STUDY REPORT

SR 302 (2014)

Reaction to Fire of Interior Wall and Ceiling Linings

– Paint Coatings

– Testing Results and Analysis

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Preface

This is the second of a series of reports prepared during research into interior wall and ceiling lining reactions to fire in the New Zealand regulatory context.

The first report in this series is titled “Simplified Reaction to Fire for Interior Wall, Ceiling and Floor Linings – Literature Review” BRANZ Study Report 301.

Acknowledgments

This work was jointly funded by the Ministry of Business, Innovation and Employment and BRANZ from the Building Research Levy.

The authors would also like to also acknowledge the assistance of the New Zealand Paint Manufacturers’ Association in the preparation of some samples for testing.

Note

This report is intended for regulators, researchers and fire engineers.

Disclaimer

The results obtained are strictly limited to the samples tested in the experimental programme. Therefore no conclusions can be drawn as to the likely performance of these materials in other situations.

No product is identified by manufacturer or brand in this report or elsewhere, as there is no endorsement or other comment by BRANZ on the performance or appropriateness of any specific product included in the range of commercially available products included in this test programme.

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Reference

Robbins A.P., Whiting P.N. and Wade C.A. 2013. *Reaction to Fire of Interior Wall and Ceiling Linings – Paint Coatings – Testing Results and Analysis, BRANZ Study Report 302*. BRANZ Ltd. Judgeford, New Zealand.

Abstract

Paint coatings on common building substrates were considered to assess the potential for simplified reaction to fire solutions for standard paint systems.

Combinations of substrate (concrete, plasterboard, plywood and medium density fibreboard) and paint systems (water-based and oil-based) were tested to ISO 5660 and assessed according to the New Zealand Building Code Verification Method 2 (2012a) Appendix A1.3 description of material Group Number calculations.

For some of the substrates tested, where sufficient specimens were included to provide resolution, a transitional paint thickness was observed. This increase in paint thickness was associated with an increase in indicated Group Number followed by a decrease in indicated Group Number with continued increasing paint thickness. This type of transitional behaviour from a protective to less protective to protective reaction to fire results is similar to that reported by Steen-Hansen and Kristoffersen (2007) for a plasterboard substrate coated with a glass fibre wallpaper and then multiple layers of latex paint. The potential protective versus less protective transitional behaviour observed for the paint thicknesses reported here needs further investigation to ensure appropriate application of test results being applied to ranges of paint coating thicknesses.

Reasonable comparability was observed between the plasterboard substrate real-world samples and the prepared samples for the test variables and analysis considered here.

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1. INTRODUCTION

The recently introduced Protection from Fire Building Code requirements included controls on the reaction to fire performance of internal surface finishes (walls, ceiling and floor coverings). These requirements entail testing to internationally recognised standards to establish where in a building a particular combination of substrate and finish will be permitted.

This project aims to provide simplified solutions to demonstrate code compliance for fire properties of surface coatings and other interior finishes. The simplified (prescriptive) solutions would ultimately be included in the Acceptable Solutions, C/AS1 to C/AS7, and Verification Method 2 (VM2) of the New Zealand Building Code (NZBC) supporting documents. This would remove the need for ongoing product testing for some specific combinations of substrate and surface coating where performance can be predetermined to fall within relevant Group Number categories required by the NZBC.

Whilst simplified solutions would clearly be of some benefit to manufacturers of both substrate and interior finishes, it will more importantly benefit all parties involved with the building inspections and compliance processes, for example:

- Specifiers and designers can propose generic combinations of products or specific products without the need to source fire test data for them
- Building consent processors can accept a proposal without needing large quantities of product data
- Monitoring during construction will be more straightforward and it will be easier to establish that the construction as built does comply
- Final inspections will not always require evidence that products used are those specified in consent documentation
- Building warrant of fitness inspections, are similarly easier as redecoration occurs during the life of a building
- Alterations to the building will be more readily accepted by councils since assessment of means of escape from fire can be conducted by comparisons of generic descriptions rather than specific products.

All of the above would result in a considerably more straightforward compliance regime for buildings and therefore significant cost savings across the board when applied to every non-residential building consent throughout the country.

1.1 Objectives

The overall objective of this project is to provide simplified solutions to demonstrate code compliance for fire properties of surface coatings and other interior finishes for some specific combinations of substrate and surface coating for non-residential building end use.

The specific objective of this piece of work is to investigate the behaviour of paint coatings on common building substrates and the potential for establishing simplified reaction to fire solutions for standard paint coating systems.

1.1.1 Scope

Interior surface finish, in relation to the scope of this work, refers to exposed surfaces of walls (fixed or movable) and ceilings within buildings. It does not include concealed or

inaccessible spaces, building contents nor furnishings that may be fixed in place within a building.

The scope of the test matrix is limited to multiple paint coats on a specified range of substrates, as representative of some wall linings in existing buildings.

It was intended that the simplified solutions would be targeted toward the lower minimum requirement (Group Number 3) applications.

Foamed plastics are outside of the scope of this report.

2. TEST METHOD

Specimens were tested to ISO 5660 Part 1 (2002) and the material Group Number assessed according to New Zealand Building Code Verification Method 2 (VM2) Appendix 1.3 Group Numbers (MBIE 2012a, 2012b) classifications.

Data sets reported here include:

- Heat Release Rate (HRR) versus time
- Peak Heat Release (PHR)
- Total Heat Released (THR)
- Total Smoke Released (TSR)
- Time to Ignition (TTI).

The analysis reported here includes the Group Number according to the VM2 (MBIE 2012a) method, as well as a sensitivity analysis of the Group Number results.

Testing was carried out using the BRANZ Cone Calorimeter in accordance with ISO 5660 Part 1 (ISO 2002).

Some samples were subjected to a simulated aging process (described in Section 3.3) before being conditioned. Specimens were not subjected to this simulated aging unless specified.

All samples were conditioned to moisture equilibrium (constant mass), at a temperature of 23±2°C and a relative humidity of 50±5% immediately prior to testing in accordance with the test standard.

All testing was carried out in a horizontal orientation, with the samples secured in the retainer frame (without the wire grid) for gypsum, plywood and medium density fibreboard substrate specimens, while only the base holder was used for the concrete substrate specimens.

All testing was carried out at an irradiance of 50 kW/m², except where specified.

3. TEST SAMPLES

The test samples were prepared in accordance with ISO 5660 Part 1 (ISO 2002).

Two main parameters were considered in sample selection:

- Substrate material
- Thickness of paint

- Type of paint (i.e. water-based versus oil-based).

Each system was prepared on full sheets of the substrate, edges removed and then the remainder cut into 100 mm squares as required for the cone testing.

3.1 Substrates

Distinctly different substrates were chosen to give a cross section of typical materials used as wall and ceiling linings within the common areas in buildings. The substrate materials selected were;

1. Concrete
    a. A homogeneous 1200 mm x 2400 mm slab of approximately 25 MPa concrete that was cut into sample sections that were prepared with the paint system. Finally, each sample section was cut into 100 mm x 100 mm specimen sizes, each approximately 40 mm thick
2. Paper-faced gypsum plasterboard (650 - 700 kg/m^3)
    a. 9.5 mm thick
3. Plywood (500 - 570 kg/m^3)
    a. 7 mm thick
    b. 10 mm thick
4. Medium density fibreboard (675 - 700 kg/m^3)
    a. 9 mm thick

This selection provided a range in the fire properties of the substrates, from non-combustible, to partly combustible, to fully combustible.

3.2 Paint

3.2.1 Water-Based Paint Systems

Water-borne paint from two different manufacturers was selected, Paints A and C, with two (eight and 16 topcoat layer) or three (four, six and eight topcoat layer) paint build. In both cases, a white matte paint system was selected as a representative coating, typical of that used on internal wall surfaces. The paint systems were selected from the commercially available range of interior paints. White paint was chosen for all samples to remove any influence that different colours may have.

For Paint A, prior to the layers of topcoat paint being applied, all substrates were initially prepared with a single coat of water-based sealer, applied in accordance with the manufacturer's specifications.

For Paint C, prior to the layers of topcoat paint being applied, all substrates were initially prepared with two coats of water-based sealer, applied in accordance with the manufacturer's specifications.

For both Paint A and Paint C, the sealer and paint were applied using a roller as per the manufacturer's specifications for surface preparation, application rate and curing times between the layers.

3.2.2 Oil-Based Paint Systems

An oil-based paint was selected, Paint B, with three levels of multiple paint layer build (four, six and eight layers of topcoat). A white semi-gloss paint system was selected as a representative coating, typical of that used on internal wall surfaces. The paint system was selected from the commercially available range of interior paints. White paint was chosen for all samples to remove any influence that different colours may have.

For Paint B, prior to the layers of paint being applied, all substrates were initially prepared with two coats of an oil-based primer, applied in accordance with the manufacturer's specifications. The sealer and paint were applied using a brush as per the manufacturer's specifications for surface preparation, application rate and curing times between the layers.

3.3 Simulated Aging

An accelerated aging regime was used as part of the preparation of some of the samples coated with Paint A after the full number of layers of paint had been applied. The simulated aging process was included to consider the potential effect of adhesion between subsequent paint layers through moisture migration within the samples. A reduced inter-layer adhesion may lead to a greater tendency for the paint layers to delaminate on exposure to a heat source.

It should be noted that the accelerated aging regime employed here was not intended to reproduce any aging effects in the properties of the paint systems and therefore considerations such as exposure to ultra violet radiation were not included in the aging process. The results are not suitable to be used to indicate the long term durability of the coating systems. It is also not a requirement to undertake accelerated aging of samples prior to testing and assignment of a material Group Number in accordance with the New Zealand Building Code Verification Method.

The aging regime consisted of eight hour cycling of the exposure conditions between 5°C and 65% humidity, and 35°C and 85% humidity. This was carried out continuously for a period of three months, after which the samples were conditioned to equilibrium in accordance with the standard, ISO 5660 Part 1 (ambient temperature of 23±2°C and relative humidity of 50±5% humidity), before testing.

3.3.1 Paint Defects after the Aging Regime

The samples submitted for testing were inspected before and after the simulated aging process. Following that process, minor visible defects were apparent on the surface of all samples, as shown in Figure 1. These minor paint defects were observed for all aged Paint A samples, both eight and 16 layer paint builds, and for the three substrates used (concrete, 9.5 mm thick paper-faced plasterboard and 10 mm thick plywood).

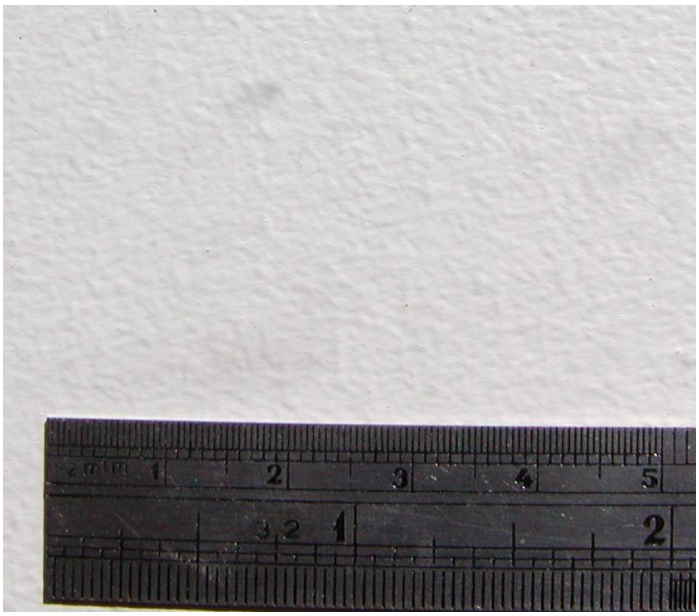


Figure 1 Example of a 16 layer acrylic-painted sample after being subjected to the simulated aging process

3.3.2 Adhesion Tests

Following the simulated aging process, a series of “pull-off” tests were carried out on a limited selection of painted samples. The pull-off tests were conducted to assess the impact of the aging regime on the inter paint layer bond strength by the comparison of results from samples not subjected to the simulated aging process and samples that had been.

The testing was conducted on five new and five aged plywood substrate samples, each with 16 layers of paint. Two tests were conducted on each sample.

Two aluminium dollies were bonded to the top paint layer of each sample and the paint layer cut through around each dolly. The test procedure consisted of pulling the aluminium dolly off the sample and measuring the tensile load at which the paint layers failed. These tests were carried out on an Instron 5569 load frame using a 10 kN load cell.

The tests on the aged samples produced a wider spread in the attained loads than the new samples. However, the mean and standard deviations (shown as thin bars in Figure 2) of the results indicated that the aging had a negligible effect on the inter paint layer adhesion.

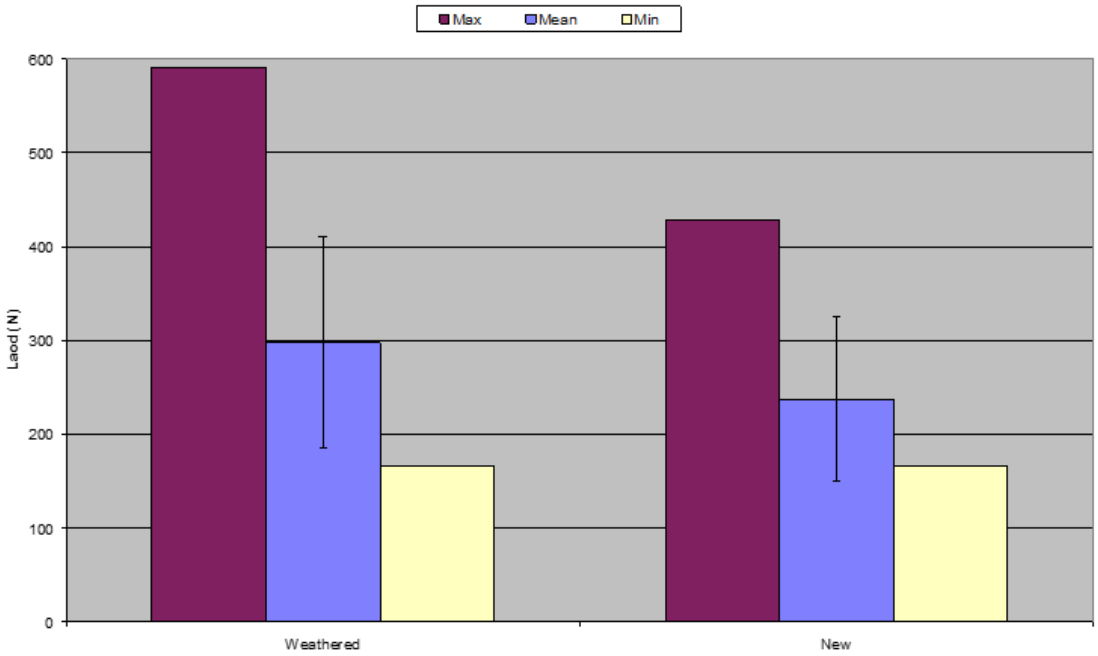


Figure 2 Adhesion "pull-off" test results comparison

3.4 Real-World Samples

Real-world samples (rws) were difficult to obtain. Five different samples of painted interior wall linings were obtained from detached dwellings during renovation. The samples were cut to the required cone test size and conditioned to ISO 5660 (2002). A summary of the descriptions of each of the real-world samples tested is presented in Table 1. Examples of each of the samples are shown in Figure 3.

Table 1 Summary of the description of the real-world samples tested

Sample Label	Substrate	Substrate Thickness (mm)	Average Paint Thickness * (µm)
rws-601	Plasterboard	8.9 - 9.6	399 (12%)
rws-602	Plasterboard	9.1 - 9.5	689 (3%)
rws-603	Hardboard	3.1 - 3.4	203 (17%)
rws-604	Plasterboard	10.7 - 10.8	1097 (2%)
rws-605	Plasterboard	9.8 - 10.4	516 (3%)

Table Notes:
* Bracketed values are the sample standard deviation as a percentage of the average paint thickness. Four manual measurements of the paint thickness were made of each sample before testing.

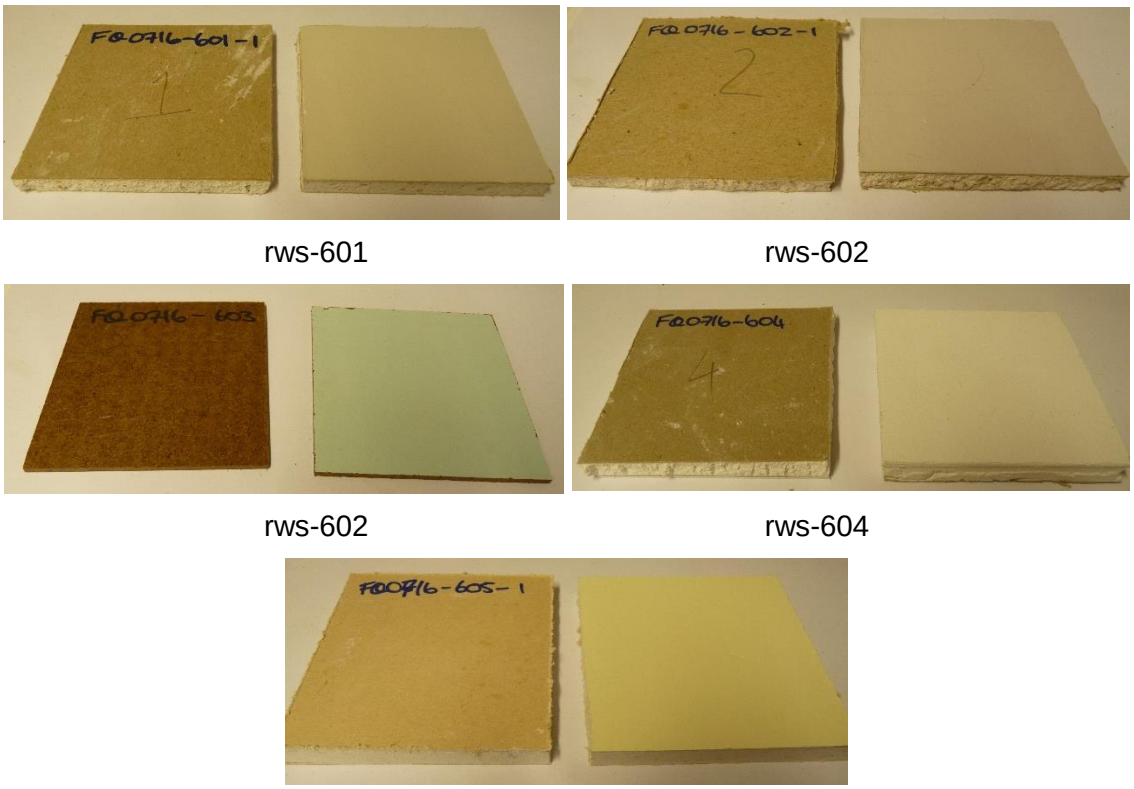


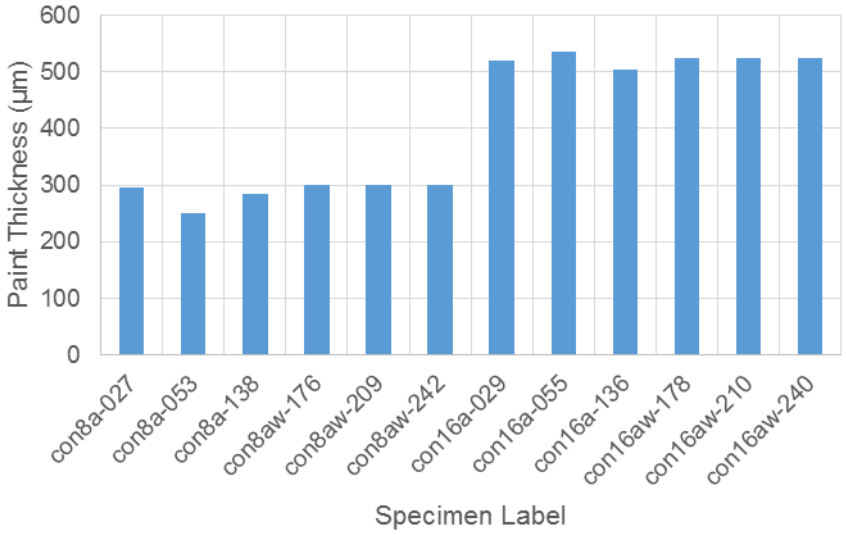
Figure 3 Examples of the real-world samples tested

In each case, the types of paint, history of the number of paint coatings and when each were applied were not available.

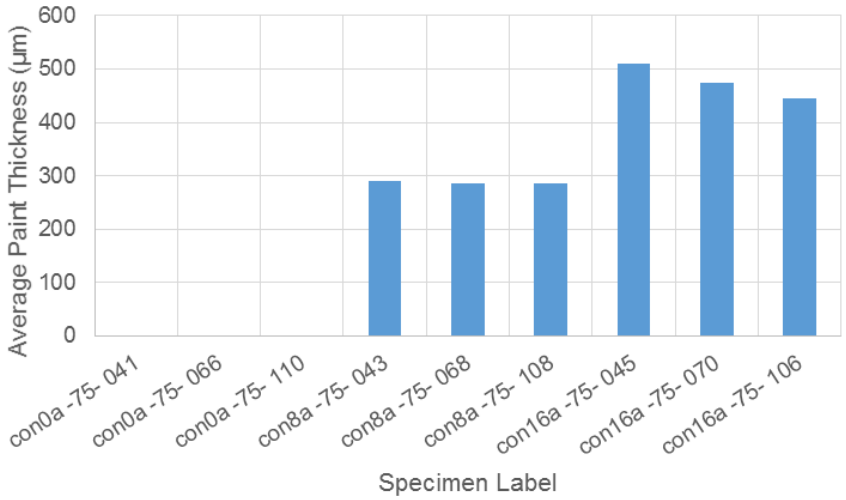
No real-world paint samples on plywood, concrete, metal or cement fibreboard substrates were located for inclusion in this test programme.

3.5 Paint Thickness

The overall paint thickness of all specimens was measured after the simulated aging process, if applied, but prior to the cone calorimeter testing. The paint thickness was measured manually at least at four points around the edge of the sample using a Vernier calliper. The precision of the Vernier calliper was ±5 µm. Experimental uncertainty (including user error) is estimated at ±50 µm. Figure 8 illustrates the average paint thickness measured of all samples for all substrate, layer number and paint type combinations.



(a)



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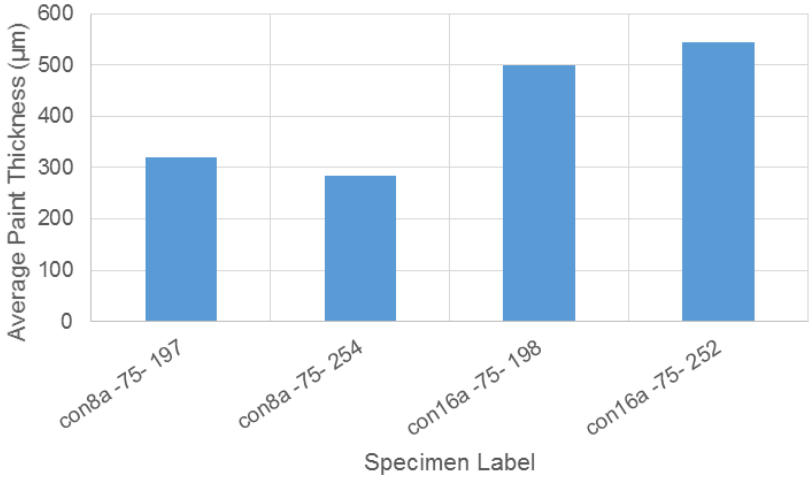
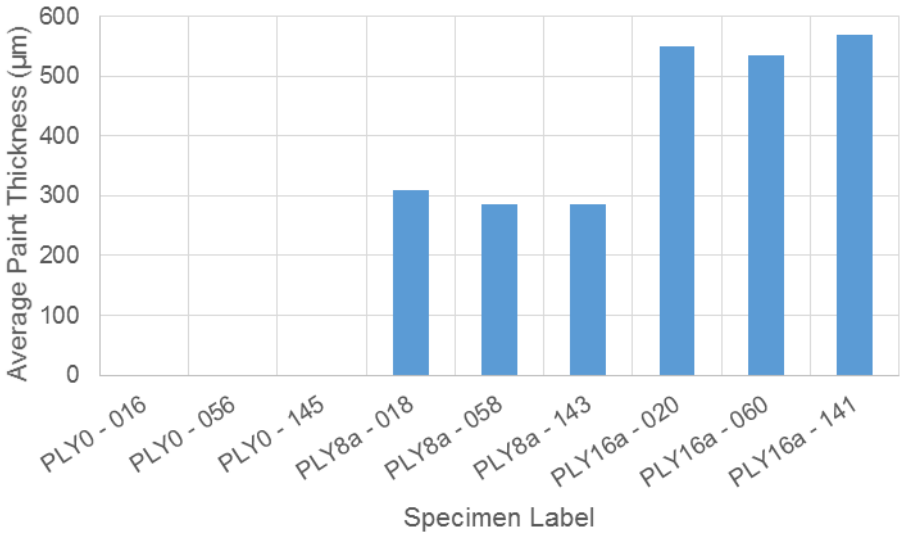
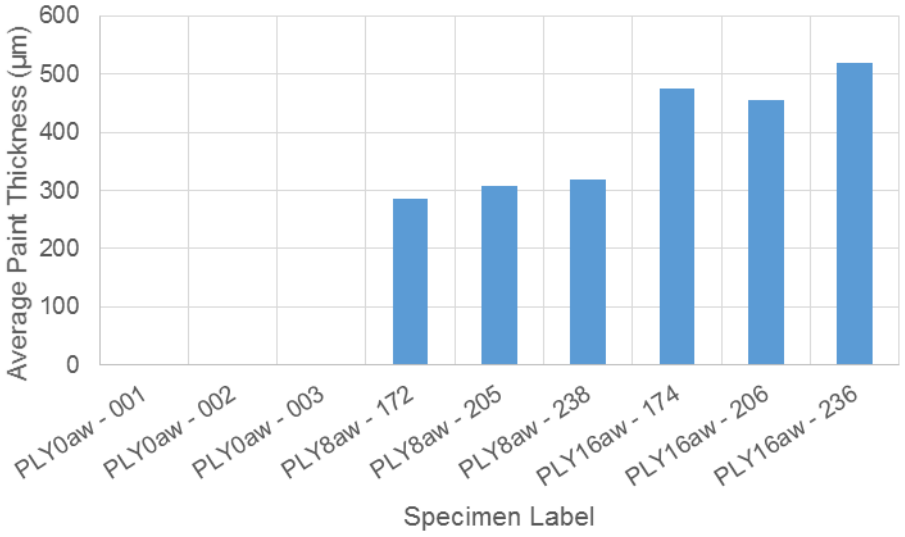


(c)

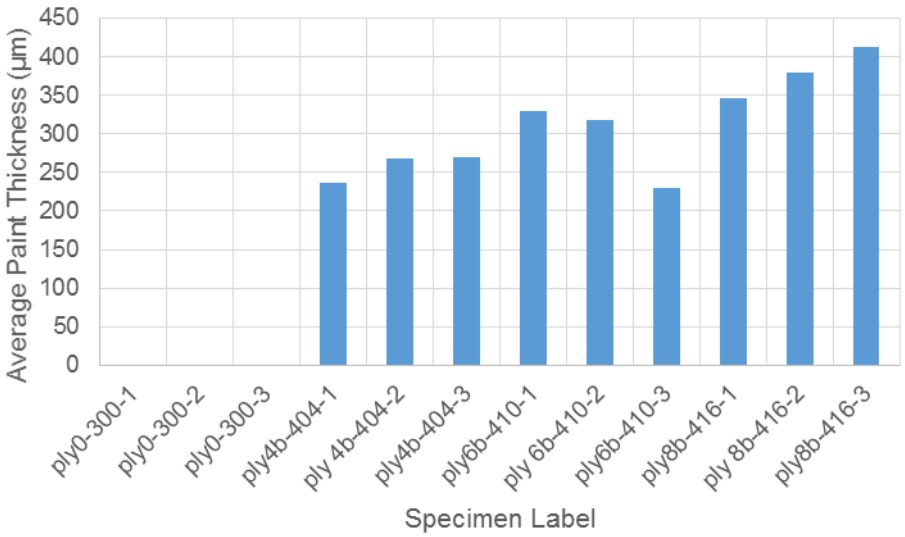
Figure 4 Average specimen paint thicknesses for concrete substrates for (a) Paint A pristine and subjected to simulated aging and tested at 50 kW/m², (b) Paint A tested at 75 kW/m² irradiance and (c) Paint A subjected to simulated aging and tested at 75 kW/m² irradiance


Average Paint Thickness (µm)
600
500
400
300
200
100
0
PLY0 - 016
PLY0 - 056
PLY0 - 145
PLY8a - 018
PLY8a - 058
PLY8a - 143
PLY16a - 020
PLY16a - 060
PLY16a - 141
Specimen Label

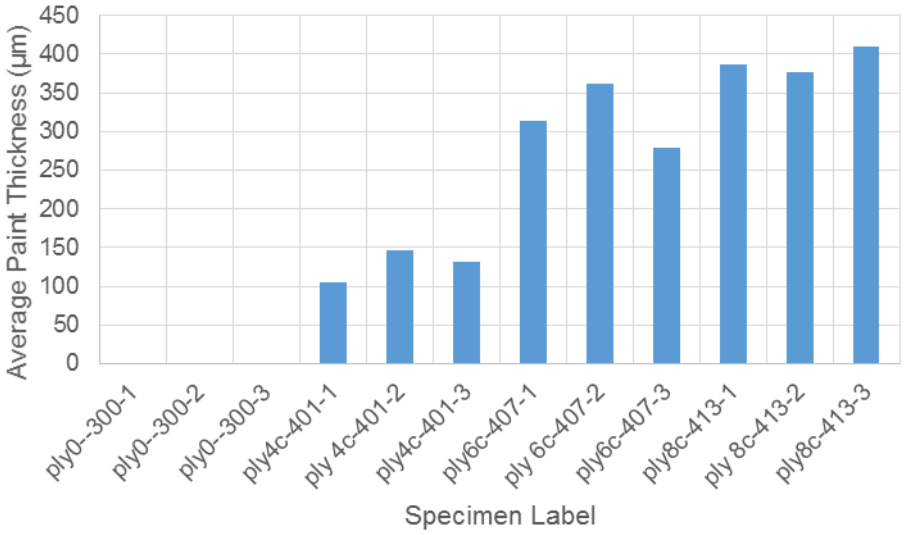
(a)


Average Paint Thickness (µm)
600
500
400
300
200
100
0
PLY0aw - 001
PLY0aw - 002
PLY0aw - 003
PLY8aw - 172
PLY8aw - 205
PLY8aw - 238
PLY16aw - 174
PLY16aw - 206
PLY16aw - 236
Specimen Label

(b)

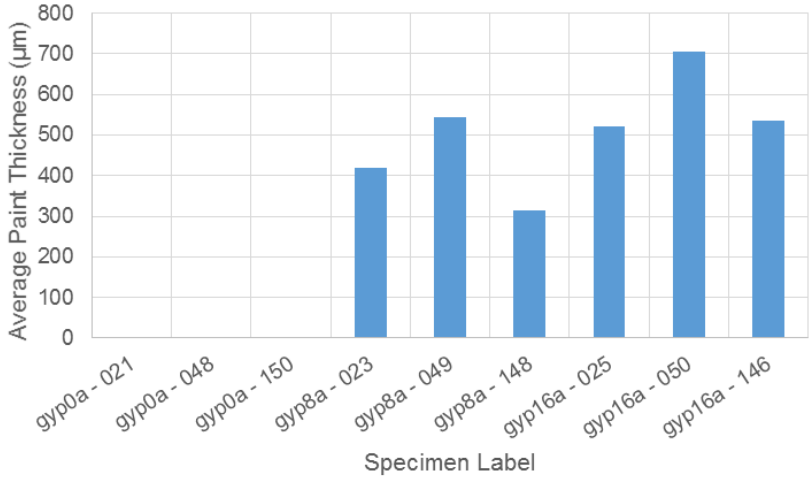

Average Paint Thickness (µm)
450
400
350
300
250
200
150
100
50
0
ply0-300-1
ply0-300-2
ply0-300-3
ply4b-404-1
ply 4b-404-2
ply4b-404-3
ply6b-410-1
ply 6b-410-2
ply6b-410-3
ply8b-416-1
ply 8b-416-2
ply8b-416-3
Specimen Label

(c)

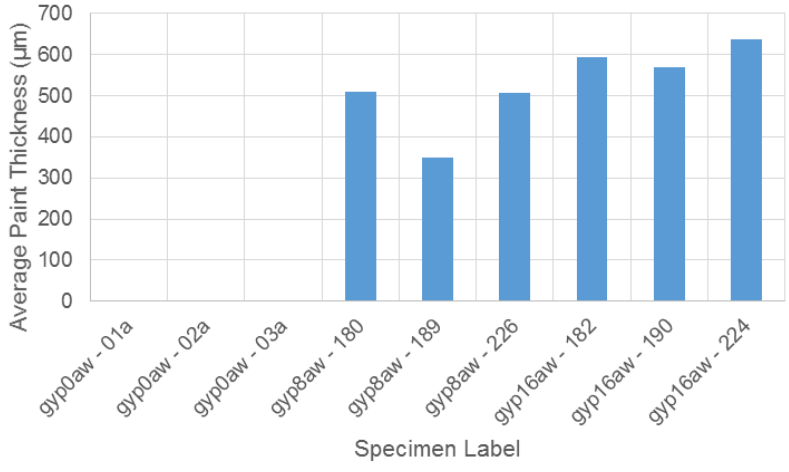


(d)

Figure 5 Average specimen paint thicknesses for (a) 10 mm plywood coated in Paint A, (b) 10 mm plywood coated in Paint A and subjected to simulated aging, (c) 7 mm plywood coated in Paint B and (c) 7 mm plywood coated in Paint C



(a)



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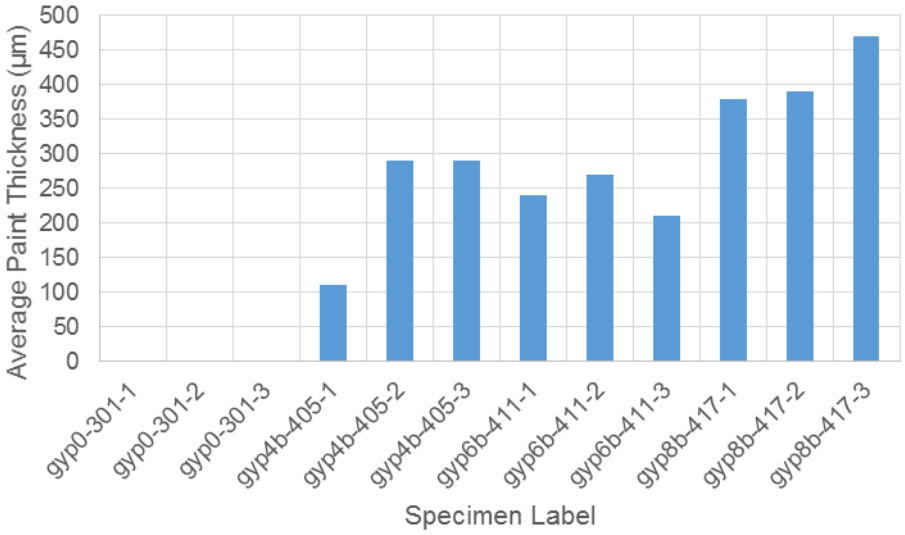
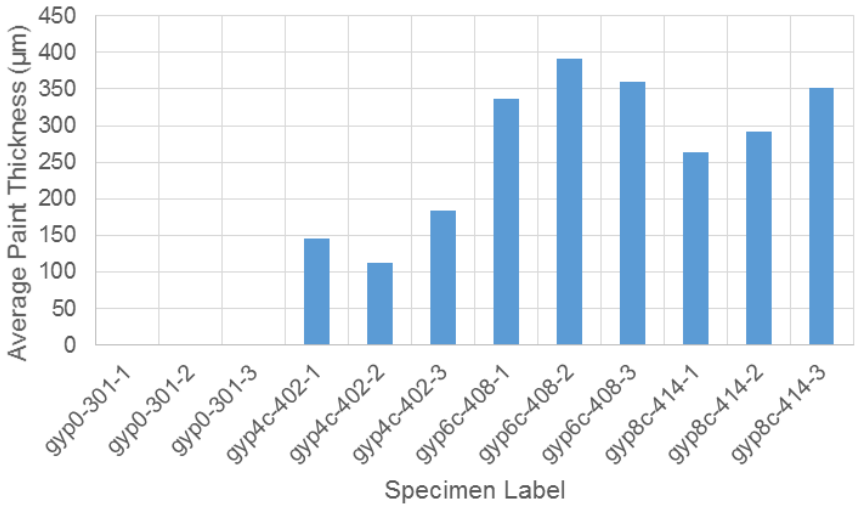
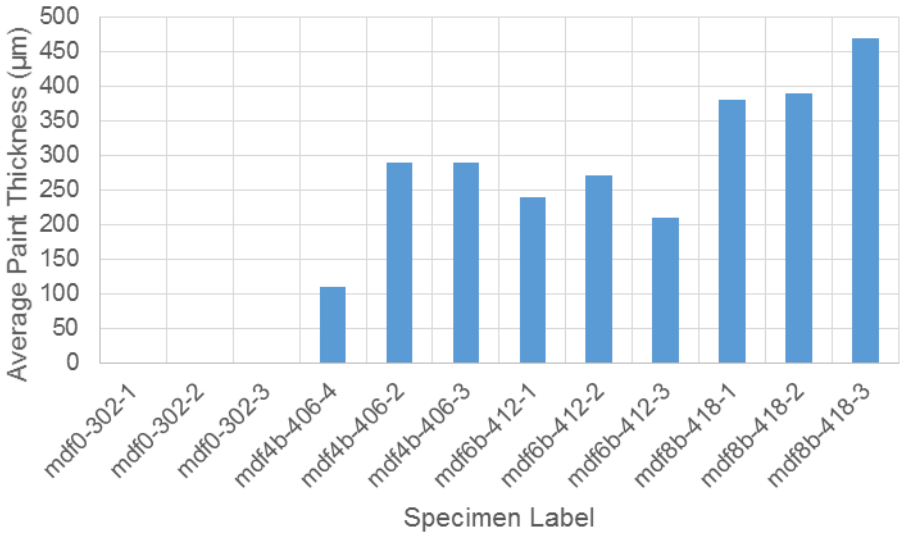


(c)

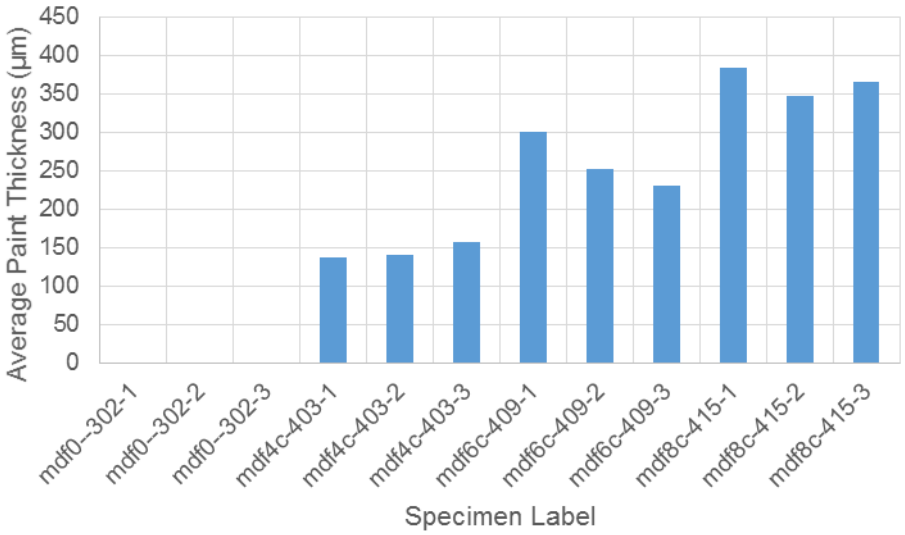


(d)

Figure 6 Average specimen paint thicknesses for plasterboard (a) coated in Paint A, (b) coated in Paint A and subjected to simulated aging, (c) coated in Paint B and (d) coated in Paint C



(a)



(b)

Figure 7 Average specimen paint thicknesses for medium density fibreboard (a) coated in Paint B and (b) coated in Paint C

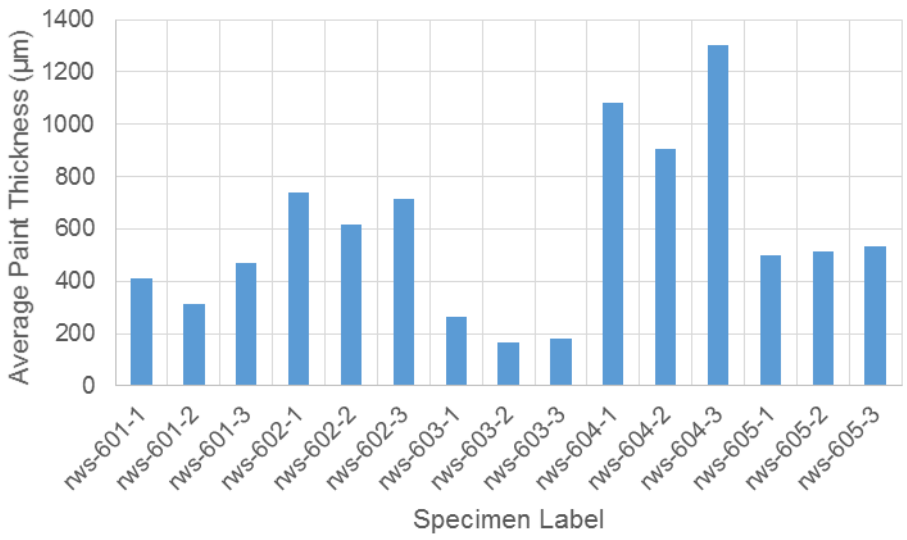


Figure 8 Average specimen paint thicknesses of the real-world samples

Average paint thickness of samples were approximately:

- Paint A, with two levels of multiple paint layer build
  - eight layers (approximately 300 to 400 µm thick)
  - 16 layers (approximately 400 to 600 µm thick).
- Paint B, with three levels of multiple paint layer build
  - four layers (approximately 100 to 250 µm thick)
  - six layers (approximately 200 to 350 µm thick)
  - eight layers (approximately 350 to 400 µm thick).
- Paint C, with three levels of multiple paint layer build
  - four layers (approximately 100 to 150 µm thick)
  - six layers (approximately 250 to 350 µm thick)
  - eight layers (approximately 340 to 400 µm thick).

3.6 Test Matrix

The testing program presented in Table 2 was designed to investigate the performance of the selected painted systems in relation to the substrate, paint coating thickness and type of paint used.

Throughout, samples were given a unique identification code consisting of:

- Three letters denoting the substrate,
  - “con” for concrete

- "cfb" for cement fibreboard
    - Nominally 6 mm thick
- "gyp" for (gypsum) plasterboard
    - Nominally 9.5 mm thick
- "PLY" for plywood
    - Nominally 10 mm thick
- "ply" for plywood
    - Nominally 7 mm thick
- "mdf" for medium density fibreboard
    - Nominally 10 mm thick
- "sht" for metal (aluminium) sheet
    - Nominally 0.4 mm thick

- A number indicating the number of topcoat paint layers
    - "0" for no paint
    - "4" for an initial sealant and four layers of topcoat
    - "6" for an initial sealant and six layers of topcoat
    - "8" for an initial sealant and eight layers of topcoat,
    - "10" for an initial sealant and 10 layers of topcoat
    - "16" for an initial sealant and 16 layers of topcoat
- A letter code
    - "a" for a water-borne paint system, specifically two coats of an initial water-based sealant coat, and multiple layers of white water-based topcoat
    - "b" for an oil-borne paint system, specifically two coats of an initial oil-based sealant coat, and eight layers of white topcoat paint
    - "c" for a water-borne paint system, specifically two coats of an initial water-based sealant coat, and multiple layers of white water-based topcoat
    - "d" for an oil-borne paint system, specifically two coats of an initial oil-based sealant coat, and eight layers of white topcoat paint
- A letter code
    - "w" if subjected to the simulated aging process (described in Section 3.3).

For example, gyp8aw, consists of paper faced (gypsum) plasterboard coated with Paint A with an initial sealant coat, and eight layers of topcoat. Each sample was uniquely identified with a three digit suffix and specimen number.

The paper-faced plasterboard (listed as "gypsum" and identified by the code "gyp" was used for visual ease of comparisons), while 7 mm thick plywood, 10 mm thick plywood, medium density fibreboard and cement fibreboard were tested without paint to identify the contribution of the substrate to the overall fire performance. Concrete is considered to be non-combustible and was not tested without paint.

Table 2 Summary of the test matrix for the samples

Paint Layers	Paint Layer and Type Code	Cone Irradiance Level (kW/m²)	
		50	75
0	0	Gypsum 10 mm plywood 7 mm plywood Medium density fibreboard	
4	4b,c	Gypsum 7 mm plywood Medium density fibreboard	
6	6b,c	Gypsum 7 mm plywood Medium density fibreboard	
8	8a,b,c	Concrete Gypsum 10 mm plywood	Concrete
8 aged	8aw	Concrete Gypsum 10 mm plywood	Concrete
16	16a	Concrete Gypsum 10 mm plywood	Concrete
16 aged	16aw	Concrete Gypsum 10 mm plywood	Concrete
Real-world samples	rws	Gypsum Fibreboard	

The irradiance levels selected for the concrete samples were set one step higher to counter the expected heat-sink characteristics of the approximately 40 mm thick concrete substrate, so that data sets were available for positive ignitions of specimens. This enabled a general trend of results to be considered.

Consistent with the test standard ISO 5660, three replicate tests were carried out for each of the above-listed substrate/paint system/heat flux combinations. Three replicates of each sample were tested.

Data sets were collated from previous testing where possible and for these it is noted that smoke production was not recorded during all testing. In addition, during the testing of previous data sets, malfunctions of the cone calorimeter meant that in a few cases data was only available for analysis on two replicates rather than the required three. Except where noted, the consistency of the two replicates was considered adequate to complete the analysis reported herein.

4. TEST RESULTS

Summaries of test results are presented in this section according to substrate followed by paint type for:

- Time to Ignition (TTI)
- Peak Heat Release Rate (HRR)
- Total Heat Released (THR)
- Total Smoke Produced (TSP), where available
- Average Specific Extinction Area (SEA), where available.

Summaries of the analysis of the results are presented in the following section, Section 5. Additional test result information and analysis is included in Appendix A.

4.1 Concrete Samples

Uncoated and Paint A coatings of concrete substrate samples are presented in this section.

4.1.1 Paint A

A summary of test results is presented in Table 3 and heat release rates versus time are shown in Figure 9, for 16 layers of Paint A tested at 75 kW/m². The majority of concrete-substrate specimens tested did not ignite. Heat release rates versus time are not included for tests where no ignition occurred.

Table 3 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for concrete samples coated with Paint A

Specimen	Time to Ignition (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
con0-	NT	-	-	-	-
con0-75-	NT	-	-	-	-
con8a-027	NI	-	-	-	-
con8a-053	NI	-	-	-	-
con8a-138	NI	-	-	-	-
con16a-029	NI	-	-	-	-
con16a-055	NI	-	-	-	-
con16a-136	NI	-	-	-	-
con8a-75-043	NI	-	-	-	-
con8a-75-068a	NI	-	-	-	-
con8a-75-108	NI	-	-	-	-
con16a-75-045	212	68.3	2.4	N/A	N/A
con16a-75-070a	109	99.3	4.8	N/A	N/A
con16a-75-106	195	106.7	9.2	N/A	N/A

Table Notes:
NT refers to Not Tested
NI refers to No Ignition observed during test
N/A refers to data not recorded

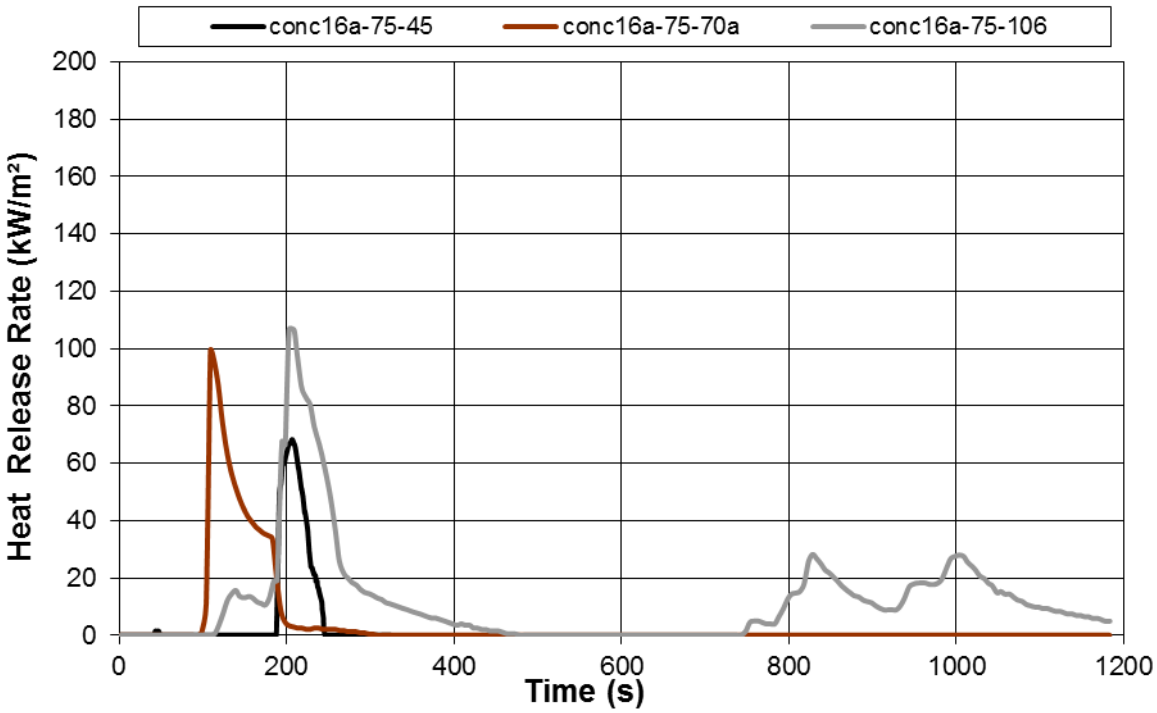


Figure 9 HRR of concrete specimens tested at 75 kW/m², with 16 layers of Paint A

4.1.1.1 Simulated Aged Samples

A summary of the test results for the concrete substrate specimens subjected to simulated aging before testing are presented in Table 4 and heat release rates versus time results for the three samples with specimen ignitions are shown in Figure 10, Figure 11 and Figure 12. Results are not shown for tests where ignition was not observed. Only two specimens of each paint layer number were tested at the 75 kW/m² irradiance.

Table 4 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for concrete samples subjected to a simulated aging process

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
con8aw-176	NI	-	-	-	-
con8aw-209	NI	-	-	-	-
con8aw-242	NI	-	-	-	-
con16aw-178	271	85.9	3.0	1.3	79
con16aw-210	297	89.0	4.3	1.5	155
con16aw-240	281	95.5	4.5	1.5	149
con8aw-75-197	154	56.2	1.5	0.3	10
con8aw-75-254	144	63.1	2.7	0.5	93
con16aw-75-198	21	78.7	4.4	N/A	N/A
con16aw-75-252	24	78.5	6.8	N/A	N/A

Table Notes:
NI refers to No Ignition observed during test

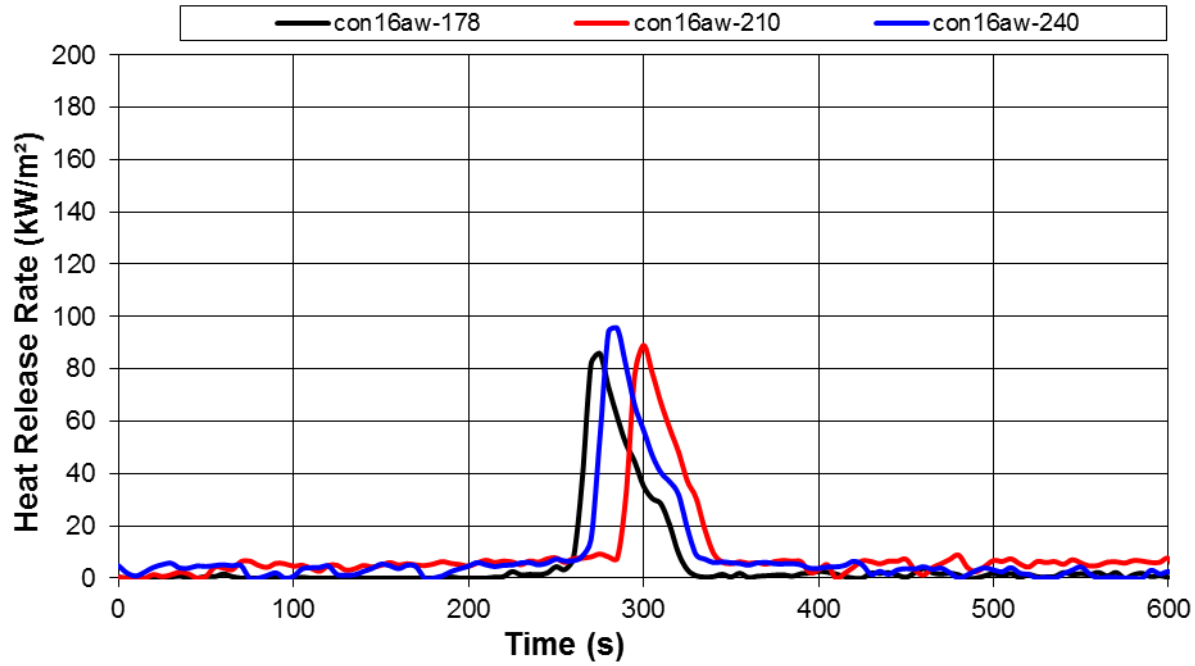


Figure 10 Heat release rate versus time for concrete specimens tested at 50 kW/m², with 16 layers of Paint A subjected to the simulated aging process

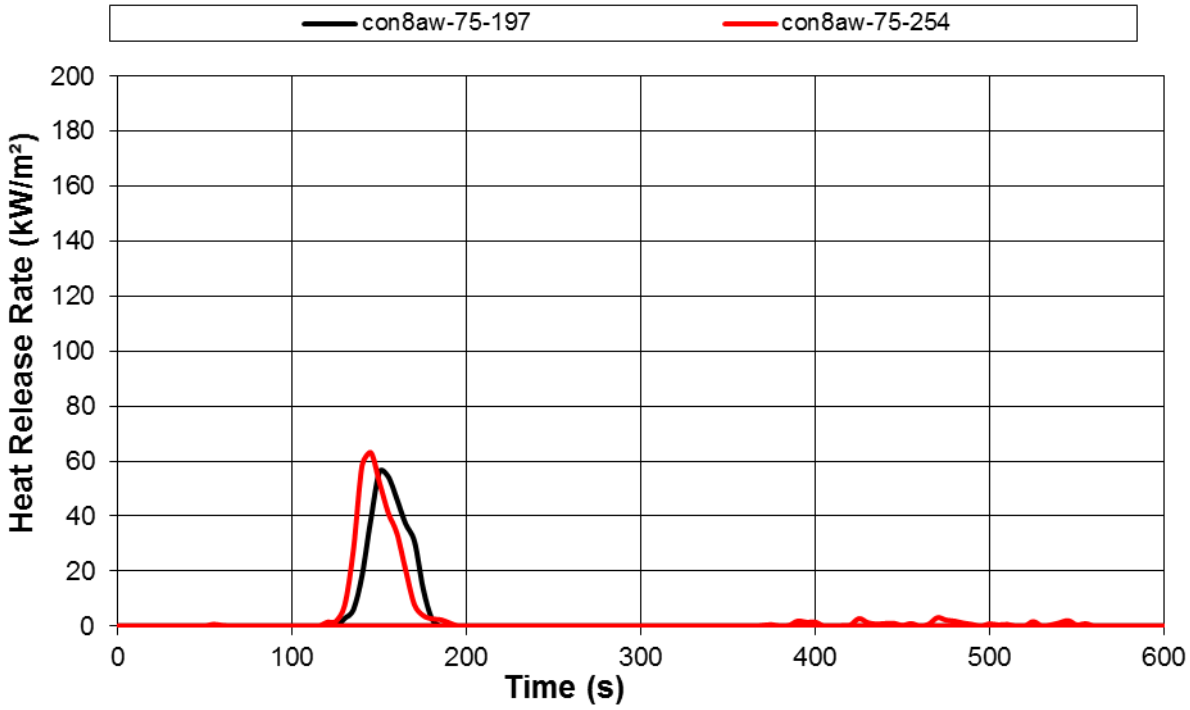


Figure 11 Heat release rate versus time for concrete specimens tested at 75 kW/m², with eight layers of water-based paint subjected to the simulated aging process

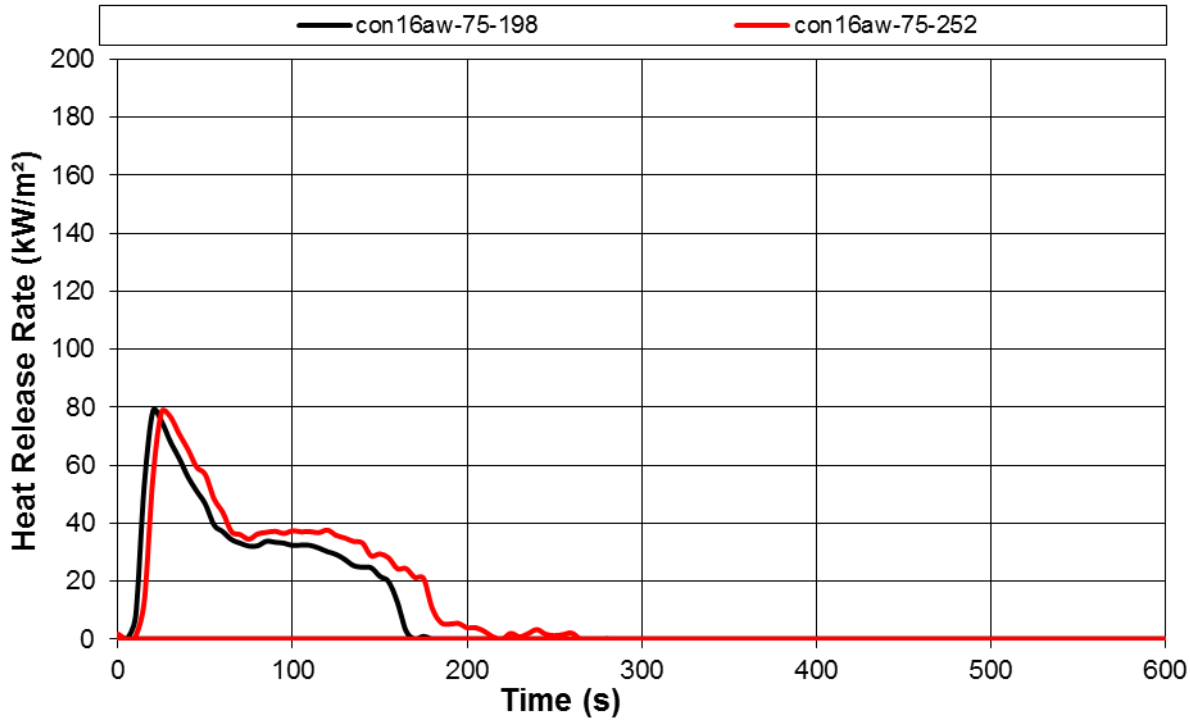


Figure 12 Heat release rate versus time for concrete specimens tested at 75 kW/m², with 16 layers of water-based paint subjected to the simulated aging process

4.2 Plasterboard Samples

Uncoated, Paint A, Paint B and Paint C coatings of plasterboard substrate samples are presented in this section.

