



STUDY REPORT

No. 201 (2008)

BRANZFIRE 2008 Compilation of Verification Data

C.A. Wade



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Preface

This report is an update of a previous report 'BRANZFIRE 2004 Compilation of Verification Data' as a result of changes made to the model. The results contained therein apply to BRANZFIRE Version 2008.2.

Acknowledgments

This work was funded by the Building Research Levy and the Foundation for Research, Science and Technology from the Public Good Science Fund.

Note

This report is intended for users of BRANZFIRE software.

BRANZFIRE 2008 Compilation of Verification Data

BRANZ Study Report SR 201

C.A. Wade

Reference

Wade CA. 2008. 'BRANZFIRE 2008 Compilation of Verification Data'.
BRANZ *Study Report 201*. BRANZ Ltd, Judgeford, New Zealand.

Abstract

This report comprises a series of comparisons between experimental data and model predictions using BRANZFIRE 2008.2. The report does not draw detailed conclusions about the acceptability or otherwise of the level of agreement reached and users are left to decide on the applicability of BRANZFIRE to the specific scenario under consideration.

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1. INTRODUCTION

This document is a compilation of verification data for the BRANZFIRE computer fire zone model.

BRANZFIRE is a computer program for simulating the spread of fire and smoke in single or multiple compartments connected to each other or to the outside with vent openings. The fire environment within each compartment is described in terms of a (hot) upper layer and a (cool) lower layer, with each layer assumed to contain homogenous volumes possessing a uniform temperature, density and species concentration at any point in time. Conservation of mass and energy are applied along with numerous empirical correlations and analytical expressions for describing the magnitude of the compartment vent flows, entrainment of air by the fire plume and various other parameters. Depending on the type of scenario selected, the user is either required to provide a heat release rate (HRR) description of the fire (for zone model applications), or provide material bench-scale fire test data (for flame spread applications).

The verification cases presented show comparisons between predictions made using the BRANZFIRE program and experimental measurements obtained from the published literature for various parameters. Readers need to have an appreciation of the uncertainties associated with both the input data used in the model and the accuracy and errors associated with the experiments when drawing conclusions about the level of agreement between model and experiment.

It is generally not possible to completely 'validate' a model for all possible uses and application because of the vast combinations and permutations possible for the wide range of input parameters. However we can provide comparative data for a limited number of configurations for which experimental data is available. It is the aim of this document to summarise some of that data.

The report does not draw detailed conclusions about the acceptability or otherwise of the level of agreement reached and, in general, users are left to decide on the applicability of BRANZFIRE to the specific scenario under consideration.

2. SINGLE ROOM WITH A VENT

2.1 VERIFICATION CASE 2-1

2.1.1 Reference

Steckler KD, Baum HR and Quintiere JG. 1983. 'Fire Induced Flows Through Room Openings – Flow Coefficients'. *NBSIR 83-2801*. National Bureau of Standards, USA.

2.1.2 Description

Steckler, Baum and Quintiere carried out a series of steady state experiments using a methane gas burner located at the centre of a room 2.8 m wide x 2.8 m long x 2.13 m high. The room was lined with a ceramic fibre insulation board. The room had a single vent opening, the size of which was able to be varied. The output from the methane burner was steady at 61.9 kW (Tests 1–10), 31.6 kW (Test 11), 105.3 kW (Test 12) and 158 kW (Test 13).

2.1.3 Input files

Steck1.mod – Steck13.mod

2.1.4 Comparison

Figure 1 and Table 1 compare the predicted and experimental data for the layer interface height, upper and lower layer temperatures, and mass flow leaving the vent. The predictions and experimental data are compared at 30 minutes. It is noted that Test 10 produced an outlier for the predicted layer height. The reason for this was not obvious, apart from the observation that the vent flow was a 'choked flow' situation where the layer height was below the sill elevation of the opening.

Figure 1. Comparison of steady state measured and predicted values

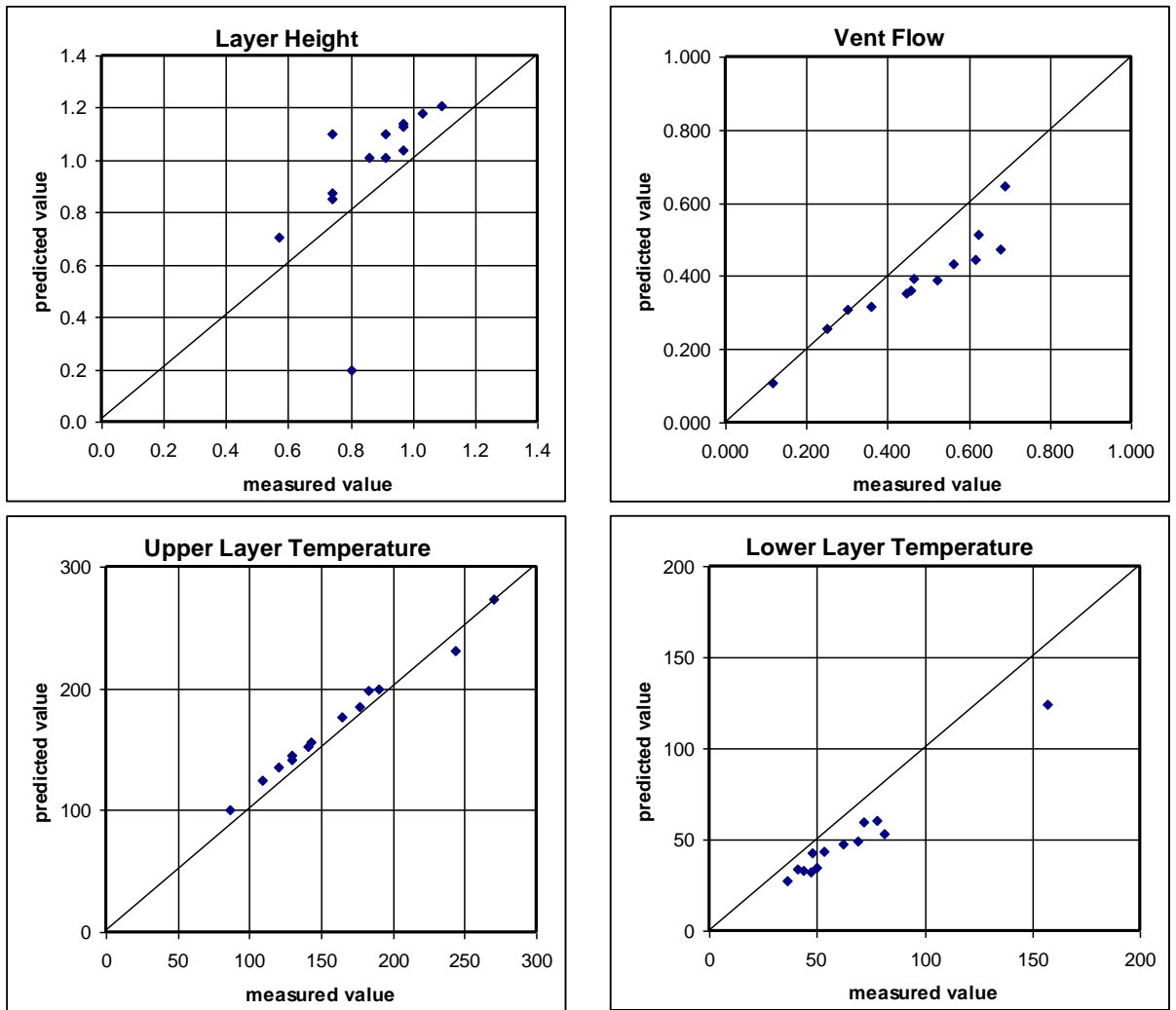


Table 1. Comparison of results for steady state conditions

	Experiment	BRANZFIRE Prediction (Version 2008.2)
Test 1: Fire size = 62.9 kW, Vent 0.24 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 26°C		
Interface height (m)	0.57 ± 0.28	0.70
Upper temp (°C)	190	200
Lower temp (°C)	72	60
Vent flow (kg/sec)	0.251	0.258
Test 2: Fire size = 62.9 kW, Vent 0.36 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 28°C		
Interface height (m)	0.74 ± 0.23	0.88
Upper temp (°C)	164	177
Lower temp (°C)	62	48
Vent flow (kg/sec)	0.358	0.316
Test 3: Fire size = 62.9 kW, Vent 0.49 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 22°C		
Interface height (m)	0.86 ± 0.28	1.01
Upper temp (°C)	141	153
Lower temp (°C)	50	35
Vent flow (kg/sec)	0.457	0.361
Test 4: Fire size = 62.9 kW, Vent 0.62 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 23°C		
Interface height (m)	0.91 ± 0.17	1.10
Upper temp (°C)	129	145
Lower temp (°C)	47	33
Vent flow (kg/sec)	0.523	0.391
Test 5: Fire size = 62.9 kW, Vent 0.74 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 29°C		
Interface height (m)	0.97 ± 0.23	1.13
Upper temp (°C)	129	142
Lower temp (°C)	48	42
Vent flow (kg/sec)	0.563	0.435

Test 6: Fire size = 62.9 kW, Vent 0.86 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 26°C		
Interface height (m)	1.03 ± 0.17	1.18
Upper temp (°C)	120	136
Lower temp (°C)	44	33
Vent flow (kg/sec)	0.616	0.447
Test 7: Fire size = 62.9 kW, Vent 0.99 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 22°C		
Interface height (m)	1.09 ± 0.23	1.21
Upper temp (°C)	109	125
Lower temp (°C)	36	28
Vent flow (kg/sec)	0.677	0.474
Test 8: Fire size = 62.9 kW, Vent 0.74 m wide x 1.38 m high with sill at 0.45 m, Ambient temperature = 30°C		
Interface height (m)	0.74 ± 0.34	1.10
Upper temp (°C)	143	156
Lower temp (°C)	53	44
Vent flow (kg/sec)	0.464	0.394
Test 9: Fire size = 62.9 kW, Vent 0.74 m wide x 0.92 m high with sill at 0.91 m, Ambient temperature = 26°C		
Interface height (m)	0.74 ± 0.34	0.85
Upper temp (°C)	177	185
Lower temp (°C)	78	60
Vent flow (kg/sec)	0.302	0.308
Test 10: Fire size = 62.9 kW, Vent 0.74 m wide x 0.46 m high with sill at 1.37 m, Ambient temperature = 16°C		
Interface height (m)	0.80 ± 0.17	0.20
Upper temp (°C)	270	273
Lower temp (°C)	157	124
Vent flow (kg/sec)	0.117	0.110

Test 11: Fire size = 31.6 kW, Vent 0.74 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 29°C		
Interface height (m)	0.97 ± 0.11	1.14
Upper temp (°C)	86	101
Lower temp (°C)	41	34
Vent flow (kg/sec)	0.446	0.354
Test 12: Fire size = 105.3 kW, Vent 0.74 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 35°C		
Interface height (m)	0.97 ± 0.11	1.04
Upper temp (°C)	183	198
Lower temp (°C)	69	49
Vent flow (kg/sec)	0.624	0.516
Test 13: Fire size = 158 kW, Vent 0.86 m wide x 1.83 m high with sill at 0 m, Ambient temperature = 36°C		
Interface height (m)	0.91 ± 0.17	1.01
Upper temp (°C)	243	231
Lower temp (°C)	81	53
Vent flow (kg/sec)	0.688	0.648

3. MULTI-ROOM SCENARIO

3.1 VERIFICATION CASE 3-1

3.1.1 Reference

Peacock RD, Davis S and Lee BT. 1988. 'An Experimental Data Set for the Accuracy Assessment of Room Fire Models'. *NBSIR 88-3752*. National Bureau of Standards, USA.

3.1.2 Description

The experiments were conducted in a three compartment configuration, with two smaller rooms opening off a corridor 12.4 m long. Details of room dimensions and construction materials may be found in Tables 1 and 2 of Peacock, Davis and Lee.

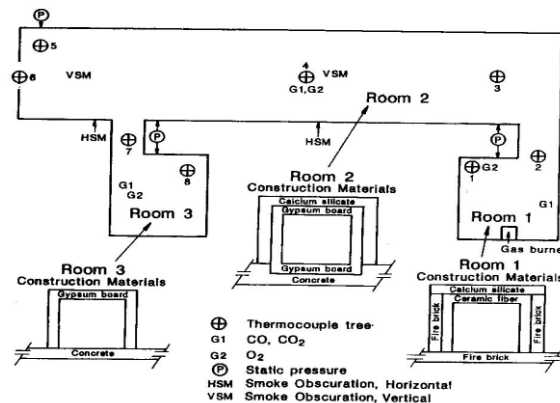


Figure 2. Experimental layout and instrumentation configuration for gas burner tests

The structure was instrumented to provide data on temperatures and mass and heat flows in a simple multi-room configuration. There were a total of eight thermocouples strategically positioned within the three rooms.

3.1.3 Input files

100Jo.mod, 300Do.mod, 500Ao.mod

3.1.4 Comparison

BRANZFIRE predictions used the measured HRR from the experiments and assumed the gas fuel was a mixture of methane and acetylene as indicated in the report. The radiant loss fraction was taken as 0.23; the net heat of combustion as 45.6 kJ/g; the soot yield as 0.049 g/g; and the CO₂ yield as 2.67 g/g.

The experiments were modelled as five connected compartments, with the two sub-passageways connecting the rooms to the corridor represented as separate rooms in the model.

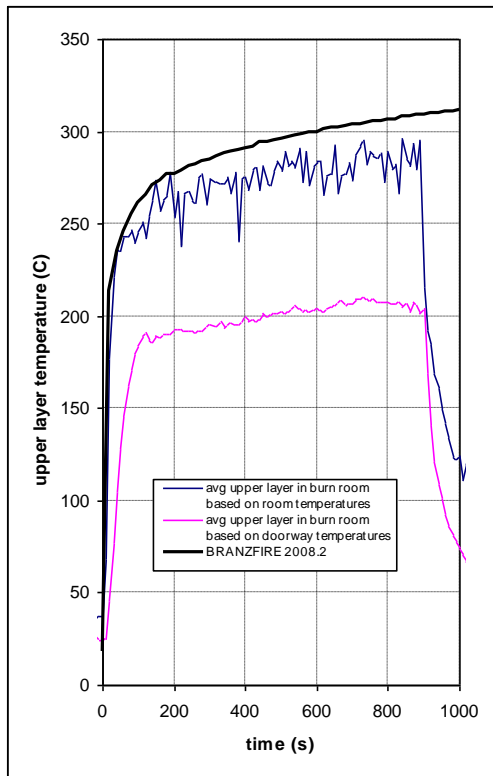
A summary of the experiments presented is shown in Table 2.

Table 2. Summary of experiments

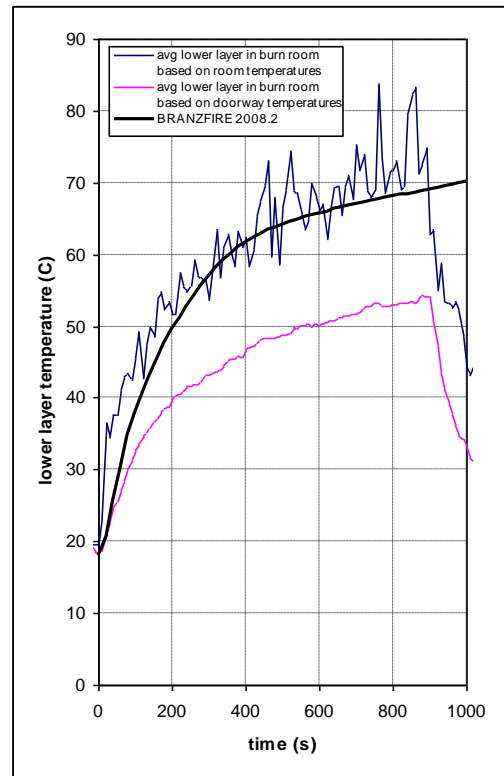
Test ID	Nominal fire size	Corridor exit	Door to Room 3
Set 1 – 100J (Figure 3)	100 kW	Open	Closed
Set 6 – 300D (Figure 4)	300 kW	Closed	Open
Set 8 – 500A (Figure 5)	500 kW	Open	Closed

Figure 3. Test 100J

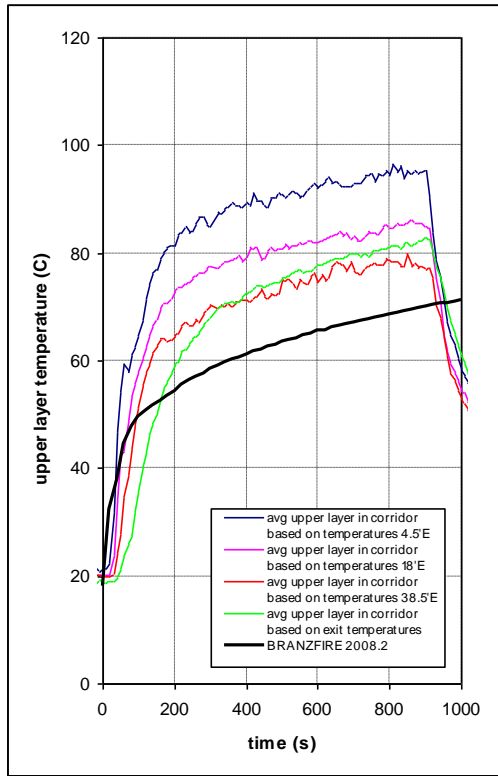
Comparison of predicted and measured parameters in the burn room and corridor for Set 1 – 100J (100 kW, corridor exit door open and third room closed).



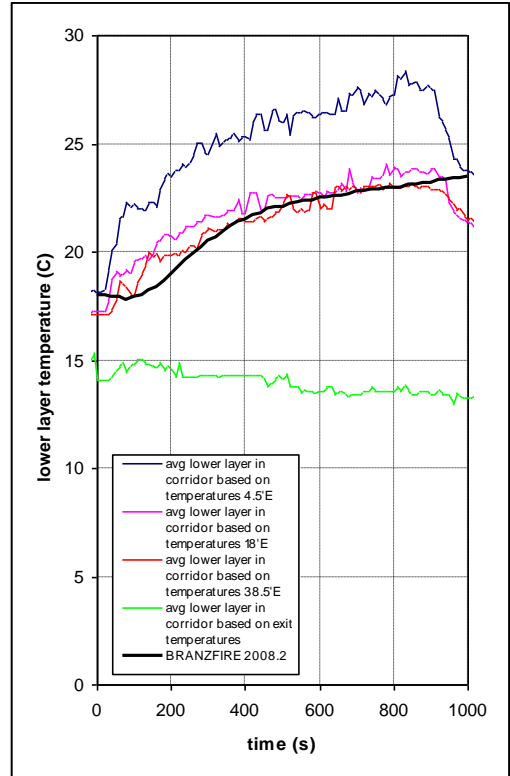
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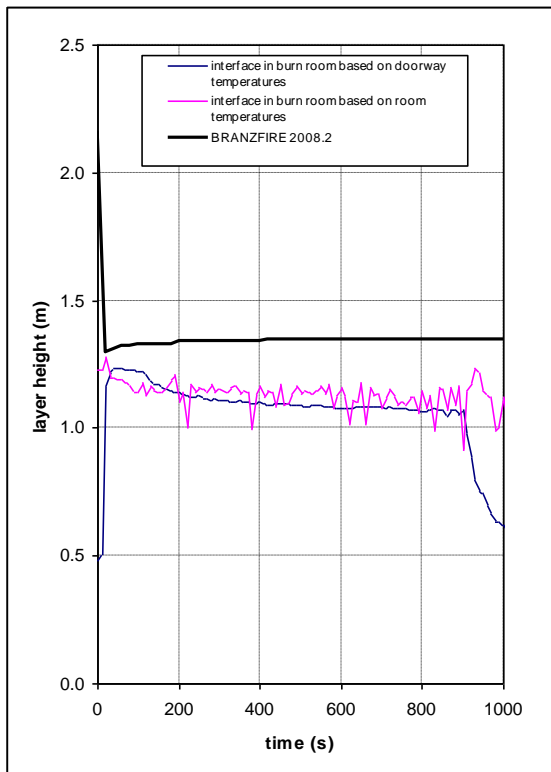
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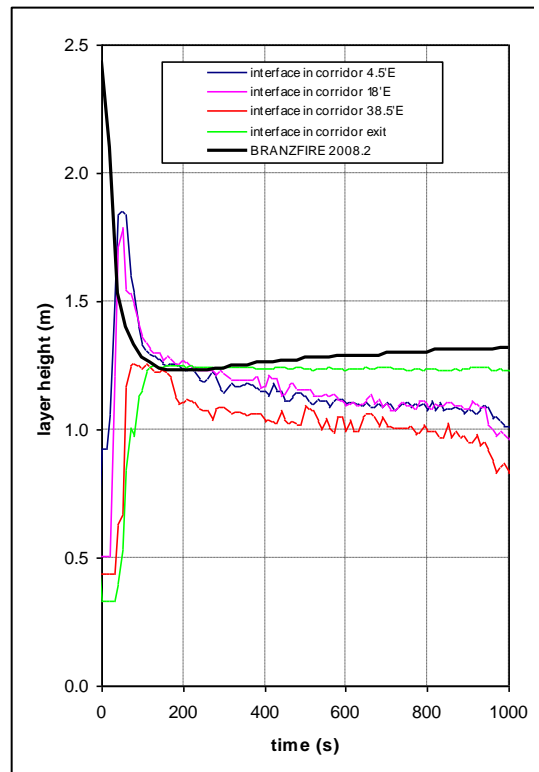
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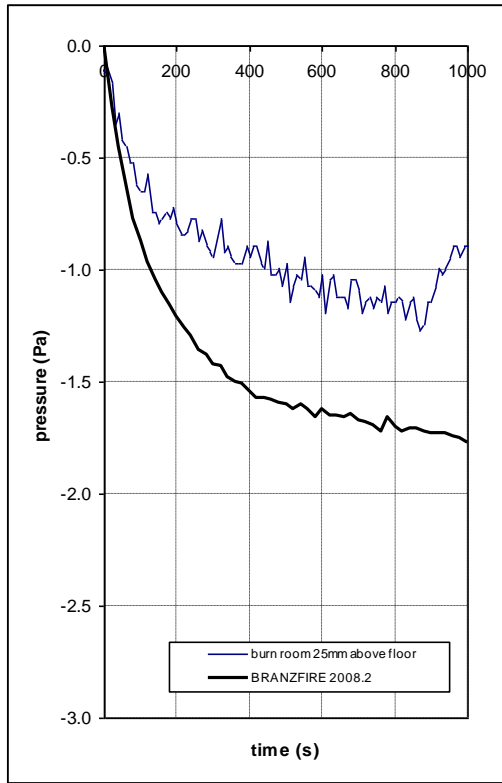
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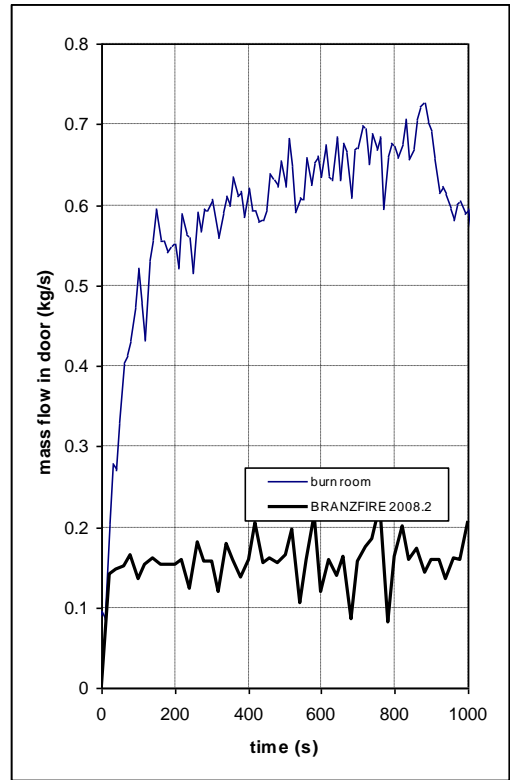
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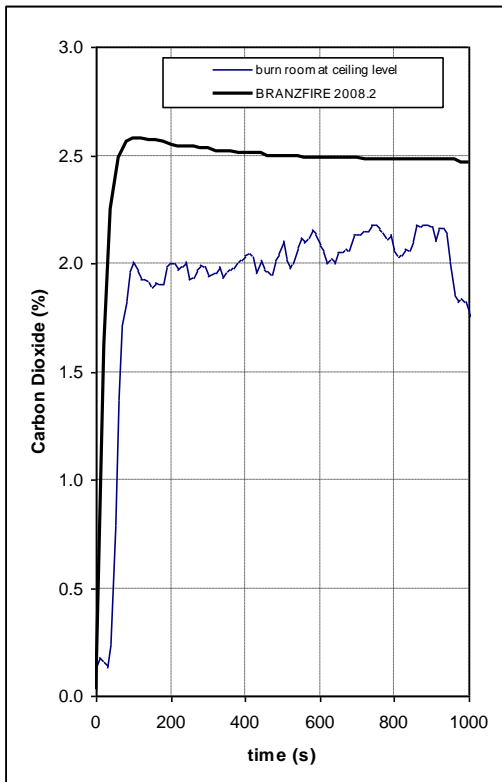
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(g)



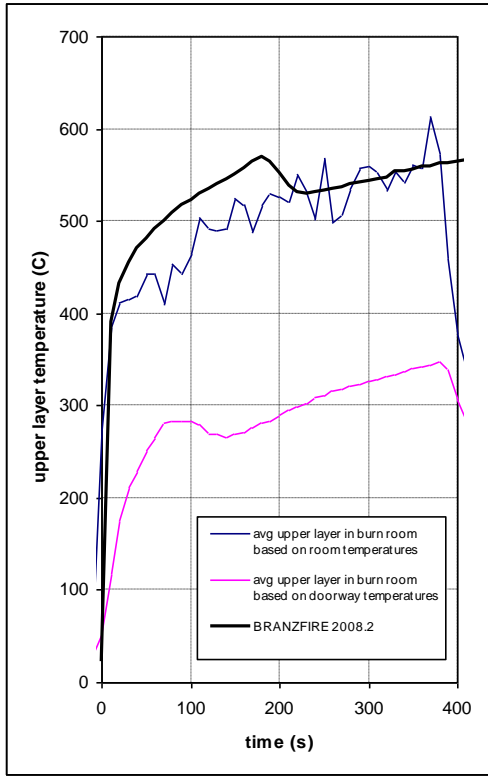
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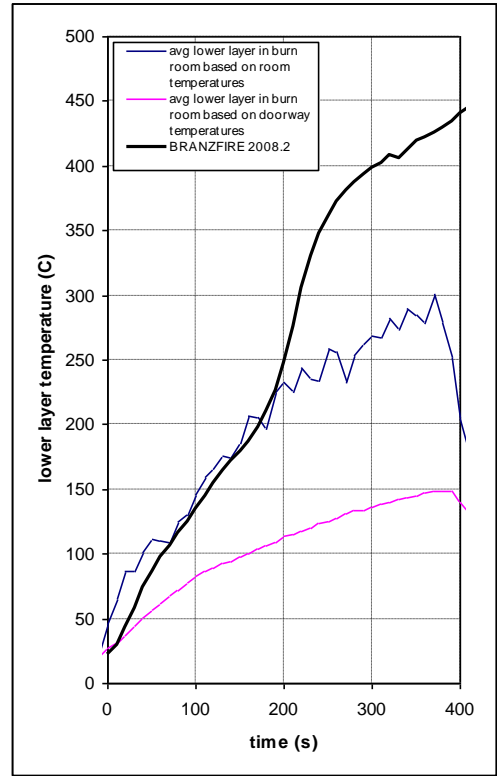
(i)

Figure 4. Test 300D

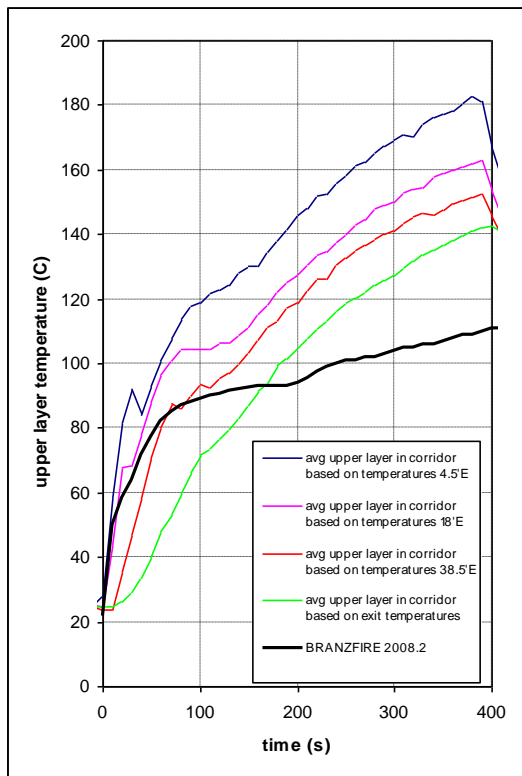
Comparison of predicted and measured parameters in the burn room and corridor for Set 6 –300D (300 kW, corridor exit door closed and third room open).



