STUDY REPORT

No. 201 (2008)

BRANZFIRE 2008 Compilation of Verification Data

C.A. Wade

FUNDED BY
THE BUILDING
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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

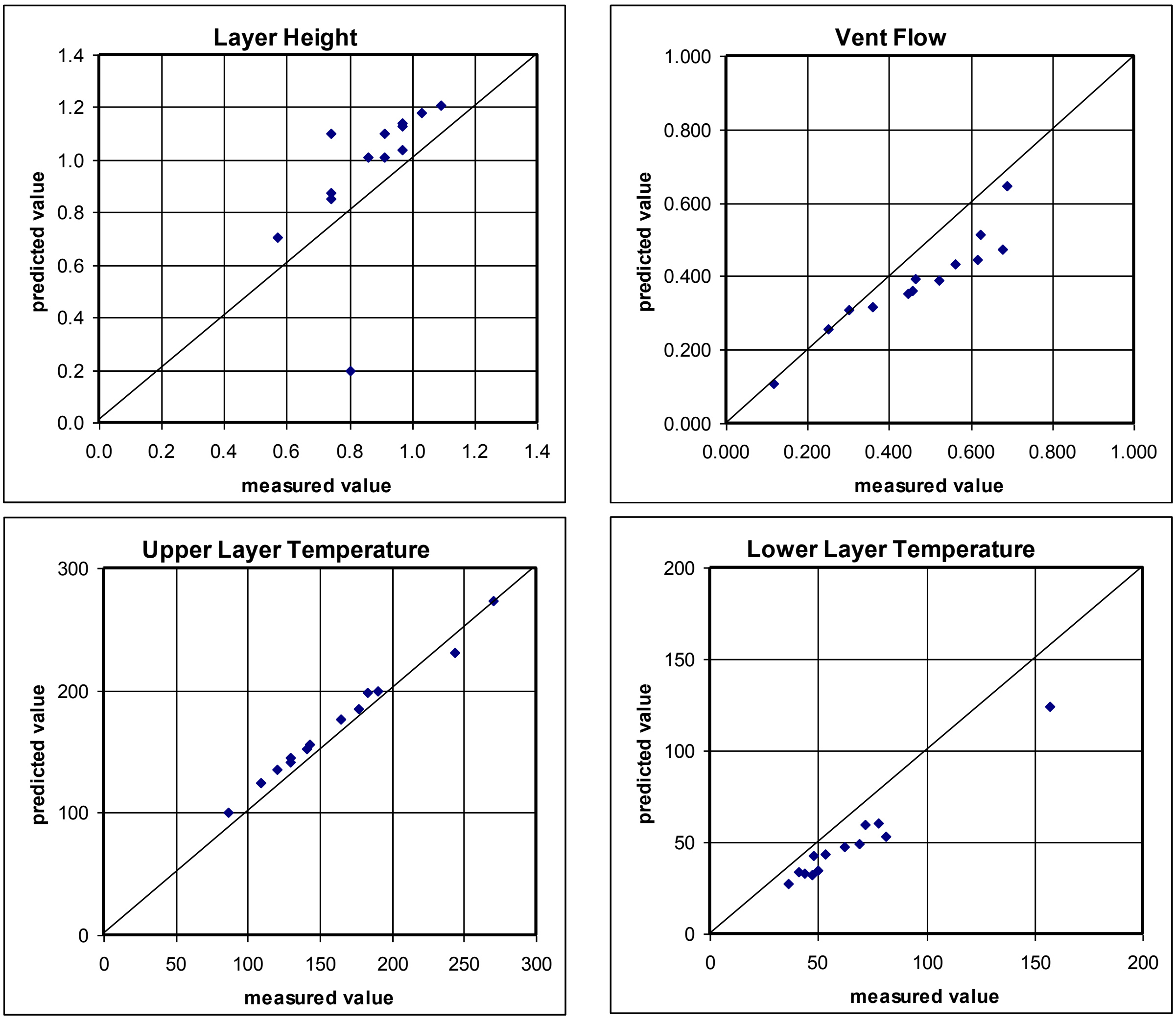


Table 1. Comparison of results for steady state conditions

	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 = 26ºC		
Interface height (m)	0.57 ± 0.28	**0.70**
Upper temp (ºC)	190	**200**
Lower temp (ºC)	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 = 28ºC		
Interface height (m)	0.74 ± 0.23	**0.88**
Upper temp (ºC)	164	**177**
Lower temp (ºC)	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 = 22ºC		
Interface height (m)	0.86 ± 0.28	**1.01**
Upper temp (ºC)	141	**153**
Lower temp (ºC)	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 = 23ºC		
Interface height (m)	0.91 ± 0.17	**1.10**
Upper temp (ºC)	129	**145**
Lower temp (ºC)	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 = 29ºC		
Interface height (m)	0.97 ± 0.23	**1.13**
Upper temp (ºC)	129	**142**
Lower temp (ºC)	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 = 26ºC		
Interface height (m)	1.03 ± 0.17	**1.18**
Upper temp (ºC)	120	**136**
Lower temp (ºC)	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 = 22ºC		
Interface height (m)	1.09 ± 0.23	**1.21**
Upper temp (ºC)	109	**125**
Lower temp (ºC)	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 = 30ºC		
Interface height (m)	0.74 ± 0.34	**1.10**
Upper temp (ºC)	143	**156**
Lower temp (ºC)	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 = 26ºC		
Interface height (m)	0.74 ± 0.34	**0.85**
Upper temp (ºC)	177	**185**
Lower temp (ºC)	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 = 16ºC		
Interface height (m)	0.80 ± 0.17	**0.20**
Upper temp (ºC)	270	**273**
Lower temp (ºC)	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 = 29ºC		
Interface height (m)	0.97 ± 0.11	**1.14**
Upper temp (ºC)	86	**101**
Lower temp (ºC)	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 = 35ºC		
Interface height (m)	0.97 ± 0.11	**1.04**
Upper temp (ºC)	183	**198**
Lower temp (ºC)	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 = 36ºC		
Interface height (m)	0.91 ± 0.17	**1.01**
Upper temp (ºC)	243	**231**
Lower temp (ºC)	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.

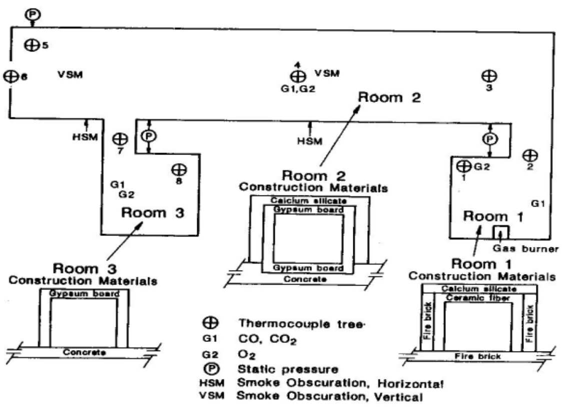


Figure 2. Experimental layout and instrumentation configuration for gas burner tests

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 trees 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 CO_2 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.

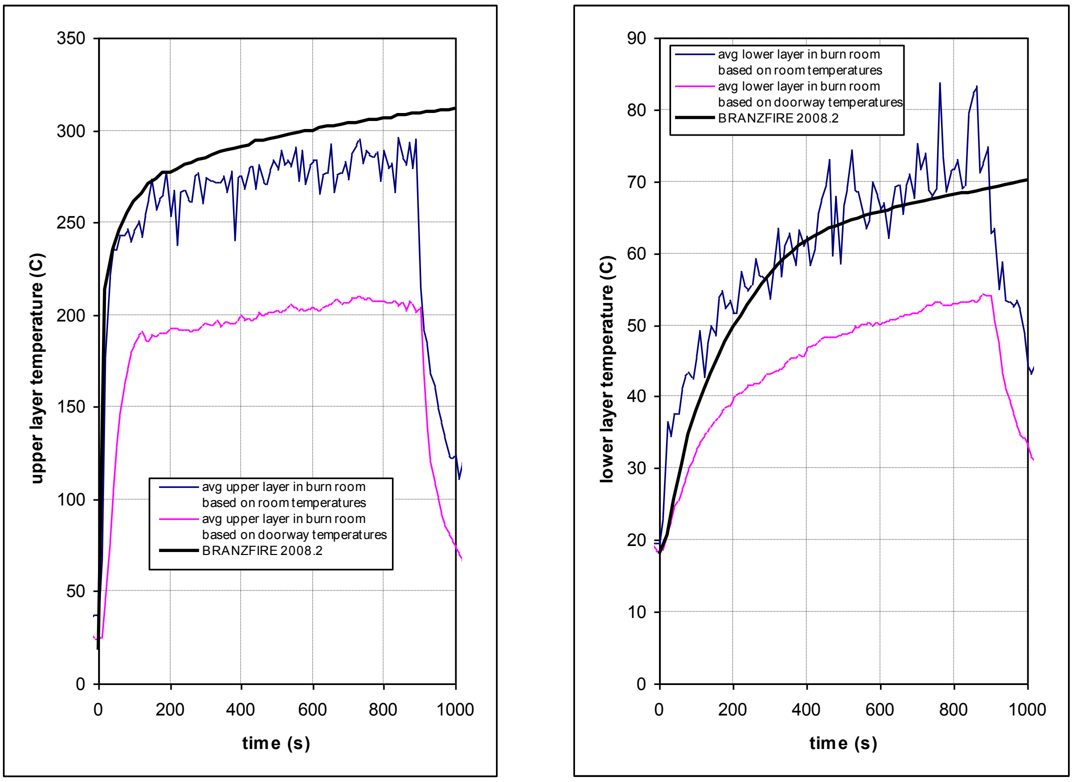
A summary of the experiments presented is shown in Table 2.

Table 2. Summary of experiments

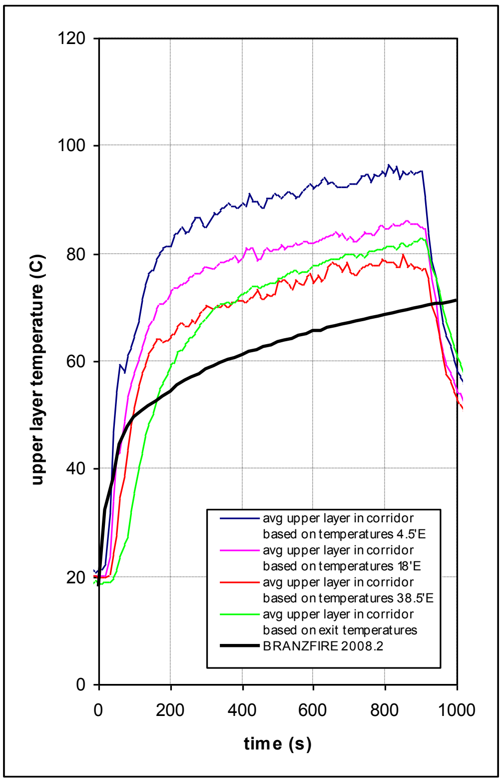
Test ID	Nominal fire size	Corridor exit	Door to Room 3
Set 1 – 100J (Figure 3)	100 kW	Open	Closed
Set 6 – 300D (Figure 4)	300 kW	Closed	Open
Set 8 – 500A (Figure 5)	500 kW	Open	Closed

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).

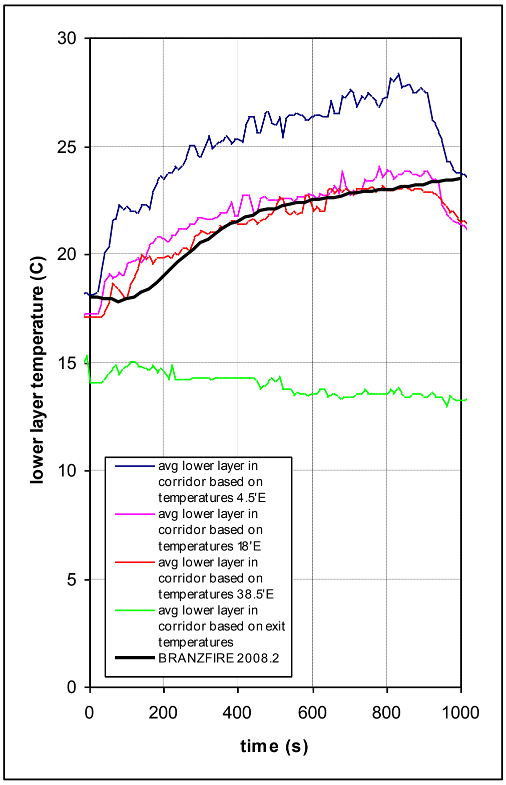


(a) (b)



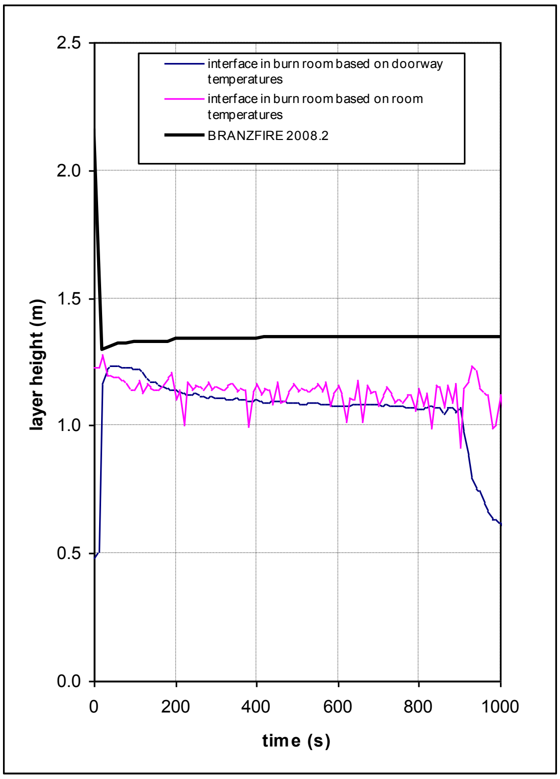
120
100
80
60
40
20
0
0
200
400
600
800
1000
upper layer temperature (C)
time (s)
avg upper layer in corridor based on temperatures 4.5'E
avg upper layer in corridor based on temperatures 18'E
avg upper layer in corridor based on temperatures 38.5'E
avg upper layer in corridor based on exit temperatures
BRANZFIRE 2008.2

(c)



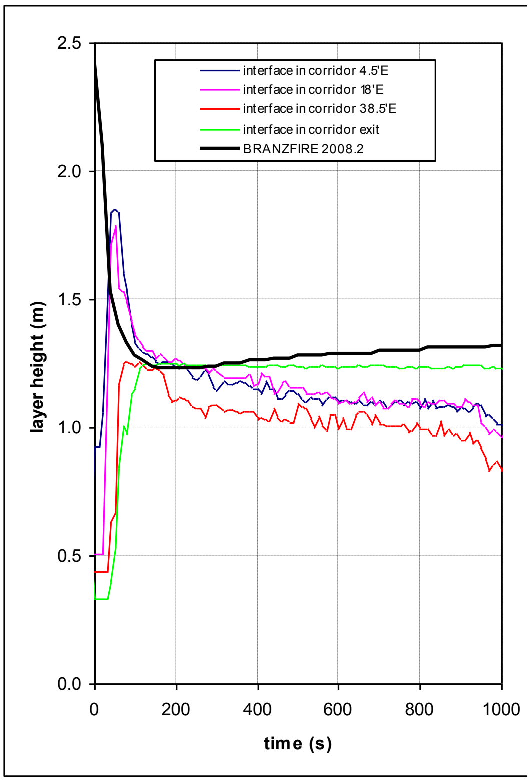
30
25
20
15
10
5
0
0
200
400
600
800
1000
lower layer temperature (C)
time (s)
avg lower layer in corridor based on temperatures 4.5'E
avg lower layer in corridor based on temperatures 18'E
avg lower layer in corridor based on temperatures 38.5'E
avg lower layer in corridor based on exit temperatures
BRANZFIRE 2008.2

(d)



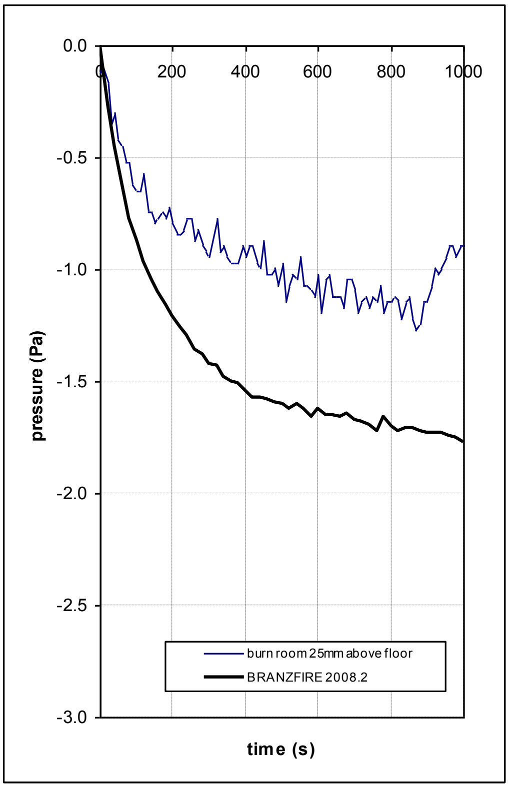
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
layer height (m)
time (s)
interface in burn room based on doorway temperatures
interface in burn room based on room temperatures
BRANZFIRE 2008.2

(e)



