CMMT-2007-049

‘Under-Flame’ Fire Tests on Timber Decks

Report to
Bushfire CRC

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February 2007

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Executive Summary

In total 13 timber decks were accessed using the:

American Urban Wildland Interface Building Test Standard 12-7A-5, Fire Resistive Standards for Decks and Other horizontal Ancillary Structures, Part A Under-flame Test.

to determine their performance and to obtain some data that could assist with future tests to be performed based on the proposed Draft AS 1530.8.1 – Bushfire Test Method.

The conclusions found were:

- Typical Australian domestic timber decking consisting of nominal 20mm thick boards did not pass the American Urban Wildland Interface Building Test Standard 12-7A-5, Fire Resistive Standards for Decks and Other horizontal Ancillary Structures, Part A Under-flame test.

- The plinth detail at the wall has a major influence on the heat load on the wall from the burning deck.

- The test procedure used was sensitive to the strength of the pilot flame used on the main burner.

- Comparative data was obtained to be used in future work looking at similar testing based on the AS 1530.8.1 – Bushfire test method.

- Modifications to the decks to try and improve their performance proved inconclusive due to alterations to the test conditions.

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1. Introduction

This report forms part of the work undertaken for the Bushfire CRC to reduce the risk of building loss and injuries to occupants due to bushfires. It investigates the performance of some typical Australian timber decking tested to the:

American Urban Wildland Interface Building Test Standard 12-7A-5, Fire Resistive Standards for Decks and Other horizontal Ancillary Structures, Part A Under-flame test.

The aim was to:

- Determine if typical Australian domestic timber decking would pass the requirements in the American Standard.
- Obtain a greater understanding of how decks behave in fires.
- Obtain some data on the performance of the decks that could assist with future tests to be performed based on the proposed Draft AS 1530.8.1 – Bushfire Test Method.

A total of 13 decks were tested covering a range of timber species and board geometries. Some variations to the standard were used to determine the effect on the decking performance of changing the type of joist, gap between the boards and the material conditioning.

2. Test Procedure

2.0 General

The tests were conducted using the American standard 12-7A-5 Part A Under-flame test [1]. The standard required the construction of a simple frame on which to support the deck test specimen (see *Figure 2-1*), above a 300 x 300mm sandbox burner producing a 80 kW fire. The frame is placed under an exhaust hood with instrumentation for measuring heat release. Both the sandbox burner and exhaust hood were available as part of the room fire test facilities (conducted to ISO 9705 [3]) at the Fire Science and Technology Laboratories at Highett in Melbourne.

The size and position of the fire beneath the deck simulates the effect of about 1 kg of paper trash burning. The height of the deck is set so the top of the flames flow up through the gaps in the decking. The deck is only exposed to the fire for 3 minutes but observed for up to 40 minutes afterwards.

Figure 2-1 Frame for Supporting Deck

(a piece of cement sheet is sitting on the steel channels where the deck is to be placed)

2.1 Summary of the Test Requirements

The following information summarises the test requirements used during the tests. Some minor changes were made to the standard requirements to take into account available joist material and conditioning facilities.

Test Specimen (see *Figure 2-2*):

- Timber deck 700mm (joist direction) x 600mm (decking board length)
- 2 x Radiata pine 150mm x 45mm joists spaced 405mm apart (360mm gap between joists)
- Decking boards connected to each joist by a single 65mm long screw with 5mm gap between boards.
- At the front end, the joist and the decking boards are flush while at the wall end the last decking board overlaps the edge of the joist by 25mm.

Test frame (see *Figure 2-3*):

- Framing for holding the deck 690mm above a 300mm x 300mm sand box burner measured to the underside of the decking boards.
- Open front and lined sides and back with 200mm gap at the base to allow for air flow to the burner. The height of the sides are approximately the same level as the top of the deck. The height of the back is 2400mm. In plan the frame is U shaped with dimensions approximately 700mm x 700mm.
- Steel channels support the joists along the bottom edge leaving only the inside face of the joist and the underside of the decking boards between the joists exposed to the flames.
- A non combustible plinth board the same depth as the joist and fastened to the back wall provides a support on which the 25mm overlap on the last decking board can rest.