A summary of the uncoated-specimen test results are presented in Table 5 and heat release rates versus time results are shown for the plasterboard substrate used in testing Paint A coatings in Figure 13, this plasterboard substrate after being subjected to the simulated aging process in Figure 14, and the plasterboard substrate used for testing Paint B and C coatings in Figure 15.

Table 5 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for plasterboard samples

Specimen Label	Used for Testing of Paint Type	Time to Ignition (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
gyp0-021	A	NI	-	-	-	-
gyp0-048	A	56	28.9	1.8	N/A	N/A
gyp0-150	A	43	81.7	2.0	0.6	58
gyp0w-001	A	36	93.7	2.0	N/A	N/A
gyp0w-002	A	31	88.1	2.1	N/A	N/A
gyp0w-003	A	34	91.3	2.1	N/A	N/A
gyp0-301-1	B,C	42	91.4	2.5	0.1	5
gyp0-301-2	B,C	41	95.7	3.2	0.1	3
gyp0-301-3	B,C	41	95.4	2.3	0.0	0

Table Notes: NI refers to No Ignition observed during test

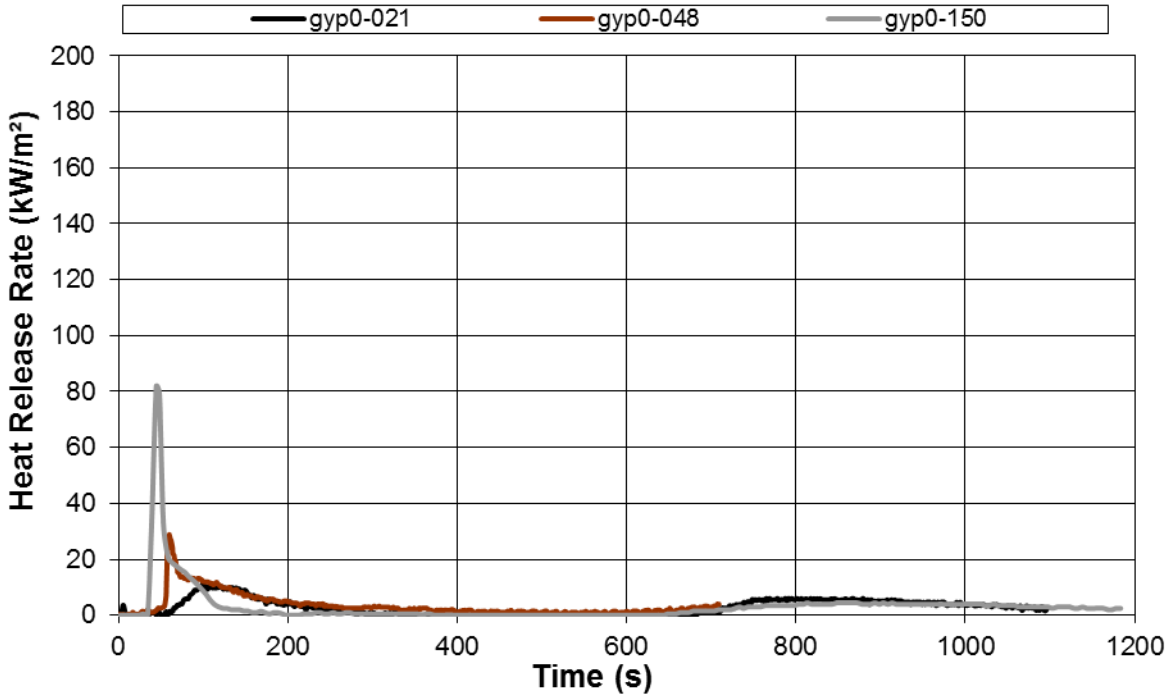


Figure 13 Heat release rate versus time for uncoated plasterboard samples (used for testing Paint A samples) tested at 50 kW/m²

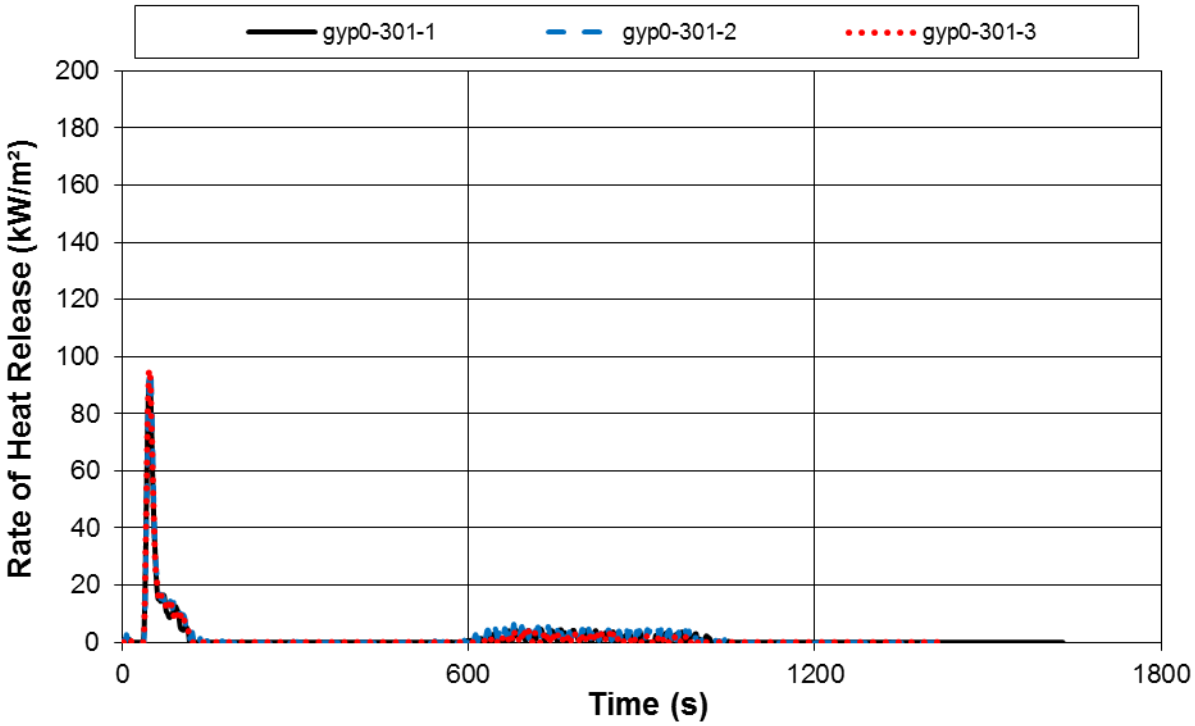


Figure 14 Heat release rate versus time for uncoated plasterboard samples (used for testing Paints B and C samples) tested at 50 kW/m²

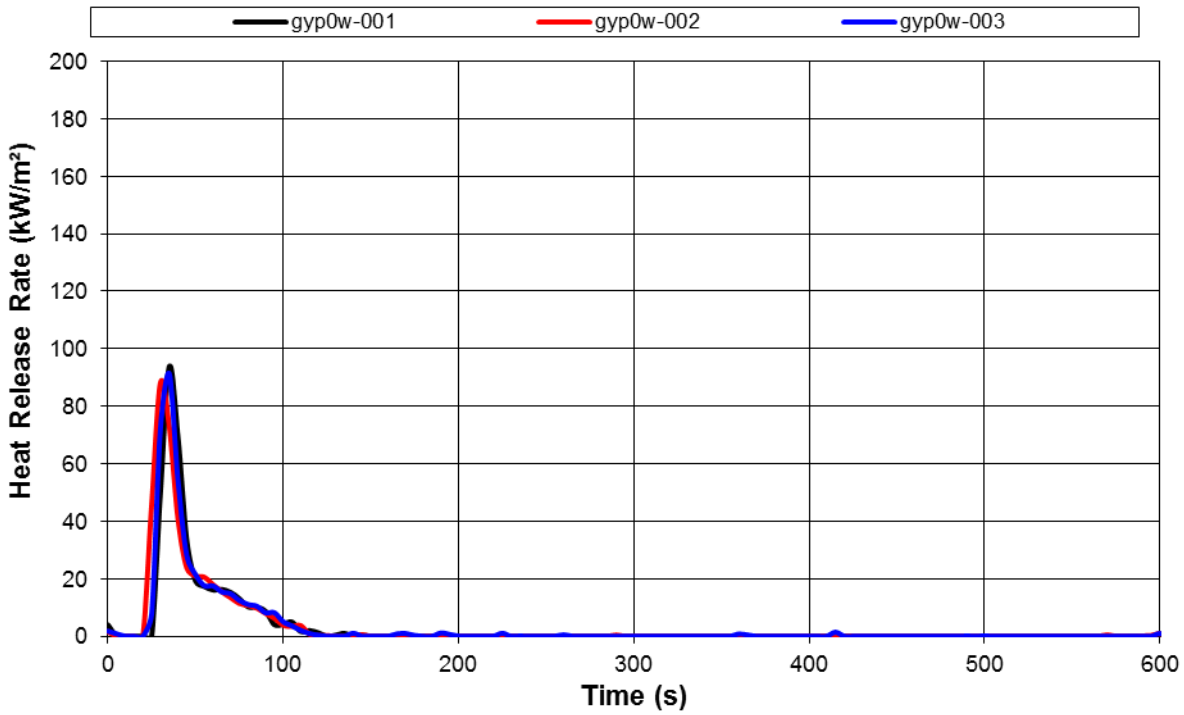


Figure 15 Heat release rates versus time for uncoated plasterboard samples (used for Paint A testing) tested at 50 kW/m², subjected to the simulated aging process

4.2.1 Paint A

Summarised results for plasterboard coated with Paint A are presented in Table 6. The heat release rates are shown for eight layers of Paint A (Figure 16) and 16 layers of Paint A (Figure 17). The associated uncoated substrate test results are included in Table 6 for ease of comparison.

Table 6 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for plasterboard samples coated with Paint A

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
gyp0-021	NI	-	-	-	-
gyp0-048	56	28.9	1.8	N/A	N/A
gyp0-150	43	81.7	2.0	0.6	58
gyp8a-023	58	111.1	5.3	N/A	N/A
gyp8a-049	56	121.6	14.6	N/A	N/A
gyp8a-148	32	192.4	4.9	0.8	84
gyp16a-025	54	144.3	10.2	N/A	N/A
gyp16a-050	51	142.8	7.7	N/A	N/A
gyp16a-146	30	188.6	9.7	1.3	102

Table Notes:
NI refers to No Ignition observed during test
N/A refers to data not recorded

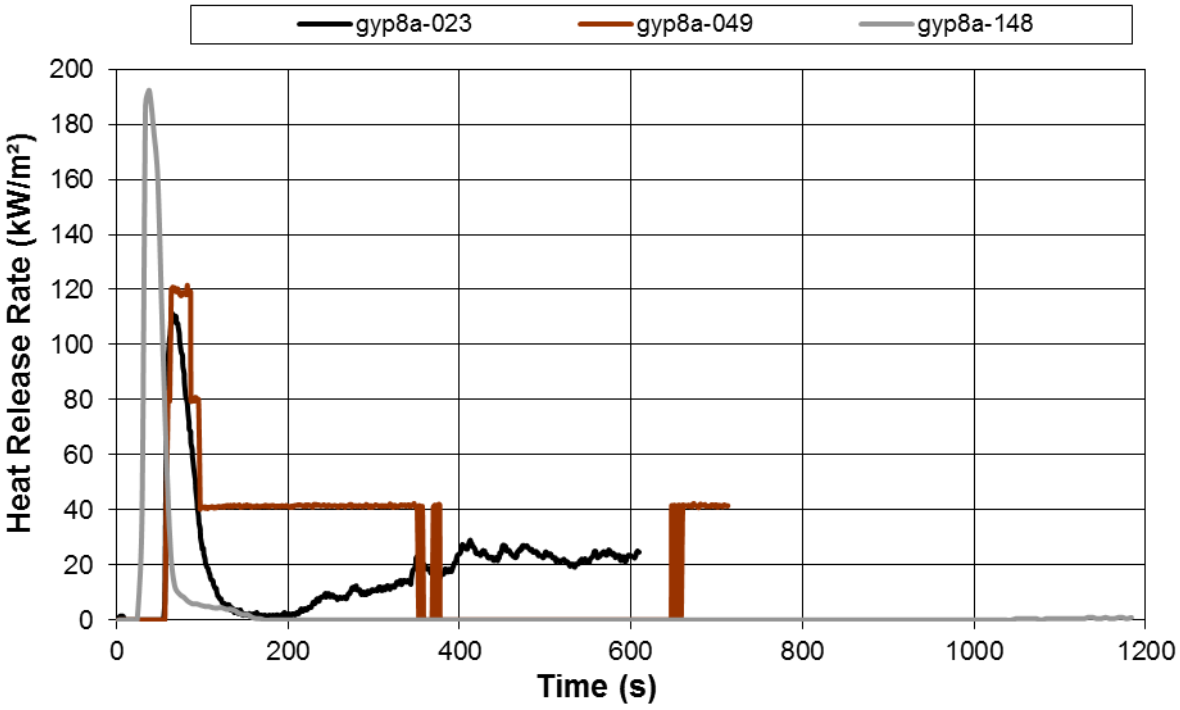


Figure 16 Heat release rate versus time for plasterboard samples tested at 50 kW/m², eight layers of Paint A

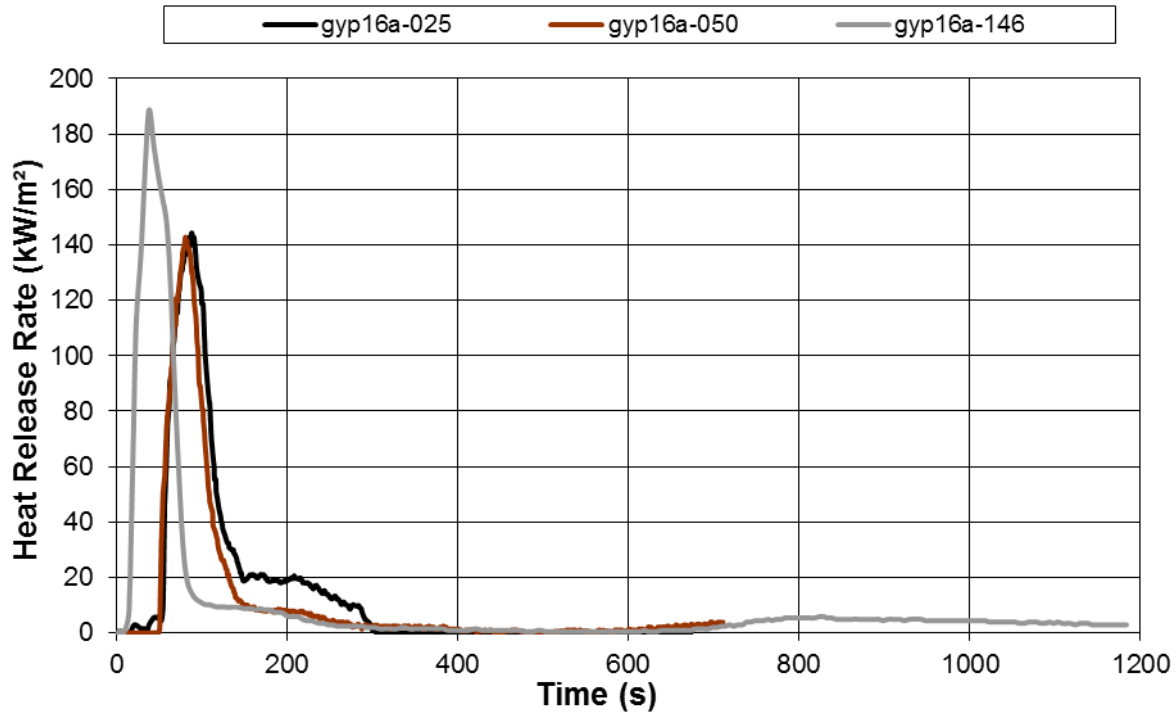


Figure 17 Heat release rate versus time for plasterboard samples tested at 50 kW/m², 16 layers of Paint A

4.2.1.1 Simulated Aged Samples

Test results for plasterboard samples coated with Paint A and subjected to a simulated aging process before testing are summarised in Table 7. Results for uncoated substrate specimens are also included for ease of comparison. Heat release rates versus time for eight layers (Figure 18) and 16 layers (Figure 19) of Paint A after being subjected to a simulated aging process are also shown.

Table 7 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for plasterboard samples coated with Paint A and subjected to a simulated aging process

Specimen Label	Time to Sustained Flaming (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
gyp0w-001	36	93.7	2.0	N/A	N/A
gyp0w-002	31	88.1	2.1	N/A	N/A
gyp0w-003	34	91.3	2.1	N/A	N/A
gyp8aw-180	50	134.9	8.0	9.3	856
gyp8aw-189	33	125.0	10.3	0.7	62
gyp8aw-226	48	136.2	6.2	12.2	912
gyp16aw-182	47	175.0	9.6	10.8	877
gyp16aw-190	45	161.6	11.6	1.2	94
gyp16aw-224	45	169.6	9.8	9.6	842

Table Notes: N/A refers to data not recorded

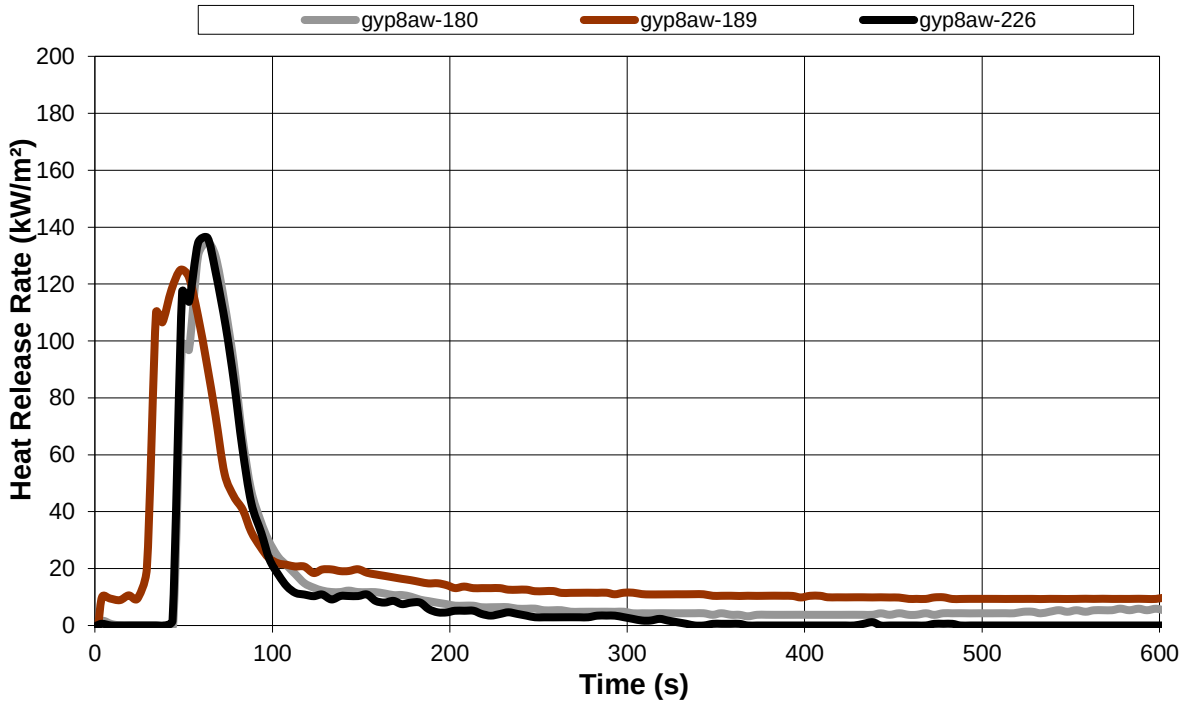


Figure 18 Heat release rate versus time for plasterboard samples tested at 50 kW/m², eight layers of Paint A subjected to the simulated aging process

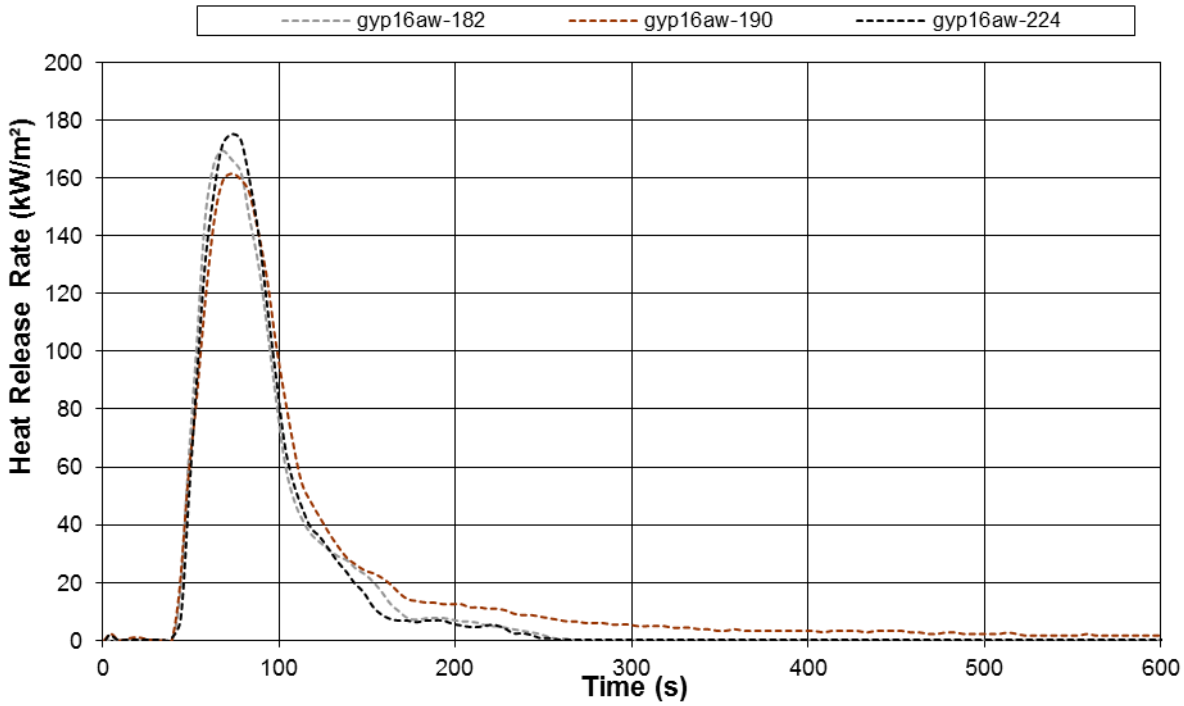


Figure 19 Heat release rate versus time for plasterboard samples tested at 50 kW/m², 16 layers of Paint A subjected to a simulated aging process

4.2.2 Paint B

Summarised results for plasterboard coated with Paint B are presented in Table 8. The associated uncoated substrate test results are also included for ease of comparison. The heat release rates versus time are shown for four layers (Figure 20), six layers (Figure 21) and eight layers (Figure 22) of Paint B.

Table 8 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for plasterboard samples coated with Paint B

Specimen Label	Time to ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
gyp0-301-1	42	91.4	2.5	0.1	5
gyp0-301-2	41	95.7	3.2	0.1	3
gyp0-301-3	41	95.4	2.3	0.0	0
gyp4b-405-1	11	177.3	8.1	0.8	51
gyp4b-405-2	15	162.2	7.0	1.0	56
gyp4b-405-3	14	176.3	8.2	0.9	54
gyp4b-411-1	20	177.5	11.2	1.1	59
gyp4b-411-2	23	214.9	9.6	1.2	63
gyp4b-411-3	15	177.3	11.2	1.4	76
gyp8b-417-1	16	202.0	12.1	1.8	94
gyp8b-417-2	17	177.5	13.4	1.6	82
gyp8b-417-3	16	171.1	10.3	1.7	88

Table Notes: N/A refers to data not recorded

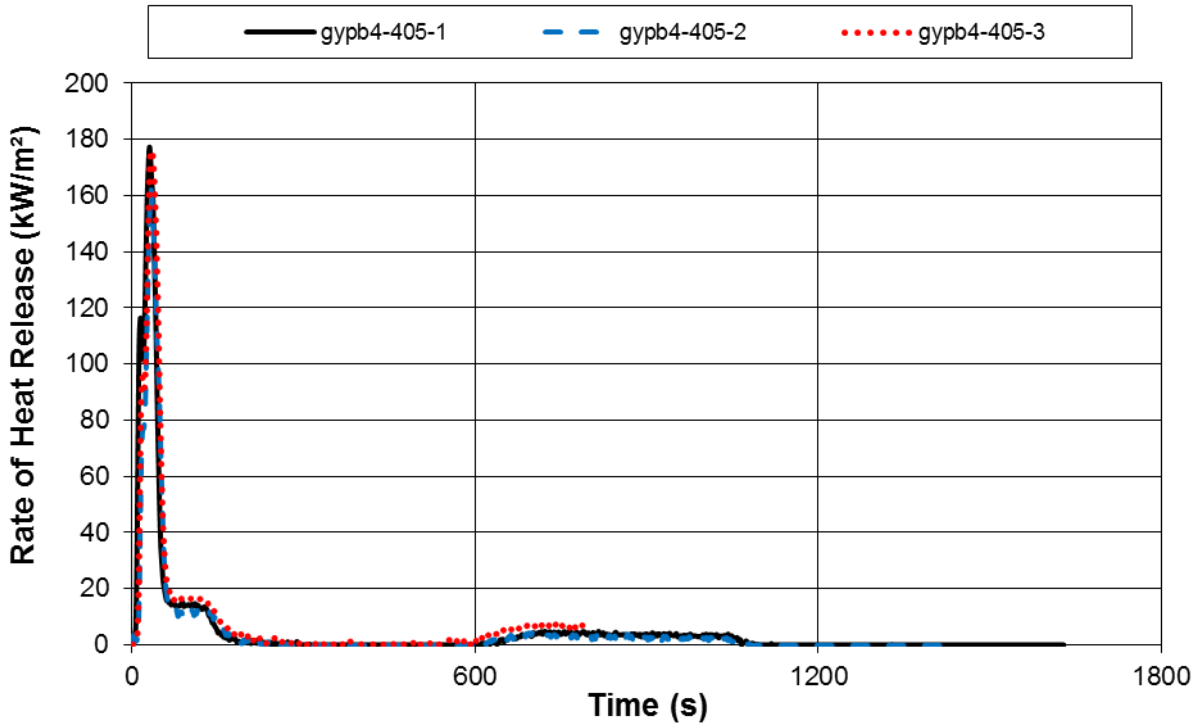


Figure 20 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with four layers of Paint B

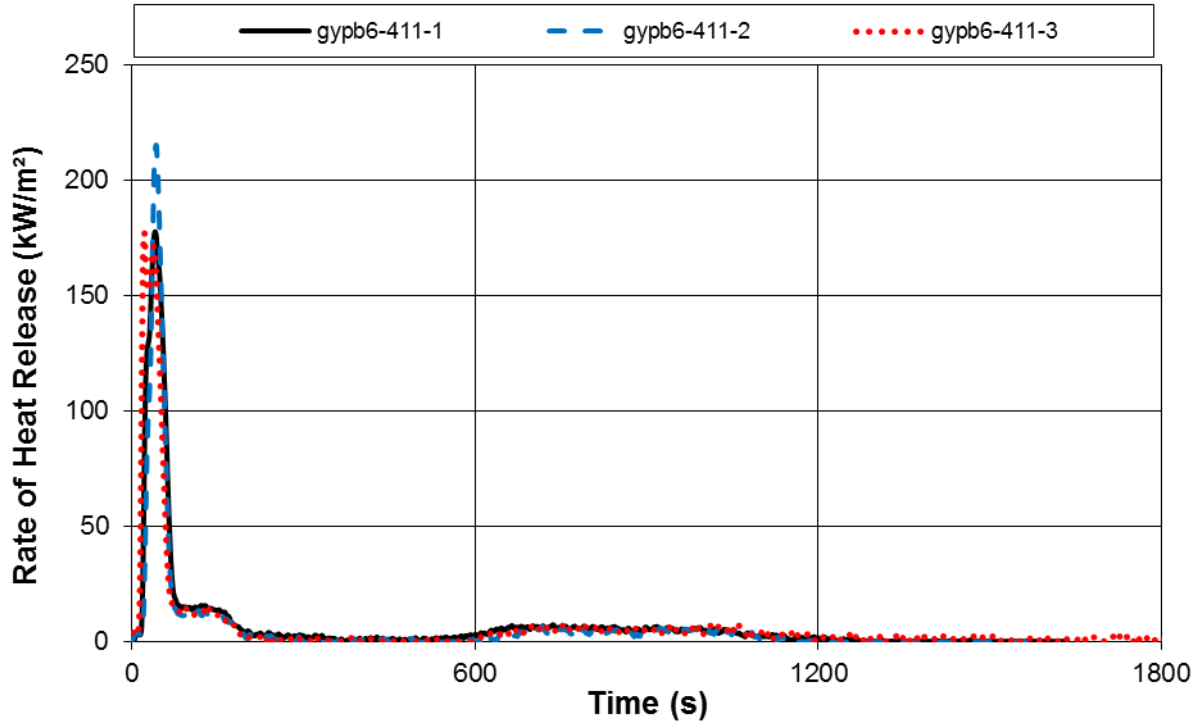


Figure 21 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with six layers of Paint B

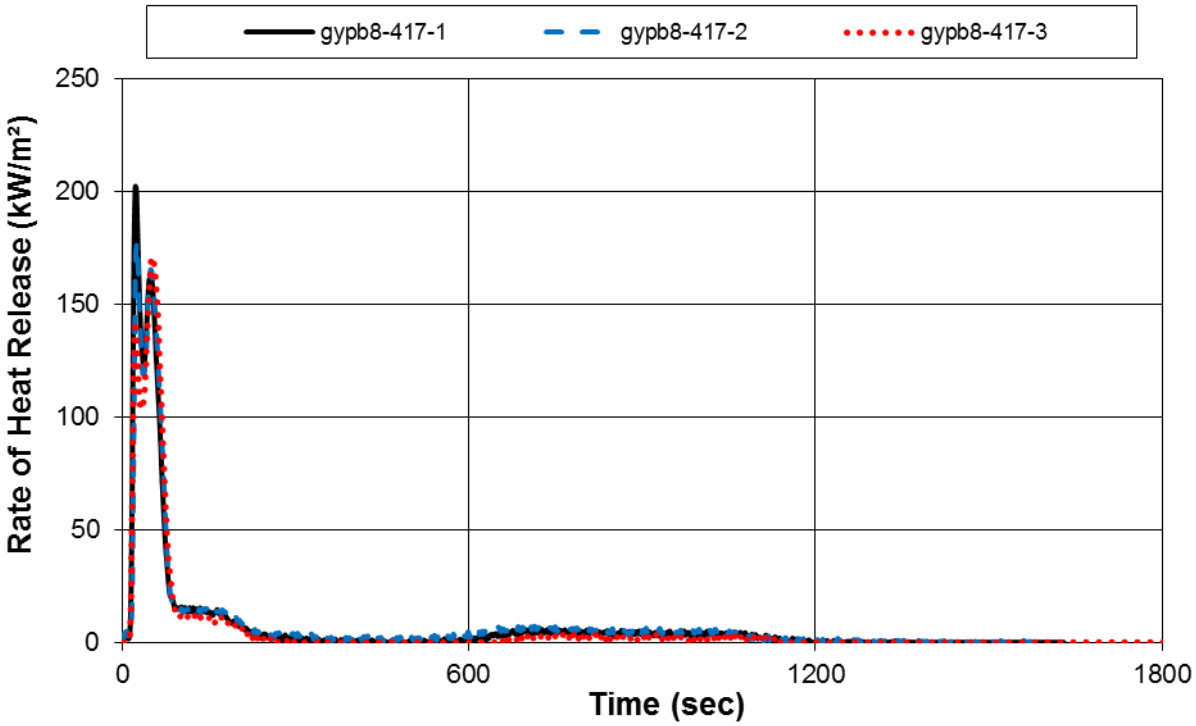


Figure 22 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with eight layers of Paint B

4.2.3 Paint C

Summarised results for plasterboard coated with Paint C are presented in Table 9. The test results for the uncoated substrate are also included in Table 9 for ease of comparison. The heat release rates versus time are shown for four layers (Figure 23), six layers (Figure 24) and eight layers (Figure 25) of Paint C.

Table 9 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for plasterboard samples coated with Paint C

Specimen Label	Time to ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
gyp0-301-1	42	91.4	2.5	0.1	5
gyp0-301-2	41	95.7	3.2	0.1	3
gyp0-301-3	41	95.4	2.3	0.0	0
gyp4c-402-1	43	188.6	8.4	0.6	14
gyp4c-402-2	41	155.3	8.5	0.3	23
gyp4c-402-3	40	183.0	5.6	0.4	31
gyp6c-408-1	40	250.5	7.3	0.6	38
gyp6c-408-2	38	257.6	8.6	0.7	42
gyp6c-408-3	48	253.3	7.8	0.7	39
gyp8c-414-1	44	265.0	7.7	0.8	46
gyp8c-414-2	39	257.8	8.4	1.0	56
gyp8c-414-3	36	259.5	7.1	0.9	55

Table Notes: N/A refers to data not recorded

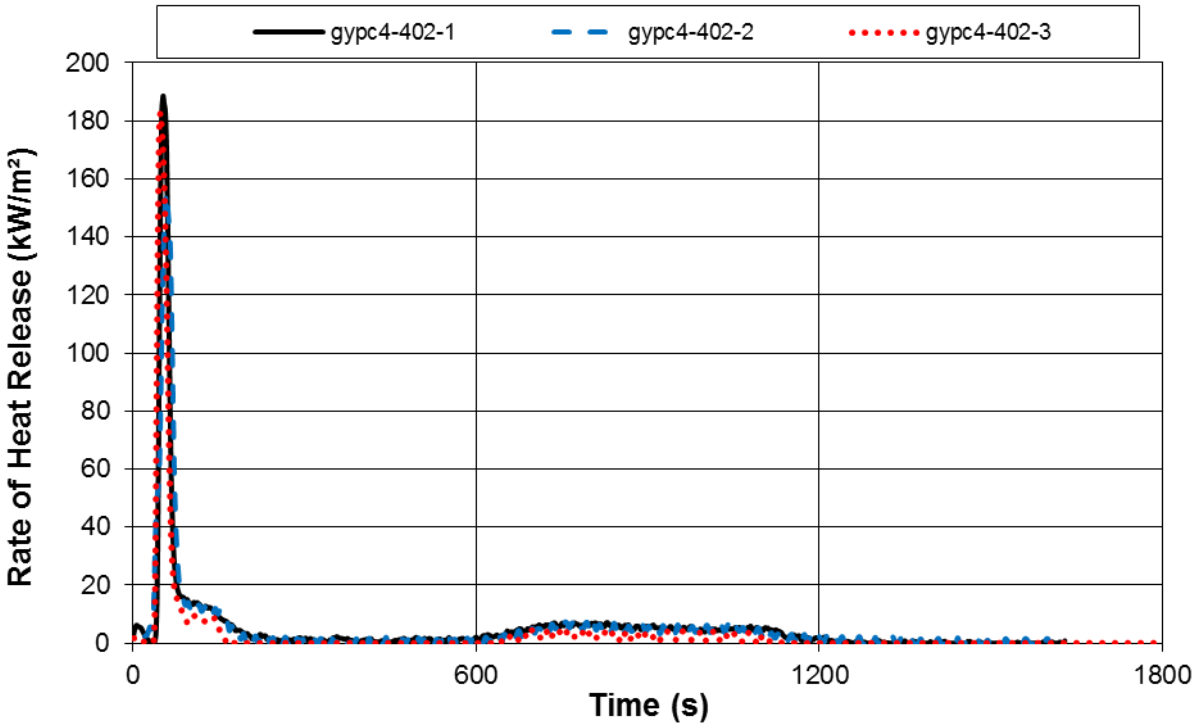


Figure 23 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with four layers of Paint C

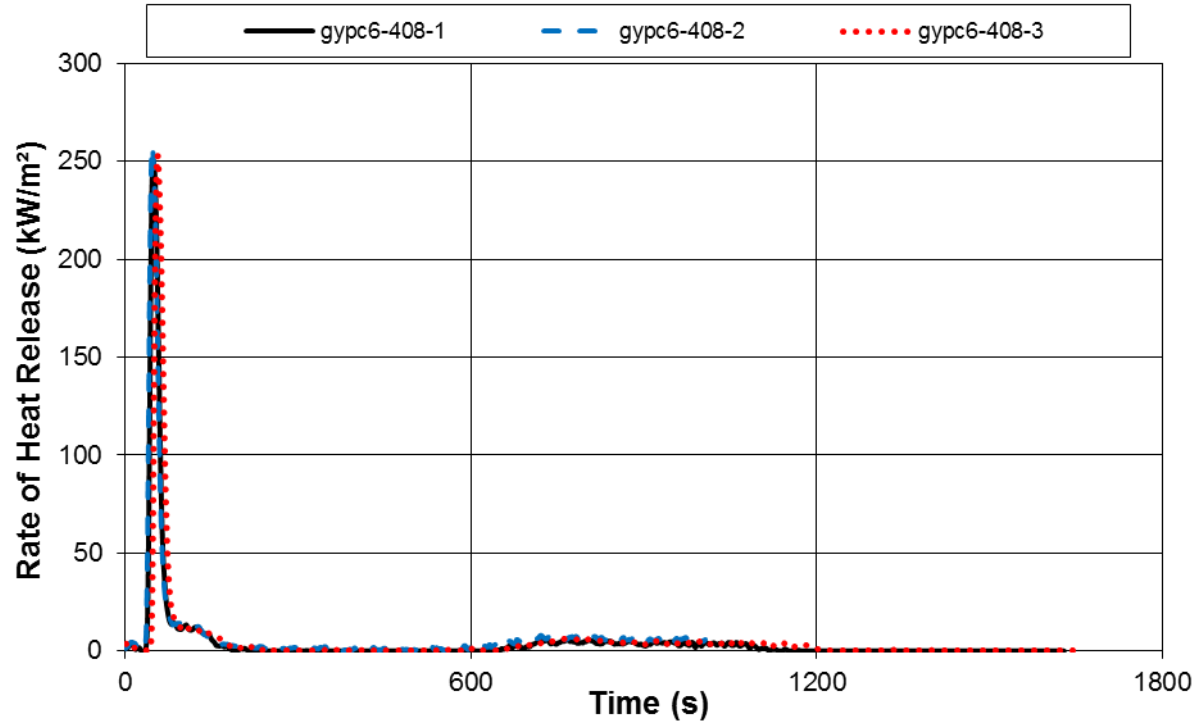


Figure 24 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with six layers of Paint C

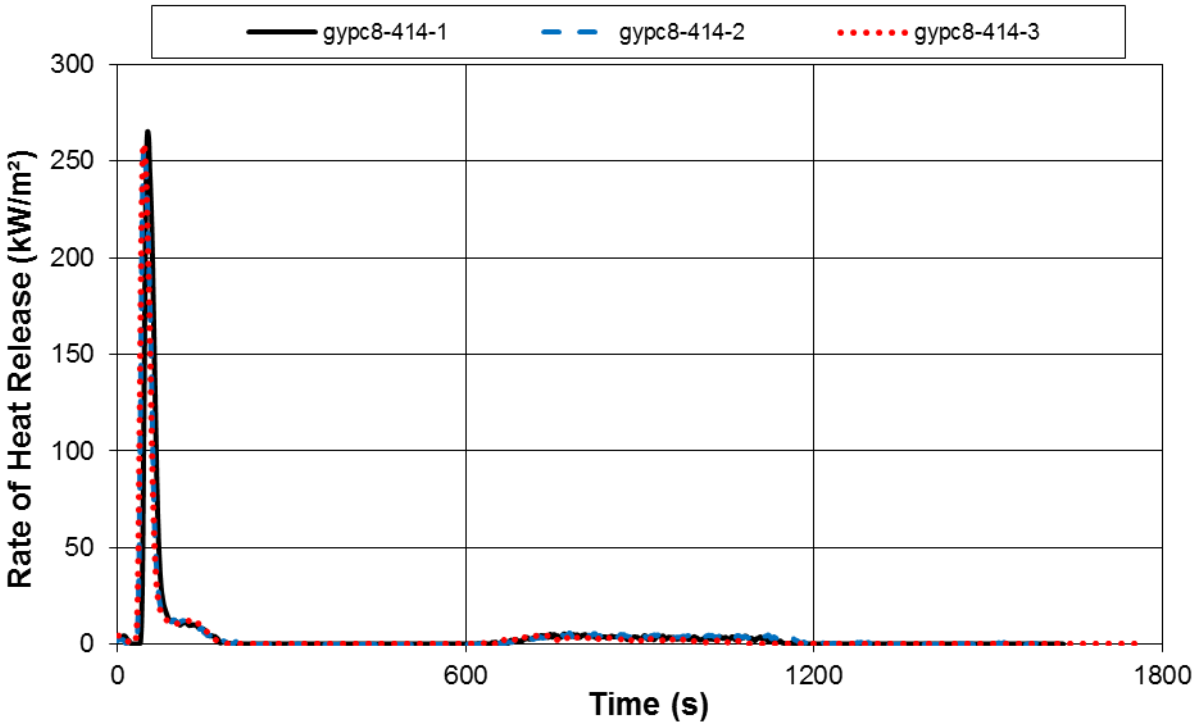


Figure 25 Heat release rate versus time for plasterboard samples tested at 50 kW/m², with eight layers of Paint C

4.3 Plywood Samples

Uncoated, Paint A-coated 10 mm thick plywood, and Paint B and Paint C coatings of 7 mm thick plywood substrate samples are presented in this section.

4.3.1 10 mm Thick Samples

A summary of the uncoated-specimen test results for 10 mm thick plywood are presented in Table 10 and heat release rates versus time results are shown for the 10 mm thick plywood substrate used in testing Paint A coatings (in Figure 26) and specimens after being subjected to the simulated aging process (in Figure 27).

Table 10 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for 10 mm thick plywood samples

Specimen Label	Time to Sustained Flaming (s)	Peak HRR (kW/m^2)	Total Heat Released (MJ/m^2)	Total Smoke Produced (m^2)	Average SEA (m^2/kg)
PLY0-016	34	183.9	23.5	N/A	N/A
PLY0-056	38	133.7	43.6	N/A	N/A
PLY0-145	19	155.9	36.2	3.1	92
PLY0w-001	22	242.1	38.4	1.9	67
PLY0w-002	21	262.1	39.7	2.2	73
PLY0w-003	35	231.4	37.5	1.9	73

Table Notes:
N/A refers to data not recorded

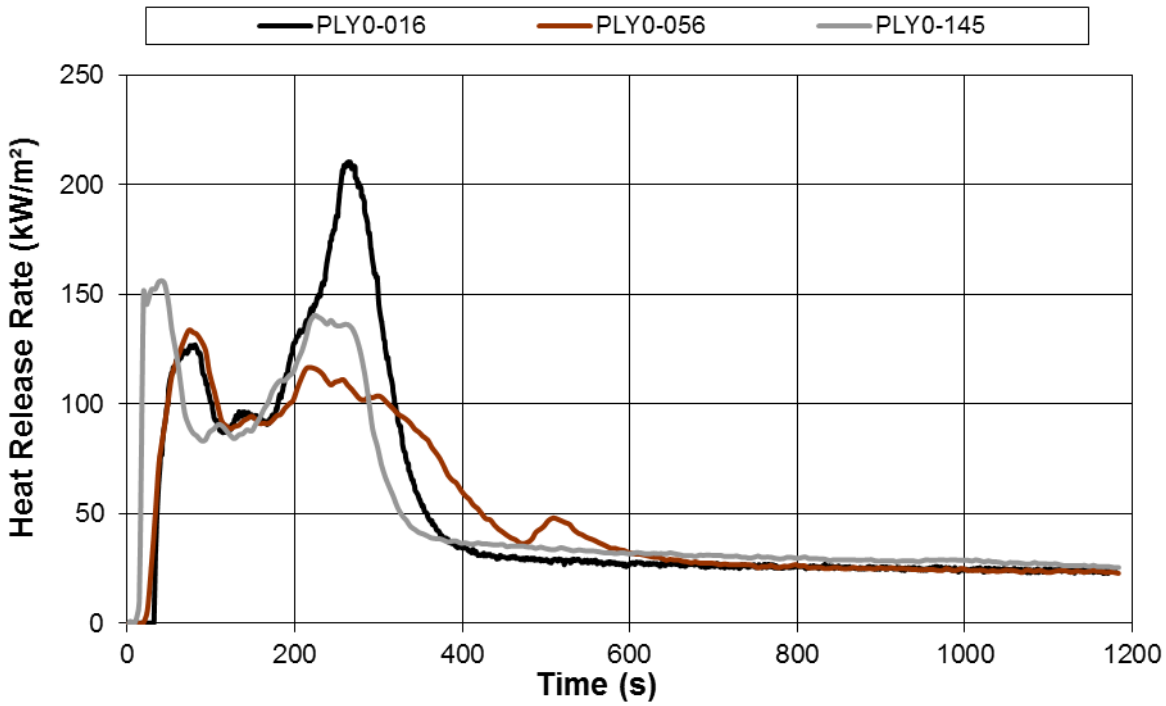


Figure 26 Heat release rate versus time for uncoated 10 mm thick plywood samples (used for testing Paint A) tested at 50 kW/m^2

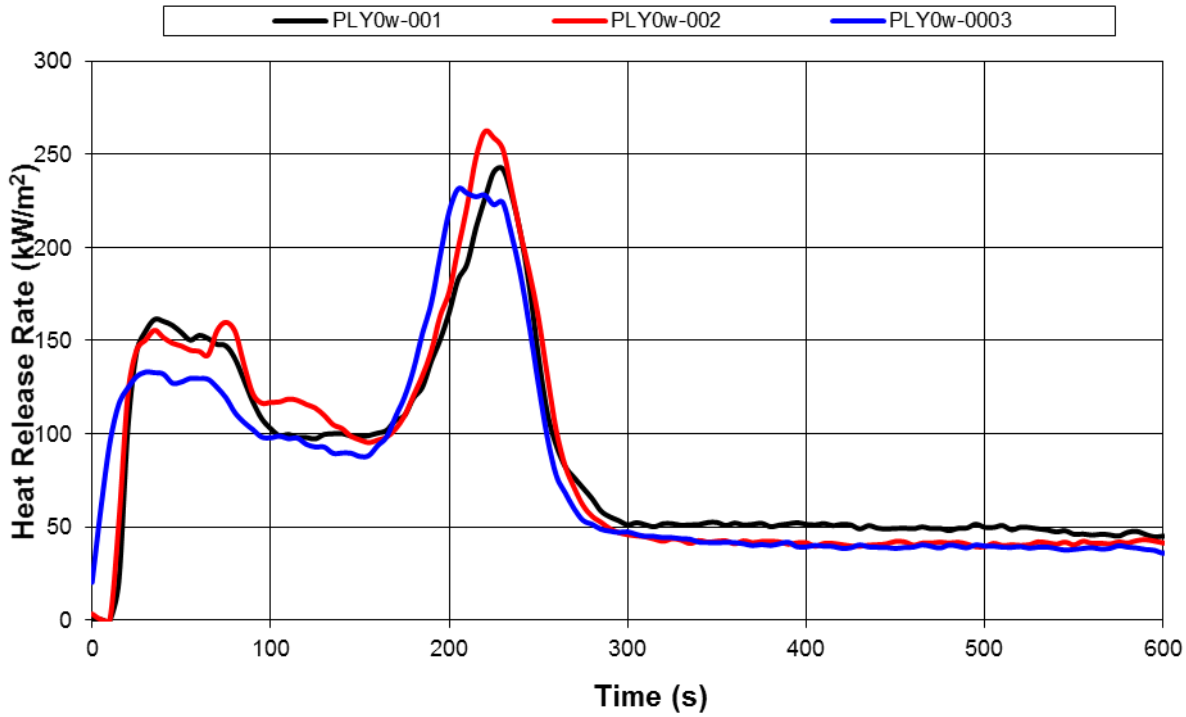


Figure 27 Heat release rate versus time for uncoated 10 mm thick plywood samples (used for testing Paint A samples) tested at 50 kW/m², subjected to a simulated aging process.

4.3.1.1 Paint A

Summarised test results for 10 mm thick plywood coated with Paint A are presented in Table 11, along with the associated uncoated specimen test results for ease of comparison. The heat release rates versus time are shown for eight layers (Figure 28) and 16 layers (Figure 29) of Paint A.

Table 11 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for 10 mm thick plywood samples

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
PLY0-016	34	183.9	23.5	N/A	N/A
PLY0-056	38	133.7	43.6	N/A	N/A
PLY0-145	19	155.9	36.2	3.1	92
PLY8a-018	45	253.0	18.1	N/A	N/A
PLY8a-058	30	181.3	45.3	N/A	N/A
PLY8a-143	26	208.3	36.4	1.9	51
PLY16a-020	23	180.6	20.1	N/A	N/A
PLY16a-060	15	192.4	49.4	N/A	N/A
PLY16a-141	15	202.8	35.4	2.4	78

Table Notes:
N/A refers to data not recorded

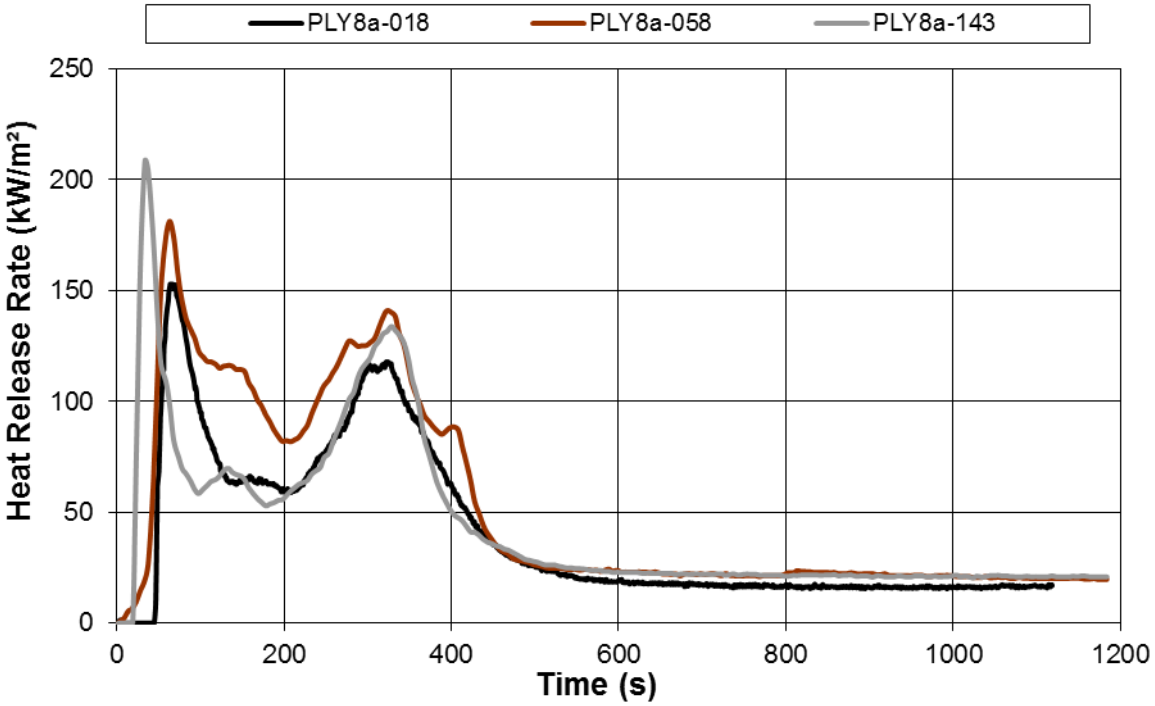


Figure 28 Heat release rate versus time for 10 mm thick plywood samples tested at 50 kW/m², with eight layers of Paint A

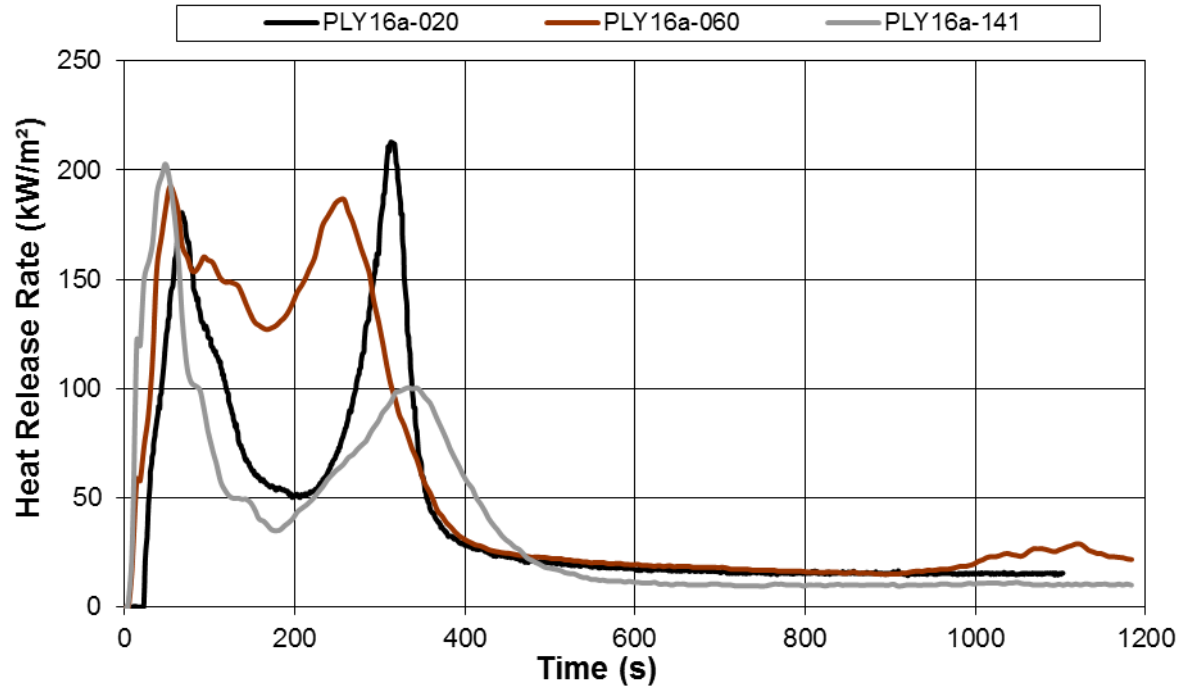


Figure 29 Heat release rate versus time for 10 mm thick plywood samples tested at 50 kW/m², with 16 layers of Paint A

4.3.1.2 Paint A – Simulated Aged Samples

Test results for plasterboard samples coated with Paint A and subjected to a simulated aging process before testing are summarised in Table 12. Results for uncoated substrate specimens are also included for ease of comparison. Heat release rates versus time for eight layers (Figure 30) and 16 layers (Figure 31) of Paint A after being subjected to a simulated aging process are also shown.

Table 12 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for 10 mm thick plywood samples subjected to a simulated aging process

Specimen Label	Time to Sustained Flaming (s)	Peak HRR (kW/m²)	Total Heat Released (MJ/m²)	Total Smoke Produced (m²)	Average SEA (m²/kg)
PLY0w-001	22	242.1	38.4	1.9	67
PLY0w-002	21	262.1	39.7	2.2	73
PLY0w-003	35	231.4	37.5	1.9	73
PLY8aw-172	29	217.9	45.6	4.4	70
PLY8aw-205	38	235.2	42.6	11.2	391
PLY8aw-238	39	187.3	40.3	10.2	365
PLY16aw-174	27	248.9	46.2	2.4	84
PLY16aw-206	33	241.4	44.6	10.7	379
PLY16aw-236	28	208.6	45.6	11.7	401

Table Notes: N/A refers to data not recorded

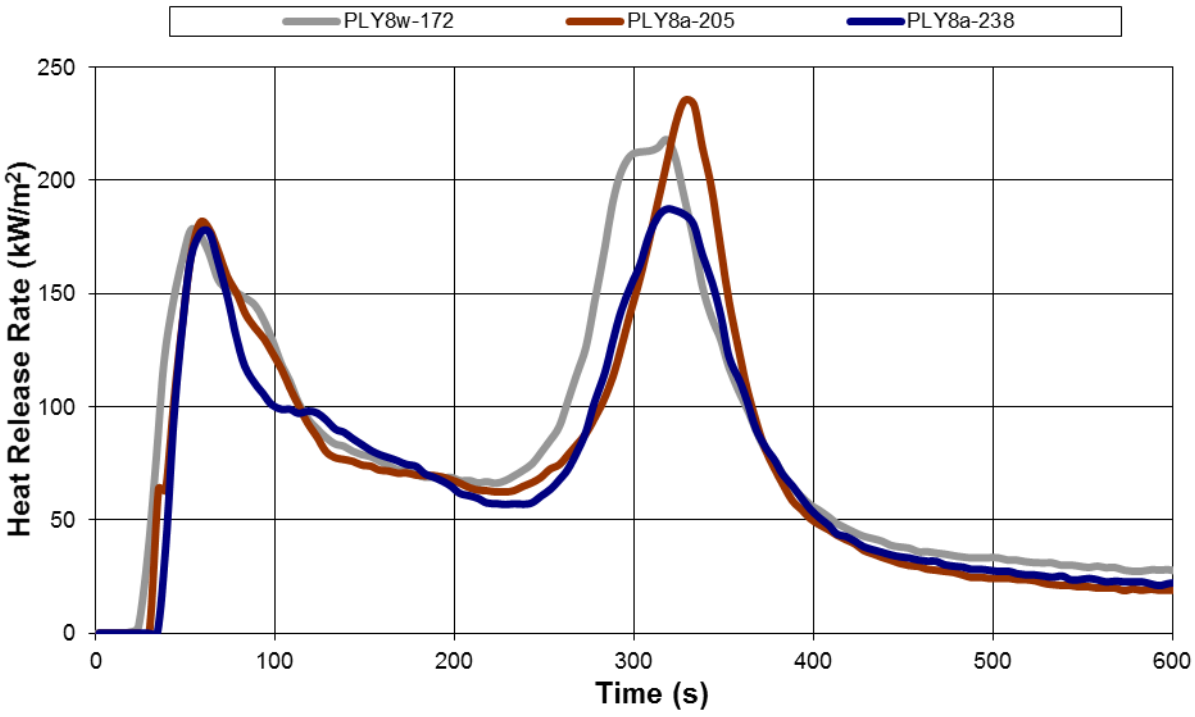


Figure 30 Heat release rate versus time for 10 mm thick plywood samples tested at 50 kW/m², with eight layers Paint A subjected to a simulated aging process

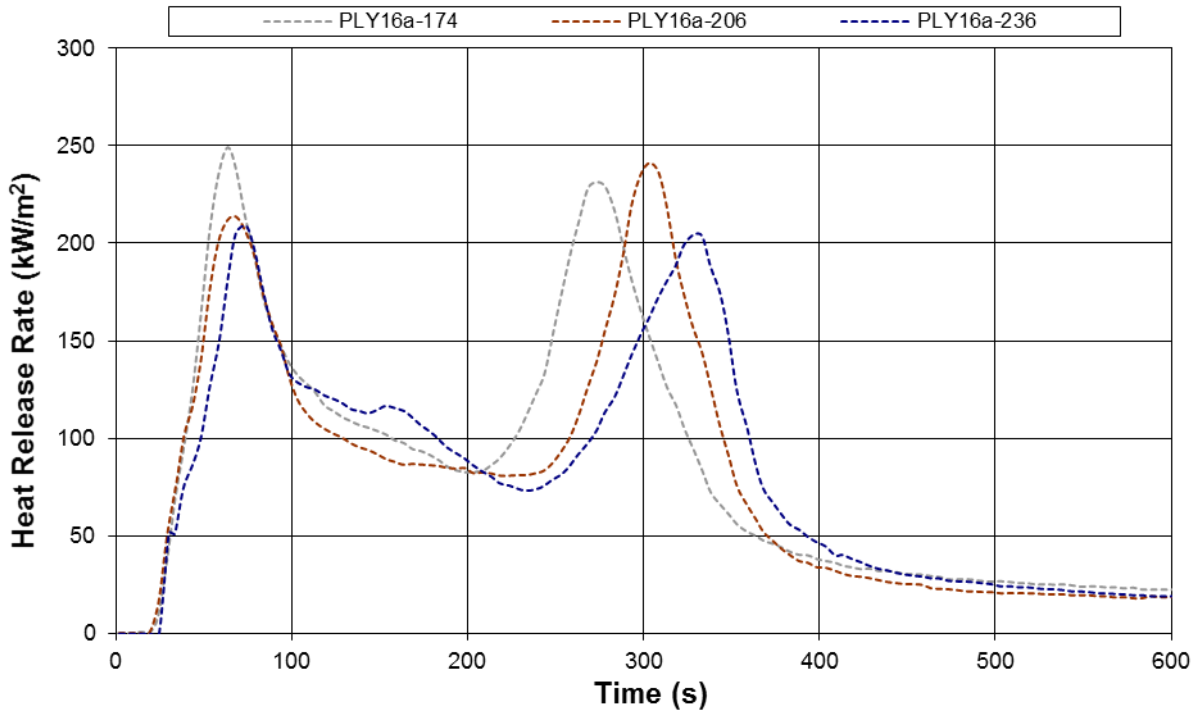


Figure 31 Heat release rate versus time for plywood samples tested at 50 kW/m², with 16 layers of Paint A subjected to a simulated aging process

4.3.2 7 mm Thick Samples

A summary of the uncoated-specimen test results for 7 mm thick plywood are presented in Table 13 and heat release rates versus time results are shown for the 7 mm thick plywood substrate used in testing Paints B and C coatings (in Figure 32).

