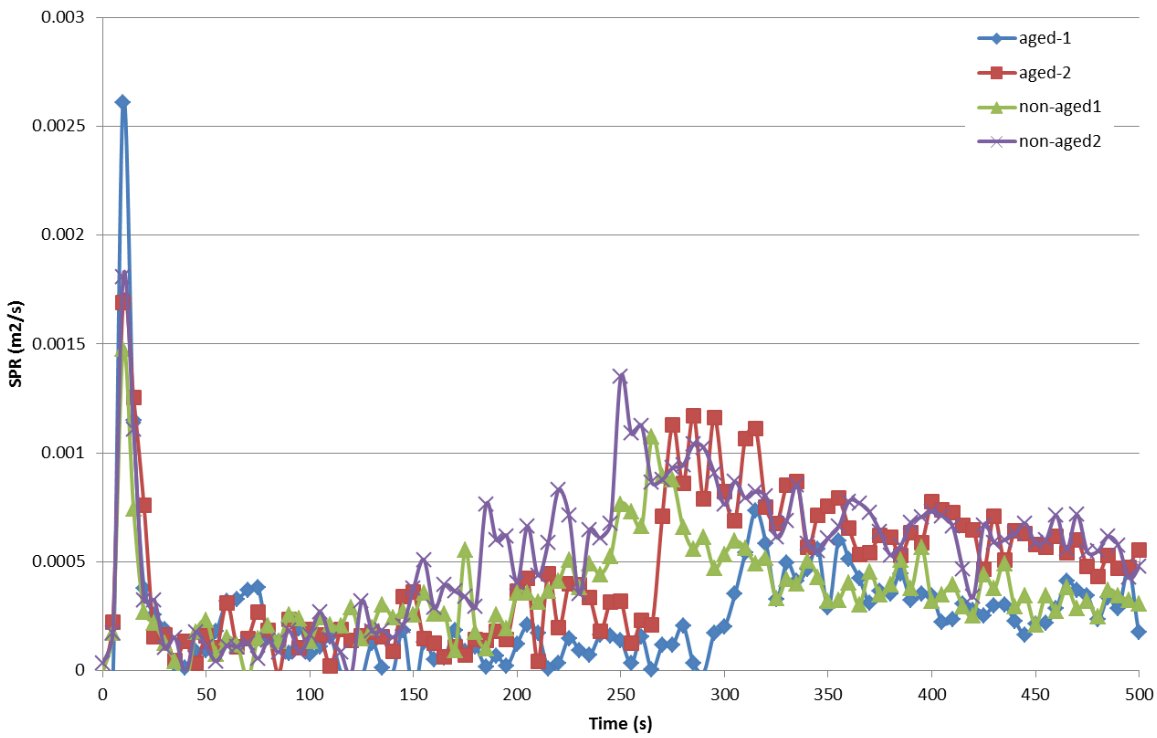

Figure 13 – Smoke Production Rate results

Table 7 – Test output summary

Material name/ID	See individual reports	Report name	See individual reports
Heat flux	35 kW/m²	Surface area	88.4 cm²
Orientation	Horizontal	Retainer frame used?	Yes

Test averages

Test	t(iq) (s)	t(fo) (s)	t(end) (s)	HRR(peak) (kW/m²)	tpeak (s)	THR (MJ/m²)	HRR(60) (kW/m²)	HRR(180) (kW/m²)	HRR(300) (kW/m²)
Mean	**5.8**	**266.8**	**892.5**	**135.70**	**10**	**21.24**	**78.72**	**56.61**	**45.04**
1	7	304	890	136.95	10	21.03	76.70	57.98	47.53
2	5	272	900	143.14	10	20.45	82.67	57.01	45.00
3	5	245	890	134.09	10	22.47	80.45	58.67	46.32
4	6	246	890	128.63	10	20.99	75.06	52.76	41.30

Test	Flux (kW/m²)	t (mm)	Area (cm²)	m(i) (g)	m(s) (g)	m(f) (g)	Δm (g/m²)	MLR(av) (g/s·m²)	$\dot{m}_{A,10-90}$ (g/s·m²)
Mean		**50**		**30.9**	**30.70**	**10.85**	**2246.2**	**2.51**	**2.78**
1	35	50	88.4	29.66	29.53	10.40	2163.7	2.40	2.73
2	35	50	88.4	29.33	29.16	10.26	2138.1	2.39	2.69
3	35	50	88.4	32.38	32.23	11.48	2346.7	2.65	2.87
4	35	50	88.4	32.08	31.90	11.24	2336.4	2.60	2.85

Test	THR(0-300) (MJ/m²)	THR(0-600) (MJ/m²)	THR(0-1200) (MJ/m²)	EHC(av) (MJ/kg)	SPR(av) (m²/s)	SEA(av) (m²/kg)	Fuel load (MJ/kg)	MARHE (kW/m²)
Mean	**13.79**	**18.19**	-	**9.46**	**0.0003**	**14.69**	**6.09**	**94.17**
1	14.64	18.64	-	9.74	0.0002	10.43	6.27	89.87
2	13.66	17.64	-	9.56	0.0003	16.43	6.16	103.23
3	14.02	19.03	-	9.57	0.0003	12.92	6.13	94.64
4	12.84	17.46	-	8.98	0.0004	18.96	5.78	88.97

Test	Date	Specimen #	Line colour	Filename
1	18/12/2018	1		C:\CC5\DATA\18120013.CSV
2	18/12/2018	2		C:\CC5\DATA\18120015.CSV
3	18/12/2018	3		C:\CC5\DATA\18120016.CSV
4	18/12/2018	4		C:\CC5\DATA\18120017.CSV

4 SBI predictions and discussion

Following the cone calorimeter testing, simulations were run using the predictive correlations – ConeTools. ConeTools provides a means of determining the potential classification class a material may achieve in the larger scale EN 13823 – Single Burning Item (SBI) test.