Test Procedure:

- Test specimens are conditioned at 45 °C and 18% Relative Humidity (RH) for at least 1 week prior to testing (~5% EMC). The American standard requires 6% EMC.
- For the first 3 minutes of the test the specimens are exposed to a 80 kW sandbox burner fire.
- The burner is then turned off and the specimen observed for up to 40 minutes.
- To pass, 3 replicates of the specimen must all have an absence of:
  - sustained flaming or glowing combustion at the end of the 40minute period
  - structural failure of any deck board and
  - peak heat release < 270 kW/m^2

    (i.e. 115 kW based on a 700mm x 610mm deck area).

Figure 2-2 Typical Timber Deck Test Specimen

Figure 2-3 Under-Flame Test Rig

3. Test Results

3.0 Specimens Tested

Only a limited range of decks could be tested due the time restraints on using the laboratory. In total 13 decks of different configurations were constructed as shown in *Table 3-1*. The samples with significant variations from the standard requirements (marked in **bold** in the table) were:

- 5, 8 and 10 – Gap of 10mm
- 11, 12 and 13 – Steel joists
- 12 and 13 – Conditioned at 23º C and 50% RH

The species were selected as representative of the types of timbers used for decking in Australia. Radiata Pine instead of CCA Treated Radiata Pine was used for health and safety reasons.

Initially decks numbered 1 to 10 were constructed and then tested on the same day to reduce any variability due to laboratory conditions. Following these tests a second series of 3 decks (Nos 11 to 13) were constructed and tested. In the later decks variations were made to try and improve the decks performance. These include:

- Replacement of the timber joists with steel C sections
- Change of conditioning environment to 23º C and 50% RH and
- The use of tapered instead of square edges on the decking boards

Table 3-1 Samples Tested for First Series of Tests

Deck No.	Deck Timber	Joist Material	Deck Board			Gap (mm)	Conditioning
			Width (mm)	Thickness (mm)	Edge Profile		
1	Radiata Pine	Radiata Pine	90	35	square	5	45º C 18% RH
2	White Cypress Pine	Radiata Pine	120	30	square	5	45º C 18% RH
3	Jarrah	Radiata Pine	85	20	square	5	45º C 18% RH
4	Merbau	Radiata Pine	90	19	square	5	45º C 18% RH
5	Merbau	Radiata Pine	90	19	square	**10**	45º C 18% RH
6	Merbau	Radiata Pine	69	19	square	5	45º C 18% RH
7	Spotted Gum	Radiata Pine	85	19	square	5	45º C 18% RH
8	Spotted Gum	Radiata Pine	85	19	square	**10**	45º C 18% RH
9	Spotted Gum	Radiata Pine	63	19	square	5	45º C 18% RH
10	Spotted Gum	Radiata Pine	63	19	square	**10**	45º C 18% RH
11	Spotted Gum	**Steel**	85	19	square	5	45º C 18% RH
12	Spotted Gum	**Steel**	85	19	square	5	**23º C 50% RH**
13	Spotted Gum	**Steel**	85	19	tapered	5	**23º C 50% RH**

3.1 First Series of Tests (Nos 1 to 10)

The initial tests were conducted at the specified burner output of 80 kW. However at this level it became obvious that all of the decks would fail both the heat release and structural criteria (see *Figure 3-1*). As a result, four of the initial 10 decks (Nos 3,5,6 and 8, see *Table 3-2*) were tested at either 60 kW or 70 kW to determine at what level they might pass. However all four decks failed the heat release criteria having peak heat releases greater than 115 kW (i.e. 270 kW/m^2 and assuming a 700mm x 610mm deck area) while the two decks tested at 70 kW failed the structural requirement as well. The peak heat release values from the tests are given in *Table 3-2*. Photos of the 4 test specimens tested at the reduced burner output are shown in *Figure 3-2* and *Figure 3-3*. The test record sheets containing plots of the heat release are given in Appendix B.