Table 13 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for uncoated 7 mm thick plywood samples coated

Specimen Label	Used for Testing of Paint Type	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
ply0-300-1	B,C	22	284.6	58.8	1.5	45
ply0-300-2	B,C	20	289.6	60.3	1.6	45
ply0-300-3	B,C	28	277.6	58.5	2.4	64

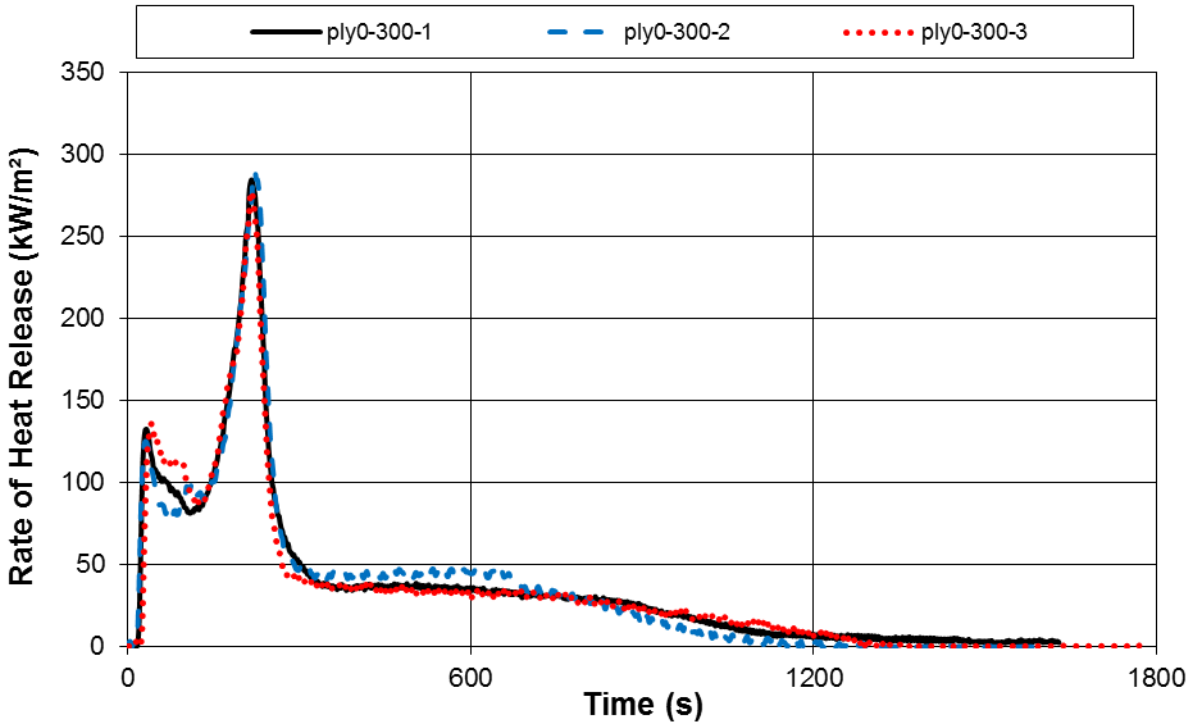


Figure 32 Heat release rate versus time for uncoated 7 mm plywood samples (used for testing Paints B and C) tested at 50 kW/m²

4.3.2.1 Paint B

Summarised results for 7 mm thick plywood coated with Paint B are presented in Table 14. The associated uncoated substrate test results are also included for ease of comparison. The heat release rates versus time are shown for four layers (Figure 33), six layers (Figure 34) and eight layers (Figure 35) of Paint B.

Table 14 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for 7 mm thick plywood samples painted with Paint B

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
ply0-300-1	22	284.6	58.8	1.5	45
ply0-300-2	20	289.6	60.3	1.6	45
ply0-300-3	28	277.6	58.5	2.4	64
ply4b-404-1	15	319.9	82.8	3.4	77
ply 4b-404-2	13	362.7	84.9	3.5	85
ply4b-404-3	16	361.4	76.7	3.9	89
ply4b-410-1	23	305.9	78.7	4.6	109
ply 4b-410-2	14	394.1	72.3	4.6	108
ply4b-410-3	17	339.7	72.9	3.6	87
ply8b-416-1	15	351.7	72.4	4.7	109
ply 8b-416-2	15	298.1	70.8	4.2	110
ply8b-416-3	21	354.9	72.1	4.7	108

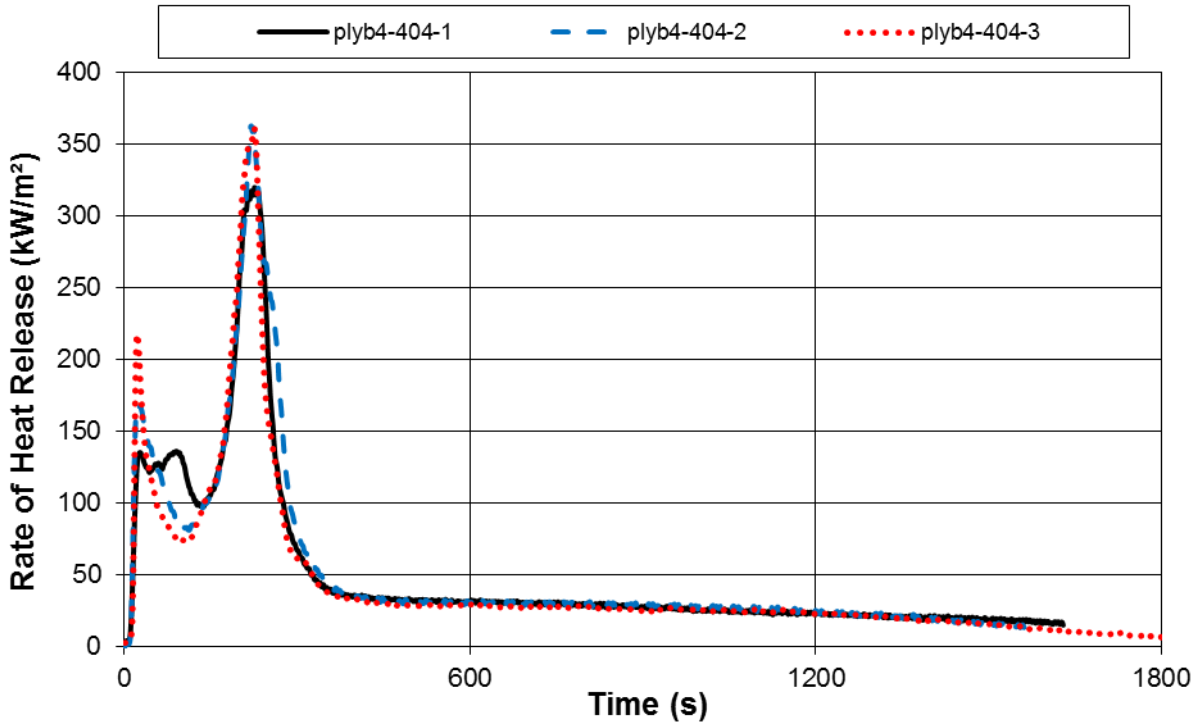


Figure 33 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with four layers of Paint B

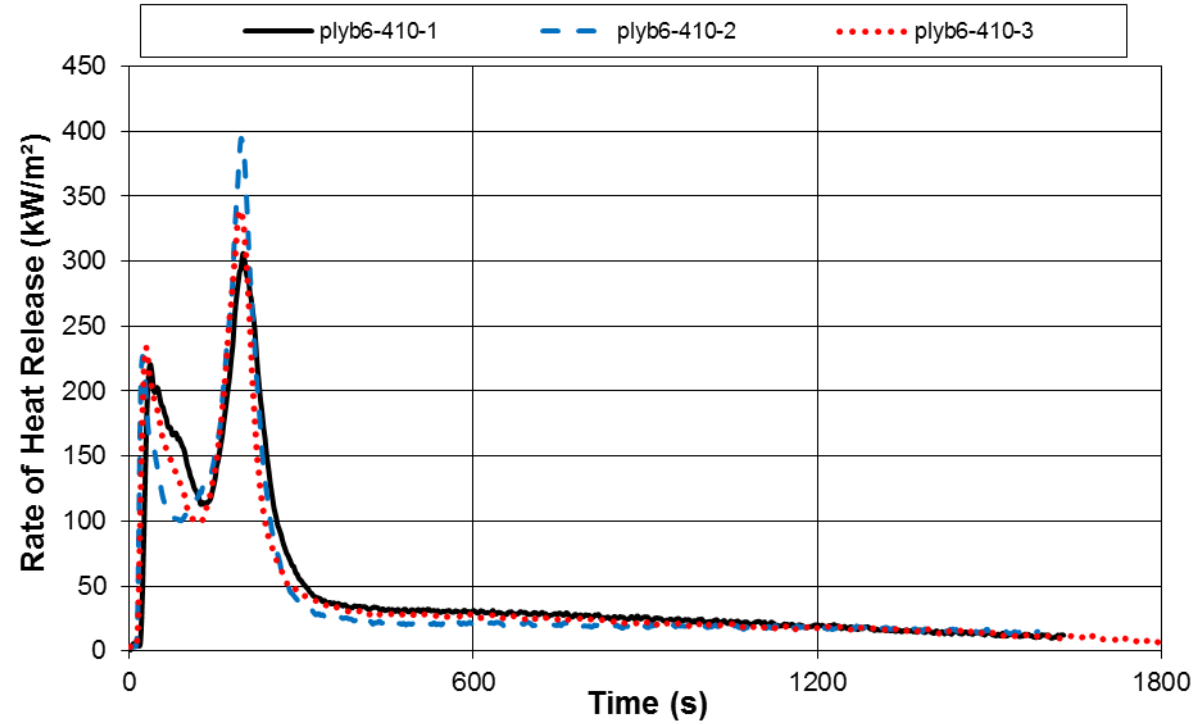


Figure 34 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with six layers of Paint B

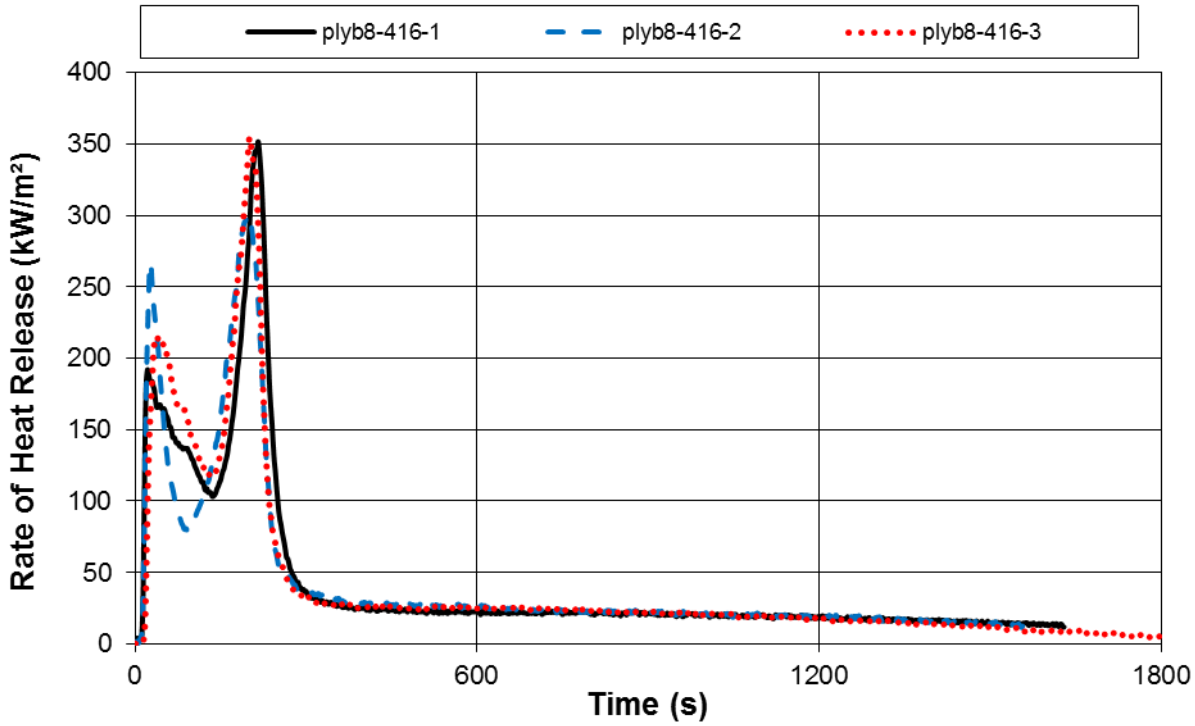


Figure 35 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with eight layers of Paint B

4.3.2.2 Paint C

Summarised results for 7 mm thick plywood coated with Paint C are presented in Table 15. The test results for the uncoated substrate are also included in Table 15 for ease of comparison. The heat release rates versus time are shown for four layers (Figure 36), six layers (Figure 37) and eight layers (Figure 38) of Paint C.

Table 15 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for 7 mm thick plywood samples painted with Paint C

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
ply0-300-1	22	284.6	58.8	1.5	45
ply0-300-2	20	289.6	60.3	1.6	45
ply0-300-3	28	277.6	58.5	2.4	64
ply4c-401-1	15	323.6	65.8	1.8	46
ply4c-401-2	17	312.1	66.3	2.0	49
ply4c-401-3	18	268.1	68.1	2.8	63
ply6c-407-1	14	382.5	77.7	2.2	57
ply6c-407-2	17	293.2	79.3	2.4	54
ply6c-407-3	13	320.2	68.8	2.0	52
ply8c-413-1	20	325.3	69.1	2.5	63
ply8c-413-2	31	351.1	78.5	3.8	89
ply8c-413-3	23	326.9	69.6	2.9	75

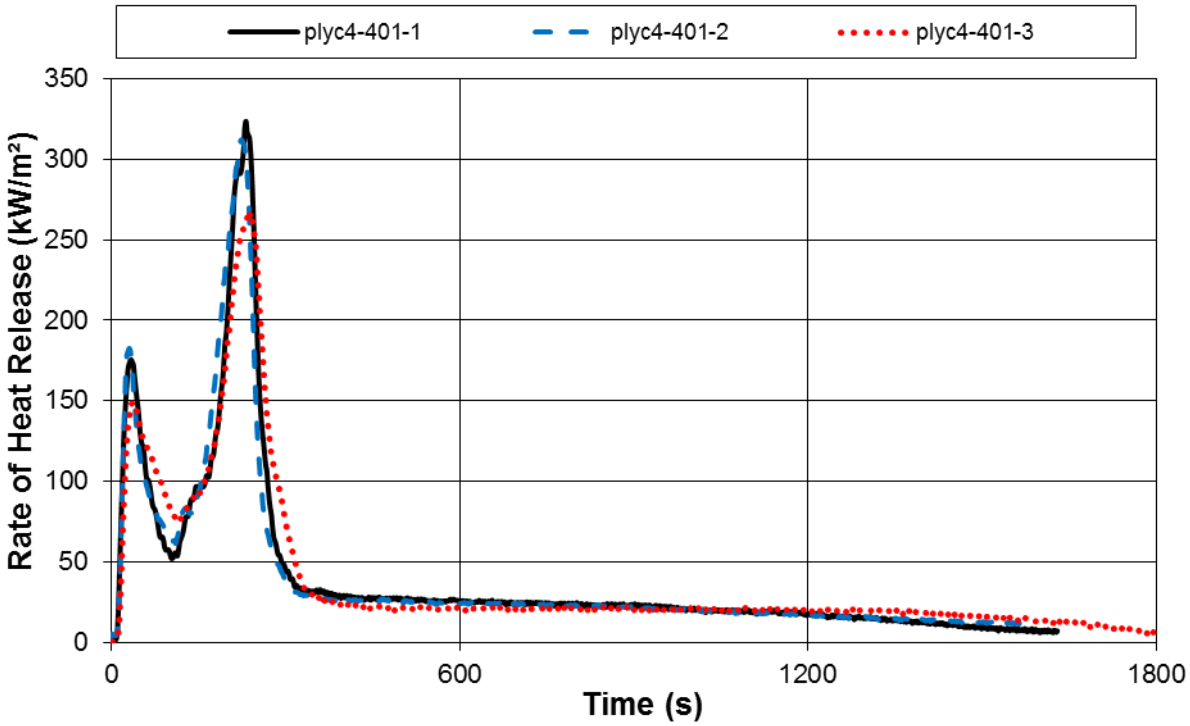


Figure 36 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with four layers of Paint C

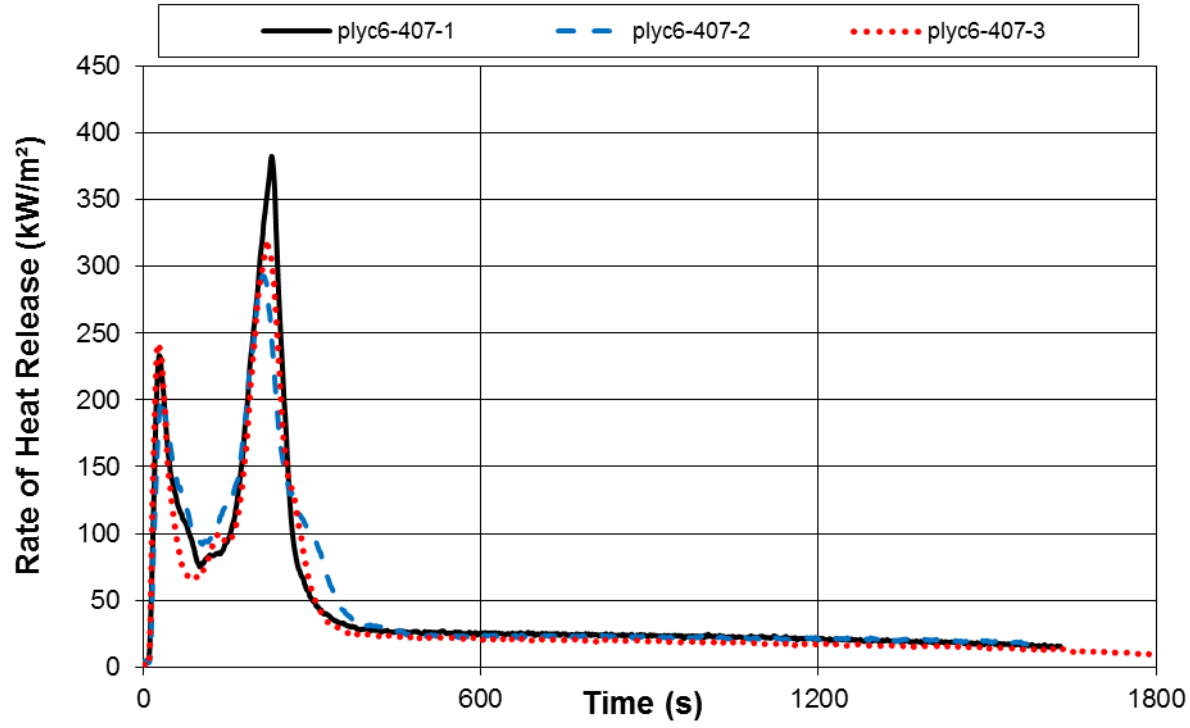


Figure 37 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with six layers of Paint C

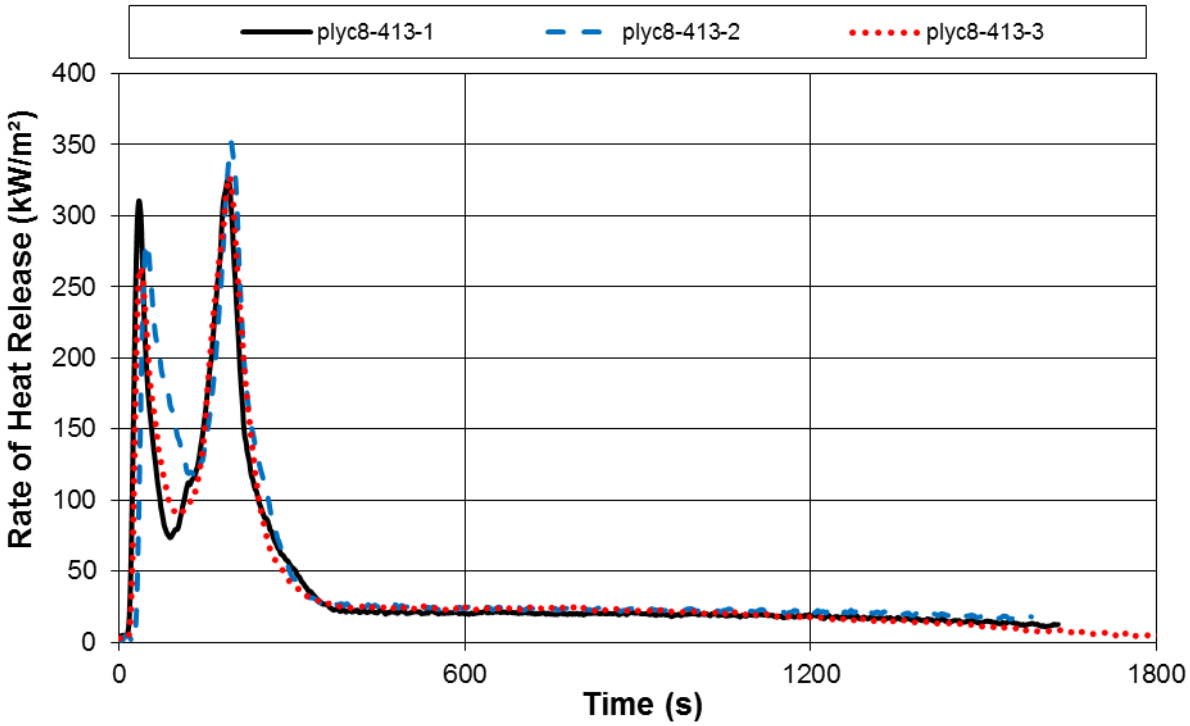


Figure 38 Heat release rate versus time for 7 mm plywood samples tested at 50 kW/m², with eight layers of Paint C

4.4 Medium Density Fibreboard Samples

A summary of the uncoated-specimen test results for medium density fibreboard are presented in Table 16 and heat release rates versus time results are shown for the medium density fibreboard substrate used in testing Paints B and C coatings (in Figure 39).

Table 16 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for uncoated medium density fibreboard used in testing Paints B and C

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
mdf0-302-1	33	370.3	105.2	4.2	65
mdf0-302-2	33	355.3	111.0	3.5	54
mdf0-302-3	31	306.9	108.6	3.6	67

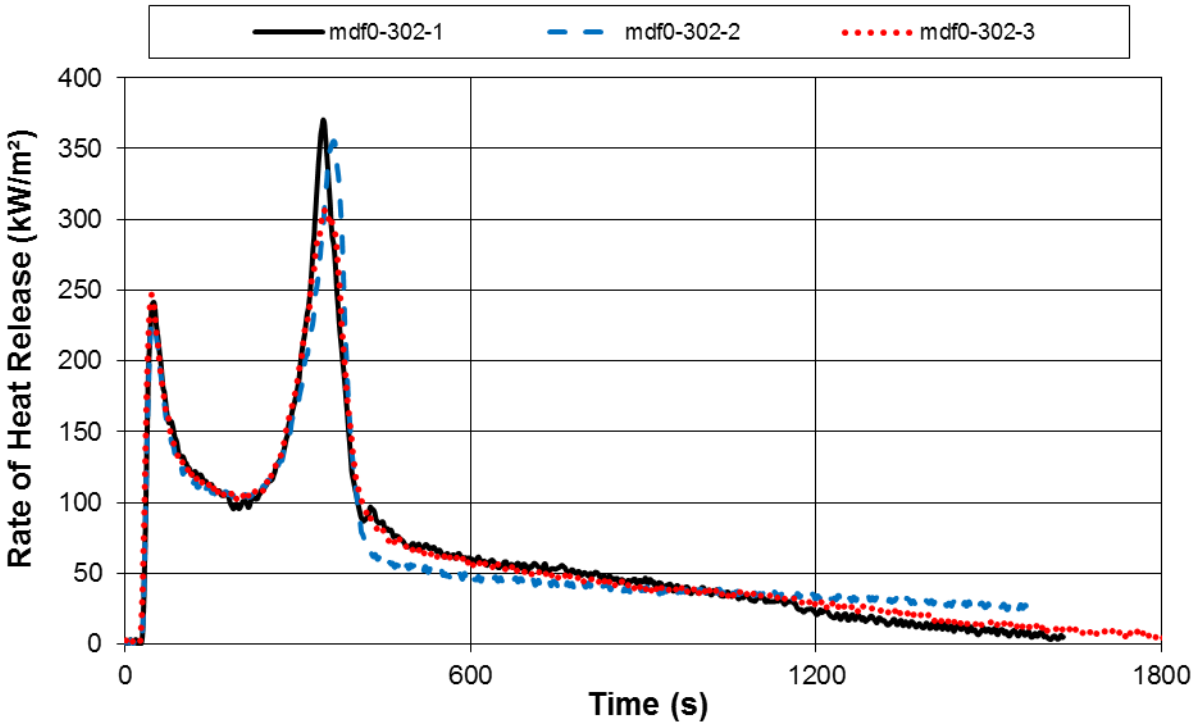


Figure 39 Heat release rate versus time for uncoated medium density fibreboard samples (used for testing Paint B and C samples) tested at 50 kW/m²

4.4.1 Paint B

Summarised results for medium density fibreboard coated with Paint B are presented in Table 17. The associated uncoated substrate test results are also included for ease of comparison. The heat release rates versus time are shown for four layers (Figure 40), six layers (Figure 41) and layers (Figure 42) of Paint B.

Table 17 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for medium density fibreboard samples painted with Paint B

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
mdf0-302-1	33	370.3	105.2	4.2	65
mdf0-302-2	33	355.3	111.0	3.5	54
mdf0-302-3	31	306.9	108.6	3.6	67
mdf4b-406-1	21	262.1	103.0	3.9	59
mdf4b-406-2	18	260.0	105.5	4.3	67
mdf4b-406-3	17	300.2	120.2	4.4	68
mdf4b-412-1	21	264.9	99.5	6.0	98
mdf4b-412-2	22	269.4	102.1	5.7	92
mdf4b-412-3	21	266.3	90.8	4.9	83
mdf8b-418-1	26	238.3	105.1	5.4	89
mdf8b-418-2	19	298.8	113.6	5.8	90
mdf8b-418-3	19	254.1	100.4	5.5	92

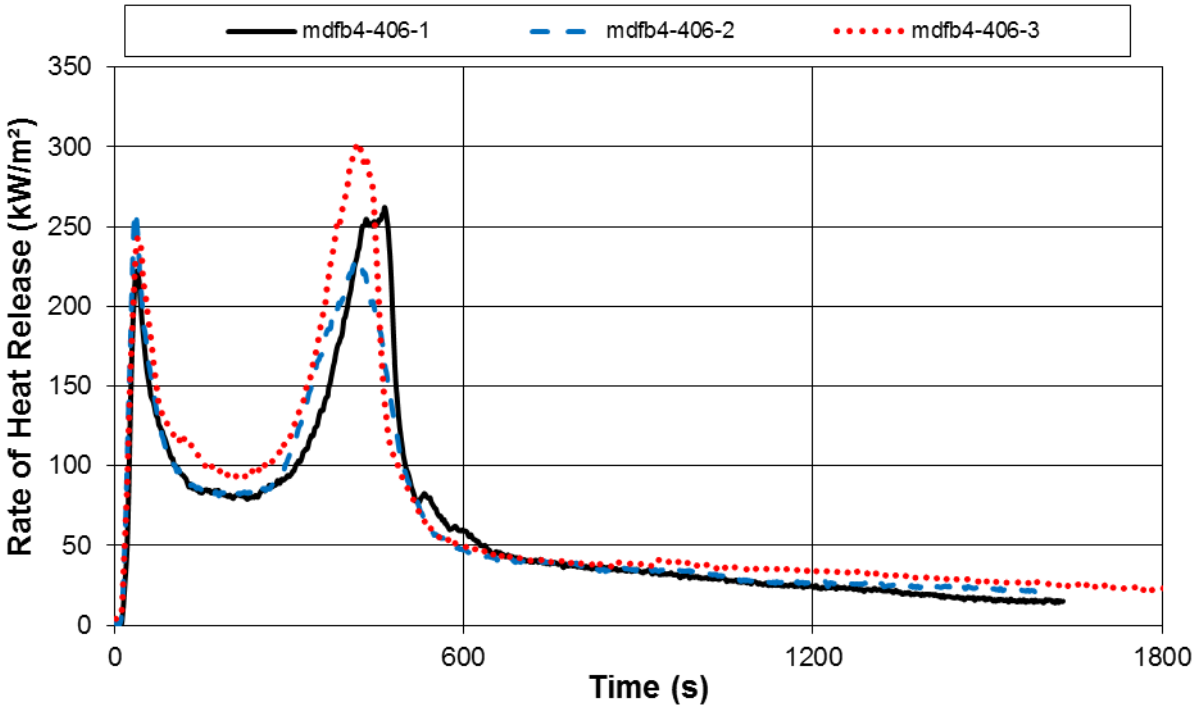


Figure 40 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with four layers of Paint B

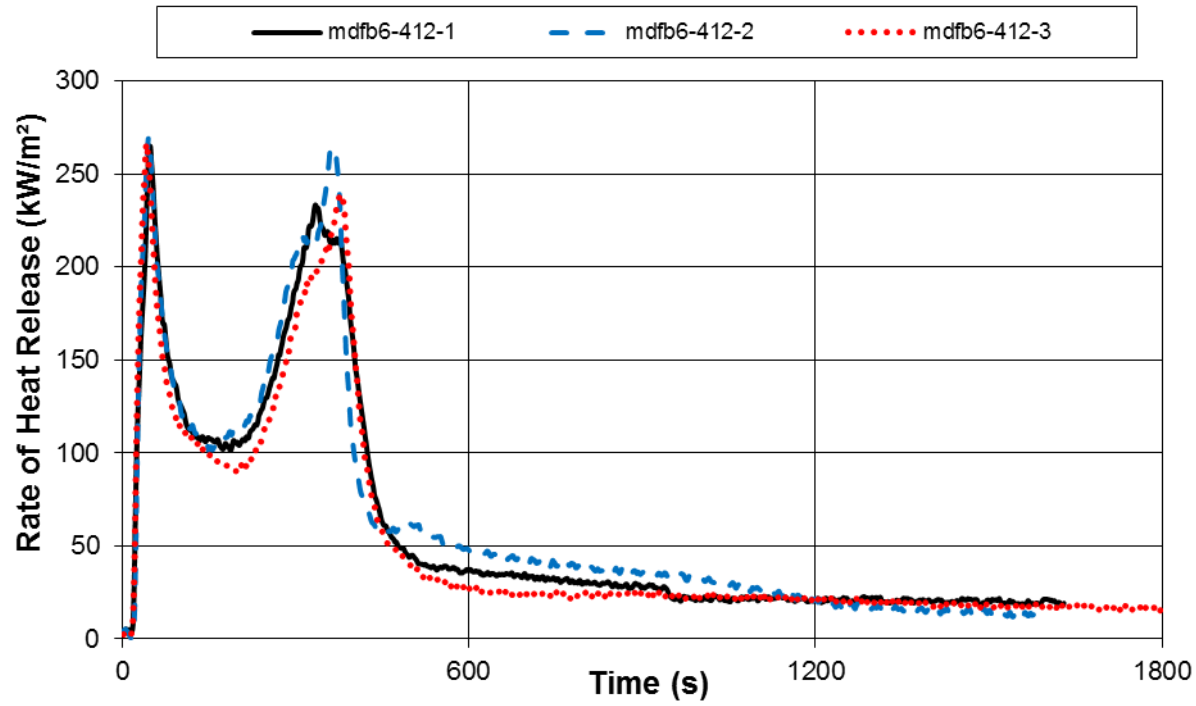


Figure 41 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with six layers of Paint B

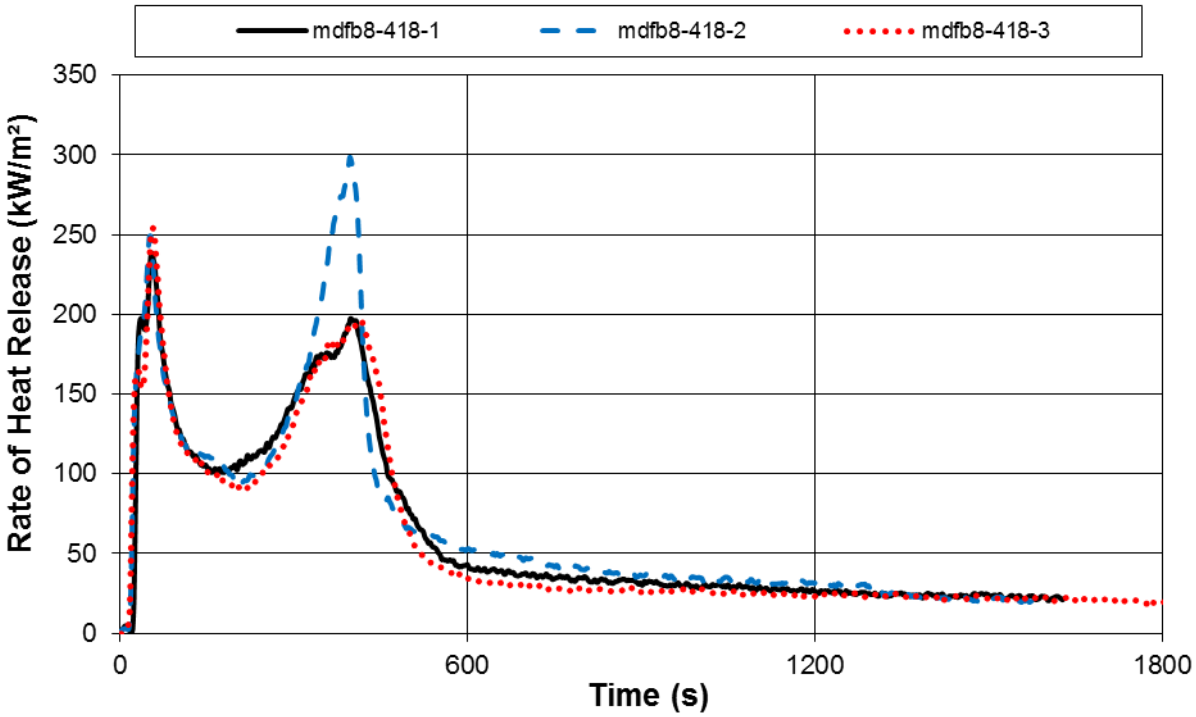


Figure 42 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with eight layers of Paint B

4.4.2 Paint C

Summarised results for medium density fibreboard coated with Paint C are presented in Table 18. The test results for the uncoated substrate are also included in Table 18 for ease of comparison. The heat release rates versus time are shown for four layers (Figure 43), six layers (Figure 44) and eight layers (Figure 45) of Paint C.

Table 18 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for medium density fibreboard samples painted with Paint C

Specimen Label	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
mdf0-302-1	33	370.3	105.2	4.2	65
mdf0-302-2	33	355.3	111.0	3.5	54
mdf0-302-3	31	306.9	108.6	3.6	67
mdf4c-403-1	18	337.2	115.5	3.0	45
mdf4c-403-2	26	287.1	110.9	2.2	34
mdf4c-403-3	20	307.1	118.5	3.4	51
mdf6c-409-1	40	330.1	116.8	3.2	50
mdf6c-409-2	39	349.7	109.0	2.8	46
mdf6c-409-3	38	367.2	111.8	3.2	52
mdf8c-415-1	36	347.3	114.2	3.5	55
mdf8c-415-2	35	332.2	106.1	3.3	54
mdf8c-415-3	35	355.2	103.8	3.5	58

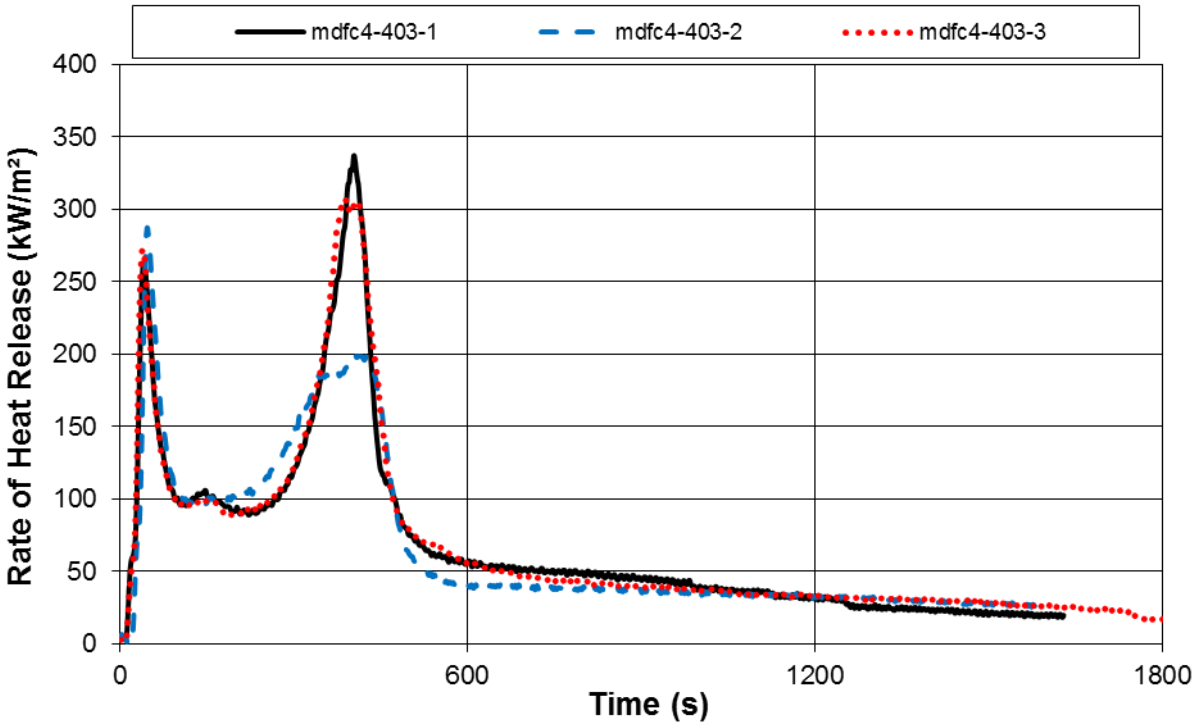


Figure 43 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with four layers of Paint C

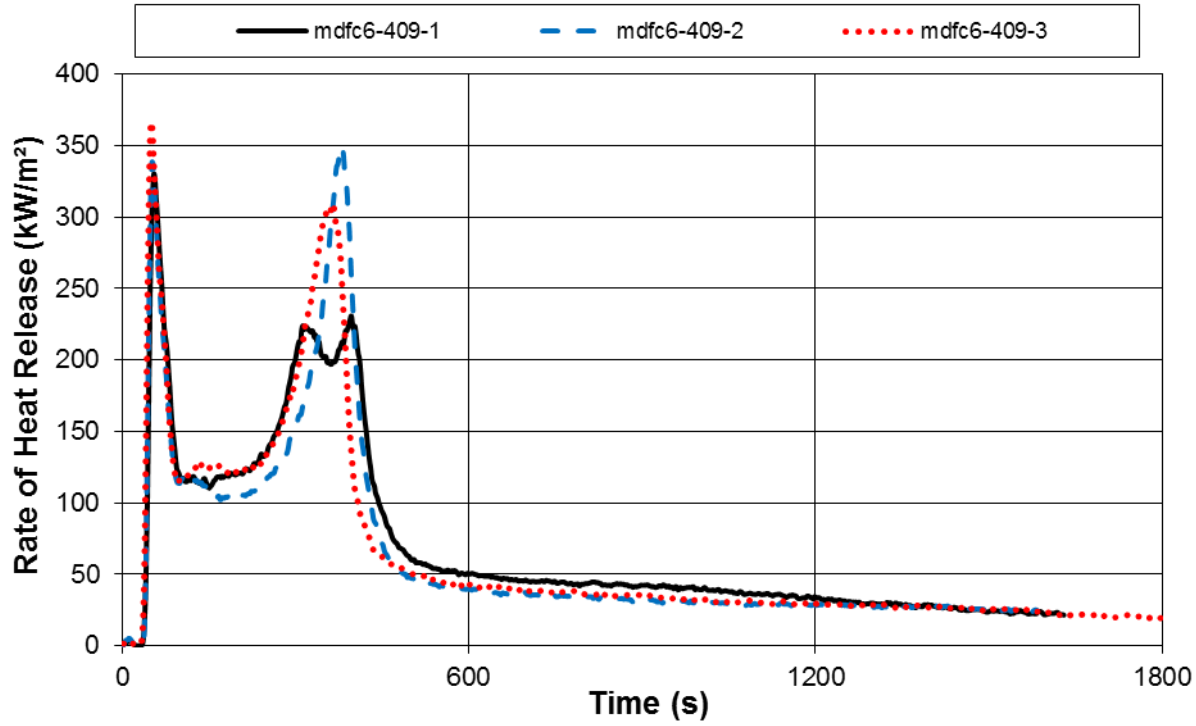


Figure 44 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with six layers of Paint C

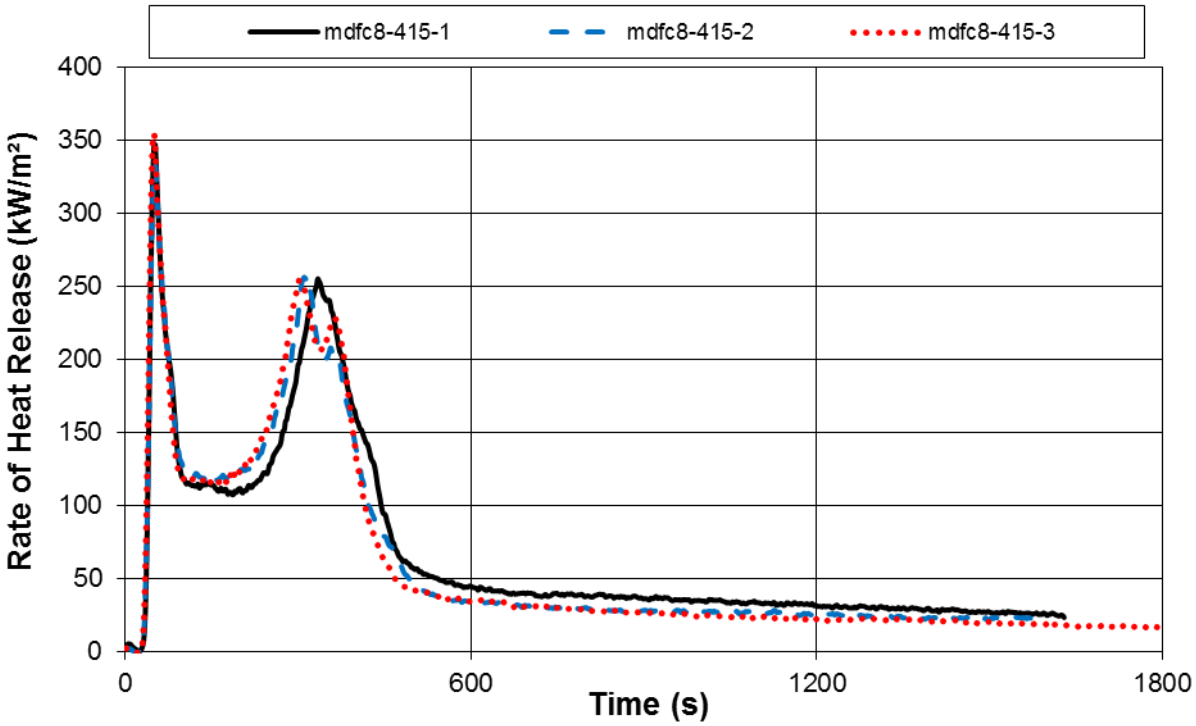


Figure 45 Heat release rate versus time for medium density fibreboard samples tested at 50 kW/m², with eight layers of Paint C

4.5 Real world samples

Summarised results for real-world samples are presented in Table 19. The heat release rates versus time are shown for sample rws-601 (Figure 46), rws-602 (Figure 47), rws-603 (Figure 48), rws-604 (Figure 49), and rws-605 (Figure 50).

Table 19 Summary of time to sustained flaming, peak heat release rate, total heat released, total smoke produced and average smoke extinction area for real-world samples

Specimen Label	Substrate	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)
rws-601-1	plasterboard	20	222.6	14.3	1.1	32
rws-601-2		17	228.1	9.5	1.2	63
rws-601-3		15	190.0	9.2	0.4	23
rws-602-1	plasterboard	15	264.9	10.5	0.7	32
rws-602-2		12	199.6	8.1	0.8	40
rws-602-3		11	218.4	9.6	0.5	28
rws-603-1	hardboard	13	421.1	54.2	3.5	102
rws-603-2		15	490.6	62.0	2.8	74
rws-603-3		15	442.9	60.3	3.2	82
rws-604-1	plasterboard	56	104.4	3.6	0.1	6
rws-604-2		63	77.1	4.0	0.1	4
rws-604-3		66	46.6	3.5	0.1	8
rws-605-1	plasterboard	36	196.5	5.6	0.2	10
rws-605-2		35	192.2	7.1	0.3	17
rws-605-3		47	172.4	5.7	0.5	31

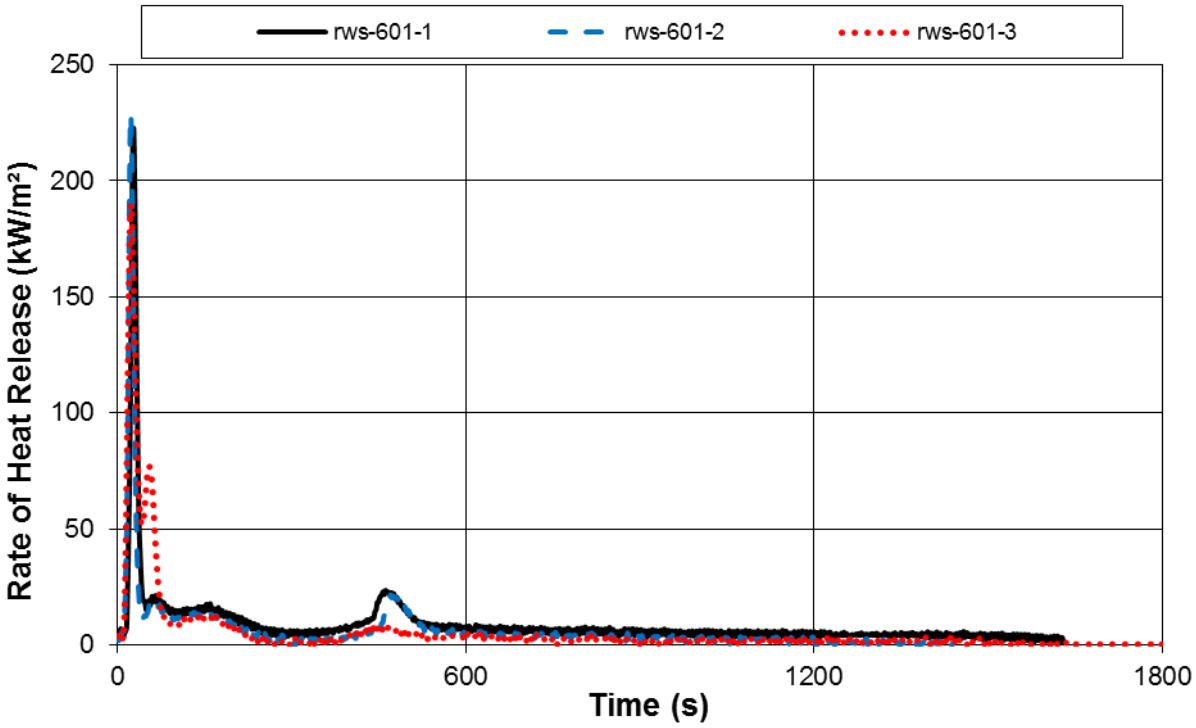


Figure 46 Heat release rate versus time for real-world samples, rws-601, tested at 50 kW/m²

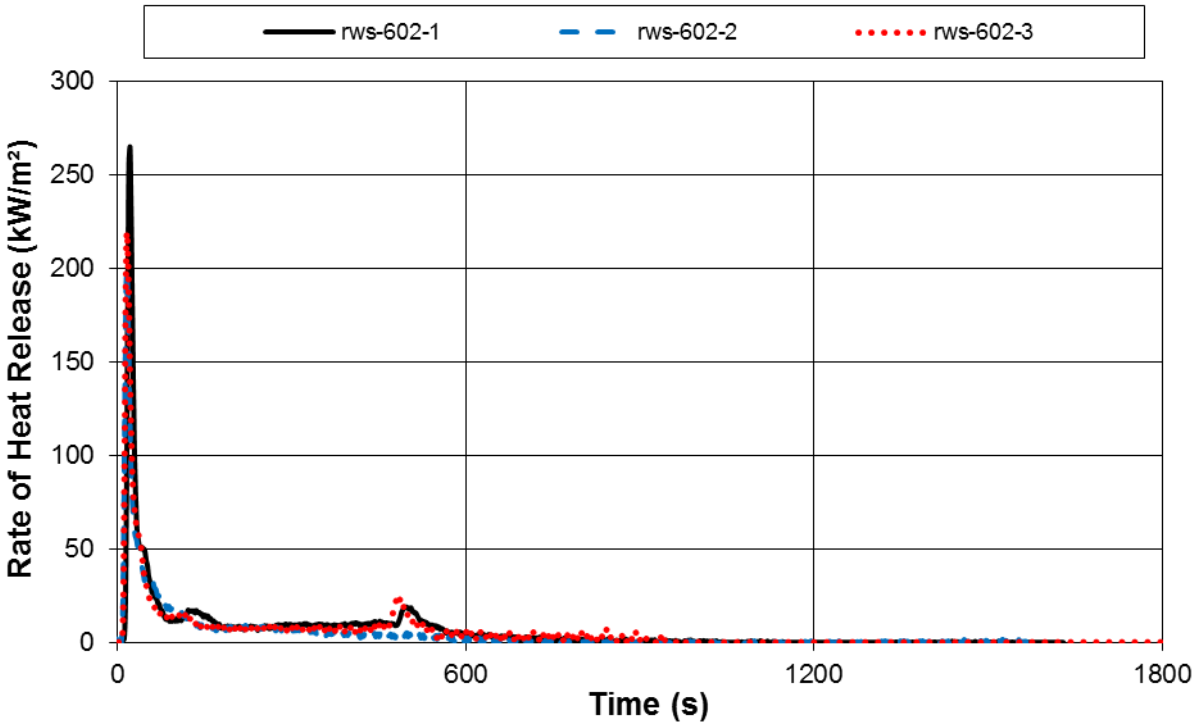


Figure 47 Heat release rate versus time for real-world samples, rws-602, tested at 50 kW/m²

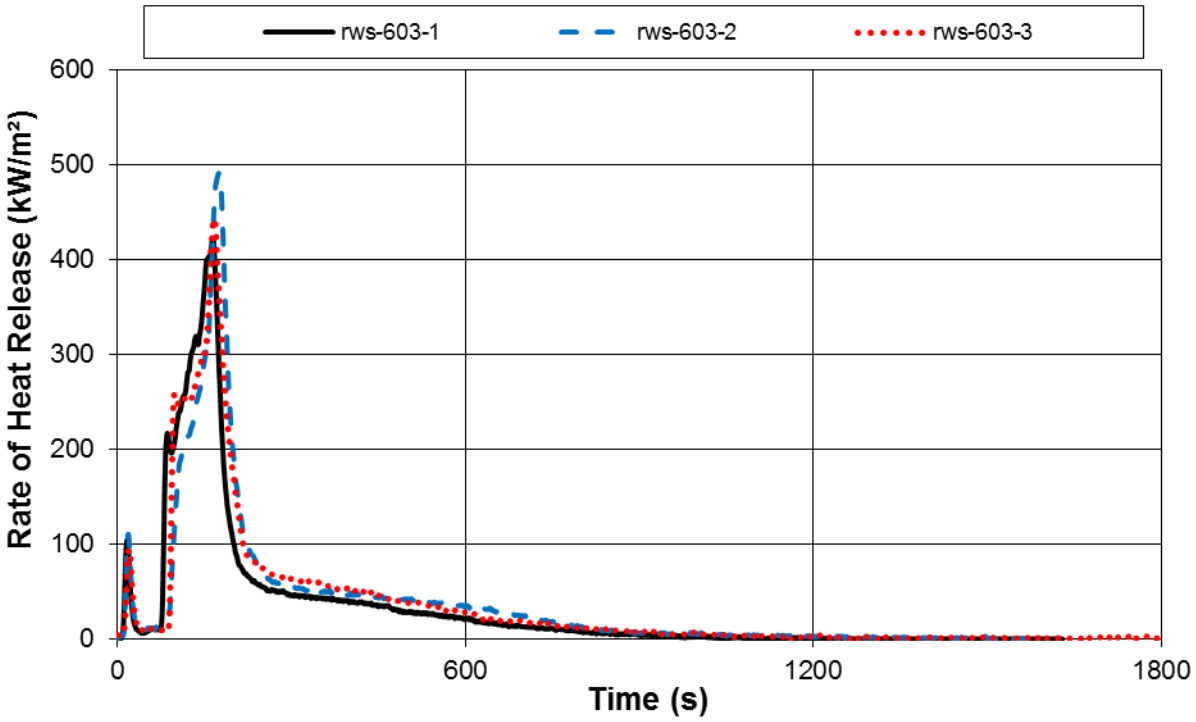


Figure 48 Heat release rate versus time for real-world samples, rws-603, tested at 50 kW/m²

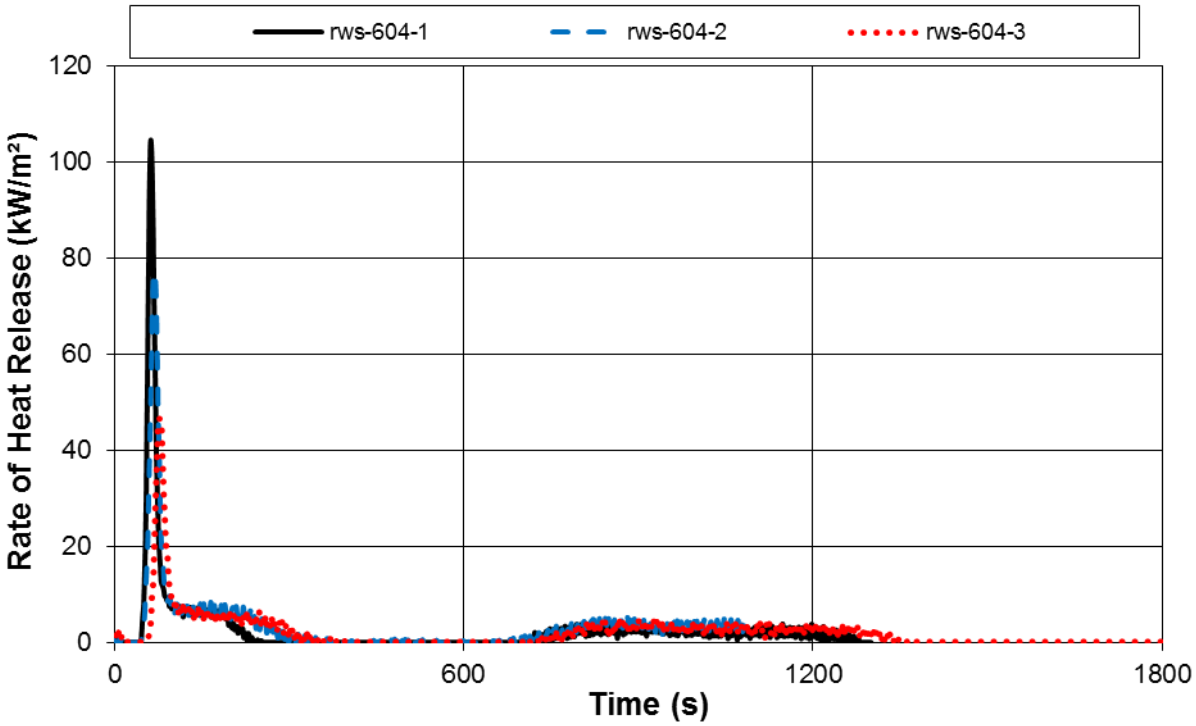


Figure 49 Heat release rate versus time for real-world samples, rws-604, tested at 50 kW/m²

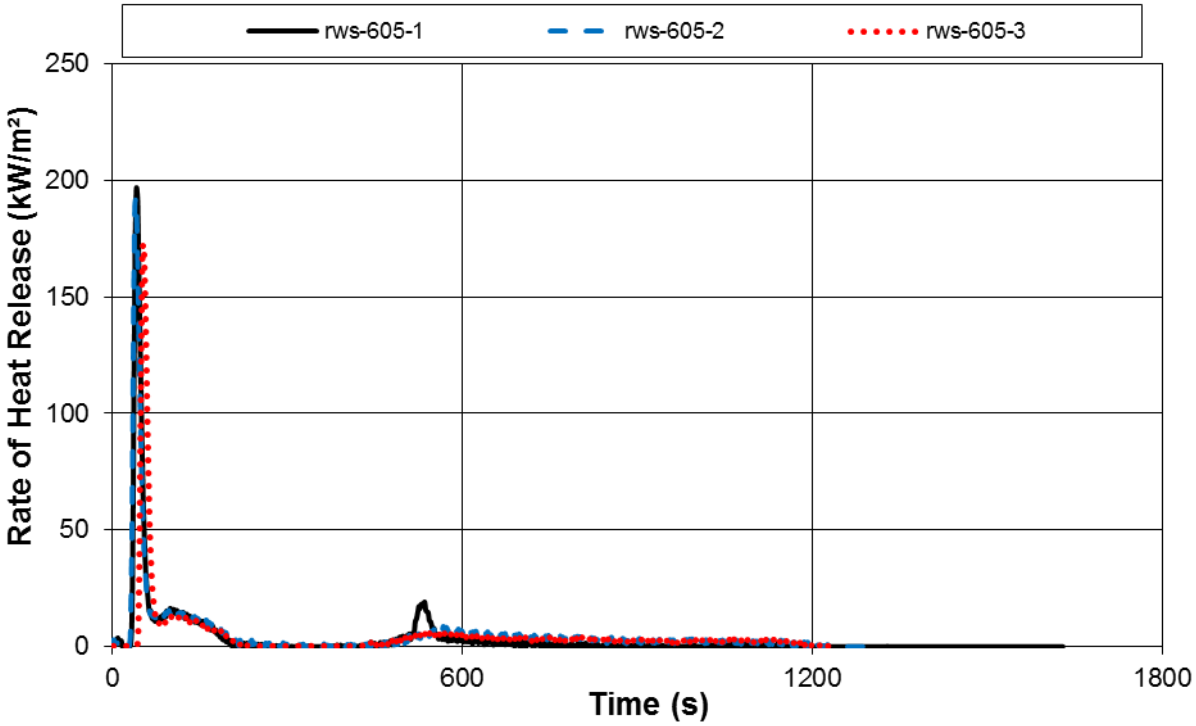


Figure 50 Heat release rate versus time for real-world samples, rws-605, tested at 50 kW/m²

5. ANALYSIS AND DISCUSSION

The experimental uncertainty associated with the key parameter is first discussed. Followed by the summaries of the analyses.