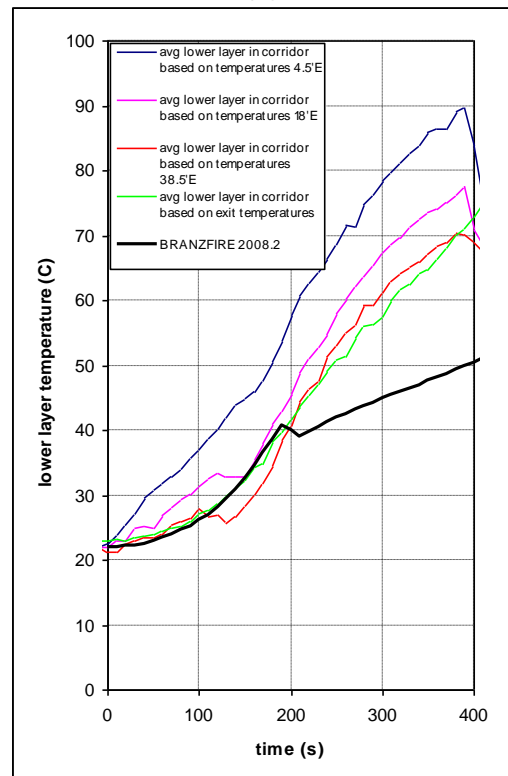
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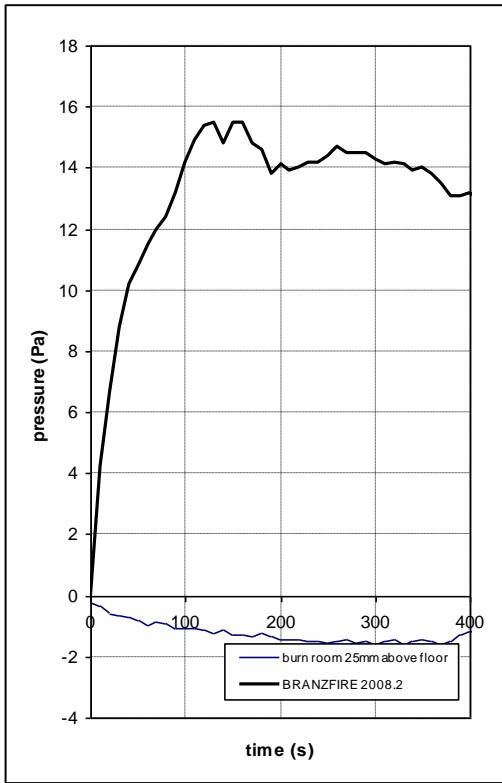
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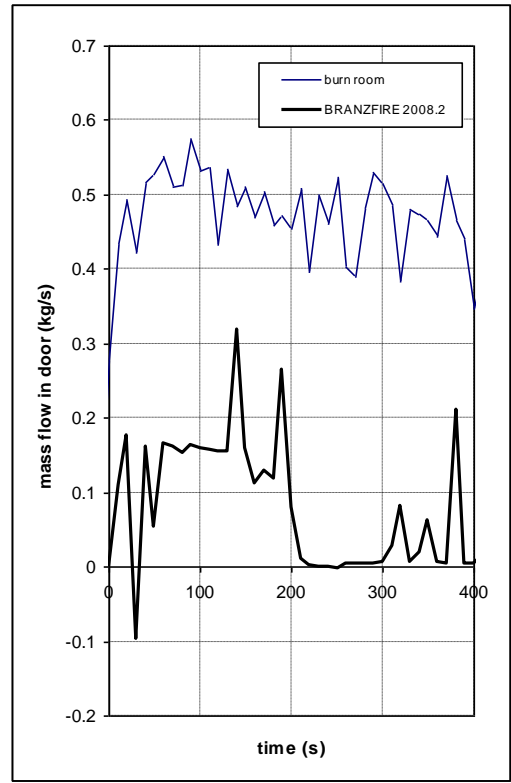
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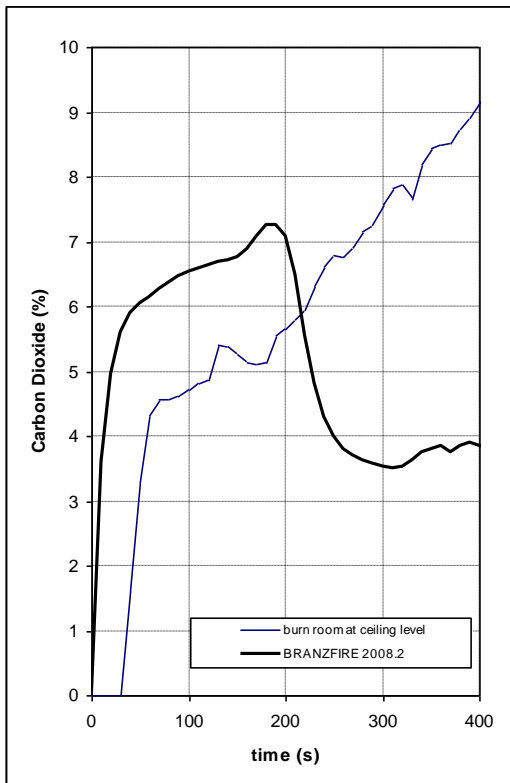
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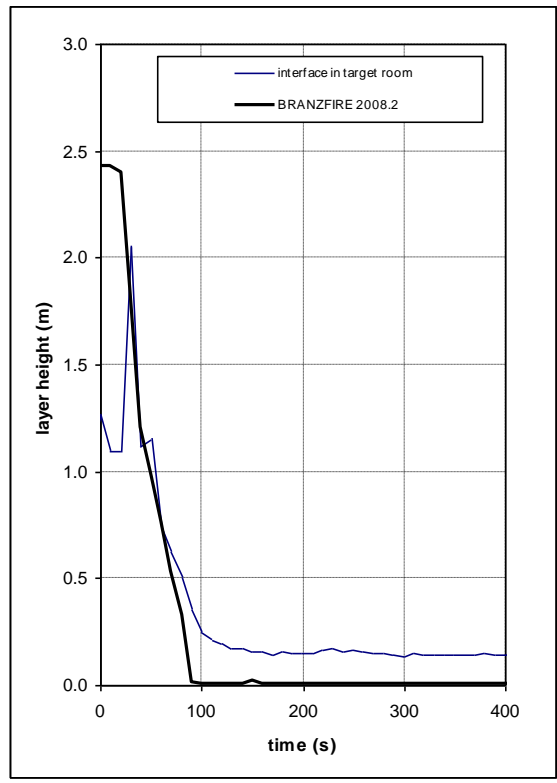
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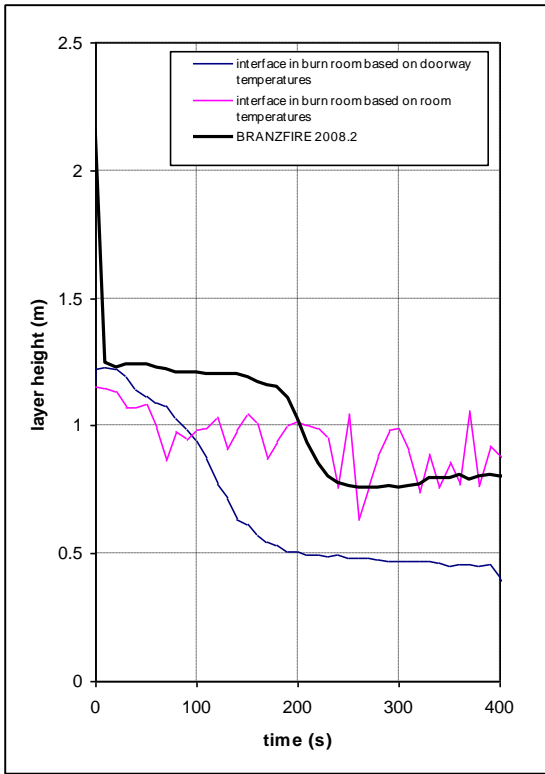
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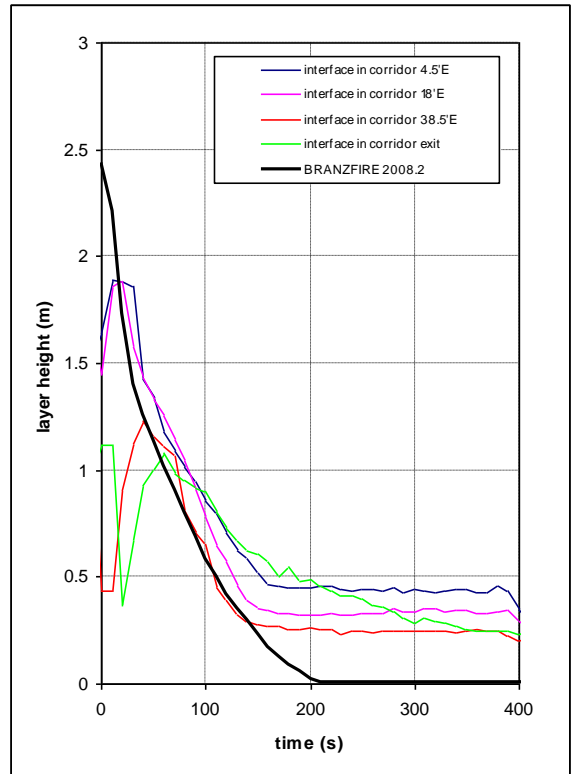
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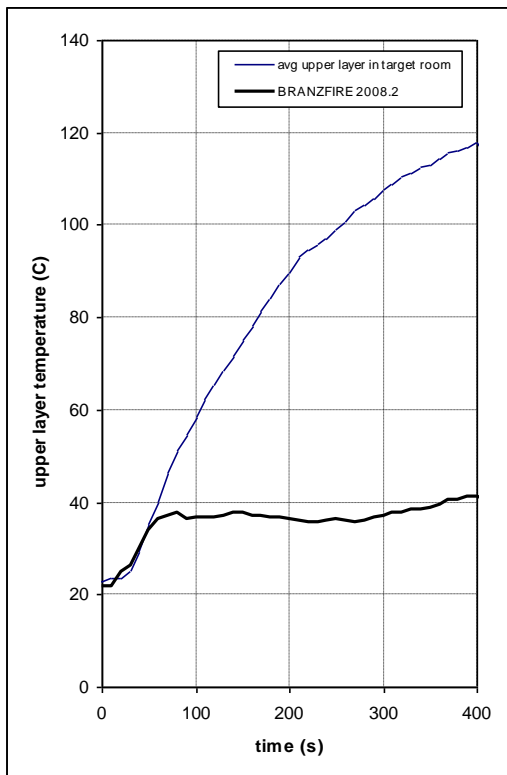
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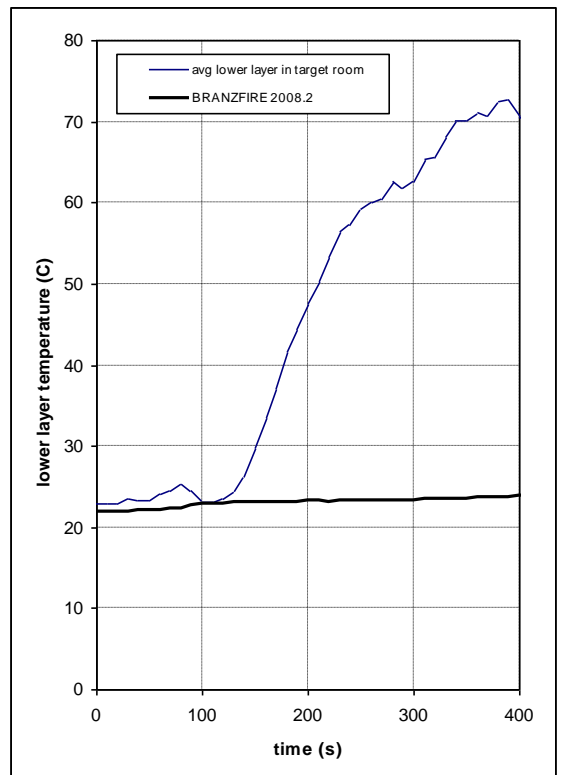
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(j)



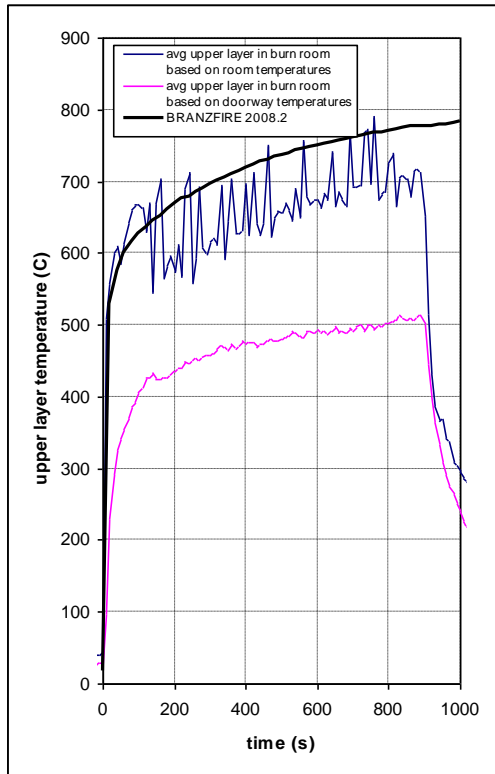
(k)



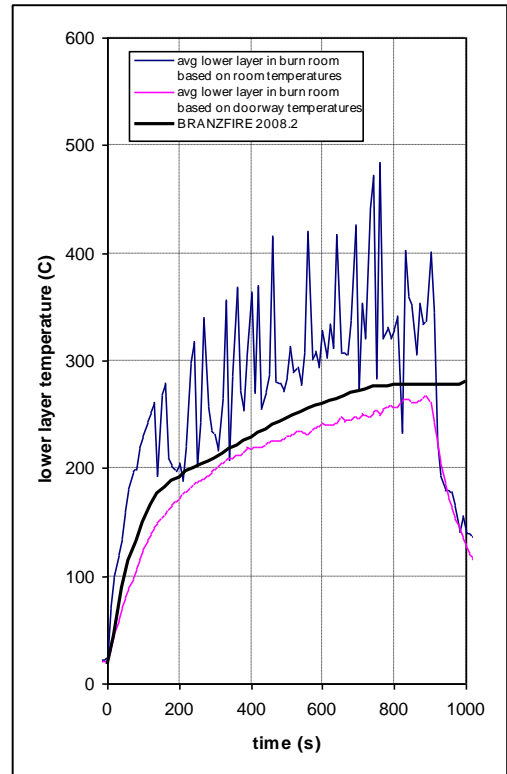
(l)

Figure 5. Test 500A

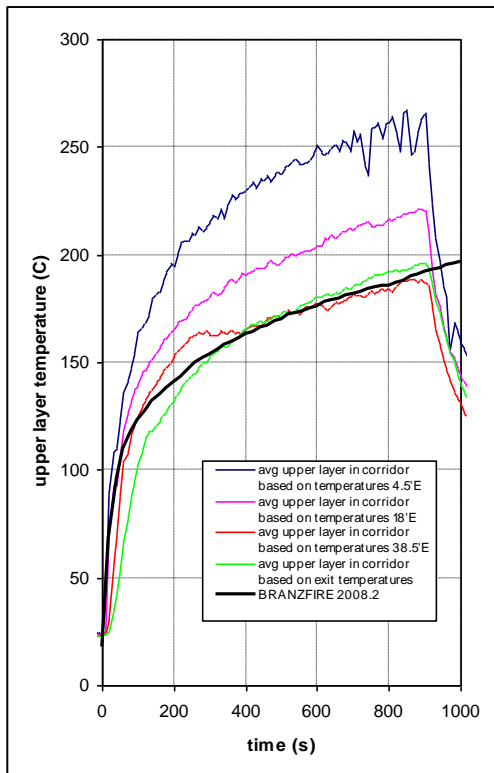
Comparison of predicted and measured parameters in the burn room and corridor for Set 8 –500A (500 kW, corridor exit door open and third room closed).



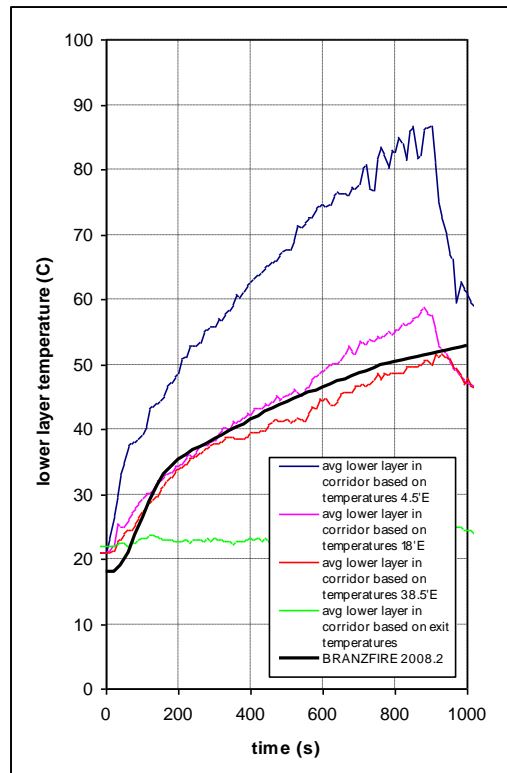
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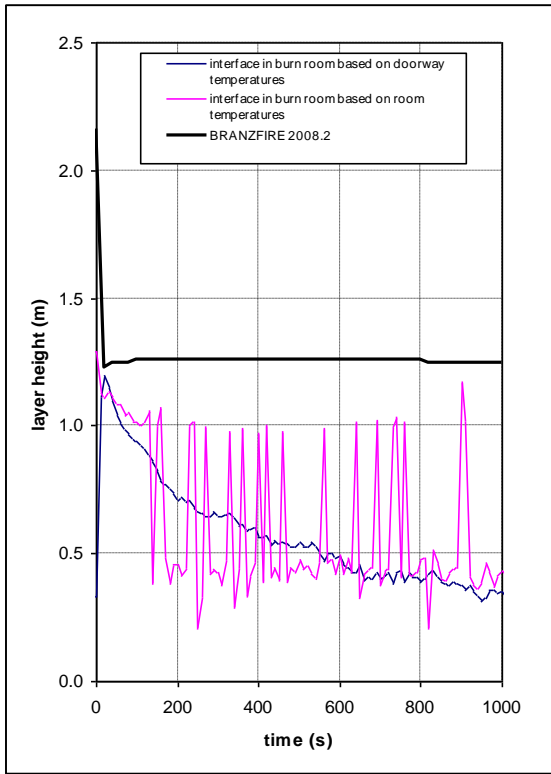
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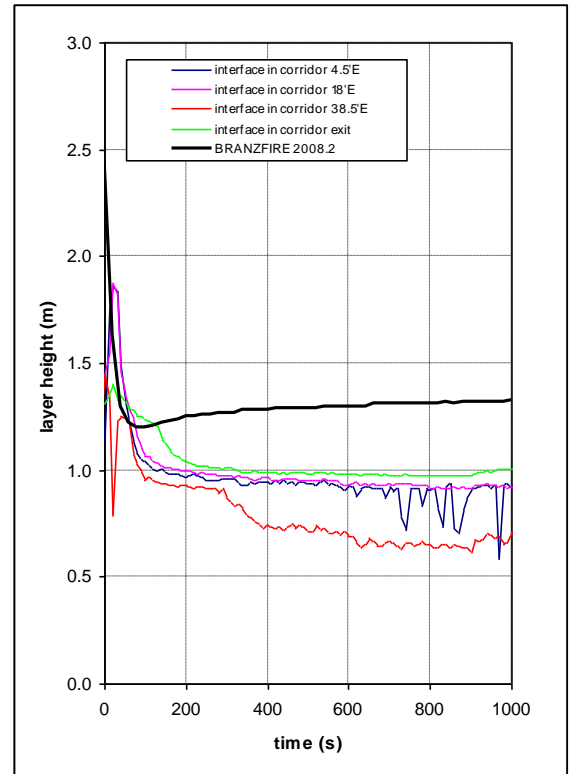
(c)



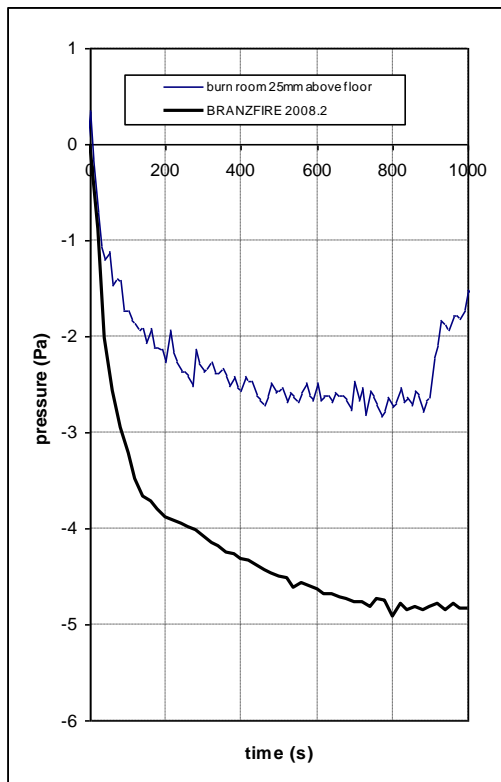
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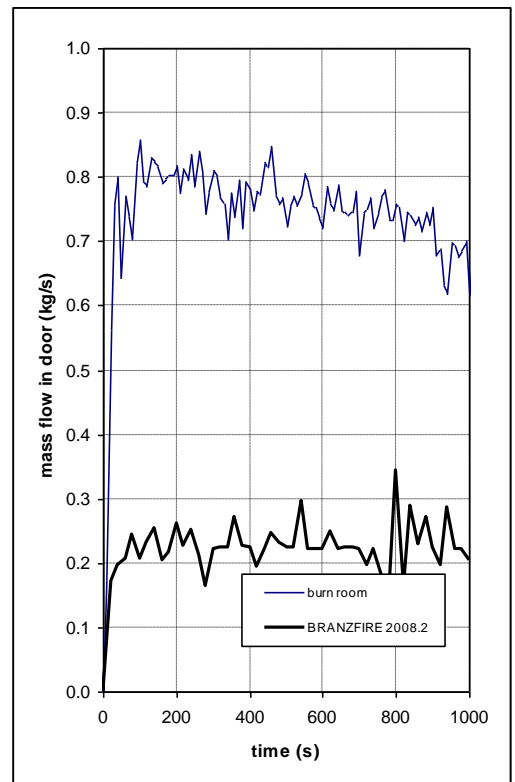
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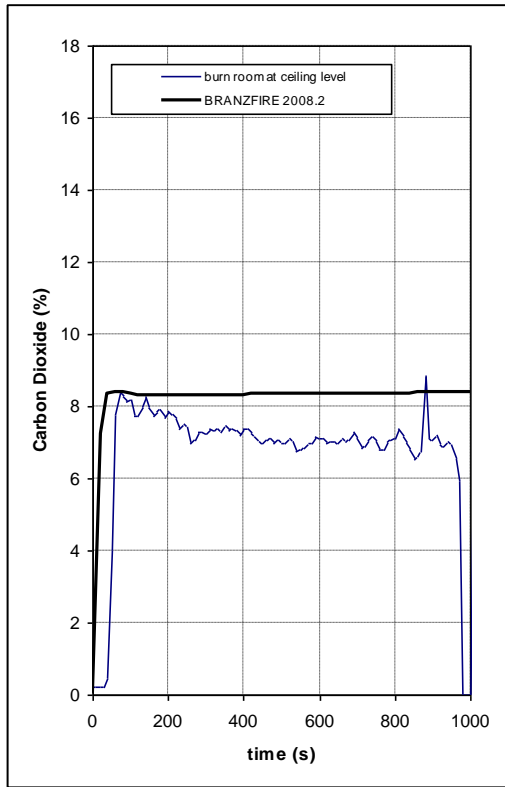
(f)



(g)



(h)



(i)

4. ISO 9705 – FIRE GROWTH ON SURFACE LININGS

4.1 VERIFICATION CASE 4-1

4.1.1 Reference

Interscience Communications Ltd (ICL). 1991. *EUREFIC European Reaction to Fire Classification*. Proceedings of the International EUREFIC Seminar, Copenhagen Denmark, September 1991.