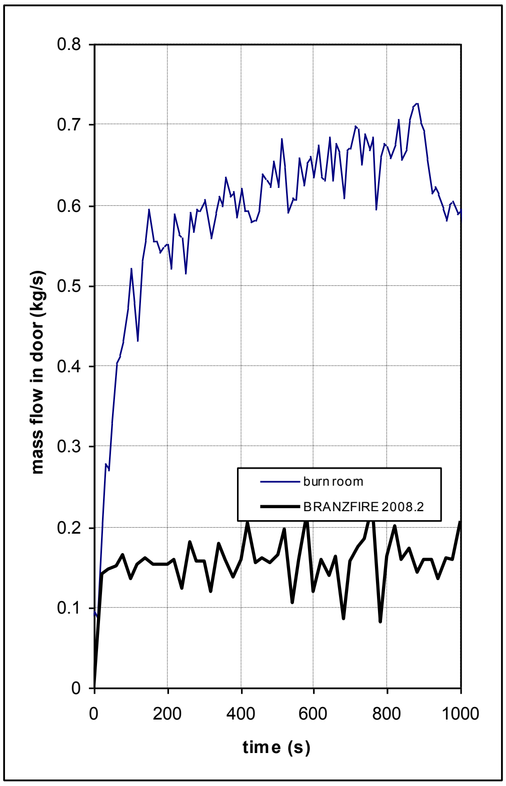
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
layer height (m)
time (s)
interface in corridor 4.5'E
interface in corridor 18'E
interface in corridor 38.5'E
interface in corridor exit
BRANZFIRE 2008.2

(f)



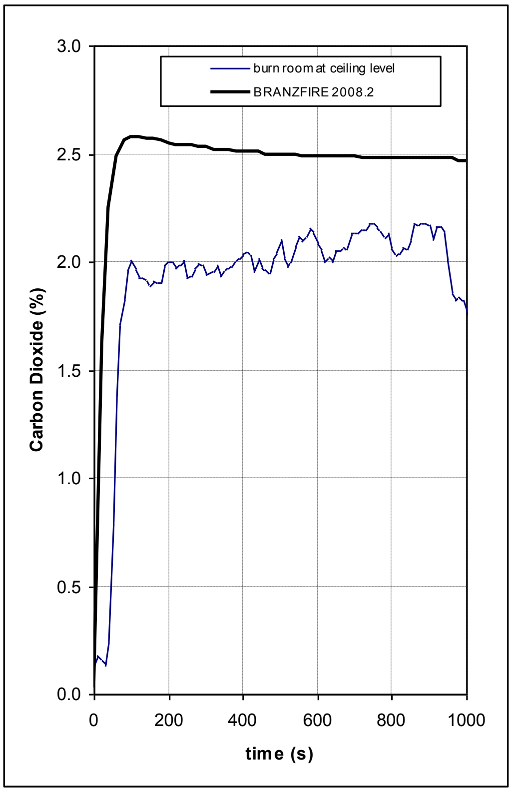
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
0
200
400
600
800
1000
pressure (Pa)
time (s)
burn room 25mm above floor
BRANZFIRE 2008.2

(g)



0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
mass flow in door (kg/s)
time (s)
burn room
BRANZFIRE 2008.2

(h)

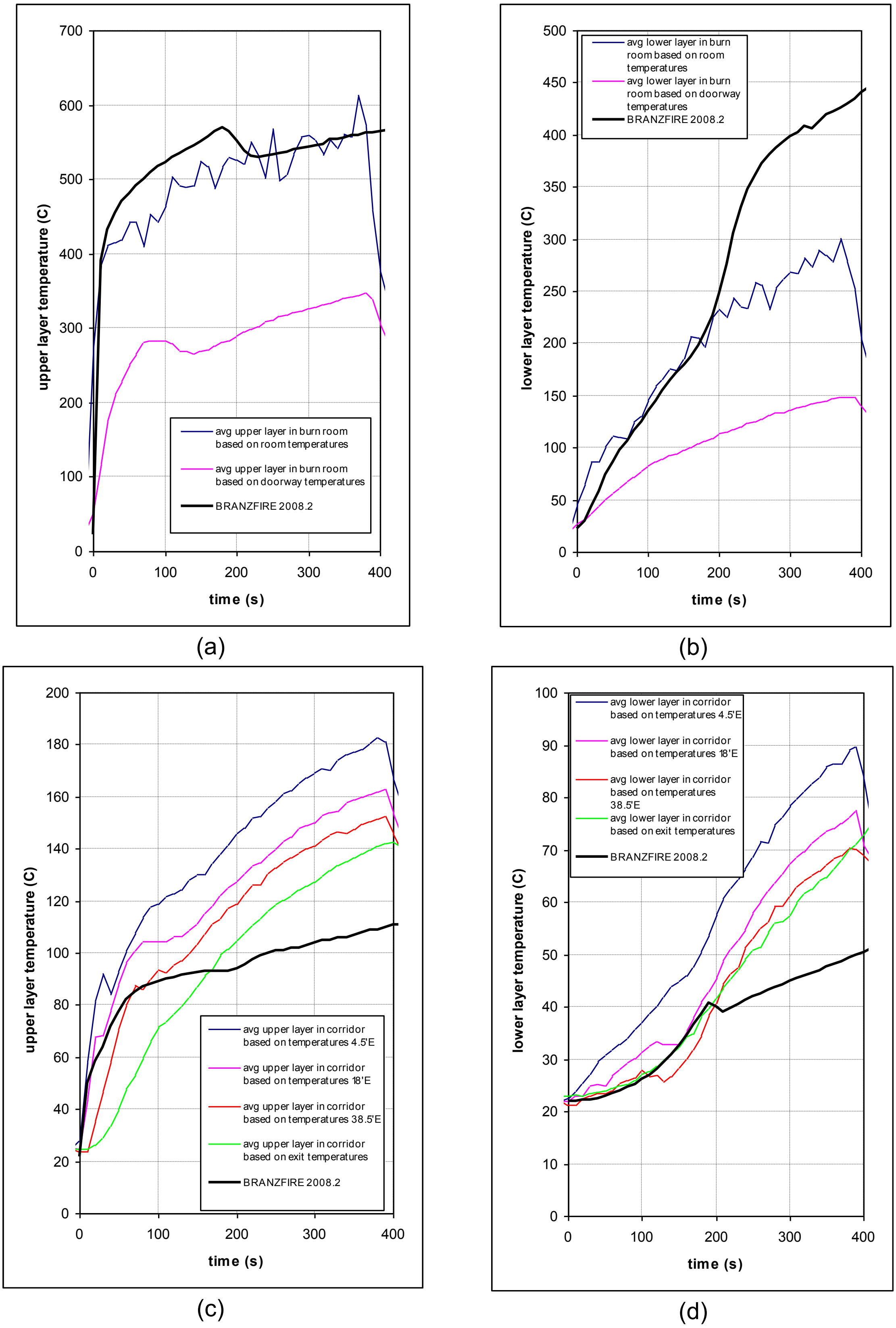


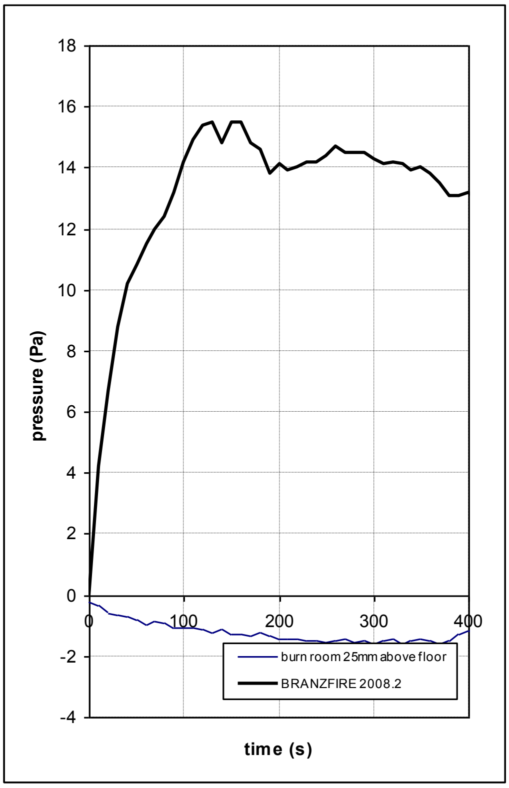
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
Carbon Dioxide (%)
time (s)
burn room at ceiling level
BRANZFIRE 2008.2

(i)

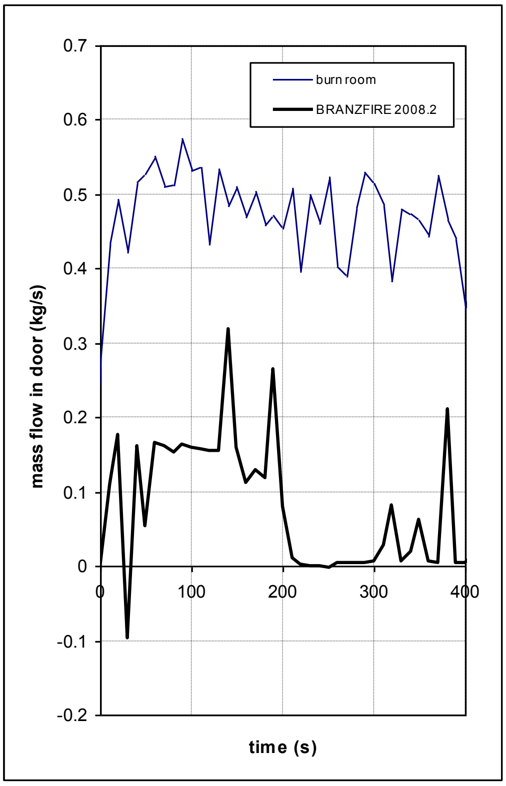
Figure 4. Test 300D

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).

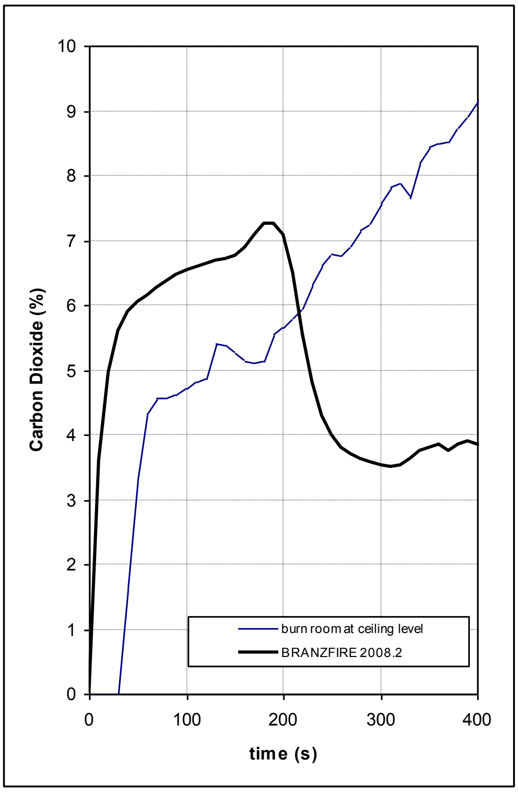



pressure (Pa)
time (s)
burn room 25mm above floor
BRANZFIRE 2008.2

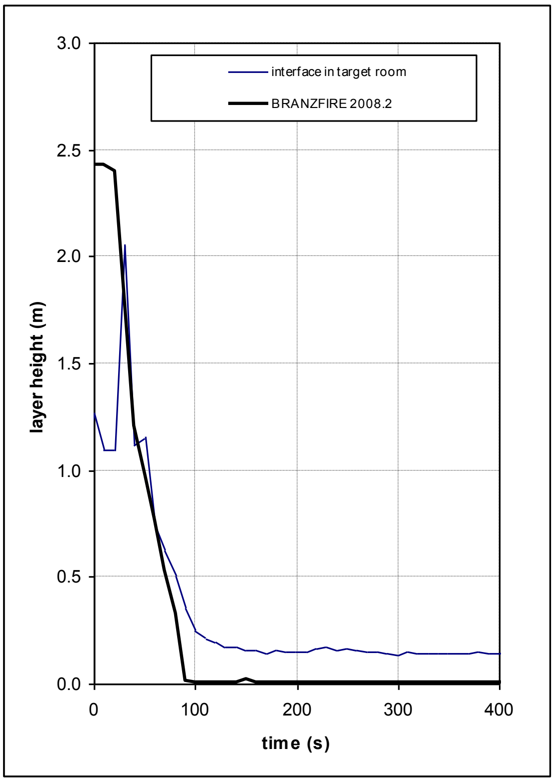
(e)


mass flow in door (kg/s)
time (s)
burn room
BRANZFIRE 2008.2

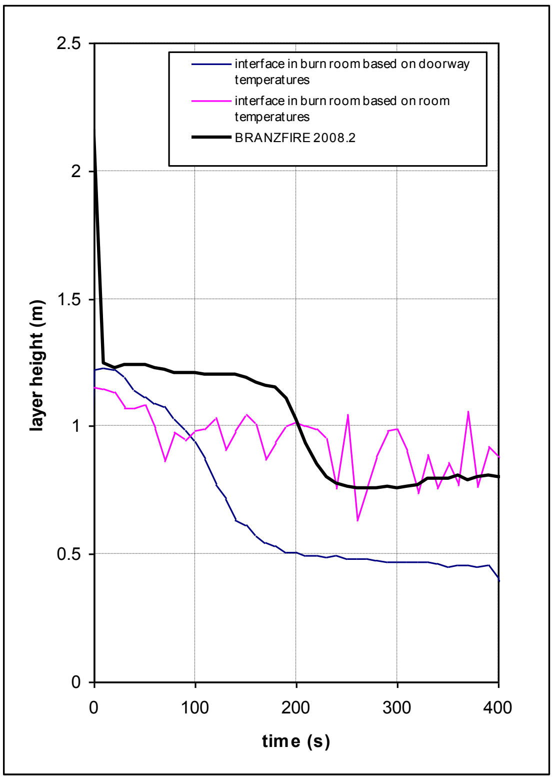
(f)


Carbon Dioxide (%)
time (s)
burn room at ceiling level
BRANZFIRE 2008.2

(g)

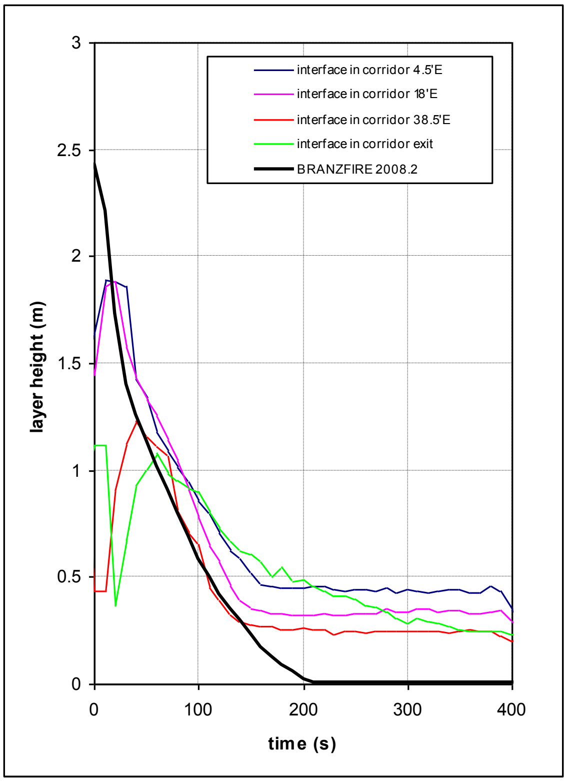

layer height (m)
time (s)
interface in target room
BRANZFIRE 2008.2

(h)



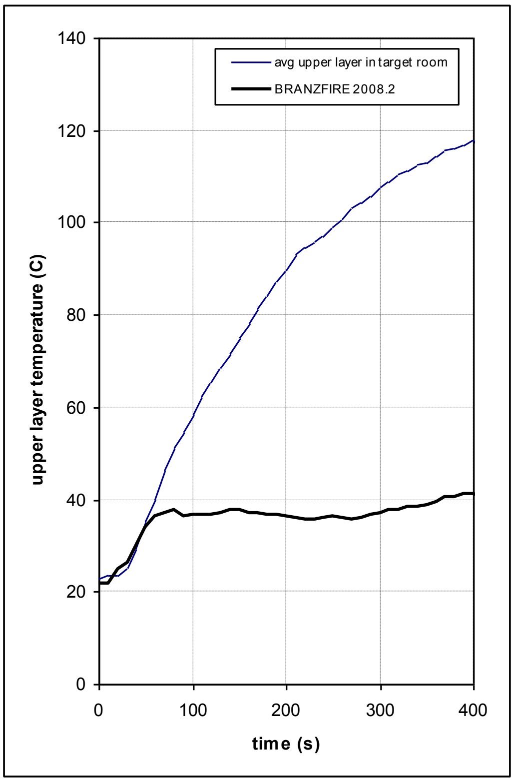
layer height (m)
time (s)
interface in burn room based on doorway temperatures
interface in burn room based on room temperatures
BRANZFIRE 2008.2

(i)



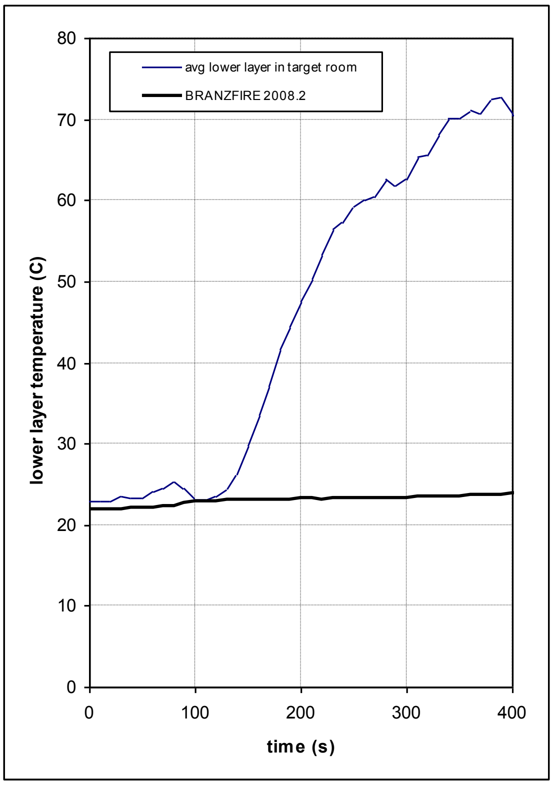
layer height (m)
time (s)
interface in corridor 4.5'E
interface in corridor 18'E
interface in corridor 38.5'E
interface in corridor exit
BRANZFIRE 2008.2