The analysis focused on the indicated material Group Numbers, as determined using the VM2 (MBIE 2012a) methodology presented in Appendix 1.3 Group Numbers, and a sensitivity analysis of the impact of a ±20% variation of the two key experimental variables (time to ignition and instantaneous heat release rate) of this calculation. The calculation of this and the analysis used here are discussed in Section 0.

Summaries of the average results are presented in this section. The spread of test results is indicated by sample standard deviations, based on the assumption of normal distributions of the data being appropriate.

Similarly to the previous section test results of the analyses, these are presented according to substrate followed by paint type. For each substrate and paint type combination, a summary of the average and sample standard deviation for each of the samples (based on 3 specimen test results) is presented for the:

- Paint thickness
- Time to ignition
- Heat release rate
- Total heat release
- Total smoke produced (where data was recorded).

In addition, the indicated Group Number for the sample is included in the summary. The results of the sensitivity analysis of the Group Number to time to ignition and instantaneous heat release rate are summarised visually for the average paint thicknesses for each combination of substrate and paint type.

5.1 Experimental Uncertainty

The relative uncertainty for the cone calorimeter heat release rate for values larger than 50 kW/m² has been previously estimated as between ±5% to ±10% (Tsantaridis 2003) using a partial derivatives approach.

Time intervals used in the collection of data during the cone calorimeter testing were two seconds.

Measurement of paint layer thickness precision was ± 5 µm. Experimental uncertainty (including user error) is estimated at ± 50 µm. Variation of paint thickness over the area of each specimen is expected as part of the application process.

5.2 Sensitivity Analysis of Group Numbers

The sensitivity analysis performed on the indicated material Group Numbers for each specimen was based on a ±20% uniform variation of the two key experimental parameters that are used in the calculation method described in Appendix 1.3 of the VM2 (MBIE 2012a).

The two key experimental variables are time to ignition (t_{ig}) and instantaneous heat release rate $[q''(t)]$. That is, a ±20% uniform distribution was applied to the experimentally acquired values for the time to ignition (t_{ig}) and each value for the instantaneous heat release rate $[q''(t)]$ (i.e. the value at each time interval) for each specimen. Latin hypercube sampling was used and 10,000 iterations were run to produce the analysis of the data set for each tested specimen.

The Group Number calculation is summarised in Section 5.2.1, for convenience.

The sensitivity of the indicated Group Number to the range of variations in time to ignition (t_{ig}) and instantaneous heat release rate $[q''(t)]$ for each specimen is presented visually as the ratio of the difference between the rate of heat release indices (I_{Q1} and I_{Q2}) and related limit ($I_{Q,10min}$, and $I_{Q,2min}$ or $I_{Q,12min}$). That is, the ratios:

$$\frac{(I_{Q1}-I_{Q,10min})}{I_{Q1}}\text{, and }\frac{(I_{Q2}-I_{Q,2min})}{I_{Q2}}\text{ or }\frac{(I_{Q2}-I_{Q,12min})}{I_{Q2}}$$

Then, if $\frac{(I_{Q1}-I_{Q,10min})}{I_{Q1}} \leq 0$, then the limit $I_{Q,12min}$ must be used to assess the value of I_{Q2}; if $\frac{(I_{Q2}-I_{Q,12min})}{I_{Q2}} \leq 0$ then the Group Number is 1, otherwise the Group Number is 2.

If $\frac{(I_{Q1}-I_{Q,10min})}{I_{Q1}} > 0$, then the limit $I_{Q,2min}$ must be used to assess the value of I_{Q2}; if $\frac{(I_{Q2}-I_{Q,2min})}{I_{Q2}} \leq 0$ then the Group Number is 3, otherwise the Group Number is 4.

The quadrants relating to each of the four Group Numbers using these ratios is visually represented as shown in the schematic of Figure 51. As data approaches the horizontal axis between 1 and 2 (highlighted in blue), the Group Number approaches the transition threshold between these two groups. As data approaches the vertical axis between 2 and 4 or between 3 and 1 (highlighted in green), the data approaches the transition threshold between Group Numbers 2 and 3. Similarly, as data approaches the horizontal axis between 3 and 4 (highlighted in red), the Group Number approaches the transition threshold between groups 3 and 4.

A “No Ignition” condition is represented on the schematic of Figure 51 as a data point at the origin.

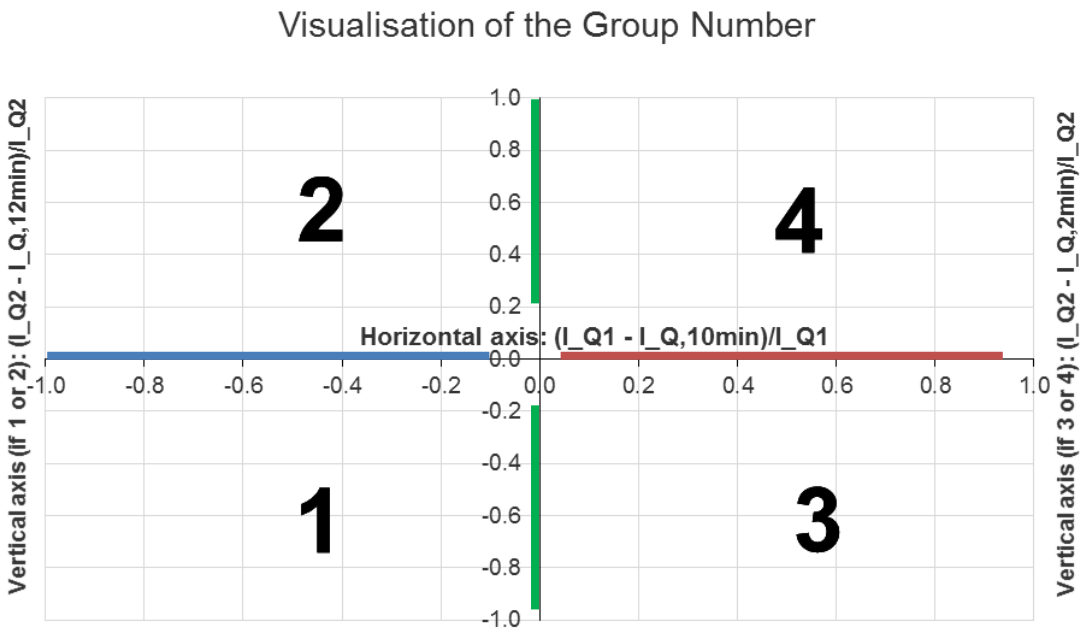


Figure 51 Schematic of the visualisation of a specimen Group Number used in the sensitivity analysis where axes relate to the ratios of how close the indices are to the limit thresholds

5.2.1 Estimating a Group Number

As described in described in Appendix 1.3 of the VM2 (MBIE 2012a), for a material tested to ISO 5660-1 (2002), the Group Number for the material must be determined in accordance with the following:

a) Data must be in the form of time and rate of heat release pairs for the duration of the test. The time interval between pairs should not be more than 5 seconds. The end of the test (t_f) is determined as defined in ISO 5660-1, as whichever occurs first

   1. 32 minutes after sustained flaming or other signs of combustion cease
   2. 30 minutes after the start of the test, if the specimen has not ignited
   3. Oxygen concentration returns to the preset value within 100 parts per million for 10 minutes or
   4. The mass of the specimen becomes zero

b) At least three replicate specimens must be tested. The following procedure must be applied separately to each specimen

   i. Determine time to ignition (t_{ig}) is defined as the time (s) when the rate of heat release reaches or first exceeds a value of 50 kW/m²

   ii. Calculate the ignitability index ($I_Q = {}^{60}/_{t_{ig}}$) expressed in reciprocal minutes

   iii. Calculate the following two rate of heat release indices

$$I_{Q1} = \int_{t_{ig}}^{t_f} \left[\frac{q''(t)}{(t - t_{ig})^{0.34}} \right] . dt$$

$$I_{Q2} = \int_{t_{ig}}^{t_f} \left[\frac{q''(t)}{(t - t_{ig})^{0.93}} \right] . dt$$

where

t refers time (s), and

$q''(t)$ refers to rate of heat release (kW/m²) at time t

iv. Calculate the following three integral limits

$$I_{Q,10min} = 6800 - 540 I_{ig}$$

$$I_{Q,2min} = 2475 - 165 I_{ig}$$

$$I_{Q,12min} = 1650 - 165 I_{ig}$$

v. Classify the material by applying the following rules

If $I_{Q1} > I_{Q,10min}$ and $I_{Q2} > I_{Q,2min}$, then the material is a Group Number 4 material

If $I_{Q1} > I_{Q,10min}$ and $I_{Q2} \leq I_{Q,2min}$, then the material is a Group Number 3 material

If $I_{Q1} \leq I_{Q,10min}$ and $I_{Q2} > I_{Q,12min}$, then the material is a Group Number 2 material

If $I_{Q1} \leq I_{Q,10min}$ and $I_{Q2} \leq I_{Q,12min}$, then the material is a Group Number 1 material

If the ignition criterion, of 50 kW/m², is not reached, then the material is a Group Number 1 material.

5.3 Concrete Samples

Following is the analysis relating to the concrete samples coated with Paint A, with and without simulated aging.

5.3.1 Samples Tested at 50 kW/m²

All concrete samples coated with Paint A tested and at an irradiance of 50 kW/m² did not ignite, except for 16 layers of paint subjected to the simulated aging process (con16aw). Average and sample standard deviations for the concrete samples coated with Paint A and tested at an irradiance of 50 kW/m² are summarised in Table 20. The sensitivity of the Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each specimen of concrete coated in 16 layers of Paint A subjected to simulated aging is shown in Figure 52.

Table 20 Summary of mean results for concrete samples tested at an incident heat flux of 50 kW/m²

Sample Code	No. Paint Layers	Simulated Aging	Average Paint Thickness** – Sample (µm)	Average Time to Ignition* (°C)	Average Peak Heat Release Rate (kW/m²)	Average Total Heat Release (MJ/m²)	Indicated VM2 Group Number
con0	0	n	0 (0%)	NT	-	-	1
con8a	8	n	277 (9%)	NI	-	-	1
con8aw		y	~300 (~10%)	NI	-	-	1
con16a	16	n	520 (3%)	NI	-	-	1
con16aw		y	~525 (~10%)	90 (5%)	4 (21%)	1 (8%)	1

Table Notes:
*No Ignition is recorded as ignition at 1200 seconds
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

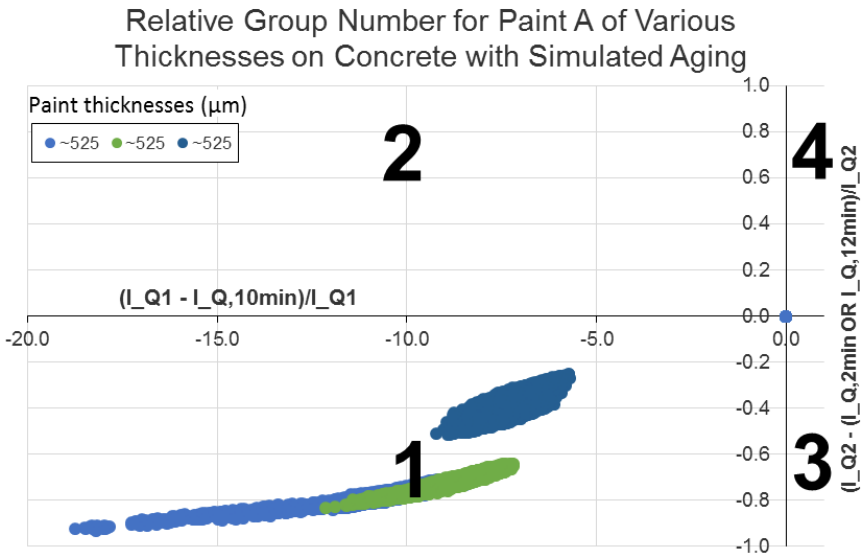


Figure 52 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the concrete specimens coated with Paint A subjected to simulated aging

5.3.2 Samples Tested at 75 kW/m²

It is to be noted that the 75 kW/m² irradiance is included here to provide an indication of the trend of the data only. The development of the estimation of the Group Number (as summarised in Section 5.2.1) was based on the 50 kW/m² irradiance level, and therefore the direct applicability of using this method to analyse the 75 kW/m² irradiance test data is dubious. However the general trend and spread of the values may provide useful, in comparison to the limited positive ignition data set available at the irradiance level of 50 kW/m².

All aged concrete samples coated with Paint A and tested and at an irradiance of 75 kW/m² ignited. Average and sample standard deviations for the concrete samples coated with Paint A and tested at an irradiance of 75 kW/m² are summarised in Table 21. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for concrete coated in Paint A is shown in Figure 53 and for samples subjected to simulated aging Figure 54.

Table 21 Summary of mean results for concrete samples tested at an incident heat flux of 75 kW/m²

Sample Code	No. Paint Layers	Simulated Aging	Average Paint Thickness** – Sample (µm)	Average Time to Ignition* (°C)	Average Peak Heat Release Rate (kW/m²)	Average Total Heat Release (MJ/m²)	VM2 Group Number Indicated
con0-75	0	n	0 (0%)	NT	-	-	N/A
con8a-75	8	n	287 (1%)	NI	-	-	N/A
con8aw-75		y	303 (8%)	149 (5%)	59.5 (8%)	1.6 (5%)	N/A
con16a-75	16	n	477 (7%)	172 (32%)	91.5 (22%)	4.8 (49%)	N/A
con16aw-75		y	523 (6%)	23 (9%)	78.5 (1%)	5.6 (30%)	N/A

Table Notes:
NT refers to Not Tested
N/A refers to Not Applicable. The estimation of the Group Number (as summarised in Section 5.2.1) is calculated to assess the indicative trend, since the methodology was developed for test results associated with an irradiance level of 50 kW/m².
* No Ignition of the sample is recorded as ignition at 1200 seconds.
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows.
** average of the average paint thicknesses of each of the three tested specimens.

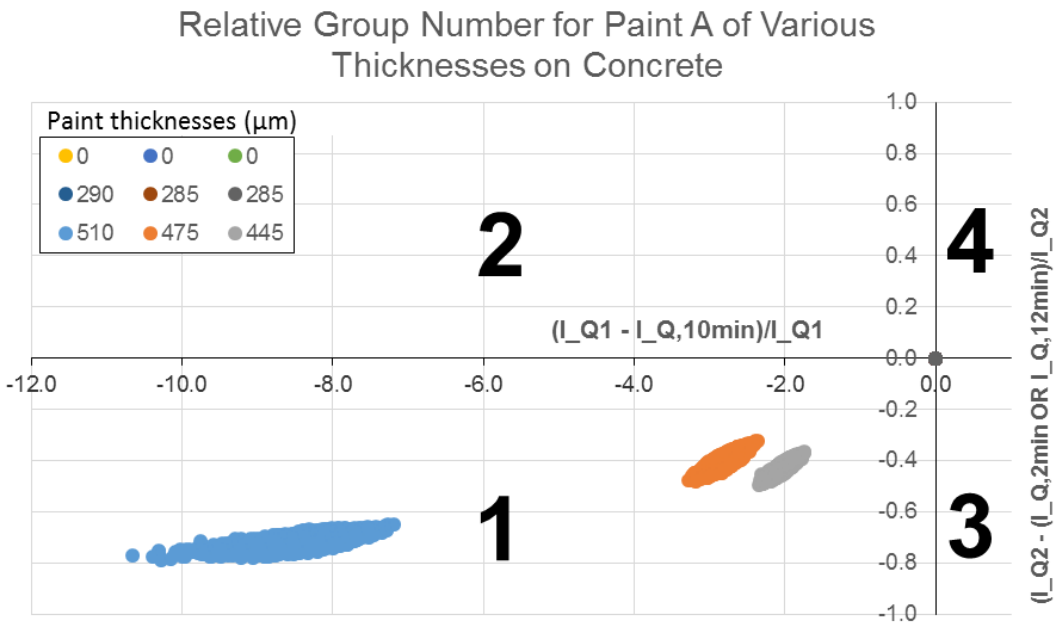


Figure 53 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the concrete specimens coated with Paint A and tested at an irradiance of 75 kW/m²

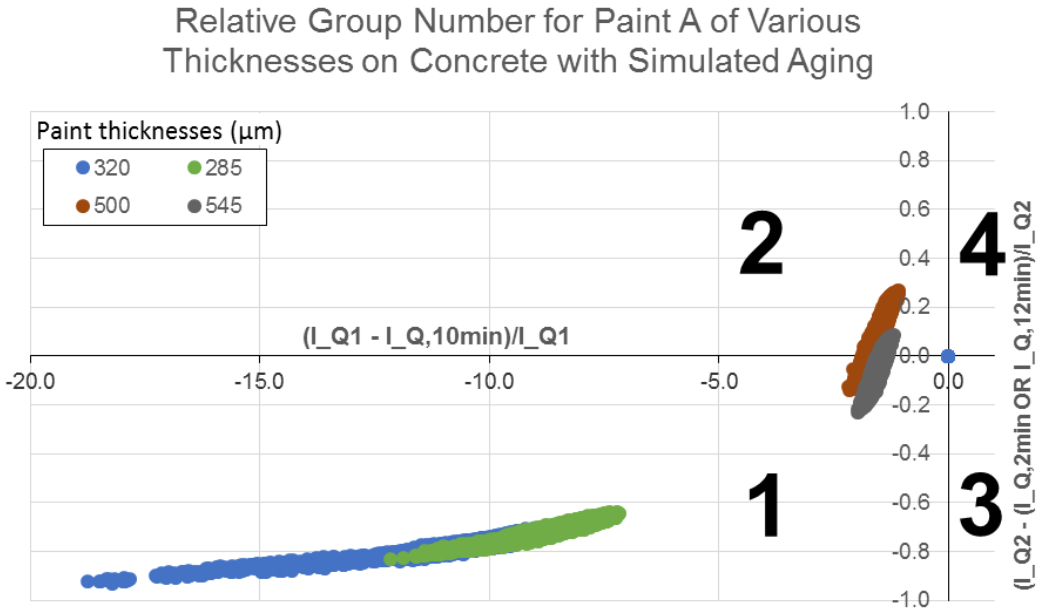


Figure 54 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) or the concrete specimens coated with Paint A, subjected to a simulated aging process and tested at an irradiance of 75 kW/m²

5.4 Plasterboard Samples

5.4.1 Paint A

Average and sample standard deviations for the plasterboard samples coated with Paint A are summarised in Table 22. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for plasterboard coated in Paint A is shown in Figure 55 and for samples subjected to simulated aging in Figure 56.

Table 22 Summary of mean results for plasterboard samples coated with Paint A

Sample Code	No. Paint Layers	Simulated Aging	Average Paint Thickness* – Sample (µm)	Average Time to Ignition (°C)	Average Peak Heat Release Rate (kW/m²)	Average Total Heat Release (MJ/m²)	VM2 Group Number Indicated
gyp0	0	n	0 (0%)	433 (154%)	40.6 (90%)	1.6 (29%)	1
gyp0w		y	0 (0%)	34 (7%)	91.0 (3%)	2.1 (3%)	1
gyp8a	8	n	427 (27%)	49 (30%)	141.5 (31%)	8.3 (66%)	2
gyp8aw		y	456 (20%)	44 (21%)	132.0 (5%)	8.2 (25%)	1
gyp16a	16	n	587 (18%)	45 (29%)	158.5 (16%)	9.2 (14%)	2
gyp16aw		y	600 (6%)	46 (3%)	168.7 (4%)	10.3 (11%)	1

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

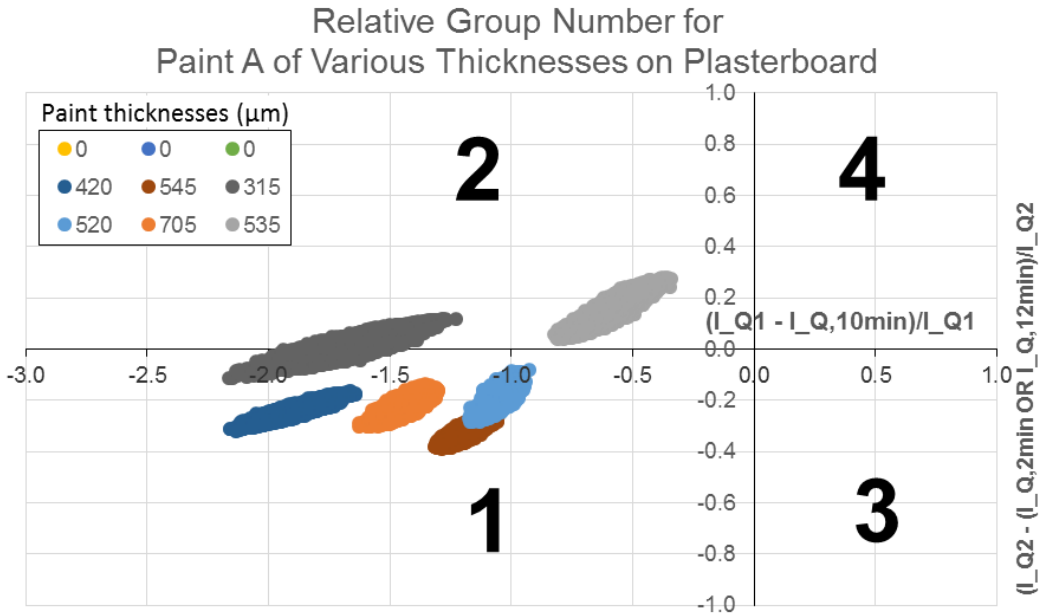


Figure 55 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the plasterboard specimens coated with Paint A

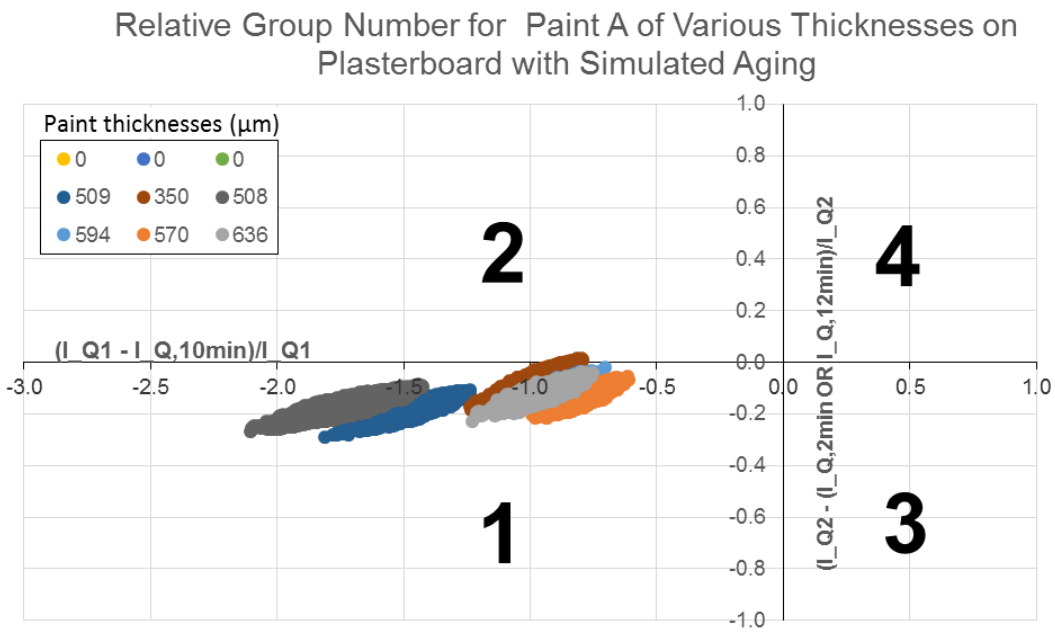


Figure 56 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the plasterboard specimens coated with Paint A and subjected to the simulated aging process

5.4.2 Paint B

Average and sample standard deviations for the plasterboard samples coated with Paint B are summarised in Table 23. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in μm) for plasterboard coated in Paint B is shown in Figure 57.

Table 23 Summary of average results for plasterboard samples coated with Paint B and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (μm)	Average Time to ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke Produced (m²)	VM2 Group Number Indicated
gyp0-301	0	0 (0%)	41.4 (0%)	94.2 (3%)	2.7 (19%)	0.0 (90%)	1
gyp4b-405	4	281 (21%)	13.0 (14%)	171.9 (5%)	7.8 (8%)	0.9 (13%)	2
gyp4b-411	6	324 (16%)	19.4 (20%	189.9 (11%)	10.7 (9%)	1.2 (12%)	2
gyp8b-417	8	482 (14%)	16.3 (3%)	183.5 (9%)	12.0 (13%)	1.7 (5%)	2

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

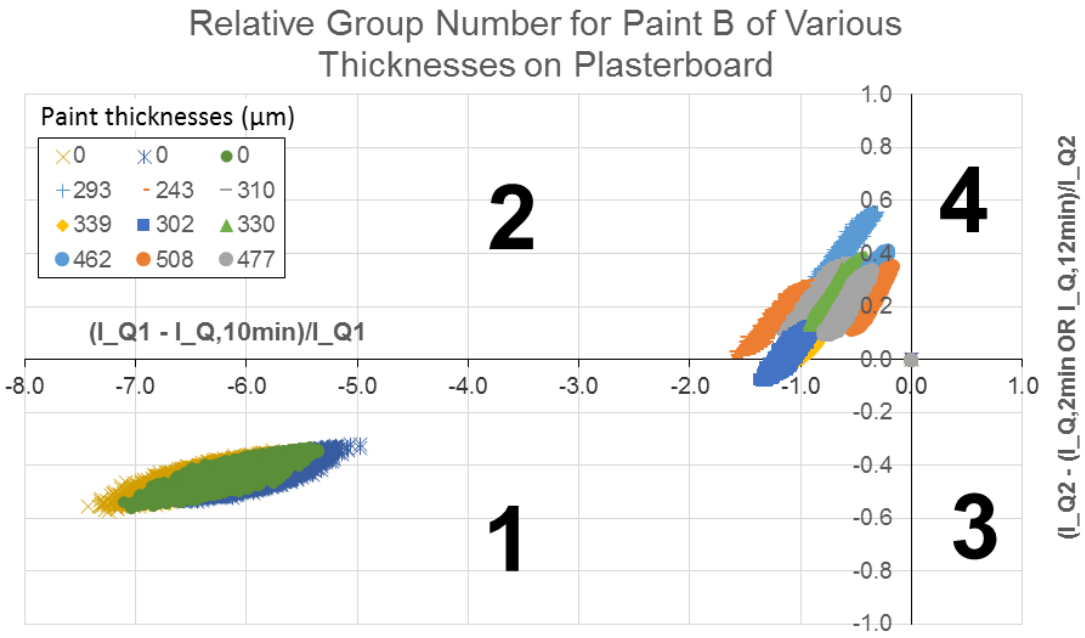


Figure 57 Visual summary of the sensitivity analysis of the Group Numbers for each specimen paint thickness (in μm) for the plasterboard specimens coated with Paint B

5.4.3 Paint C

Average and sample standard deviations for the plasterboard samples coated with Paint C are summarised in Table 24. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for plasterboard coated in Paint C is shown in Figure 58.

Table 24 Summary of average results for plasterboard samples coated with Paint B and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (µm)	Average Time to ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke Produced (m²)	VM2 Group Number Indicated
gyp0-301	0	0 (0%)	41.4 (0%)	94.2 (3%)	2.7 (19%)	0.0 (90%)	1
gyp4c-402	4	144 (29%)	41.7 (4%)	175.6 (10%)	7.5 (22%)	0.4 (38%)	1
gyp6c-408	6	361 (13%)	42.0 (12%)	253.8 (1%)	7.9 (8%)	0.7 (13%)	2
gyp8c-414	8	303 (22%)	39.6 (10%)	260.8 (1%)	7.7 (8%)	0.9 (8%)	2

Table Notes: () numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

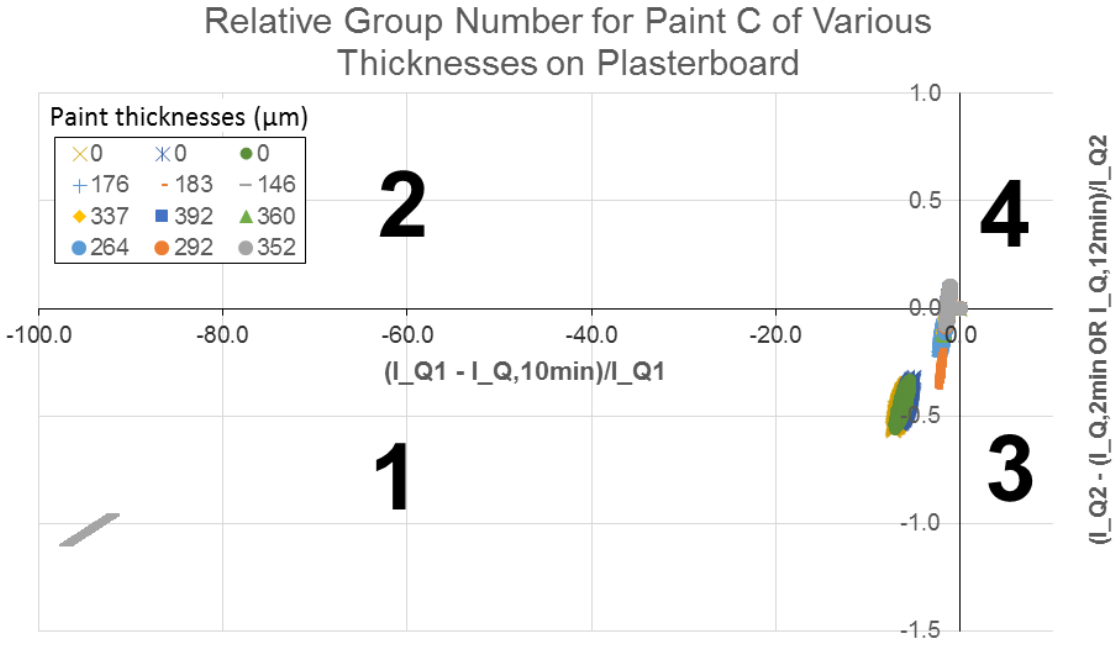


Figure 58 Visual summary of the sensitivity analysis of the Group Numbers for each specimen paint thickness (in µm) for the plasterboard specimens coated with Paint C.

5.5 Plywood samples

5.5.1 10 mm thick plywood samples

5.5.1.1 Paint A

Average and sample standard deviations for the 10 mm thick plywood samples coated with Paint A are summarised in Table 25. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for plasterboard coated in Paint A is shown in Figure 59 and for samples subjected to simulated aging in Figure 60.

Table 25 Summary of mean results for plywood samples tested at an incident heat flux of 50 kW/m²

Sample Code	No. Paint Layers	Simulated Aging	Average Paint Thickness* – Sample (µm)	Average Time to Ignition (°C)	Average Peak Heat Release Rate (kW/m²)	Average Total Heat Release (MJ/m²)	Indicated VM2 Group Number
PLY0	0	n	0 (0%)	30 (33%)	157.8 (16%)	34.4 (30%)	3
PLY0w		y	0 (0%)	26 (30%)	245.2 (6%)	38.5 (3%)	4
PLYa8	8	n	293 (5%)	34 (30%)	180.9 (15%)	33.3 (42%)	3
PLY8aw		y	303 (6%)	35 (16%)	213.5 (11%)	42.8 (6%)	3
PLY16a	16	n	552 (3%)	18 (26%)	191.9 (6%)	35.0 (42%)	3
PLY16aw		y	483 (7%)	29 (11%)	233.0 (9%)	45.5 (2%)	3

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

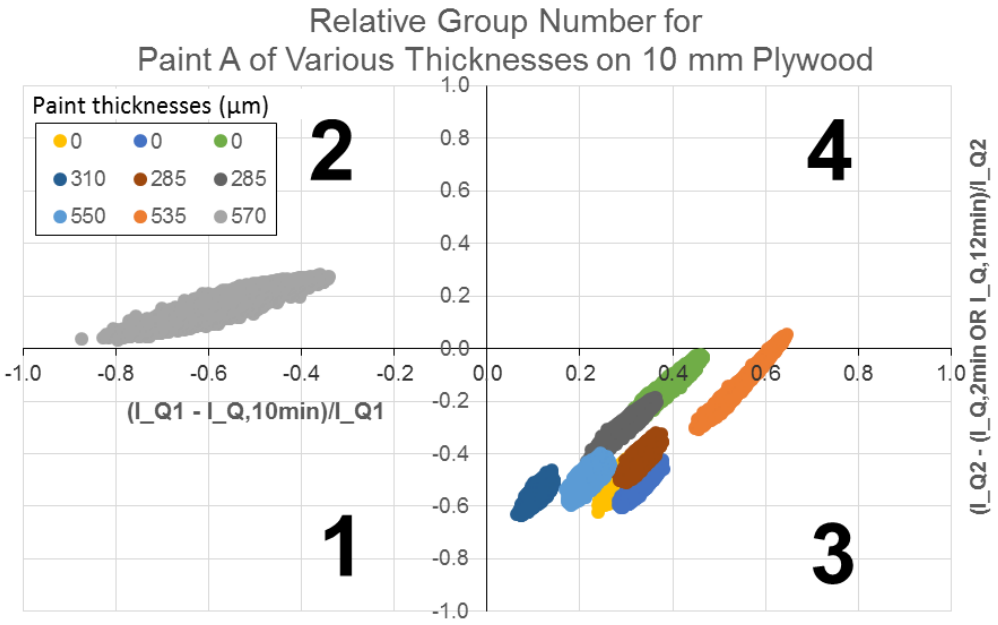


Figure 59 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the 10 mm thick plywood specimens coated with Paint A

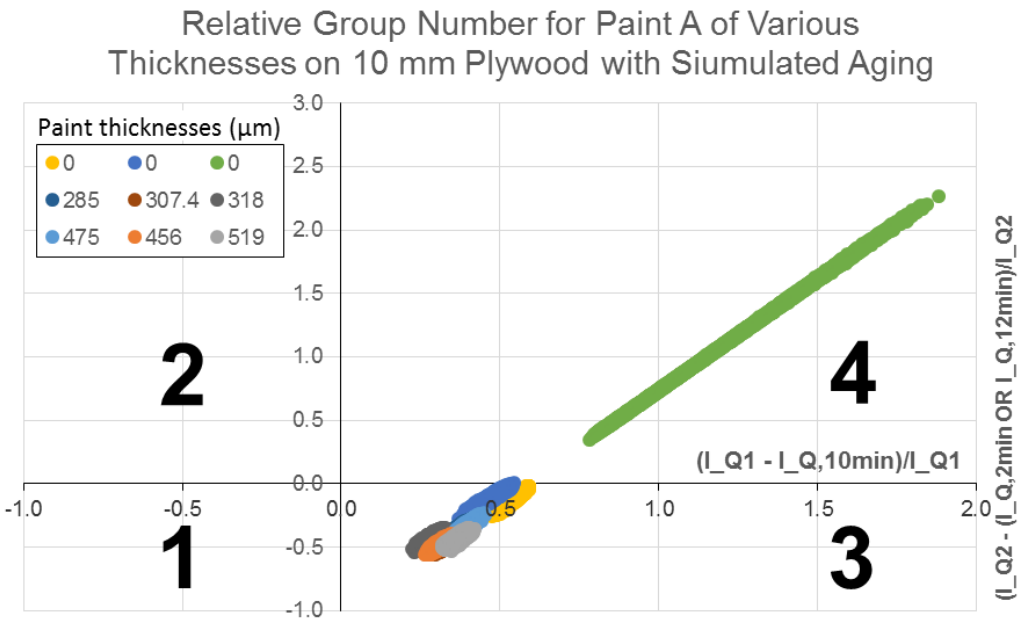


Figure 60 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the 10 mm thick plywood specimens coated with a Paint A and subjected to the simulated aging process

5.5.2 7 mm Thick Plywood Samples

5.5.2.1 Paint B

Average and sample standard deviations for the 7 mm thick plywood samples coated with Paint B are summarised in Table 26. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in μm) for 7 mm thick plywood coated in Paint B is shown in Figure 61.

Table 26 Summary of average results for 7 mm plywood samples coated with Paint B and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (μm)	Average Time to Ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke (m²)	Indicated VM2 Group Number
ply0-300	0	0 (0%)	23.1 (18%)	284.0 (2%)	59.2 (2%)	1.8 (24%)	3
ply4b-404	4	258 (23%)	14.5 (9%)	348.0 (7%)	81.5 (5%)	3.6 (7%)	4
ply6b-410	6	295 (20%)	18.0 (23%)	346.6 (13%)	74.7 (5%)	4.3 (13%)	4
ply8b-416	8	379 (16%)	16.8 (20%)	334.9 (10%)	71.8 (1%)	4.5 (5%)	4

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

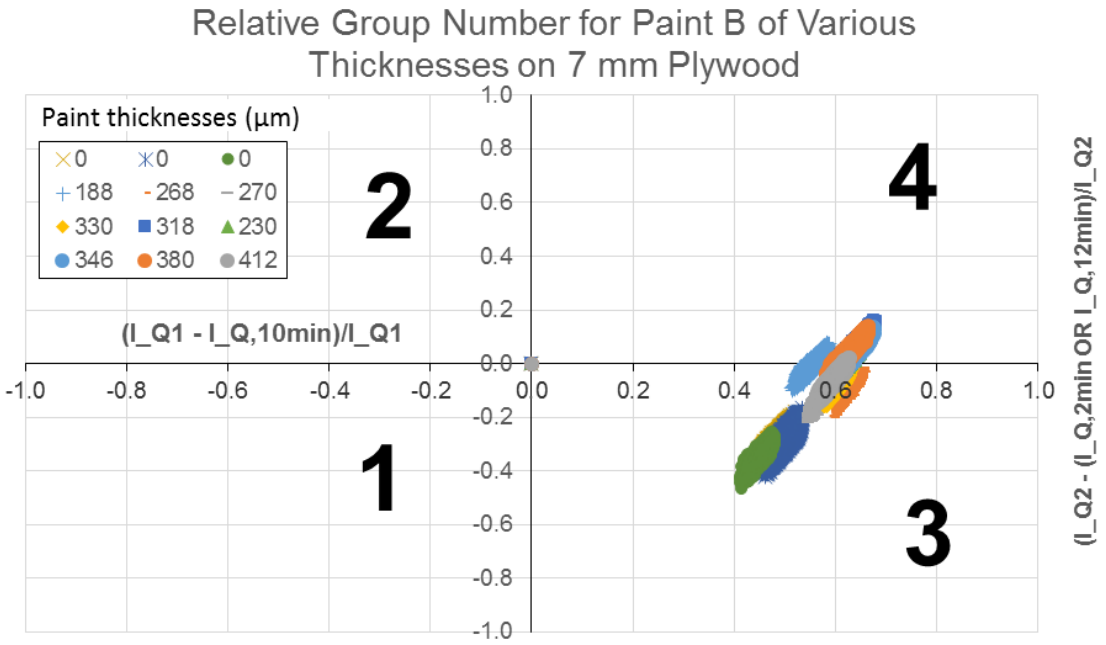


Figure 61 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in μm) for the 7 mm thick plywood specimens coated with a Paint B

5.5.2.2 Paint C

Average and sample standard deviations for the 7 mm thick plywood samples coated with Paint C are summarised in Table 27. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for 7 mm thick plywood coated in Paint C is shown in Figure 62.

Table 27 Summary of average results for 7 mm plywood samples coated with Paint B and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (µm)	Average Time to Ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke (m²)	Indicated VM2 Group Number
ply0-300	0	0 (0%)	23.1 (18%)	284.0 (2%)	59.2 (2%)	1.8 (24%)	3
ply4c-401	4	129 (31%)	16.4 (9%)	301.3 (10%)	66.7 (2%)	2.2 (24%)	3
ply6c-407	6	316 (23%)	14.5 (14%)	331.9 (14%)	75.3 (8%)	2.2 (10%)	4
ply8c-413	8	391 (9%)	24.5 (24%)	334.4 (4%)	72.4 (7%)	3.1 (21%)	3

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

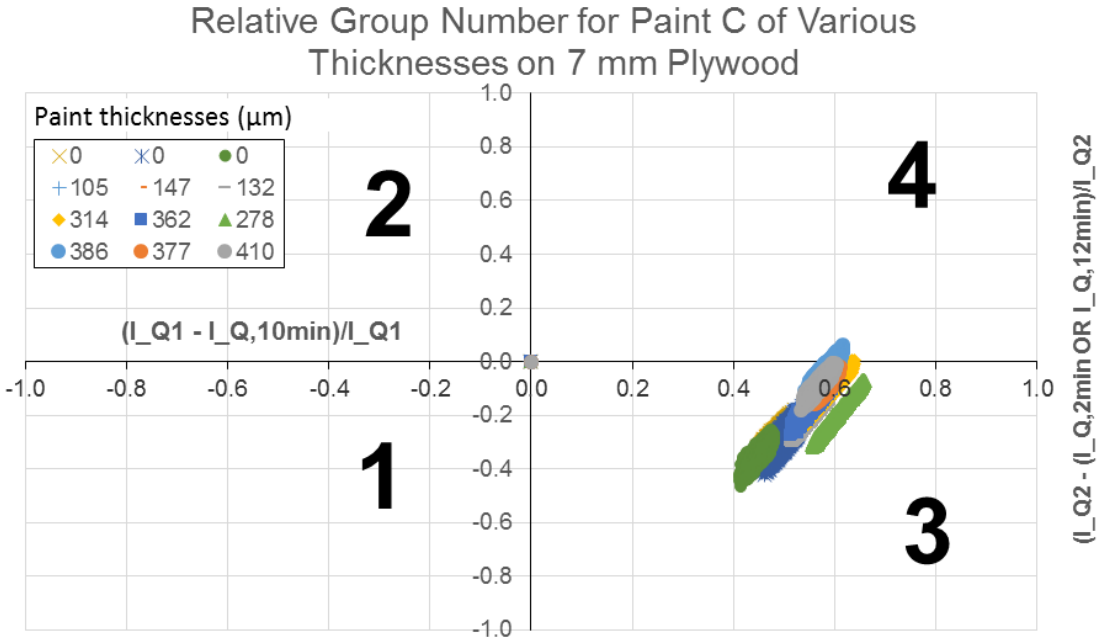


Figure 62 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the 7 mm thick plywood specimens coated with a Paint C

5.6 Medium Density Fibreboard

5.6.1 Paint B

Average and sample standard deviations for the medium density fibreboard samples coated with Paint B are summarised in Table 28. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in μm) for medium density fibreboard coated in Paint B is shown in Figure 63.

Table 28 Summary of average results for medium density fibreboard samples coated with Paint B and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (μm)	Average Time to Ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke (m²)	Indicated VM2 Group Number
mdf0-302	0	0 (0%)	32.4 (4%)	344.2 (10%)	108.3 (3%)	3.7 (10%)	3
mdf4b-406	4	243 (33%)	18.9 (12%)	274.1 (8%)	109.6 (8%)	4.2 (6%)	3
mdf4b-412	6	263 (19%)	21.5 (3%)	266.9 (1%)	97.5 (6%)	5.5 (10%)	3
mdf8b-418	8	427 (8%)	21.2 (18%)	263.7 (12%)	106.4 (6%)	5.6 (4%)	3

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

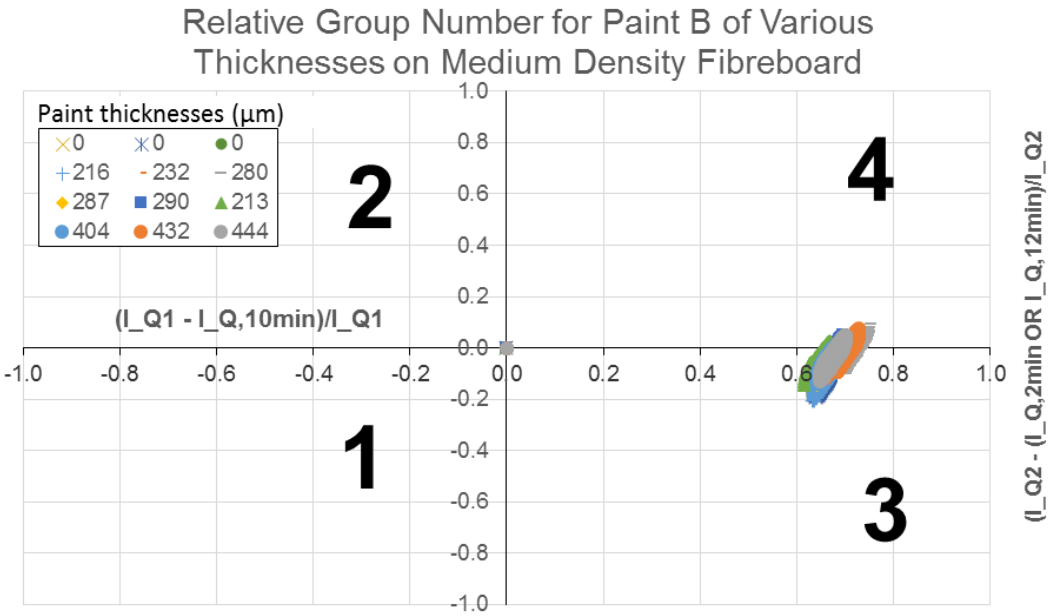


Figure 63 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in μm) for the medium density fibreboard specimens coated with a Paint B

5.6.2 Paint C

Average and sample standard deviations for the medium density fibreboard samples coated with Paint C are summarised in Table 29. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for each paint thickness (in µm) for medium density fibreboard coated in Paint C is shown in Figure 64.

Table 29 Summary of average results for medium density fibreboard samples coated with Paint C and associated sample standard deviations

Sample Code	Number of Paint Layers	Average Paint Thickness* – Sample (µm)	Average Time to Ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke (m²)	Indicated VM2 Group Number
mdf0-302	0	0 (0%)	32.4 (4%)	344.2 (10%)	108.3 (3%)	3.7 (10%)	3
mdf4c-403	4	145 (23%)	20.9 (20%)	310.5 (8%)	115.0 (3%)	2.9 (21%)	3
mdf6c-409	6	256 (25%)	39.0 (4%)	349.0 (5%)	112.5 (4%)	3.1 (7%)	4
mdf8c-415	8	365 (14%)	35.2 (3%)	344.9 (3%)	108.0 (5%)	3.4 (4%)	3

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

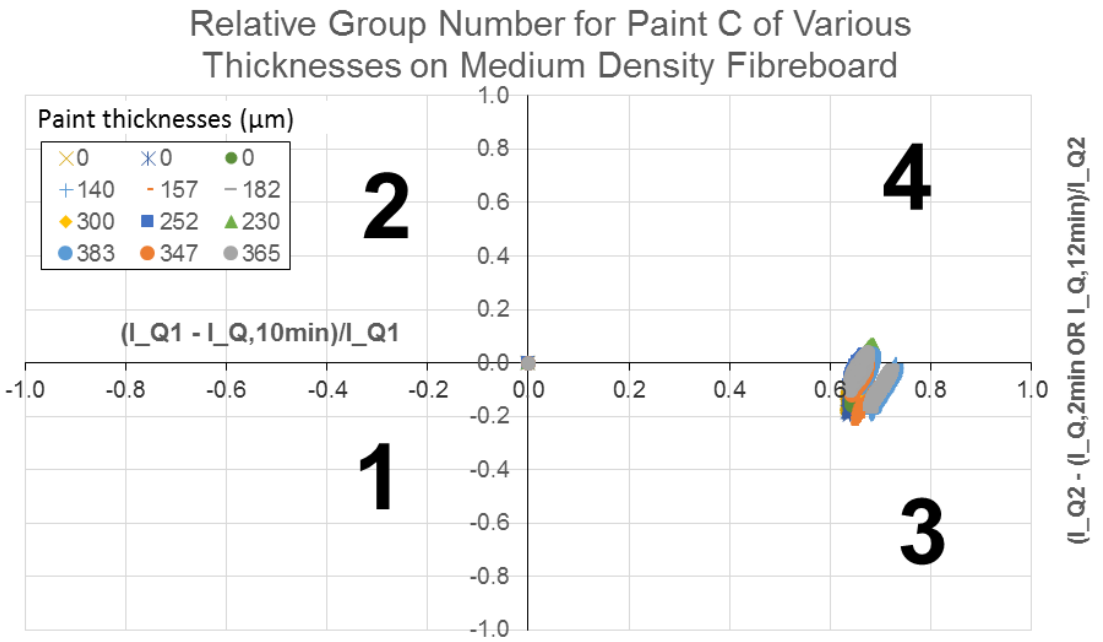


Figure 64 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the medium density fibreboard specimens coated with a Paint C

5.7 Real-World Samples

Average and sample standard deviations for each of the real-world samples are summarised in Table 30. The sensitivity of the specimen Group Numbers to a ±20% variation of the experimental time to ignition and instantaneous heat release rates for

paint thicknesses (in µm) for each of the real-world samples are shown in Figure 65 to Figure 69 for samples rws-601 to rws-605, respectively.

Table 30 Summary of average results for real-world sample and associated sample standard deviations

Sample Code	Substrate	Average Paint Thickness* – Sample (µm)	Average Time to Ignition (s)	Average Peak HRR (kW/m²)	Average Total HR (MJ/m²)	Average Total Smoke (m²)	Indicated VM2 Group Number
rws-601	plasterboard	399 (12%)	17.1 (15%)	213.6 (10%)	11.0 (26%)	0.9 (48%)	2
rws-602	plasterboard	689 (3%)	12.6 (17%)	227.6 (15%)	9.4 (13%)	0.7 (17%)	2
rws-603	hardboard	203 (17%)	14.6 (10%)	451.5 (8%)	58.8 (7%)	3.1 (11%)	3
rws-604	plasterboard	1097 (2%)	61.6 (8%)	76.0 (38%)	3.7 (6%)	0.1 (32%)	1
rws-605	plasterboard	516 (3%)	39.3 (17%)	187.0 (7%)	6.1 (14%)	0.3 (53%)	1

Table Notes:
() numbers in brackets indicate the sample standard deviation as a percentage of the mean value it follows
* average of the average paint thicknesses of each of the three tested specimens

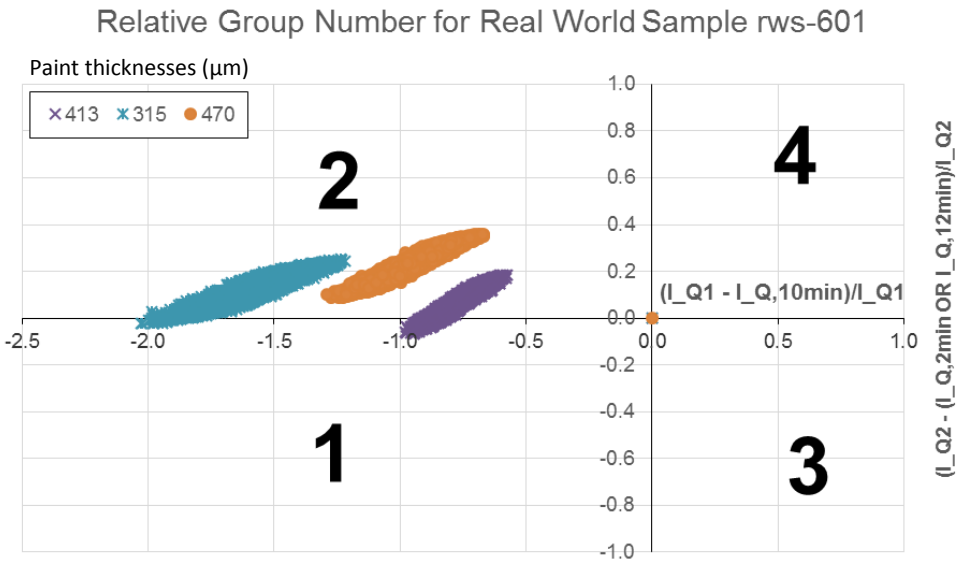


Figure 65 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the real-world sample rws-601

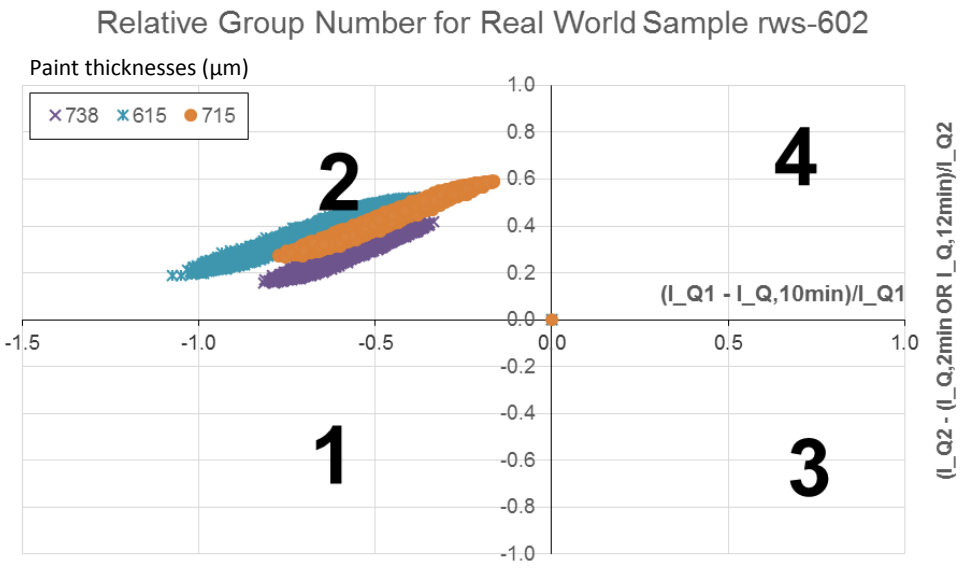


Figure 66 Visual summary of the sensitivity analysis of the Group Numbers for each paint thickness (in µm) for the real-world sample rws-602

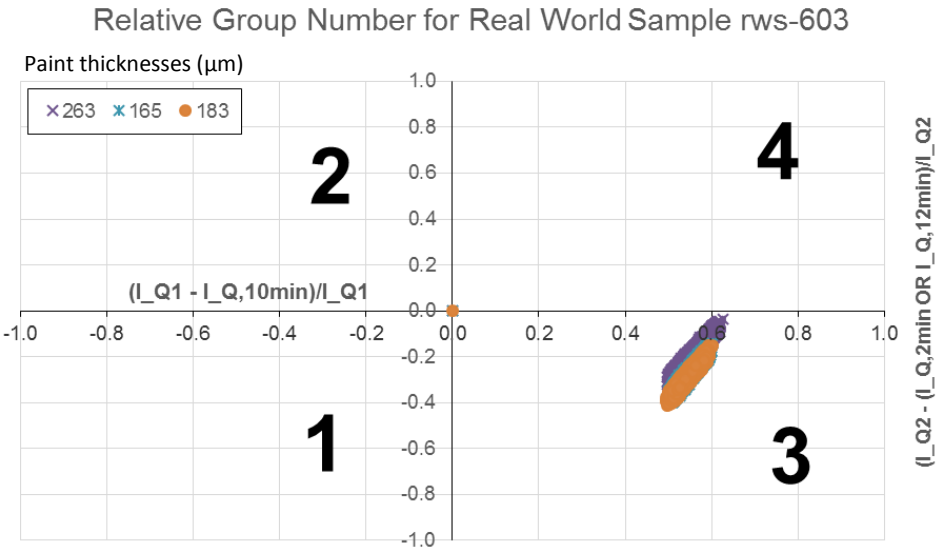


Figure 67 Visual summary of the sensitivity analysis of the Group Numbers for each specimen paint thickness (in µm) for the real-world sample rws-603

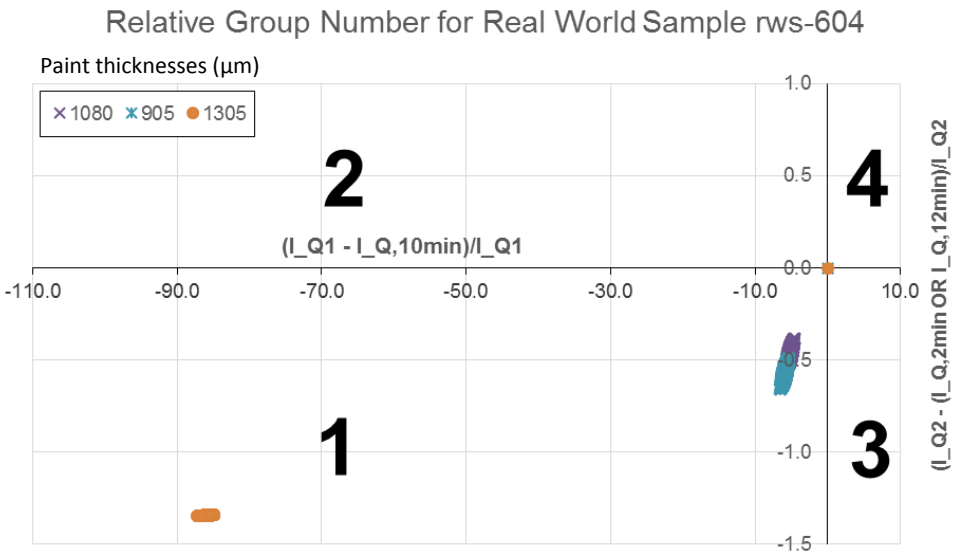


Figure 68 Visual summary of the sensitivity analysis of the Group Numbers for each specimen paint thickness (in µm) for the real-world sample rws-604

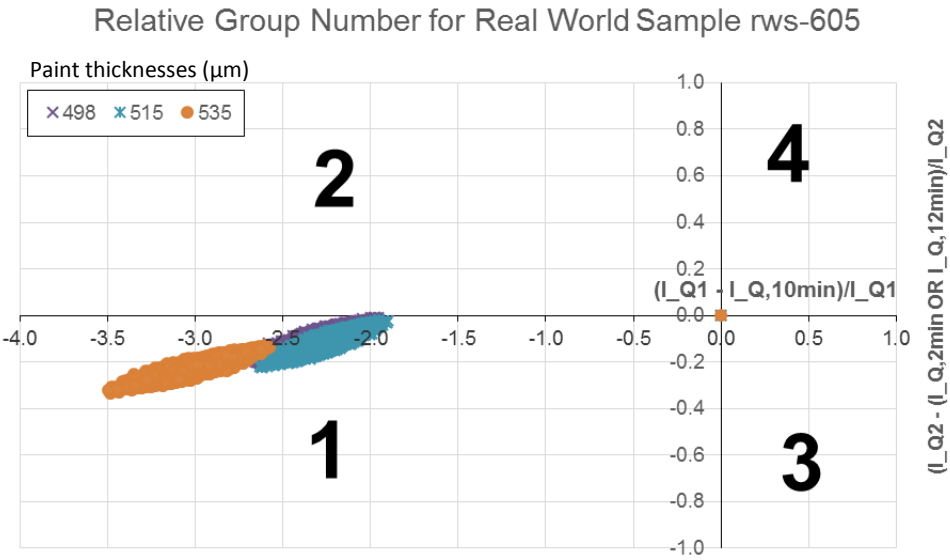


Figure 69 Visual summary of the sensitivity analysis of the Group Numbers for each specimen paint thickness (in µm) for the real-world sample rws-605

5.8 Test Variables versus Paint Thickness

In this section the test variables for each specimen are considered in relation to the thickness of the coating for each substrate. The test variables considered in this section are:

- Time to ignition
- Peak heat release rate
- Total heat released
- Total smoke produced
- The analysed value for the indication of the Group Number for each specimen.