Some observations noted were:

- The Radiata Pine deck performed the worst having the highest peak heat release and post burner heat release of 250 kW and 60 kW respectively. Also, although the deck was only allowed to burn for 6 minutes post burner, it was obvious that it would have completely burnt out if it had been allowed to continue to burn.
- The White Cypress Pine deck which had 30mm thick boards compared with the 20mm used for the majority of decks, showed that thicker boards performed better in terms of the structural criteria.
- The plinth detail has a major effect on the combustion of the decking board next to the wall. In all tests the gap between the plinth and the decking board acted as a chimney for the flames to ignite the board then as a heat trap to incubate the fire. This resulted in a high heat load on the wall adjacent to the deck as shown in *Figure 3-4*.
- The heat from the burning pine joists increase the combustion on the adjacent decking (see *Figure 3-5*).

Figure 3-1 A Typical Deck after Testing

Table 3-2 Peak Heat Release Values for the First Series of Tests

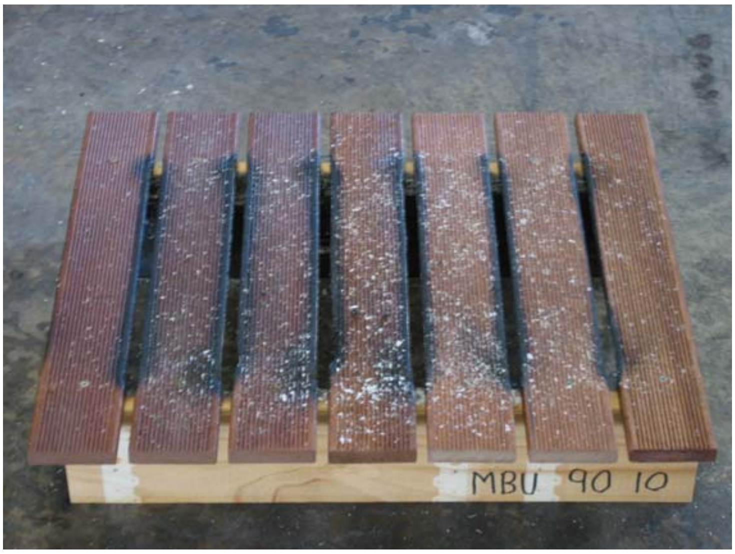
Deck No.	Deck Timber	Deck Board Width (mm)	Deck Board Thickness (mm)	Gap (mm)	Burner Output (kW)	Peak Heat Release (kW)
1	Radiata Pine	90	35	5	80	250
2	White Cypress Pine	120	30	5	80	180
3	Jarrah	85	20	5	60	140
4	Merbau	90	19	5	80	160
5	Merbau	90	19	**10**	60	150
6	Merbau	69	19	5	70	170
7	Spotted Gum	85	19	5	80	180
8	Spotted Gum	85	19	**10**	70	170
9	Spotted Gum	63	19	5	80	210
10	Spotted Gum	63	19	**10**	80	190

(a) Deck No 6

(b) Deck No 8

Figure 3-2 Decks tested with 70kW burner

(a) Deck No. 3



(b) Deck No. 5

Figure 3-3 Decks tested with 60kW burner

Figure 3-4 Plinth detail causes severe heat load on adjacent wall

Figure 3-5 Heat from the burning pine joists impinging on the decking

3.2 Second Series of Tests (Nos 11 to 13)

The second series of tests looked at improving the performance of the decks by replacing the board next to the wall with a steel section, using steel joists, a 23º C and 50% RH condition environment and, in one case, a 30° tapered edged board. The later change originating from the burn pattern evident in the first series of tests where the edge of the boards burn in a tapered pattern as shown in *Figure 3-6*. A comparison of the tapered board used and a previously burnt square edged board is shown in *Figure 3-7* .

Figure 3-6 Tapered burn pattern on edge of decking boards

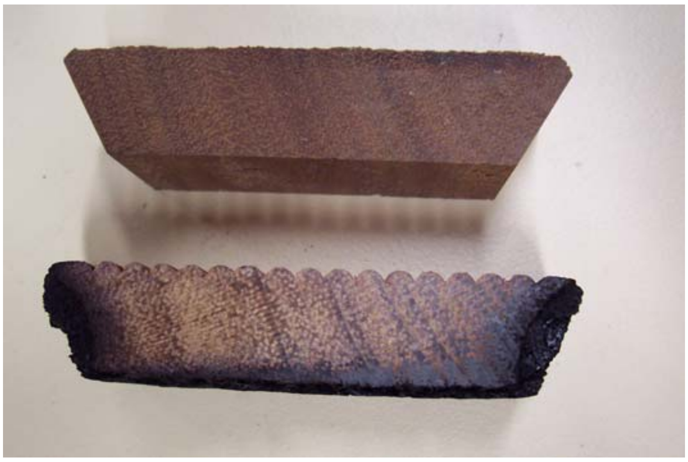


Figure 3-7 Comparison of tapered edge and burnt square edged board

The reasons for selecting these changes were:

- To prevent the detail around the plinth causing a high heat load on the wall by replacing the last board with a steel section (see *Figure 3-8*).
- During the first series of tests the pine joists were observed to add significantly to the heat loading on the decking boards.
- The easing of the conditioning requirements from 45 °C and 18% RH to 23º C and 50% RH is in line with the recommendations in the Draft AS 1530.8.1 – Bushfire Test Method.
- Using a tapered edge board may reduce the heat concentration in the gap between the boards.

The peak heat release results of the tests are given in *Table 3-3*. After test photos of the decks are shown in *Figure 3-8*.

While the results indicate a large improvement in the performance, a close analysis indicates that the test conditions were different between the first and second series of tests. An analysis of the data including video records indicates that the strength of the pilot flame was different between the two series of tests. The second series of tests was conducted with a stronger pilot flame resulting in some of the main burner flame being blown out the front of the deck and reducing its impact. Hence the results are not reliable.

Due to limited access to the lab the tests could not be repeated. However it is proposed to cover these comparative tests in future work based on the AS 1530.8.1 test procedure involving the use of a radiant panel test rig.

Table 3-3 Peak Heat Release Values for Second Series of Tests

Deck No.	Deck Timber	Joist	Conditioning	Edge	Burner Output (kW)	Peak Heat Release (kW)
11	Spotted Gum	Steel	45º C 18% RH	Square	80	140
12	Spotted Gum	Steel	23º C 50% RH	Square	80	120
13	Spotted Gum	Steel	23º C 50% RH	Tapered	80	130

Figure 3-8 Second Series Timber Deck Test Specimens (from top: Nos 11,12 & 13) After Testing

4. Conclusions

The following conclusions were found:

- Typical Australian domestic timber decking consisting of nominal 20mm thick boards did not pass the American Urban Wildland Interface Building Test Standard 12-7A-5, Fire Resistive Standards for Decks and Other horizontal Ancillary Structures, Part A Under-flame test.

- The plinth detail at the wall has a major influence on the heat load on the wall from the burning deck.

- The test procedure used was sensitive to the strength of the pilot flame used on the main burner.

- Comparative data was obtained to be used in future work looking at similar testing based on the AS 1530.8.1 – Bushfire test method.

- Modifications to the decks to try and improve their performance proved inconclusive due to alterations to the test conditions.

5. References

1. American Urban Wildland Interface Building Test Standard 12-7A-5, Fire Resistive Standards for Decks and Other horizontal Ancillary Structures, Part A Under-flame Test.

2. Standards Australia (2006) Draft AS 1530.8.1 – Methods for fire tests on building materials, components and structures, Part 8.1: Test on elements of construction for building exposed to radiant heat and small flaming sources during bushfires. (short title: Bushfire test method – Medium to Severe categories), Standards Australia, Sydney.

3. Fire Tests - Full-Scale Room Test for Surface Products, ISO 9705 International Organization for Standardization, Geneva, Switzerland, (1993).

APPENDIX A – Material Properties

Table A.1 Typical Properties of Timbers Conditioned to EMC at 23° C and 50% RH

Species	Density (kg/m^3)	MC (%)
Radiata Pine	550	11
Cypress Pine	700	12
Jarrah	950	12
Merbau	900	12
Spotted Gum	1100	12

Table A.2 Typical Properties of Timbers Conditioned to EMC at 45° C and 18% RH

Species	MC (%)
Radiata Pine	4.5
Cypress Pine	4.5
Jarrah	5.0
Merbau	5.0
Spotted Gum	5.5

APPENDIX B – Test Record Sheets

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Fire Science and Technology Laboratory

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Phone: (03) 9252 6000 Fax: (03) 9252 6244

TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 1**

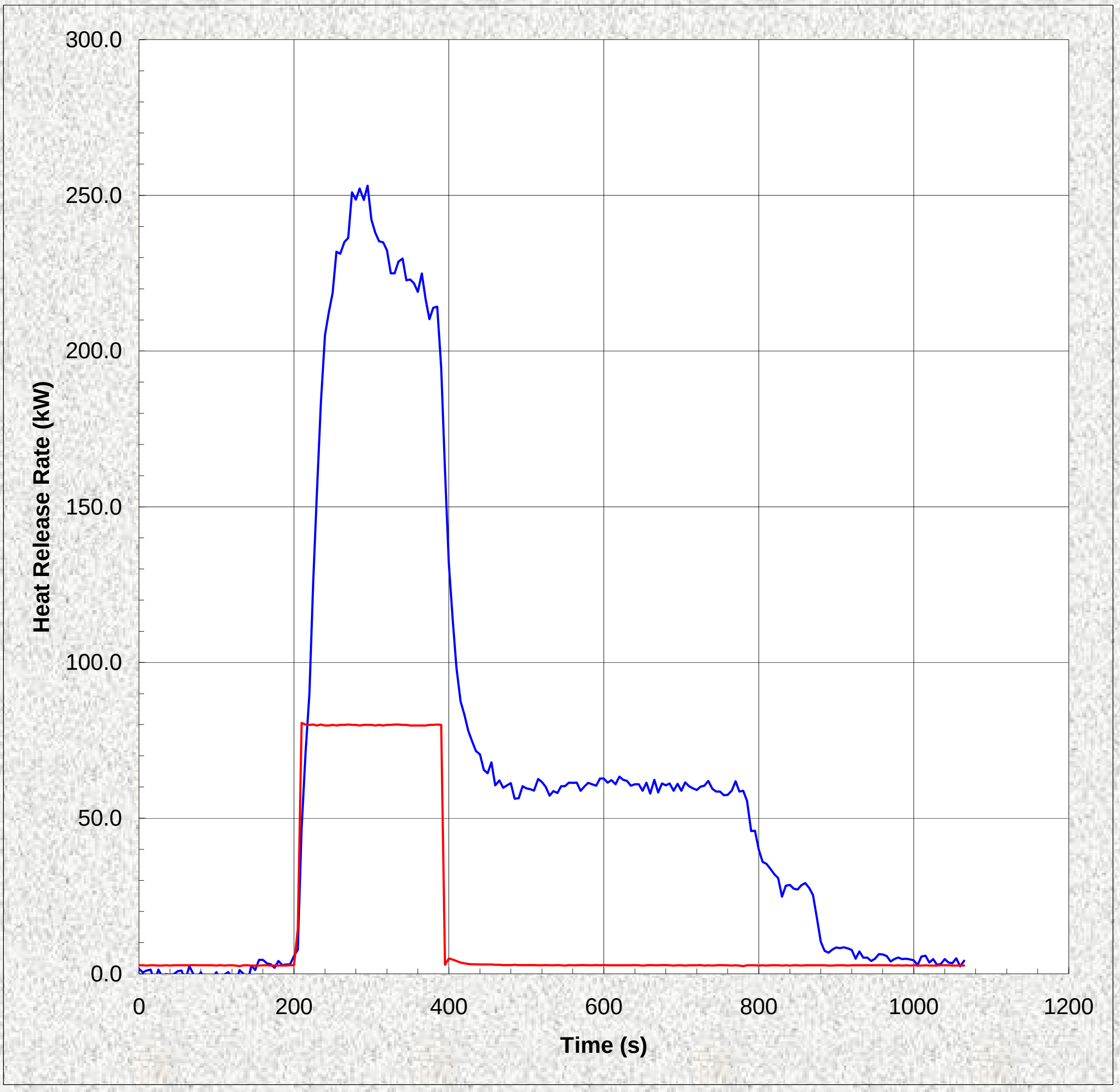
Title	Date
Under Deck Flame Test - 12-7A-5	10/Mar/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1337	**80kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.22				**253**

Material	Comment
Radiata Pine	**Fire Extinguished at 800s**

Heat Release Rate - Time



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TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 2**