(j)



upper layer temperature (C)
time (s)
avg upper layer in target room
BRANZFIRE 2008.2

(k)

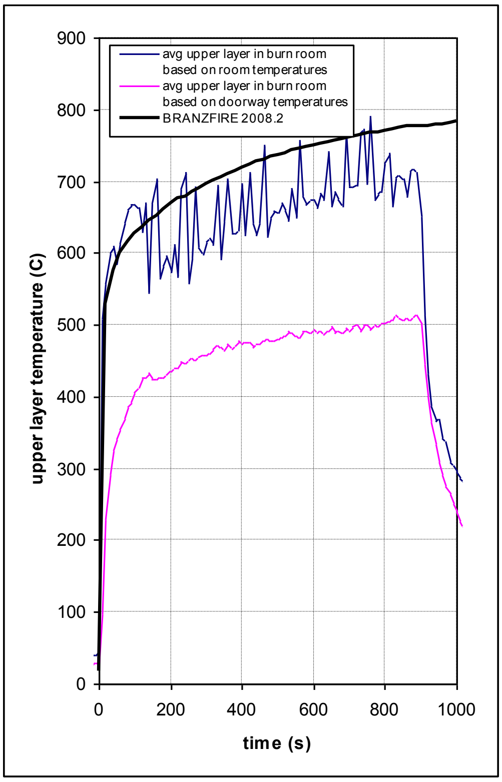


lower layer temperature (C)
time (s)
avg lower layer in target room
BRANZFIRE 2008.2

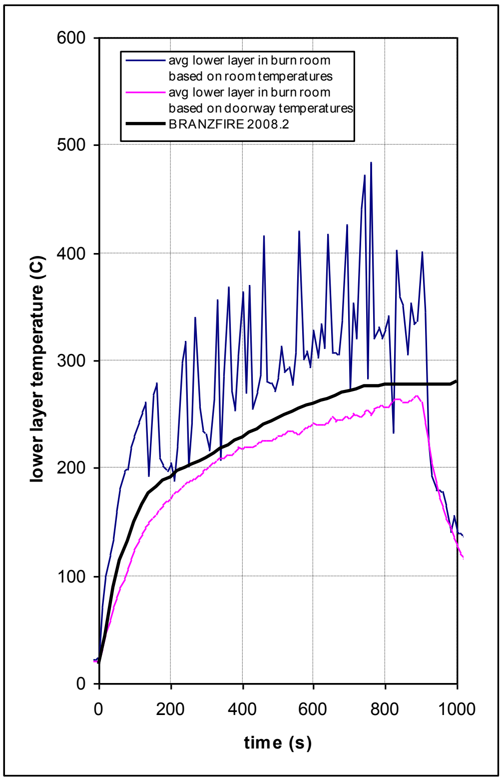
(l)

Figure 5. Test 500A

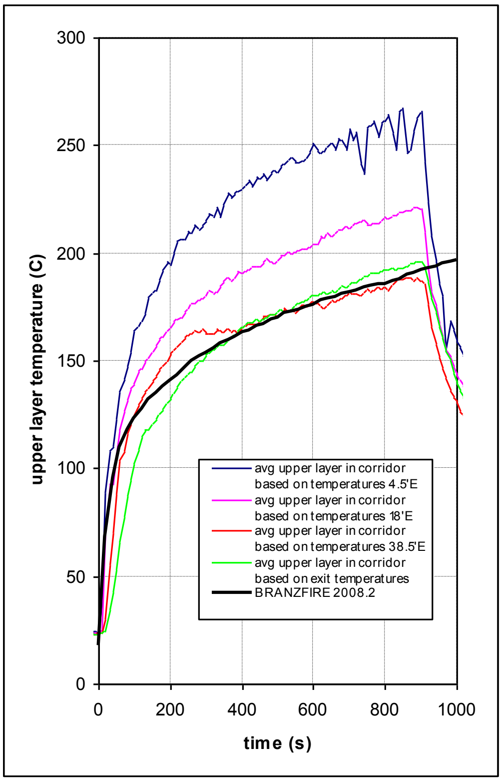
Comparison of predicted and measured parameters in the burn room and corridor for Set 8 –500A (500 kW, corridor exit door open and third room closed).



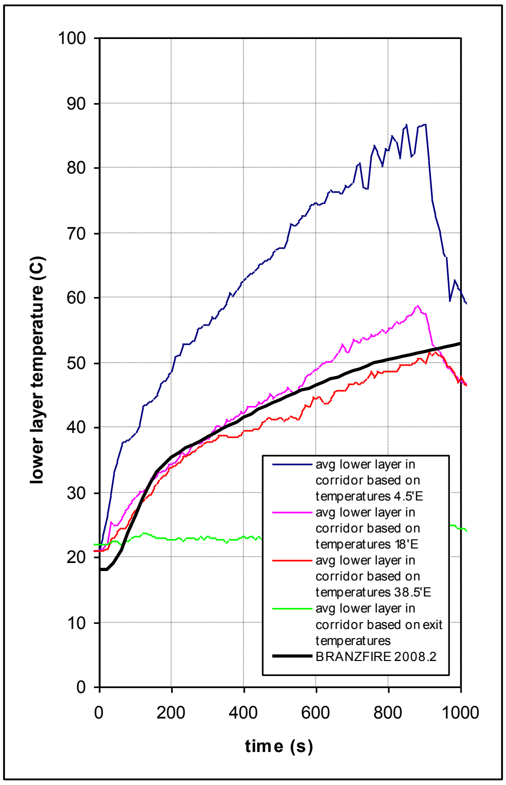
(a)



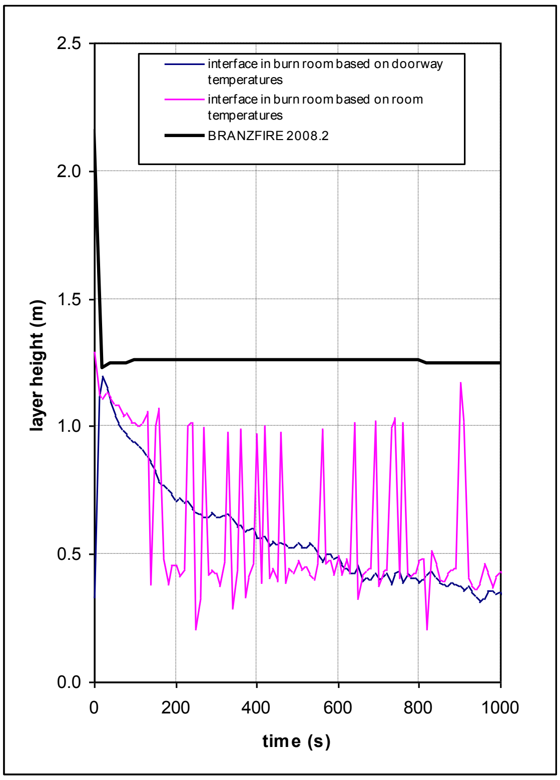
(b)



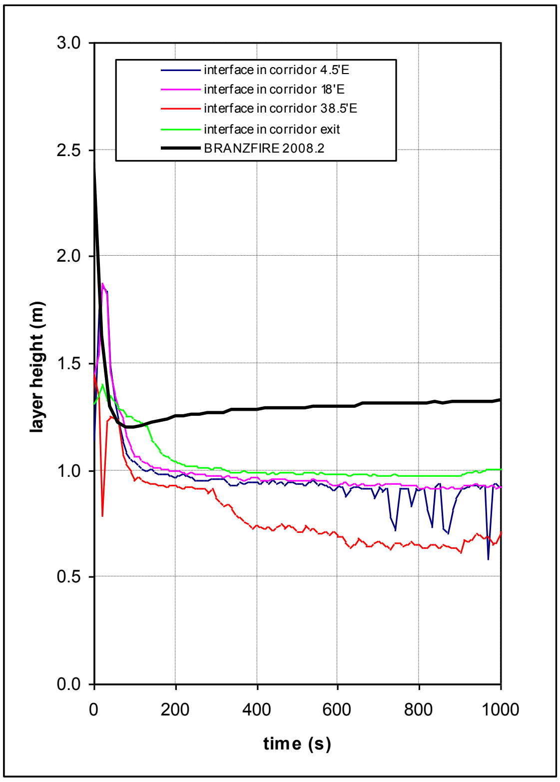
(c)



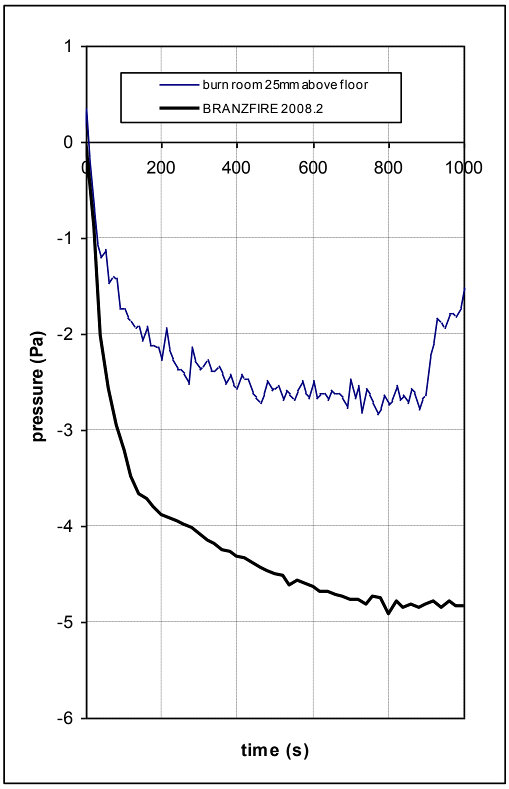
(d)


interface in burn room based on doorway temperatures
interface in burn room based on room temperatures
BRANZFIRE 2008.2
layer height (m)
time (s)
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000

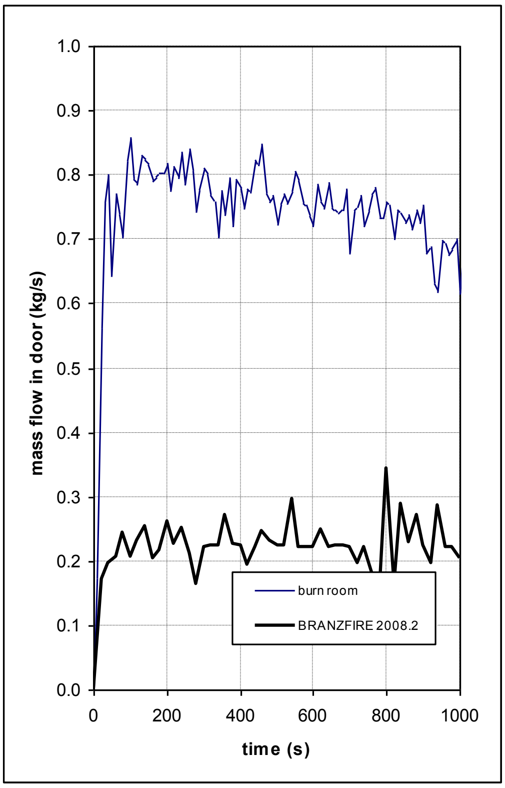
(e)


interface in corridor 4.5'E
interface in corridor 18'E
interface in corridor 38.5'E
interface in corridor exit
BRANZFIRE 2008.2
layer height (m)
time (s)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000

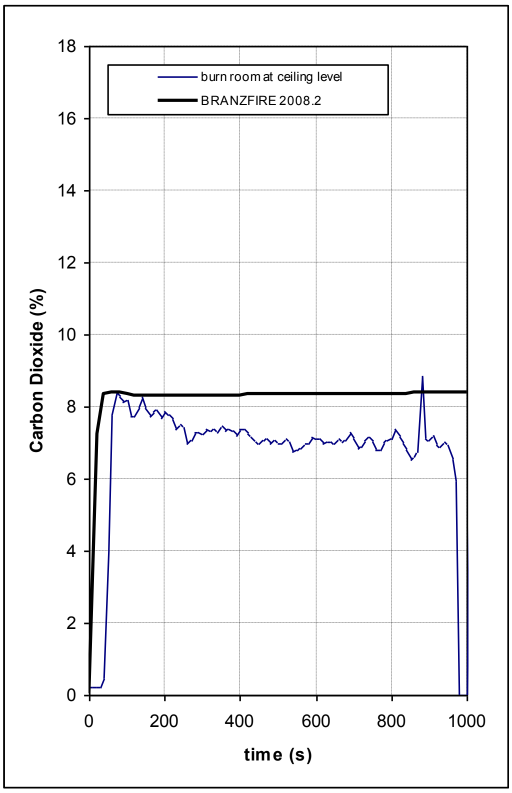
(f)


burn room 25mm above floor
BRANZFIRE 2008.2
pressure (Pa)
time (s)
1
0
-1
-2
-3
-4
-5
-6
200
400
600
800
1000

(g)


burn room
BRANZFIRE 2008.2
mass flow in door (kg/s)
time (s)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
200
400
600
800
1000

(h)



burn room at ceiling level
BRANZFIRE 2008.2
Carbon Dioxide (%)
time (s)
0
2
4
6
8
10
12
14
16
18
0
200
400
600
800
1000

(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)