An indication of the spread of the data is also considered in terms of the average paint thickness for the samples based on substrate and the number of paint layers applied. The test variables that are considered in terms of the spread of data are:

- Average time to ignition
- Average peak heat release rate
- Average total heat released
- Average total smoke produced for each sample.

5.8.1 Concrete

The average specimen paint thickness for each concrete specimen tested at 50 kW/m² versus time to ignition is shown in Figure 70, peak heat release rate is shown in Figure 71, total heat released is shown in Figure 72, total smoke produced is shown in Figure 73 and the analysed value for the indication of the Group Number is shown in Figure 74.

The spread of data was not included for concrete-substrate samples, as insufficient data is available for this type of analysis to be useful. The low number of data points are because of the high “No Ignition” results for the concrete specimens tested with a 50 kW/m² irradiance.

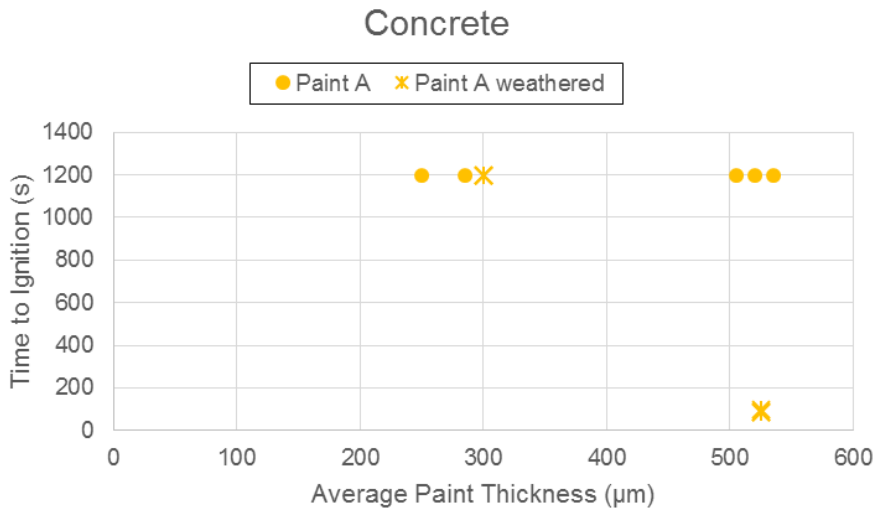


Figure 70 Time to ignition versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

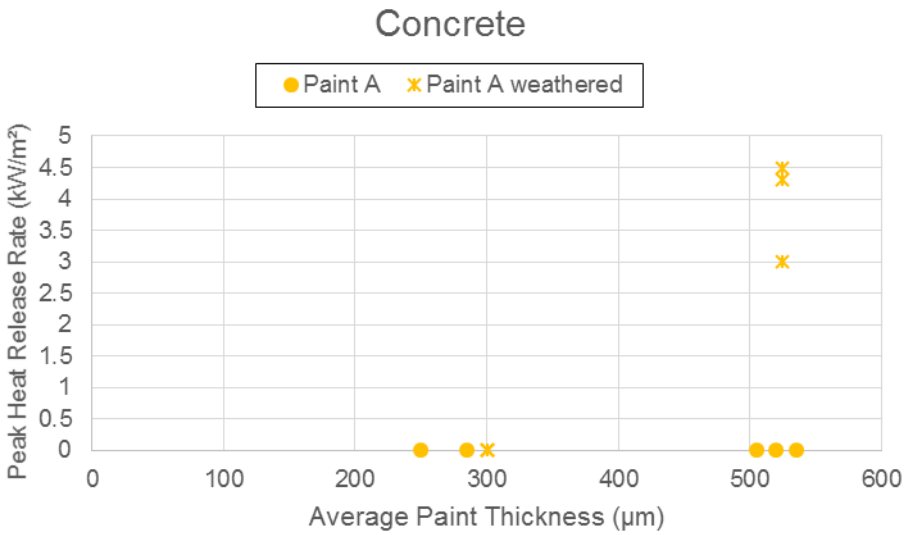


Figure 71 Peak heat release rate versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

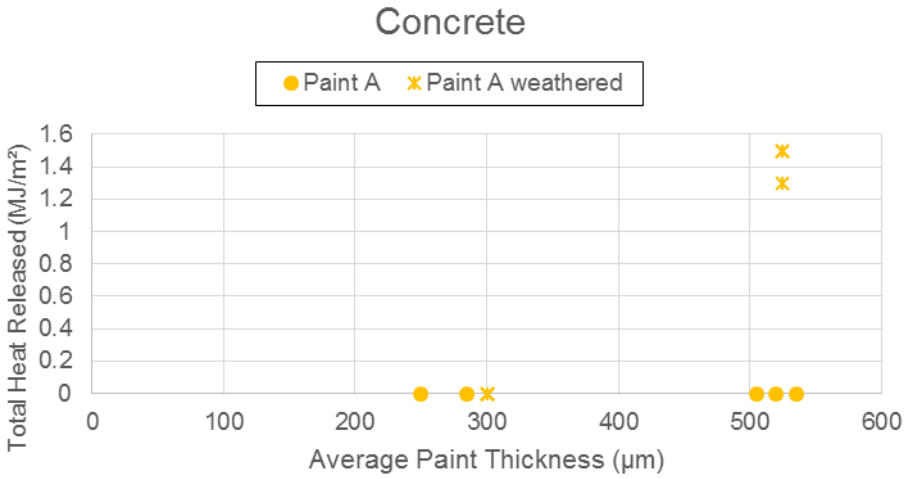


Figure 72 Total heat released versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

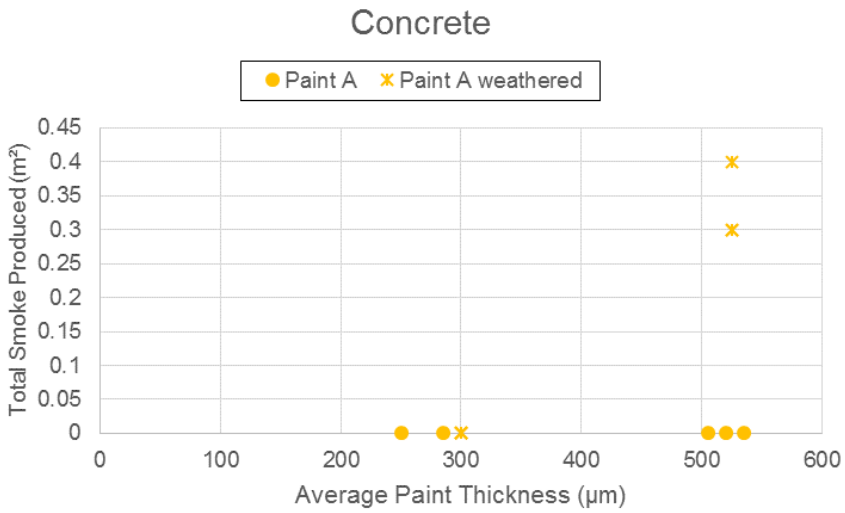


Figure 73 Total smoke produced versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

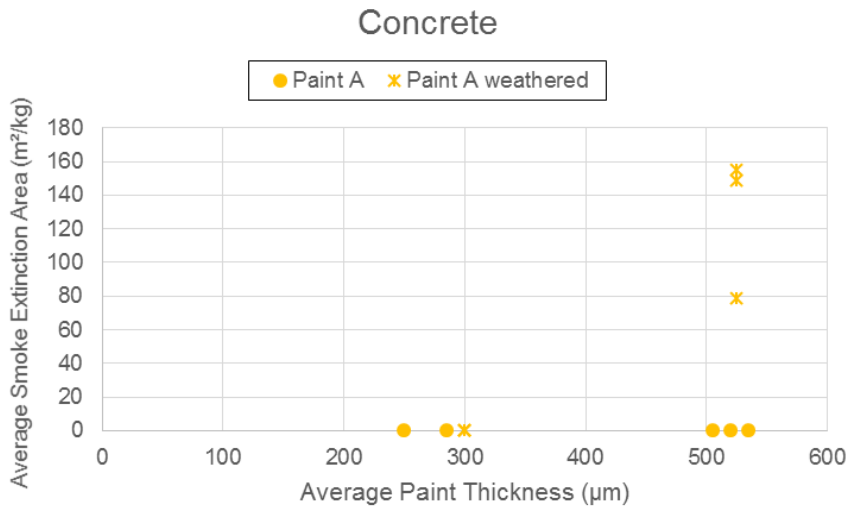


Figure 74 Average smoke extinction area versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

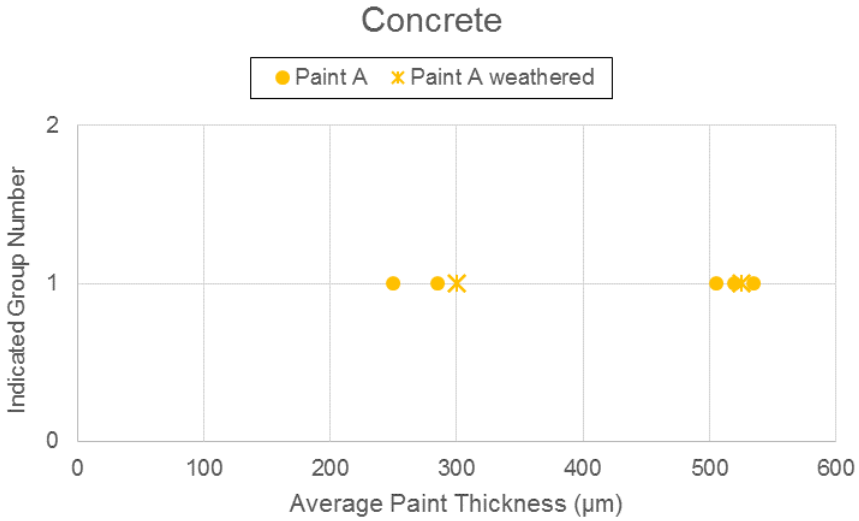


Figure 75 Indicated Group Number versus average paint thickness for each of the concrete specimens tested at 50 kW/m²

5.8.2 Plasterboard

The average specimen paint thickness for each plasterboard specimen versus time to ignition is shown in Figure 76, peak heat release rate is shown in Figure 77, total heat released is shown in Figure 78, total smoke produced is shown in Figure 79 and the analysed value for the indication of the Group Number is shown in Figure 80.

An indication of the spread of the average test results for each number of paint layers on plasterboard samples versus average time to ignition is shown in Figure 81, average peak heat release rate is shown in Figure 82, average total heat released is shown in Figure 83 and average total smoke produced is shown in Figure 84.

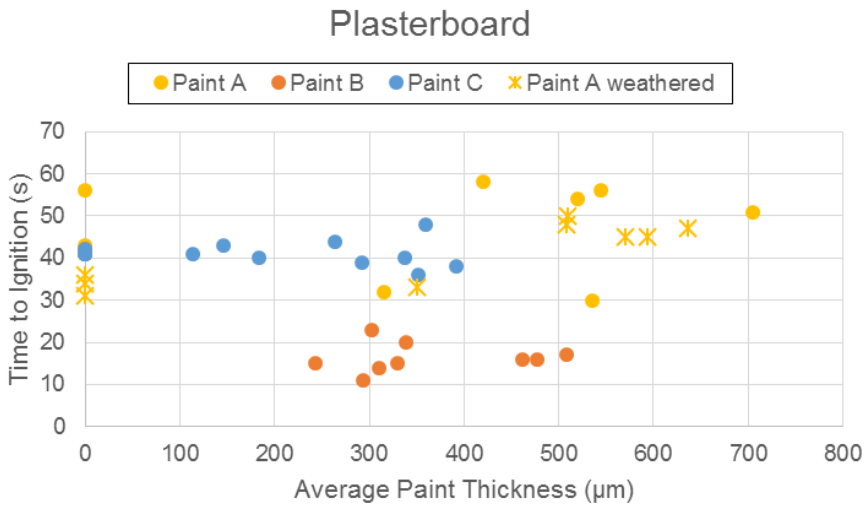


Figure 76 Time to ignition versus average paint thickness for each of the plasterboard specimens

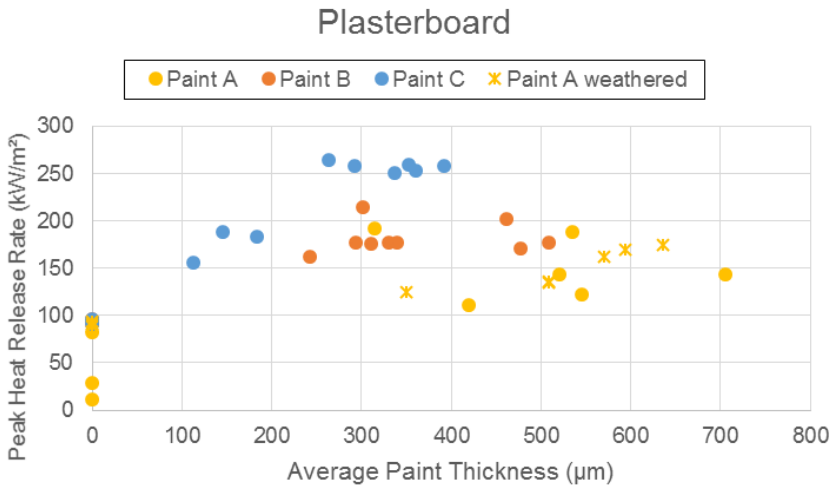


Figure 77 Peak heat release rate versus average paint thickness for each of the plasterboard specimens

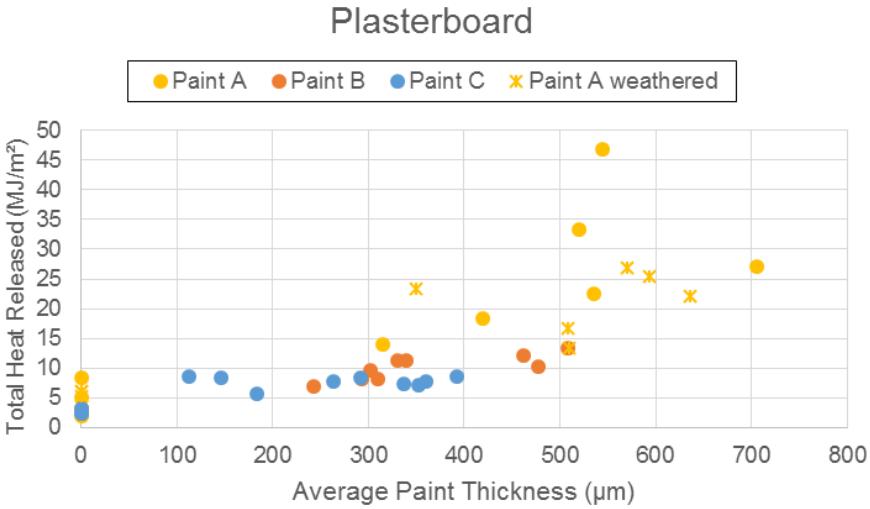


Figure 78 Total heat released versus average paint thickness for each of the plasterboard specimens

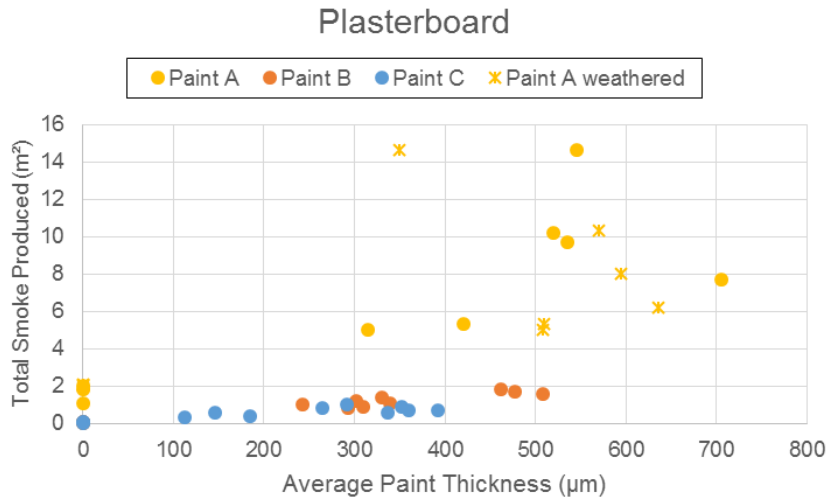


Figure 79 Total smoke produced versus average paint thickness for each of the plasterboard specimens

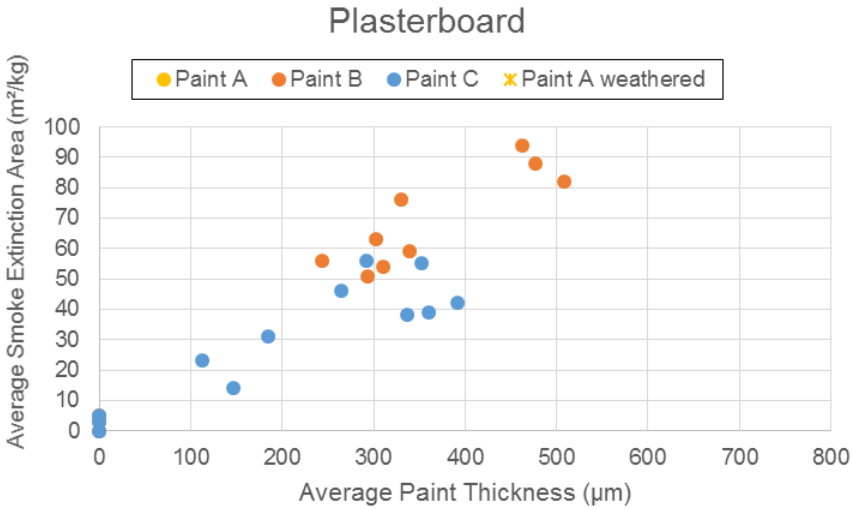


Figure 80 Average smoke extinction area versus average paint thickness for each of the plasterboard specimens

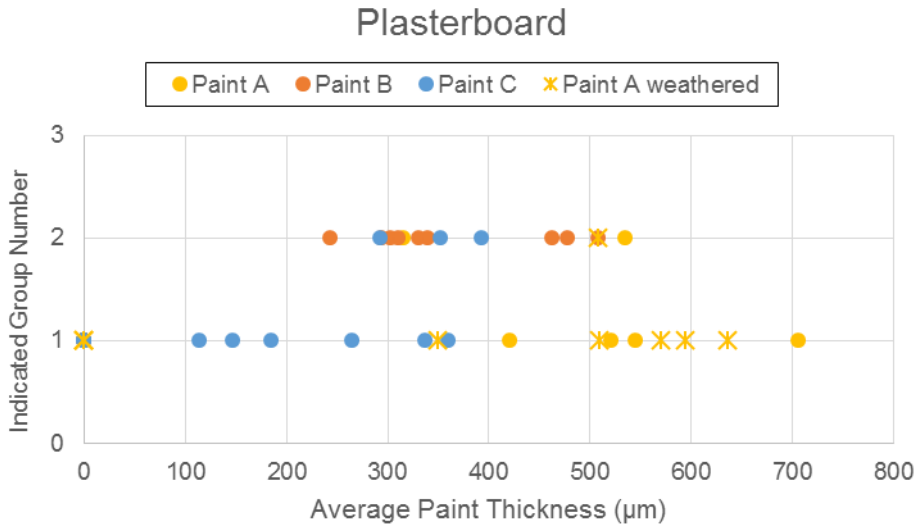


Figure 81 Indicated Group Number versus average paint thickness for each of the plasterboard specimens

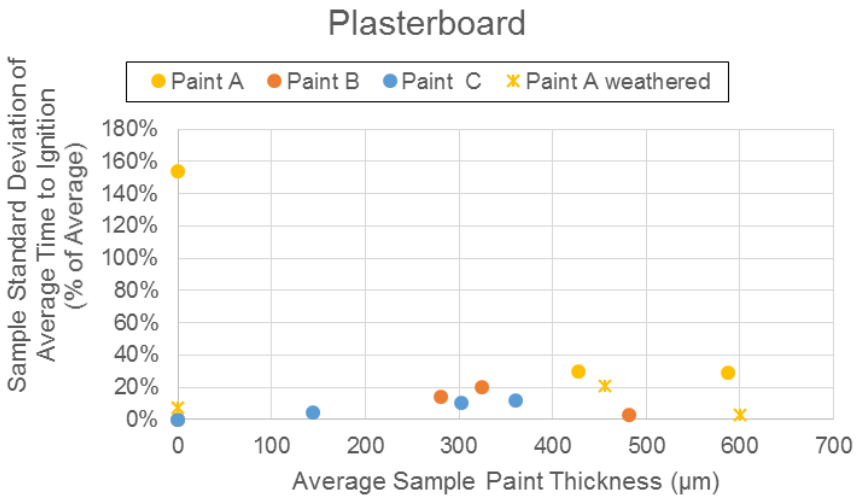


Figure 82 Sample standard deviation of the average time to ignition, as a percentage of the average value, versus average paint thickness for each of the plasterboard samples

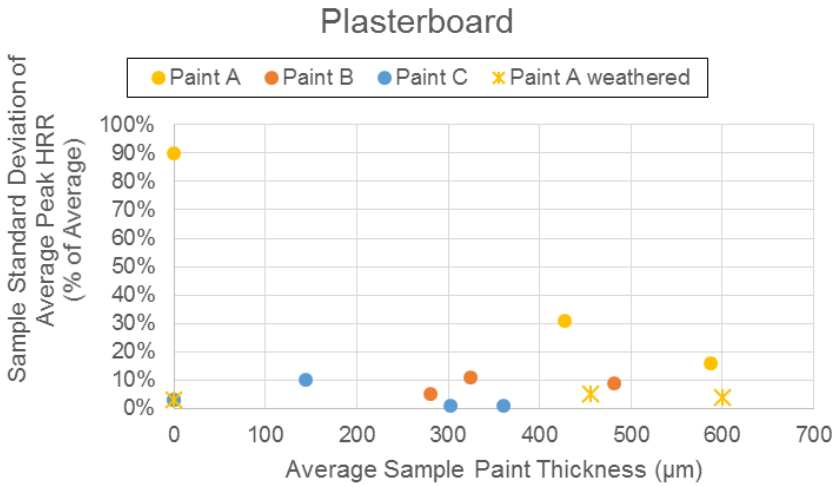


Figure 83 Sample standard deviation of the average peak heat release rate, as a percentage of the average value, versus average paint thickness for each of the plasterboard samples

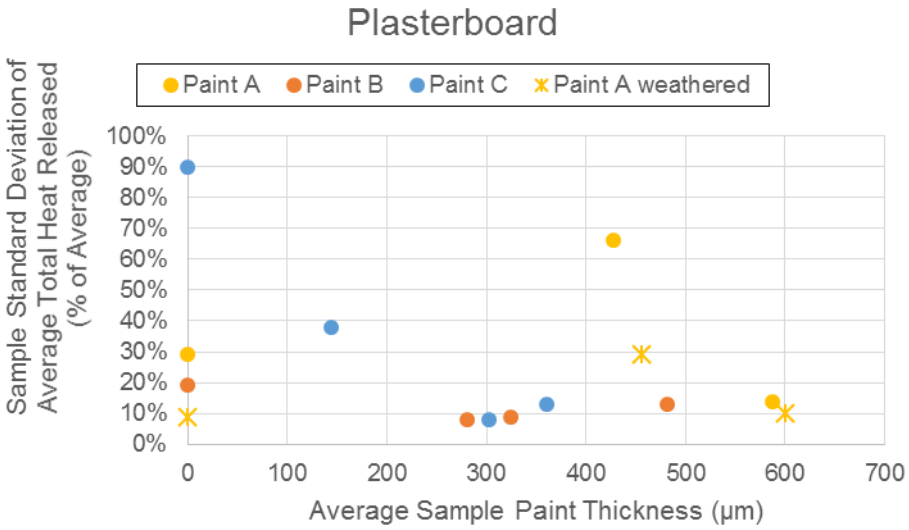


Figure 84 Sample standard deviation of the average total heat released, as a percentage of the average value, versus average paint thickness for each of the plasterboard samples

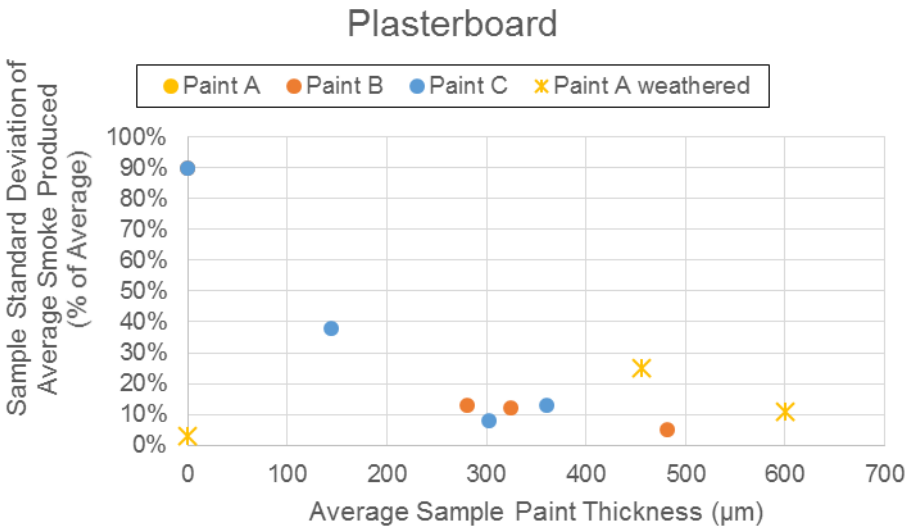


Figure 85 Sample standard deviation of the average smoke produced, as a percentage of the average value, versus average paint thickness for each of the plasterboard samples

5.8.3 Plywood

5.8.3.1 10 mm Thick Plywood

The average specimen paint thickness for each 10 mm thick plywood specimen versus time to ignition is shown in Figure 85, peak heat release rate is shown in Figure 86, total heat released is shown in Figure 87, total smoke produced is shown in Figure 88 and the analysed value for the indication of the Group Number is shown in Figure 89.

An indication of the spread of the average test results for each number of paint layers on 10 mm thick plywood samples versus average time to ignition is shown in Figure 90, average peak heat release rate is shown in Figure 91, average total heat released is shown in Figure 92 and average total smoke produced is shown in Figure 93.

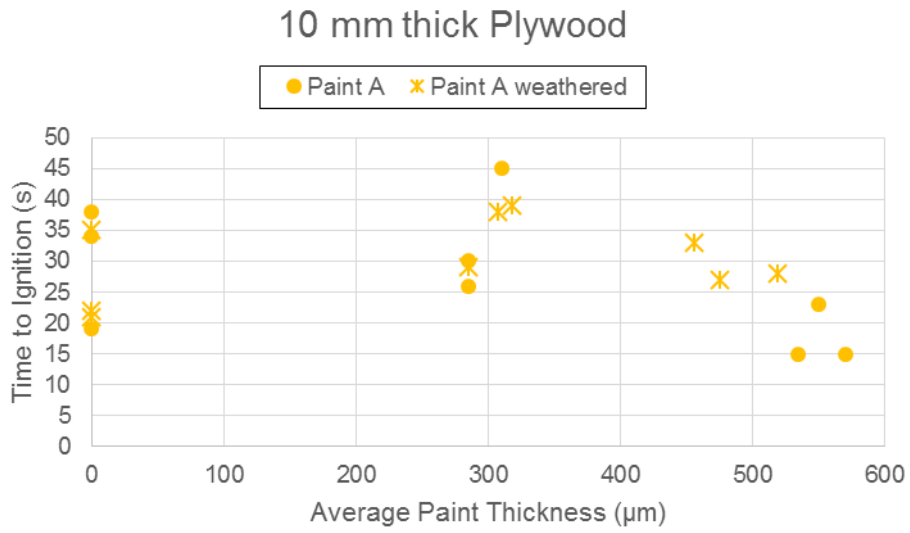


Figure 86 Time to ignition versus average paint thickness for each of the 10 mm thick plywood specimens

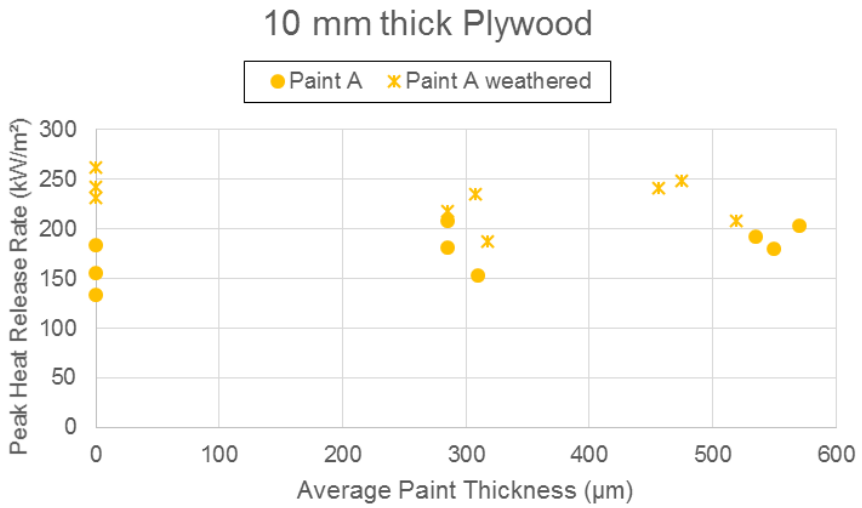


Figure 87 Peak heat release rate versus average paint thickness for each of the 10 mm thick plywood specimens

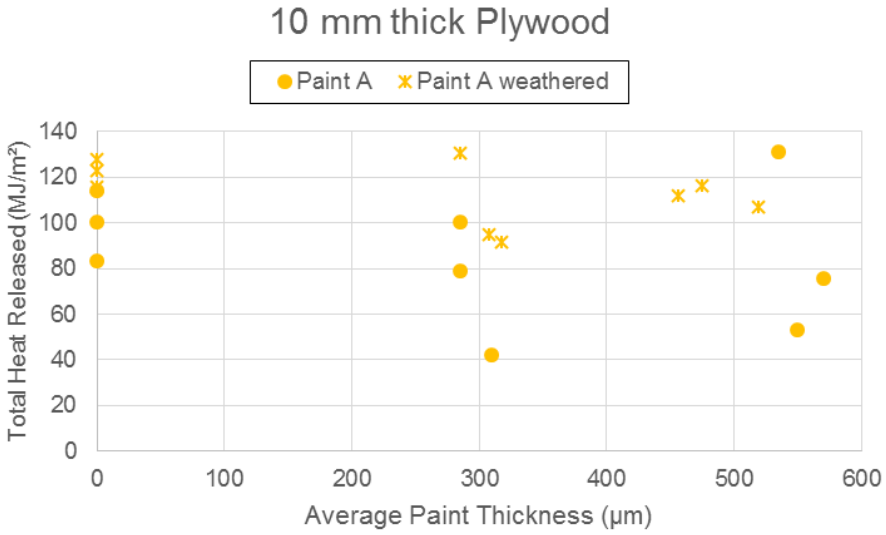


Figure 88 Total heat released versus average paint thickness for each of the 10 mm thick plywood specimens

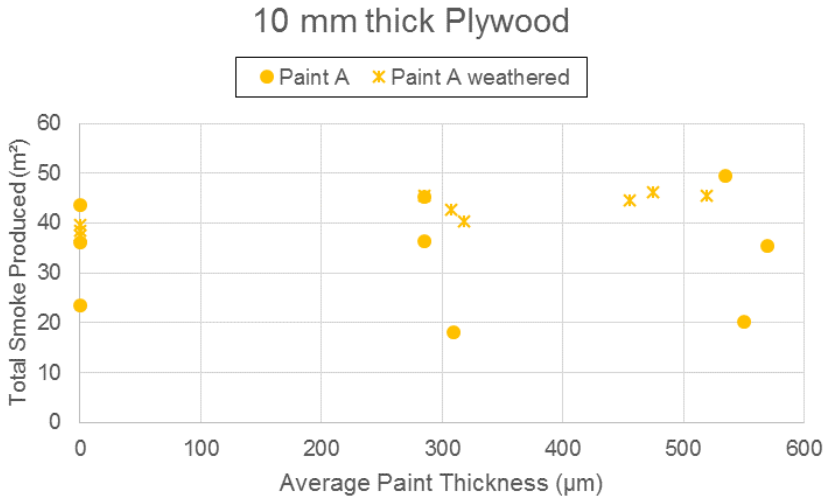


Figure 89 Total smoke produced versus average paint thickness for each of the 10 mm thick plywood specimens

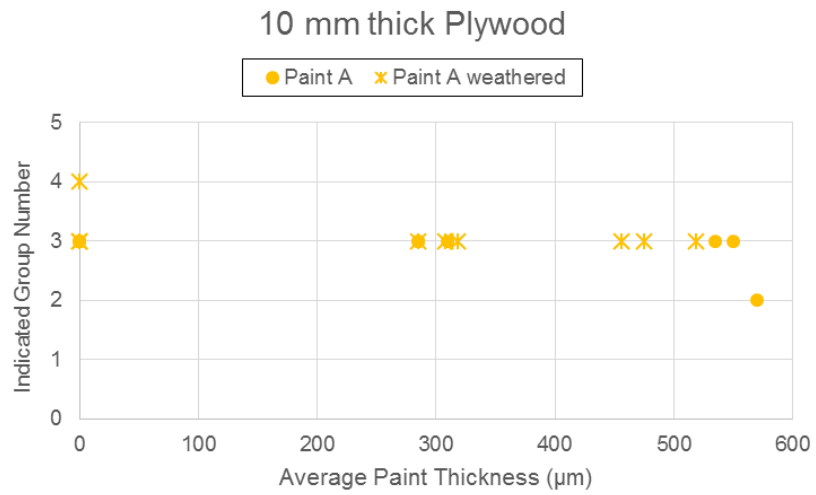


Figure 90 Indicated Group Number versus average paint thickness for each of the 10 mm thick plywood specimens

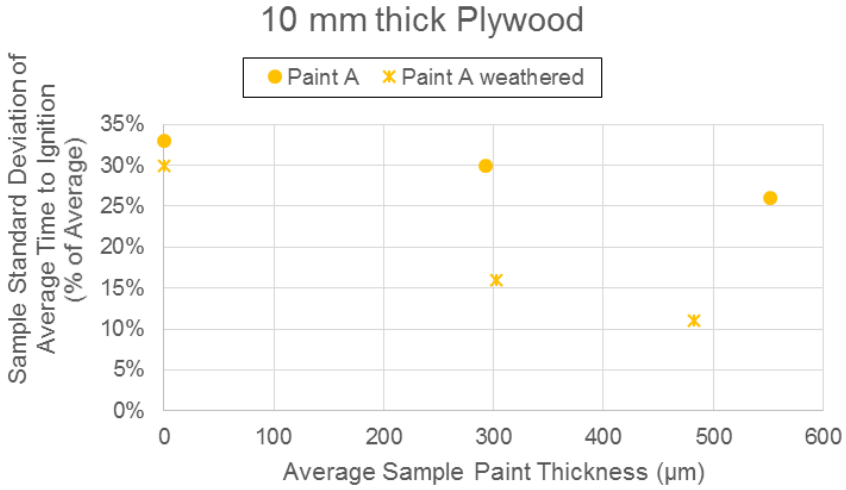


Figure 91 Sample standard deviation of the average time to ignition, as a percentage of the average value, versus average paint thickness for each of the 10 mm thick plywood samples

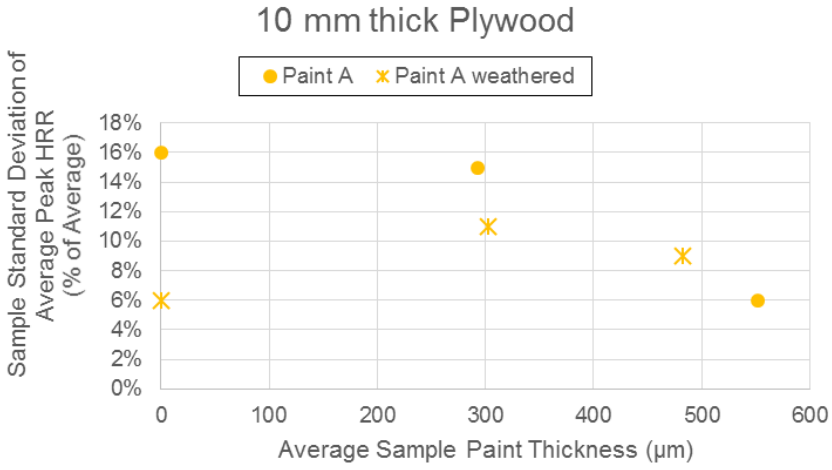


Figure 92 Sample standard deviation of the average peak heat release rate, as a percentage of the average value, versus average paint thickness for each of the 10 mm thick plywood samples

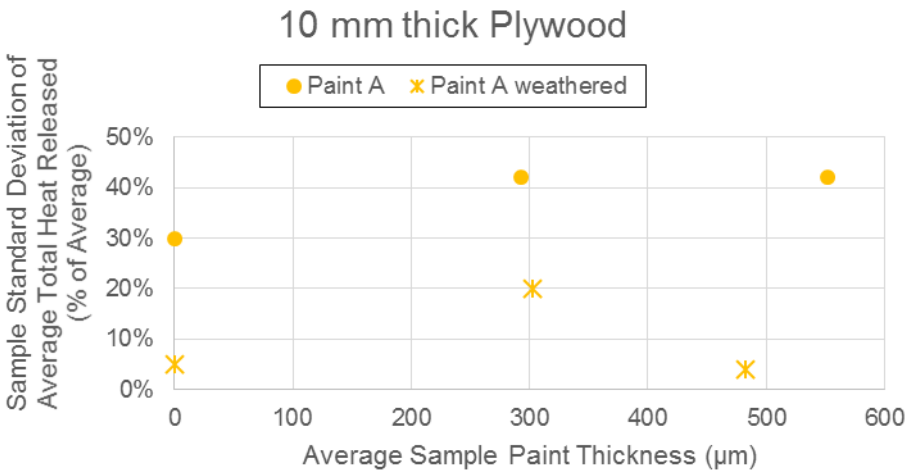


Figure 93 Sample standard deviation of the average smoke produced, as a percentage of the average value, versus average paint thickness for each of the 10 mm thick plywood samples

5.8.3.2 7 mm Thick Plywood

The average specimen paint thickness for each 7 mm thick plywood specimen versus time to ignition is shown in Figure 94, peak heat release rate is shown in Figure 95, total heat released is shown in Figure 96, total smoke produced is shown in Figure 97, the analysed value for the average smoke extinction area is shown in Figure 98 and an indication of the Group Number is shown in Figure 99.

An indication of the spread of the average test results for each number of paint layers on 7 mm thick plywood samples versus average time to ignition is shown in Figure 100, average peak heat release rate is shown in Figure 101, average total heat released is shown in Figure 102 and average total smoke produced is shown in Figure 103.

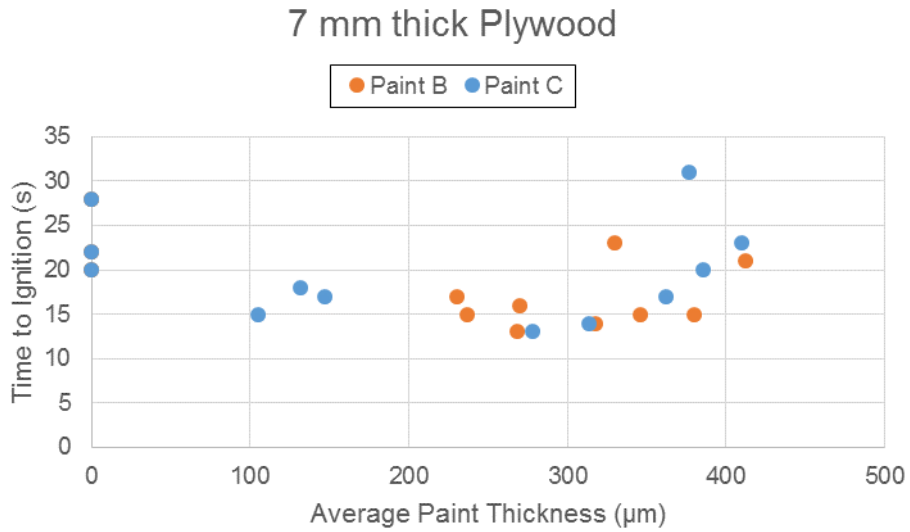


Figure 94 Time to ignition versus average paint thickness for each of the 7 mm thick plywood specimens

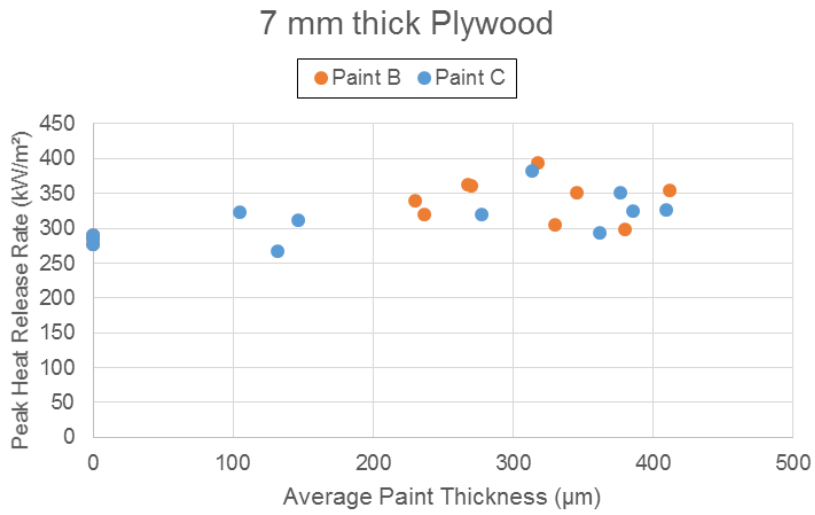


Figure 95 Peak heat release rate versus average paint thickness for each of the 7 mm thick plywood specimens

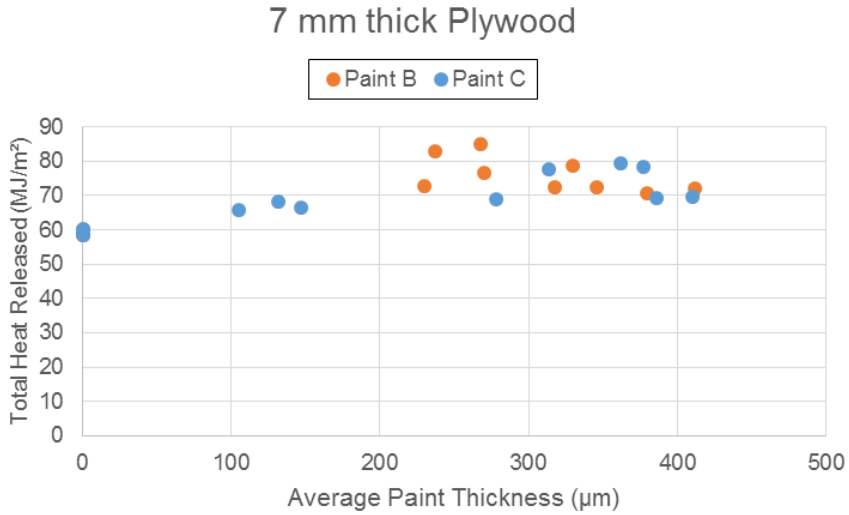


Figure 96 Total heat released versus average paint thickness for each of the 7 mm thick plywood specimens

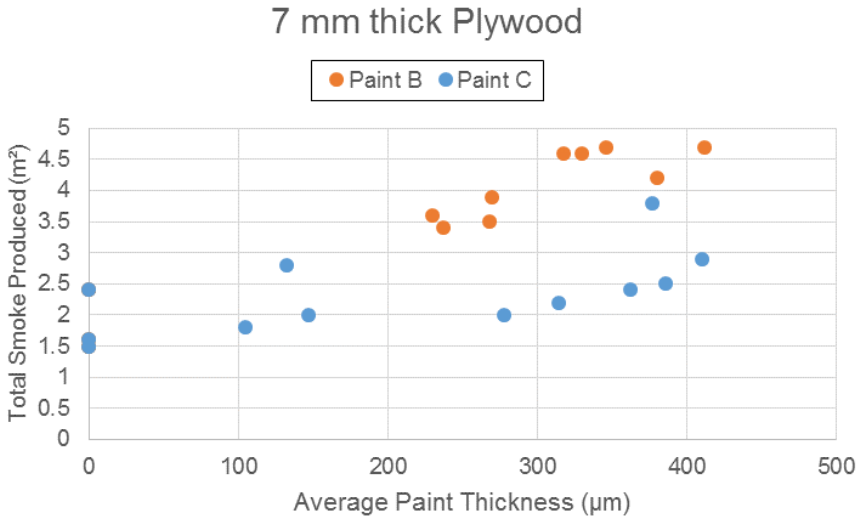


Figure 97 Total smoke produced versus average paint thickness for each of the 7 mm thick plywood specimens

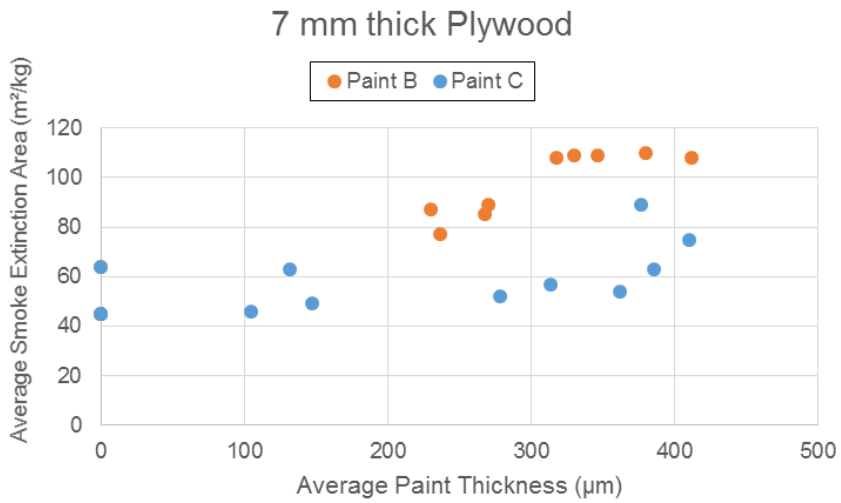


Figure 98 Average smoke extinction area versus average paint thickness for each of the 7 mm thick plywood specimens

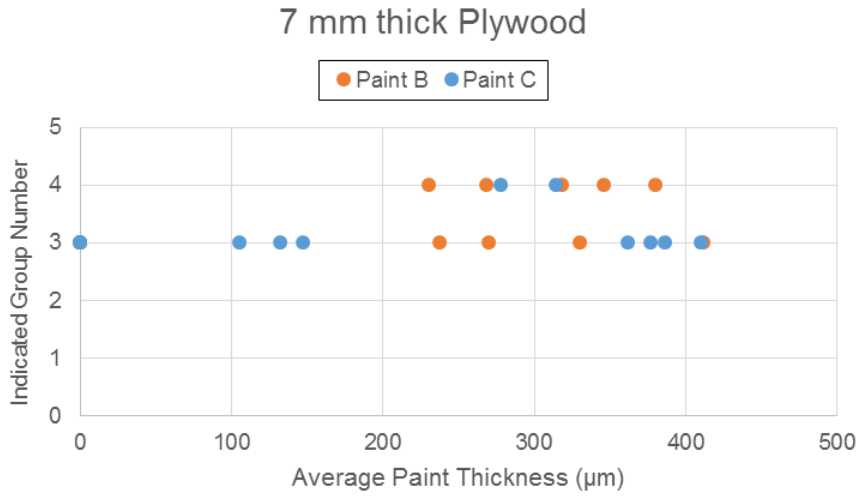


Figure 99 Indicated Group Number versus average paint thickness for each of the 7 mm thick plywood specimens

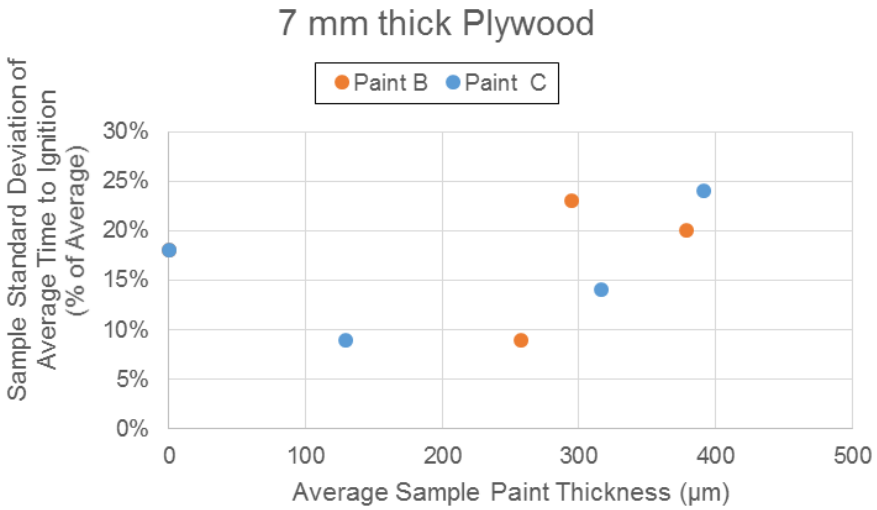


Figure 100 Sample standard deviation of the average time to ignition, as a percentage of the average value, versus average paint thickness for each of the 7 mm thick plywood samples

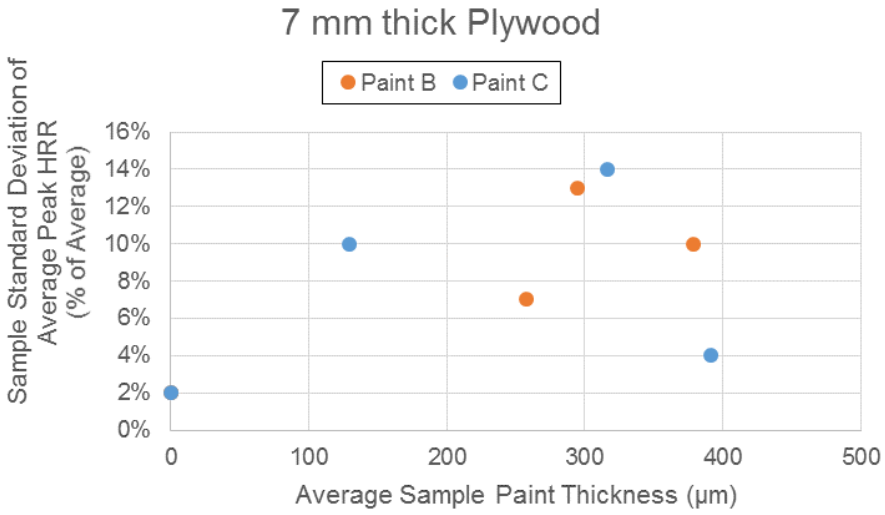


Figure 101 Sample standard deviation of the average peak heat release rate, as a percentage of the average value, versus average paint thickness for each of the 7 mm thick plywood samples

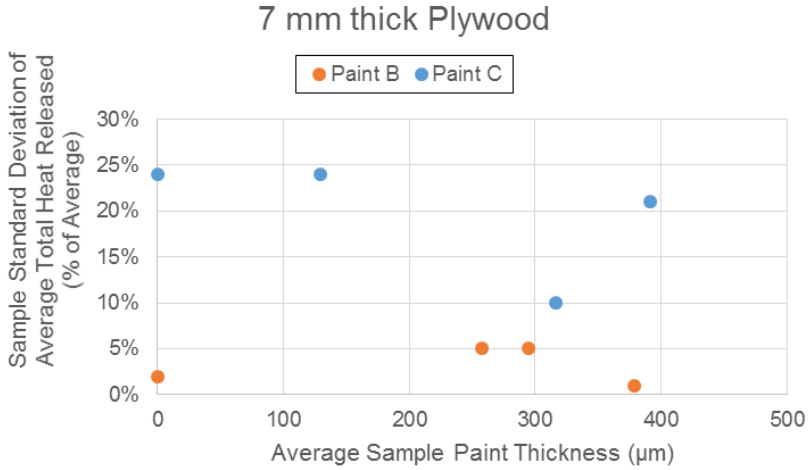


Figure 102 Sample standard deviation of the average total heat released, as a percentage of the average value, versus average paint thickness for each of the 7 mm thick plywood samples

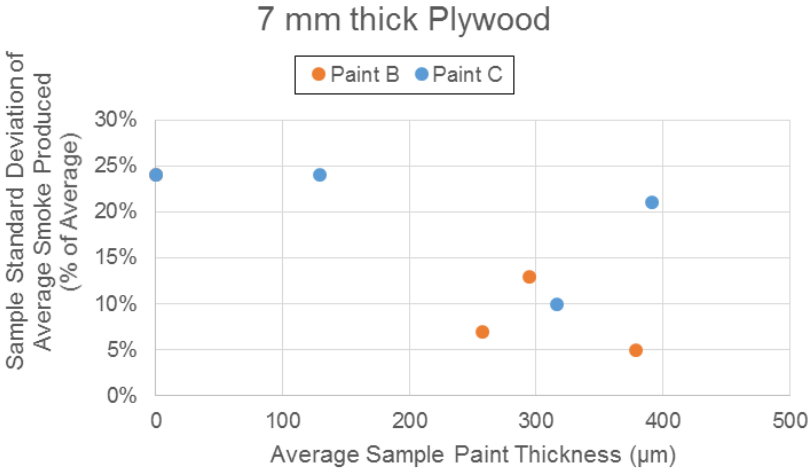


Figure 103 Sample standard deviation of the average smoke produced, as a percentage of the average value, versus average paint thickness for each of the 7 mm thick plywood samples

5.8.4 Medium Density Fibreboard

The average specimen paint thickness for each medium density fibreboard specimen versus time to ignition is shown in Figure 104, peak heat release rate is shown in Figure 105, total heat released is shown in Figure 106, total smoke produced is shown in Figure 107, the analysed value for the average smoke extinction area is shown in Figure 108 and an indication of the Group Number is shown in Figure 109.

An indication of the spread of the average test results for each number of paint layers on medium density fibreboard samples versus average time to ignition is shown in Figure 110, average peak heat release rate is shown in Figure 111, average total heat released is shown in Figure 112 and average total smoke produced is shown in Figure 113.