4.1.2 Input files

Eumat1.mod, Eumat2.mod, Eumat3.mod, Eumat4.mod, Eumat5.mod, Eumat6.mod, Eumat9.mod, Eumat10.mod, Eumat11.mod

4.1.3 Description

The EUREFIC research programme included experiments on 11 different surface lining products using the ISO 9705 full-scale room test apparatus and ISO 5660 cone calorimeter. BRANZFIRE modelling relies on use of the cone calorimeter test data for input to the model.

The ISO 9705 test procedure requires that a square gas burner be placed in the corner of a room (3.6 m long x 2.4 m wide x 2.4 m high). The room had a single opening 2 m high by 0.8 m wide in the wall located opposite the burner. The burner dimensions were 170 mm square. Three walls and the ceiling were lined with the surface lining material. The burner output was controlled to be 100 kW for 10 minutes followed by 300 kW for a further 10 minutes. The total HRR was determined using oxygen consumption calorimetry techniques after measuring the oxygen concentration of the exhaust gases. A fire size of 1 MW in the ISO 9705 room is generally considered to be indicative of 'flashover', and if reached, the test is terminated.

4.1.4 Comparison

Nine of the 11 materials are shown here in a comparison of the HRR measured in the ISO 9705 test compared to the predicted values over the 20 minute period of the test. The available small-scale test data for the two materials omitted were considered to be inadequate and they are therefore not included in the comparison.

The available cone calorimeter data for each material comprised experiments carried out at three different external heat fluxes, typically 25, 35 and 50 kW/m². The BRANZFIRE model used all the available data and the FTP method of correlating the ignition times.

Figure 6 to Figure 14 show the measured and predicted HRR for each material.

Eurefic Material #1 - ISO 9705
Painted gypsum paper-faced plasterboard (12 mm thick)

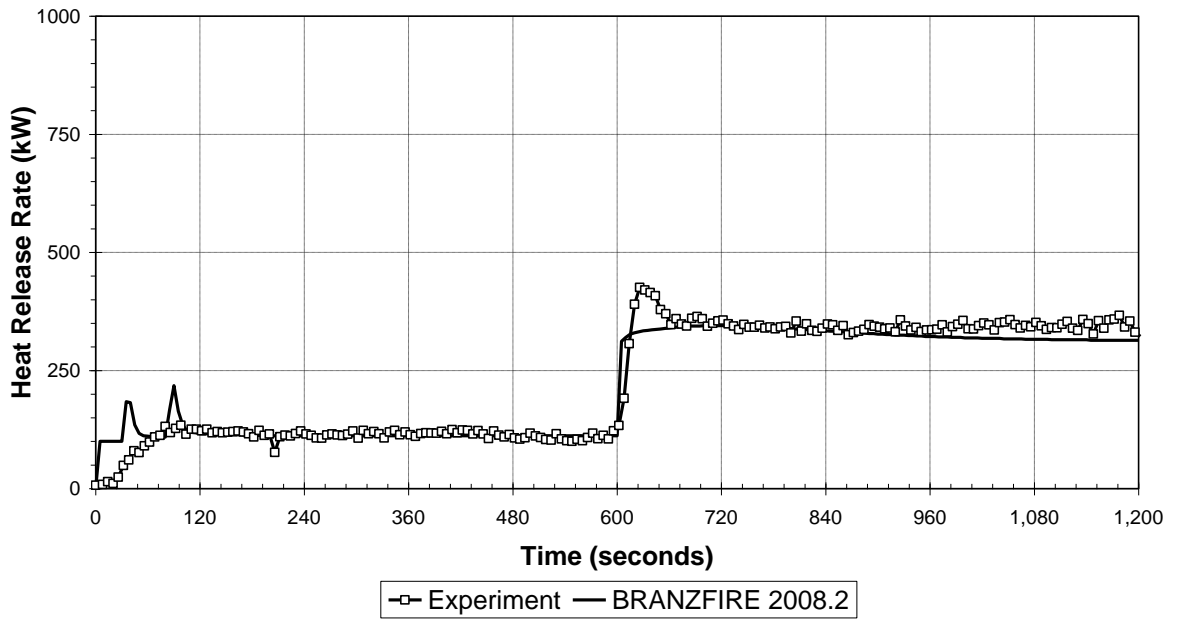


Figure 6. Painted gypsum paper-faced plasterboard

Eurefic Material #2 - ISO 9705
Ordinary birch plywood (12 mm thick)

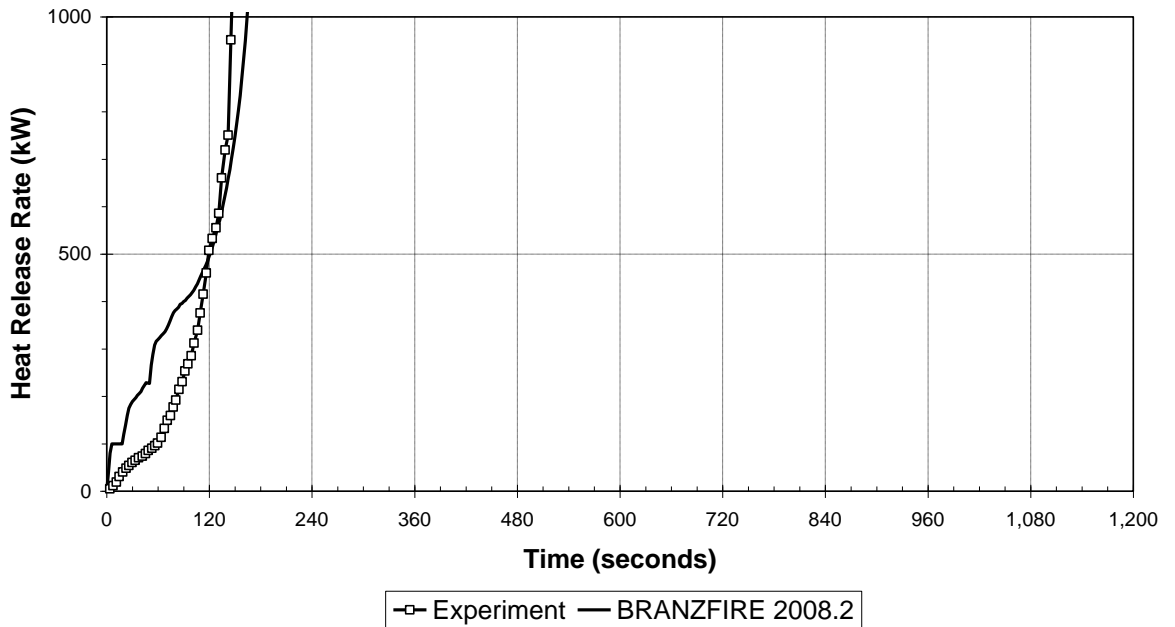


Figure 7. Ordinary birch plywood

Eurefic Material #3 - ISO 9705
Textile wallcovering on gypsum paper-faced plasterboard (12 mm thick)

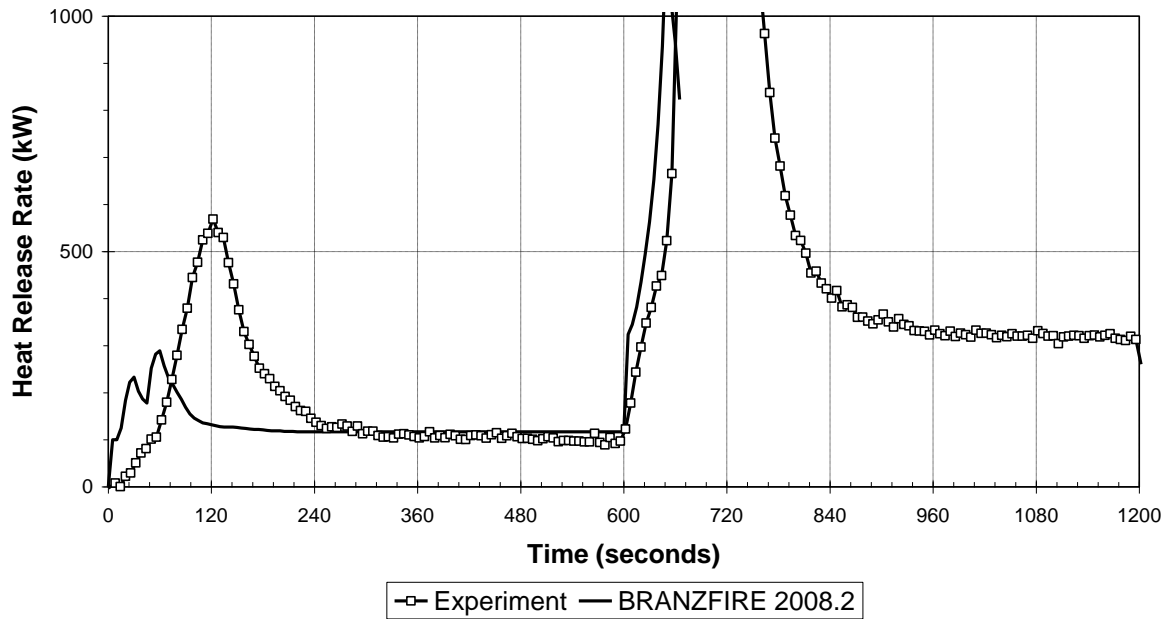


Figure 8. Textile wall covering on gypsum paper-faced plasterboard

Eurefic Material #4 - ISO 9705
Melamine-faced high density non-combustible board (12.5 mm thick)

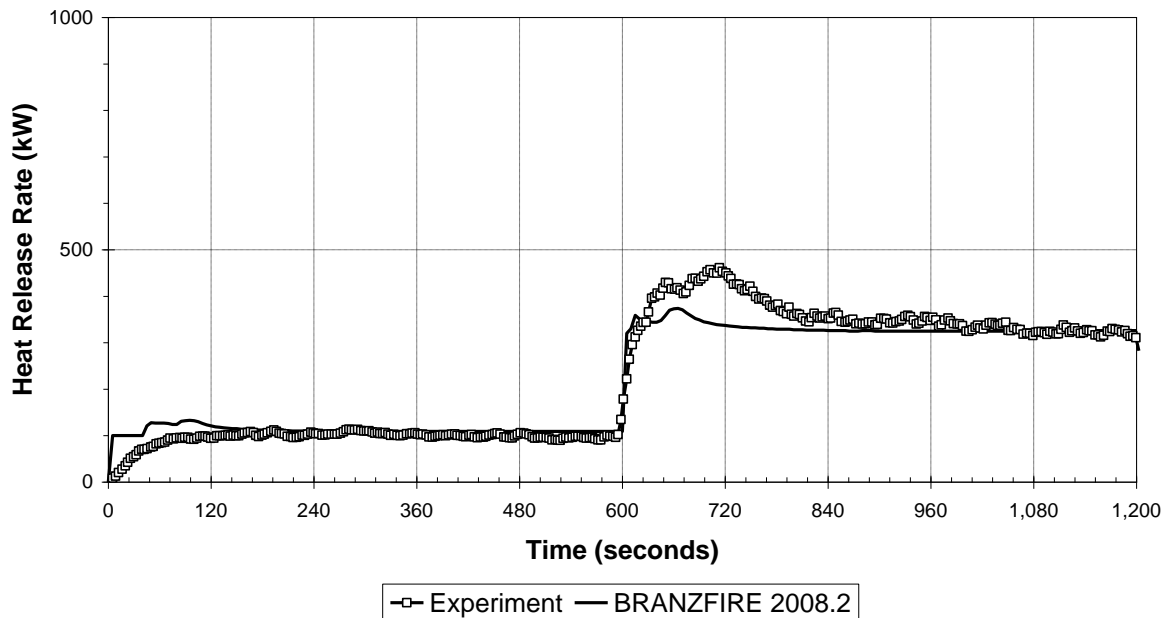


Figure 9. Melamine-faced high density non-combustible board

Eurefic Material #5 - ISO 9705
Plastic-faced steel sheet on mineral wool (23 mm thick)

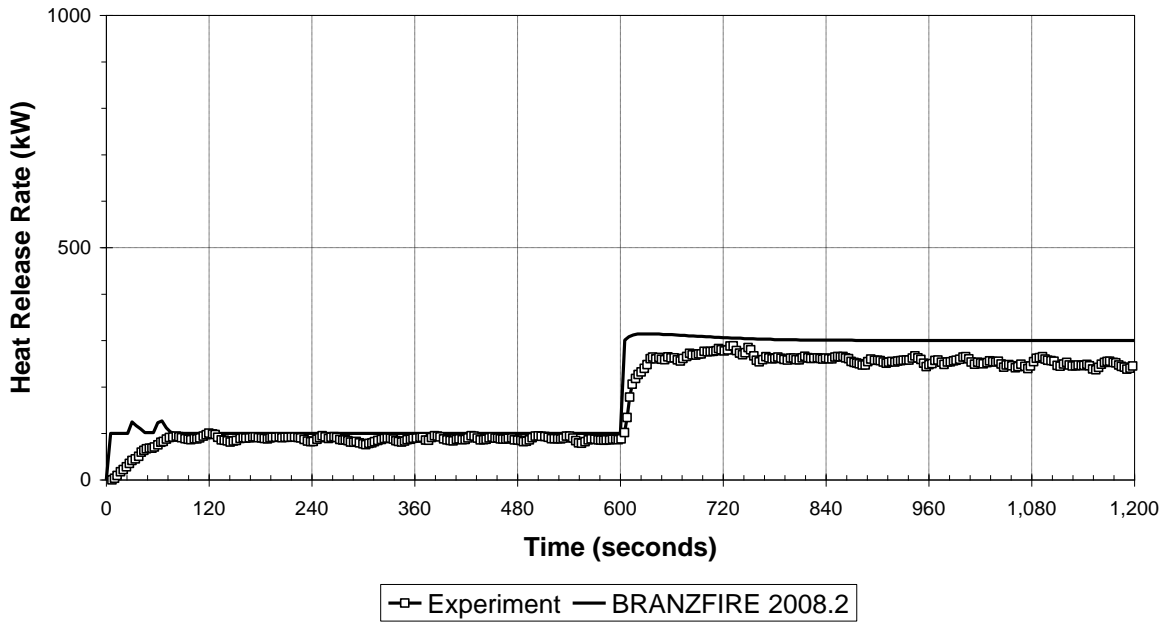


Figure 10. Plastic-faced steel sheet on mineral wool

Eurefic Material #6 - ISO 9705
FR particleboard type B1 (16 mm thick)

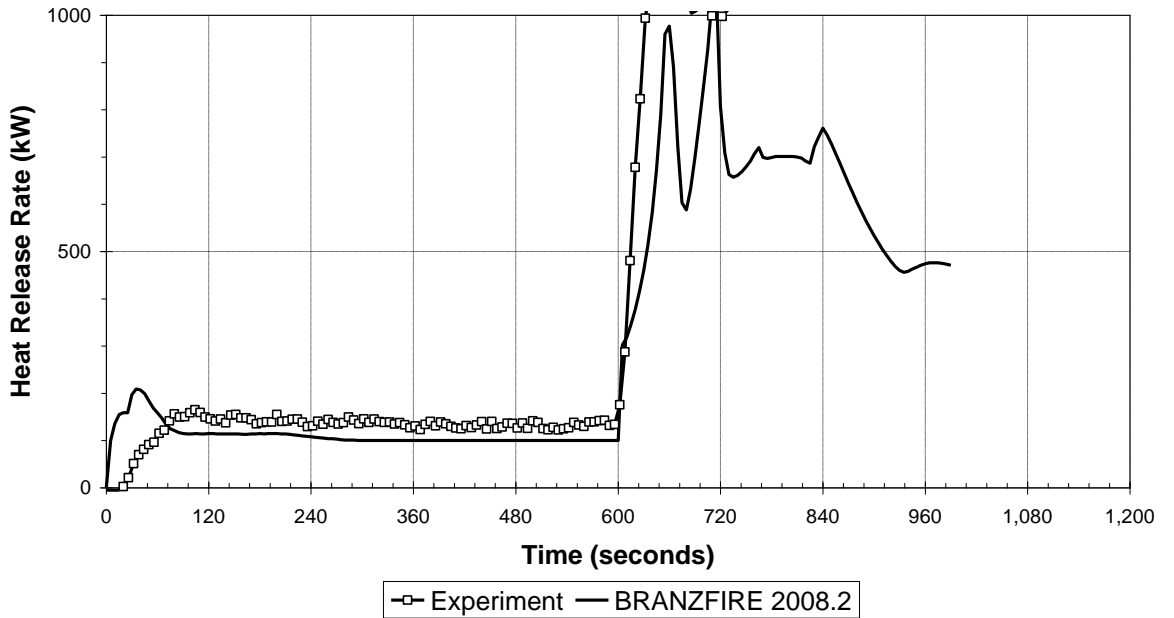


Figure 11. FR particleboard Type B1

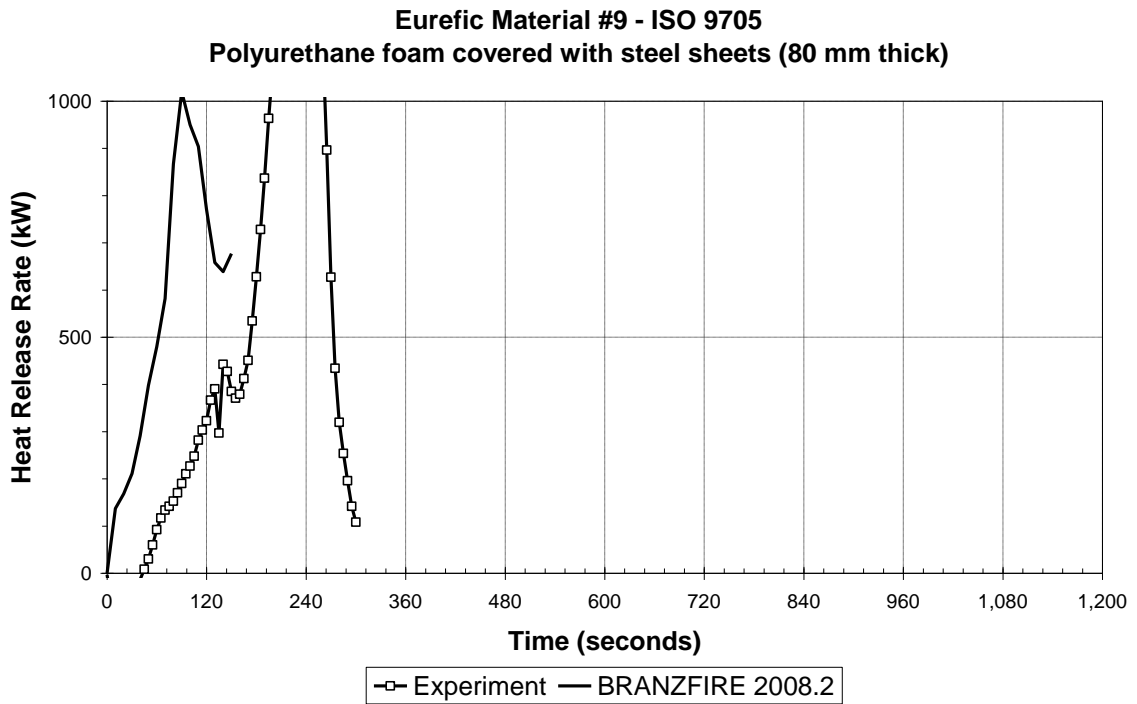


Figure 12. Polyurethane foam covered with steel sheets

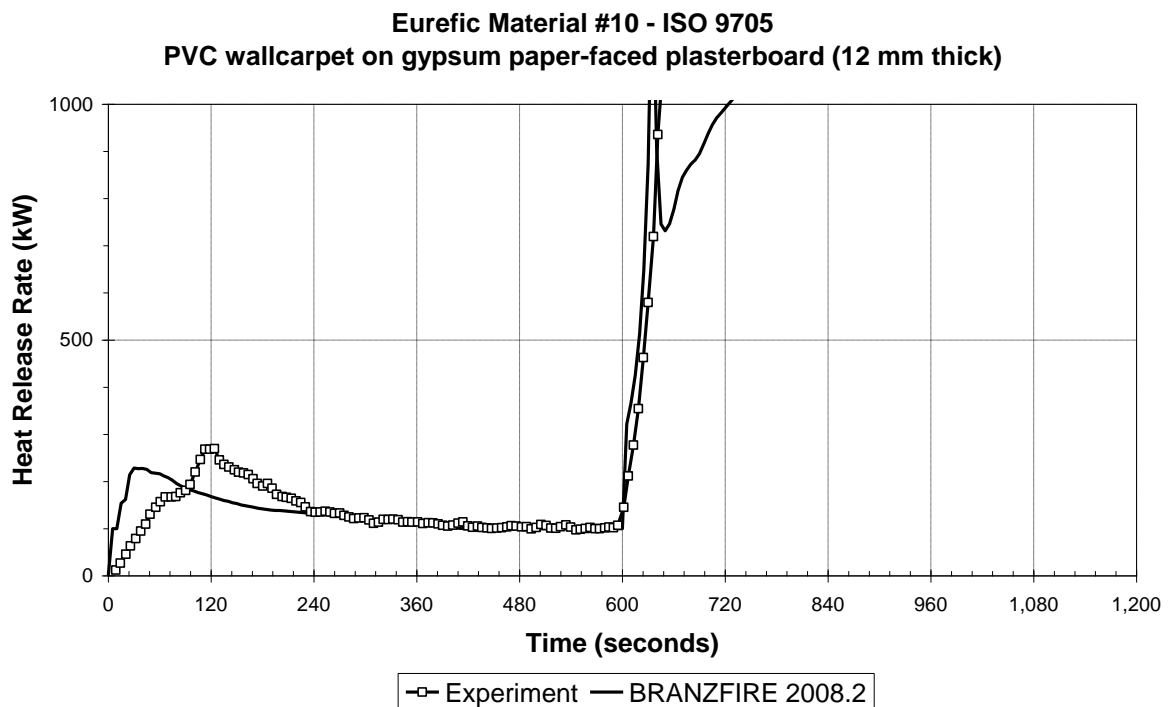


Figure 13. PVC wall carpet on gypsum paper-faced plasterboard

Eurefic Material #11 - ISO 9705
FR polystyrene foam (25 mm thick)

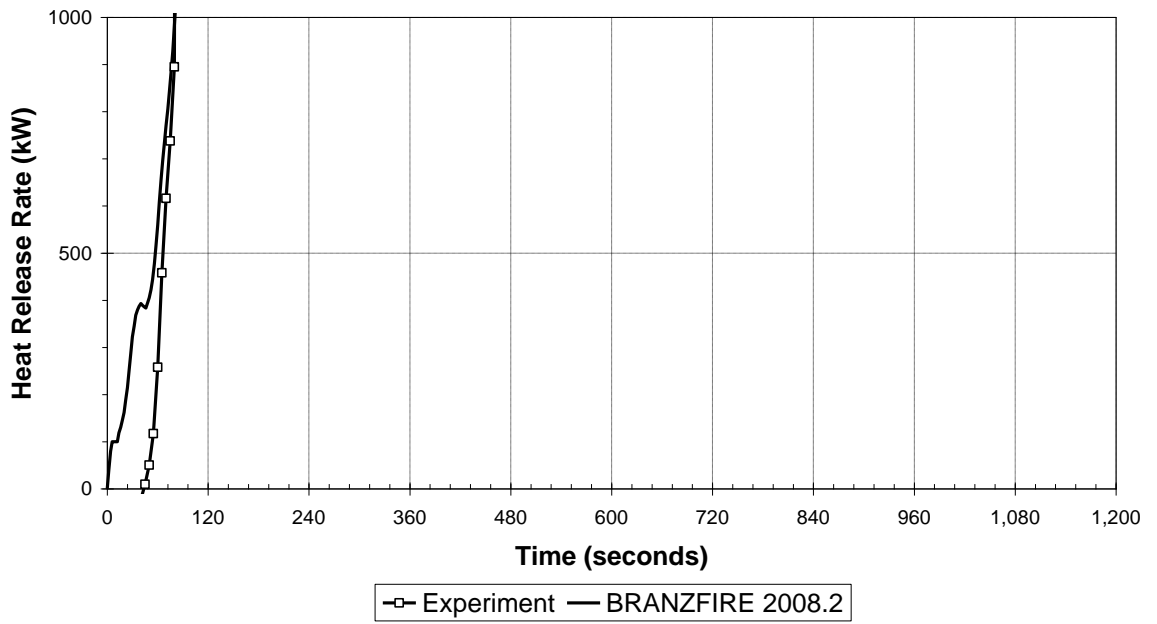


Figure 14. FR polystyrene foam

4.2 VERIFICATION CASE 4-2

4.2.1 Reference

Dowling V, McArthur NA, Webb AK, Leonard JE and Blackmore J. 1999. *Large Scale Fire Tests on Three Building Materials*. Proceedings 3rd International Conference on Fire Research and Engineering, Chicago, USA.

4.2.2 Input files

PB115.mod, Ply104.mod, Ply104ceiling.mod, Ply104wall.mod, Ply108.mod, Ply108ceiling.mod, Ply108wall.mod

4.2.3 Description

Experiments were conducted on three surface lining materials (16 mm plasterboard, 4 mm fire retardant treated plywood and 4 mm non-fire retardant plywood) using the ISO 9705 full-scale room test apparatus and bench scale cone calorimeter. The set-up and test procedure were similar to that described in Section 4.1, except that the burner dimensions were 300 mm square.

In the case of the fire retardant and non-fire retardant plywoods, additional tests were carried out with the plywood fixed to the wall only and the ceiling only.

4.2.4 Comparison

A comparison of the HRR measured in the ISO 9705 test with the BRANZFIRE predicted values over the 20 minute period of the test is shown in Figure 15 to Figure 21.