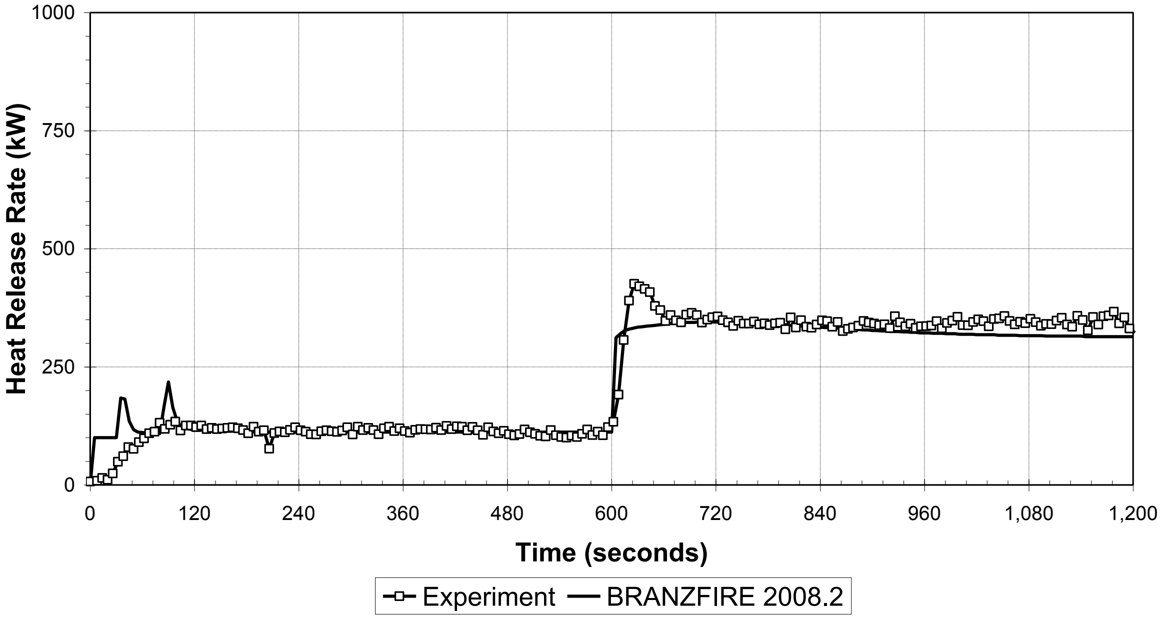


Figure 6. Painted gypsum paper-faced plasterboard

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

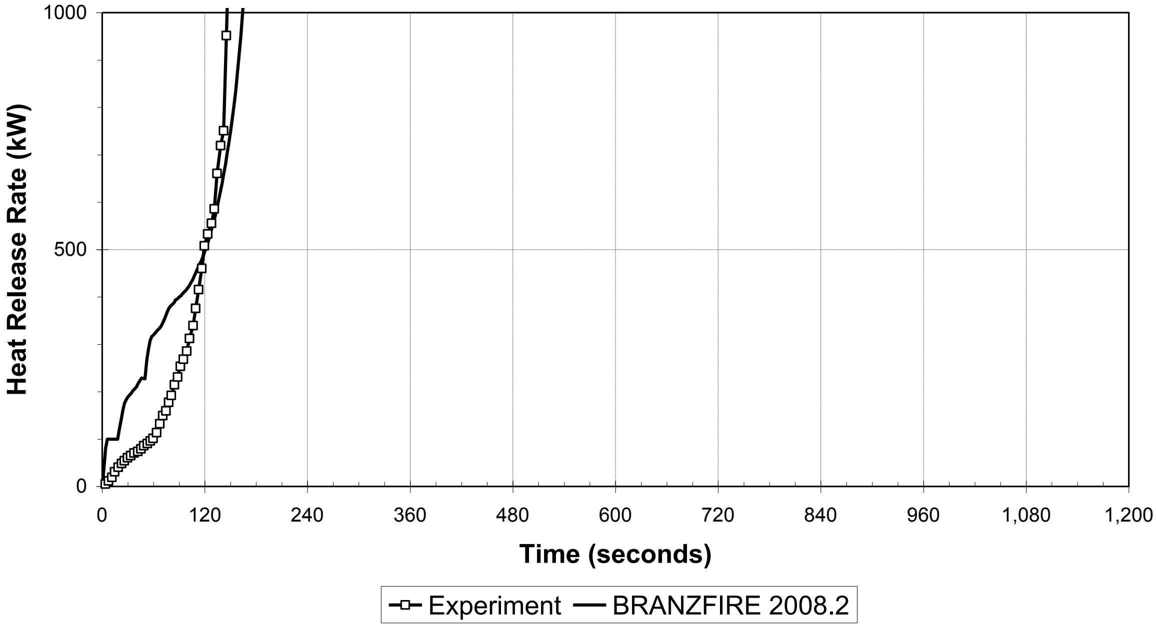


Figure 7. Ordinary birch plywood

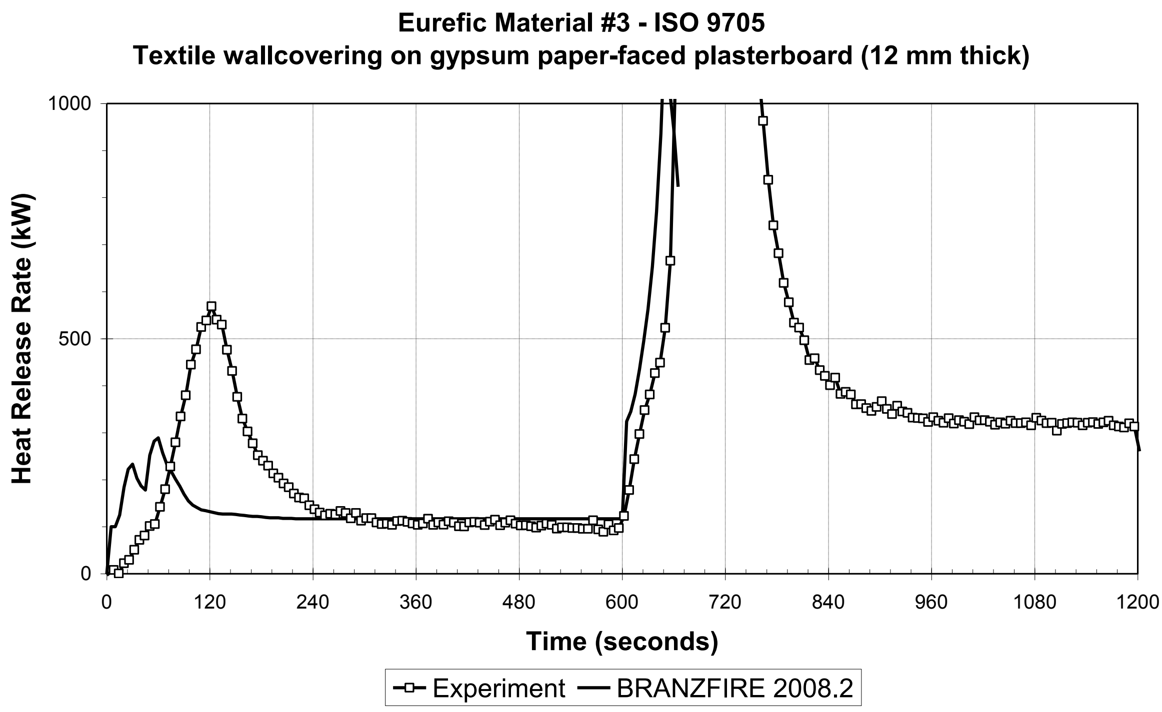


Figure 8. Textile wall covering on gypsum paper-faced plasterboard

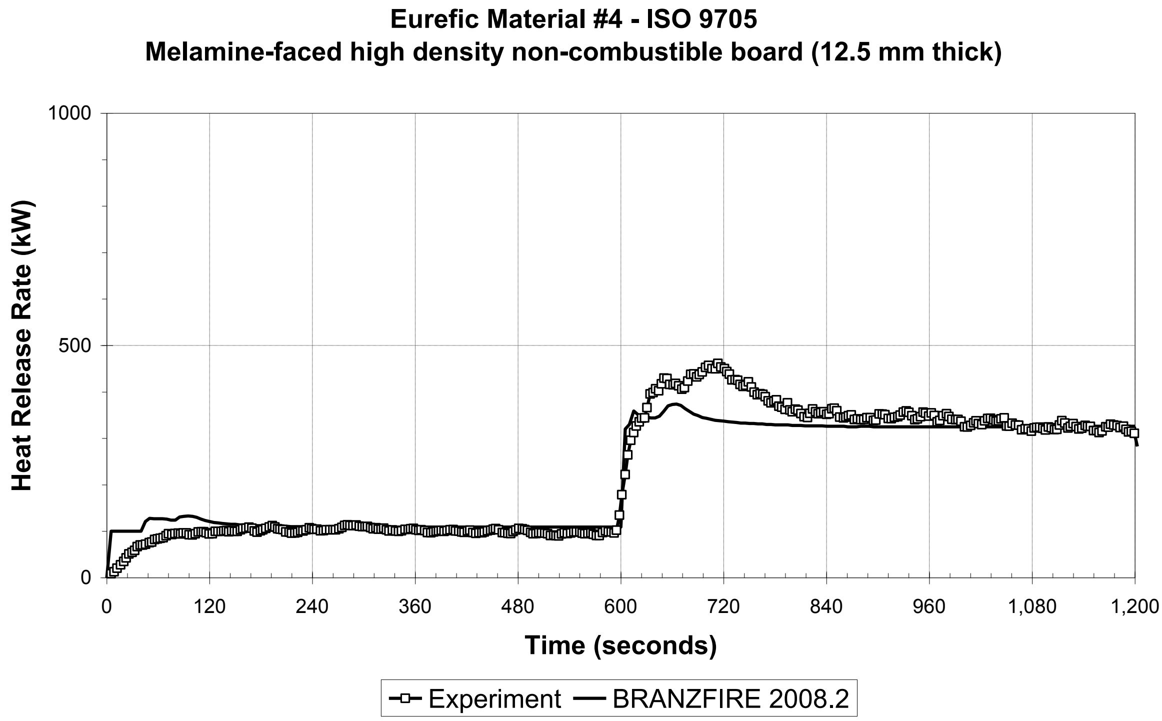


Figure 9. Melamine-faced high density non-combustible board

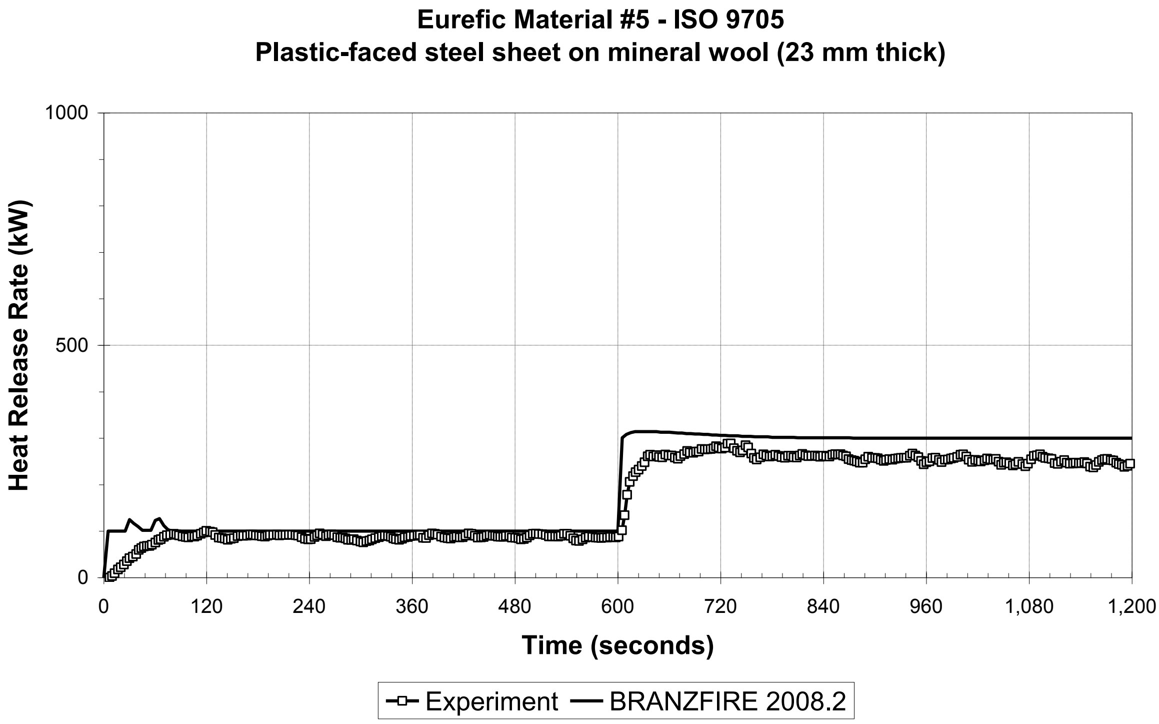


Figure 10. Plastic-faced steel sheet on mineral wool

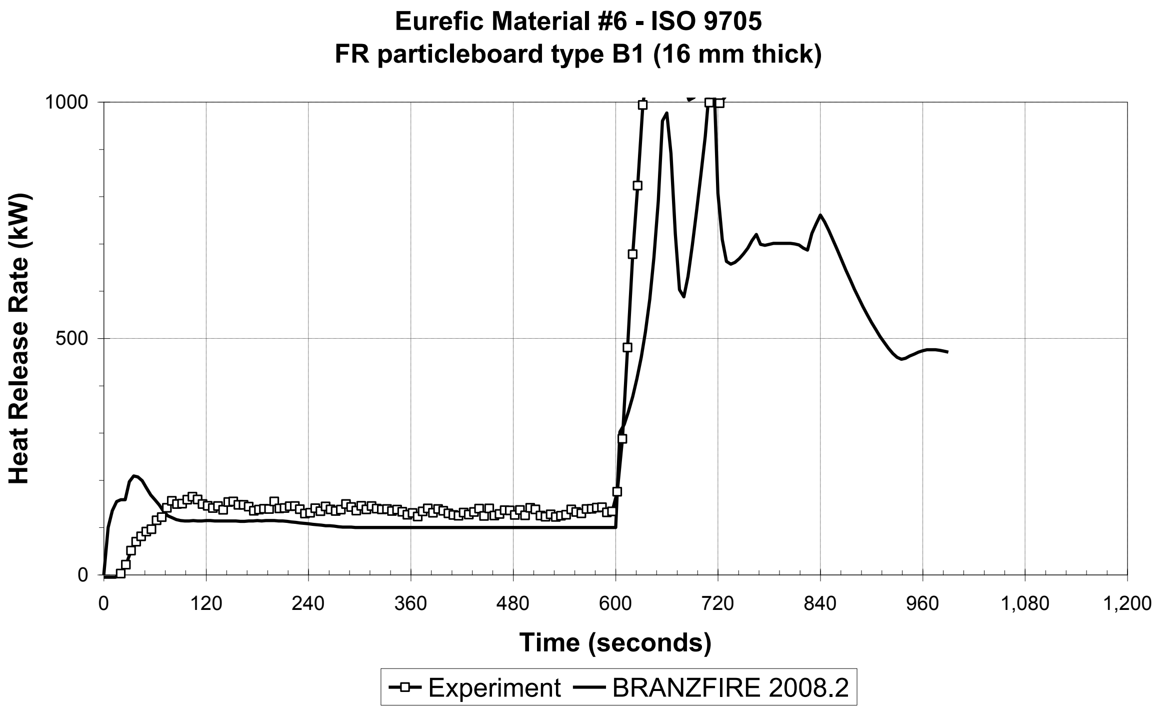


Figure 11. FR particleboard Type B1

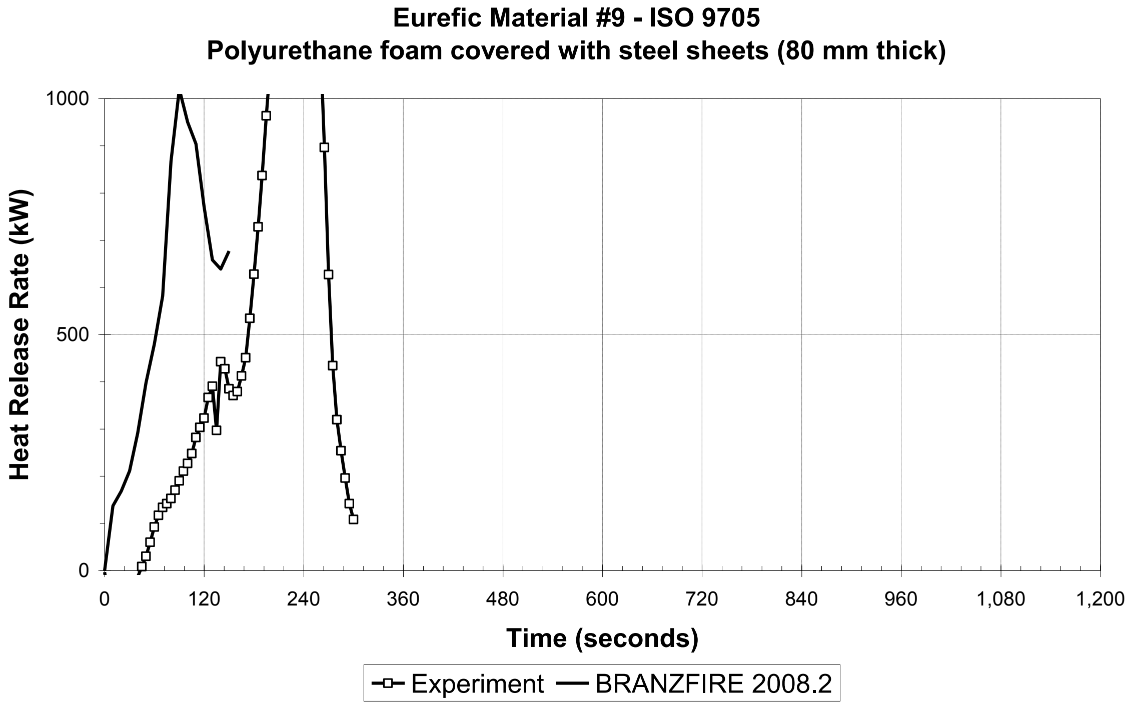


Figure 12. Polyurethane foam covered with steel sheets

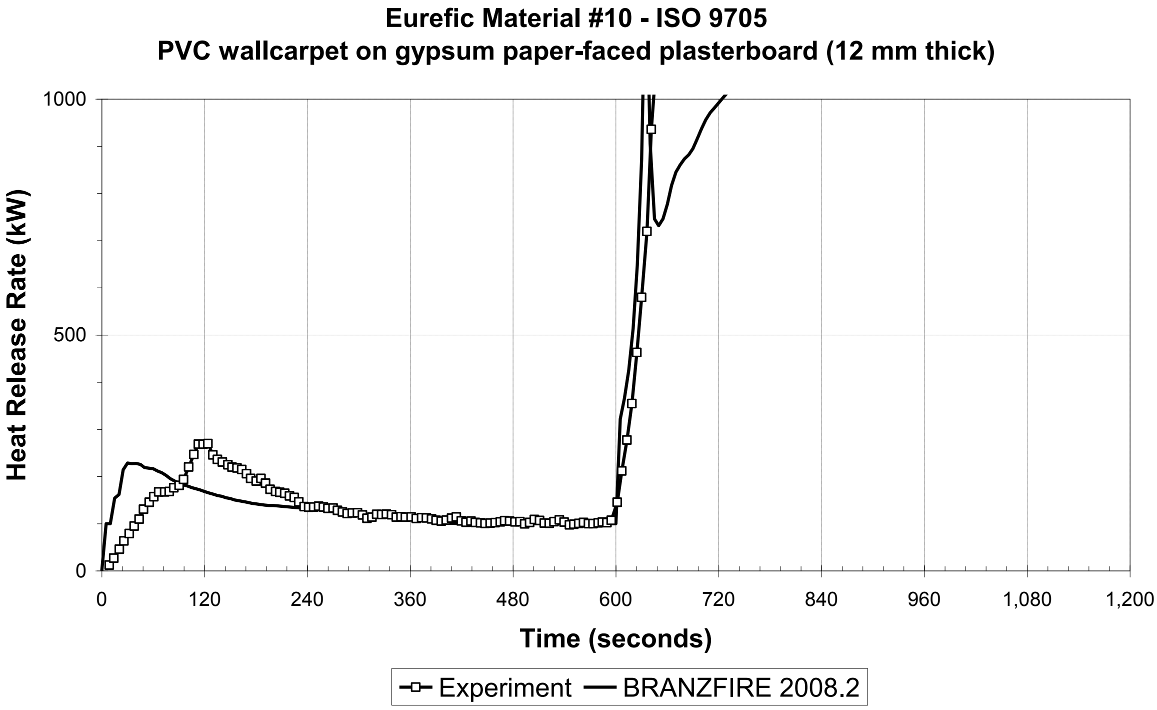


Figure 13. PVC wall carpet on gypsum paper-faced plasterboard

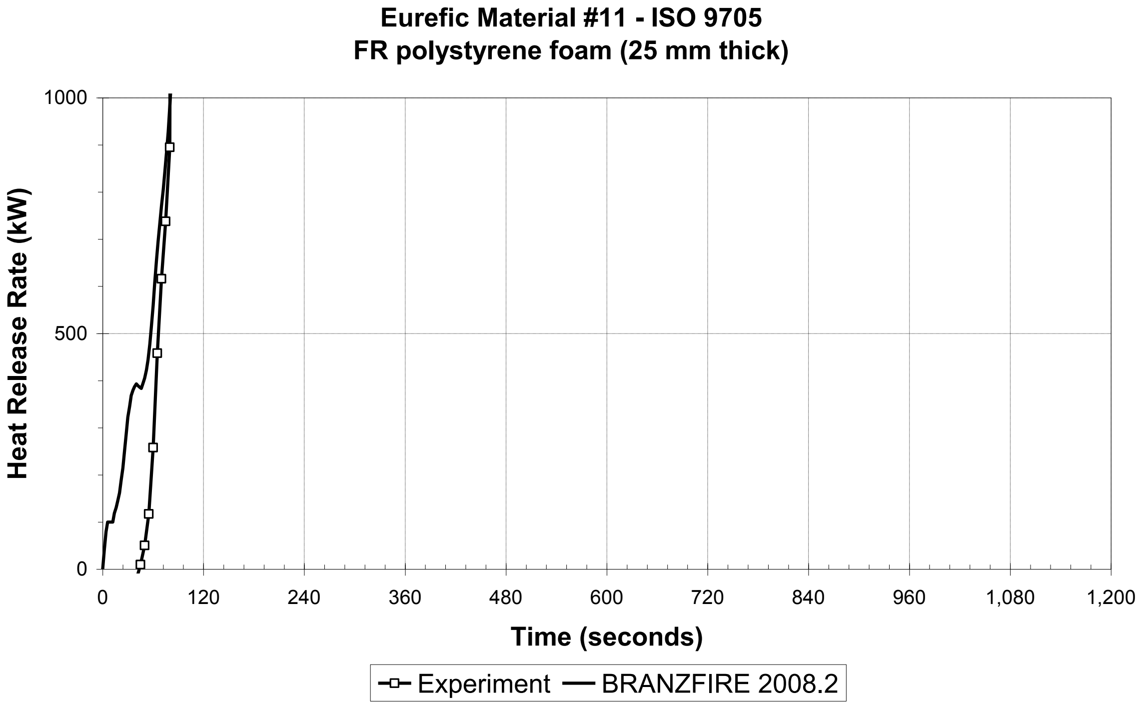


Figure 14. FR polystyrene foam

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, Ply104ceil.mod, Ply104wall.mod, Ply108.mod, Ply108ceil.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.