4.1 Principles of ConeTools model [1]

Three major assumptions are made within ConeTools to model heat release rate in the SBI test:

1. The burning area growth rate and the heat release rate are decoupled.
2. The burning area growth rate is proportional to the ease of ignition, i.e. the inverse of the time to ignition in small scale.
3. The history of the heat release rate per unit area at each location in the SBI test is the same as in small scale.

4.2 Model Limitations

The model used is in essence an empirically based model, and thus has certain limitations in its predictive capabilities. Thus, results from the model are only considered indicative and cannot be considered as definitive as to what the products results may end up being an actual SBI test. The modelling results cannot be used as a ground for requesting/obtaining the classification for the product – the tests must be performed. Test results are highly dependent on a number of factors, of which the model cannot completely account for. These include:

- Model is limited to assessing parameters associated with heat release of the product. Other performance criteria (e.g. smoke production, burning droplets) are not assessed with the model;
- Product geometry
- Product homogeneity
- Whether the product melts significantly
- Surface treatments (these may react differently compared to small scale tests that use a different method of ignition and heating sources, e.g. cone calorimeters radiant cone vs SBI sand burner)
- Environmental conditions
- Unknown factors

Simulations and Prediction of EN 13823:

Based on the cone tests, simulations were run in order to get a prediction on the performance of the material sample in a large-scale classification test (EN 13823 – SBI test).

Collecting all the knowledge obtained from the cone calorimeter, simulation and expert judgement, the material samples are estimated to achieve the following EN 13823 classification:

Table 8 – estimated EN 13823 SBI test results

Sample ID	Sample name	SBI prediction	
		Non-aged	aged
A	Paper fibre insulation	E or worse	E or worse
B	Lamb wool	E or worse	E or worse
C	Wood fibre insulation	E or worse	E or worse
D	Cork	E or worse	E or worse
E	Straw	E or worse	E or worse
F	Sea grass	E or worse	E or worse

4.3 Discussion of results

As can be observed from both the individual cone calorimeter tests and the predictions of SBI results, on the issue of aged vs non-aged, little difference can be observed. In almost all the measureable outcomes from the cone calorimeter tests, variation between aged and non-aged, could be considered within the experimental uncertainty of the test itself.

The only output from the testing that had an observable difference in some of the samples was the total heat release (THR), showing a reduced THR for the aged samples vs the non-aged (reference) samples in e.g. the cork, wood fibre and paper fibre, the greatest of these being the paper fibre (papiruld) sample. This result showed a drop in THR of approximately 5 MJ/m2.

One possible explanation for this slight change in results for the aged vs non-aged samples is that the aged samples have simply lost some of their volatile compounds (e.g. via off gassing) during the ageing process. However, this result is only slight and it is only observable for the products contain wood type (cellulosic) materials. As can be seen from the larger scale test predictions, these slight changes are not likely to change or impact the classification testing of these products, especially as they are predicted to be class E products before any ageing had been performed. It is suggested for future studies, to run additional tests with specimens of higher classification class (preferable class B). It would be expected, especially for biological material in which FR impregnation may be required, that a more dramatic impact may be seen on aged specimens. This would also help to clarify on the appropriateness of the chosen testing method.

The choice of test method could be discussed further, and may depend on the desired outcomes. Microscale testing in apparatuses such as the Micro Combustion Calorimeter (MCC) may show larger differences in the test samples (Aged vs non-aged) due to the higher resolution of the test, however due to the product type (non-homogeneous insulation material) this type of testing is highly dependent on the test sample (as test samples are in the order of milligrams), thus a much larger number of tests would be required in order to get an indication of the expected range of results that could occur simply within one sample material. Large or "real-world" testing i.e. in the SBI, is the other option, and would give the most realistic results in terms of effects to the building material as a whole (in terms of aging). However, this requires much larger sample sizes and the cost of this type of testing is out of the scope for this project. It is therefore considered that the chosen test apparatus (Cone Calorimeter) is likely the most appropriate for this type of investigation, as it offers a comprise between the two extremes discussed above.

5 Additional notes and limitations

- Estimated results provided in this report are as stated, they are considered predictions only based on the limited testing and information on the product that was performed and provided. This report gives no guarantee on the product result when tested in EN 13823 – SBI test. Results are dependent on many factors that cannot be account for in the methodology used in this report, and therefore SBI testing will still be required in order to obtain an actual classification.

6 References:

[1] P. Van Hees, T. Hertzberg, A.S. Hansen, Development of a Screening Method for the SBI and Room Corner using the Cone Calorimeter, 2002.

Appendix A – EN1323 Euroclass classification system

Main classification		Smoke classification		Flaming droplets/particles classification	
A2 and B	$FIGRA_{0,2MJ} \leq 120$ W/s LFS < specimen edge $THR_{600s} \leq 7,5$ MJ	**s1**	$SMOGRA \leq 30$ m^2/s^2 $TSP_{600s} \leq 50$ m^2	**d0**	No flaming droplets/part.
C	$FIGRA_{0,4MJ} \leq 250$ W/s LFS < specimen edge $THR_{600s} \leq 15$ MJ	**s2**	$SMOGRA \leq 180$ m^2/s^2 $TSP_{600s} \leq 200$ m^2	**d1**	No flaming droplets/part. persisting > 10 s
D	$FIGRA \leq 750$ W/s	**s3**	-	**d2**	-