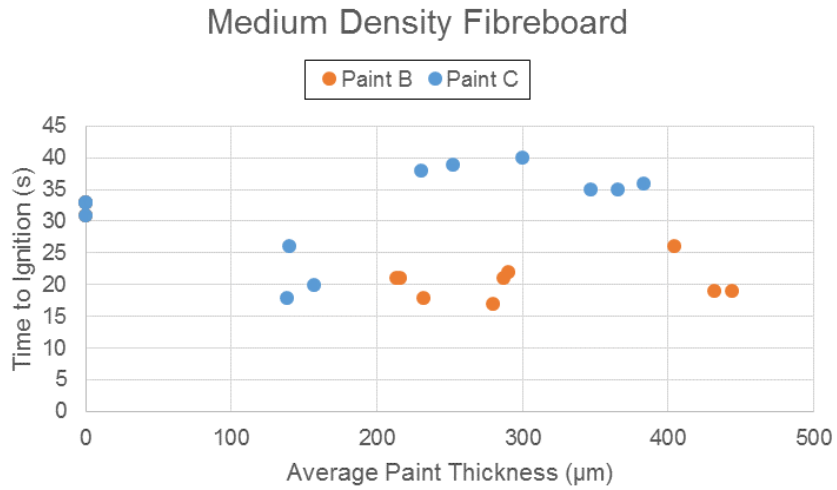


Figure 104 Time to ignition versus average paint thickness for each of the medium density fibreboard specimens

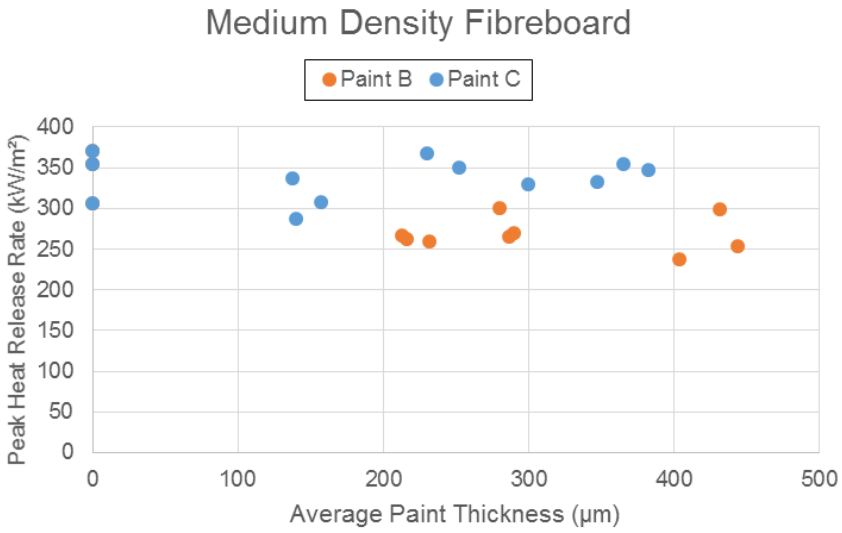


Figure 105 Peak heat release rate versus average paint thickness for each of the medium density fibreboard specimens

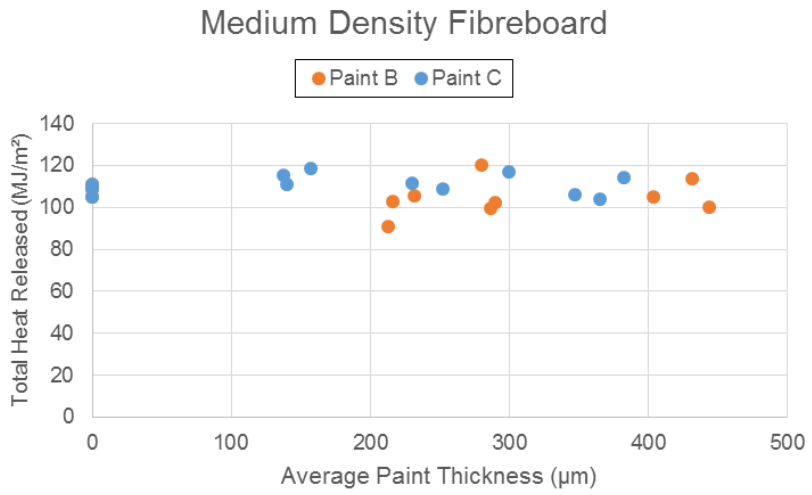


Figure 106 Total heat released versus average paint thickness for each of the medium density fibreboard specimens

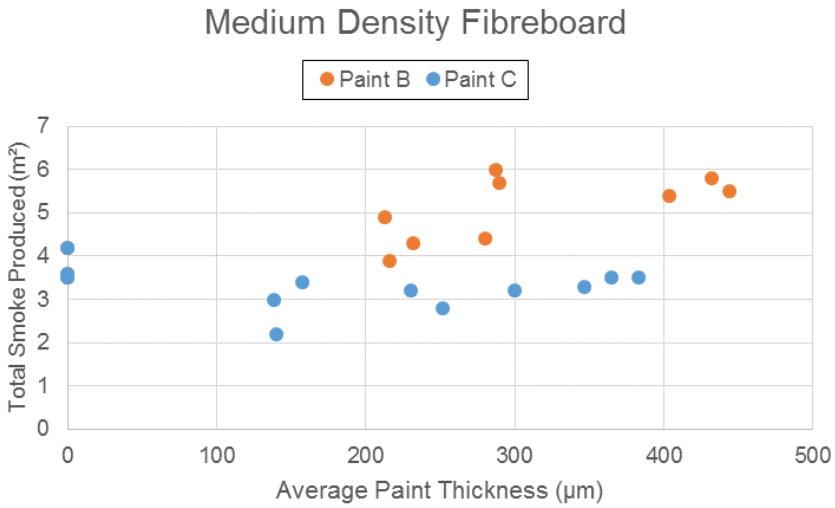


Figure 107 Total smoke produced versus average paint thickness for each of the medium density fibreboard specimens

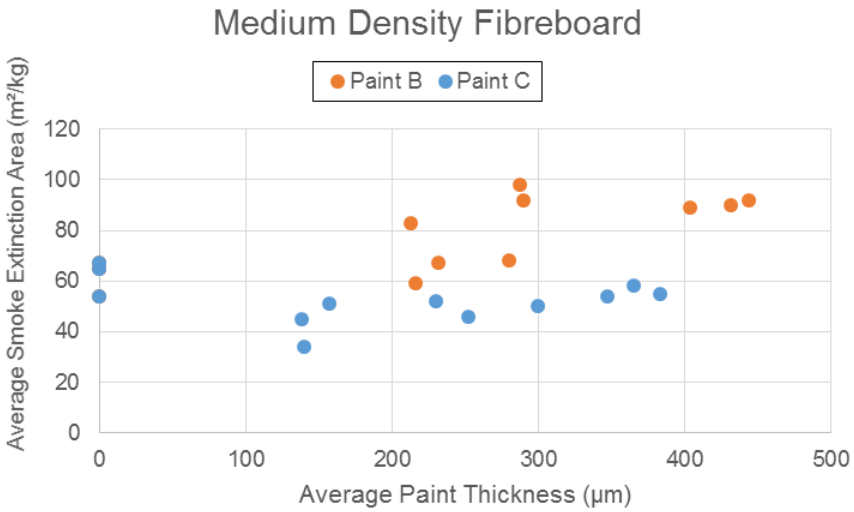


Figure 108 Average smoke extinction area versus average paint thickness for each of the medium density fibreboard specimens

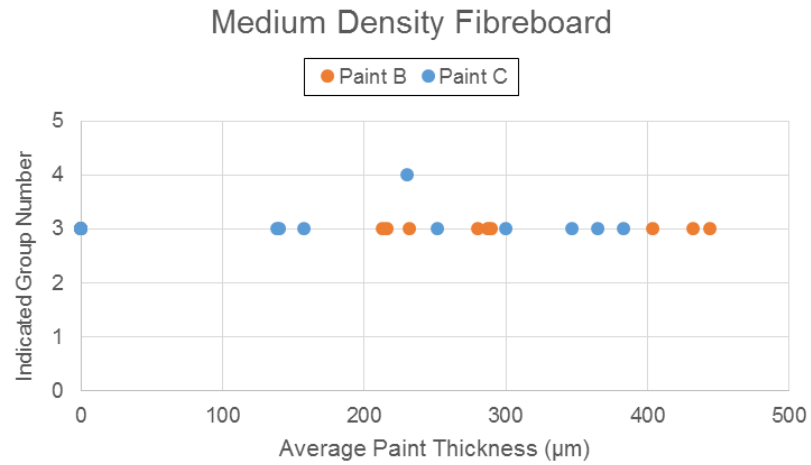


Figure 109 Indicated Group Number versus average paint thickness for each of the medium density fibreboard specimens

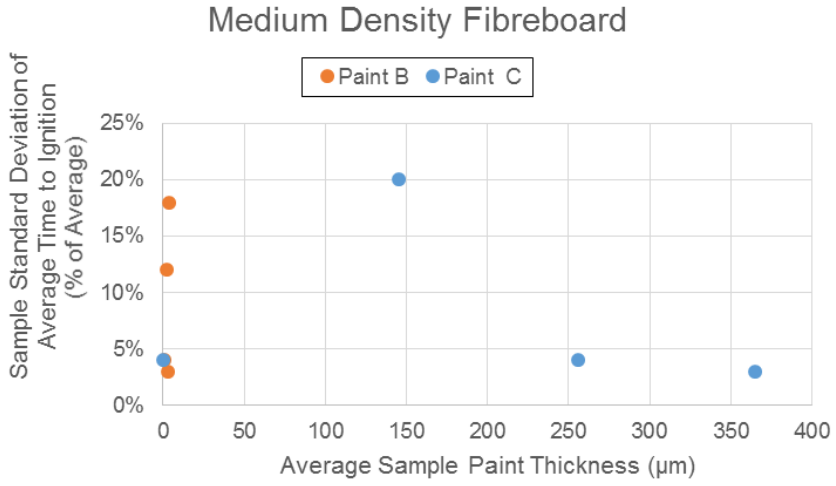


Figure 110 Sample standard deviation of the average time to ignition, as a percentage of the average value, versus average paint thickness for each of the medium density fibreboard samples

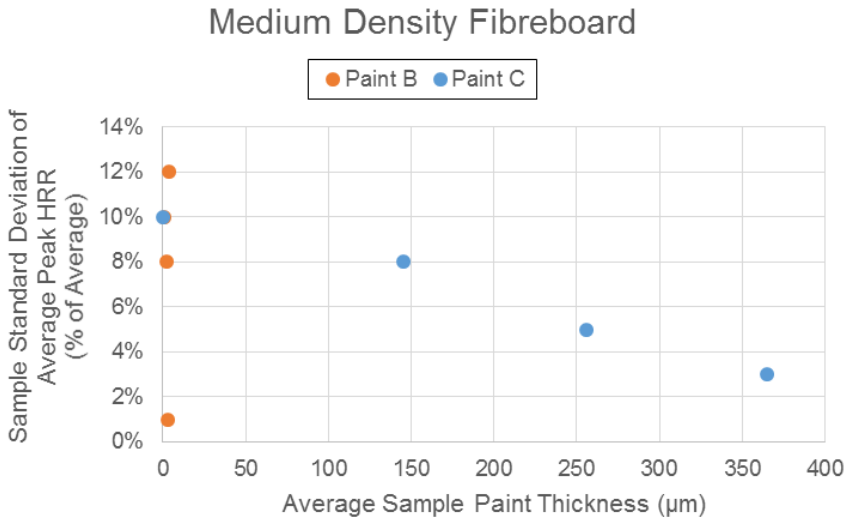


Figure 111 Sample standard deviation of the average peak heat release rate, as a percentage of the average value, versus average paint thickness for each of the medium density fibreboard samples

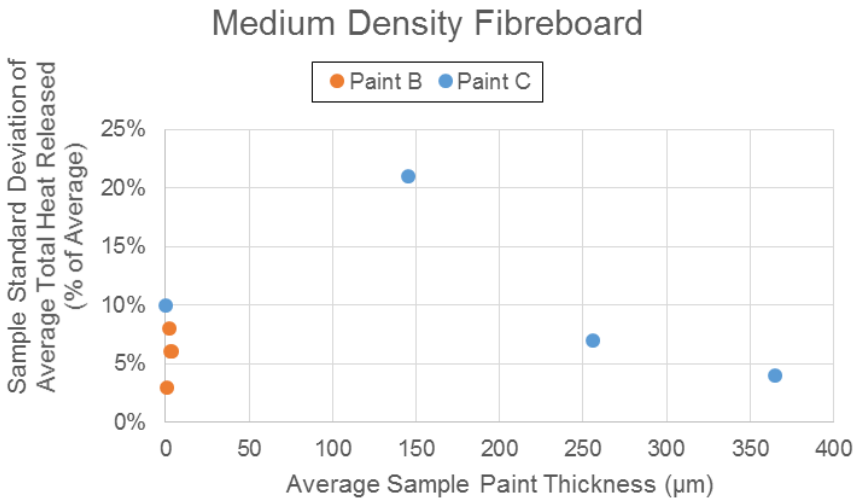


Figure 112 Sample standard deviation of the average total heat released, as a percentage of the average value, versus average paint thickness for each of the medium density fibreboard samples

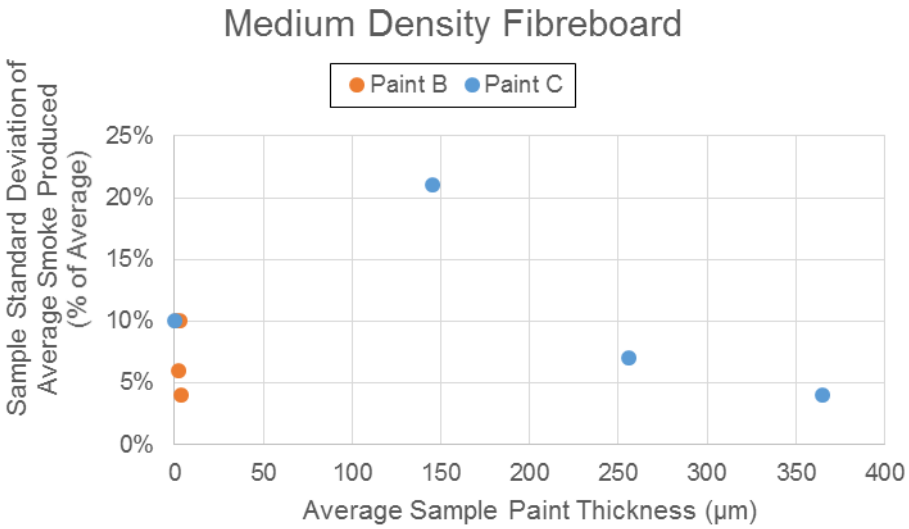


Figure 113 Sample standard deviation of the average smoke produced, as a percentage of the average value, versus average paint thickness for each of the medium density fibreboard samples

5.9 Effect of Paint Thickness on Reaction to Fire

Initially the reaction to fire measure of material Group Number is considered for each substrate.

A summary of the relative group number for all (i.e. uncoated and Paint A aged and pristine coated) concrete samples (with positive ignitions, tested at 50 kW/m²) is shown in Figure 114. Of the 12 samples tested, only the 16-layer specimens subjected to the simulated aging process ignited, with an average paint thickness of approximately 525 µm. It is noted that no positive ignition would be interpreted as an indicated material Group Number of 1. Therefore, considering this as well as the results for a ±20% uniform variation of the key test variable used in the calculation of the Group Number, all the

samples tested would have achieved an indicated Group Number of 1 with the ±20% variation of calculation input values.

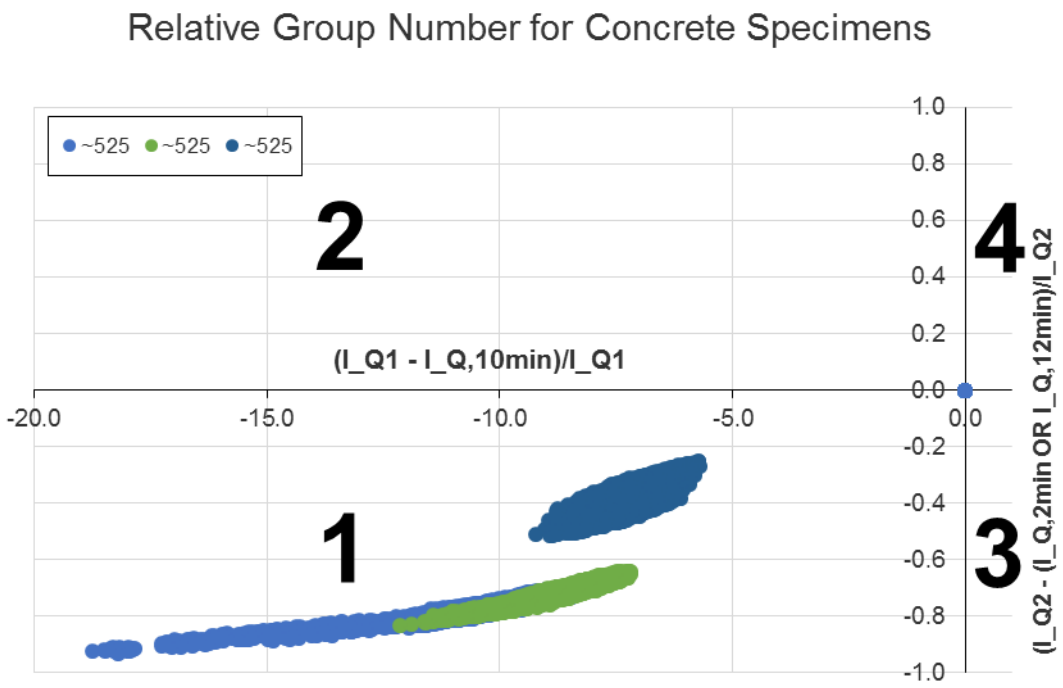
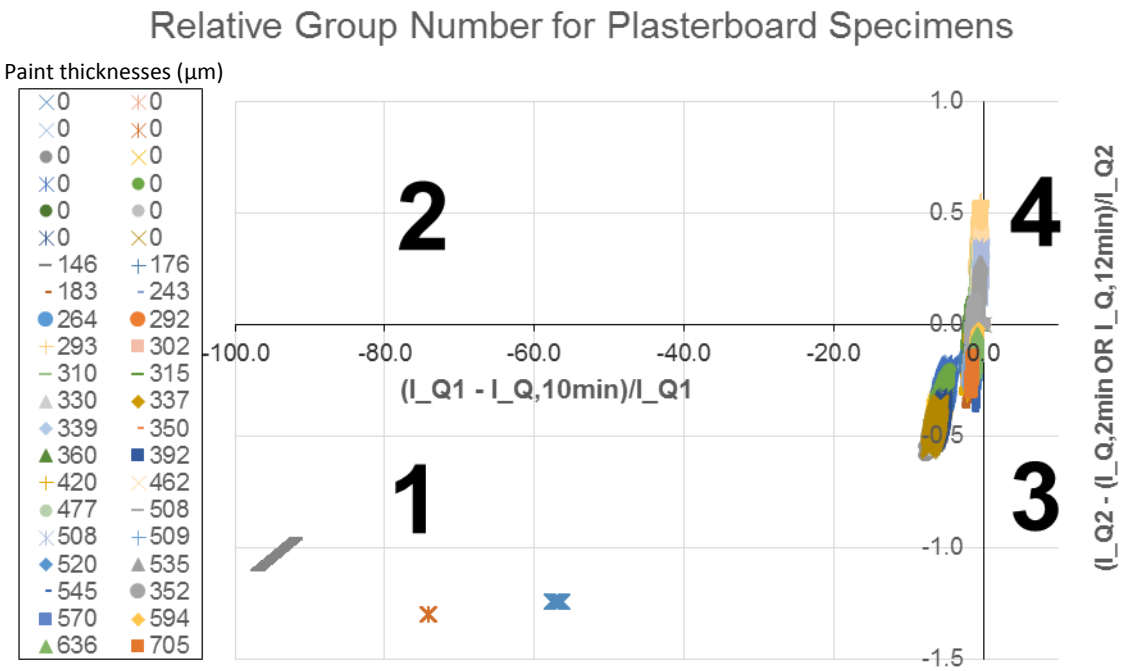


Figure 114 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for all the concrete substrate specimens tested with positive ignitions

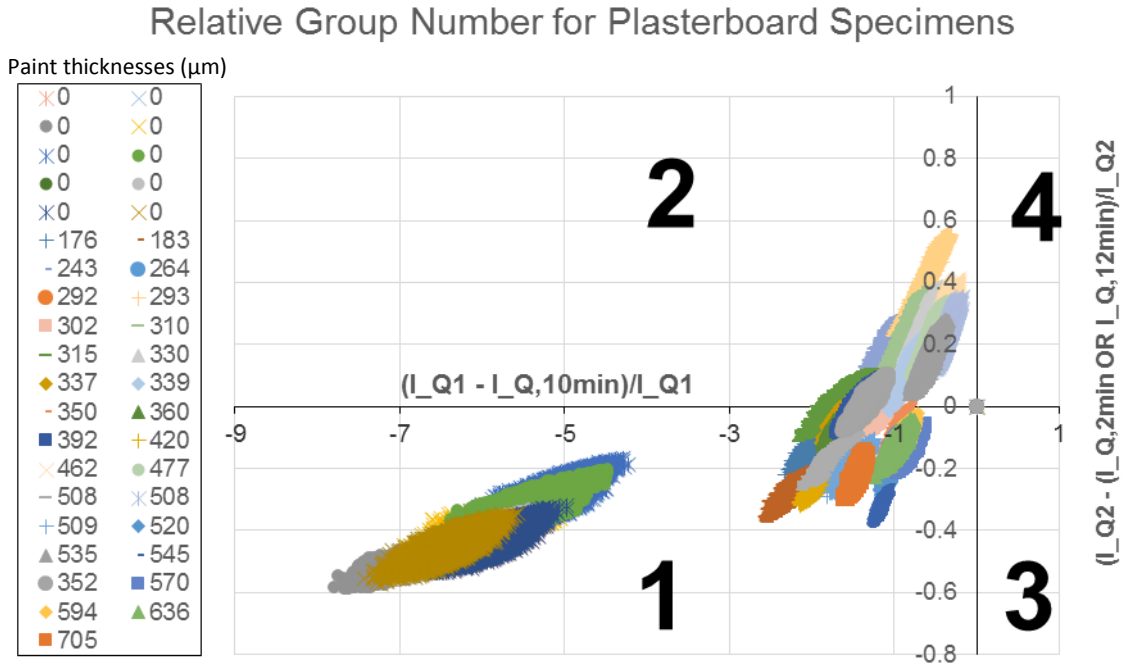
A summary of the relative group number for all (i.e. uncoated, Paint A aged and pristine, Paint B and Paint C coated) plasterboard samples is shown in Figure 115 (a). Removing the three outliers on the negative horizontal axis (that were associated with paint thickness of 0, 0 and 146 µm) provides a clearer visualisation of the data closer to the vertical axis (b). The results are an indicated material Group Number (including a ±20% uniform variation in the calculation input values) of 2 or better for all the plasterboard samples tested.

Considering the variation of the indicated Group Number with paint thickness, as shown in Figure 80, there is a trend for an increase of Group Number with increasing paint thickness followed by a decrease in indicated Group Number with increasing paint thickness. Where the threshold for an indicated Group Number of 2 is associated with approximate paint thicknesses of 250 to 550 µm. For paint thickness of less than 250 µm and greater than 550 µm an indicated Group Number of 1 was achieved. The plasterboard specimen have the greatest number of comparable results; however, this trend was also observed for the 7 mm thick plywood specimens (Figure 99), with the transitional paint thicknesses in the range of approximately 200 to 400 µm.

Similarly, considering only paint thicknesses less than 400 µm, the indicated material Group Numbers, including a ±20% uniform variation in the calculation input values, are also 2 or better for all the plasterboard samples tested, as shown in Figure 115 (a). Furthermore, considering only water-borne paint coatings and including a ±20% uniform variation in the calculation input values, the indicated material Group Numbers are also 2 or better for all the plasterboard samples tested, as shown in Figure 115 (b). Only three specimens have water-borne paint thicknesses less than 200 µm, and these all have indicated material Group Numbers of 1 (as presented in Sections 4.2 and 5.4).

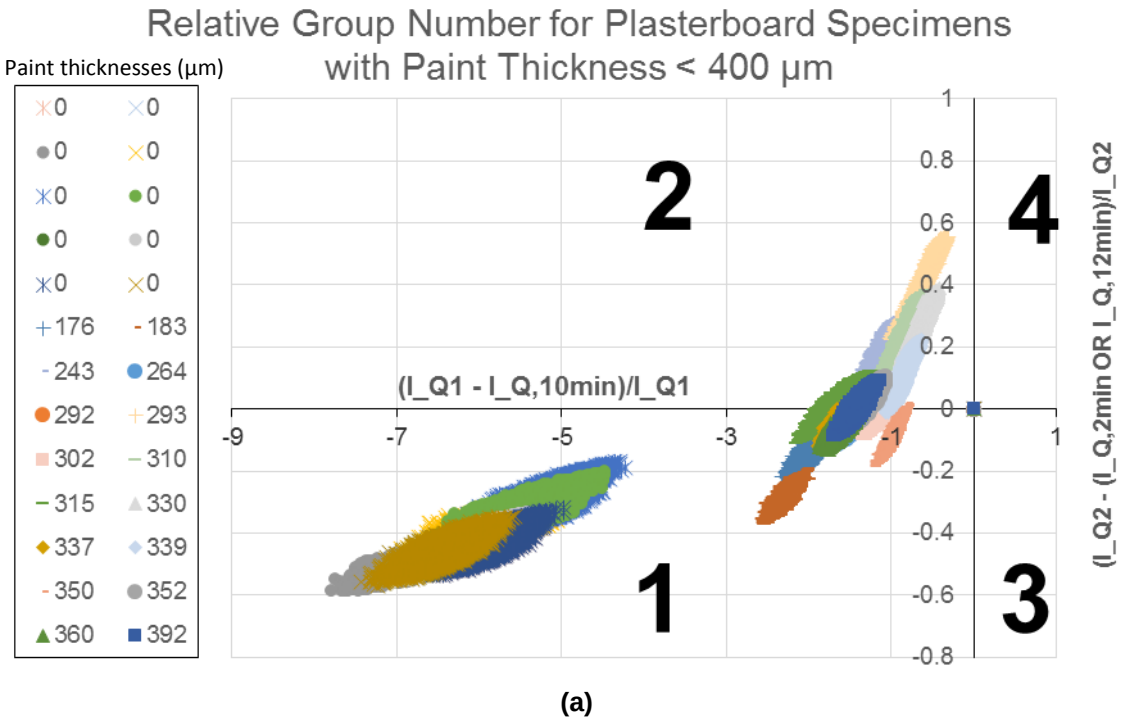


(a)

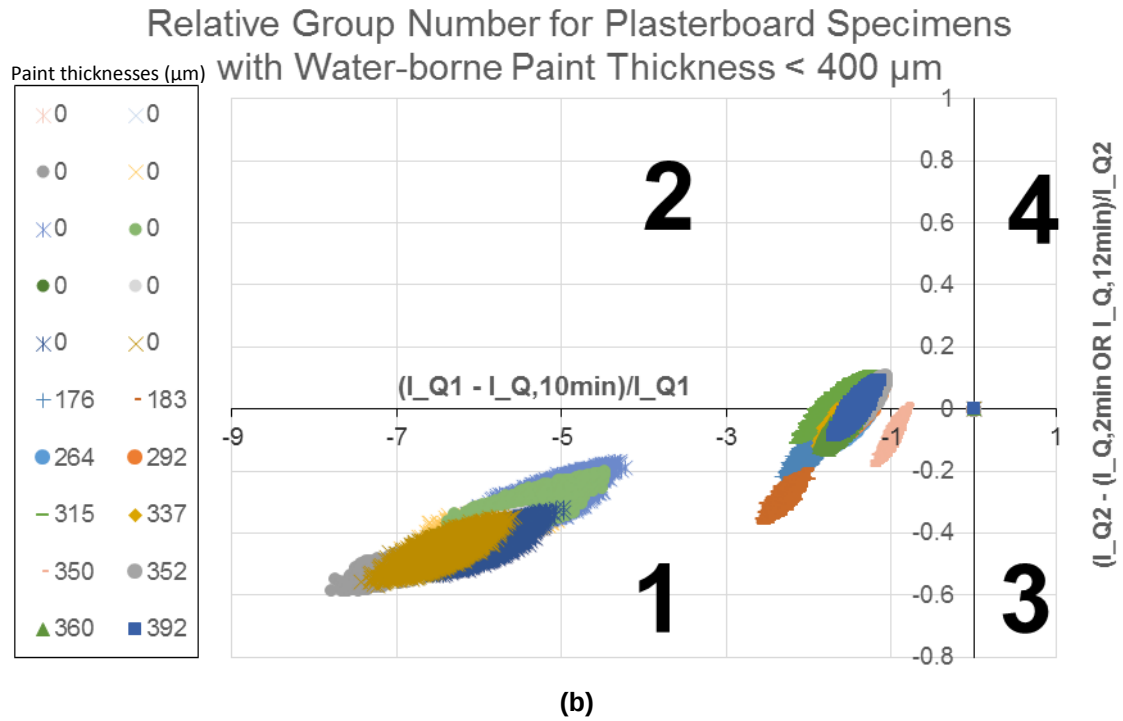


(b)

Figure 115 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for (a) all the plasterboard substrate specimens tested, (b) after removing the three outliers (three maximum values for the negative horizontal axis, with paint thickness of 0, 0 and 146µm), (c)



(a)

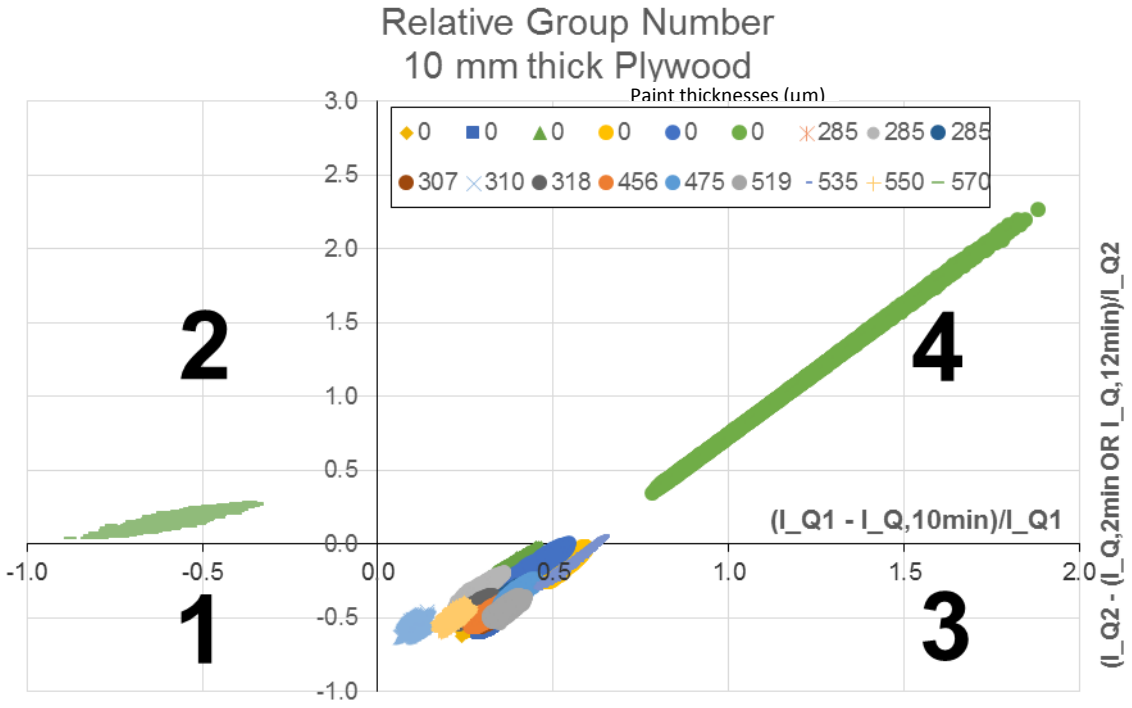


(b)

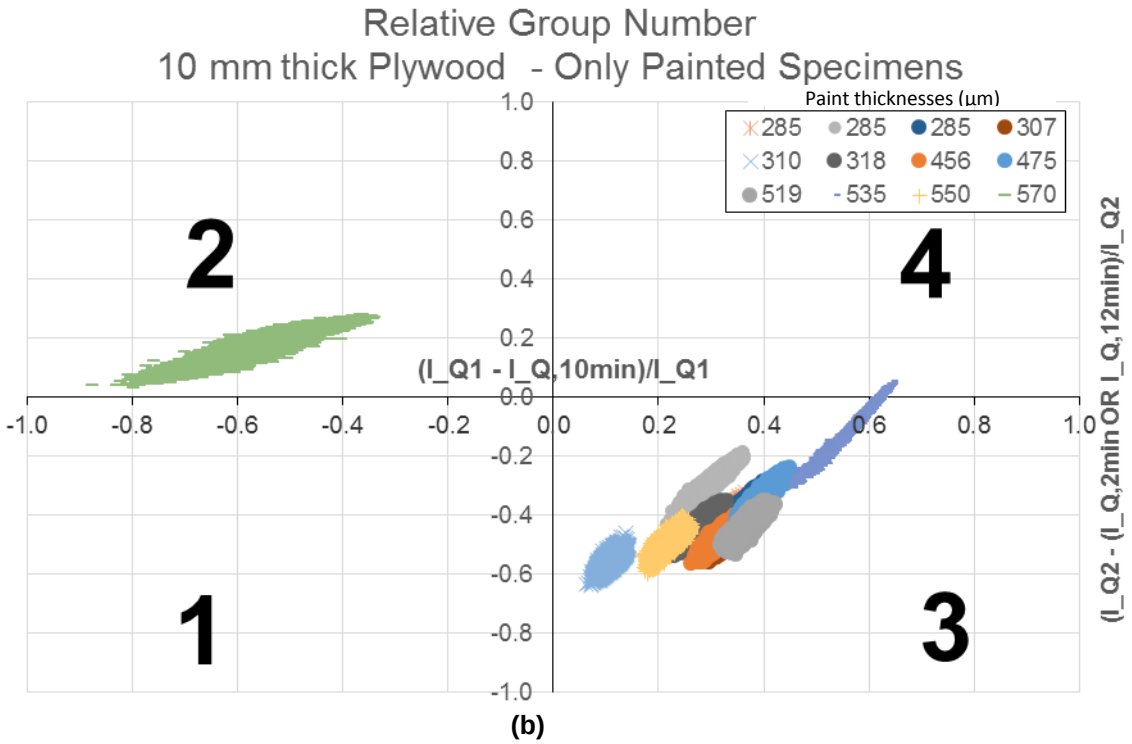
Figure 116 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for the plasterboard substrate specimens tested with (a) all paint thicknesses greater than 400 µm (excluding the 3 outliers on the negative x-axis), and (b) all water-borne paint thicknesses greater than 400 µm (excluding the 3 outliers on the negative x-axis)

A summary of the relative group number for all (i.e. uncoated, and Paint A aged and pristine coated) 10 mm thick plywood samples is shown in Figure 117 (a). Removing the uncoated specimens provides a clear indication that the paint coatings improved the reaction to fire performance in terms of the indicated Group Number, as shown by the

visual comparison of Figure 117 (a), (b) and also in the test variable results presented in Sections **Error! Reference source not found.** and **Error! Reference source not found.**. The indicated Group Numbers (including a ±20% uniform variation in the calculation input values) for 10 mm thick plywood coated with paint of less than 400 µm is 3 or better, as shown in Figure 118.



(a)



(b)

Figure 117 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for the 10 mm thick plywood substrate specimens tested for (a) all specimens tested, and (b) only paint-coated specimens tested (i.e. uncoated specimen results removed).

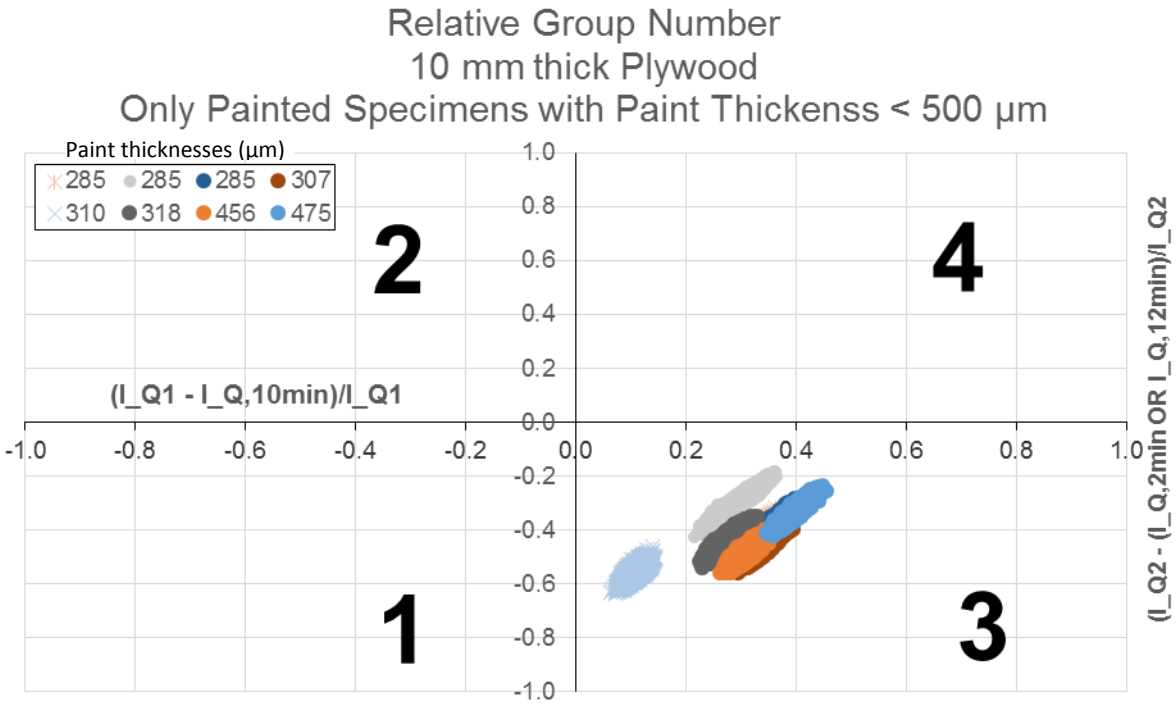
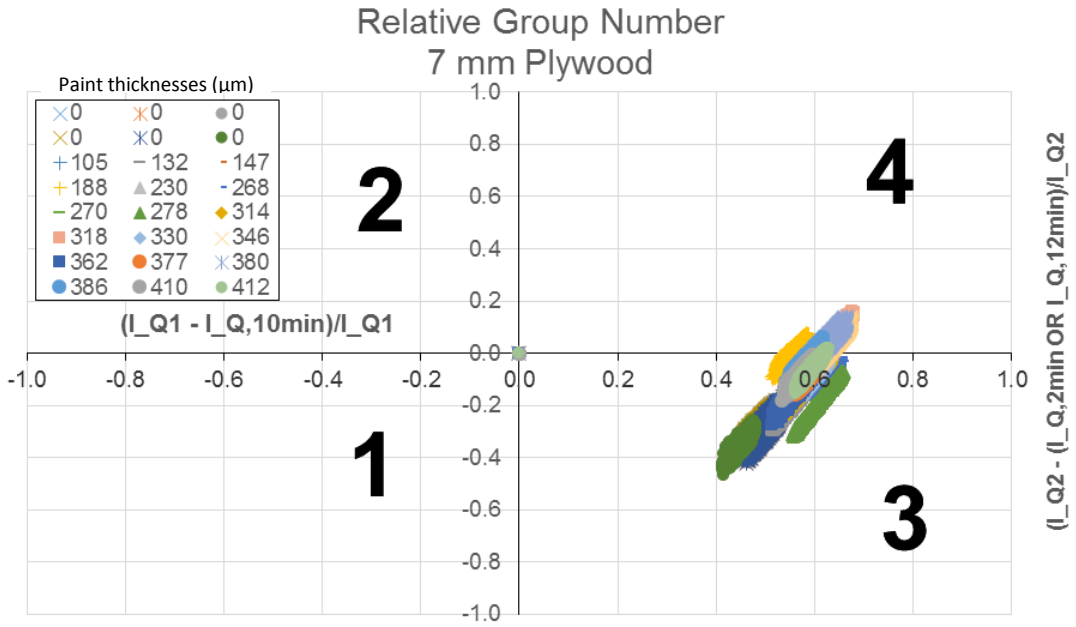
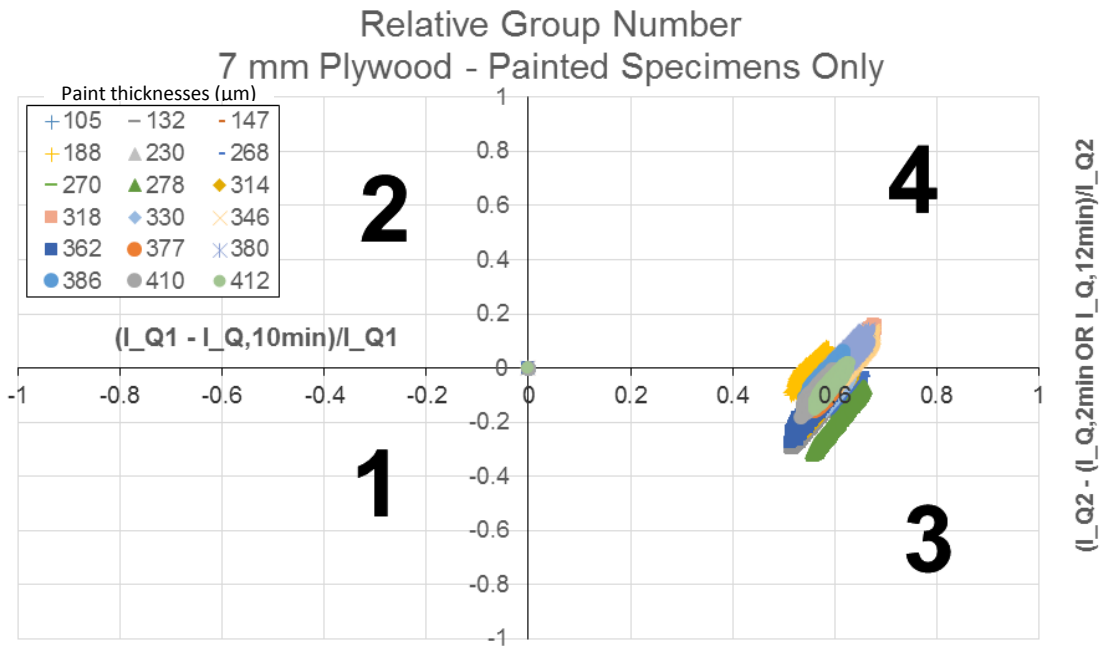


Figure 118 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for painted specimens with paint thicknesses less than 500 µm on the 10 mm thick plywood substrate specimens

A summary of the relative group number for all (i.e. uncoated, and Paint B and C coated) 7 mm thick plywood samples is shown in Figure 119 (a). Removing the uncoated specimens provides a clear indication that the paint coatings worsened the reaction to fire performance in terms of the indicated Group Number, as shown by the visual comparison of Figure 119 (a), (b) and also in the test variable results presented in Sections 4.3.2 and 5.5.2. The indicated Group Numbers (including a ±20% uniform variation in the calculation input values) for uncoated 7 mm thick plywood coated are 3, and with a paint coating is 4 or better.



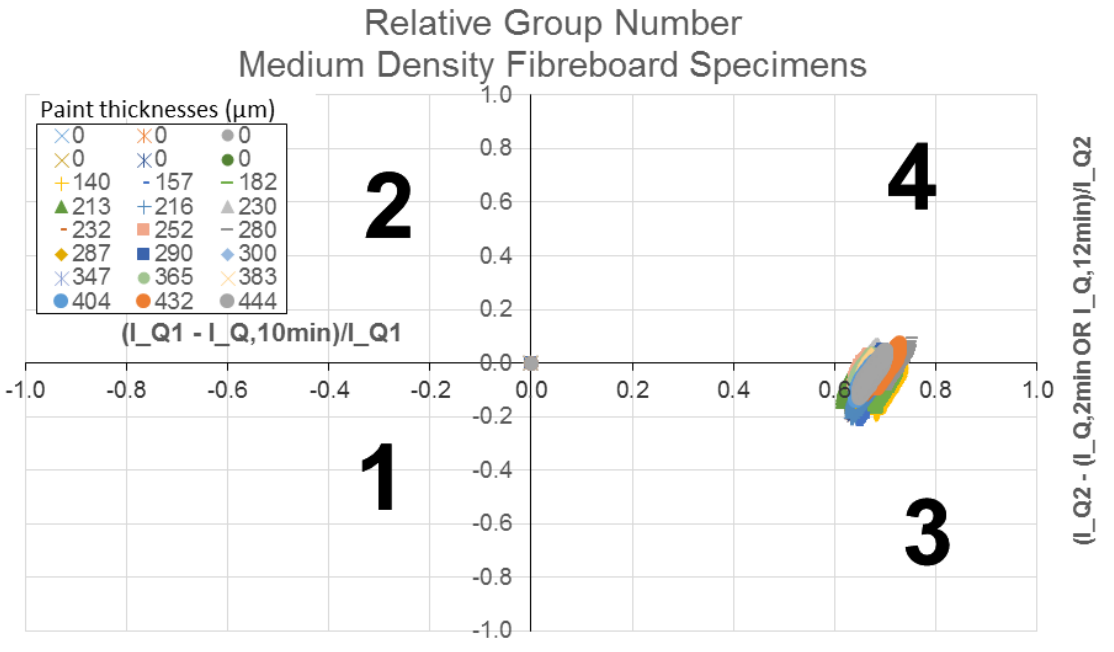
(a)



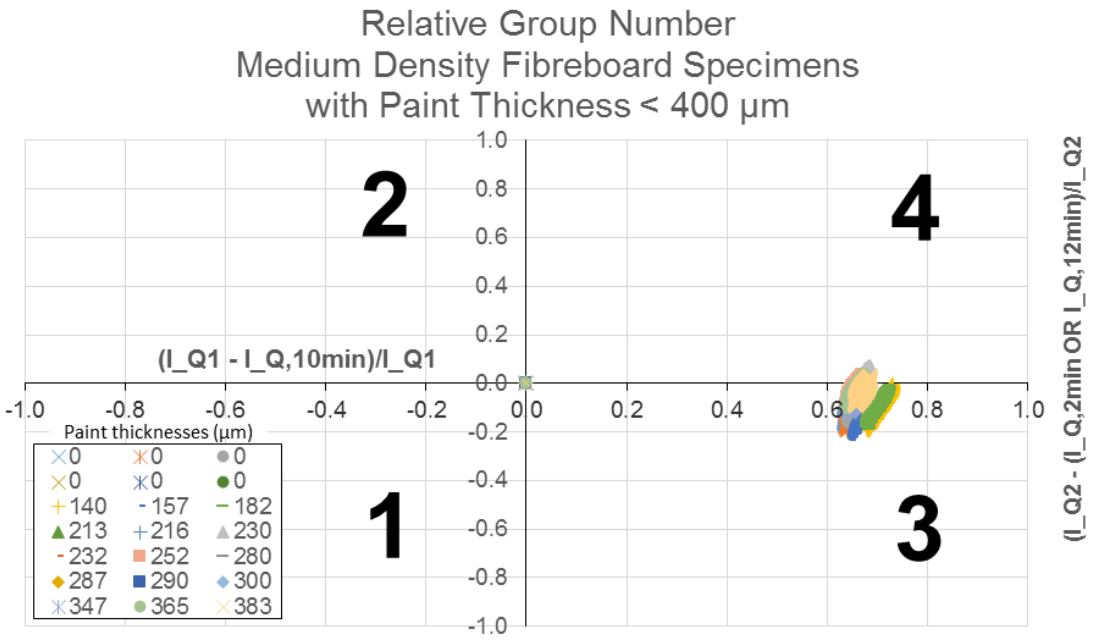
(b)

Figure 119 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for the 7 mm thick plywood substrate specimens tested for (a) all specimens tested, and (b) only paint-coated specimens tested (i.e. uncoated specimen results removed).

A summary of the relative group number for all (i.e. uncoated, and Paint B and C coated) medium density fibreboard specimens is shown in Figure 120 (a). Considering specimens with paint coatings of thickness less than 400 µm shows very little variation in the indicated Group Number, as shown by the visual comparison of Figure 120 (a), (b) and also in the test variable results presented in Sections 4.4 and 5.6. The indicated Group Numbers (including a ±20% uniform variation in the calculation input values) for the medium density fibreboard specimens is on the border between 3 and 4.



(a)



(b)

Figure 120 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for various paint thicknesses for the 7 mm thick plywood substrate specimens tested for (a) all specimens tested, and (b) only paint-coated specimens tested (i.e. uncoated specimen results removed).

5.9.1 Impact of Simulated Aging

Only some of Paint A-coated specimens were subjected to the simulated aging process. The substrates coated with Paint A are concrete, plasterboard and 10 mm thick plywood.

Considering the difference in test results between pristine specimens and ones subjected to the simulated aging process:

- Concrete substrate specimens showed little variation for the test variables for the eight layers of paint (as presented in Section 5.8.1). However, a measurable worsening of test variables is evident for the aged 16-layer specimens compared to similar paint coat thickness for the pristine specimens.
- Plasterboard substrate specimens showed insignificant variations between test results associated with pristine specimens and those subjected to the simulated aging process for the paint type and thicknesses considered (as presented in Section 5.8.2).
- 10 mm thick plywood substrate specimens, similarly to the plasterboard specimen results, showed insignificant variations between test results associated with pristine specimens and those subjected to the simulated aging process for the paint type and thicknesses tested (as presented in Section 5.8.3.1).

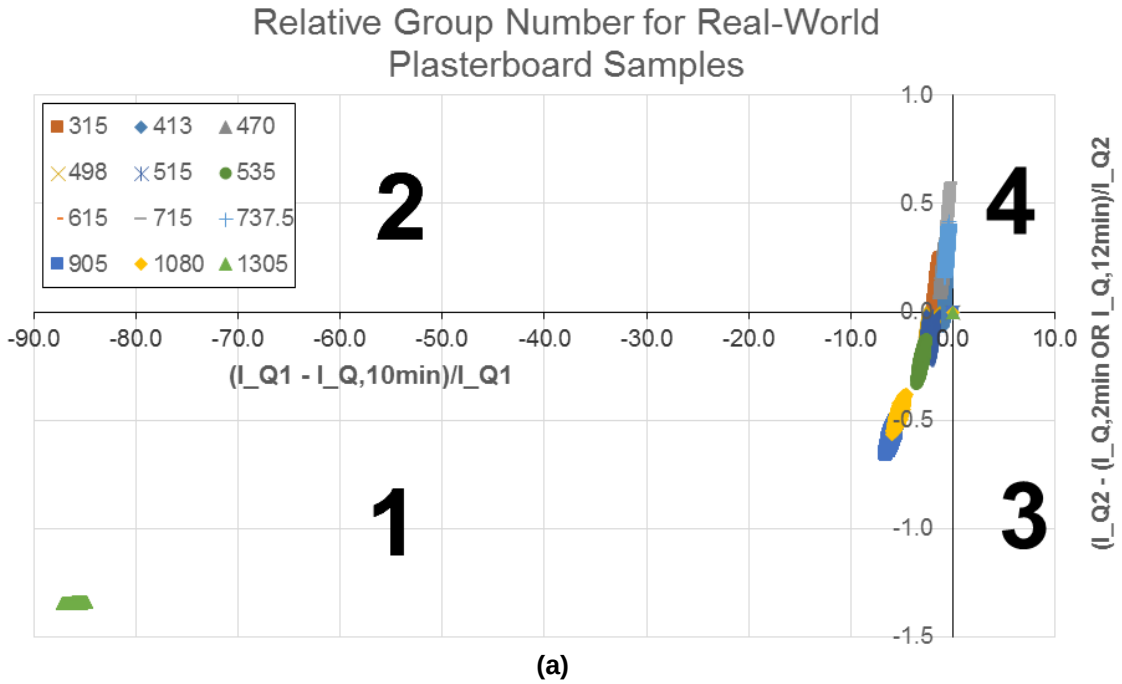
5.9.2 Consideration of Real-World Sample Results

The representation of real multi-layered paint systems by the samples prepared specifically for this test programme was a consideration and therefore real-world specimens were sought for inclusion in the testing. Dirt, grime and surface aging, in combination with imperfect surface preparation of the existing paint, would lead to a significantly reduced level of bonding between subsequent refurbishment coats. This would be expected if the surfaces were not appropriately prepared before new coats of paint were applied. For the real-world samples located for this test programme, lack of surface treatment between paint coatings was not visually evident.

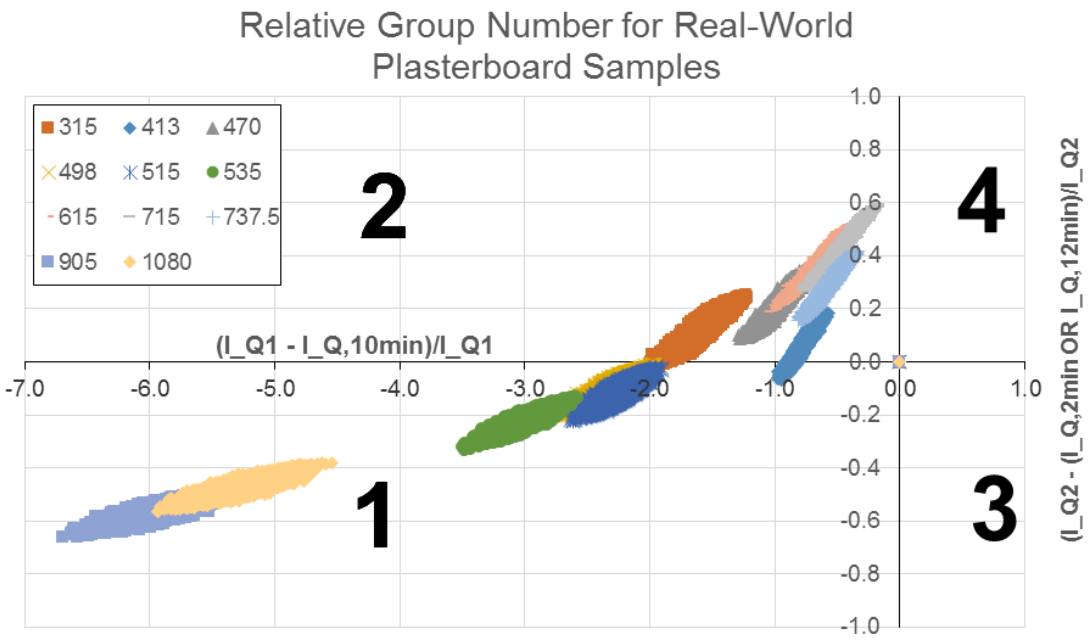
The real-world specimen and average sample results cannot be compared directly with the multi-layer painted samples prepared for the test series conducted here. Neither the specific type of paint and substrate, nor history are known. Therefore the real-world samples only provide a general indication of whether there are any particular outliers. Considering this there are only five different samples, four of which were plasterboard substrates with a single sample on a fibreboard.

A visual summary of the relative group numbers for the real-world plasterboard substrate samples is shown in Figure 121 (a) for all the tested specimens (i.e. a summary of Figure 65, Figure 66, Figure 68 and Figure 69). Removing the results for the thickest painted specimen (1305 µm) provides a clearer visual summary, as shown in Figure 121 (b).

General comparison of the relative group numbers based on substrate for the plasterboard samples of the real-world samples (Section 5.7 and Figure 121) and those prepared for testing indicates (Section 5.4 and Figure 115) show a similar spread. This provides an indication that the preparation of samples for this test programme are similar to the real-world that were located.



(a)



(b)

Figure 121 Summary of relative group number (based on test data with a ±20% variation of the time to ignition and instantaneous heat release rate) for (a) all the plasterboard substrate real-world samples tested, and (b) all except for the thickest paint layer specimen

6. CONCLUSIONS

Considering material Group Numbers for paint coatings of the substrates tested, from the results and analysis presented here, the following results have been obtained for the combinations of materials tested at an irradiance of 50 kW/m² and calculating the Group Number in accordance with the VM2 (MBIE 2012a) description including a ±20% variation of key calculation input values:

- The (37 mm thick) concrete specimens with paint coatings up to 500 µm achieved an indicated Group Number of 1
- The (9.5 mm thick) plasterboard specimens with paint coatings up to 400 µm achieved an indicated Group Number of 2 or better
- The (9.5 mm thick) plasterboard specimens with water-borne paint coatings up to 100 µm achieved an indicated Group Number of 1
- The 10 mm thick plywood specimens with water-borne paint coatings up to 400 µm achieved an indicated Group Number of 3 or better
- The 7 mm thick plywood specimens with paint coatings achieved worse indicated Group Numbers than the uncoated specimens
- The (10 mm thick) medium density fibreboard substrate specimens with paint coatings up to approximately 400 µm produced indicated Group Numbers clustered at the threshold between 3 and 4

- For all tested specimens where smoke was recorded, the Specific Extinction Area values did not exceed the 250 m²/kg limit of VM2 Appendix A1.2 (MBIEa, 2012).

Care must be taken when specifying paint coating thicknesses, considering the observation for the plasterboard (Figure 80) and 7 mm thick plywood (Figure 99) specimens tested of a transitional paint thickness where an increase in paint thickness was associated with an increase in indicated Group Number followed by a decrease in indicated Group Number with an increasing paint thickness. For tested plasterboard specimens, the paint thicknesses associated with a transition to the next indicated Group Number was approximately 250 to 550 µm. For tested 7 mm thick plywood specimens, this transitional observation was for paint thicknesses of approximately 200 to 400 µm. This type of transitional behaviour from a protective to less protective to protective reaction to fire results is similar to that reported by Steen-Hansen and Kristoffersen (2007) for a plasterboard substrate coated with a glass fibre wallpaper and then multiple layers of latex paint. The potential protective versus less protective transitional behaviour observed for the paint thicknesses reported here needs further investigation to ensure appropriate application of test results being applied to ranges of paint coating thicknesses.

Reasonable comparability was observed between the plasterboard substrate real-world samples and the prepared samples for the test variables and analysis considered here.

6.1 Disclaimer

The results obtained are strictly limited to the samples tested in this experimental programme. Therefore no conclusions can be drawn as to the likely performance of these materials in other situations.

No product is identified by manufacturer or brand in this report or elsewhere, as there is no endorsement or other comment by BRANZ on the performance or appropriateness of any specific product included in the range of commercially available products included in this test programme.

7. RECOMMENDATIONS

The following recommendations relate to further research work on the fire hazard of multiple-layered paint systems.

- Completion of the testing proposed in the full test matrix (included in Appendix A.1 Table 31).

- Testing of a wider range of real-world samples representing the full range of substrate types and thicknesses, and types and thicknesses of paint coatings. Location of appropriate and useful samples is a recognised issue. A longer collection timeframe and partnerships with demolition contractor and builders may be useful in locating samples for future test programmes.

- In future research, a series of full-scale ISO 9705 room-corner tests carried out on a limited selection of those systems submitted for cone calorimeter testing would provide smoke values, as well as valuable comparative data for both

indicated Group Number and total smoke production from cone calorimeter test results.

- Further investigation of protective versus less protective transitional behaviour of various paint coating thicknesses.

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APPENDIX A SUMMARY OF TESTING

A summary of all the tests used in this report are included here. This section is sorted by substrate materials.

A.1 Full Test Matrix

The intended full test matrix is presented in Table 31. However this matrix was not completed due to unforeseen circumstances at the laboratory. The combinations of substrate and paint type that were not tested are highlighted in yellow.