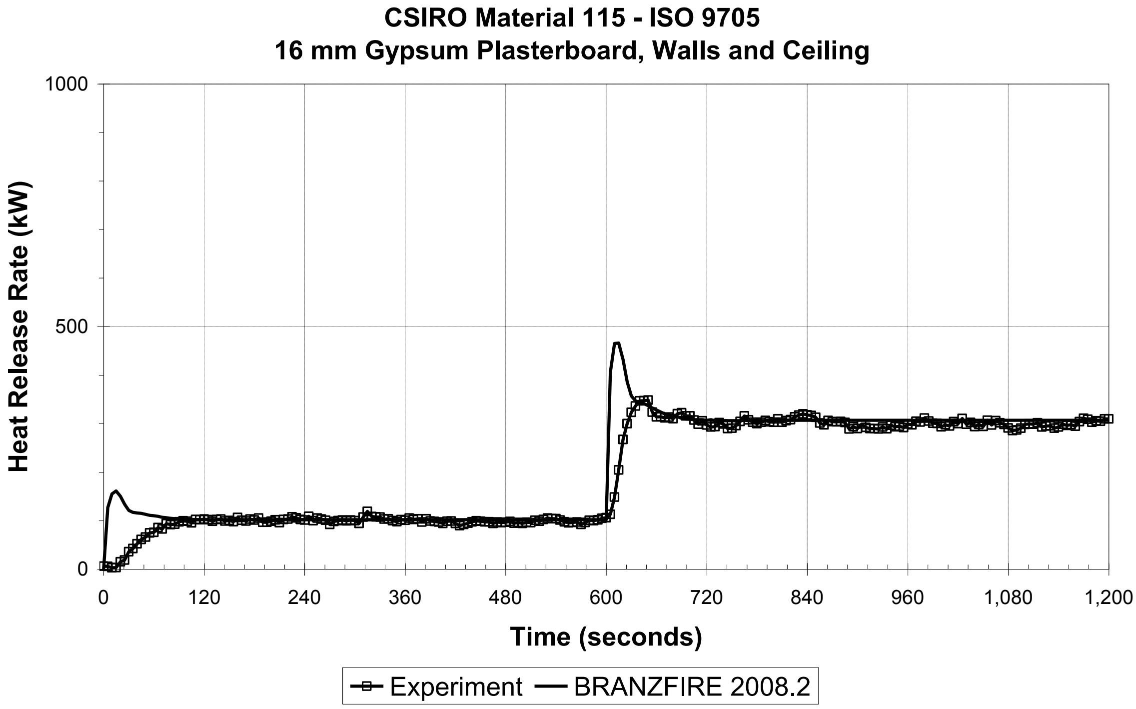


Figure 15. Gypsum plasterboard, wall and ceiling

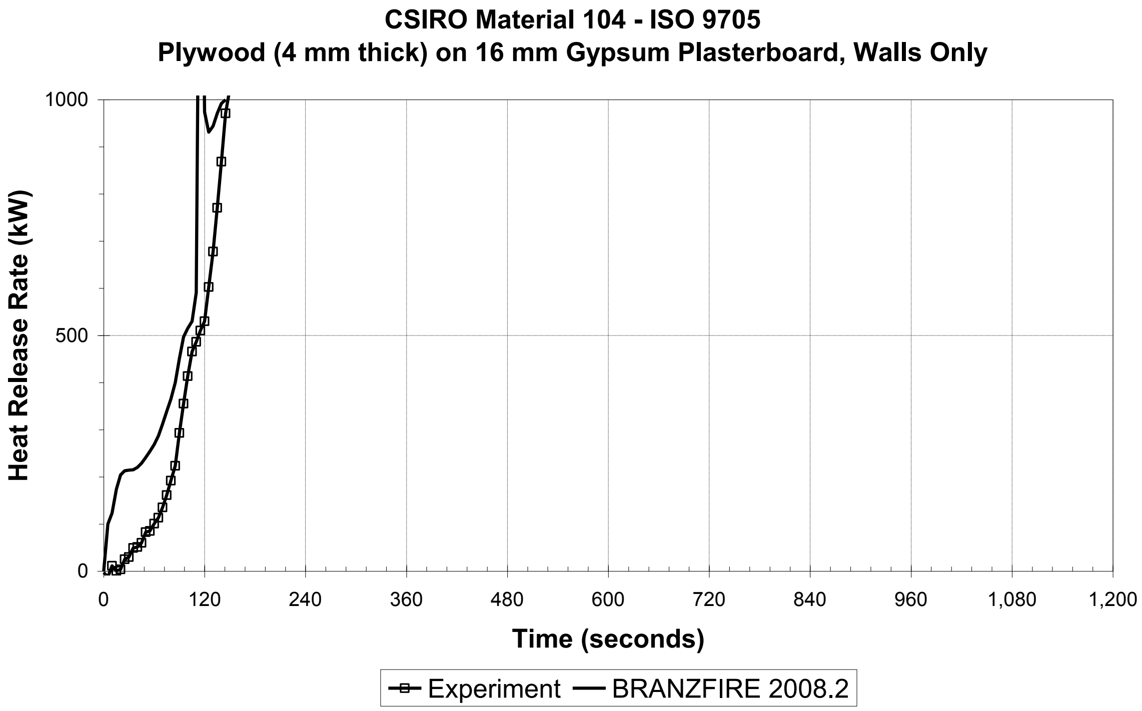


Figure 16. Plywood, walls only

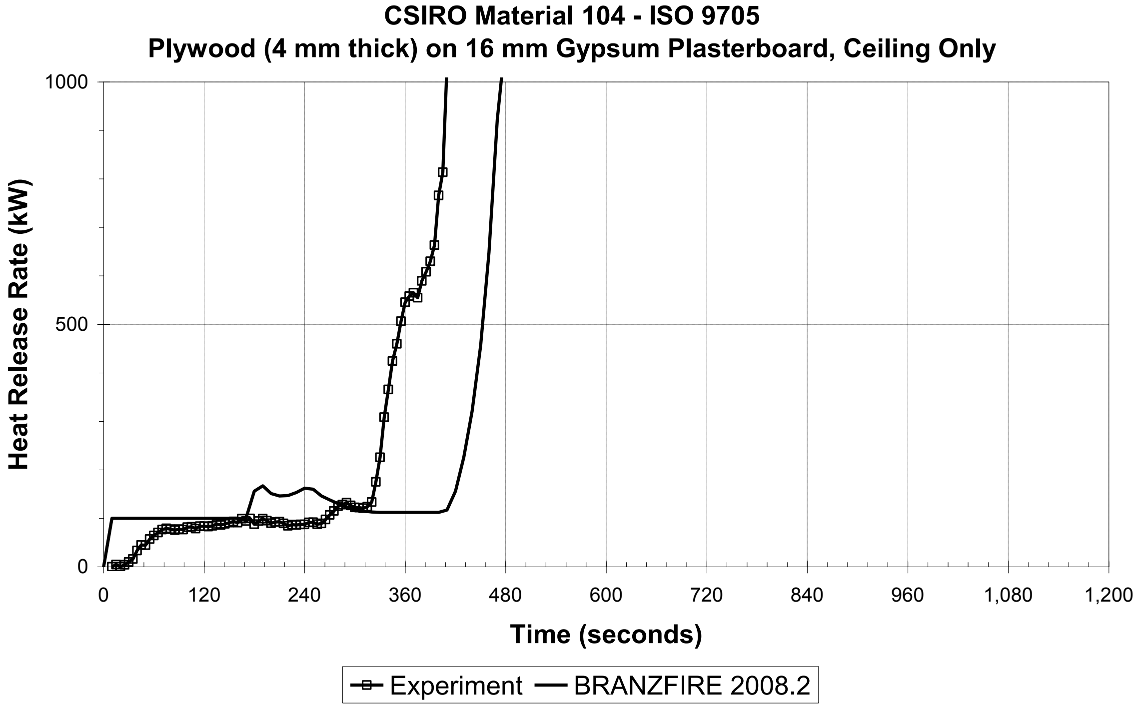


Figure 17. Plywood, ceiling only

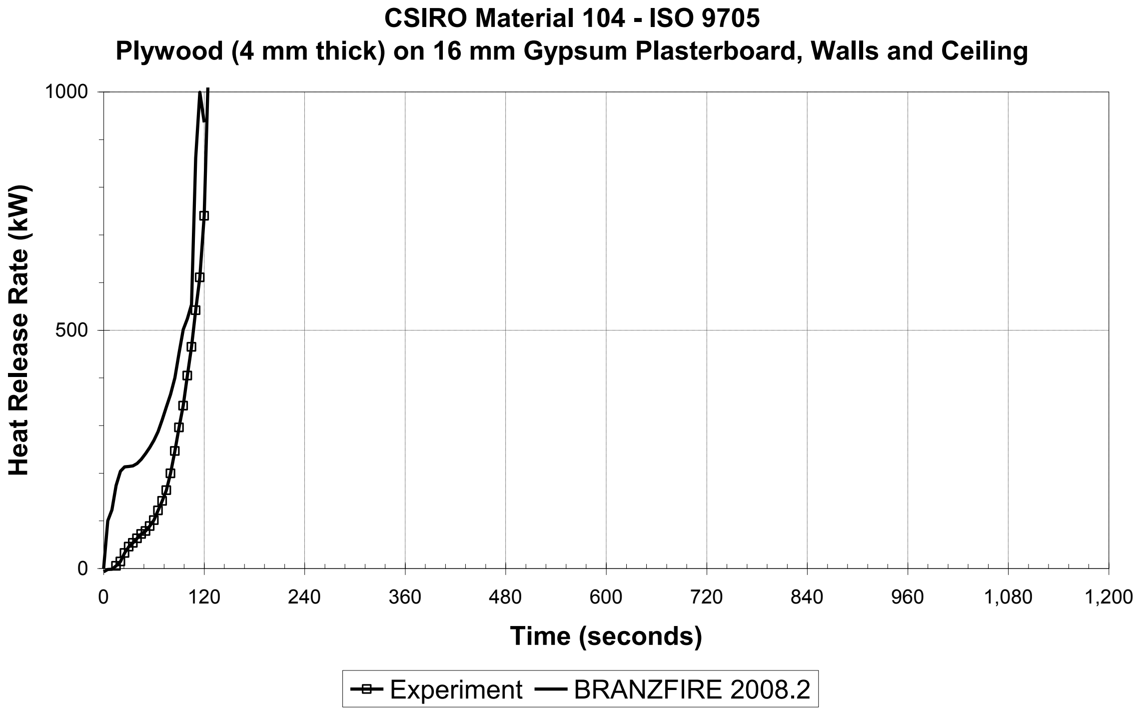


Figure 18. Plywood, walls and ceiling

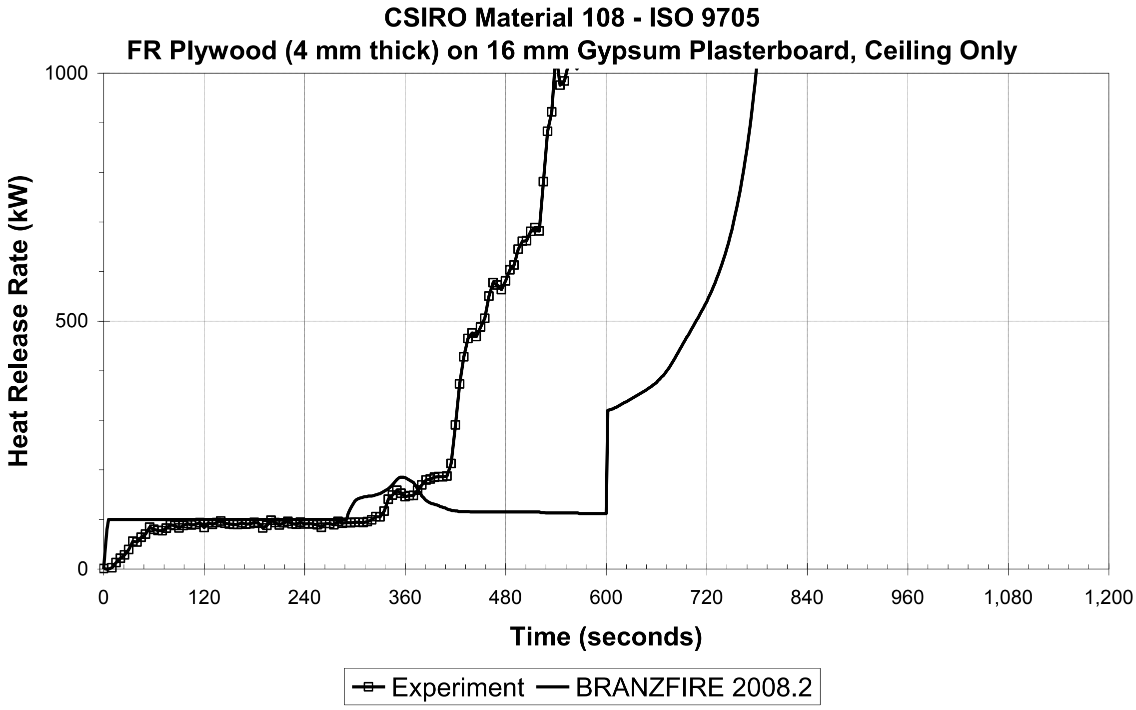


Figure 19. FR plywood, ceiling only

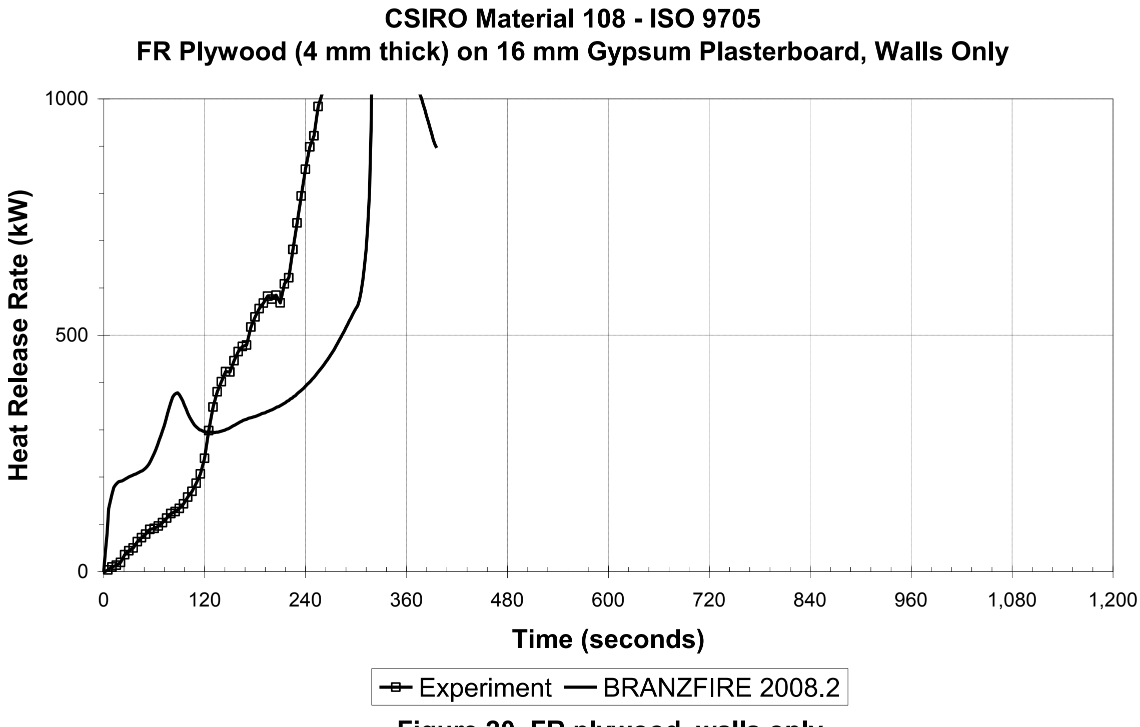


Figure 20. FR plywood, walls only

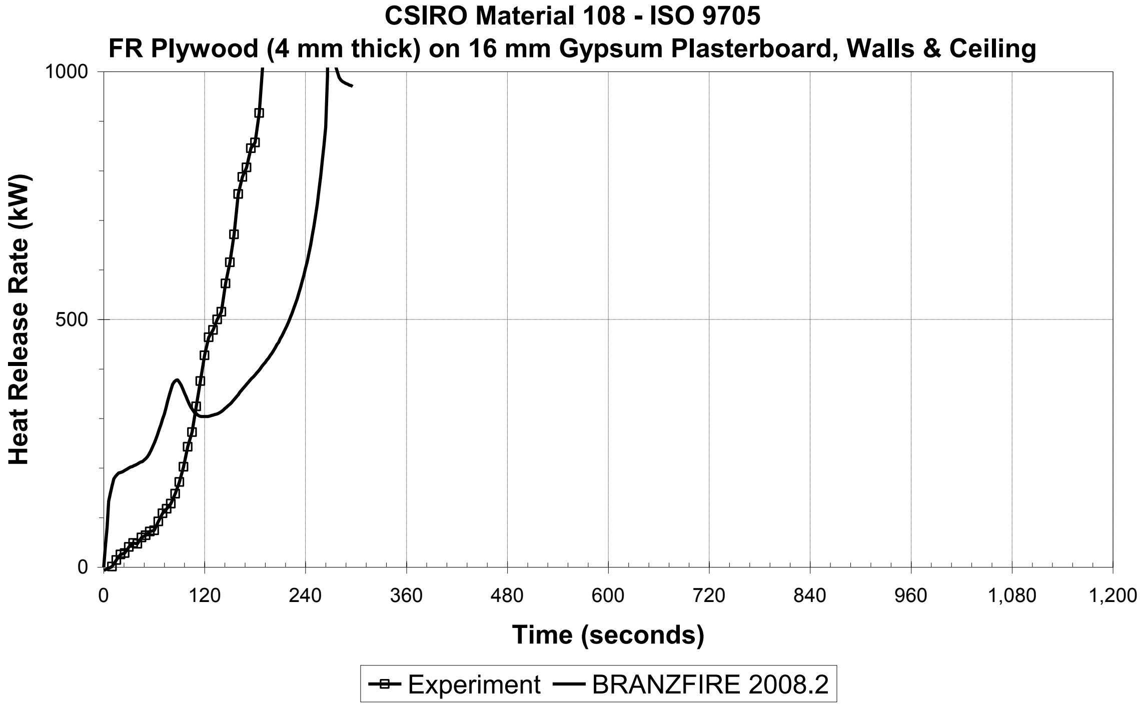


Figure 21. FR plywood, walls and ceiling

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/m^3. 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.

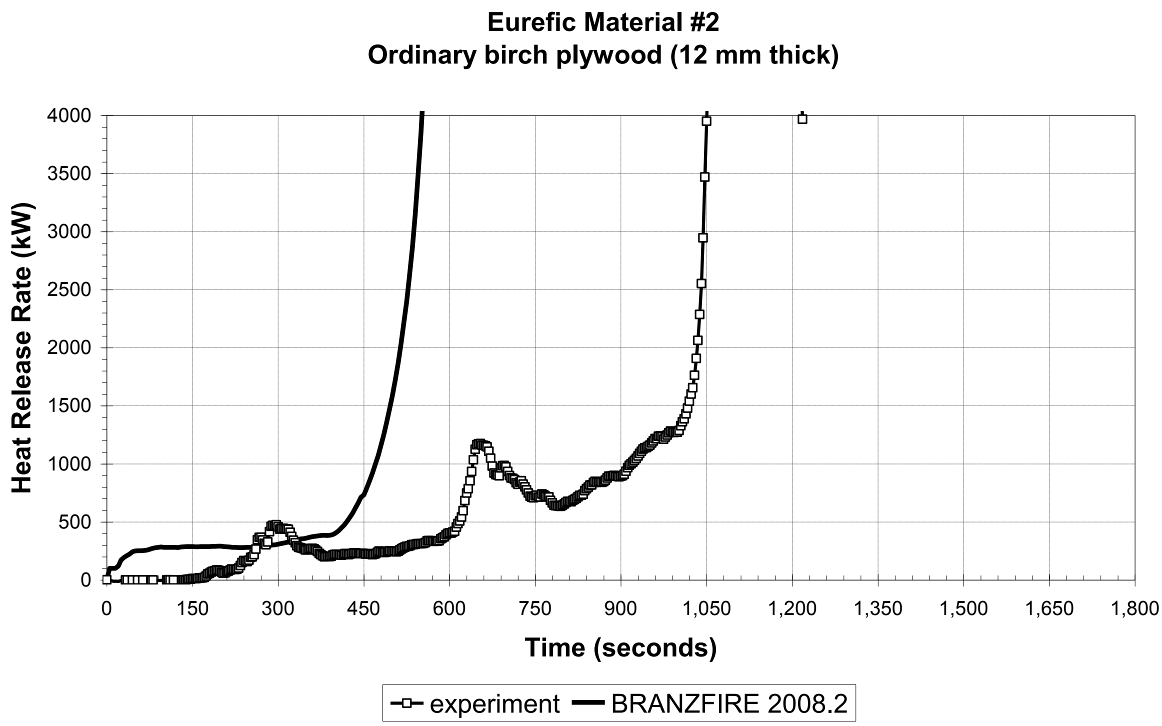


Figure 22. Ordinary birch plywood

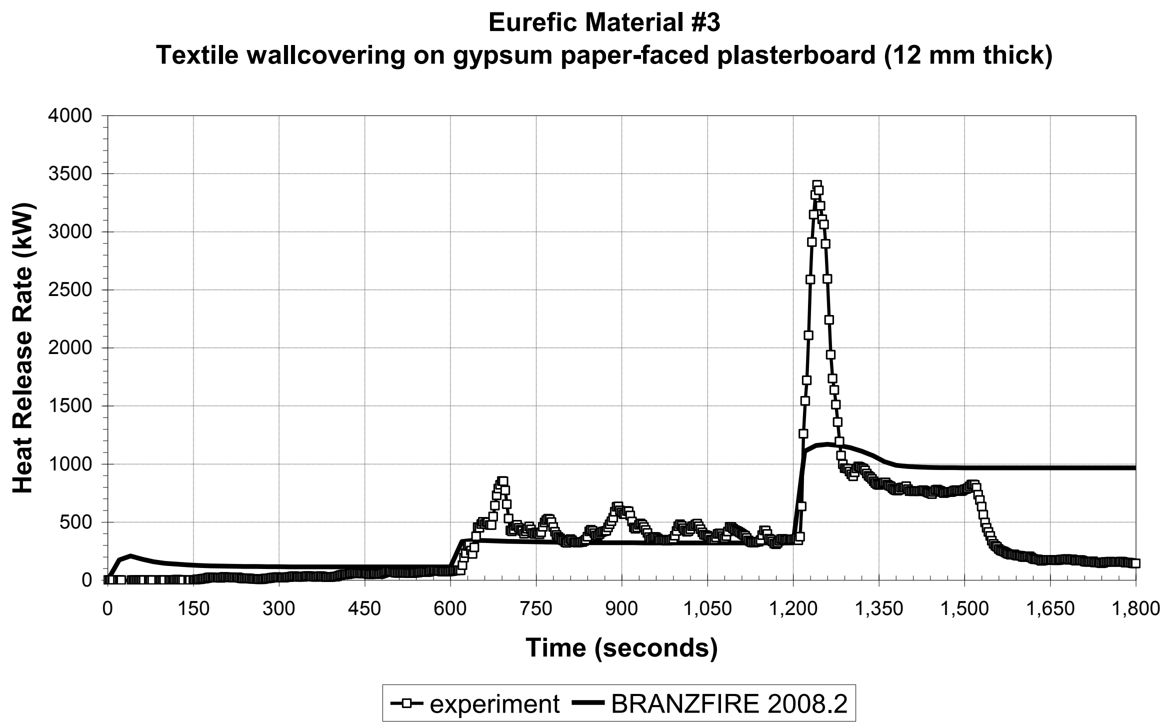


Figure 23. Textile wall covering on gypsum paper-faced plasterboard