**CSIRO Material 115 - ISO 9705
16 mm Gypsum Plasterboard, Walls and Ceiling**

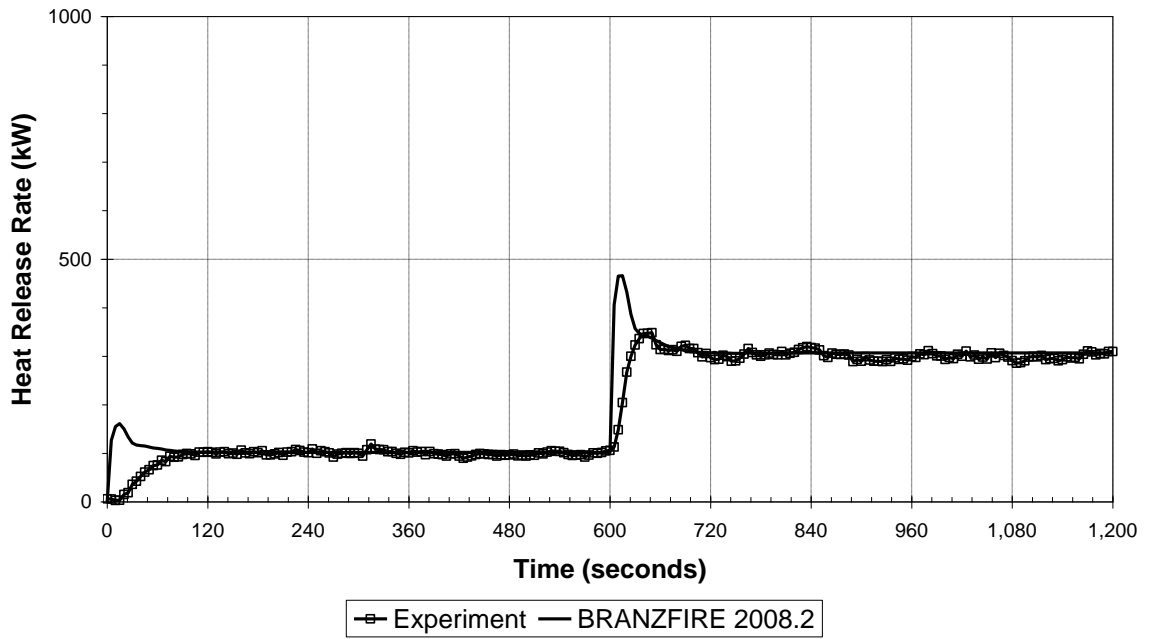


Figure 15. Gypsum plasterboard, wall and ceiling

**CSIRO Material 104 - ISO 9705
Plywood (4 mm thick) on 16 mm Gypsum Plasterboard, Walls Only**

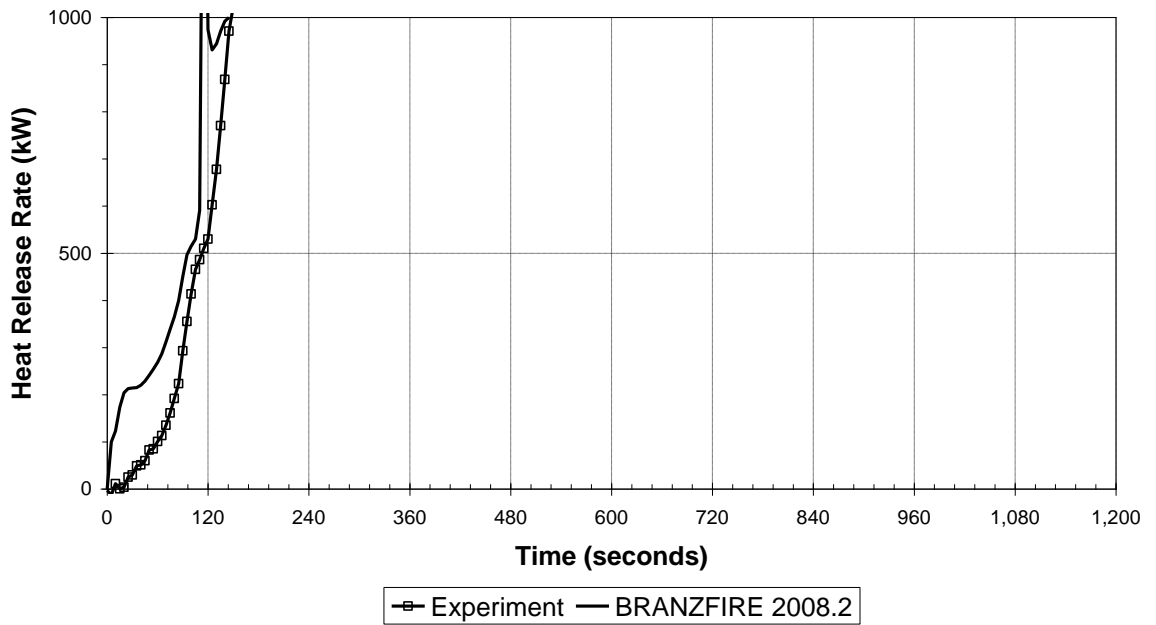


Figure 16. Plywood, walls only

CSIRO Material 104 - ISO 9705
 Plywood (4 mm thick) on 16 mm Gypsum Plasterboard, Ceiling Only

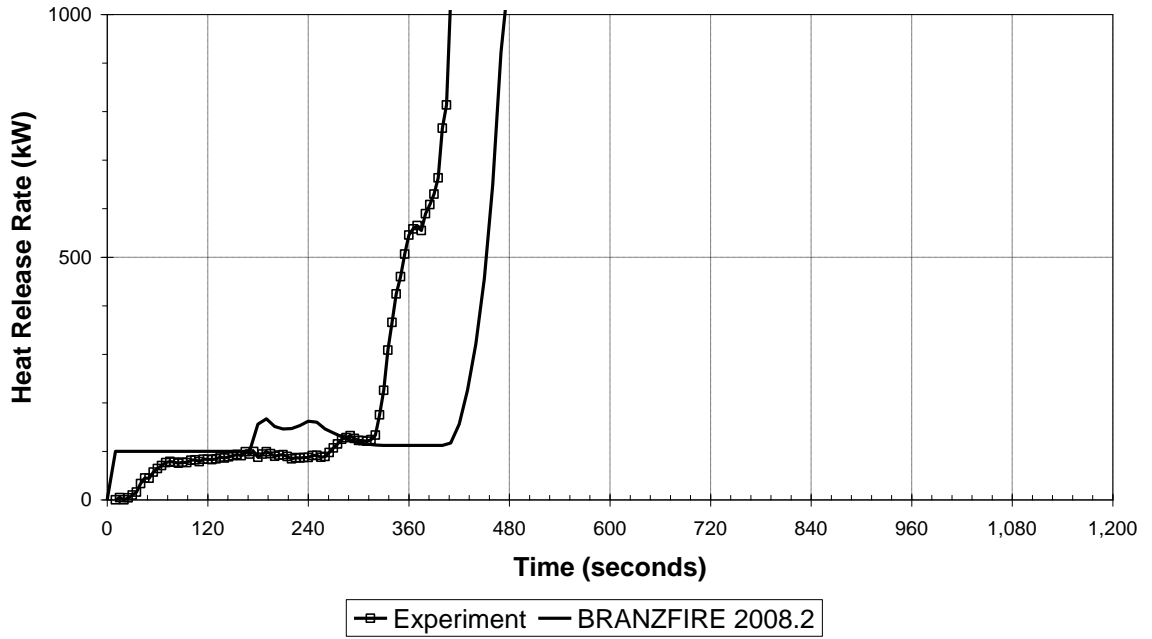


Figure 17. Plywood, ceiling only

CSIRO Material 104 - ISO 9705
 Plywood (4 mm thick) on 16 mm Gypsum Plasterboard, Walls and Ceiling

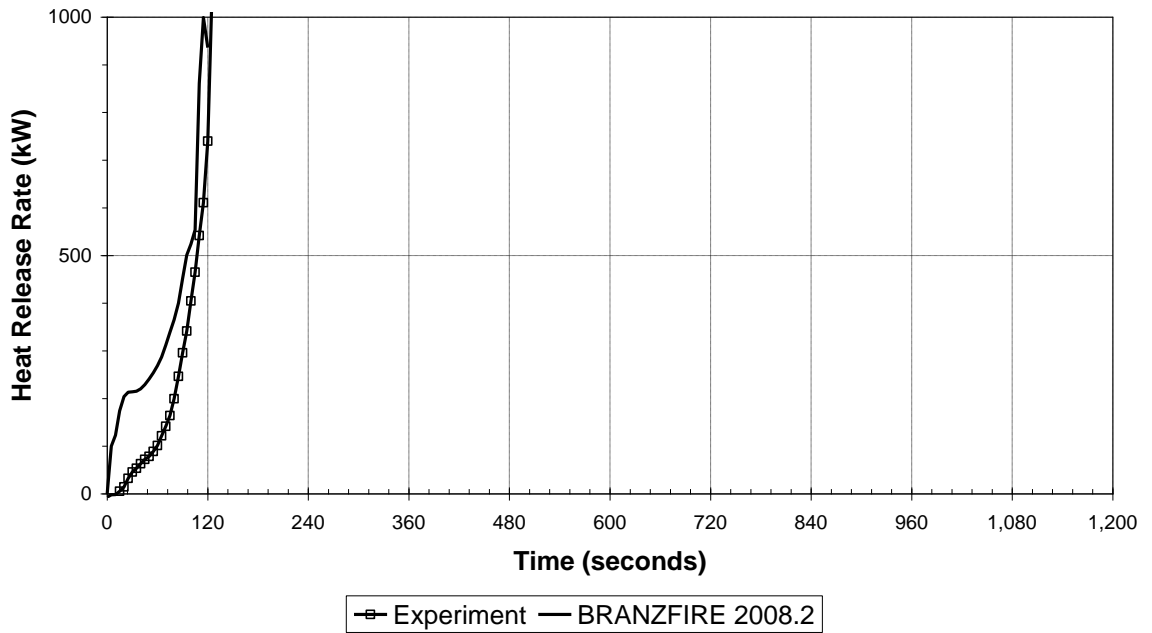


Figure 18. Plywood, walls and ceiling

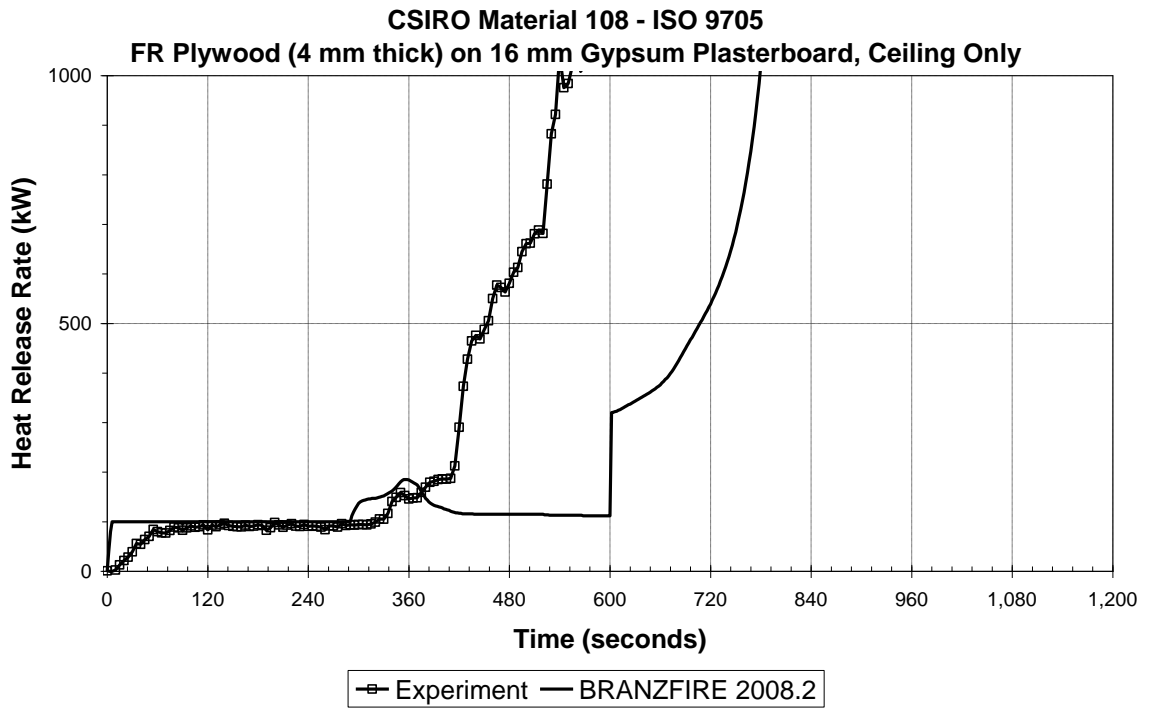


Figure 19. FR plywood, ceiling only

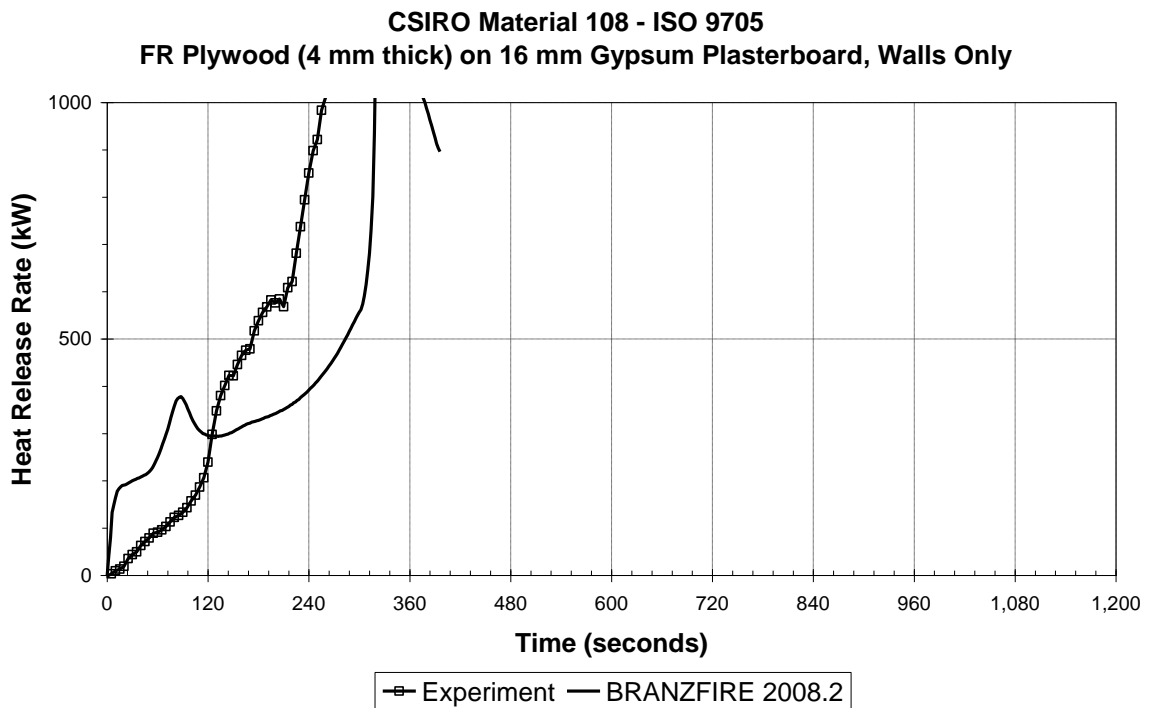


Figure 20. FR plywood, walls only

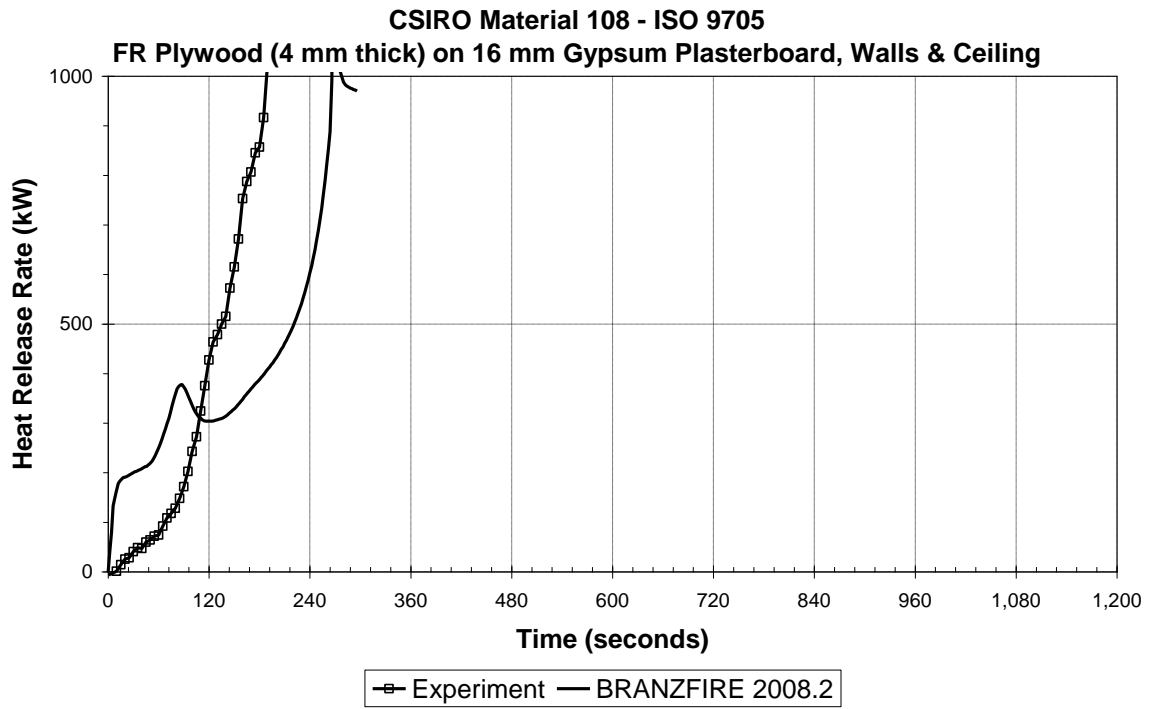


Figure 21. FR plywood, walls and ceiling

5. LARGE ROOM – FIRE GROWTH ON SURFACE LININGS

5.1 VERIFICATION CASE 5-1

5.1.1 Reference

Mikkola E and Kokkala M. 1991. *Experimental Programme of EUREFIC*. In EUREFIC Seminar Proceedings, 11-22 September 1991, Copenhagen, Denmark. Interscience Communications Ltd.

5.1.2 Input files

hugeroom_e2.mod, hugeroom_e3.mod, hugeroom_e6.mod, hugeroom_e10.mod

5.1.3 Description

The test room was 4.9 m high, 9 m wide and 6.75 m deep with a single door opening of 2 x 2 m in the wall opposite the gas burner. The walls and ceiling of the test room were made of 200 mm thick lightweight concrete of density 500 kg/m³. The burner was located in a corner and the heat output was 100 kW for 10 minutes, 300 kW for the next 10 minutes and 900 kW for the last 10 minutes. Walls and ceiling were lined with surface lining products selected from the EUREFIC project.

5.1.4 Comparison

A comparison of the HRR measured in the large-scale tests with the BRANZFIRE predicted values over the 20 minute period of the test is shown in Figure 22 to Figure 25.

**Eurefic Material #2
Ordinary birch plywood (12 mm thick)**

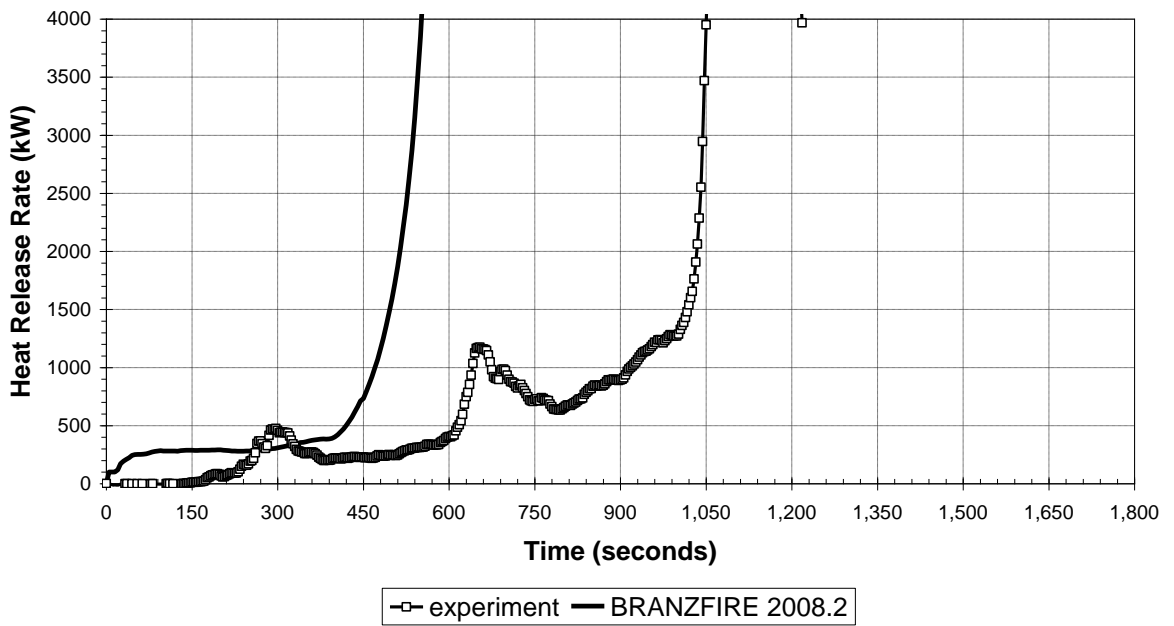


Figure 22. Ordinary birch plywood

**Eurefic Material #3
Textile wallcovering on gypsum paper-faced plasterboard (12 mm thick)**

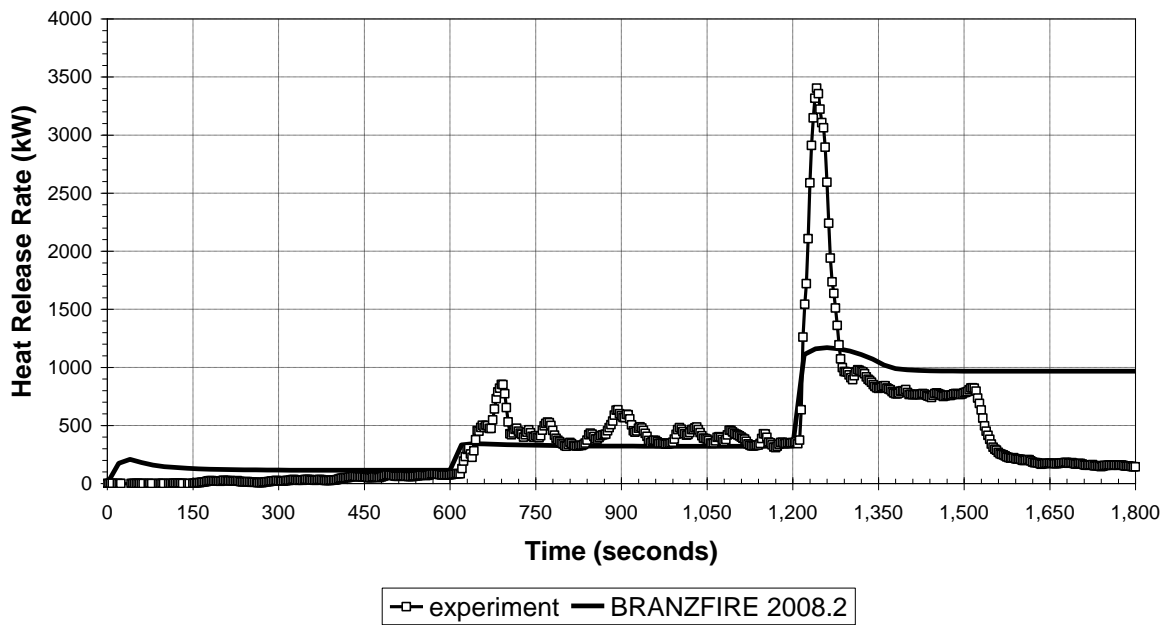


Figure 23. Textile wall covering on gypsum paper-faced plasterboard

Eurefic Material #6
FR particleboard type B1 (16 mm thick)

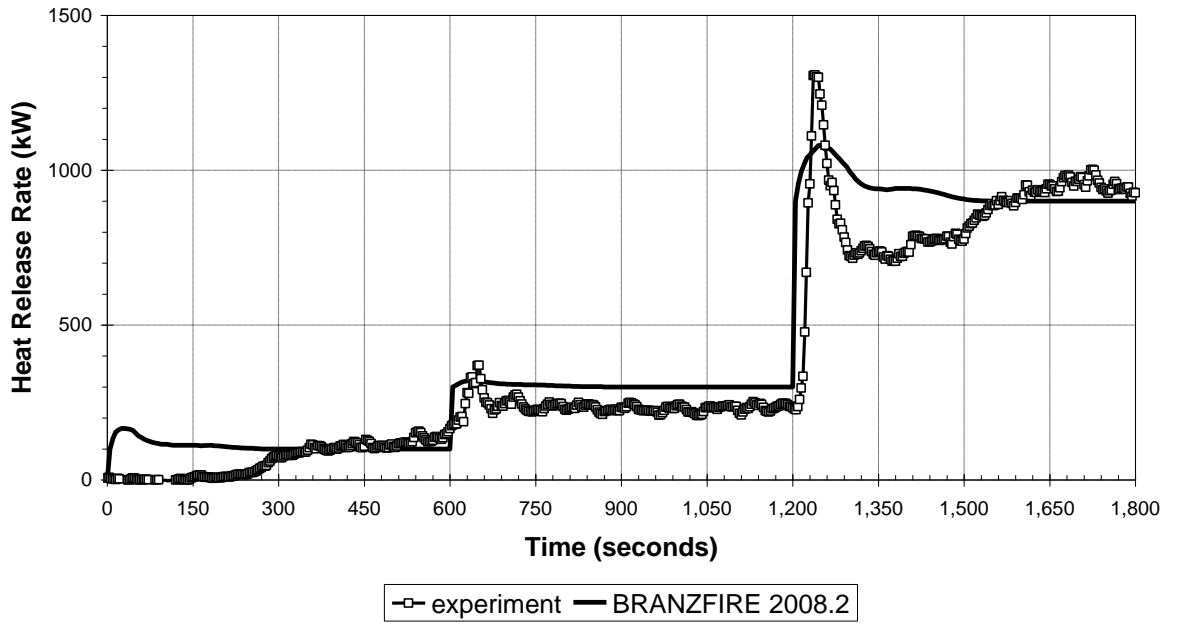


Figure 24. FR particleboard Type B1

Eurefic Material #10
PVC wallcarpet on gypsum paper-faced plasterboard (12 mm thick)

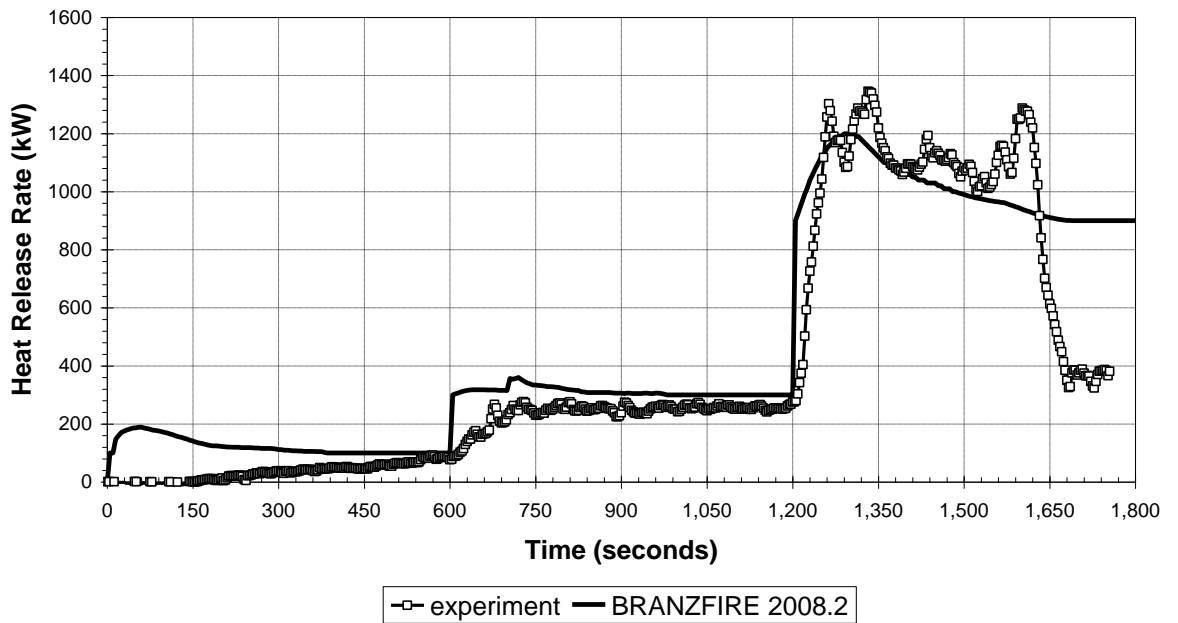


Figure 25. PVC wall carpet on gypsum paper-faced plasterboard

6. POST-FLASHOVER FIRE IN SINGLE COMPARTMENT

6.1 VERIFICATION CASE 6-1

6.1.1 Reference

Nyman J. 2002. 'Equivalent Fire Resistance Ratings of Construction Elements Exposed to Realistic Fires'. *Fire Engineering Research Report 02/13*. University of Canterbury, Christchurch, New Zealand.