Table 31 Intended full test matrix

Paint Layers	Code	Cone Irradiance Level (kW/m²)	
		50	75
0	0	Cement fibreboard Sheet metal Gypsum 10 mm plywood 7 mm plywood Medium density fibreboard	
4	4b,c,d,e	Cement fibreboard Sheet metal Gypsum 10 mm plywood Medium density fibreboard	
6	6b,c,d,e	Cement fibreboard Sheet metal Gypsum 10 mm plywood Medium density fibreboard	
8	8a,b,c,d,e	Cement fibreboard Sheet metal Concrete Gypsum 7 mm plywood 10 mm plywood Medium density fibreboard	Concrete
8 aged	8aw	Concrete Gypsum 10 mm Plywood	Concrete
16	16a	Concrete Gypsum 10 mm plywood	Concrete
16 aged	16aw	Concrete Gypsum 10 mm plywood	Concrete
Real –world samples	rws	Gypsum Fibreboard	

A.2 Concrete Samples

A.2.1 Paint A - Tested at an Irradiance of 50 kW/m²

Table 32 Summary table of concrete specimen test results at an irradiance of 50 kW/m²

Specimen Label	Incident Radiation (kW)	Substrate Thickness (mm)	Paint Type	Paint	Aged	Paint Thickness (µm)	Time to Ignition (°C)	Peak Heat Release Rate (kW/m²)	Total Heat Release (MJ)	Total Smoke Produced (m²)	Average Specific Extinction Area	NZ Group Number
con8a-027	50	37	A	8	n	295	1200	-	-	-	-	1
con8a-053	50	37	A	8	n	250	1200	-	-	-	-	1
con8a-138	50	37	A	8	n	285	1200	-	-	-	-	1
con8aw-176	50	37	A	8	y	300	1200	-	-	-	-	1
con8aw-209	50	37	A	8	y	300	1200	-	-	-	-	1
con8aw-242	50	37	A	8	y	300	1200	-	-	-	-	1
con16a-029	50	37	A	16	n	520	1200	-	-	-	-	1
con16a-055	50	37	A	16	n	535	1200	-	-	-	-	1
con16a-136	50	37	A	16	n	505	1200	-	-	-	-	1
con16aw-178	50	37	A	16	y	525	85.9	3	1.3	0.3	79	1
con16aw-210	50	37	A	16	y	525	89	4.3	1.5	0.4	155	1
con16aw-240	50	37	A	16	y	525	95.5	4.5	1.5	0.3	149	1

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

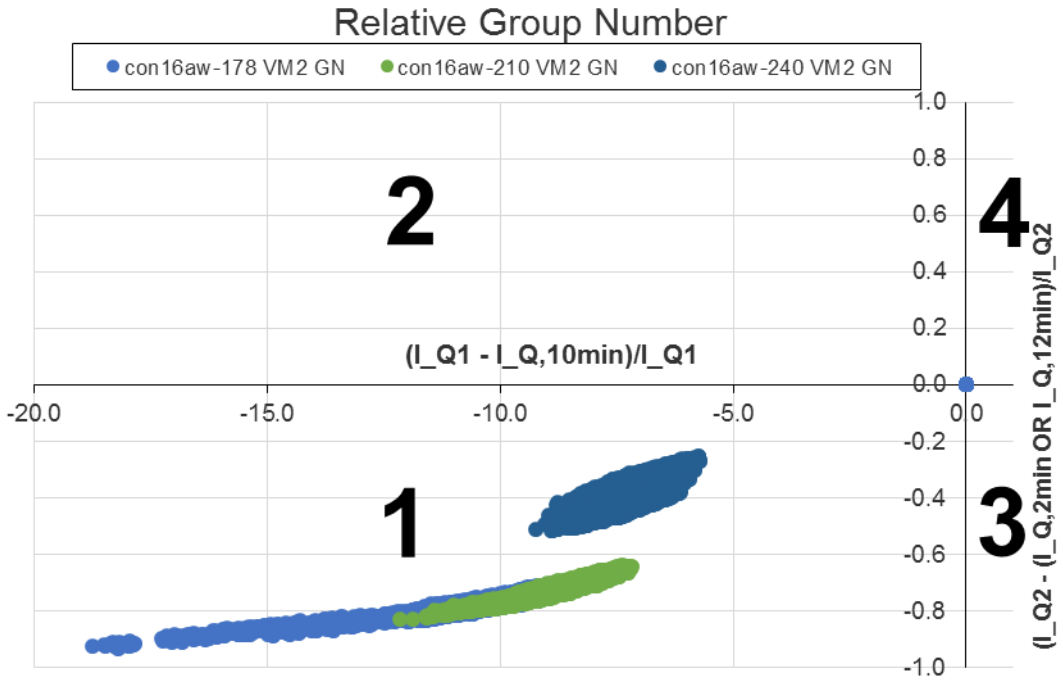

Figure 122 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for concrete samples with 16 coats of Paint A, subjected to a simulated aging process, and tested at an irradiance of 50 kW/m²

A.2.2 Paint A - Tested at an Irradiance of 75 kW/m²

Table 33 Summary table of concrete specimen test results at an irradiance of 75 kW/m²

Specimen Label	Incident Radiation (kW)	Substrate Thickness (mm)	Paint Type	No. Paint Layers	Simulated Aging Process	Average Paint Thickness (µm)	Time to Ignition (s)	Peak Heat Release Rate (kW/m²)	Total Heat Release (MJ/m²)	Average Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
con0-75 - 041	75	37	-	0	n	0	1200	-	-	-	1
con0-75 - 066	75	37	-	0	n	0	1200	-	-	-	1
con0-75 - 110	75	37	-	0	n	0	1200	-	-	-	1
con8a-75 - 043	75	37	A	8	n	290	1200	5.5	0.1	-	1
con8a-75 - 068	75	37	A	8	n	285	1200	4.8	0.1	-	1
con8a-75 - 108	75	37	A	8	n	285	1200	31.7	5	-	1
con8aw-75 - 197	75	37	A	8	y	320	154	56	1.5	-	1
con8aw-75 - 254	75	37	A	8	y	285	144	63	1.6	-	1
con16a-75 - 045	75	37	A	16	n	510	212	68.3	2.4	-	1
con16a-75 - 070	75	37	A	16	n	475	109	99.4	4.8	-	1
con16a-75 - 106	75	37	A	16	n	445	195	106.7	7.1	-	1
con16aw-75 - 198	75	37	A	16	y	500	21	79	4.4	-	2
con16aw-75 - 252	75	37	A	16	y	545	24	78	6.8	-	1

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

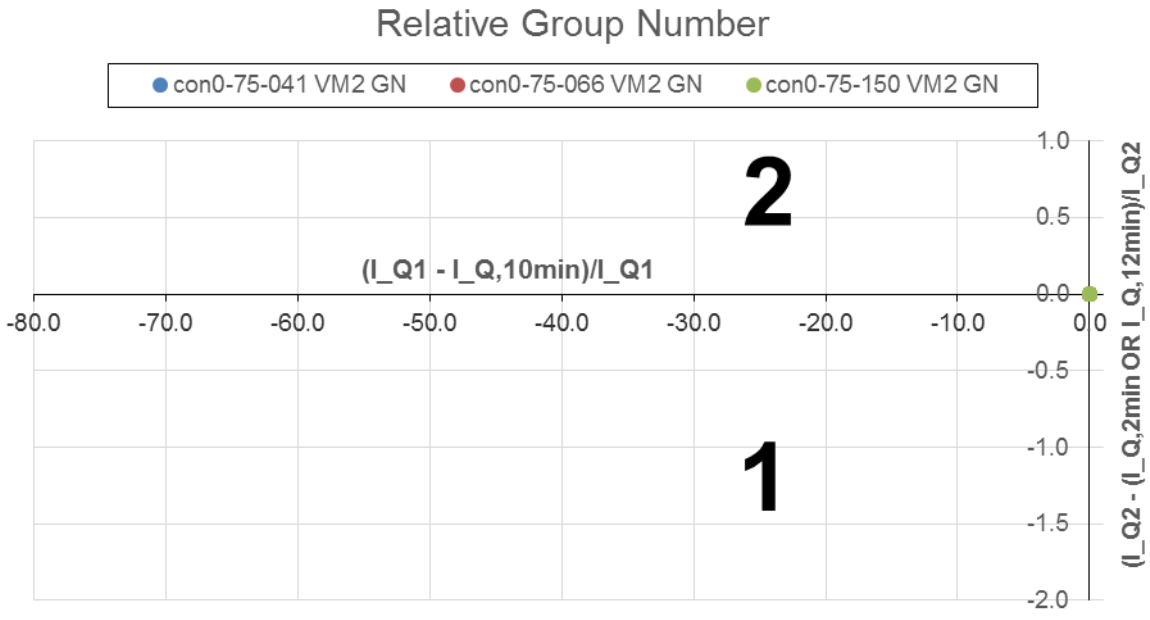

Figure 123 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated concrete samples and tested at an irradiance of 75 kW/m²

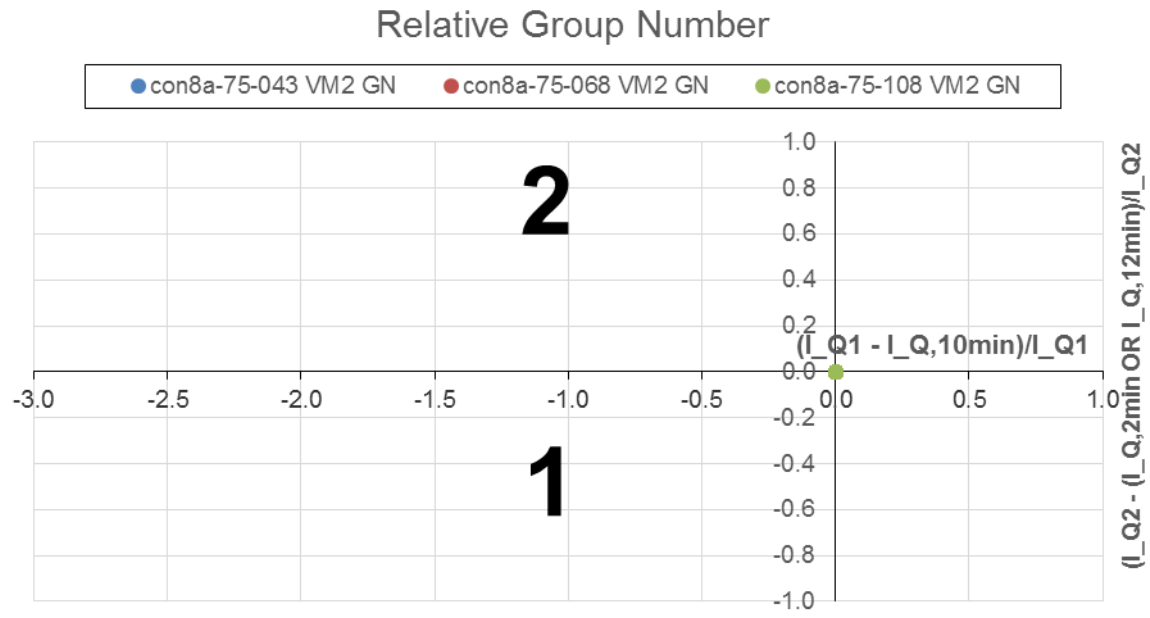

Figure 124 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for concrete samples with eight coats of Paint A and tested at an irradiance of 75 kW/m²

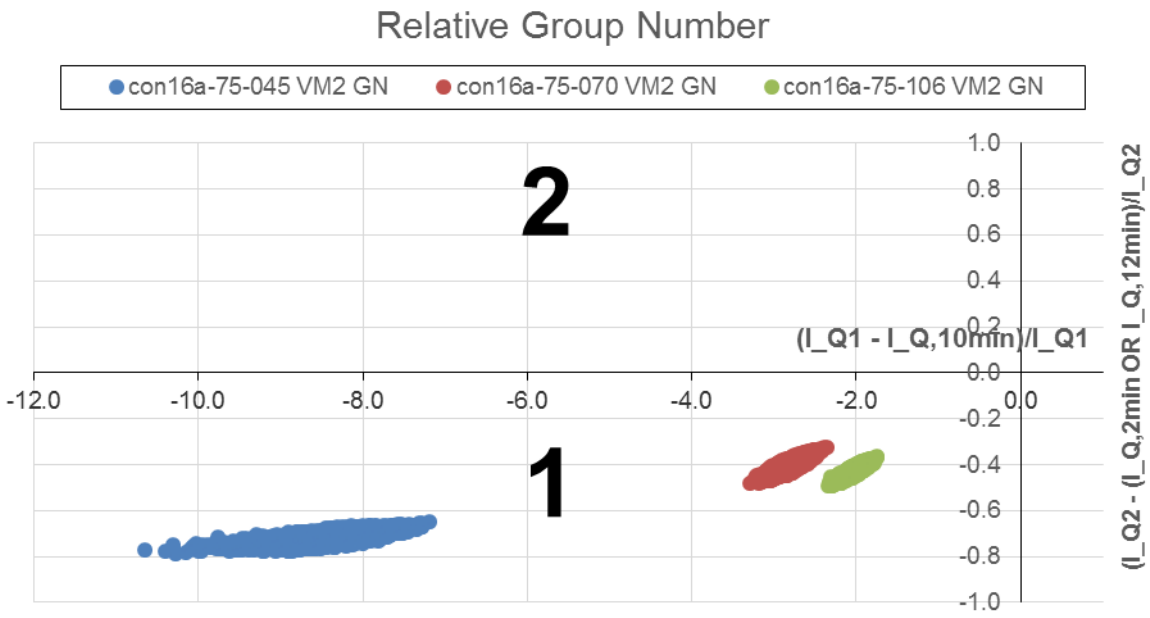

Figure 125 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for concrete samples with 16 coats of Paint A and tested at an irradiance of 75 kW/m²

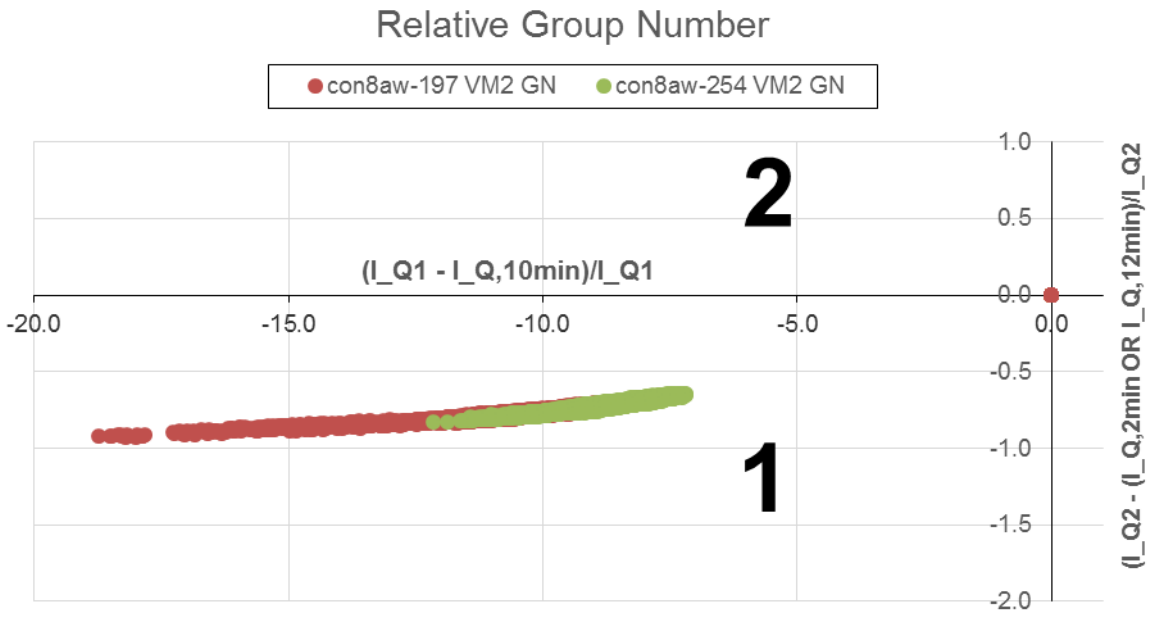

Figure 126 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for concrete samples with eight coats of Paint A, subjected to a simulated aging process, and tested at an irradiance of 75 kW/m²

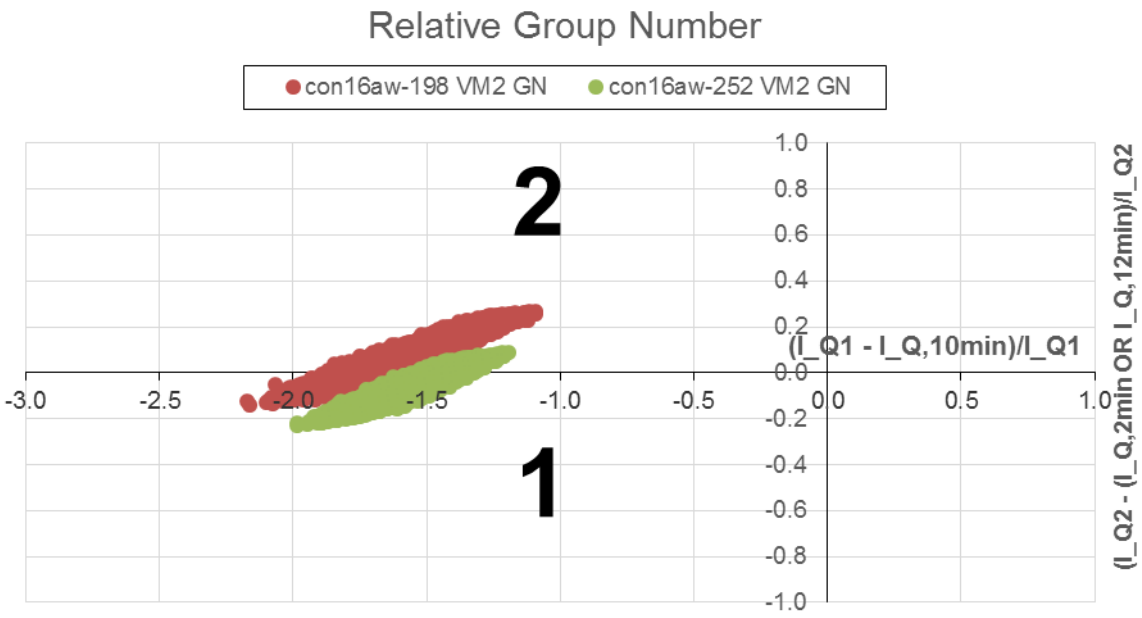

Figure 127 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for concrete samples with 16 coats of Paint A, subjected to a simulated aging process, and tested at an irradiance of 75 kW/m²

A.3 Plasterboard Samples

Table 34 Summary table of uncoated plasterboard tests performed

Specimen Label	Plasterboard Thickness (mm)	Paint Type	No. Paint Layers	Paint Thickness (μm)	Simulated Aging Process	Time to Ignition (°C)	Peak Heat Release Rate (kW/m²)	Average Heat Release Rate (kW/m²)	Total Heat Release (MJ)	VM2 Group Number Indication	Average Specific Extinction Area
gyp0 - 021	9.5	-	0	0	n	1200	11.2	2	1.1	1	-
gyp0 - 048	9.5	-	0	0	n	56	28.9	8.4	1.8	1	-
gyp0 - 150	9.5	-	0	0	n	43	81.7	5	2	1	-
gyp0aw - 001	9.5	-	0	0	y	36	93.7	6.1	2	1	-
gyp0aw - 002	9.5	-	0	0	y	31	88.1	6.1	2.1	1	-
gyp0aw - 003	9.5	-	0	0	y	34	91.3	5.2	2.1	1	-
gyp0-301-1	10.1	-	0	0	0	42	91.4	2.5	0.1	1	5
gyp0-301-2	10.2	-	0	0	0	41	95.7	3.2	0.1	1	3
gyp0-301-3	10.2	-	0	0	0	41	95.4	2.3	0.0	1	0

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

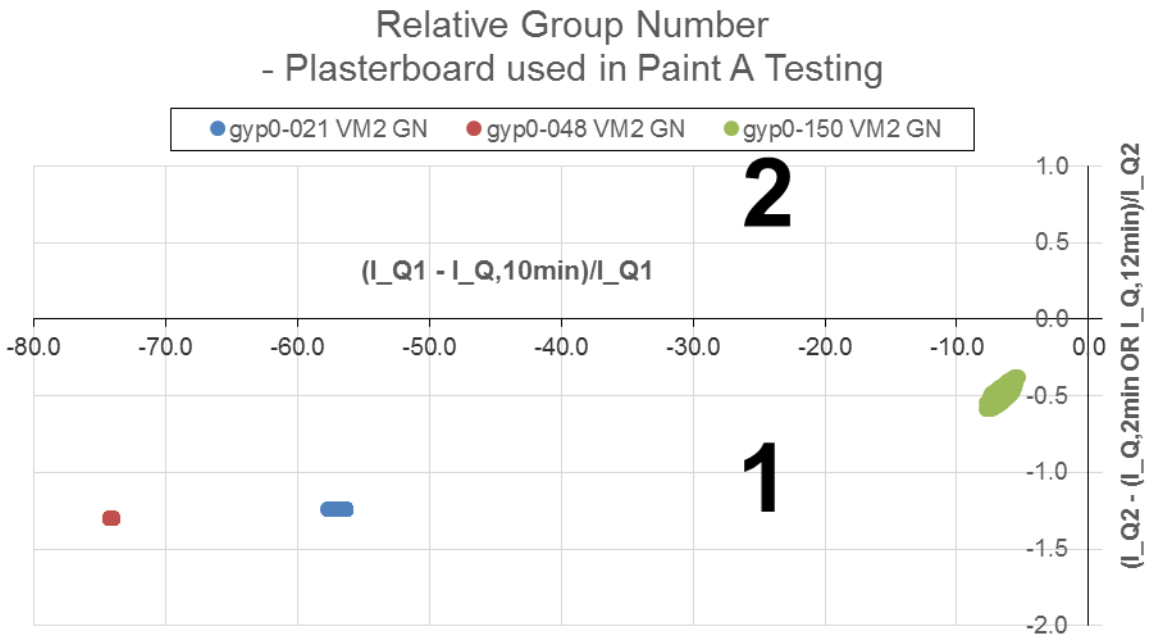

Figure 128 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated plasterboard samples (used in testing Paint A samples)

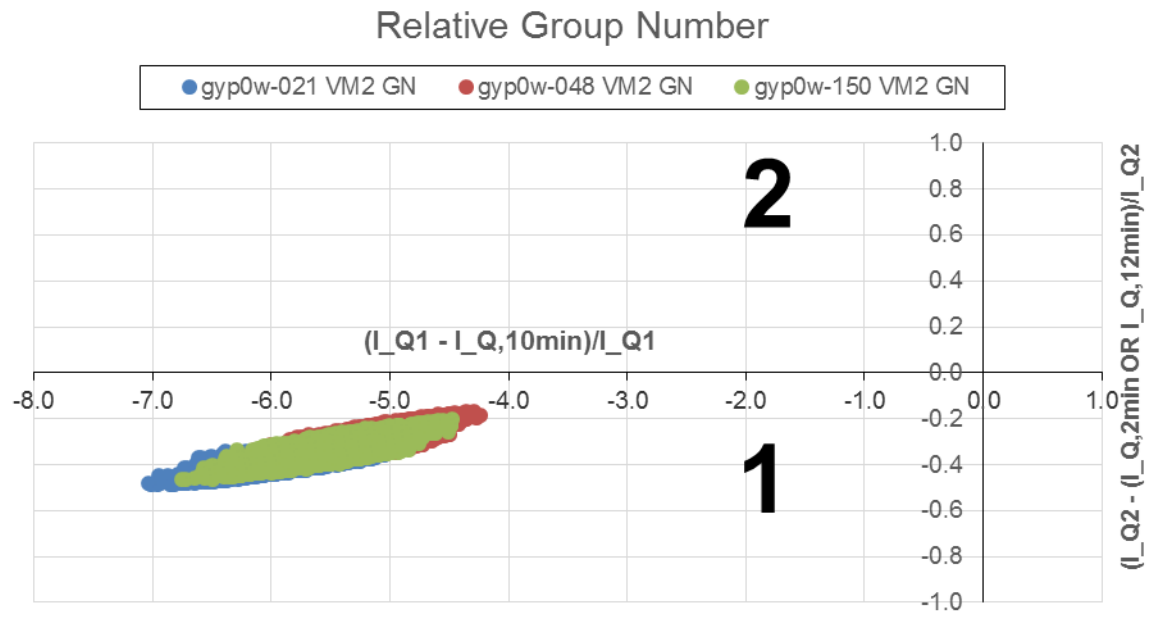

Figure 129 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated plasterboard samples (used for testing Paint A samples) and subjected to a simulated aging process

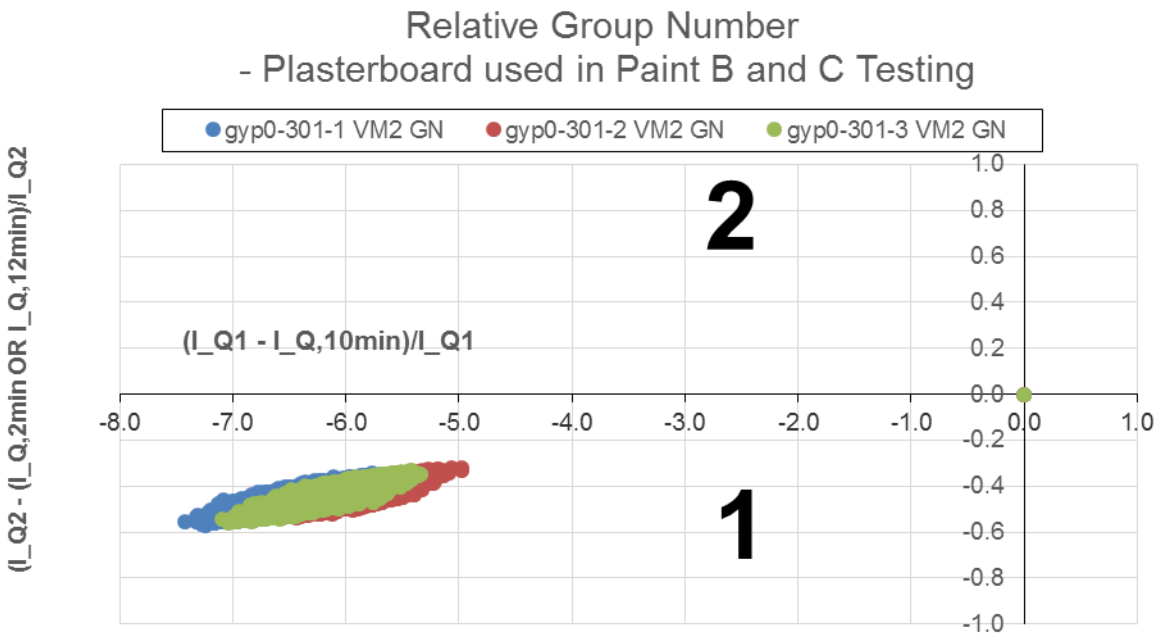

Figure 130 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated plasterboard samples (used in testing Paints B and C samples)

A.3.1 Paint A

Table 35 Summary table of plasterboard tests performed

Specimen Label	Incident Radiation (kW)	Plasterboard Thickness (mm)	Paint Type	No. Paint Layers	Paint Thickness (µm)	Simulated Aging Process	Time to Ignition (°C)	Peak Heat Release Rate (kW/m²)	Average Heat Release Rate (kW/m²)	Total Heat Release (MJ)	VM2 Group Number Indication	Average Specific Extinction Area
gyp0 - 021	50	9.5	-	0	0	n	1200	11.2	2	1.1	1	-
gyp0 - 048	50	9.5	-	0	0	n	56	28.9	8.4	1.8	1	-
gyp0 - 150	50	9.5	-	0	0	n	43	81.7	5	2	1	-
gyp0aw - 001	50	9.5	-	0	0	y	36	93.7	6.1	2	1	-
gyp0aw - 002	50	9.5	-	0	0	y	31	88.1	6.1	2.1	1	-
gyp0aw - 003	50	9.5	-	0	0	y	34	91.3	5.2	2.1	1	-
gyp8a - 023	50	9.5	A	8	420	n	58	111	18.4	5.3	1	-
gyp8a - 049	50	9.5	A	8	545	n	56	121.6	46.9	14.6	1	-
gyp8a - 148	50	9.5	A	8	315	n	32	192	14	5	2	-
gyp8aw - 180	50	9.5	A	8	509	y	50	134.9	13.4	8	1	-
gyp8aw - 189	50	9.5	A	8	350	y	33	125	23.4	10.3	1	-
gyp8aw - 226	50	9.5	A	8	508	y	48	136.2	16.6	6.2	1	-
gyp16a - 025	50	9.5	A	16	520	n	54	144	33.4	10.2	1	-
gyp16a - 050	50	9.5	A	16	705	n	51	142.8	27	7.7	1	-
gyp16a - 146	50	9.5	A	16	535	n	30	188.6	22.6	9.7	2	-
gyp16aw - 182	50	9.5	A	16	594	y	45	169.6	25.4	9.8	1	-
gyp16aw - 190	50	9.5	A	16	570	y	45	161.6	26.8	11.6	1	-
gyp16aw - 224	50	9.5	A	16	636	y	47	175	22.1	9.6	1	-

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

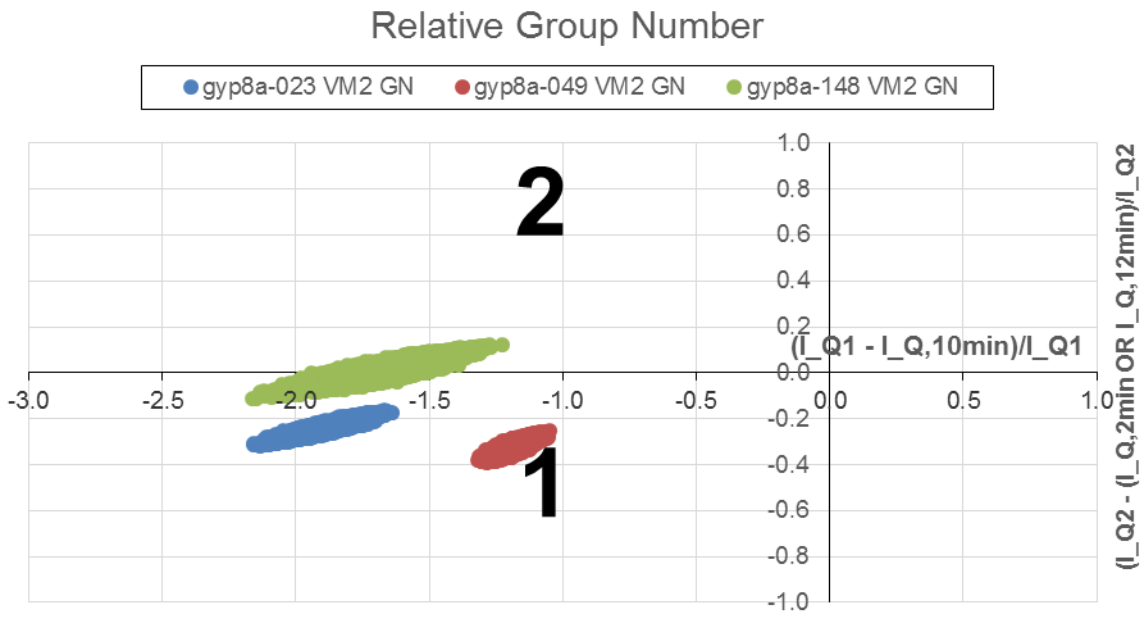

Figure 131 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with eight coats of Paint A

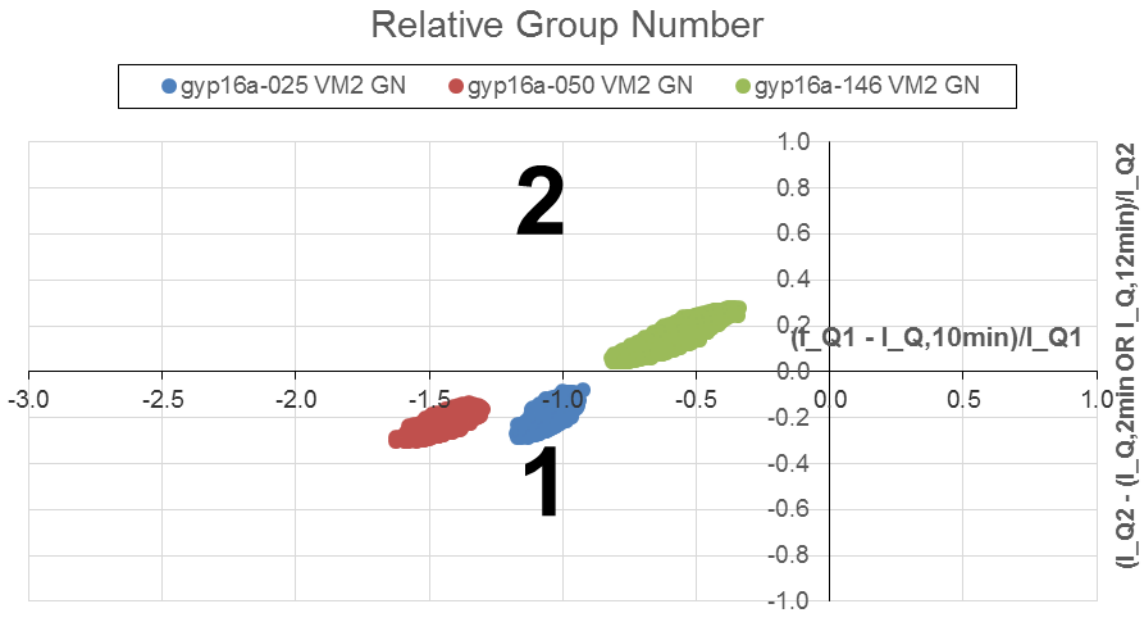

Figure 132 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with 16 coats of Paint A

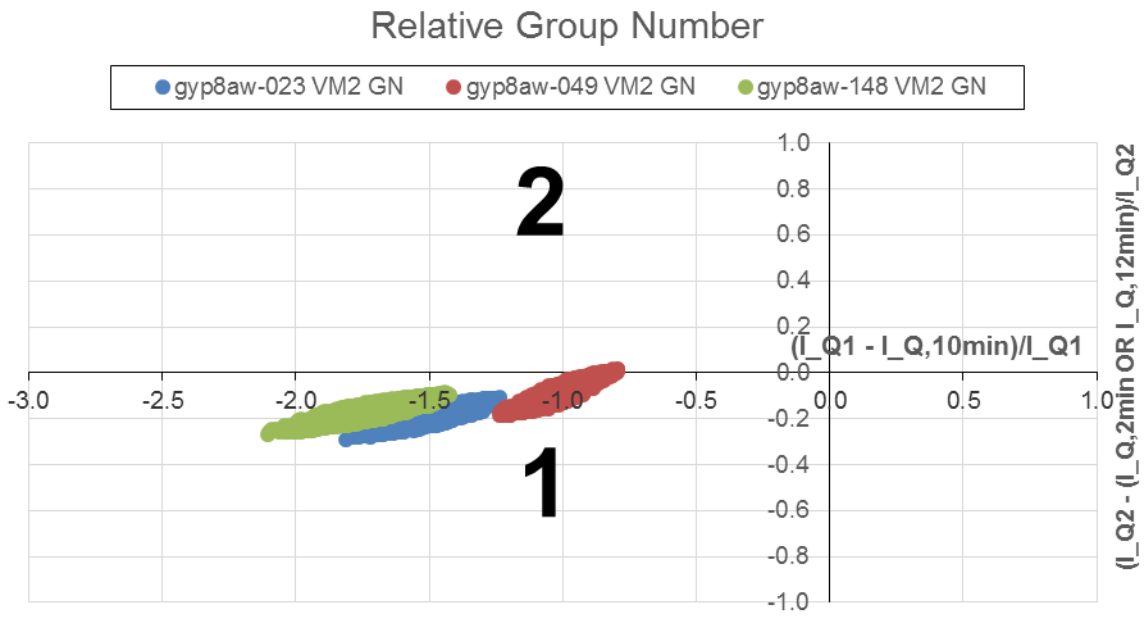

Figure 133 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with eight coats of Paint A and subjected to a simulated aging process

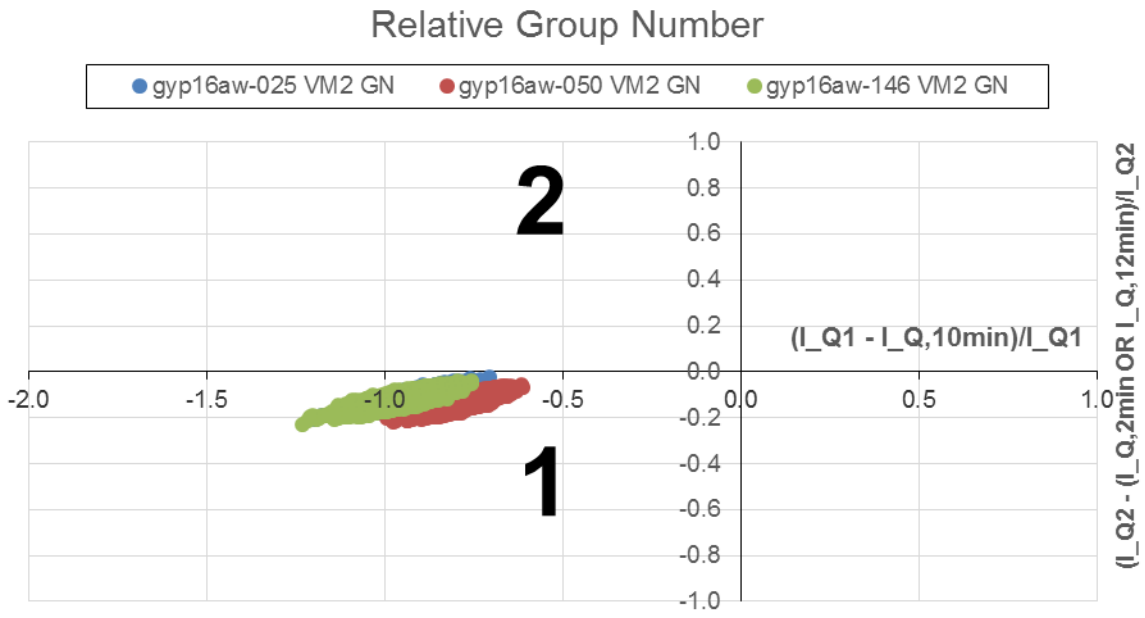

Figure 134 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with 16 coats of Paint A and subjected to a simulated aging process

A.3.2 Paint B

Table 36 Summary table of plasterboard specimens coated with Paint B test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
gyp0-301-1	10.1	-	0	0	0	42	91.4	2.5	0.1	5	1
gyp0-301-2	10.2	-	0	0	0	41	95.7	3.2	0.1	3	1
gyp0-301-3	10.2	-	0	0	0	41	95.4	2.3	0.0	0	1
gyp4b-405-1	10.35	B	4	293	15	11	177.3	8.1	0.8	51	2
gyp4b-405-2	10.30	B	4	243	22	15	162.2	7.0	1.0	56	2
gyp4b-405-3	10.24	B	4	310	21	14	176.3	8.2	0.9	54	2
gyp4b-411-1	10.33	B	4	339	12	20	177.5	11.2	1.1	59	2
gyp4b-411-2	10.34	B	4	302	5	23	214.9	9.6	1.2	63	2
gyp4b-411-3	10.11	B	4	330	27	15	177.3	11.2	1.4	76	2
gyp8b-417-1	10.29	B	8	462	7	16	202.0	12.1	1.8	94	2
gyp8b-417-2	10.44	B	8	508	14	17	177.5	13.4	1.6	82	2
gyp8b-417-3	10.50	B	8	477	18	16	171.1	10.3	1.7	88	2

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

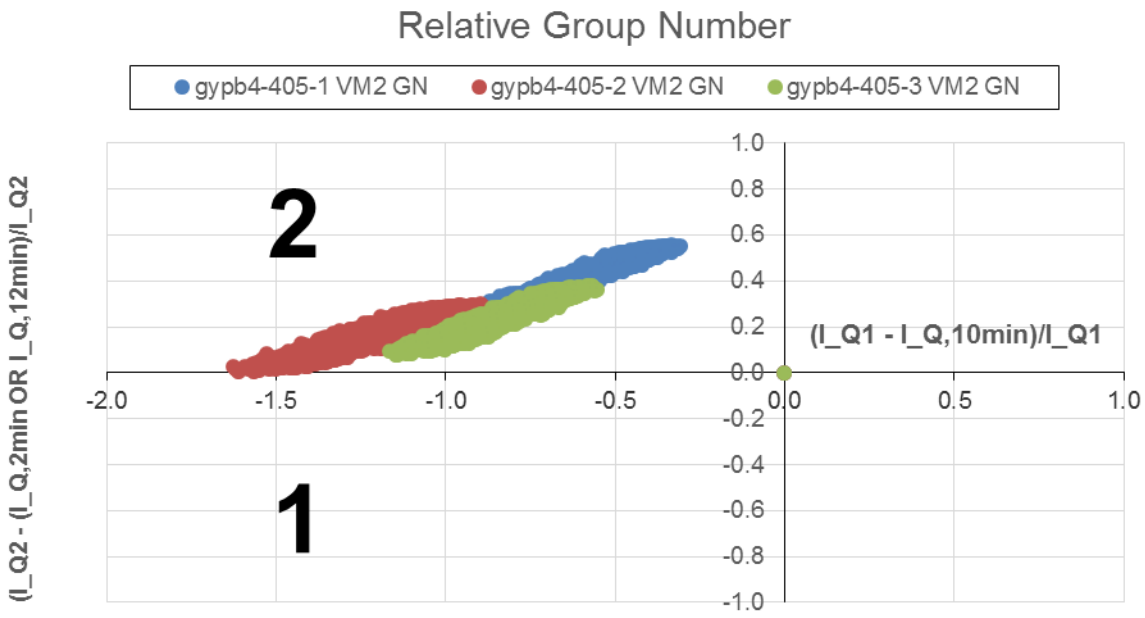

Figure 135 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with four coats of Paint B

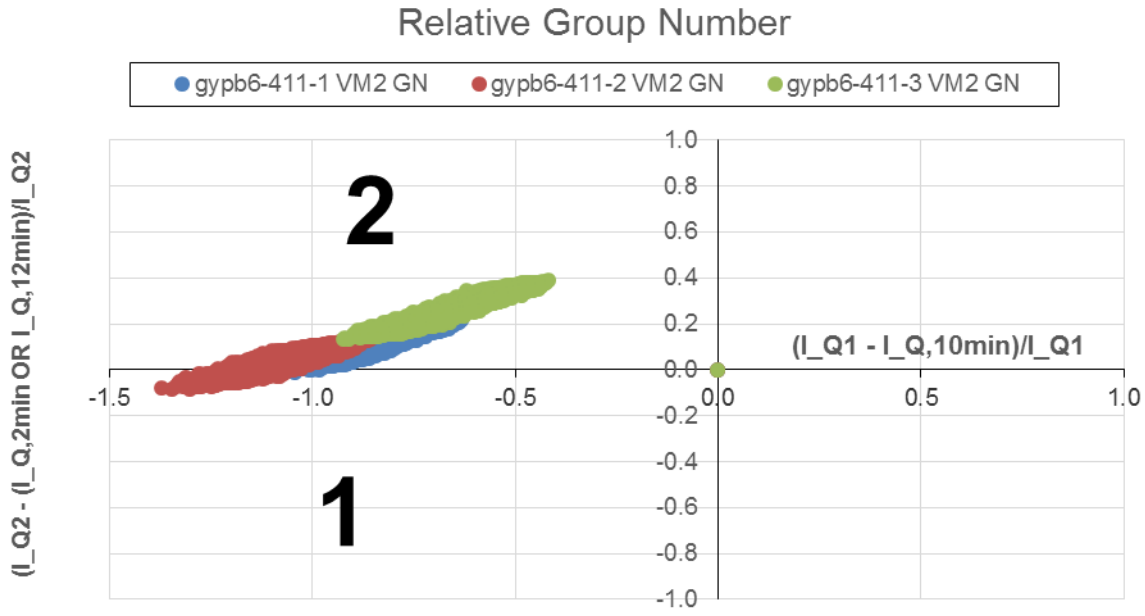

Figure 136 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with six coats of Paint B

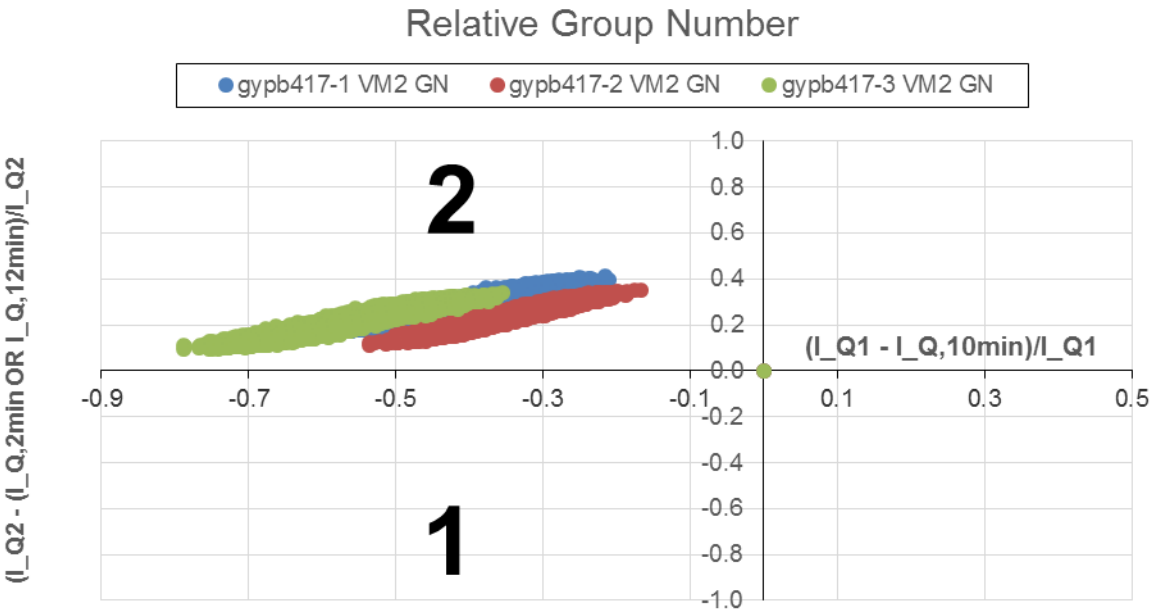

Figure 137 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with eight coats of Paint B

A.3.3 Paint C

Table 37 Summary table of plasterboard specimens coated with Paint C test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
gyp0-301-1	10.1	-	0	0	0	42	91.4	2.5	0.1	5	1
gyp0-301-2	10.2	-	0	0	0	41	95.7	3.2	0.1	3	1
gyp0-301-3	10.2	-	0	0	0	41	95.4	2.3	0.0	0	1
gyp4c-402-1	10.70	C	4	146	23	43	188.6	8.4	0.6	14	1
gyp4c-402-2	10.29	C	4	113	25	41	155.3	8.5	0.3	23	1
gyp4c-402-3	10.45	C	4	184	16	40	183.0	5.6	0.4	31	1
gyp6c-408-1	10.28	C	6	337	17	40	250.5	7.3	0.6	38	1
gyp6c-408-2	10.09	C	6	392	5	38	257.6	8.6	0.7	42	2
gyp6c-408-3	10.10	C	6	360	13	48	253.3	7.8	0.7	39	1
gyp8c-414-1	10.30	C	8	264	20	44	265.0	7.7	0.8	46	1
gyp8c-414-2	10.21	C	8	292	27	39	257.8	8.4	1.0	56	2
gyp8c-414-3	10.28	C	8	352	11	36	259.5	7.1	0.9	55	2

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

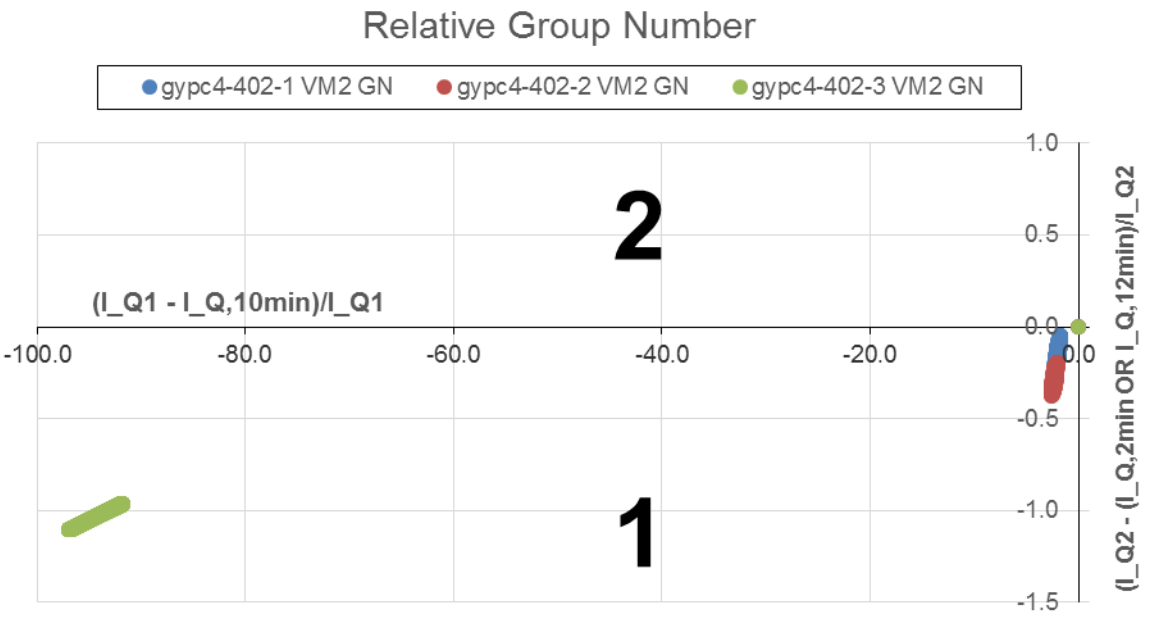

Figure 138 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with four coats of Paint C

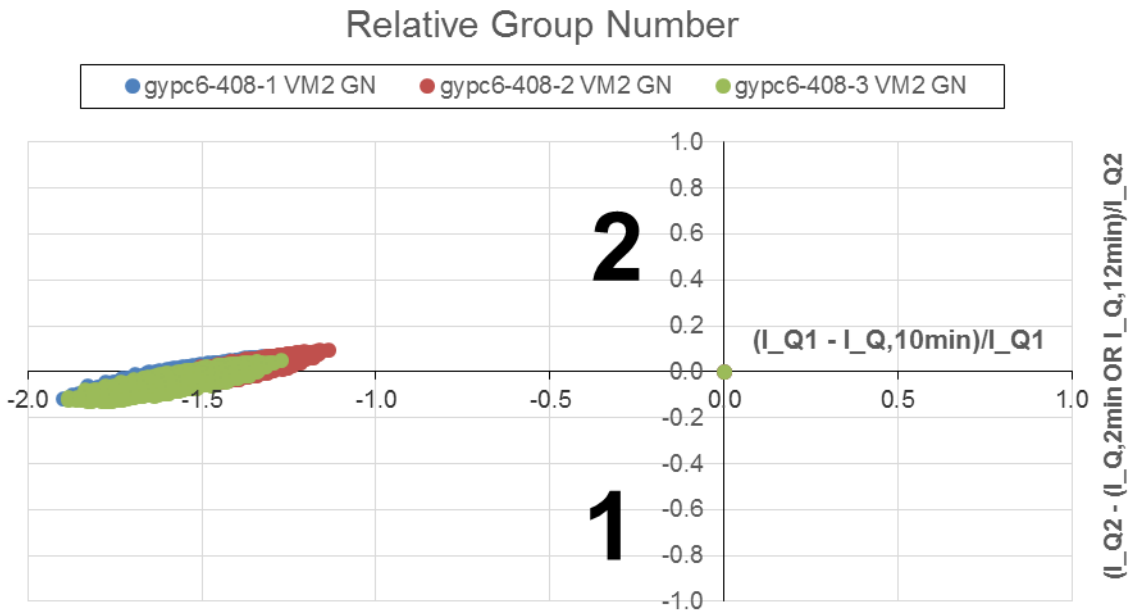

Figure 139 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with six coats of Paint C

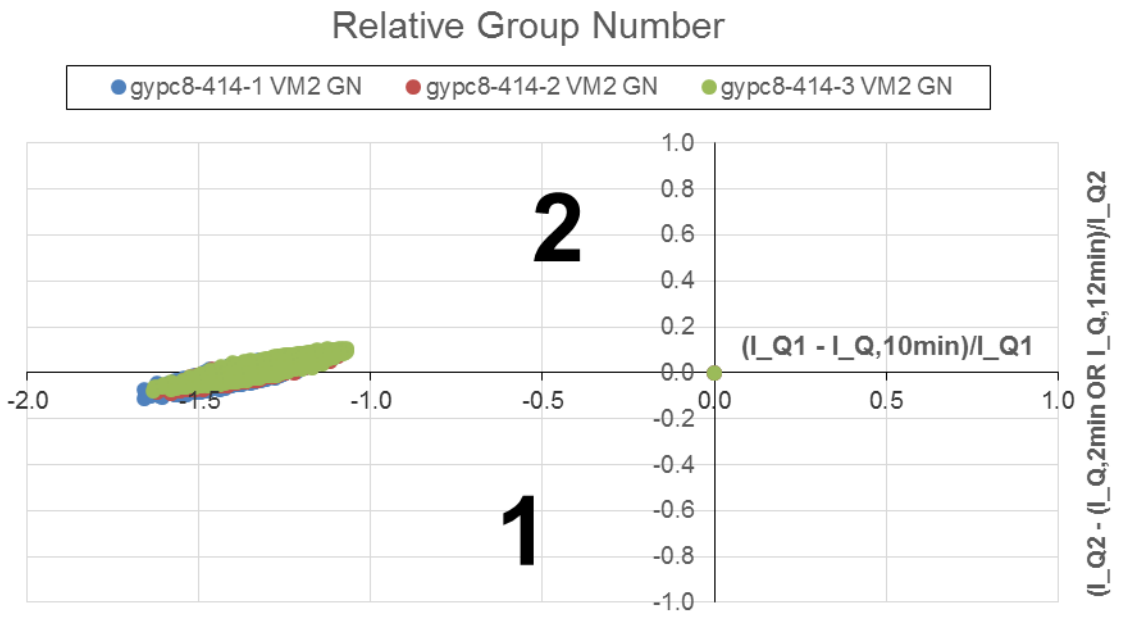

Figure 140 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for plasterboard samples with eight coats of Paint C

A.4 Plywood Samples

Table 38 Summary table of 10 mm plywood specimen test results

Specimen Label	Incident Radiation (kW)	Substrate Thickness (mm)	Paint Type	No. Paint Layers	Simulated Aging Process	Average Paint Thickness (μm)	Time to Ignition (s)	Peak Heat Release Rate (kW/m²)	Average Heat Release Rate (kW/m²)	Total Heat Release (MJ)	Average Specific Extinction Area (m²/kg)	VM2 Group Number Indication
PLY0 - 016	50	10	-	0	n	0	34	183.9	113.9	23.5	-	3
PLY0 - 056	50	10	-	0	n	0	38	133.7	83.1	43.6	-	3
PLY0 - 145	50	10	-	0	n	0	19	155.9	100.6	36.2	-	3
PLY0w - 001	50	10	-	0	y	0	22	242.1	122.7	38.4	-	3
PLY0w - 002	50	10	-	0	y	0	21	262.1	127.9	39.7	-	3
PLY0w - 003	50	10	-	0	y	0	35	231.4	115.7	37.5	-	4
ply0-300-1	50	7	-	0	0	0	22	284.6	58.8	1.5	45	3
ply0-300-2	50	7	-	0	0	0	20	289.6	60.3	1.6	45	3
ply0-300-3	50	7	-	0	0	0	28	277.6	58.5	2.4	64	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

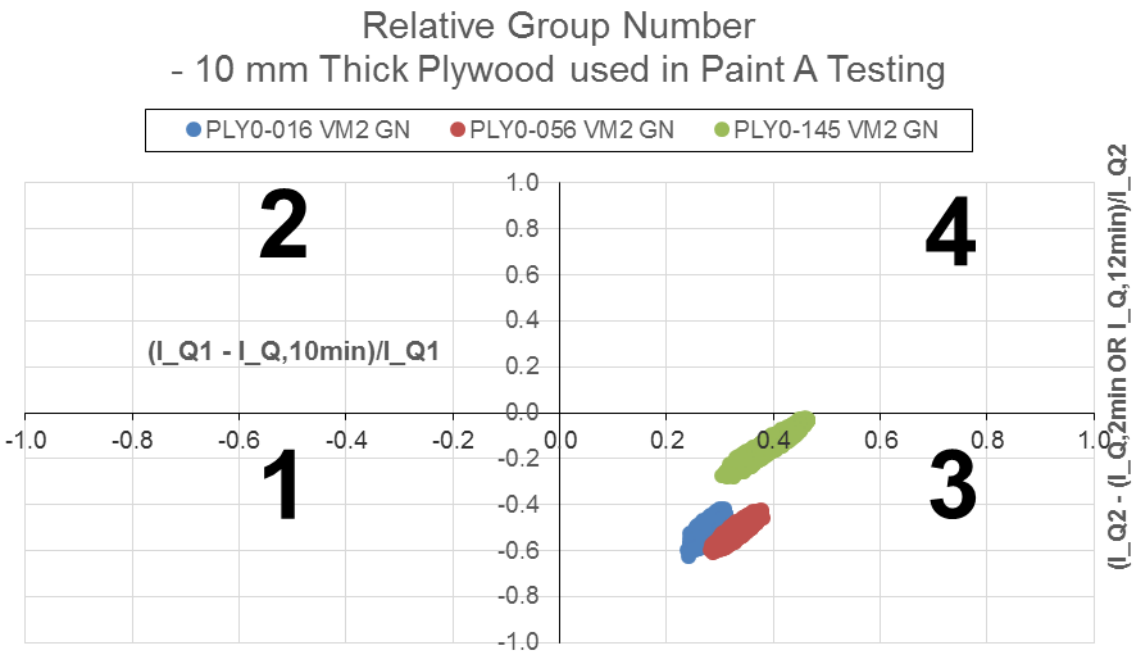

Figure 141 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated 10 mm thick plywood samples (used for testing Paint A samples)

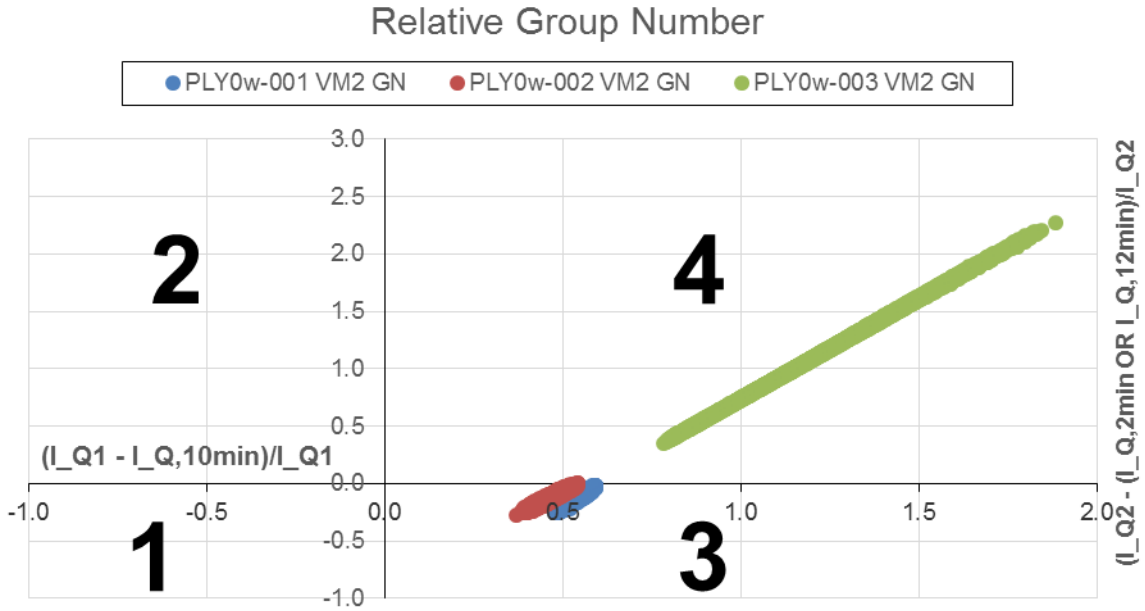

Figure 142 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated 10 mm thick plywood samples and subjected to a simulated aging process (used for testing Paint A samples)

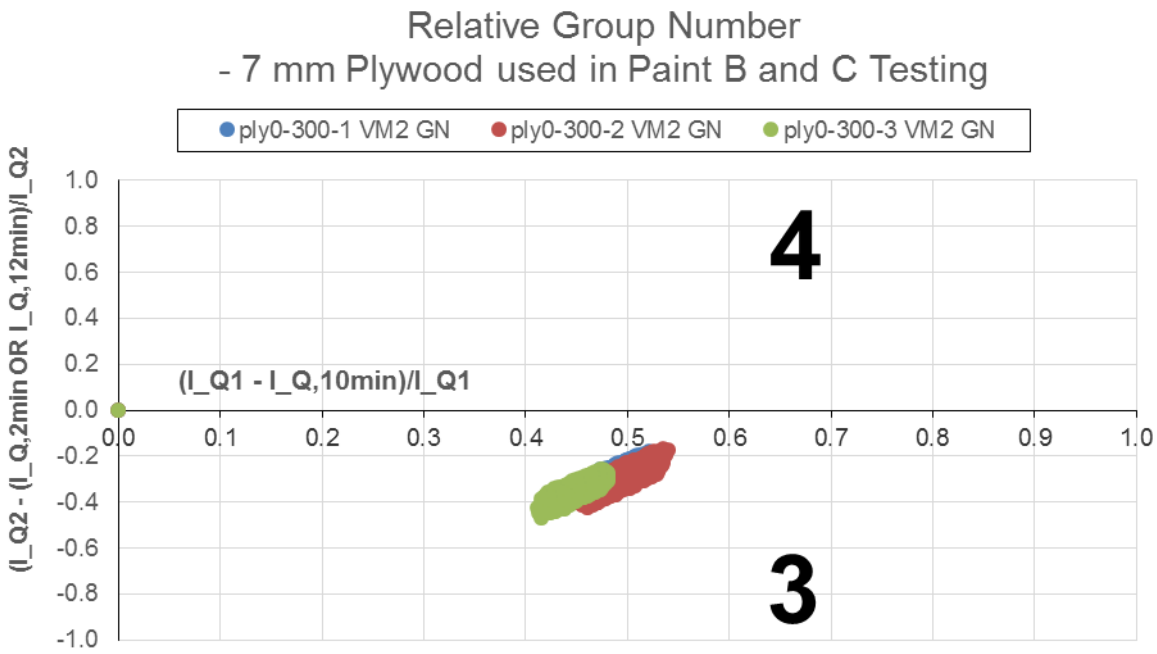

Figure 143 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated 7 mm thick plywood samples (used for testing Paints B and C samples)

A.4.1 Paint A

Table 39 Summary table of 10 mm plywood specimen test results

Specimen	Incident Radiation (kW)	Substrate Thickness (mm)	Paint Type	No. Paint Layers	Simulated Aging Process	Average Paint Thickness (μm)	Time to Ignition (s)	Peak Heat Release Rate (kW/m²)	Average Heat Release Rate (kW/m²)	Total Heat Release (MJ)	Average Specific Extinction Area (m²/kg)	VM2 Group Number Indication
PLY0 - 016	50	10	-	0	n	0	34	183.9	113.9	23.5	-	3
PLY0 - 056	50	10	-	0	n	0	38	133.7	83.1	43.6	-	3
PLY0 - 145	50	10	-	0	n	0	19	155.9	100.6	36.2	-	3
PLY0w - 001	50	10	-	0	y	0	22	242.1	122.7	38.4	-	3
PLY0w - 002	50	10	-	0	y	0	21	262.1	127.9	39.7	-	3
PLY0w - 003	50	10	-	0	y	0	35	231.4	115.7	37.5	-	4
PLY8a - 018	50	10	A	8	n	310	45	153	41.9	18.1	-	3
PLY8a - 058	50	10	A	8	n	285	30	181.3	100.5	45.3	-	3
PLY8a - 143	50	10	A	8	n	285	26	208.3	78.9	36.4	-	3
PLY8aw - 172	50	10	A	8	y	285	29	217.9	130.8	45.6	-	3
PLY8aw - 205	50	10	A	8	y	307.4	38	235.2	95	42.6	-	3
PLY8aw - 238	50	10	A	8	y	318	39	187.3	91.8	40.3	-	3
PLY16a - 020	50	10	A	16	n	550	23	180.6	53.4	20.1	-	3
PLY16a - 060	50	10	A	16	n	535	15	192.4	131.3	49.4	-	3
PLY16a - 141	50	10	A	16	n	570	15	202.8	75.5	35.4	-	2
PLY16aw - 174	50	10	A	16	y	475	27	248.9	116.5	46.2	-	3
PLY16aw - 206	50	10	A	16	y	456	33	241.4	112.1	44.6	-	3
PLY16aw - 236	50	10	A	16	y	519	28	208.6	107.2	45.6	-	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