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

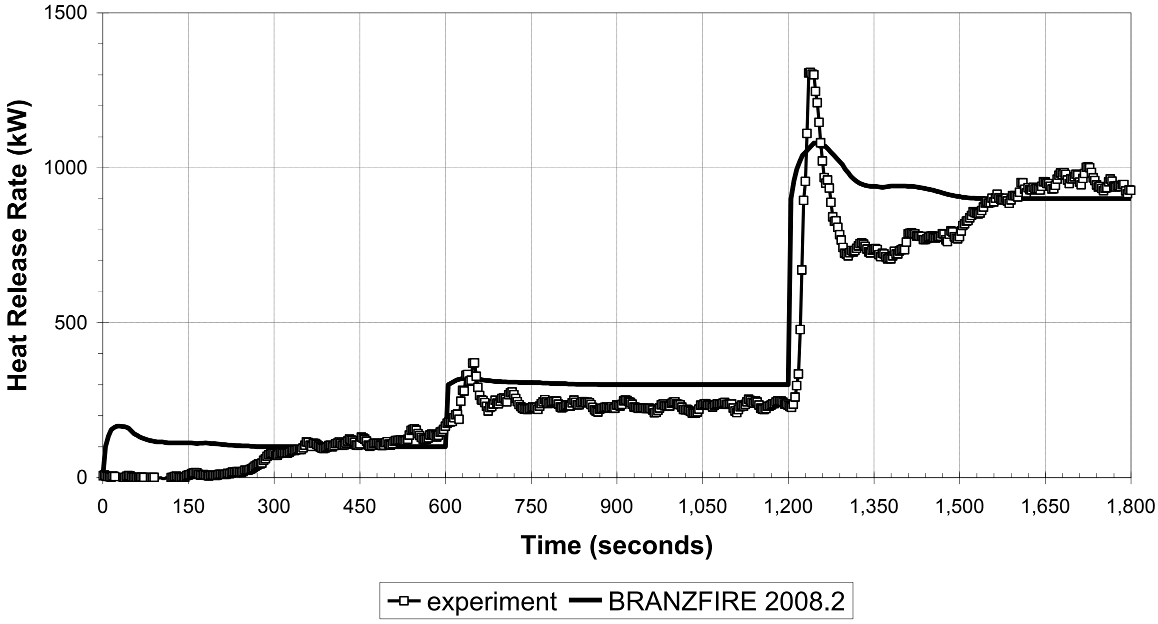


Figure 24. FR particleboard Type B1

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

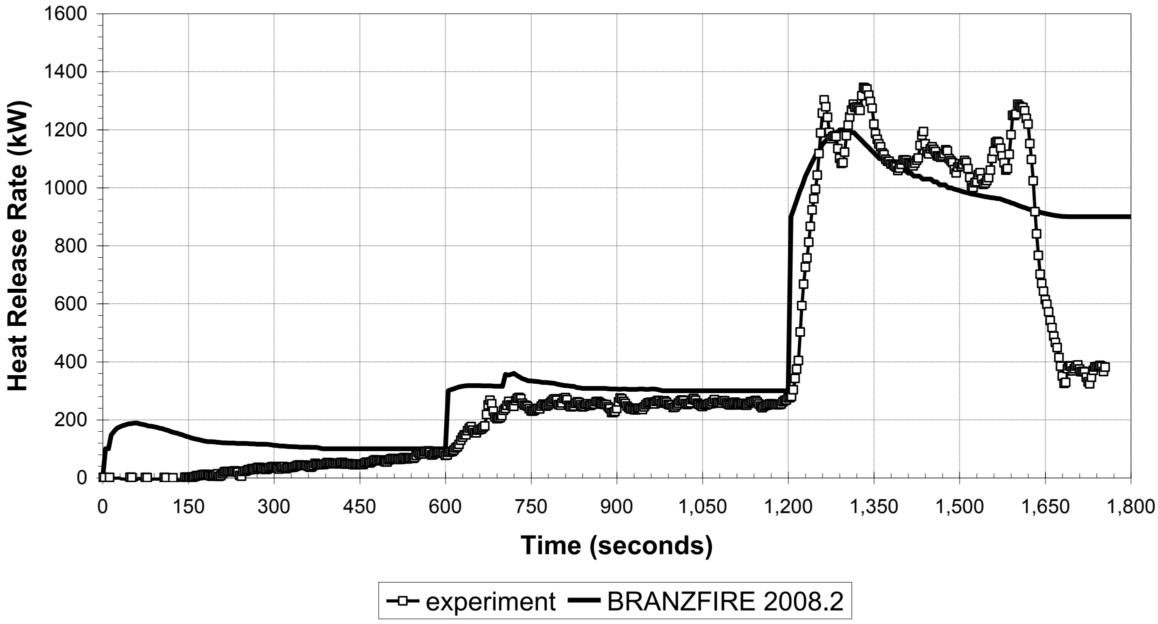


Figure 25. PVC wall carpet on gypsum paper-faced plasterboard

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.

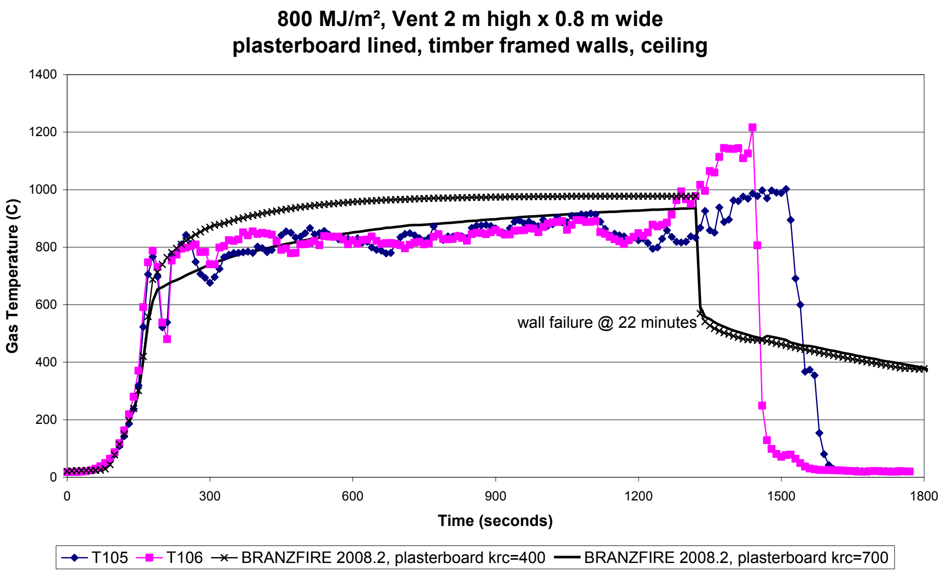


Figure 26. Gas temperatures 800 MJ/m², vent 2 x 0.8 m

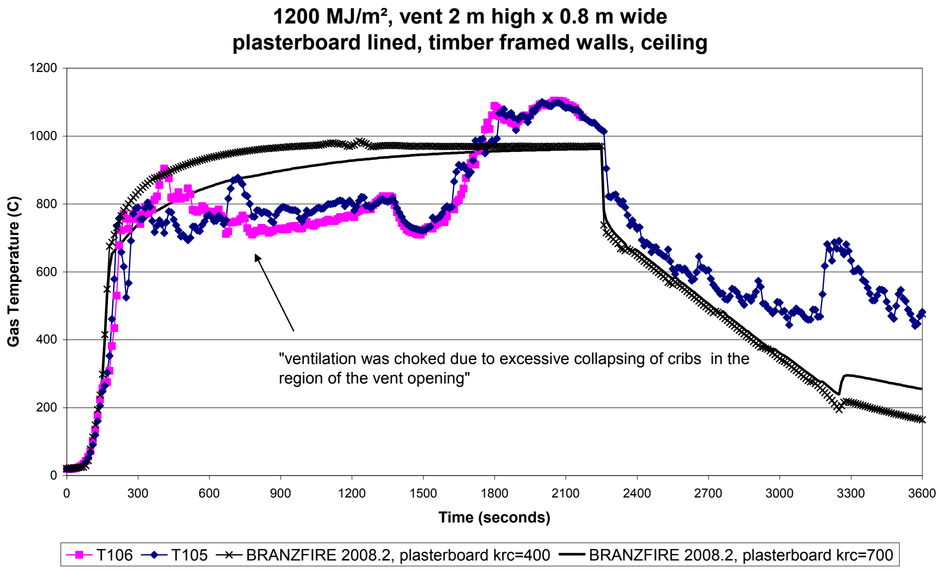


Figure 27. Gas temperatures 1200 MJ/m², vent 2 x 0.8 m

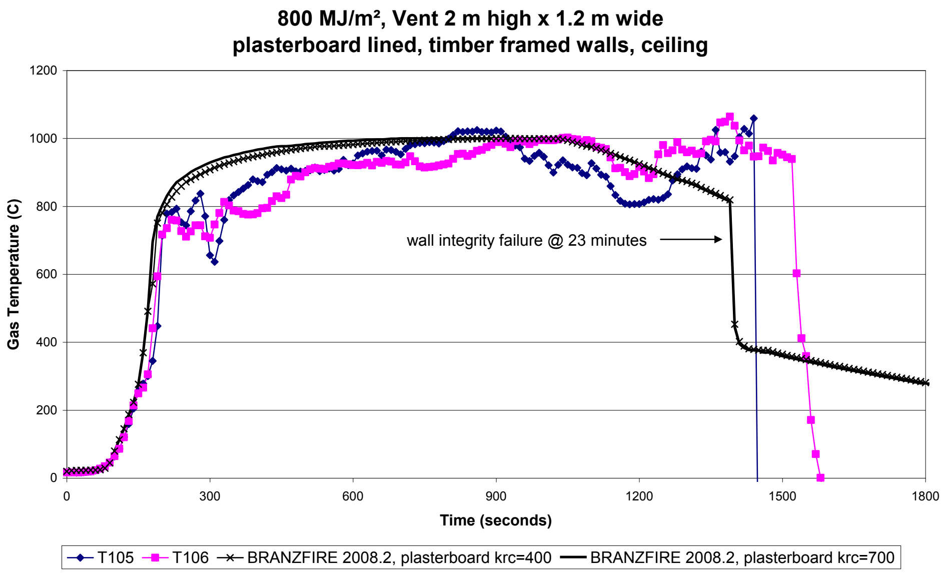


Figure 28. Gas temperatures 800 MJ/m², vent 2 x 1.2 m

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 W/mK, α = 4.2E-07, E = 72 GPa, β = .83E-05 K-1) for soda-lime-silica float glass taken from the Pilkington technical literature. A breaking stress of σ_f = 47 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)