6.1.2 Input files

590A.mod, 590A-krc400.mod, 590B.mod, 590B-krc400.mod, 590C.mod, 590C-krc400.mod

6.1.3 Description

A set of three full-scale compartment tests were carried out using numerous light timber framed (LTF) and light steel framed non-loadbearing walls (mostly plasterboard lined) and LTF ceiling/floor assemblies. The compartments had dimensions 3.6 m long x 2.4 m wide x 2.4 m high. In each test, a polyurethane foam upholstered sofa was ignited with the fire spreading to a series of wood cribs also in the compartment. Wall integrity failures were observed in each of the three tests at 22, 37.5 and 23 minutes respectively. In the modelling, additional vents were opened at these times.

6.1.4 Comparison

The HRR of a similar sofa was measured using a room calorimeter and the data collected was used to describe the initial burning item in the BRANZFIRE simulation.

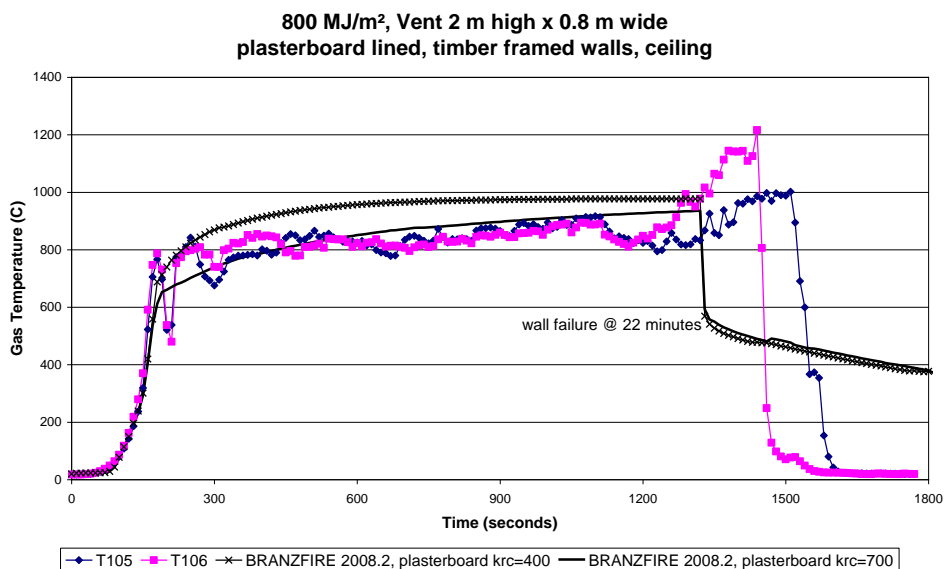


Figure 26. Gas temperatures 800 MJ/m², vent 2 x 0.8 m

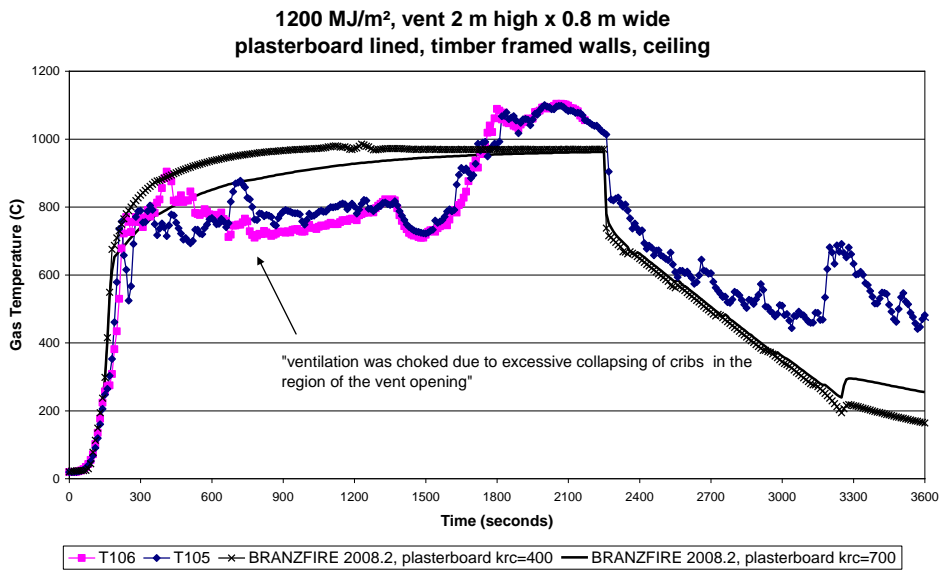


Figure 27. Gas temperatures 1200 MJ/m², vent 2 x 0.8 m

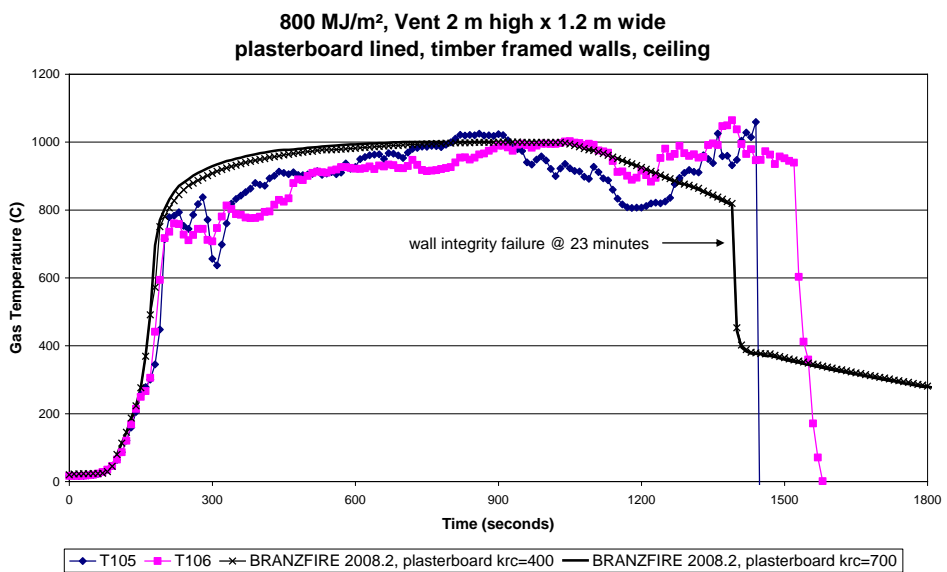


Figure 28. Gas temperatures 800 MJ/m², vent 2 x 1.2 m

7. GLASS FRACTURE

7.1 VERIFICATION CASE 7-1

7.1.1 References

Parry R. 2002. 'Implementation of a Glass Fracture Module for the BRANZFIRE Compartment Zone Modelling Software'. *Fire Engineering Research Report No. 2002-5*. University of Canterbury, Christchurch, New Zealand.

Parry R, Wade CA and Spearpoint M. 2003. 'Implementing a Glass Fracture Module in the BRANZFIRE Zone Model'. *Journal of Fire Protection Engineering* 13(3): 157-183.

Shields TJ, Silcock GWH and Flood M. 2002. 'Performance of a Single Glazing Assembly Exposed to Enclosure Corner Fires of Increasing Severity'. *Fire and Materials* (25): 123-152.

Shields TJ, Silcock GWH and Flood M. 2002. 'Performance of a Single Glazing Assembly Exposed to a Fire in the Centre of an Enclosure'. *Fire and Materials* (26): 51-75.

7.1.2 Input files

glass1.mod, glass1f.mod, glass2.mod, glass2f.mod, glass3.mod, glass3f.mod, glass4.mod, glass4f.mod, glass5.mod, glass5f.mod, glass6.mod, glass6f.mod, glass7.mod, glass7f.mod, glass8.mod, glass8f.mod

7.1.3 Description

Pan fires of varying size burning mineralised methylated spirits were located in the corner and in the centre of a vented compartment 3.6 x 2.4 x 2.4 m as described by Shields, Silcock and Flood. The pans were elevated 300 mm above floor level. There was a doorway vent 0.4 m wide x 2 m high, and a glazed window assembly comprising three panes. Pane 1 measured 0.844 x 0.844 m with the sill at a height of 1.06 m. Pane 2 measured 0.844 x 0.844 m with the sill at floor level. Pane 3 measured 0.844 m wide x 1.895 m high with the sill at floor level. In all cases the glazing was 6 mm thick with a 20 mm shaded edge and with properties ($k = 0.937 \text{ W/mK}$, $\alpha = 4.2\text{E-}07$, $E = 72 \text{ GPa}$, $\beta = .83\text{E-}05 \text{ K-}1$) for soda-lime-silica float glass taken from the Pilkington technical literature. A breaking stress of $\sigma_f = 47 \text{ MPa}$ was used.

BRANZFIRE was used to simulate the fire environment in the compartment and to predict the time of first fracture for each glazed pane. The HRR for each size of pan as published by Shields et al was used as input with fuel properties selected as for ethanol.

The model includes the option to include, or not, additional heat flux from the flame to the glass. Results for both these options are presented. It was assumed that no glass fallout occurred so that the first pane did not result in any change in vent area or influence the fracture times of any of the other windows.

7.1.4 Comparison

The predicted glass fracture times are compared with the measured time to first cracking and results summarised in Table 3.

Best agreement was obtained for Pane 1 where the glass was entirely submerged in the hot layer. BRANZFIRE was not able to adequately predict the fracture time for Pane 2 where the glass was predicted to be located entirely within the lower gas layer in the room, unless radiant heating from the flame was included. The data presented in Table 3 apply to the specific experiments associated with the published HRR data.

There were also duplicate experiments reported (typically 3–5) for each pan size and location. The data is presented graphically in Figure 29 and Figure 30 with error bars indicating the uncertainty (2 standard deviation) associated with the experimental data.

Table 3. Comparison with FireSERT Compartment Fire Tests (with flame flux heating not modelled, with flame flux heating modelled in brackets)

Pan fire size (m)	Pane 1 – sill 1.06 m (0.844 x 0.844 m)		Pane 2 – sill 0 m (0.844 x 0.844 m)		Pane 3 – sill 0 m (0.844 x 1.895 m)	
	Vent 3		Vent 2		Vent 4	
	Time to first crack (sec)	Predicted time (sec)	Time to first crack (sec)	Predicted time (sec)	Time to first crack (sec)	Predicted time (sec)
0.5 x 0.5 corner	347	215 (198)	578	DNF (DNF)	326	210 (198)
0.7 x 0.7 corner	126	122 (113)	234	DNF (455)	136	120 (115)
0.8 x 0.8 corner	131	112 (101)	202	DNF (384)	121	110 (103)
0.9 x 0.9 corner	70	87 (77)	145	DNF (227)	82	86 (79)
0.6 x 0.6 centre	475	361 (206)	675	DNF (252)	857	353 (203)
0.7 x 0.7 centre	282	279 (157)	348	DNF (180)	315	274 (155)
0.8 x 0.8 centre	195	198 (99)	309	207 (103)	111	195 (98)
0.9 x 0.9 centre	126	259 (187)	156	260 (187)	110	257 (186)

DNF = did not fracture

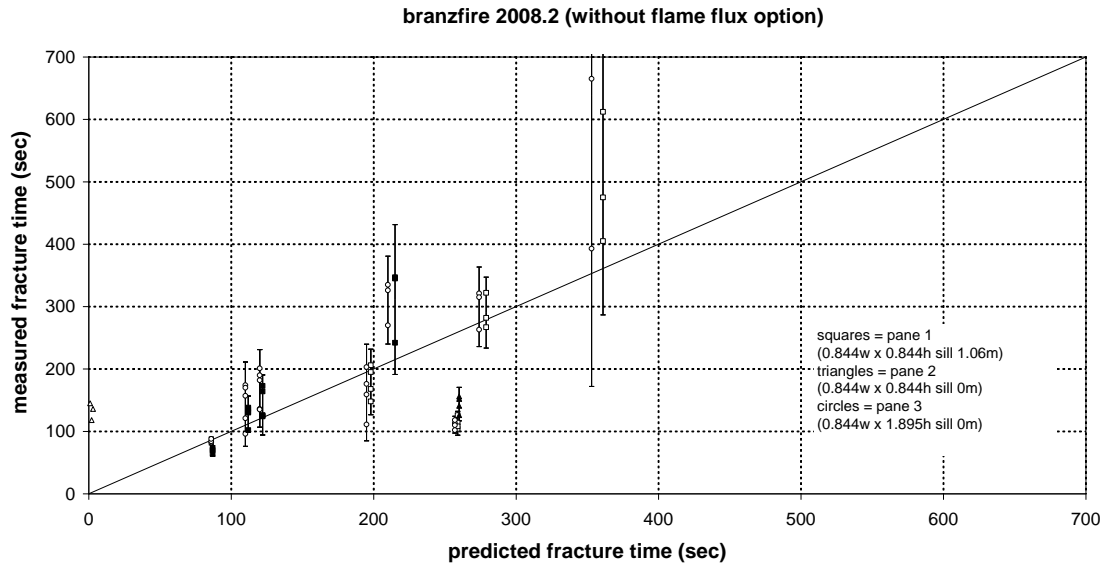


Figure 29. Comparison of predicted vs measured glass fracture times (error bars span 2 standard deviation)

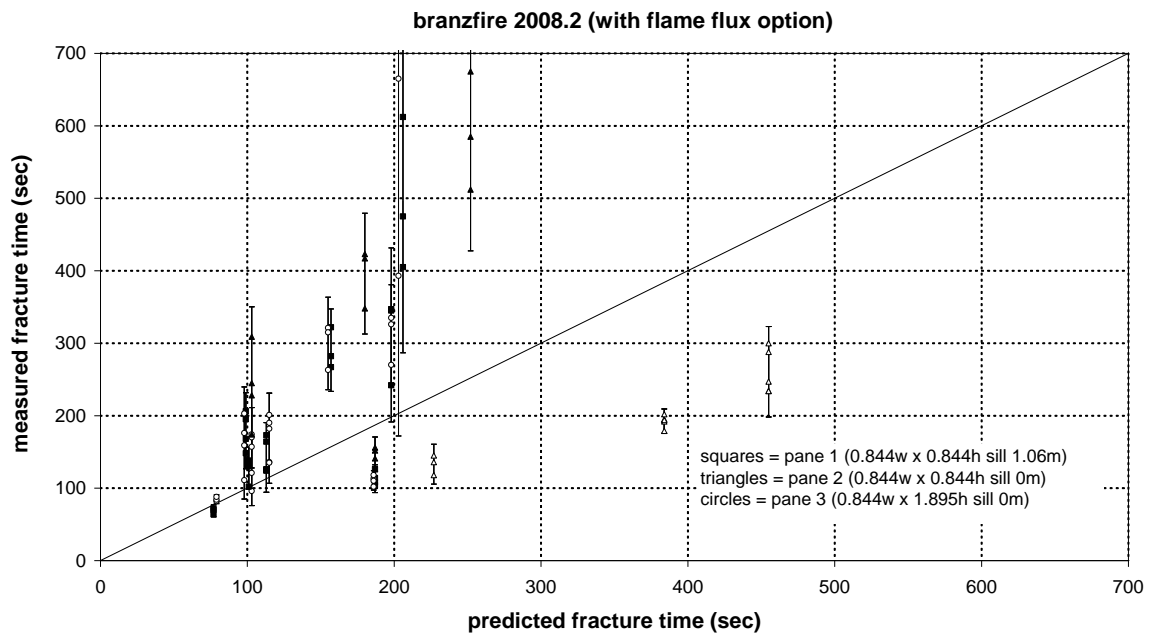


Figure 30. Comparison of predicted vs measured glass fracture times (error bars span 2 standard deviation)

8. SPRINKLER AND DETECTOR RESPONSE TIME

8.1 VERIFICATION CASE 8-1

8.1.1 References

Davis WD. 1999. 'Zone Fire Model JET: A Model for the Prediction of Detector Activation and Gas Temperature in the Presence of a Smoke Layer'. *NISTIR 6324*. National Institute of Codes and Standards, USA.

Gott JE, Lowe DL, Notarianni KA and Davis WD. 1997. 'Analysis of High Bay Hangar Facilities for Fire Detector Sensitivity and Placement'. *NIST TN 1423*. National Institute of Codes and Standards, USA.

8.1.2 Input files

heat-r3-d250.mod, heat-r6.1-d250.mod, heat-r8.5-d250.mod, heat-r9.1-d250.mod, heat-r11.6-d250.mod, smoke-high.mod, smoke-normal.mod, smoke-r0.mod, smoke-r3.1.mod, smoke-r6.1.mod, smoke-r8.5.mod, smoke-r9.1.mod, smoke-r11.6.mod, spr-r0-d150.mod, spr-r0-d300.mod, spr-r3.1-d150.mod, spr-r3.1-d300.mod, spr-r6.1-d150.mod, spr-r6.1-d300.mod, spr-r8.5-d150.mod, spr-r8.5-d300.mod

8.1.3 Description

A series of JP-5 pool fires were conducted in a hangar of size 97.8 x 73.8 x 15.1 m. The fires were centred under a draft curtained area 18.3 x 24.4 m with a ceiling height of 14.9 m. The draft curtain was 3.7 m deep. The roof and draft curtains were assumed to be of sheet steel construction.

Ambient temperature = 25°C.

The fire was a 2.5 m diameter pan of JP-5 fuel, size 7.7 MW fire estimated to reach maximum steady state value after 90 seconds.

Energy yield (kJ/g) = 42.0

CO₂ yield (kg/kg fuel) = 2.850

Soot yield (kg/kg fuel) = 0.037

Radiant loss fraction = 0.31

Sprinkler characteristics: RTI = 35 (m.s)^{1/2}, actuation temperature 79°C, C-factor = 0.5, with the deflector positioned 0.3 m below the ceiling. There was no actual water flow in this experiment.

Smoke optical density for alarm (1/m) = 0.097

Detector characteristic length number (m) = 15.0

Distance below ceiling (m) = 0.025

Detector response is based on OD inside the detector chamber.

8.1.4 Comparison

Table 4 shows the results of the BRANZFIRE prediction compared to the experimentally measured response time of the sprinkler devices, and of the ceiling jet temperature.

Table 4. Sprinkler response and ceiling jet temperatures

Radial distance (m)	Predicted sprinkler activation time (sec)	Measured sprinkler activation time (sec)	Predicted ceiling jet temp (C) at 150 mm below ceiling and at 500 sec	Measured ceiling jet temp (C)
0	76	78	118	147 ^a
3.1	122	88, 104, 147, nr	113	
6.1	142	140, 144, 207, 251	101	88 ^b
8.5	nr	247, 295	92	83 ^a
9.1	nr	439, nr		
11.6	nr	nr, nr		

a – 150 mm below ceiling

b – average of 4 thermocouples (N, S, W, E) positioned 150 mm below ceiling

nr – no response

Table 5 shows the results of the BRANZFIRE prediction compared to the experimentally measured response time of the heat detector.

The thermal detector parameters used were: RTI = 50 (m.s)^{1/2}, link actuation temperature 57.2°C, located 250 mm below the ceiling.

Table 5. Heat detector response

Radial distance (m)	Predicted heat detector activation time (sec)	Measured heat detector activation times (sec)
3.0	63	19, 65, 69, 85
6.1	67	27, 65, 65, 69
8.5	74	65, 69
9.1	76	32, 69
11.6	82	73, 85

Table 6 shows the results of the BRANZFIRE prediction compared to the experimentally measured response time of the photoelectric smoke detector.

Table 6. Smoke detector response

Radial distance (m)	Predicted photoelectric smoke detector activation time (sec)	Measured photoelectric smoke detector activation time (sec)
0	28	
3.1	32	18,27,27,38
6.1	43	23,27,31,42
8.5	50	27,31
9.1	51	31,46
11.6	57	51,nr

8.2 VERIFICATION CASE 8-2

8.2.1 References

Davis WD, Notarianni KA and McGrattan KB. 1996. 'Comparison of Fire Model Predictions with Experiments Conducted in a Hangar with 15 m Ceiling'. *NISTIR 5927*. National Institute of Codes and Standards, USA.

8.2.2 Input files

500kWfire.mod, 500kWfire-alp.mod, 500kWfire-jet.mod, 500kWfire-smoke.mod, 2700kWfire.mod, 2700kWfire-jet.mod, b2700kWfire.mod

8.2.3 Description

A series of JP-5 pool fires were conducted in a hangar of size 97.8 x 73.8 x 15.1 m. The fires were centred under a draft curtained area 18.3 x 24.4 m with a ceiling height of 14.9 m. The draft curtain was 3.7 m deep. Two experiments burning pans of JP-5 fuel were conducted in the hangar.

The roof and draft curtains were assumed to be of sheet steel construction.

Data from two fires are presented here:

- 1) Fire was a pan of JP-5 fuel, nominal size 500 kW fire. Ambient temperature = 28°C.
- 2) Fire was a pan of JP-5 fuel, nominal size 2700 kW fire. Ambient temperature = 27°C.

Energy yield (kJ/g) = 42

CO₂ yield (kg/kg fuel) = 2.850

Soot yield (kg/kg fuel) = 0.037

Radiant loss fraction = 0.31

Smoke optical density for alarm (1/m) = 0.036 (2.5% per foot)

Distance below ceiling (m) = 0.250

Detector response is based on OD outside the detector chamber.