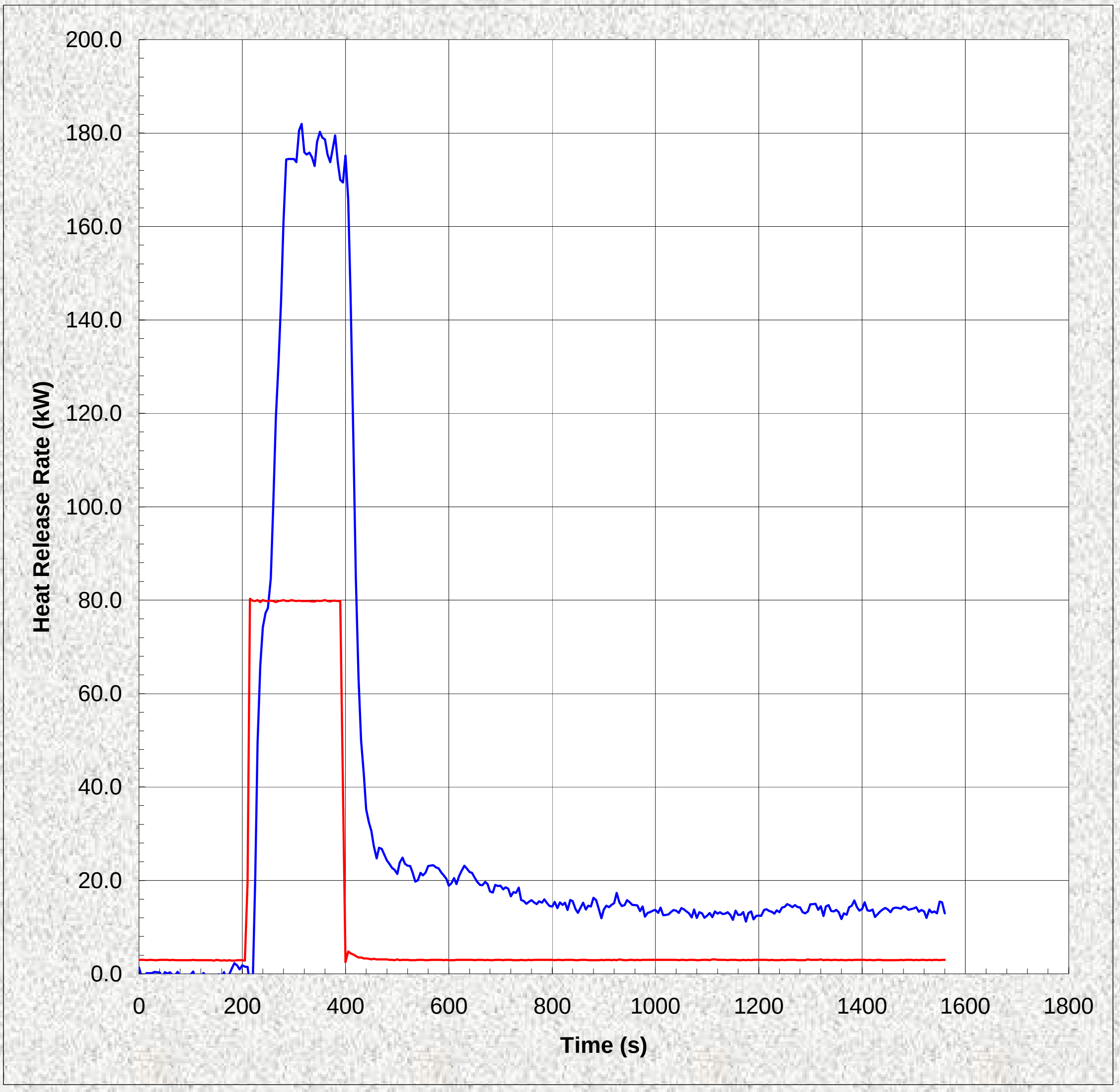
Title	Date
Under Deck Flame Test - 12-7A-5	10/Mar/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1328	**80kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.25				**182**