	Pane 1 – sill 1.06 m (0.844 x 0.844 m) Vent 3		**Pane 2 – sill 0 m (0.844 x 0.844 m) Vent 2**		**Pane 3 – sill 0 m (0.844 x 1.895 m) Vent 4**	
Pan fire size (m)	**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

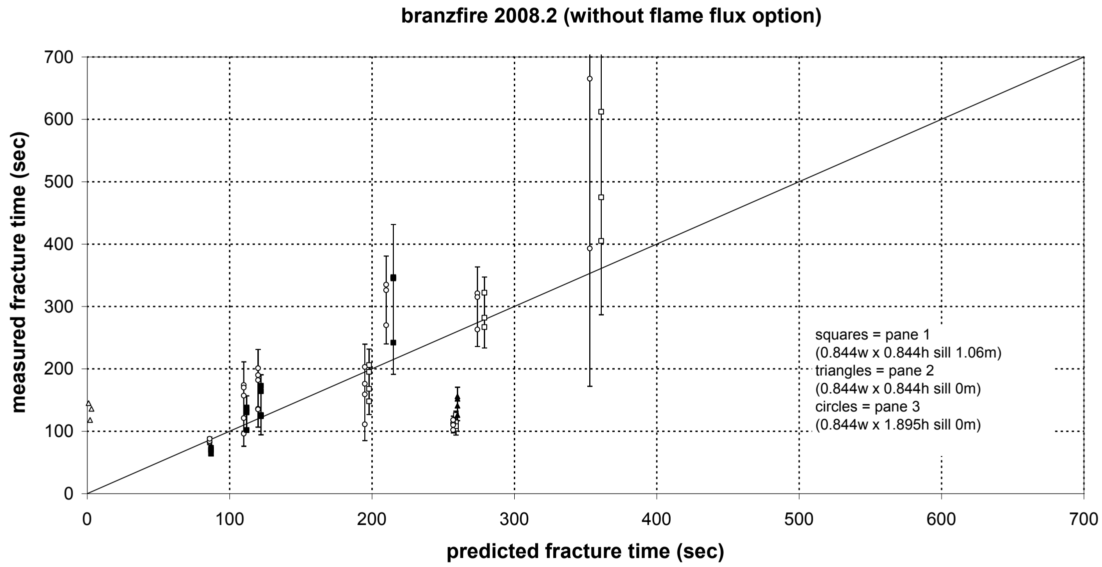


Figure 29. Comparison of predicted vs measured glass fracture times (error bars span 2 standard deviation)

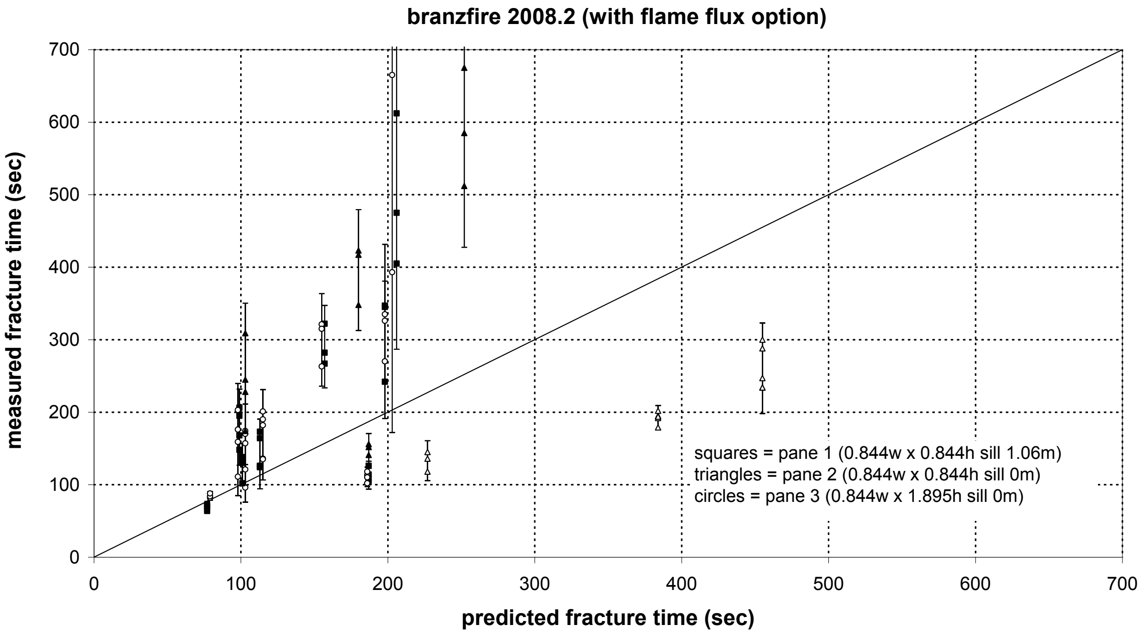


Figure 30. Comparison of predicted vs measured glass fracture times (error bars span 2 standard deviation)

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 = 25ºC.

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

CO_2 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 79ºC, 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)½, link actuation temperature 57.2ºC, 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 = 28ºC.
2) Fire was a pan of JP-5 fuel, nominal size 2700 kW fire. Ambient temperature = 27ºC.

Energy yield (kJ/g) = 42

CO_2 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.

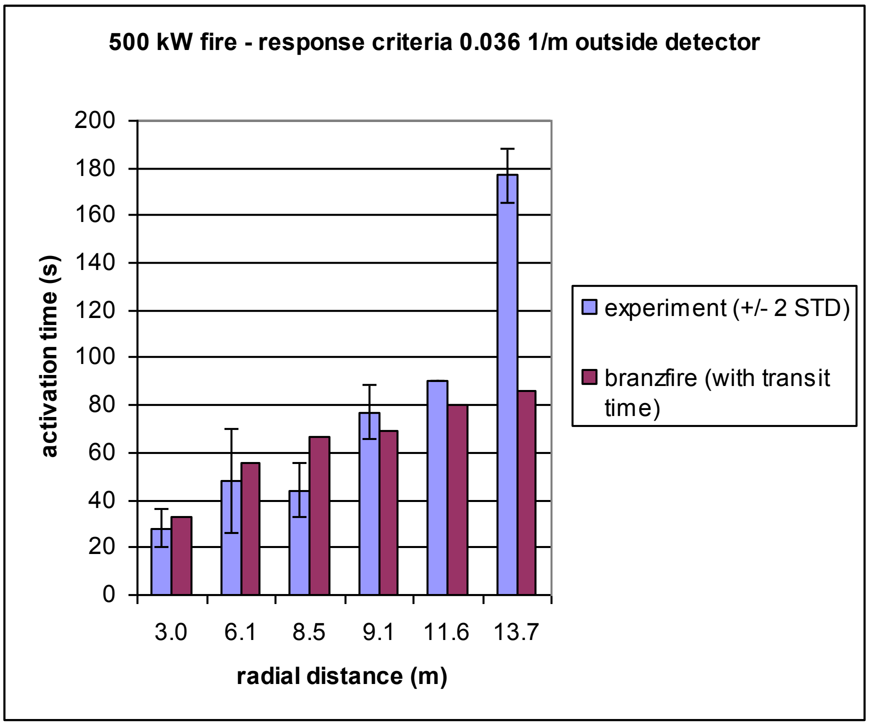


Figure 31. Smoke alarm response 500 kW

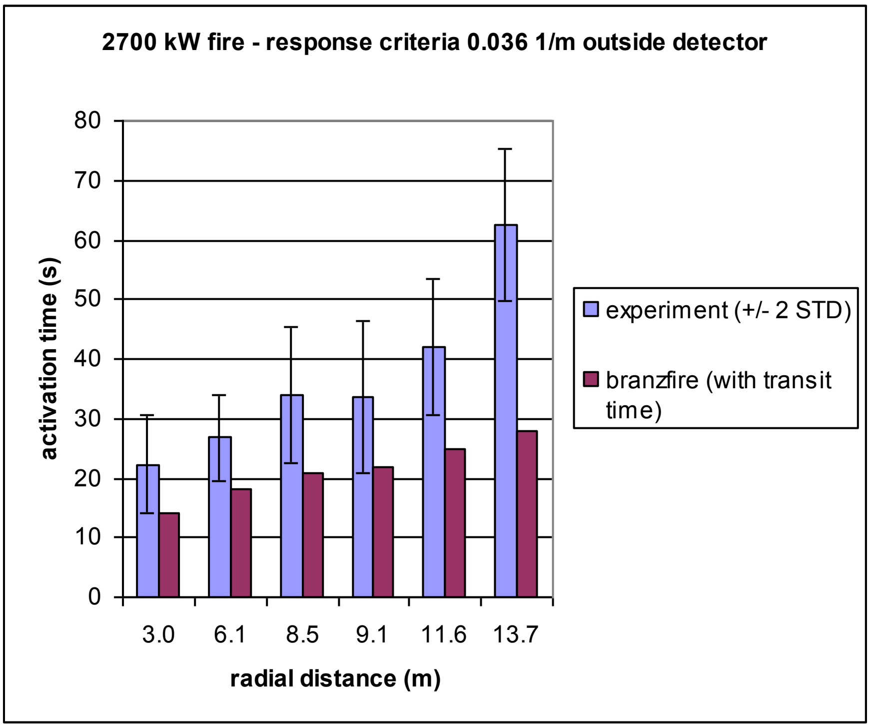
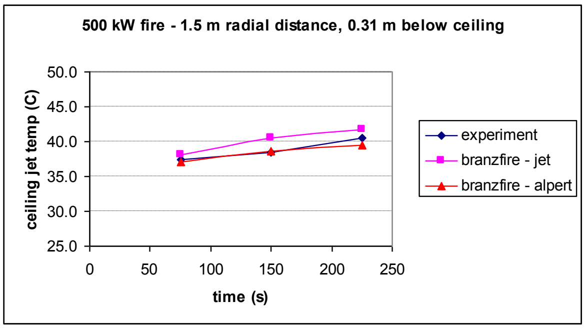


Figure 32. Smoke alarm response 2700 kW



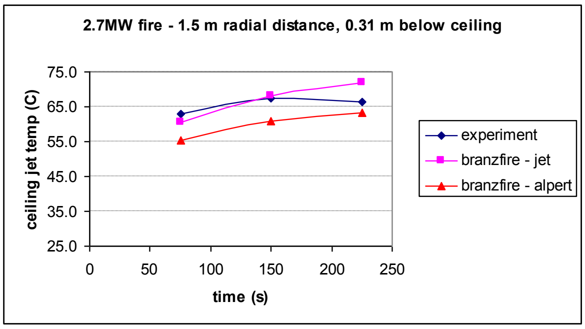
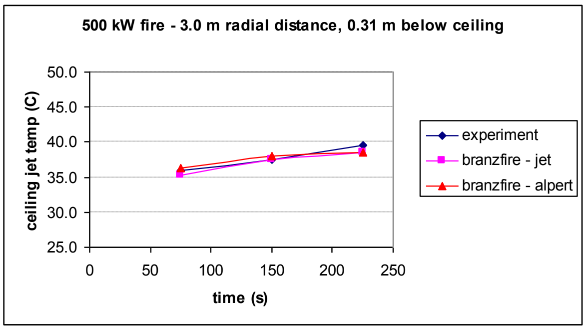


Figure 33. Ceiling jet temp 500 kW @ 1.5 m

Figure 34. Ceiling jet temp 2700 kW @ 1.5 m



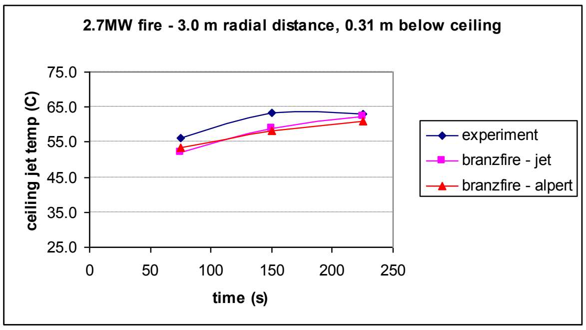
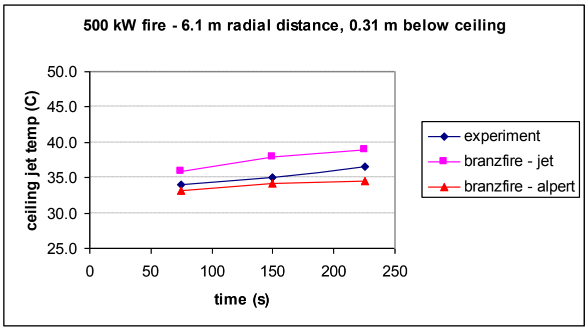


Figure 35. Ceiling jet temp 500 kW @ 3.0 m

Figure 36. Ceiling jet temp 2700 kW @ 3.0 m



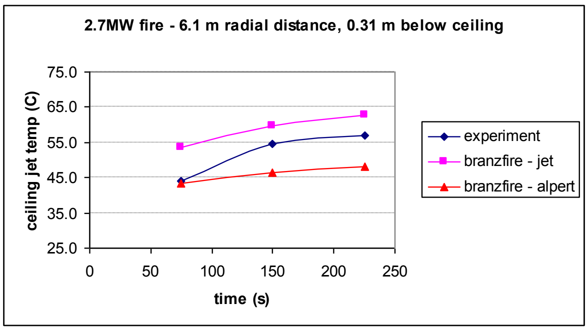
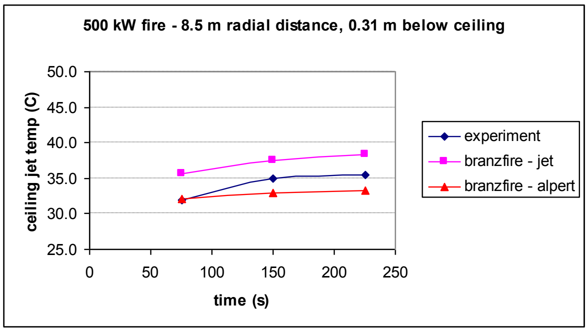