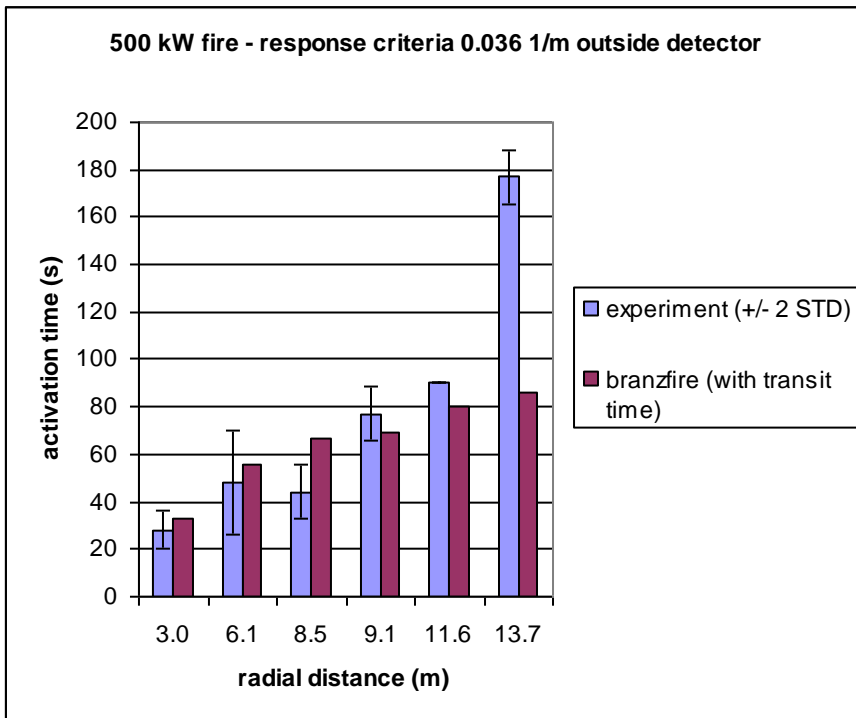


Figure 31. Smoke alarm response 500 kW

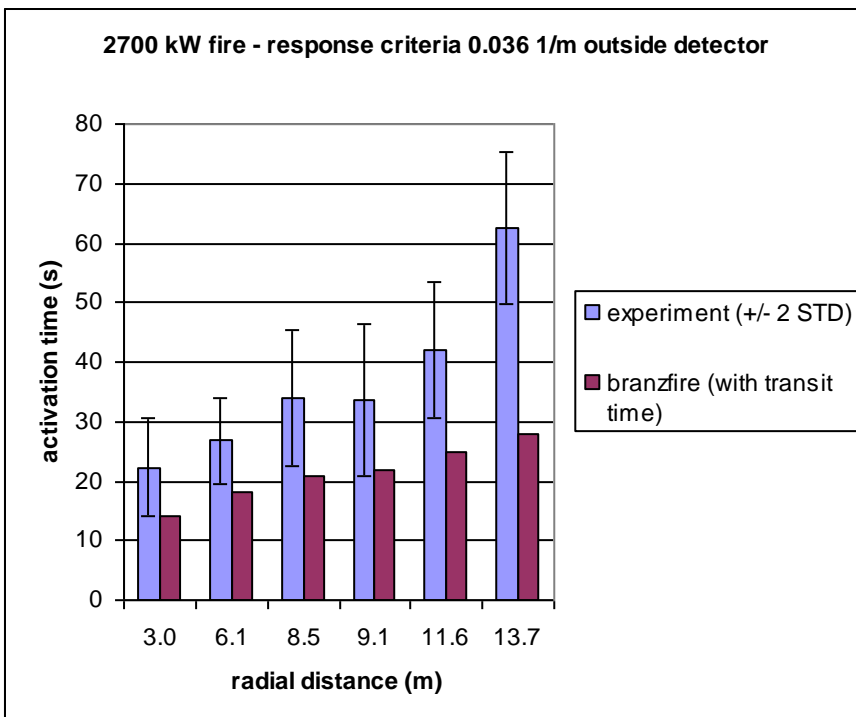


Figure 32. Smoke alarm response 2700 kW

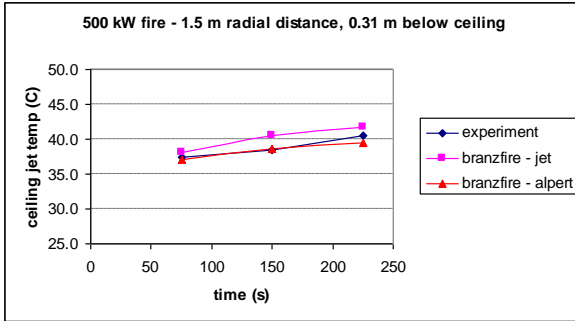


Figure 33. Ceiling jet temp 500 kW @ 1.5 m

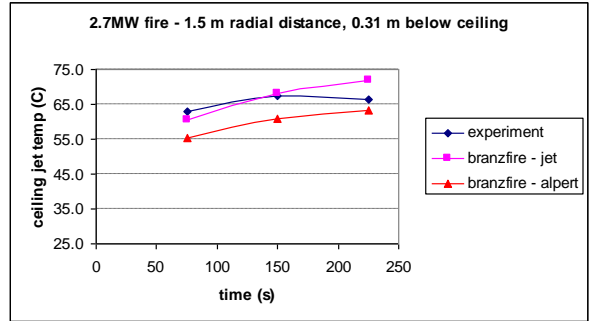


Figure 34. Ceiling jet temp 2700 kW @ 1.5 m

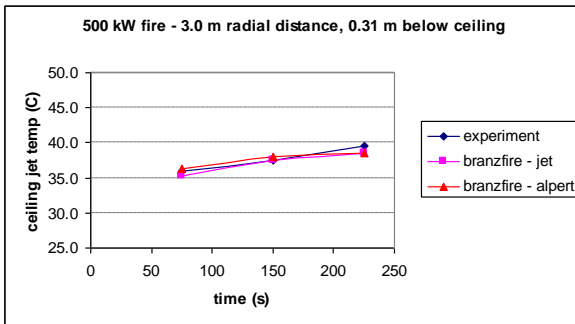


Figure 35. Ceiling jet temp 500 kW @ 3.0 m

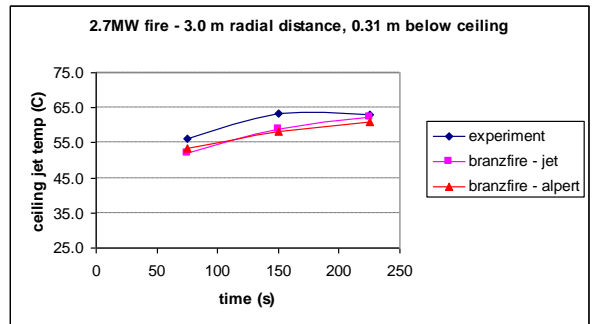


Figure 36. Ceiling jet temp 2700 kW @ 3.0 m

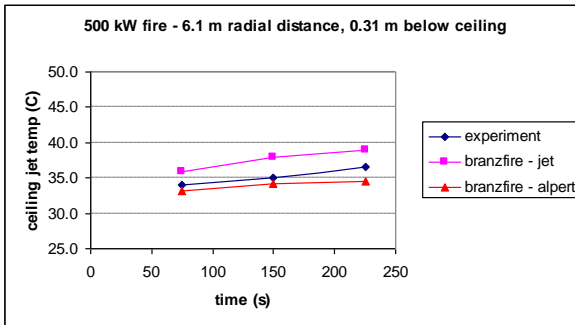


Figure 37. Ceiling jet temp 500 kW @ 6.1 m

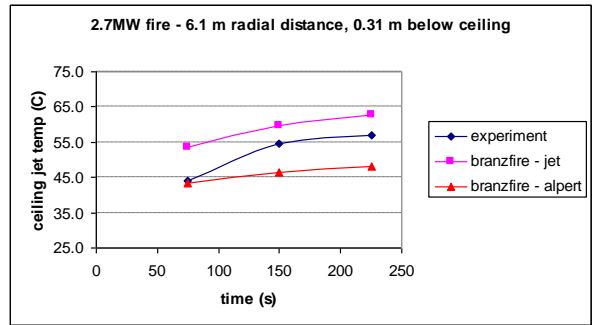


Figure 38. Ceiling jet temp 2700 kW @ 6.1 m

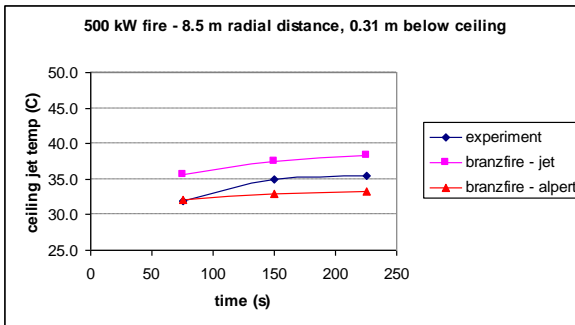


Figure 39. Ceiling jet temp 500 kW @ 8.5 m

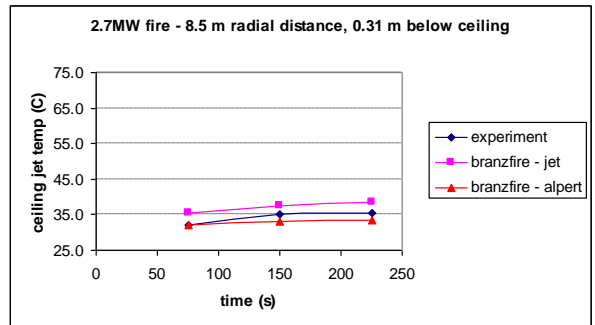


Figure 40. Ceiling jet temp 2700 kW @ 8.5 m

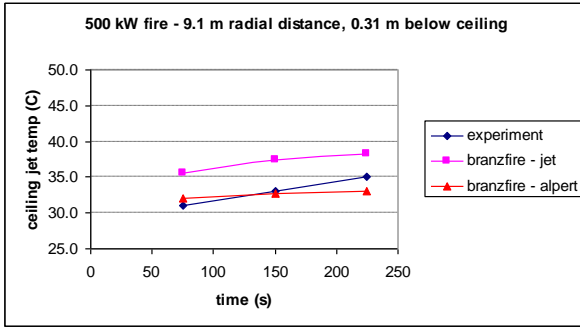


Figure 41. Ceiling jet temp 500 kW @ 9.1 m

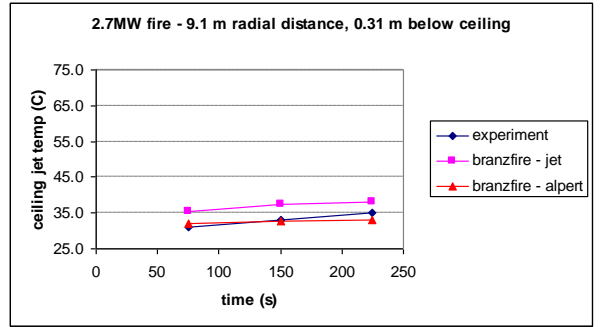


Figure 42. Ceiling jet temp 2700 kW @ 9.1 m

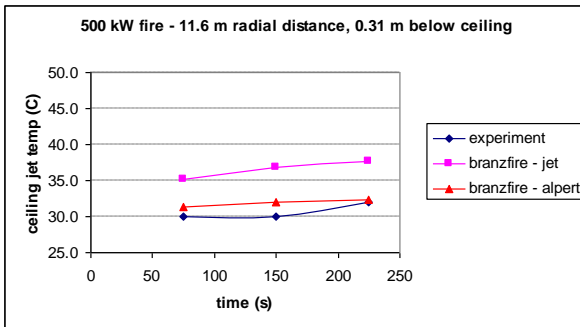


Figure 43. Ceiling jet temp 500 kW @ 11.6 m

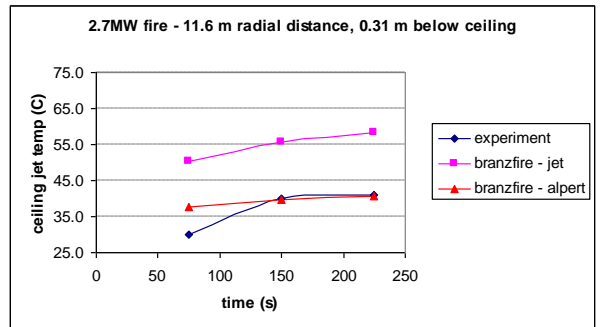


Figure 44. Ceiling jet temp 2700 kW @ 11.6 m

8.3 VERIFICATION CASE 8-3

8.3.1 References

Bittern, A. 2004. 'Analysis of FDS Predicted Sprinkler Activation Times with Experiments'. *Masters of Engineering in Fire Engineering Report*. University of Canterbury, Christchurch, New Zealand.

Wade CA, Spearpoint M, Bittern A and Tsai K (Wei-heng). 2007. 'Assessing the Sprinkler Activation Predictive Capability of the BRANZFIRE Fire Model'. *Fire Technology* (43): 175-193.

8.3.2 Input files

(missing)

8.3.3 Experiment description

A set of 22 fire experiments were conducted where a single chair was burned in an enclosure. Two sprinkler heads were installed for each experiment and the sprinkler activation time, chair mass loss rate and gas temperature profile in the room were measured and reported by Bittern. A bare-wire Type K thermocouple was located adjacent to each sprinkler head, and stainless steel sheathed, mineral insulated Type K thermocouples were used to measure the gas temperature, away from the sprinkler, at depths of 0.1 m, 0.3 m and 1.4 m below the ceiling.

Two different fire location positions (centre and corner of the enclosure) and two different door configurations (open and shut) were investigated. Table 7 summarises the position of the fire and the door configuration for each experiment. Experiment 11 was excluded for this comparison as no mass loss data for the chair was collected.

The compartment was built from timber-framed walls and ceiling and lined with painted 10 mm thickness gypsum plasterboard. The compartment had internal dimensions of 8 x 4 x 2.4 m high. The compartment layout is shown in Figure 45. The door set was made of a wooden frame with a plywood door leaf with dimensions of 0.8 m wide x 2.1 m high. The floor of the compartment was concrete.

Table 7. Fire position and door configuration

Experiment no.	Fire position	Door configuration
1-10	Centre	Open
12-15	Centre	Shut
16-22	Corner	Shut

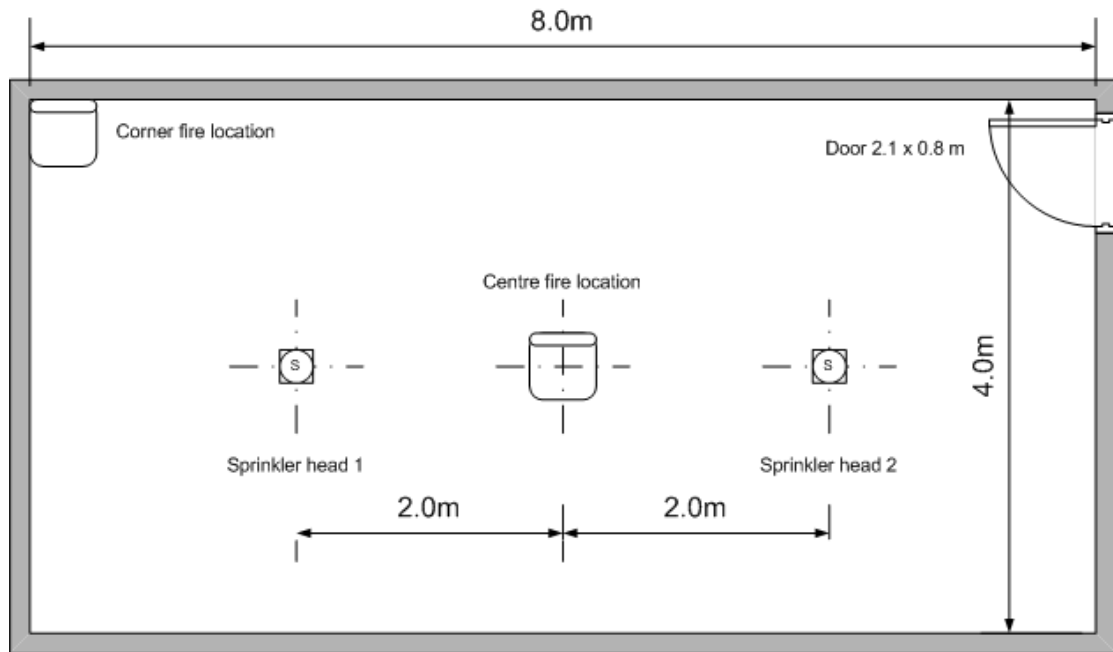


Figure 45. Compartment layout (plan view)

The fuel package used for each experiment was made from two flexible polyurethane foam slabs (to form the seat and back of the chair) and covered with fabric as shown in Figure 46. The foam was 28 kg/m³ cushion grade non-fire retardant treated and the fabric was 10 g/m² acrylic. The foam was typical of that used in domestic furniture in New Zealand. Each foam slab measured 500 x 400 x 100 mm in size, weighed approximately 0.56 kg and was arranged to form the seat as shown in Figure 46. Plasterboard (10 mm) was used to form a backing board for the seat assembly to prevent the foam from dropping to the floor when burning. The chair was placed on a load cell to record the mass loss during the experiment with the base of the seat approximately 0.65 m above the floor. The seat was ignited with a solid petroleum fire-lighter (20 x 20 x 10 mm) positioned at the interface between the back and the seat.



Figure 46. Upholstered chair in centre fire position (extracted from Bittern, 2004)

The average heat of combustion of the foam was measured in a cone calorimeter to be 21.0 MJ/kg (Tests 1–10) and 20.4 MJ/kg (Tests 11–22). This was used with the measured mass loss rate for each experiment to determine the HRR of the chair.

Two sprinkler heads spaced 4 m apart and generally complying with the New Zealand Standard NZS 4541:2003 were installed beneath the ceiling for each experiment. There were four different models of sprinkler head used for the experiments:

1. Residential Type A: pendent, nominal activation temperature 68°C (TYCO F680)
2. Residential Type B: pendent, nominal activation temperature 68°C (TYCO 2234)
3. Standard Response SS68: pendent, standard coverage, nominal activation temperature 68°C (TYCO 3251)
4. Standard Response SS93: pendent, standard coverage, nominal activation temperature 93°C (TYCO 3251).

The four sprinkler heads were supplied by the manufacturer TYCO and were selected based on sprinkler head availability. The selected sprinkler heads provided a variation in activation temperature and RTI.

The sprinkler heads were not charged with flowing water during the experiment, but the pipe sections connected to the head did contain water under pressure. This was achieved by holding the water back with a closing valve in the pipe network. Pressure gauges were also installed immediately upstream of each sprinkler head, but before the closing valve, to indicate sprinkler activation.

Technical data for each sprinkler head is shown in Table 8. The RTI was based on a manufacturer's estimate. A conduction factor of $0.4 \text{ (m/s)}^{1/2}$ was selected for the base case for all the sprinklers in this study.

The glass bulbs were typically about 20 mm long, with the mid-point located approximately 15 mm below the ceiling. The heat-sensitive element therefore spanned a depth from 5–25 mm below the ceiling.

Table 8. Sprinkler head data (base case)

	Activation temperature	RTI	C-factor
Residential Type A (3 mm glass bulb)	68°C	$36 \text{ m}^{1/2}\text{s}^{1/2}$	$0.4 \text{ (m/s)}^{1/2}$
Residential Type B (3 mm glass bulb)	68°C	$36 \text{ m}^{1/2}\text{s}^{1/2}$	$0.4 \text{ (m/s)}^{1/2}$
Standard Response SS68 (5 mm glass bulb)	68°C	$95 \text{ m}^{1/2}\text{s}^{1/2}$	$0.4 \text{ (m/s)}^{1/2}$
Standard Response SS93 (5 mm glass bulb)	93°C	$95 \text{ m}^{1/2}\text{s}^{1/2}$	$0.4 \text{ (m/s)}^{1/2}$

8.3.4 Experiment results

The radial distance from the centre of the fire plume to each sprinkler head was 2 m for experiments 1–15. Regarding experiments 16–22 with the corner fire location, the radial distances between the fire and the sprinkler heads were 2.8 m and 6.3 m for heads 1 and 2 respectively.

Since the primary fuel was flexible polyurethane foam, the radiant loss fraction assumed in the fire model was 0.46 based on the ratio of the radiative to chemical heat of combustion for GM23 foam from the literature. Other combustion parameter settings in the fire model were as for polyurethane foam.

A summary of the fire model input data is given in Table 9.

Table 9. Summary of fire model input data

Fire model	BRANZFIRE ver. 2005.2
Plume option	McCaffrey's correlation
Thermal properties – walls and ceiling 10 mm gypsum plasterboard	$\rho = 731 \text{ kg/m}^3$ $k = 0.17 \text{ W/mK}$ $\varepsilon = 0.88$
Thermal properties – floor 100 mm concrete	$\rho = 2300 \text{ kg/m}^3$ $k = 1.2 \text{ W/mK}$ $\varepsilon = 0.50$
Ambient conditions	RH = 65% ambient temperature as per the experiments
Fuel radiant loss fraction	0.46
Heat of combustion	21.0 MJ/kg (Tests 1–10) 20.4 MJ/kg (Tests 11–22)
Soot yield	0.227 g/g
Height of fire above floor	0.65 m

8.3.5 Simulation results

Figure 47 shows a comparison of the measured and predicted sprinkler activation times for the base case with the JET ceiling jet option. Simulations were terminated at 600 seconds – when no activation was predicted during that time it appears as 600 seconds on the figure. For experiments (1–15), with the fire located centrally between the sprinkler heads, on average the prediction was 21% longer than the measured activation times. In the case of the corner fire experiments (16–22), agreement between the predictions and experiments was reasonable (37% longer) for the sprinkler head located nearest the fire (at 2.8 m), but agreement was poor (98% longer – for experiments 16–19) for the sprinkler head located furthest from the fire (at 6.3 m). This suggests that the drop-off in ceiling jet temperature with radial distance in the model was too great compared to the actual case.

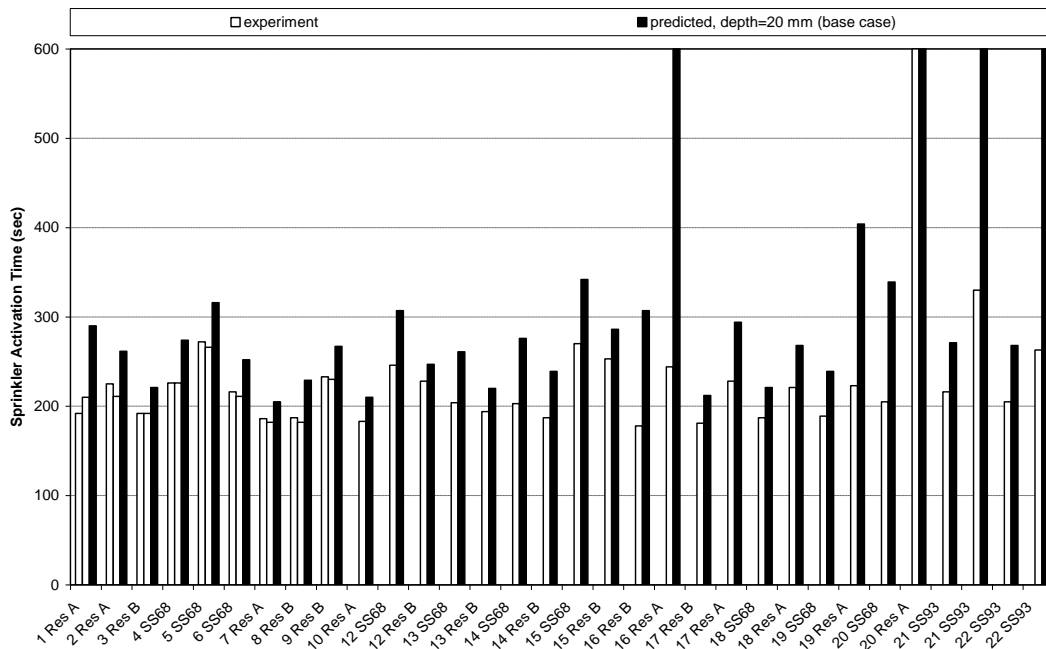


Figure 47. Comparison of measured and predicted activation time for base case – with BRANZFIRE/JET model

8.3.6 Gas temperatures at the sprinkler location

Figure 48 compares the measured and predicted gas temperatures (in the ceiling jet) at the location of the sprinkler at the measured time of sprinkler activation. The predicted gas temperatures (based on the JET ceiling jet option) are generally higher than the measured gas temperatures, with a few exceptions. Better agreement is achieved for the centre fires compared with the corner fires. Given that the predicted sprinkler response times are longer than the measured times, this result suggests that the assumed thermal response characteristics for the sprinklers are conservative.

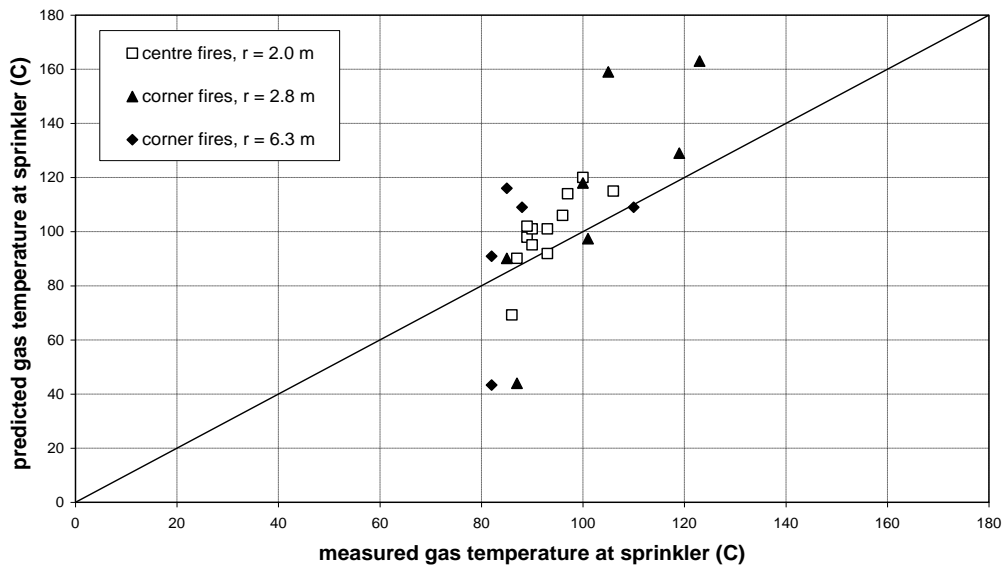


Figure 48. Comparison of the measured and predicted gas temperatures at the location of the sprinkler at the measured sprinkler activation time

8.3.7 CONCLUSIONS

The response of sprinklers in small rooms is strongly influenced by the presence of a developing hot layer. If using the BRANZFIRE model for predicting sprinkler response times, the use of the JET ceiling jet option is recommended, particularly for small rooms, as better agreement with experimental results is expected.

The JET ceiling jet option (for the base case) gave sprinkler activation times that were, on average, 21% longer than the measured response times for fires located in the centre of the room. Furthermore, the mismatch of the predictions (based on the JET ceiling jet model and the experimental results) increases with distance from the plume. The use of the Alpert ceiling jet option indicated much longer response times in small rooms compared to actual response times. However, this would usually be considered conservative for design purposes.

9. SMOKE DENSITY

9.1 VERIFICATION CASE 9-1

9.1.1 References

Davis WD, Cleary T, Donnelly M and Hellerman S. 2003. 'Predicting Smoke and Carbon Monoxide Detector Response in the Ceiling Jet in the Presence of a Smoke Layer'. *NISTIR 6976*. National Institute of Codes and Standards, USA.

9.1.2 Input files

davis1.mod, davis2.mod, davis3.mod

9.1.3 Description

Three experiments using a small propene (C₃H₆) gas burner and conducted in an enclosure with floor dimensions 3.15 x 3.02 m are presented. A sand burner was centred in the room with the height between the top of the burner and the ceiling as shown below.

Experiment	Burner output	Burner to ceiling height
A	2.5 kW	1.50 m
B	2.5 kW	2.19 m
C	7.6 kW	1.50 m

The ceiling construction was described as acoustic ceiling tile and walls were glazed cinderblock. A helium-neon laser extinction smoke meter measured obscuration and this was located 1 m from the plume centreline and 63.5 mm beneath the ceiling. By measuring the reduction in the beam intensity, the smoke density was determined, assuming the extinction coefficient per unit mass was 8.71 m²/g.

Assumptions:

- Propene soot yield = 0.095 g/g
- Radiant fraction = 0.32
- Heat of combustion = 40.5 kJ/g

9.1.4 Comparison

Figure 49 to Figure 51 show a comparison between the smoke densities determined from the three experiments with the BRANZFIRE prediction.