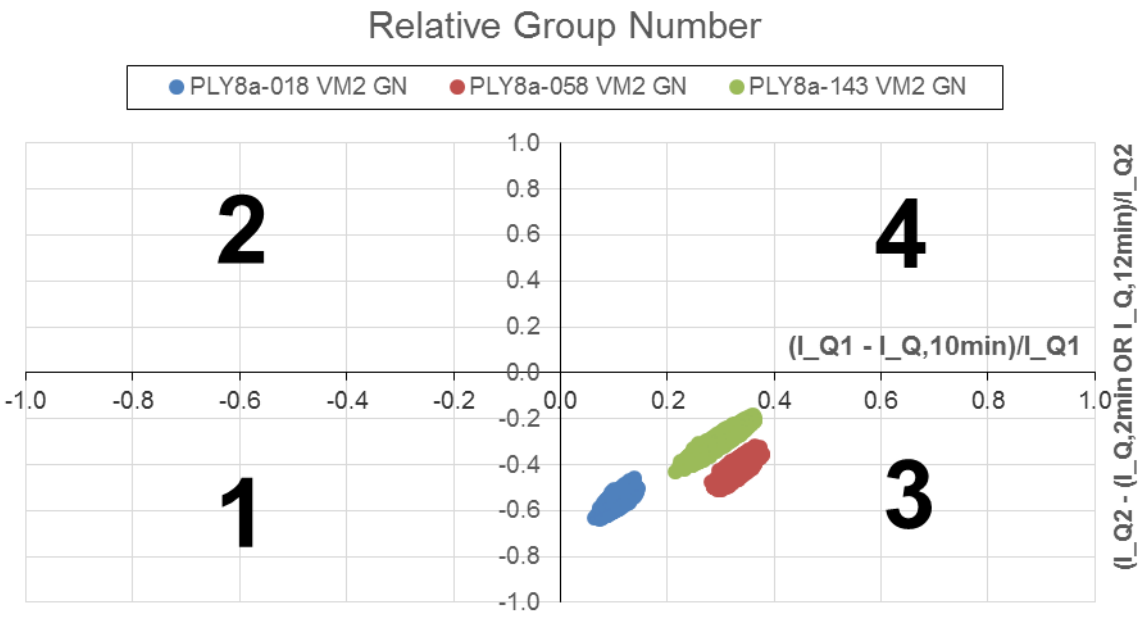

Figure 144 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 10 mm thick plywood samples with eight layers of Paint A

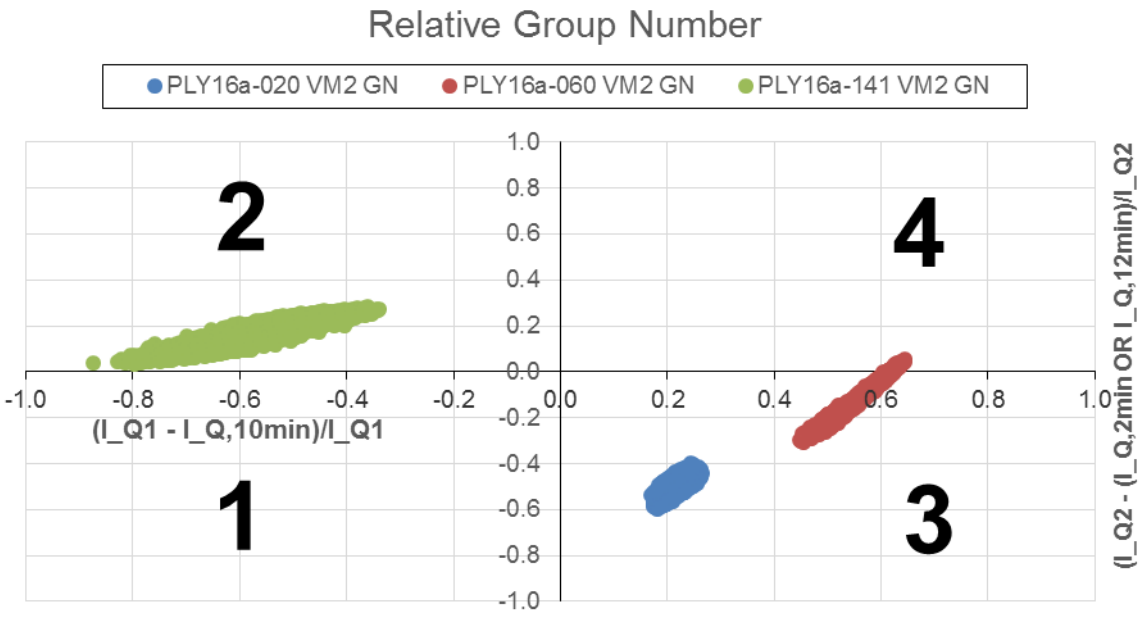

Figure 145 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 10 mm thick plywood samples with 16 layers of Paint A

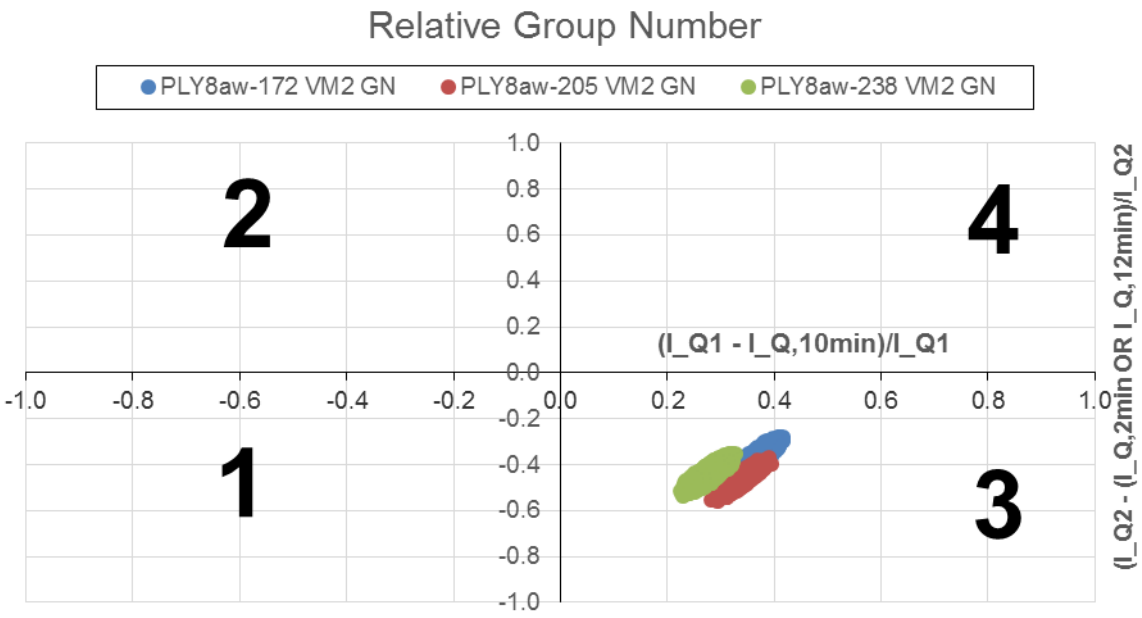

Figure 146 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 10 mm thick plywood samples with eight layers of Paint A, subjected to a simulated aging process

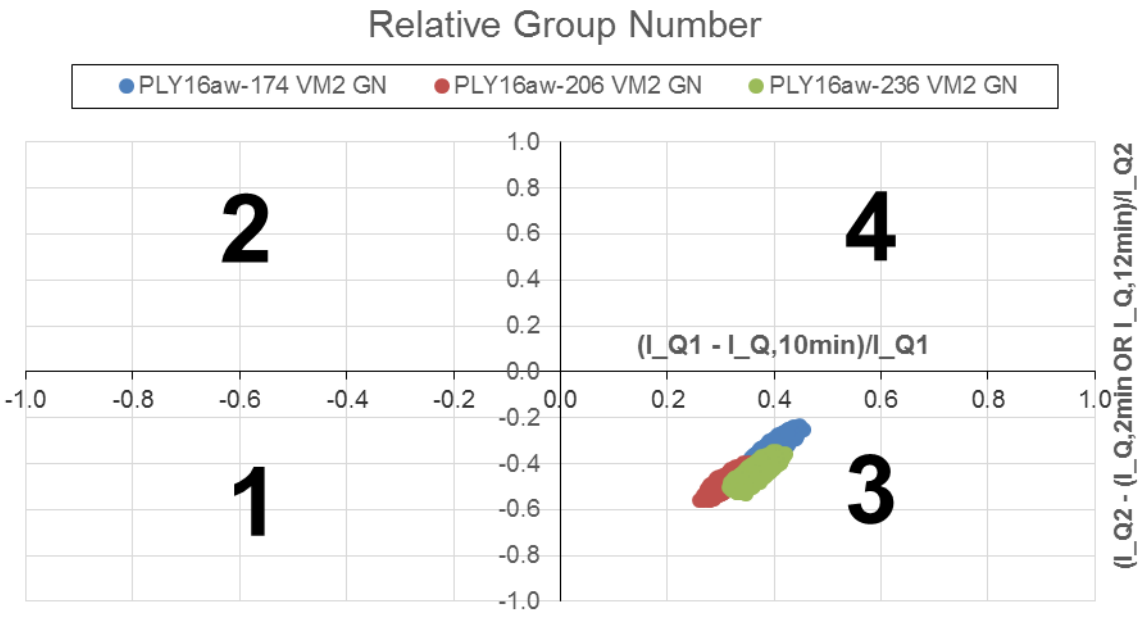

Figure 147 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 10 mm thick plywood samples with 16 layers of Paint A, subjected to a simulated aging process

A.4.2 Paint B

Table 40 Summary table of plywood specimens coated with Paint B test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
ply0-300-1	7	-	0	0	0	22	284.6	58.8	1.5	45	3
ply0-300-2	7	-	0	0	0	20	289.6	60.3	1.6	45	3
ply0-300-3	7	-	0	0	0	28	277.6	58.5	2.4	64	3
ply4b-404-1	7.67	B	4	237	20	15	319.9	82.8	3.4	77	3
ply 4b-404-2	7.68	B	4	268	29	13	362.7	84.9	3.5	85	4
ply4b-404-3	7.71	B	4	270	22	16	361.4	76.7	3.9	89	3
ply4b-410-1	7.79	B	4	330	15	23	305.9	78.7	4.6	109	3
ply 4b-410-2	7.62	B	4	318	9	14	394.1	72.3	4.6	108	4
ply4b-410-3	7.68	B	4	230	14	17	339.7	72.9	3.6	87	4
ply8b-416-1	7.73	B	8	346	11	15	351.7	72.4	4.7	109	4
ply 8b-416-2	7.84	B	8	380	22	15	298.1	70.8	4.2	110	4
ply8b-416-3	7.87	B	8	412	11	21	354.9	72.1	4.7	108	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

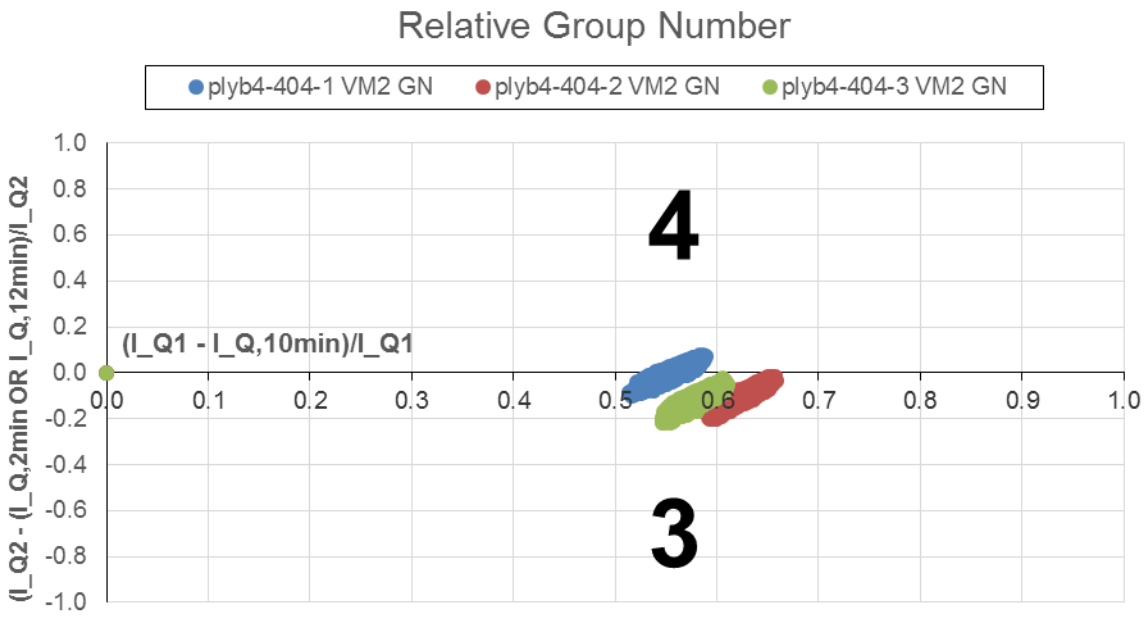

Figure 148 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with four layers of Paint B

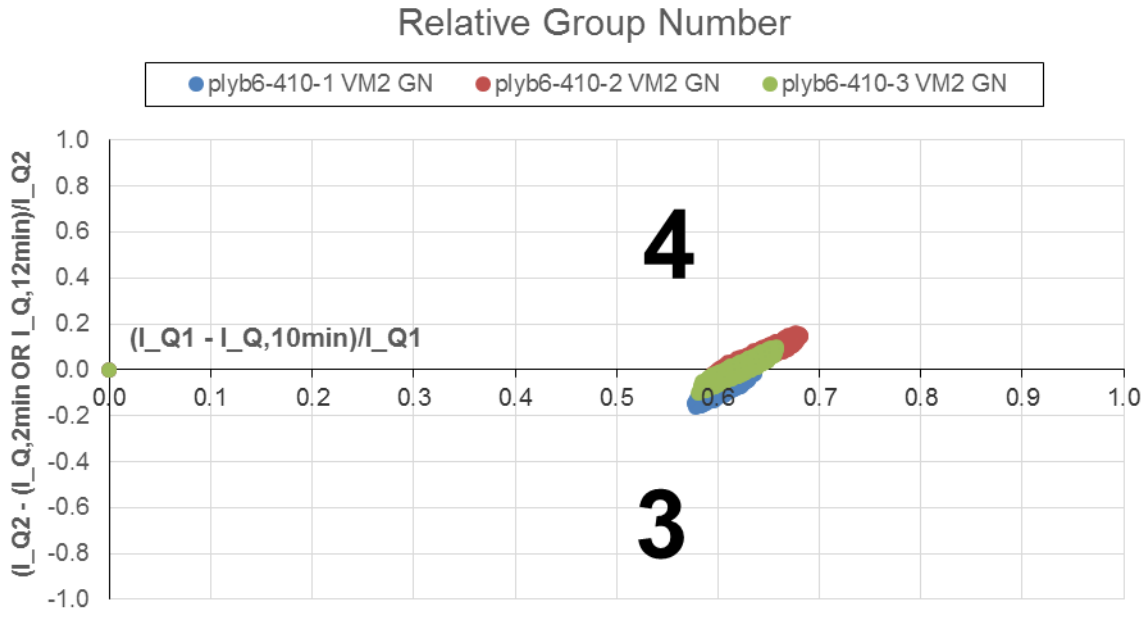

Figure 149 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with six layers of Paint B

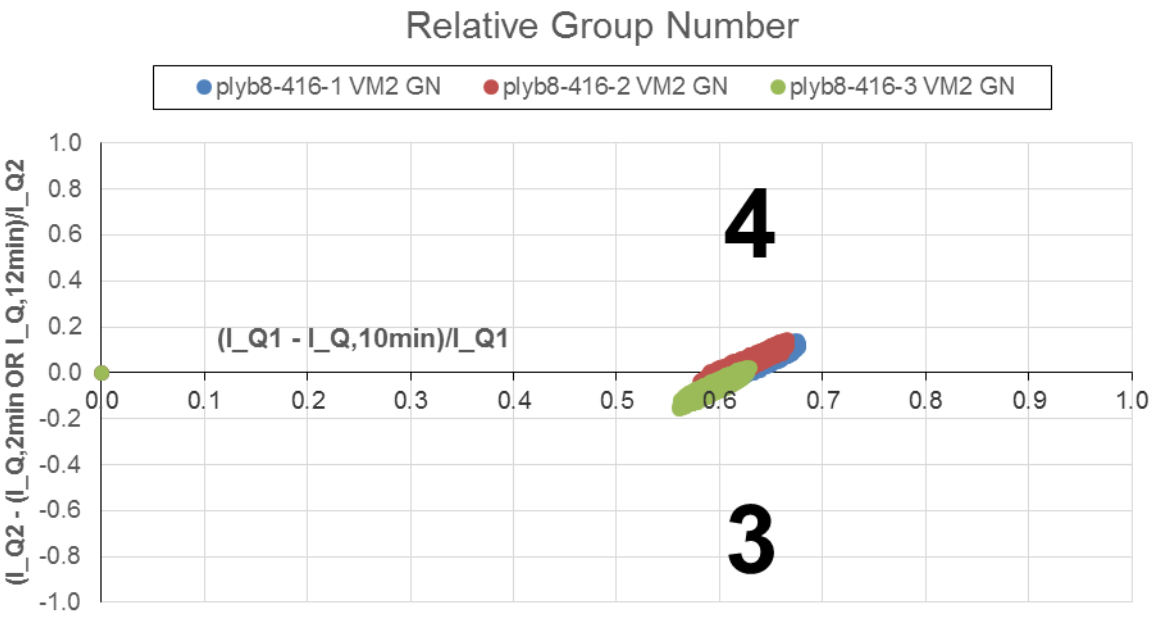

Figure 150 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with eight layers of Paint B

A.4.3 Paint C

Table 41 Summary table of plywood specimens coated with Paint C test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
ply0-300-1		-	0	0	0	22	284.6	58.8	1.5	45	3
ply0-300-2		-	0	0	0	20	289.6	60.3	1.6	45	3
ply0-300-3		-	0	0	0	28	277.6	58.5	2.4	64	3
ply4c-401-1	7.61	C	4	105	14	15	323.6	65.8	1.8	46	3
ply4c-401-2	7.50	C	4	147	26	17	312.1	66.3	2.0	49	3
ply4c-401-3	7.57	C	4	132	39	18	268.1	68.1	2.8	63	3
ply6c-407-1	7.04	C	6	314	21	14	382.5	77.7	2.2	57	4
ply6c-407-2	7.63	C	6	362	26	17	293.2	79.3	2.4	54	3
ply6c-407-3	7.49	C	6	278	11	13	320.2	68.8	2.0	52	4
ply8c-413-1	7.64	C	8	386	10	20	325.3	69.1	2.5	63	3
ply8c-413-2	7.47	C	8	377	9	31	351.1	78.5	3.8	89	3
ply8c-413-3	7.51	C	8	410	8	23	326.9	69.6	2.9	75	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

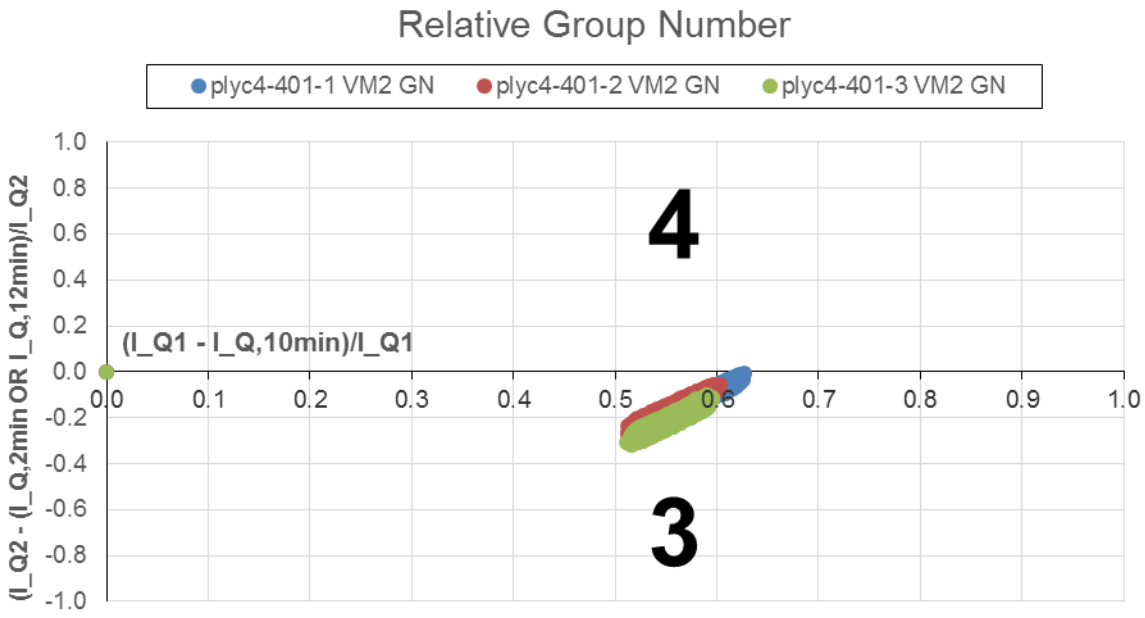

Figure 151 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with four layers of Paint C

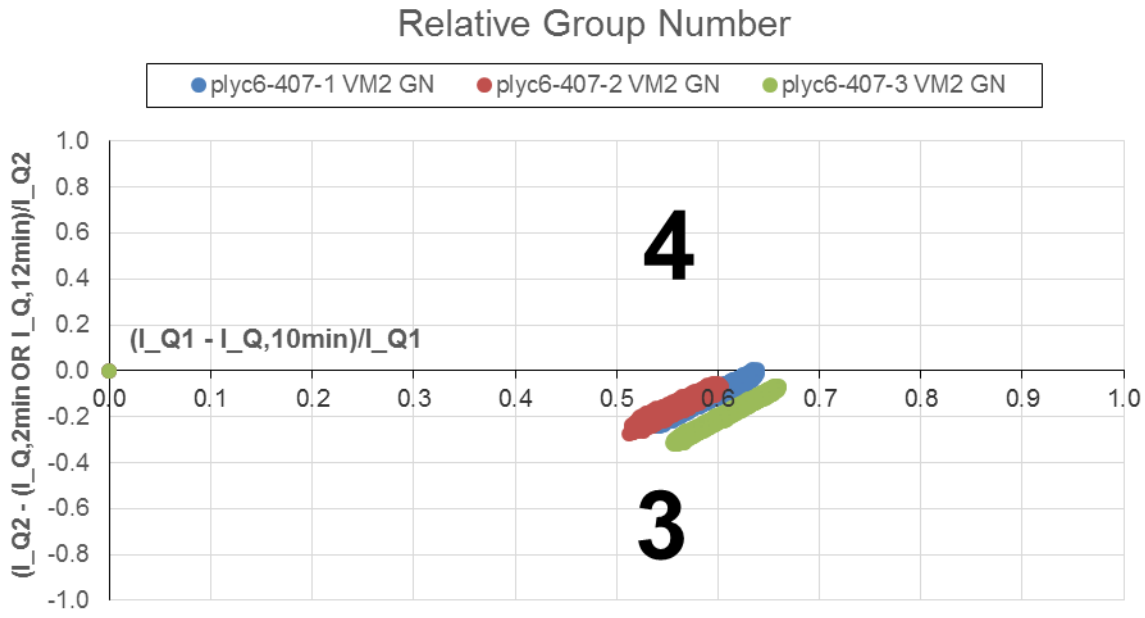

Figure 152 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with six layers of Paint C

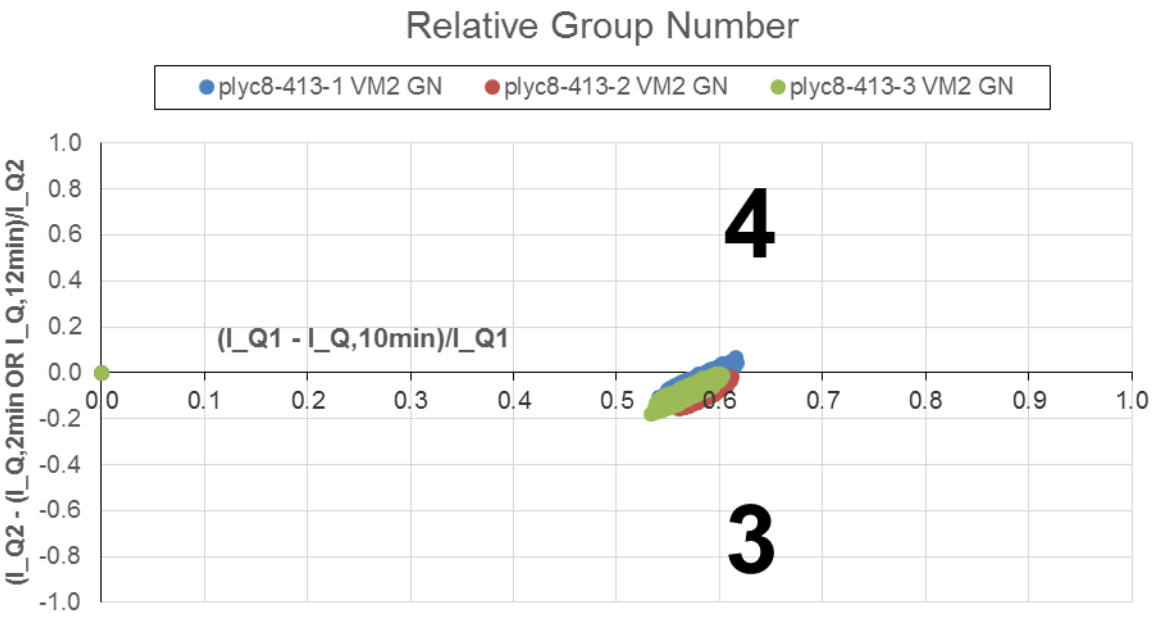

Figure 153 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for 7 mm thick plywood samples with eight layers of Paint C

A.5 Medium Density Fibreboard Samples

Table 42 Summary table of uncoated medium density fibreboard specimens test results (used with Paints B and C)

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
mdf0-302-1	9.1	-	0	0	0	33	370.3	105.2	4.2	65	3
mdf0-302-2	9.2	-	0	0	0	33	355.3	111.0	3.5	54	3
mdf0-302-3	9.3	-	0	0	0	31	306.9	108.6	3.6	67	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

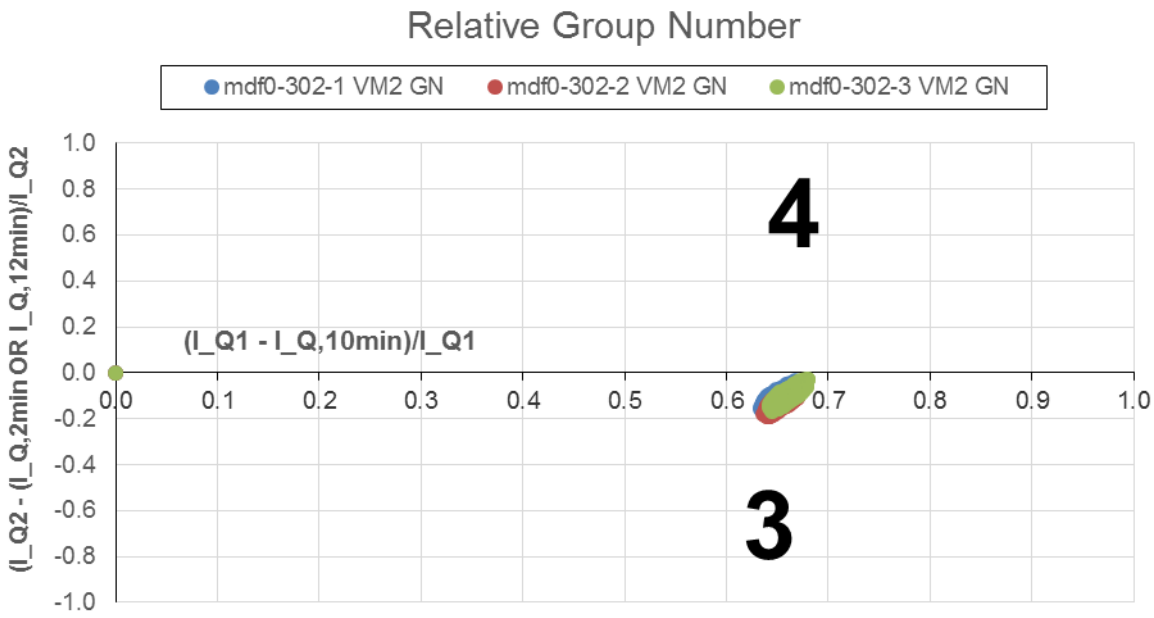

Figure 154 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for uncoated medium density fibreboard samples (used for Paints B and C)

A.5.1 Paint B

Table 43 Summary table of medium density fibreboard specimens coated with Paint B test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
mdf0-302-1	9.1	-	0	0	0	33	370.3	105.2	4.2	65	3
mdf0-302-2	9.2	-	0	0	0	33	355.3	111.0	3.5	54	3
mdf0-302-3	9.3	-	0	0	0	31	306.9	108.6	3.6	67	3
mdf4b-406-1	9.26	b	4	216	37	21	262.1	103.0	3.9	59	3
mdf4b-406-2	9.28	b	4	232	35	18	260.0	105.5	4.3	67	3
mdf4b-406-3	9.23	b	4	280	29	17	300.2	120.2	4.4	68	3
mdf4b-412-1	9.08	b	4	287	12	21	264.9	99.5	6.0	98	3
mdf4b-412-2	9.11	b	4	290	20	22	269.4	102.1	5.7	92	3
mdf4b-412-3	9.1	b	4	213	9	21	266.3	90.8	4.9	83	3
mdf8b-418-1	9.14	b	8	404	7	26	238.3	105.1	5.4	89	3
mdf8b-418-2	9.19	b	8	432	7	19	298.8	113.6	5.8	90	3
mdf8b-418-3	9.28	b	8	444	7	19	254.1	100.4	5.5	92	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

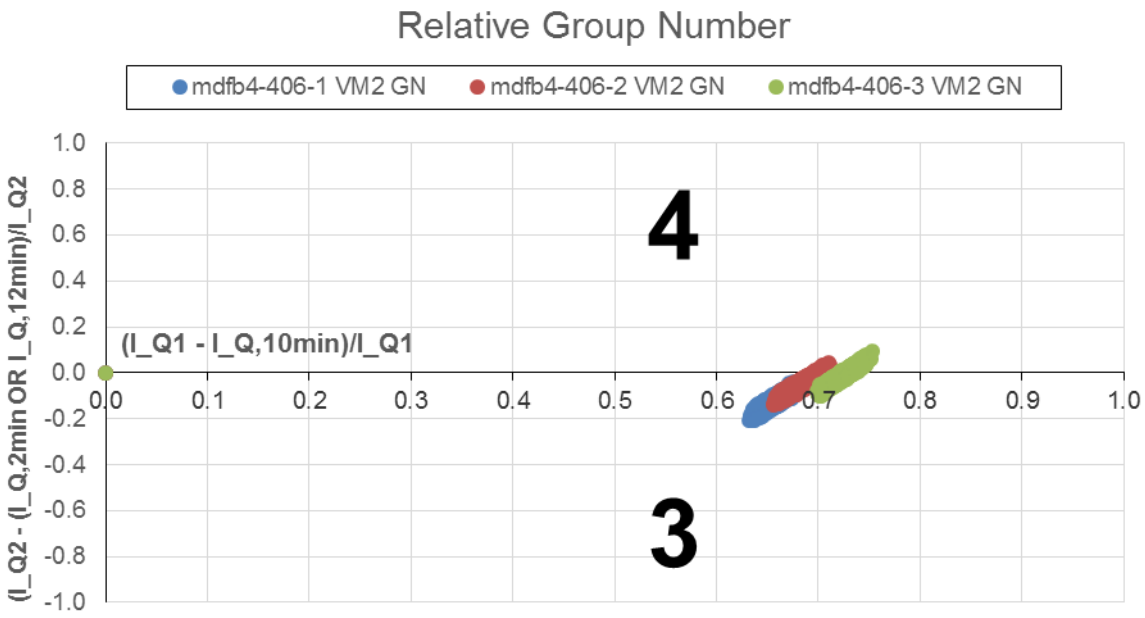

Figure 155 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with four layers of Paint B

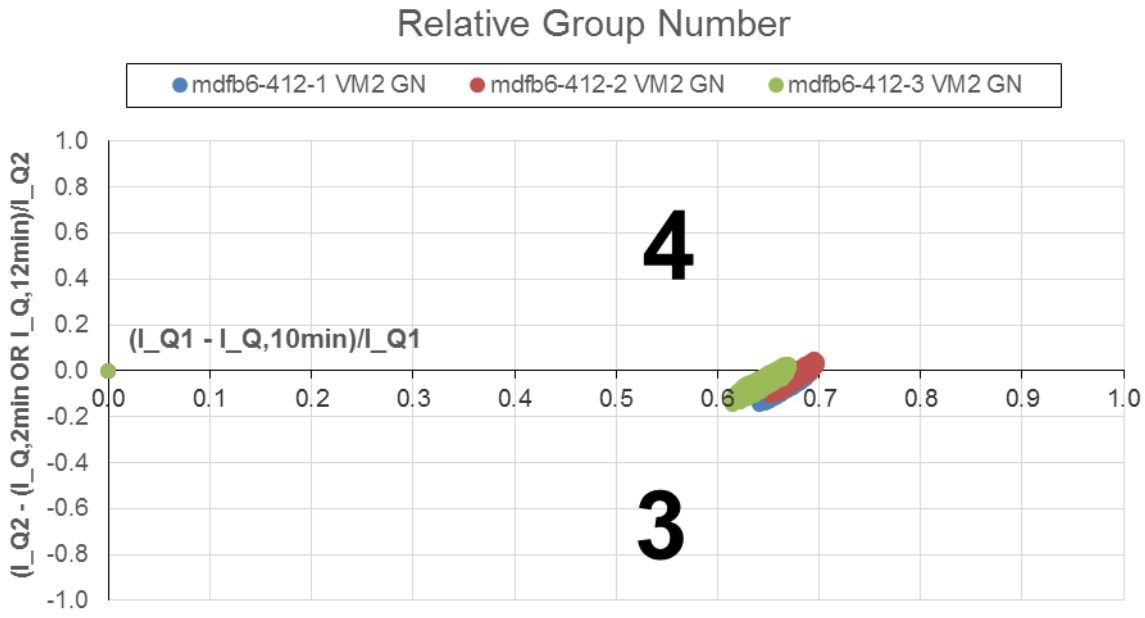

Figure 156 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with six layers of Paint B

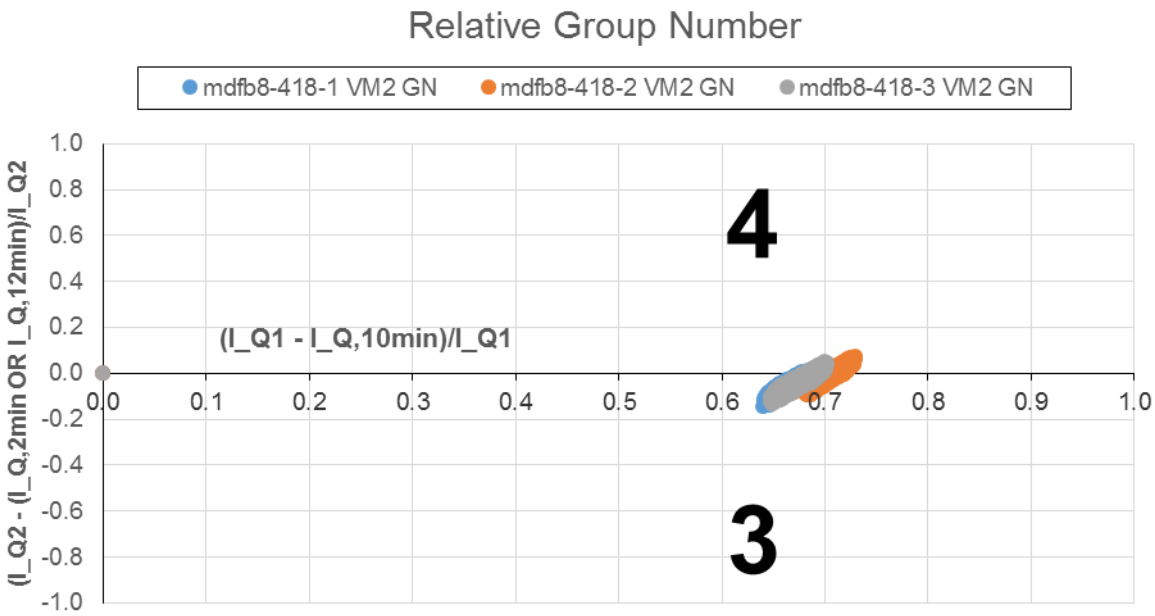

Figure 157 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with eight layers of Paint B

A.5.2 Paint C

Table 44 Summary table of medium density fibreboard specimens coated with Paint C test results

Specimen Label	Total Thickness (mm)	Paint Type	Number of Paint Layers	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
mdf0-302-1		-	0	0	0	33	370.3	105.2	4.2	65	3
mdf0-302-2		-	0	0	0	33	355.3	111.0	3.5	54	3
mdf0-302-3		-	0	0	0	31	306.9	108.6	3.6	67	3
mdf4c-403-1	9.32	C	4	138	30	18	337.2	115.5	3.0	45	3
mdf4c-403-2	9.33	C	4	140	17	26	287.1	110.9	2.2	34	3
mdf4c-403-3	9.25	C	4	157	24	20	307.1	118.5	3.4	51	3
mdf6c-409-1	9.29	C	6	300	7	40	330.1	116.8	3.2	50	3
mdf6c-409-2	9.33	C	6	252	21	39	349.7	109.0	2.8	46	3
mdf6c-409-3	9.34	C	6	230	36	38	367.2	111.8	3.2	52	4
mdf8c-415-1	9.24	C	8	383	19	36	347.3	114.2	3.5	55	3
mdf8c-415-2	9.24	C	8	347	9	35	332.2	106.1	3.3	54	3
mdf8c-415-3	9.18	C	8	365	13	35	355.2	103.8	3.5	58	3

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

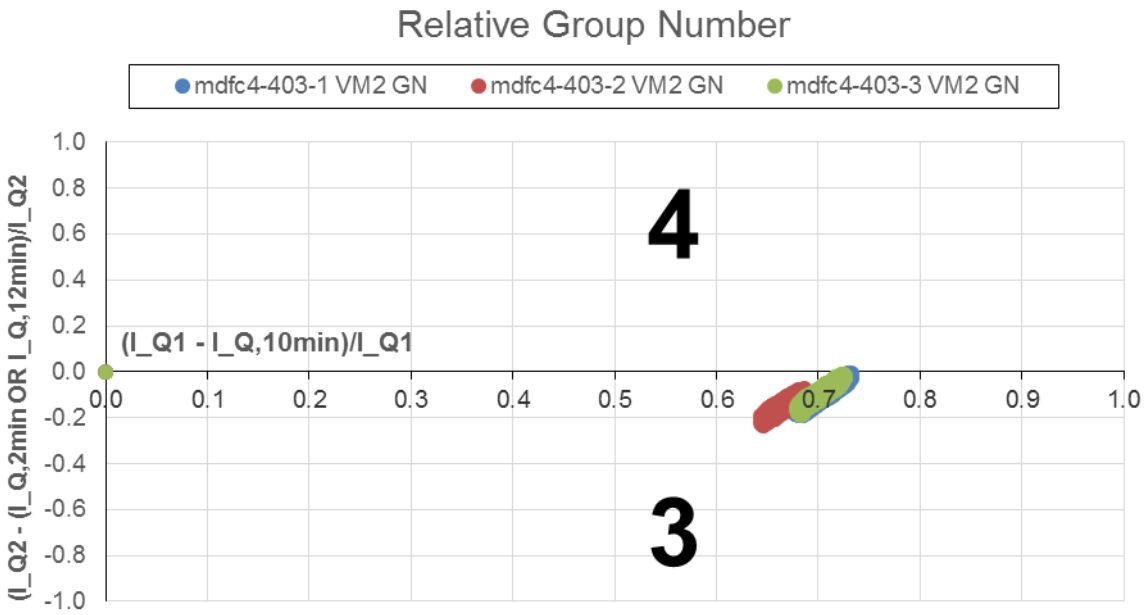

Figure 158 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with four layers of Paint C

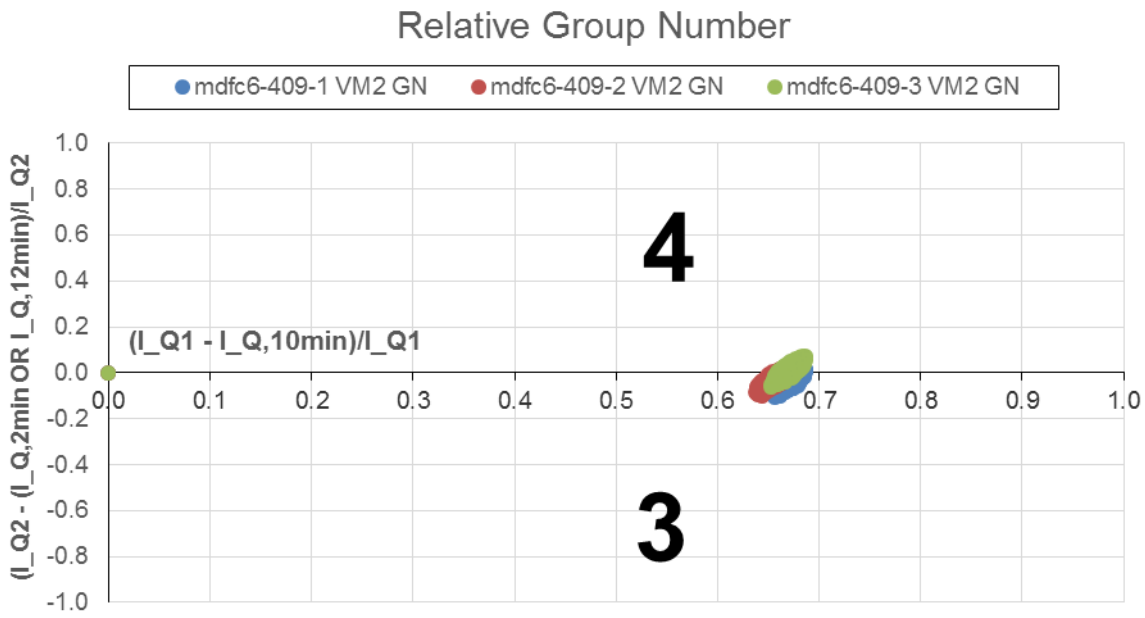

Figure 159 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with six layers of Paint C

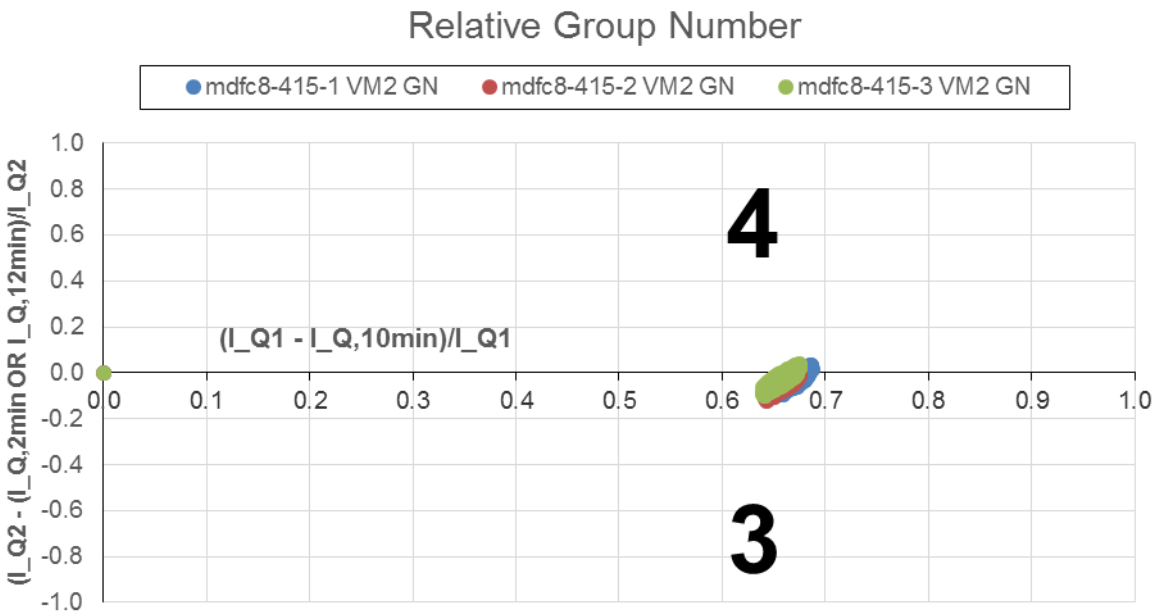

Figure 160 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for medium density fibreboard samples with eight layers of Paint C

A.6 Real World Specimens

Table 45 Summary of real-world specimen test results

Specimen Label	Substrate	Total Thickness (mm)	Total Mass (g)	Average Paint Thickness of Specimen (µm)	Sample Standard Deviation Paint Thickness* (%)	Time to Ignition (s)	Peak HRR (kW/m²)	Total HR (MJ/m²)	Total Smoke (m²)	Specific Extinction Area (m²/kg)	Indicated VM2 Group Number
rws-601-1	plasterboard	9.3	87.6	413	63	20	222.6	14.3	1.1	32	2
rws-601-2		9.6	86.5	315	57	17	228.1	9.5	1.2	63	2
rws-601-3		8.9	82.2	470	36	15	190.0	9.2	0.4	23	2
rws-602-1	plasterboard	9.1	84.3	738	16	15	264.9	10.5	0.7	32	2
rws-602-2		9.5	83.5	615	36	12	199.6	8.1	0.8	40	2
rws-602-3		9.5	84.6	715	21	11	218.4	9.6	0.5	28	2
rws-603-1	hardboard	3.1	35.8	263	16	13	421.1	54.2	3.5	102	3
rws-603-2		3.4	37.7	165	50	15	490.6	62.0	2.8	74	3
rws-603-3		3.4	37.6	183	25	15	442.9	60.3	3.2	82	3
rws-604-1	plasterboard	10.7	75.1	1080	9	56	104.4	3.6	0.1	6	1
rws-604-2		10.7	77	905	16	63	77.1	4.0	0.1	4	1
rws-604-3		10.8	80.4	1305	20	66	46.6	3.5	0.1	8	1
rws-605-1	plasterboard	9.8	71.2	498	21	36	196.5	5.6	0.2	10	1
rws-605-2		10.4	72.6	515	17	35	192.2	7.1	0.3	17	1
rws-605-3		10.3	71.9	535	12	47	172.4	5.7	0.5	31	1

Table Notes:
* Sample standard deviation of paint thickness as a percentage of the average for the specimen. At least four manual measurements were collected for each specimen.

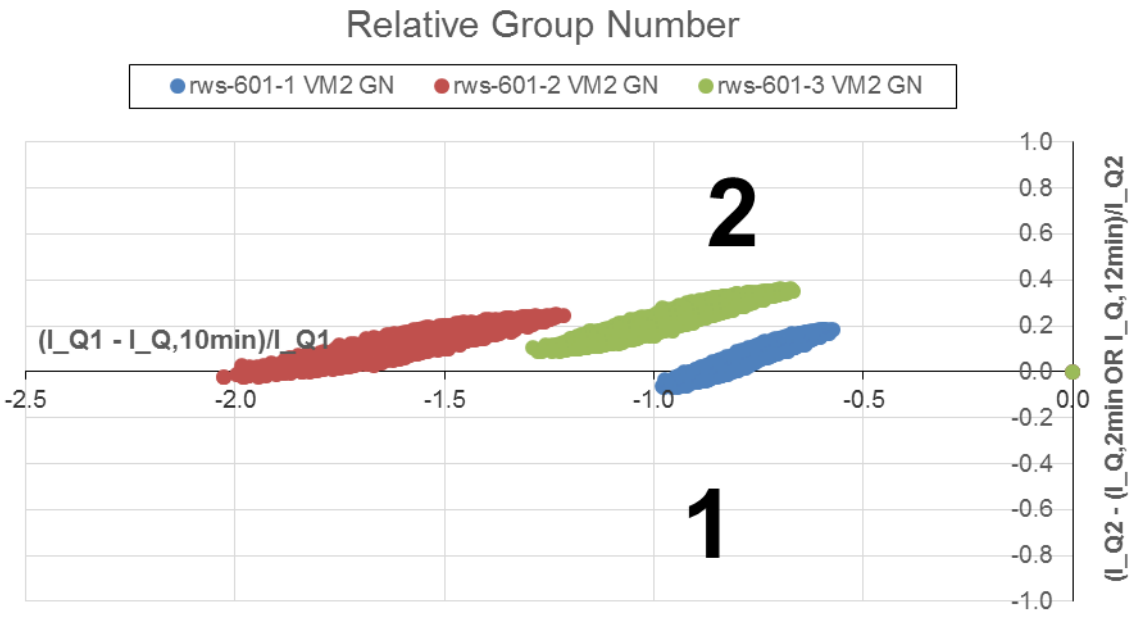

Figure 161 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for the real-world samples rws-601

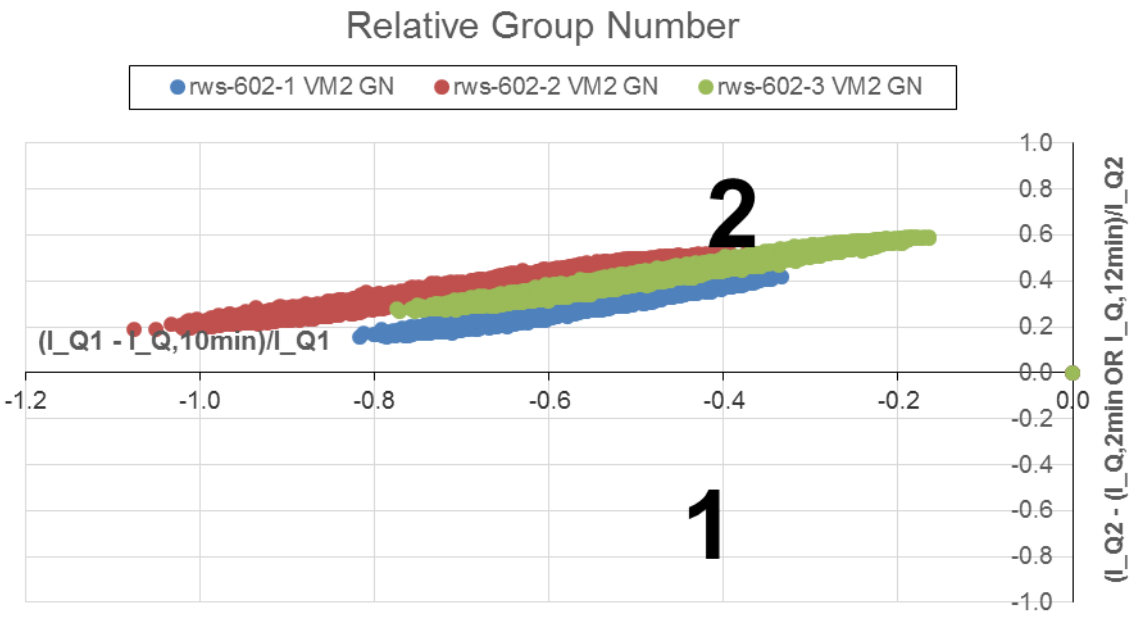

Figure 162 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for the real-world samples rws-602

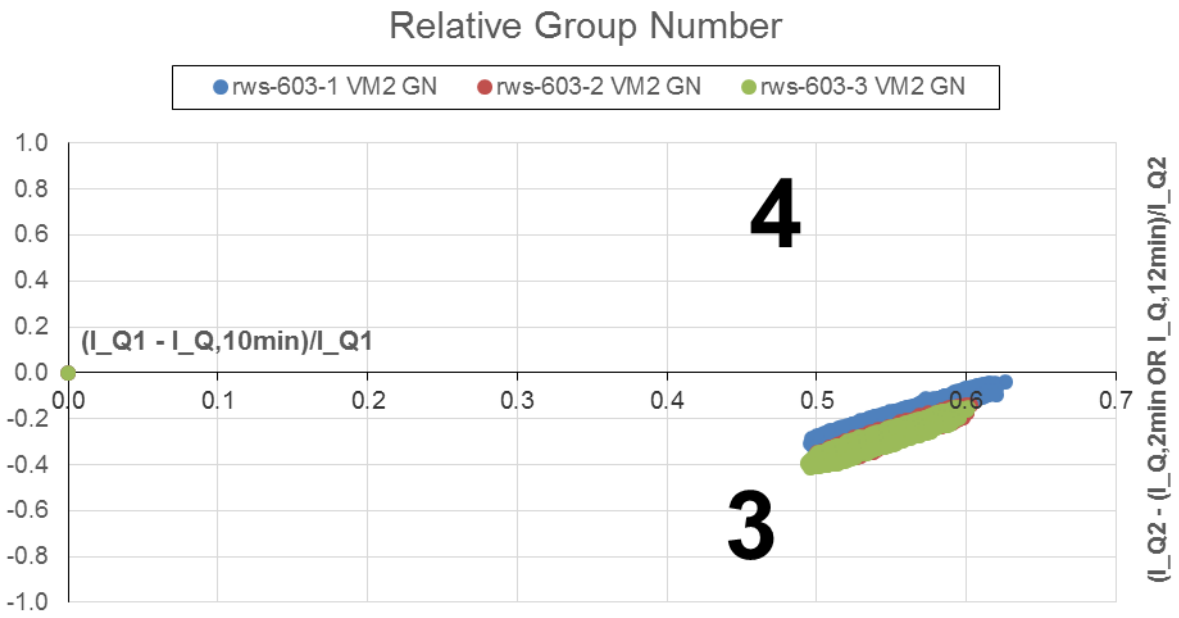

Figure 163 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for the real-world samples rws-603

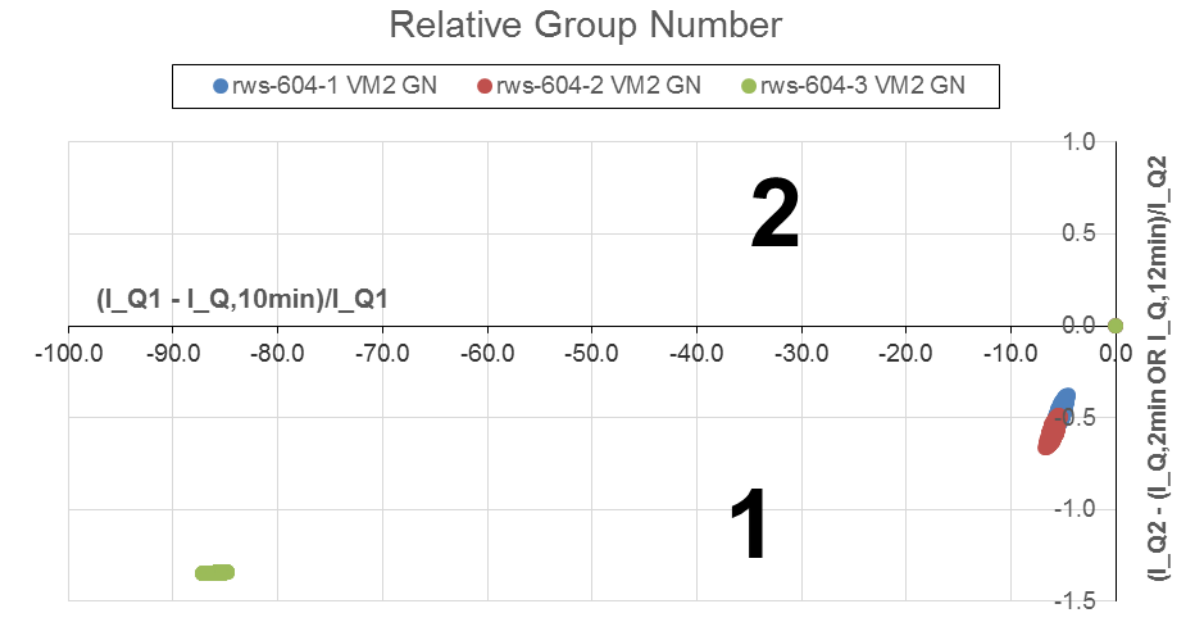

Figure 164 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for the real-world samples rws-604

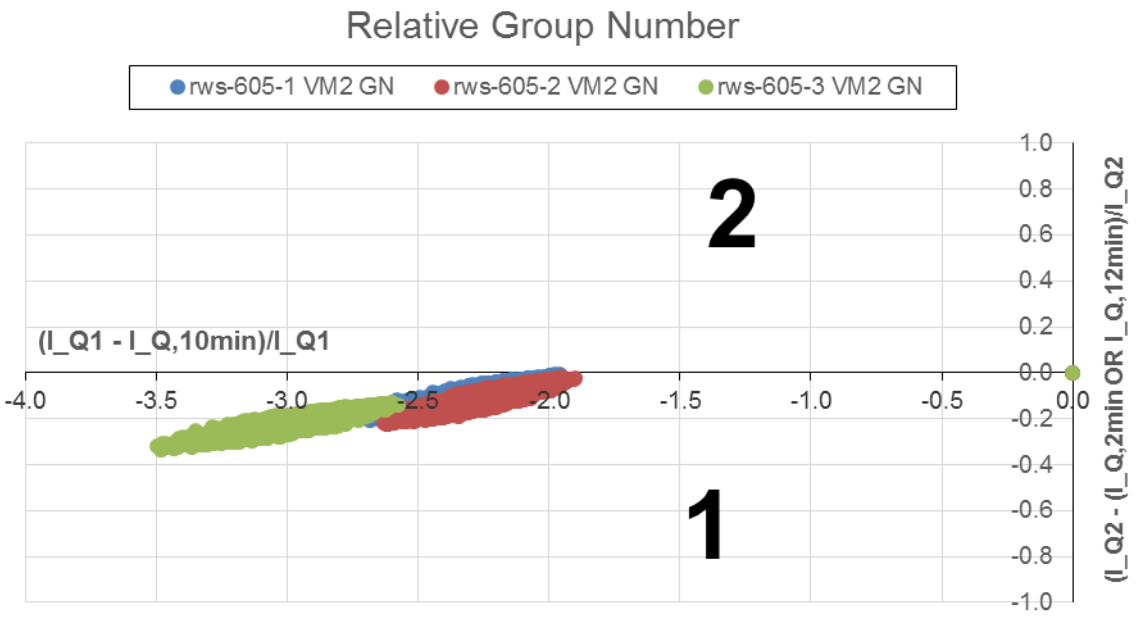

Figure 165 Visual summary of sensitivity analysis performed on the indicated Group Numbers for a ±20% uniform variation in the experimental instantaneous heat release rate and time to ignition for the real-world samples rws-605