Figure 37. Ceiling jet temp 500 kW @ 6.1 m

Figure 38. Ceiling jet temp 2700 kW @ 6.1 m



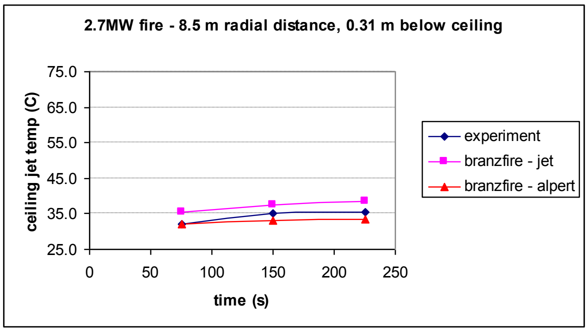


Figure 39. Ceiling jet temp 500 kW @ 8.5 m

Figure 40. Ceiling jet temp 2700 kW @ 8.5 m

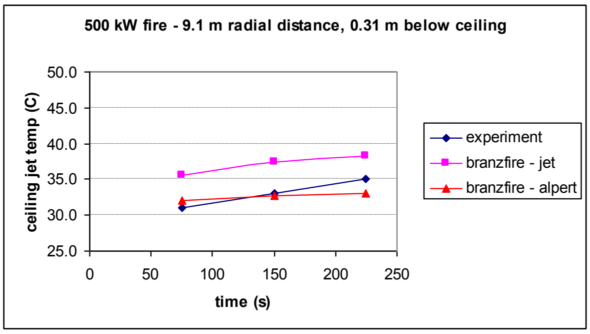


Figure 41. Ceiling jet temp 500 kW @ 9.1 m

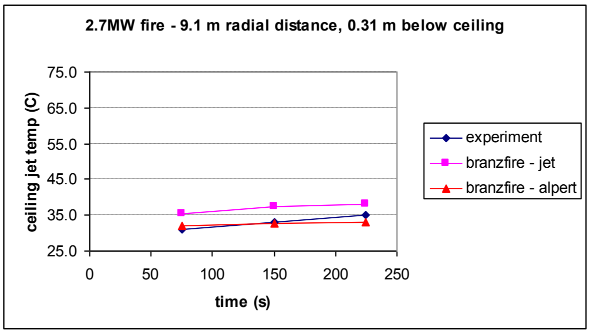


Figure 42. Ceiling jet temp 2700 kW @ 9.1 m

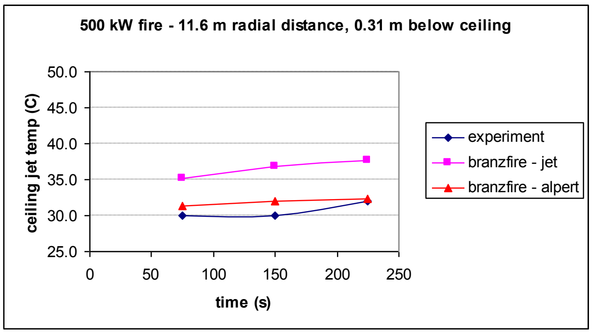


Figure 43. Ceiling jet temp 500 kW @ 11.6 m

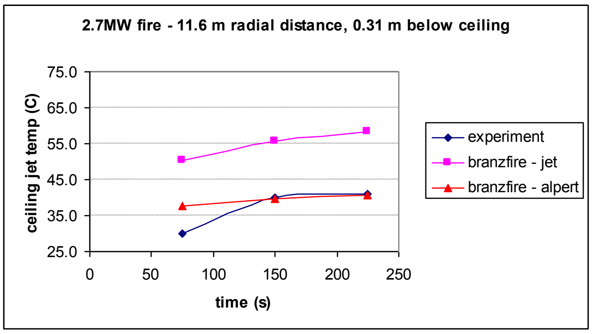


Figure 44. Ceiling jet temp 2700 kW @ 11.6 m

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

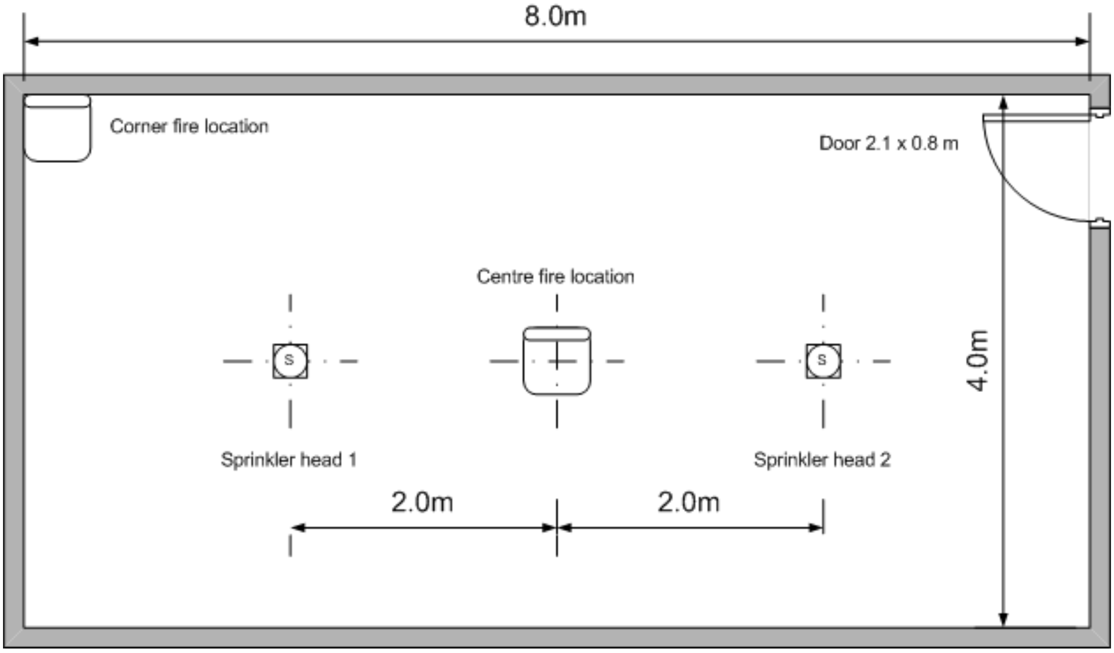


Figure 45. Compartment layout (plan view)

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 $(m/s)^{1/2}$ 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 $m^{1/2}s^{1/2}$	0.4 $(m/s)^{1/2}$
Residential Type B (3 mm glass bulb)	68°C	36 $m^{1/2}s^{1/2}$	0.4 $(m/s)^{1/2}$
Standard Response SS68 (5 mm glass bulb)	68°C	95 $m^{1/2}s^{1/2}$	0.4 $(m/s)^{1/2}$
Standard Response SS93 (5 mm glass bulb)	93°C	95 $m^{1/2}s^{1/2}$	0.4 $(m/s)^{1/2}$

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	ρ = 731 kg/m³ k = 0.17 W/mK ε = 0.88
Thermal properties – floor 100 mm concrete	ρ = 2300 kg/m³ k = 1.2 W/mK ε = 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.

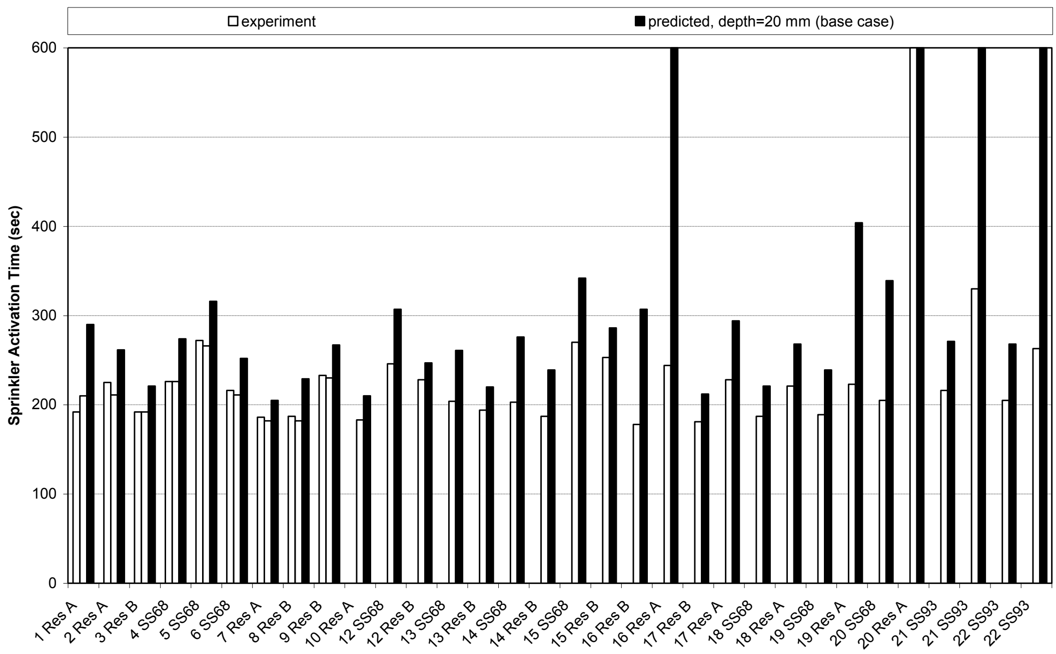


Figure 47. Comparison of measured and predicted activation time for base case – with BRANZFIRE/JET model

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.

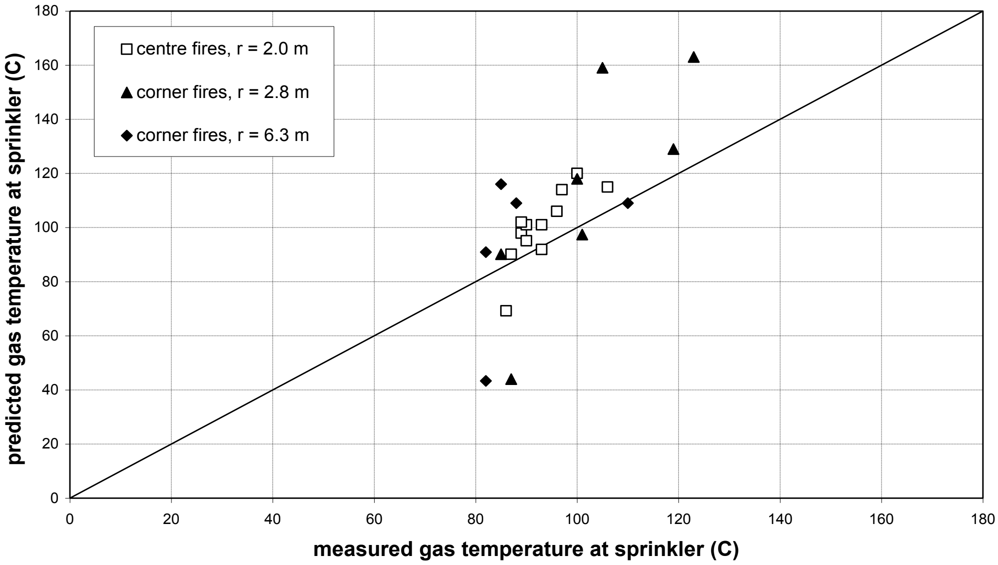


Figure 48. Comparison of the measured and predicted gas temperatures at the location of the sprinkler at the measured sprinkler activation time

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 m^2/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.

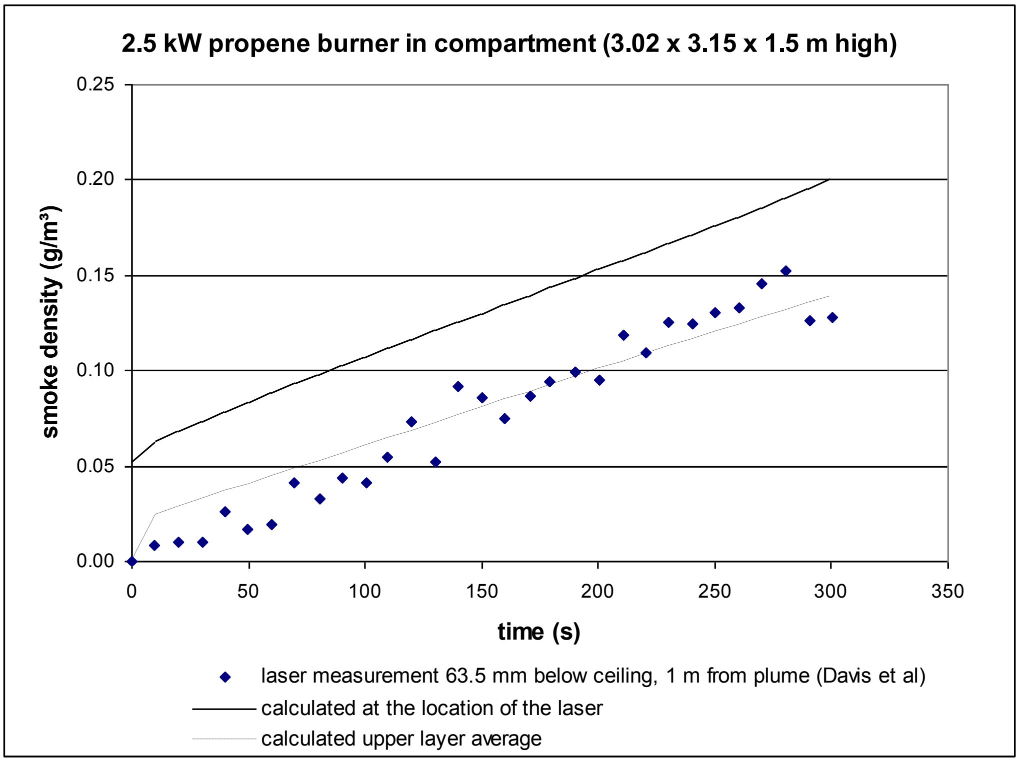


Figure 49. Experiment A – 2.5 kW propene burner 1.5 m below ceiling

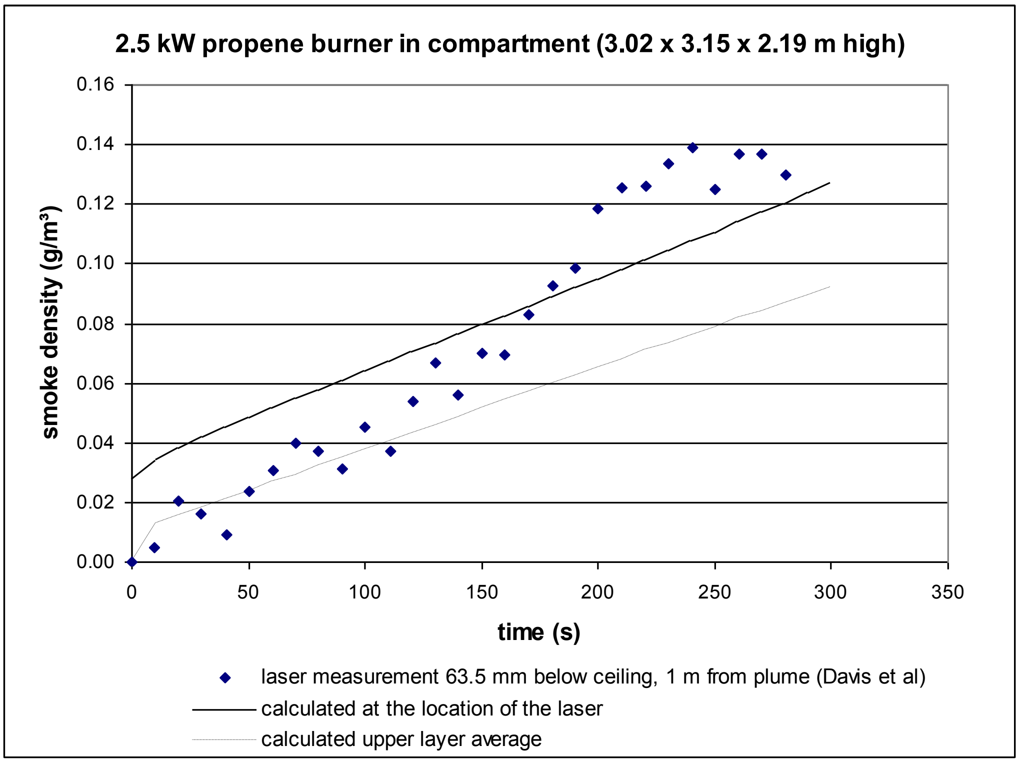


Figure 50. Experiment B – 2.5 kW propene burner 2.19 m below ceiling

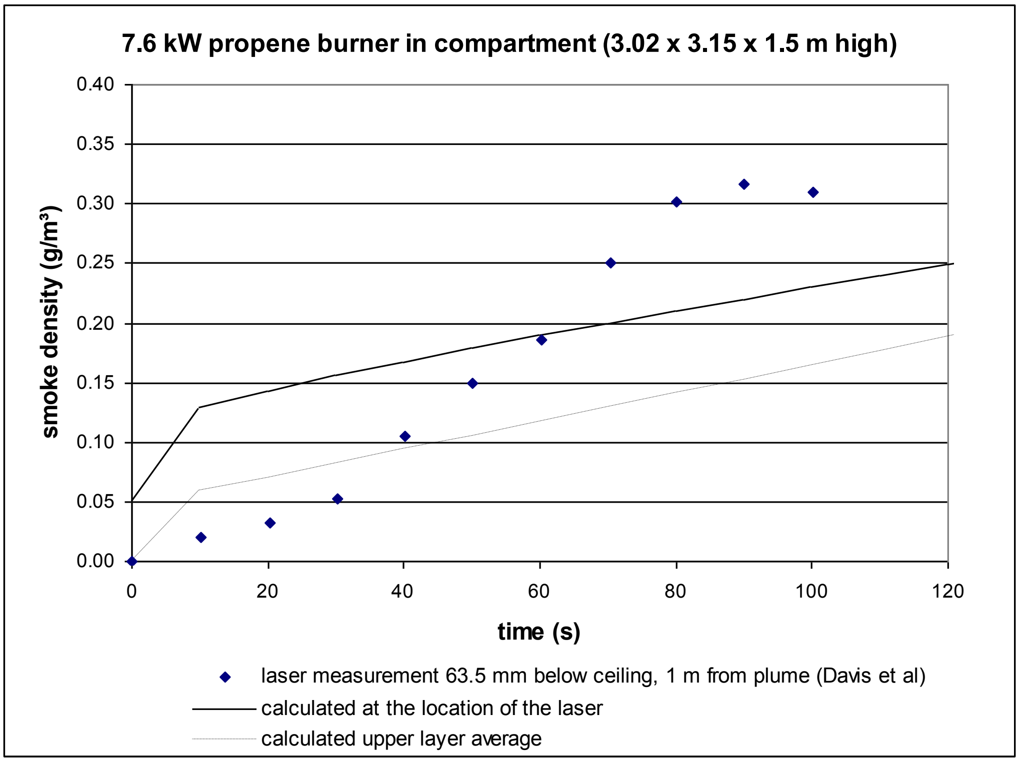


Figure 51. Experiment C – 7.6 kW propene burner 1.5 m below ceiling

APPENDIX A SUMMARY OF INPUTS

A.1 Case 2–1

```
Friday,July 18,2008,11:43 AM
Input Filename : Steck1.mod

BRANZFIRE Multi-Compartment Fire Model (Ver 2008.2)

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Steady State Fire Experiments

====================================================================
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
====================================================================
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
====================================================================
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)

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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/m3) =                  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/m3) =                         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/m3) =               720.0
        Ceiling Substrate Conductivity (W/m.K) =          0.120
        Ceiling Substrate Thickness (mm) =                13.0

        Floor Surface is Fire Brick
        Floor Density (kg/m3) =                           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/m3) =                            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/m3) =                  930.0
        Wall Substrate Conductivity (W/m.K) =             0.170
        Wall Substrate Thickness (mm) =                   13.0

        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) =                          13.0

        Ceiling Substrate is Plasterboard
        Ceiling Substrate Density (kg/m3) =               930.0
        Ceiling Substrate Conductivity (W/m.K) =          0.170
        Ceiling Substrate Thickness (mm) =                13.0

        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

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/m3) =                            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/m3) =                  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
```

A.4 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 : hugeroom_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.
```