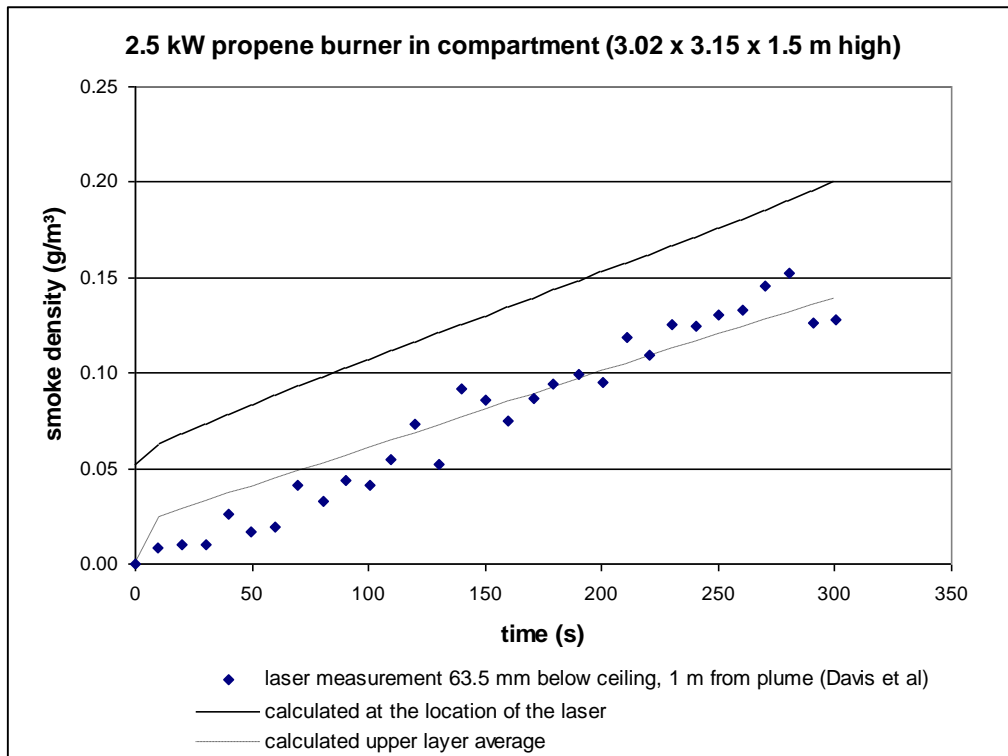


Figure 49. Experiment A – 2.5 kW propene burner 1.5 m below ceiling

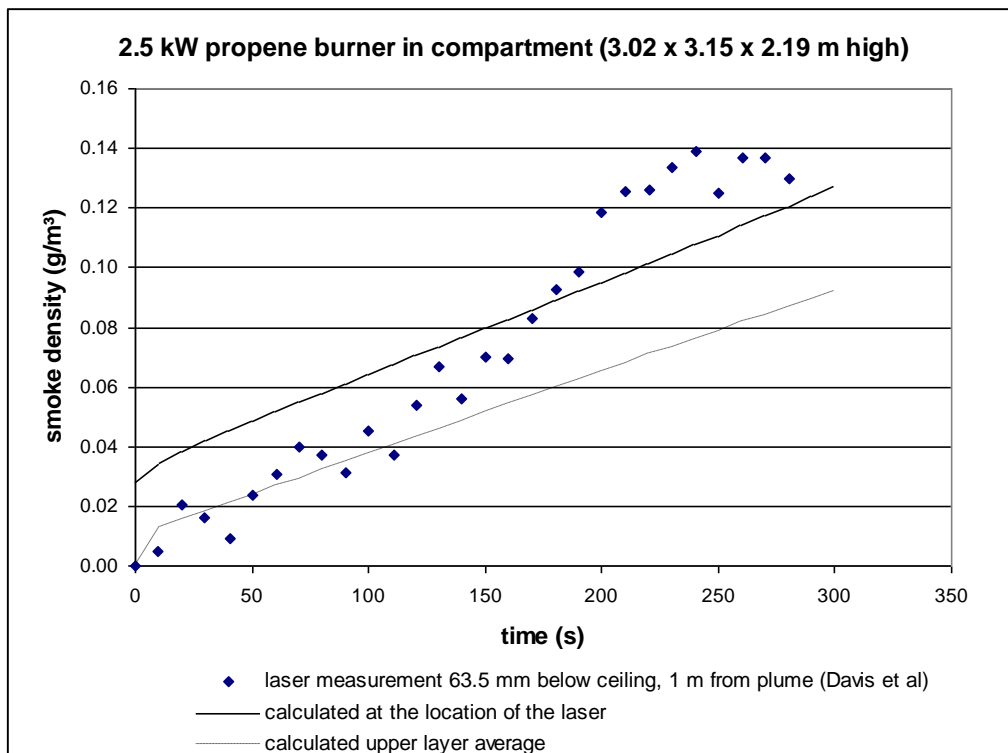


Figure 50. Experiment B – 2.5 kW propene burner 2.19 m below ceiling

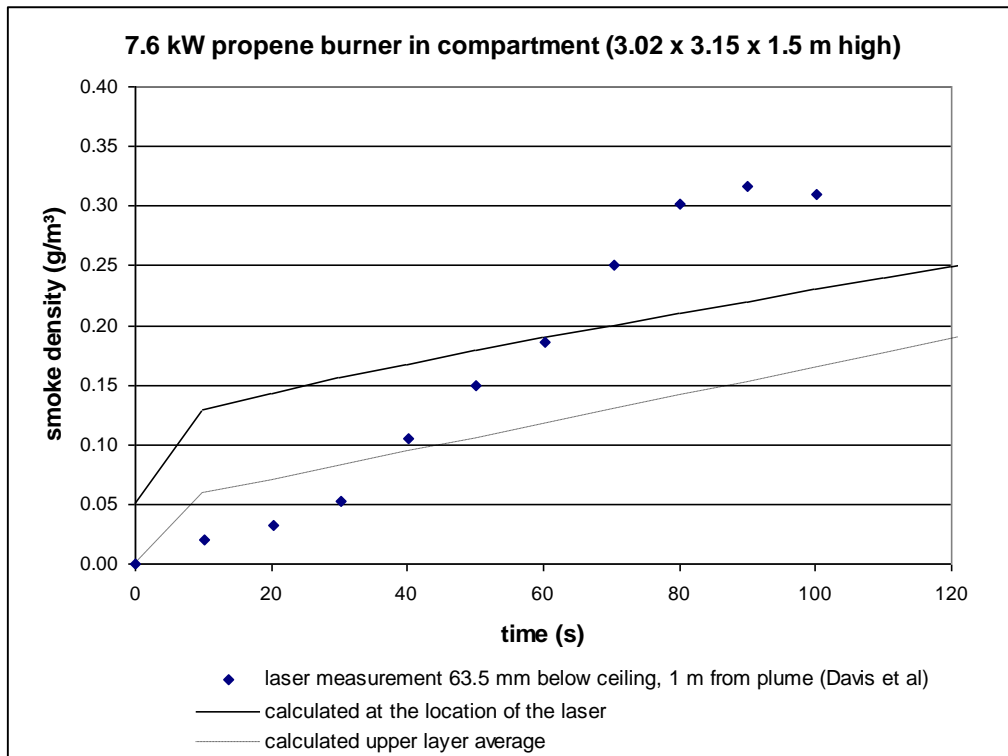


Figure 51. Experiment C – 7.6 kW propene burner 1.5 m below ceiling

APPENDIX A SUMMARY OF INPUTS

A.1 Case 2-1

Friday, July 18, 2008, 11:43 AM
Input Filename : Steckl.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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Steady State Fire Experiments

Description of Rooms

```
=====  
Description of Rooms  
=====  
Room 1 :  
Room Length (m) = 2.80  
Room Width (m) = 2.80  
Maximum Room Height (m) = 2.13  
Minimum Room Height (m) = 2.13  
Floor Elevation (m) = 0.000  
Room 1 has a flat ceiling.  
  
Wall Surface is Ceramic fibre insulation board  
Wall Density (kg/m3) = 128.0  
Wall Conductivity (W/m.K) = 0.090  
Wall Emissivity = 0.97  
Wall Thickness (mm) = 50.0  
  
Wall Substrate is Concrete  
Wall Substrate Density (kg/m3) = 2300.0  
Wall Substrate Conductivity (W/m.K) = 1.200  
Wall Substrate Thickness (mm) = 150.0  
  
Ceiling Surface is Ceramic fibre insulation board  
Ceiling Density (kg/m3) = 128.0  
Ceiling Conductivity (W/m.K) = 0.090  
Ceiling Emissivity = 0.97  
Ceiling Thickness (mm) = 50.0  
  
Ceiling Substrate is Concrete  
Ceiling Substrate Density (kg/m3) = 2300.0  
Ceiling Substrate Conductivity (W/m.K) = 1.200  
Ceiling Substrate Thickness (mm) = 150.0  
  
Floor Surface is Concrete  
Floor Density (kg/m3) = 2300.0  
Floor Conductivity (W/m.K) = 1.200  
Floor Emissivity = 0.50  
Floor Thickness = (mm) 100.0  
  
=====
```

Wall Vents

```
=====  
Wall Vents  
=====  
From room 1 to outside, Vent No 1  
Vent Width (m) = 0.240  
Vent Height (m) = 1.830  
Vent Sill Height (m) = 0.000  
Vent Soffit Height (m) = 1.830  
Opening Time (sec) = 0  
Closing Time (sec) = 0  
  
=====
```

Ceiling/Floor Vents

Ambient Conditions

```
=====  
Ambient Conditions  
=====  
Interior Temp (C) = 26.0  
Exterior Temp (C) = 26.0  
Relative Humidity (%) = 65  
  
=====
```

Tenability Parameters

```

=====
Monitoring Height for Visibility and FED (m) =          1.50
Occupant Activity Level =                             Light
Visibility calculations assume:                       reflective signs
FED Start Time (sec)                                 0
FED End Time (sec)                                   600
=====

```

Sprinkler / Detector Parameters

No thermal detector or sprinkler installed.

Mechanical Ventilation (to/from outside)

Mechanical Ventilation not installed in Room 1

Description of the Fire

```

=====
Radiant Loss Fraction =                               0.14
CO Yield pre-flashover(g/g) =                        0.040
Soot Alpha Coefficient =                             2.50
Smoke Epsilon Coefficient =                          1.20
Smoke Emission Coefficient (1/m) =                   6.45
Characteristic Mass Loss per Unit Area (kg/s.m2) =   0.011
Air Entrainment in Plume uses McCaffrey (default)
=====

```

Burning Object No 1

```

Located in Room                                     1
Energy Yield (kJ/g) =                              49.6
CO2 Yield (kg/kg fuel) =                            2.720
Soot Yield (kg/kg fuel) =                            0.013
HCN Yield (kg/kg fuel) =                             0.000
Fire Height (m) =                                    0.020
Fire Location (m) =                                  Centre

```

```

Time (sec)           Heat Release (kW)
0                     0
10                    63
1000                  63

```

Postflashover Inputs

Postflashover model is OFF.

A.2 Case 3-1

Wednesday, February 13, 2008, 05:22 PM
Input Filename : 100Jo.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.1)

Copyright Notice - This software is provided for evaluation only and may not be used for commercial purposes.

NBSIR 88-3752 - experiment 100J - corridor open to outside, door to third room closed

Description of Rooms

```

=====
Room 1 : First Room
Room Length (m) =          2.34
Room Width (m) =           2.34
Maximum Room Height (m) =  2.16
Minimum Room Height (m) =  2.16
Floor Elevation (m) =      0.000
Room 1 has a flat ceiling.

Wall Surface is Ceramic fibre insulation board
Wall Density (kg/m3) =      128.0
Wall Conductivity (W/m.K) =  0.090
=====

```

Wall Emissivity =	0.97
Wall Thickness (mm) =	50.0
Wall Substrate is Fire Brick	
Wall Substrate Density (kg/m ³) =	750.0
Wall Substrate Conductivity (W/m.K) =	0.360
Wall Substrate Thickness (mm) =	113.0
Ceiling Surface is Ceramic fibre insulation board	
Ceiling Density (kg/m ³) =	128.0
Ceiling Conductivity (W/m.K) =	0.090
Ceiling Emissivity =	0.97
Ceiling Thickness (mm) =	50.0
Ceiling Substrate is Calcium Silicate	
Ceiling Substrate Density (kg/m ³) =	720.0
Ceiling Substrate Conductivity (W/m.K) =	0.120
Ceiling Substrate Thickness (mm) =	13.0
Floor Surface is Fire Brick	
Floor Density (kg/m ³) =	750.0
Floor Conductivity (W/m.K) =	0.360
Floor Emissivity =	0.80
Floor Thickness = (mm)	113.0
Room 2 : First Room Corridor Stub	
Room Length (m) =	1.03
Room Width (m) =	1.02
Maximum Room Height (m) =	2.00
Minimum Room Height (m) =	2.00
Floor Elevation (m) =	0.000
Room 2 has a flat ceiling.	
Wall Surface is Calcium Silicate	
Wall Density (kg/m ³) =	720.0
Wall Conductivity (W/m.K) =	0.120
Wall Emissivity =	0.83
Wall Thickness (mm) =	13.0
Wall Substrate is Plasterboard	
Wall Substrate Density (kg/m ³) =	930.0
Wall Substrate Conductivity (W/m.K) =	0.170
Wall Substrate Thickness (mm) =	13.0
Ceiling Surface is Calcium Silicate	
Ceiling Density (kg/m ³) =	720.0
Ceiling Conductivity (W/m.K) =	0.120
Ceiling Emissivity =	0.83
Ceiling Thickness (mm) =	13.0
Ceiling Substrate is Plasterboard	
Ceiling Substrate Density (kg/m ³) =	930.0
Ceiling Substrate Conductivity (W/m.K) =	0.170
Ceiling Substrate Thickness (mm) =	13.0
Floor Surface is concrete	
Floor Density (kg/m ³) =	2300.0
Floor Conductivity (W/m.K) =	1.200
Floor Emissivity =	0.50
Floor Thickness = (mm)	100.0
Room 3 : Second Room = corridor	
Room Length (m) =	12.19
Room Width (m) =	2.44
Maximum Room Height (m) =	2.44
Minimum Room Height (m) =	2.44
Floor Elevation (m) =	0.000
Room 3 has a flat ceiling.	
Wall Surface is Calcium Silicate	
Wall Density (kg/m ³) =	720.0
Wall Conductivity (W/m.K) =	0.120
Wall Emissivity =	0.83
Wall Thickness (mm) =	12.7
Wall Substrate is Plasterboard	
Wall Substrate Density (kg/m ³) =	930.0

Wall Substrate Conductivity (W/m.K) =	0.170
Wall Substrate Thickness (mm) =	12.7
Ceiling Surface is Calcium Silicate	
Ceiling Density (kg/m3) =	720.0
Ceiling Conductivity (W/m.K) =	0.120
Ceiling Emissivity =	0.83
Ceiling Thickness (mm) =	12.7
Ceiling Substrate is Plasterboard	
Ceiling Substrate Density (kg/m3) =	930.0
Ceiling Substrate Conductivity (W/m.K) =	0.170
Ceiling Substrate Thickness (mm) =	12.7
Floor Surface is Plasterboard	
Floor Density (kg/m3) =	930.0
Floor Conductivity (W/m.K) =	0.170
Floor Emissivity =	0.88
Floor Thickness = (mm)	12.7
Room 4 : Third room corridor stub	
Room Length (m) =	0.94
Room Width (m) =	0.79
Maximum Room Height (m) =	2.04
Minimum Room Height (m) =	2.04
Floor Elevation (m) =	0.000
Room 4 has a flat ceiling.	
Wall Surface is Plasterboard	
Wall Density (kg/m3) =	930.0
Wall Conductivity (W/m.K) =	0.170
Wall Emissivity =	0.88
Wall Thickness (mm) =	13.0
Ceiling Surface is Plasterboard	
Ceiling Density (kg/m3) =	930.0
Ceiling Conductivity (W/m.K) =	0.170
Ceiling Emissivity =	0.88
Ceiling Thickness (mm) =	13.0
Floor Surface is Concrete, Steckler	
Floor Density (kg/m3) =	2200.0
Floor Conductivity (W/m.K) =	1.750
Floor Emissivity =	0.94
Floor Thickness = (mm)	102.0
Room 5 : third room	
Room Length (m) =	2.22
Room Width (m) =	2.24
Maximum Room Height (m) =	2.43
Minimum Room Height (m) =	2.43
Floor Elevation (m) =	0.000
Room 5 has a flat ceiling.	
Wall Surface is Plasterboard	
Wall Density (kg/m3) =	930.0
Wall Conductivity (W/m.K) =	0.170
Wall Emissivity =	0.88
Wall Thickness (mm) =	12.7
Ceiling Surface is Plasterboard	
Ceiling Density (kg/m3) =	930.0
Ceiling Conductivity (W/m.K) =	0.170
Ceiling Emissivity =	0.88
Ceiling Thickness (mm) =	12.7
Floor Surface is Concrete, Steckler	
Floor Density (kg/m3) =	2200.0
Floor Conductivity (W/m.K) =	1.750
Floor Emissivity =	0.94
Floor Thickness = (mm)	102.0
=====	
Wall Vents	
=====	
From room 1 to 2 , Vent No 1	
Vent Width (m) =	0.810

Vent Height (m) = 1.600
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 1.600
 Opening Time (sec) = 0
 Closing Time (sec) = 0

From room 2 to 3 , Vent No 1
 Vent Width (m) = 1.020
 Vent Height (m) = 2.000
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 2.000
 Opening Time (sec) = 0
 Closing Time (sec) = 0

From room 3 to 4 , Vent No 1
 Vent Width (m) = 0.790
 Vent Height (m) = 2.040
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 2.040
 Opening Time (sec) = 0
 Closing Time (sec) = 0

From room 3 to outside, Vent No 1
 Vent Width (m) = 0.760
 Vent Height (m) = 2.030
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 2.030
 Opening Time (sec) = 0
 Closing Time (sec) = 0

=====
 Ceiling/Floor Vents
 =====

Ambient Conditions
 =====

Interior Temp (C) = 18.0
 Exterior Temp (C) = 15.0
 Relative Humidity (%) = 51

Tenability Parameters
 =====

Monitoring Height for Visibility and FED (m) = 2.00
 Occupant Activity Level = Light
 Visibility calculations assume: reflective signs
 FED Start Time (sec) = 0
 FED End Time (sec) = 1000

Sprinkler / Detector Parameters
 =====

Sprinkler installed in Room 1
 Sprinkler is off.
 Response Time Index (m.s)^{1/2} = 278.0
 Sprinkler C-Factor (m.s)^{1/2} = 0.00
 Radial Distance (m) = 3.20
 Actuation Temperature (C) = 68.0
 Water Spray Density (mm/min) = 0.0
 Distance below ceiling (mm) = 25
 Ceiling Jet model used is NIST JET.

Mechanical Ventilation (to/from outside)
 =====

Mechanical Ventilation not installed in Room 1
 Mechanical Ventilation not installed in Room 2
 Mechanical Ventilation not installed in Room 3
 Mechanical Ventilation not installed in Room 4
 Mechanical Ventilation not installed in Room 5

Description of the Fire
 =====

Radiant Loss Fraction = 0.22
 CO Yield pre-flashover(g/g) = 0.040
 Soot Alpha Coefficient = 2.50

Smoke Epsilon Coefficient = 1.20
 Smoke Emission Coefficient (1/m) = 6.45
 Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.011
 Air Entrainment in Plume uses McCaffrey (default)

Burning Object No 1

Located in Room 1
 Energy Yield (kJ/g) = 45.6
 CO2 Yield (kg/kg fuel) = 2.670
 Soot Yield (kg/kg fuel) = 0.049
 HCN Yield (kg/kg fuel) = 0.000
 Fire Height (m) = 0.500
 Fire Location (m) = Wall

Time (sec)	Heat Release (kW)
0	0
5	103
1000	103

=====
 Postflashover Inputs
 =====

Postflashover model is OFF.

A.3 Case 4-1

Friday, July 18, 2008, 09:52 AM
 Input Filename : Eumat1.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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ISO 9705 painted gypsum plasterboard (E1)

=====
 Description of Rooms
 =====

Room 1 :

Room Length (m) = 3.60
 Room Width (m) = 2.40
 Maximum Room Height (m) = 2.40
 Minimum Room Height (m) = 2.40
 Floor Elevation (m) = 0.000
 Room 1 has a flat ceiling.

Wall Surface is plasterboard, painted gypsum paper-faced
 Wall Density (kg/m3) = 731.0
 Wall Conductivity (W/m.K) = 0.170
 Wall Emissivity = 0.88
 Wall Thickness (mm) = 13.0

Wall Substrate is Lightweight concrete
 Wall Substrate Density (kg/m3) = 800.0
 Wall Substrate Conductivity (W/m.K) = 0.210
 Wall Substrate Thickness (mm) = 150.0

Ceiling Surface is plasterboard, painted gypsum paper-faced
 Ceiling Density (kg/m3) = 731.0
 Ceiling Conductivity (W/m.K) = 0.170
 Ceiling Emissivity = 0.88
 Ceiling Thickness (mm) = 13.0

Ceiling Substrate is Lightweight concrete
 Ceiling Substrate Density (kg/m3) = 800.0
 Ceiling Substrate Conductivity (W/m.K) = 0.210
 Ceiling Substrate Thickness (mm) = 150.0

Floor Surface is Lightweight concrete
 Floor Density (kg/m3) = 800.0
 Floor Conductivity (W/m.K) = 0.210
 Floor Emissivity = 0.50
 Floor Thickness = (mm) 150.0

=====

Wall Vents

=====

From room 1 to outside, Vent No 1

Vent Width (m) =	0.800
Vent Height (m) =	2.000
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	2.000
Opening Time (sec) =	0
Closing Time (sec) =	0

=====

Ceiling/Floor Vents

=====

=====

Ambient Conditions

=====

Interior Temp (C) =	20.0
Exterior Temp (C) =	20.0
Relative Humidity (%) =	65

=====

Tenability Parameters

=====

Monitoring Height for Visibility and FED (m) =	1.50
Occupant Activity Level =	Light
Visibility calculations assume:	reflective signs
FED Start Time (sec)	0
FED End Time (sec)	1200

=====

Sprinkler / Detector Parameters

=====

No thermal detector or sprinkler installed.

=====

Mechanical Ventilation (to/from outside)

=====

Mechanical Ventilation not installed in Room 1

=====

Description of the Fire

=====

Radiant Loss Fraction =	0.29
CO Yield pre-flashover(g/g) =	0.040
Soot Alpha Coefficient =	2.50
Smoke Epsilon Coefficient =	1.20
Smoke Emission Coefficient (1/m) =	13.32
Characteristic Mass Loss per Unit Area (kg/s.m2) =	0.011
Air Entrainment in Plume uses McCaffrey (default)	

Burning Object No 1

Located in Room	1
Energy Yield (kJ/g) =	43.7
CO2 Yield (kg/kg fuel) =	2.340
Soot Yield (kg/kg fuel) =	0.010
HCN Yield (kg/kg fuel) =	0.000
Fire Height (m) =	0.340
Fire Location (m) =	Corner

Time (sec)	Heat Release (kW)
0	0
5	100
600	100
605	300
1200	300
1205	900
1800	900

=====

Postflashover Inputs

=====

Postflashover model is OFF.

=====

Flame Spread Inputs

=====

```

=====
This simulation includes flame spread on linings.
Cone Calorimeter Ignition data is correlated using the Flux Time Product method.
Quintiere's Room Corner Model is used.

```

```

Flame length power = 1.000
Flame area constant = 0.0065
Burner Width (m) = 0.170

```

Room 1

Wall Lining

```

Cone HRR data file used = e1.txt
Heat of combustion (kJ/g) = 4.1
Soot/smoke yield (g/g)= 0.010
Min surface temp for spread (C) = 478.0
Lateral flame spread parameter = 3.3
Ignition temperature (C) = 467.1
Thermal inertia = 0.358
Critical Flux for Ignition (kW/m2) = 23.5
Ignition Correlation Power, n
(1=thermally thin; 0.5=thermally thick) = 1.00
Flux Time Product (FTP) = 1175

```

Ceiling Lining

```

Cone HRR data file used = e1.txt
Heat of combustion (kJ/g) = 4.1
Soot/smoke yield (g/g)= 0.010
Ignition temperature (C) = 467.1
Thermal inertia = 0.358
Critical Flux for Ignition (kW/m2) = 23.5
Ignition Correlation Power, n
(1=thermally thin; 0.5=thermally thick) = 1.00
Flux Time Product (FTP) = 1175

```

A4 Case 4-2

Friday, July 18, 2008, 11:08 AM

Input Filename : PB115.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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ISO 9705 CSIRO Plasterboard 115

Description of Rooms

Room 1 :

```

Room Length (m) = 3.60
Room Width (m) = 2.40
Maximum Room Height (m) = 2.40
Minimum Room Height (m) = 2.40
Floor Elevation (m) = 0.000
Room 1 has a flat ceiling.

```

```

Wall Surface is Plasterboard, Australia
Wall Density (kg/m3) = 810.0
Wall Conductivity (W/m.K) = 0.160
Wall Emissivity = 0.88
Wall Thickness (mm) = 16.0

```

```

Wall Substrate is Gypsum paper-faced plasterboard (9.5 mm)
Wall Substrate Density (kg/m3) = 760.0
Wall Substrate Conductivity (W/m.K) = 0.160
Wall Substrate Thickness (mm) = 16.0

```

```

Ceiling Surface is Plasterboard, Australia
Ceiling Density (kg/m3) = 810.0
Ceiling Conductivity (W/m.K) = 0.160
Ceiling Emissivity = 0.88
Ceiling Thickness (mm) = 16.0

```

```

Ceiling Substrate is Gypsum paper-faced plasterboard (9.5 mm)
Ceiling Substrate Density (kg/m3) = 760.0
Ceiling Substrate Conductivity (W/m.K) = 0.160
Ceiling Substrate Thickness (mm) = 16.0

```

Floor Surface is Gypsum paper-faced plasterboard (9.5 mm)
 Floor Density (kg/m3) = 760.0
 Floor Conductivity (W/m.K) = 0.160
 Floor Emissivity = 0.88
 Floor Thickness = (mm) 16.0

=====

Wall Vents

=====

From room 1 to outside, Vent No 1

Vent Width (m) =	0.800
Vent Height (m) =	2.000
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	2.000
Opening Time (sec) =	0
Closing Time (sec) =	0

=====

Ceiling/Floor Vents

=====

Ambient Conditions

=====

Interior Temp (C) =	20.0
Exterior Temp (C) =	20.0
Relative Humidity (%) =	65

=====

Tenability Parameters

=====

Monitoring Height for Visibility and FED (m) =	1.50
Occupant Activity Level =	Light
Visibility calculations assume:	reflective signs
FED Start Time (sec)	0
FED End Time (sec)	1200

=====

Sprinkler / Detector Parameters

=====

No thermal detector or sprinkler installed.

=====

Mechanical Ventilation (to/from outside)

=====

Mechanical Ventilation not installed in Room 1

=====

Description of the Fire

=====

Radiant Loss Fraction =	0.30
CO Yield pre-flashover(g/g) =	0.040
Soot Alpha Coefficient =	2.50
Smoke Epsilon Coefficient =	1.20
Smoke Emission Coefficient (1/m) =	0.80
Characteristic Mass Loss per Unit Area (kg/s.m2) =	0.011
Air Entrainment in Plume uses McCaffrey (default)	

Burning Object No 1

Located in Room	1
Energy Yield (kJ/g) =	43.7
CO2 Yield (kg/kg fuel) =	2.340
Soot Yield (kg/kg fuel) =	0.006
HCN Yield (kg/kg fuel) =	0.000
Fire Height (m) =	0.300
Fire Location (m) =	Corner

Time (sec)	Heat Release (kW)
0	0
5	100
600	100
601	300
1500	300

=====

Postflashover Inputs

=====
Postflashover model is OFF.
=====

Flame Spread Inputs
=====

This simulation includes flame spread on linings.
Cone Calorimeter Ignition data is correlated using the Flux Time Product method.
Quintiere's Room Corner Model is used.

Flame length power = 1.000
Flame area constant = 0.0065
Burner Width (m) = 0.300

Room 1

Wall Lining

Cone HRR data file used = pb115all.txt
Heat of combustion (kJ/g) = 3.1
Soot/smoke yield (g/g)= 0.015
Min surface temp for spread (C) = 380.0
Lateral flame spread parameter = 14.0
Ignition temperature (C) = 504.3
Thermal inertia = 0.047
Critical Flux for Ignition (kW/m2) = 27.7
Ignition Correlation Power, n
(1=thermally thin; 0.5=thermally thick) = 0.50
Flux Time Product (FTP) = 12642

Ceiling Lining

Cone HRR data file used = pb115all.txt
Heat of combustion (kJ/g) = 3.1
Soot/smoke yield (g/g)= 0.015
Ignition temperature (C) = 504.3
Thermal inertia = 0.047
Critical Flux for Ignition (kW/m2) = 27.7
Ignition Correlation Power, n
(1=thermally thin; 0.5=thermally thick) = 0.50
Flux Time Product (FTP) = 12642

A.5 Case 5-1

Friday, July 18, 2008, 11:07 AM

Input Filename : hugerom_e2.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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ISO 9705 Full-scale room corner fire test simulation

=====
Description of Rooms
=====

Room 1 : large room

Room Length (m) = 6.75
Room Width (m) = 9.00
Maximum Room Height (m) = 4.90
Minimum Room Height (m) = 4.90
Floor Elevation (m) = 0.000
Room 1 has a flat ceiling.

Wall Surface is plywood, ordinary
Wall Density (kg/m3) = 725.0
Wall Conductivity (W/m.K) = 0.120
Wall Emissivity = 0.88
Wall Thickness (mm) = 12.0

Wall Substrate is Lightweight concrete
Wall Substrate Density (kg/m3) = 800.0
Wall Substrate Conductivity (W/m.K) = 0.210
Wall Substrate Thickness (mm) = 200.0

Ceiling Surface is plywood, ordinary
Ceiling Density (kg/m3) = 725.0
Ceiling Conductivity (W/m.K) = 0.120
Ceiling Emissivity = 0.88
Ceiling Thickness (mm) = 12.0

Ceiling Substrate is Lightweight concrete
 Ceiling Substrate Density (kg/m3) = 800.0
 Ceiling Substrate Conductivity (W/m.K) = 0.210
 Ceiling Substrate Thickness (mm) = 200.0

Floor Surface is Lightweight concrete
 Floor Density (kg/m3) = 800.0
 Floor Conductivity (W/m.K) = 0.210
 Floor Emissivity = 0.50
 Floor Thickness = (mm) 200.0

=====
 Wall Vents
 =====

From room 1 to outside, Vent No 1
 Vent Width (m) = 2.000
 Vent Height (m) = 2.000
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 2.000
 Opening Time (sec) = 0
 Closing Time (sec) = 0

=====
 Ceiling/Floor Vents
 =====

=====
 Ambient Conditions
 =====

Interior Temp (C) = 20.0
 Exterior Temp (C) = 20.0
 Relative Humidity (%) = 65

=====
 Tenability Parameters
 =====

Monitoring Height for Visibility and FED (m) = 1.50
 Occupant Activity Level = Light
 Visibility calculations assume: reflective signs
 FED Start Time (sec) 0
 FED End Time (sec) 1200

=====
 Sprinkler / Detector Parameters
 =====

No thermal detector or sprinkler installed.

=====
 Mechanical Ventilation (to/from outside)
 =====

Mechanical Ventilation not installed in Room 1

=====
 Description of the Fire
 =====

Radiant Loss Fraction = 0.30
 CO Yield pre-flashover(g/g) = 0.040
 Soot Alpha Coefficient = 2.50
 Smoke Epsilon Coefficient = 1.20
 Smoke Emission Coefficient (1/m) = 13.32
 Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.011
 Air Entrainment in Plume uses McCaffrey (default)

Burning Object No 1

Located in Room 1
 Energy Yield (kJ/g) = 47.3
 CO2 Yield (kg/kg fuel) = 2.850
 Soot Yield (kg/kg fuel) = 0.024
 HCN Yield (kg/kg fuel) = 0.000
 Fire Height (m) = 0.300
 Fire Location (m) = Corner

Time (sec)	Heat Release (kW)
0	0
5	100
600	100

601	300
1200	300
1201	900
1800	900

=====
Postflashover Inputs
=====

Postflashover model is OFF.

=====
Flame Spread Inputs
=====

This simulation includes flame spread on linings.
Cone Calorimeter Ignition data is correlated using the Flux Time Product method.
Quintiere's Room Corner Model is used.

Flame length power =	1.000
Flame area constant =	0.0065
Burner Width (m) =	0.170

Room 1

Wall Lining

Cone HRR data file used =	e2.txt
Heat of combustion (kJ/g) =	11.9
Soot/smoke yield (g/g)=	0.009
Min surface temp for spread (C) =	164.0
Lateral flame spread parameter =	13.0
Ignition temperature (C) =	428.0
Thermal inertia =	0.178
Critical Flux for Ignition (kW/m2)	19.5
Ignition Correlation Power, n	
(1=thermally thin; 0.5=thermally thick)	1.00
Flux Time Product (FTP)	780

Ceiling Lining

Cone HRR data file used =	e2.txt
Heat of combustion (kJ/g) =	11.9
Soot/smoke yield (g/g)=	0.009
Ignition temperature (C) =	428.0
Thermal inertia =	0.178
Critical Flux for Ignition (kW/m2)	19.5
Ignition Correlation Power, n	
(1=thermally thin; 0.5=thermally thick)	1.00
Flux Time Product (FTP)	780

A.6 Case 6-1

Friday, July 18, 2008, 09:49 AM

Input Filename : 590A.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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=====
Description of Rooms
=====

Room 1 :

Room Length (m) =	3.60
Room Width (m) =	2.40
Maximum Room Height (m) =	2.40
Minimum Room Height (m) =	2.40
Floor Elevation (m) =	0.000

Room 1 has a flat ceiling.

Wall Surface is gypsum plasterboard (postflashover)

Wall Density (kg/m3) =	720.0
Wall Conductivity (W/m.K) =	0.200
Wall Emissivity =	0.90
Wall Thickness (mm) =	13.0

Ceiling Surface is gypsum plasterboard (postflashover)

Ceiling Density (kg/m3) =	720.0
Ceiling Conductivity (W/m.K) =	0.200
Ceiling Emissivity =	0.90
Ceiling Thickness (mm) =	13.0

Floor Surface is particleboard, low density
 Floor Density (kg/m3) = 590.0
 Floor Conductivity (W/m.K) = 0.078
 Floor Emissivity = 0.88
 Floor Thickness = (mm) 20.0

=====

Wall Vents

=====

From room 1 to outside, Vent No 1
 Vent Width (m) = 0.800
 Vent Height (m) = 2.000
 Vent Sill Height (m) = 0.000
 Vent Soffit Height (m) = 2.000
 Opening Time (sec) = 0
 Closing Time (sec) = 0

From room 1 to outside, Vent No 2
 Vent Width (m) = 2.400
 Vent Height (m) = 2.000
 Vent Sill Height (m) = 0.400
 Vent Soffit Height (m) = 2.400
 Opening Time (sec) = 1320
 Closing Time (sec) = 0

=====

Ceiling/Floor Vents

=====

Ambient Conditions

=====

Interior Temp (C) = 20.0
 Exterior Temp (C) = 20.0
 Relative Humidity (%) = 65

=====

Tenability Parameters

=====

Monitoring Height for Visibility and FED (m) = 2.00
 Occupant Activity Level = Light
 Visibility calculations assume: reflective signs
 FED Start Time (sec) 0
 FED End Time (sec) 600

=====

Sprinkler / Detector Parameters

=====

No thermal detector or sprinkler installed.

=====

Mechanical Ventilation (to/from outside)

=====

Mechanical Ventilation not installed in Room 1

=====

Description of the Fire

=====

Radiant Loss Fraction = 0.35
 CO Yield pre-flashover(g/g) = 0.040
 Soot Alpha Coefficient = 2.50
 Smoke Epsilon Coefficient = 1.20
 Smoke Emission Coefficient (1/m) = 0.80
 Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.011
 Air Entrainment in Plume uses McCaffrey (default)

Burning Object No 1

Located in Room 1
 Energy Yield (kJ/g) = 25.0
 CO2 Yield (kg/kg fuel) = 1.500
 Soot Yield (kg/kg fuel) = 0.194
 Fire Height (m) = 0.300
 Fire Location (m) = Centre

Time (sec) Heat Release (kW)
 0 1

4	2
7	2
10	2
13	2
16	2
19	2
22	2
25	2
28	2
31	1
34	1
37	2
40	1
43	1
46	2
49	2
52	2
55	1
58	2
61	3
64	2
67	3
70	7
73	10
76	12
79	15
82	25
85	35
88	48
91	74
94	96
97	114
100	132
103	134
106	170
109	157
112	173
115	224
118	262
121	256
124	348
127	387
130	389
133	390
136	492
139	566
142	656
145	717
148	742
151	974
154	1191
157	1177
160	1574
163	1800
166	1739
169	2280
172	2451
175	2401
178	2643
181	3032
184	2490
187	2567
190	2745
193	2611
196	2460
199	2708
202	2461
205	2383
208	2274
211	2181
214	2211
217	2703
220	2723
223	2368
226	2164
229	2060
232	1662

235	1328
238	1204
241	1050
244	771
247	635
250	537
253	467
256	401
259	390
262	297
265	316
268	250
271	185
274	204
277	213
280	200
283	191
286	201
289	190
292	178
295	181
298	177
301	162
304	176
307	163
310	155
313	138
316	131
319	150
322	154
325	112
328	126
331	150
334	143
337	131
340	138
343	121
346	103
349	117
352	122
355	101
358	103
361	81
364	98
367	93
370	87
373	89
376	92
379	85
382	92
385	97
388	90
391	88
394	82
397	93
400	80
403	79
406	88
409	83
412	84
415	79
418	83
421	75
424	91
427	85
430	72
433	75
436	81
439	67
442	74
445	77
448	71
451	81
454	69
457	64
460	73
463	62

466	69
469	50
472	57
475	49
478	56
481	64
484	44
487	54
490	53
493	56
496	46
499	56
502	56
505	51
508	39
511	50
514	46
517	45
520	44
523	43
526	47
529	41
532	40
535	36
538	42
541	37
544	40
547	50
550	45
553	42
556	45
559	47
562	43
565	43
568	37
571	43
574	43
577	44
580	38
583	41
586	40
589	38
592	34
595	37
598	42
601	39

```
=====
Postflashover Inputs
=====
```

Postflashover model is ON.

FLED (MJ/m2) =	800
Fuel Density (kg/m3) =	500
Average heat of Combustion (MJ/kg) =	13.0
Wood Crib Stick Thickness (m) =	0.050
Wood Crib Stick Spacing (m) =	0.100

A.7 Case 7-1

Friday, July 18, 2008, 10:34 AM
Input Filename : glass1.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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0.5 x 0.5 m pan in corner

```
=====
Description of Rooms
=====
```

Room 1 :		
Room Length (m) =	3.60	
Room Width (m) =	2.40	
Maximum Room Height (m) =	2.40	

Minimum Room Height (m) =	2.40
Floor Elevation (m) =	0.000
Room 1 has a flat ceiling.	
Wall Surface is plasterboard	
Wall Density (kg/m3) =	810.0
Wall Conductivity (W/m.K) =	0.160
Wall Emissivity =	0.88
Wall Thickness (mm) =	12.5
Wall Substrate is ceramic fibreboard	
Wall Substrate Density (kg/m3) =	336.0
Wall Substrate Conductivity (W/m.K) =	0.080
Wall Substrate Thickness (mm) =	50.0
Ceiling Surface is calcium silicate	
Ceiling Density (kg/m3) =	720.0
Ceiling Conductivity (W/m.K) =	0.120
Ceiling Emissivity =	0.83
Ceiling Thickness (mm) =	6.0
Ceiling Substrate is Lightweight concrete	
Ceiling Substrate Density (kg/m3) =	800.0
Ceiling Substrate Conductivity (W/m.K) =	0.210
Ceiling Substrate Thickness (mm) =	125.0
Floor Surface is calcium silicate	
Floor Density (kg/m3) =	720.0
Floor Conductivity (W/m.K) =	0.120
Floor Emissivity =	0.83
Floor Thickness = (mm)	6.0
Floor Substrate is concrete, lightweight	
Floor Substrate Density (kg/m3) =	800.0
Floor Substrate Conductivity (W/m.K) =	0.210
Floor Substrate Thickness (mm) =	100.0

=====

Wall Vents

=====

From room 1 to outside, Vent No 1	
Vent Width (m) =	0.400
Vent Height (m) =	2.000
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	2.000
Opening Time (sec) =	0
Closing Time (sec) =	0
From room 1 to outside, Vent No 2	
Vent Width (m) =	0.844
Vent Height (m) =	0.844
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	0.844
Opening Time (sec) =	0
Closing Time (sec) =	0
Glass fracture is modelled for this vent	
Glass Thickness (mm) =	6.0
Glass Fracture to Fallout Time (sec) =	2000
Glass Shading Depth (mm) =	20.0
Glass Fracture Stress (MPa) =	47
Glass Expansion Coefficient (/C) =	0.0000083
Glass Conductivity (W/mK) =	0.94
Glass Diffusivity (m2/s) =	4.2E-07
Glass Modulus (W/mK) =	72000
Glass is heated by gas layers only.	
From room 1 to outside, Vent No 3	
Vent Width (m) =	0.844
Vent Height (m) =	0.844
Vent Sill Height (m) =	1.060
Vent Soffit Height (m) =	1.904
Opening Time (sec) =	0
Closing Time (sec) =	0
Glass fracture is modelled for this vent	
Glass Thickness (mm) =	6.0
Glass Fracture to Fallout Time (sec) =	2000
Glass Shading Depth (mm) =	20.0

Glass Fracture Stress (MPa) = 47
 Glass Expansion Coefficient (/C) = 0.0000083
 Glass Conductivity (W/mK) = 0.94
 Glass Diffusivity (m2/s) = 4.2E-07
 Glass Modulus (W/mK) = 72000
 Glass is heated by gas layers only.

From room 1 to outside, Vent No 4
 Vent Width (m) = 0.844
 Vent Height (m) = 1.870
 Vent Sill Height (m) = 0.020
 Vent Soffit Height (m) = 1.890
 Opening Time (sec) = 0
 Closing Time (sec) = 0
 Glass fracture is modelled for this vent
 Glass Thickness (mm) = 6.0
 Glass Fracture to Fallout Time (sec) = 2000
 Glass Shading Depth (mm) = 20.0
 Glass Fracture Stress (MPa) = 47
 Glass Expansion Coefficient (/C) = 0.0000083
 Glass Conductivity (W/mK) = 0.94
 Glass Diffusivity (m2/s) = 4.2E-07
 Glass Modulus (W/mK) = 72000
 Glass is heated by gas layers only.

=====
 Ceiling/Floor Vents
 =====

Ambient Conditions
 =====

Interior Temp (C) = 20.0
 Exterior Temp (C) = 20.0
 Relative Humidity (%) = 65

=====
 Tenability Parameters
 =====

Monitoring Height for Visibility and FED (m) = 1.50
 Occupant Activity Level = Light
 Visibility calculations assume: reflective signs
 FED Start Time (sec) = 0
 FED End Time (sec) = 1200

=====
 Sprinkler / Detector Parameters
 =====

No thermal detector or sprinkler installed.

=====
 Mechanical Ventilation (to/from outside)
 =====

Mechanical Ventilation not installed in Room 1

=====
 Description of the Fire
 =====

Radiant Loss Fraction = 0.25
 CO Yield pre-flashover(g/g) = 0.040
 Soot Alpha Coefficient = 2.50
 Smoke Epsilon Coefficient = 1.20
 Smoke Emission Coefficient (1/m) = 0.80
 Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.015
 Air Entrainment in Plume uses McCaffrey (default)

Burning Object No 1

Located in Room 1
 Energy Yield (kJ/g) = 25.6
 CO2 Yield (kg/kg fuel) = 1.510
 Soot Yield (kg/kg fuel) = 0.008
 Fire Height (m) = 0.300
 Fire Location (m) = Corner

Time (sec)	Heat Release (kW)
0	0
60	92

90	110
300	130
540	130
760	144
792	136
960	154
1092	146
1158	36

```

=====
Postflashover Inputs
=====
Postflashover model is OFF.

```

A.8 Case 8-1

Friday, July 18, 2008, 10:44 AM
Input Filename : heat-r3-d250.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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Description of Rooms

```

=====
Room 1 : draft curtained area
Room Length (m) = 24.40
Room Width (m) = 18.30
Maximum Room Height (m) = 14.90
Minimum Room Height (m) = 14.90
Floor Elevation (m) = 0.000
Room 1 has a flat ceiling.

Wall Surface is steel (mild)
Wall Density (kg/m3) = 7850.0
Wall Conductivity (W/m.K) = 45.800
Wall Emissivity = 0.90
Wall Thickness (mm) = 3.0

Ceiling Surface is steel (mild)
Ceiling Density (kg/m3) = 7850.0
Ceiling Conductivity (W/m.K) = 45.800
Ceiling Emissivity = 0.90
Ceiling Thickness (mm) = 3.0

Floor Surface is concrete
Floor Density (kg/m3) = 2300.0
Floor Conductivity (W/m.K) = 1.200
Floor Emissivity = 0.50
Floor Thickness = (mm) 100.0

```

Wall Vents

```

=====
From room 1 to outside, Vent No 1
Vent Width (m) = 85.400
Vent Height (m) = 11.200
Vent Sill Height (m) = 0.000
Vent Soffit Height (m) = 11.200
Opening Time (sec) = 0
Closing Time (sec) = 0

```

Ceiling/Floor Vents

Ambient Conditions

```

=====
Interior Temp (C) = 25.0
Exterior Temp (C) = 25.0
Relative Humidity (%) = 65

```

Tenability Parameters

```

=====
Monitoring Height for Visibility and FED (m) = 2.00
Occupant Activity Level = Light
Visibility calculations assume: reflective signs
FED Start Time (sec) 0
FED End Time (sec) 600
=====

```

=====
Sprinkler / Detector Parameters
=====

```

Heat detector installed in Room 1
Response Time Index (m.s)^1/2 = 50.0
Radial Distance (m) = 3.0
Actuation Temperature (C) = 57.2
Distance below ceiling (mm) = 250
Ceiling Jet model used is NIST JET.
=====

```

=====
Mechanical Ventilation (to/from outside)
=====

Mechanical Ventilation not installed in Room 1

=====
Description of the Fire
=====

```

Radiant Loss Fraction = 0.31
CO Yield pre-flashover(g/g) = 0.040
Soot Alpha Coefficient = 2.50
Smoke Epsilon Coefficient = 1.20
Smoke Emission Coefficient (1/m) = 13.32
Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.011
Air Entrainment in Plume uses McCaffrey (default)
=====

```

Burning Object No 1

```

Located in Room 1
Energy Yield (kJ/g) = 42.0
CO2 Yield (kg/kg fuel) = 2.850
Soot Yield (kg/kg fuel) = 0.037
HCN Yield (kg/kg fuel) = 0.000
Fire Height (m) = 0.000
Fire Location (m) = Centre
=====

```

Time (sec)	Heat Release (kW)
0	0
90	7700
1000	7700

=====
Postflashover Inputs
=====

Postflashover model is OFF.

A.9 Case 8-2

Friday, July 18, 2008, 09:49 AM
Input Filename : 500kWfire.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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=====
Description of Rooms
=====

```

Room 1 : draft curtained area
Room Length (m) = 24.40
Room Width (m) = 18.30
Maximum Room Height (m) = 14.90
Minimum Room Height (m) = 14.90
Floor Elevation (m) = 0.000
Room 1 has a flat ceiling.

Wall Surface is steel (mild)
Wall Density (kg/m3) = 7850.0
=====

```

Wall Conductivity (W/m.K) =	45.800
Wall Emissivity =	0.90
Wall Thickness (mm) =	3.0
Ceiling Surface is steel (mild)	
Ceiling Density (kg/m3) =	7850.0
Ceiling Conductivity (W/m.K) =	45.800
Ceiling Emissivity =	0.90
Ceiling Thickness (mm) =	3.0
Floor Surface is concrete	
Floor Density (kg/m3) =	2300.0
Floor Conductivity (W/m.K) =	1.200
Floor Emissivity =	0.50
Floor Thickness = (mm)	100.0

=====
Wall Vents
=====

From room 1 to outside, Vent No 1

Vent Width (m) =	85.400
Vent Height (m) =	11.200
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	11.200
Opening Time (sec) =	0
Closing Time (sec) =	0

=====
Ceiling/Floor Vents
=====

=====
Ambient Conditions
=====

Interior Temp (C) =	28.0
Exterior Temp (C) =	28.0
Relative Humidity (%) =	65

=====
Tenability Parameters
=====

Monitoring Height for Visibility and FED (m) =	2.00
Occupant Activity Level =	Light
Visibility calculations assume:	reflective signs
FED Start Time (sec)	0
FED End Time (sec)	600

=====
Sprinkler / Detector Parameters
=====

Heat detector installed in Room	1
Response Time Index (m.s) ^{1/2} =	35.0
Radial Distance (m) =	3.0
Actuation Temperature (C) =	79.0
Distance below ceiling (mm) =	310
Ceiling Jet model used is Alpert's.	
Smoke Detector in Room 1	
Smoke Optical Density for Alarm (1/m)	0.036
Detector Characteristic Length Number (m)	10.0
Detector Sensitivity (%/ft)	2.5
Radial Distance from Plume (m)	3.000
Distance below Ceiling (m)	0.250
Detector response is based on OD outside the detector chamber.	

=====
Mechanical Ventilation (to/from outside)
=====

Mechanical Ventilation not installed in Room 1

=====
Description of the Fire
=====

Radiant Loss Fraction =	0.35
CO Yield pre-flashover(g/g) =	0.040
Soot Alpha Coefficient =	2.50
Smoke Epsilon Coefficient =	1.20
Smoke Emission Coefficient (1/m) =	13.32
Characteristic Mass Loss per Unit Area (kg/s.m2) =	0.011
Air Entrainment in Plume uses McCaffrey (default)	

Burning Object No 1

Located in Room	1
Energy Yield (kJ/g) =	40.5
CO2 Yield (kg/kg fuel) =	2.830
Soot Yield (kg/kg fuel) =	0.042
HCN Yield (kg/kg fuel) =	0.000
Fire Height (m) =	0.000
Fire Location (m) =	Centre

Time (sec)	Heat Release (kW)
0	0
1	99
20	174
50	273
100	388
200	481
300	478

=====
Postflashover Inputs
=====

Postflashover model is OFF.

A.10 Case 9-1

Friday, July 18, 2008, 09:51 AM
Input Filename : davis1.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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=====
Description of Rooms
=====

Room 1 :

Room Length (m) =	3.02
Room Width (m) =	3.15
Maximum Room Height (m) =	1.50
Minimum Room Height (m) =	1.50
Floor Elevation (m) =	0.000
Room 1 has a flat ceiling.	
Wall Surface is concrete, lightweight	
Wall Density (kg/m3) =	800.0
Wall Conductivity (W/m.K) =	0.210
Wall Emissivity =	0.50
Wall Thickness (mm) =	100.0
Ceiling Surface is ceramic fibreboard	
Ceiling Density (kg/m3) =	336.0
Ceiling Conductivity (W/m.K) =	0.080
Ceiling Emissivity =	0.90
Ceiling Thickness (mm) =	20.0
Floor Surface is concrete	
Floor Density (kg/m3) =	2300.0
Floor Conductivity (W/m.K) =	1.200
Floor Emissivity =	0.50
Floor Thickness = (mm)	100.0

=====
Wall Vents
=====

From room 1 to outside, Vent No 1

Vent Width (m) =	0.000
Vent Height (m) =	0.000
Vent Sill Height (m) =	0.000
Vent Soffit Height (m) =	0.000
Opening Time (sec) =	0
Closing Time (sec) =	0

=====

Ceiling/Floor Vents

Ambient Conditions

Interior Temp (C) = 20.0
Exterior Temp (C) = 20.0
Relative Humidity (%) = 65

Tenability Parameters

Monitoring Height for Visibility and FED (m) = 2.00
Occupant Activity Level = Light
Visibility calculations assume: reflective signs
FED Start Time (sec) 0
FED End Time (sec) 10000

Sprinkler / Detector Parameters

No thermal detector or sprinkler installed.

Mechanical Ventilation (to/from outside)

Mechanical Ventilation not installed in Room 1

Description of the Fire

Radiant Loss Fraction = 0.32
CO Yield pre-flashover(g/g) = 0.040
Soot Alpha Coefficient = 2.50
Smoke Epsilon Coefficient = 1.20
Smoke Emission Coefficient (1/m) = 13.32
Characteristic Mass Loss per Unit Area (kg/s.m2) = 0.011
Air Entrainment in Plume uses McCaffrey (default)

Burning Object No 1

Located in Room 1
Energy Yield (kJ/g) = 40.5
CO2 Yield (kg/kg fuel) = 2.800
Soot Yield (kg/kg fuel) = 0.095
HCN Yield (kg/kg fuel) = 0.000
Fire Height (m) = 0.000
Fire Location (m) = Centre

Time (sec)	Heat Release (kW)
0	3
1000	3

Postflashover Inputs

Postflashover model is OFF.