Material	Comment
White Cypress Pine	

Heat Release Rate - Time



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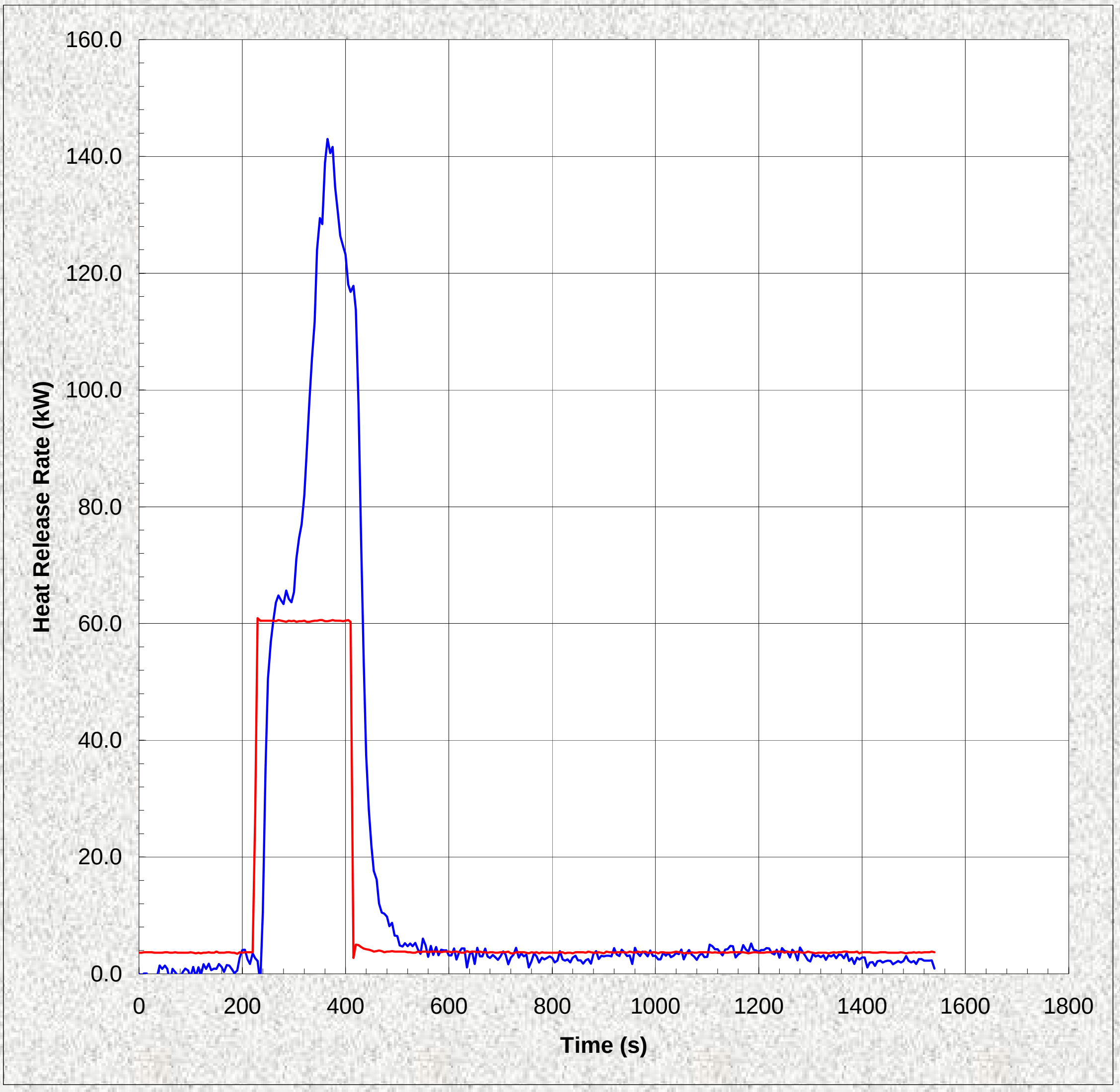
TEST RECORD SHEET

Client	**Bushfire CRC**
Test Number	**No 3**
Title	**Under Deck Flame Test - 12-7A-5**
Date	10/Mar/06
Test Code	J1335
Burner Output (kW)	**60 kW**
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.30
Peak Heat Release (kW)	**143**
Material	**Jarrah**
Comment	

Heat Release Rate - Time



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TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 4**

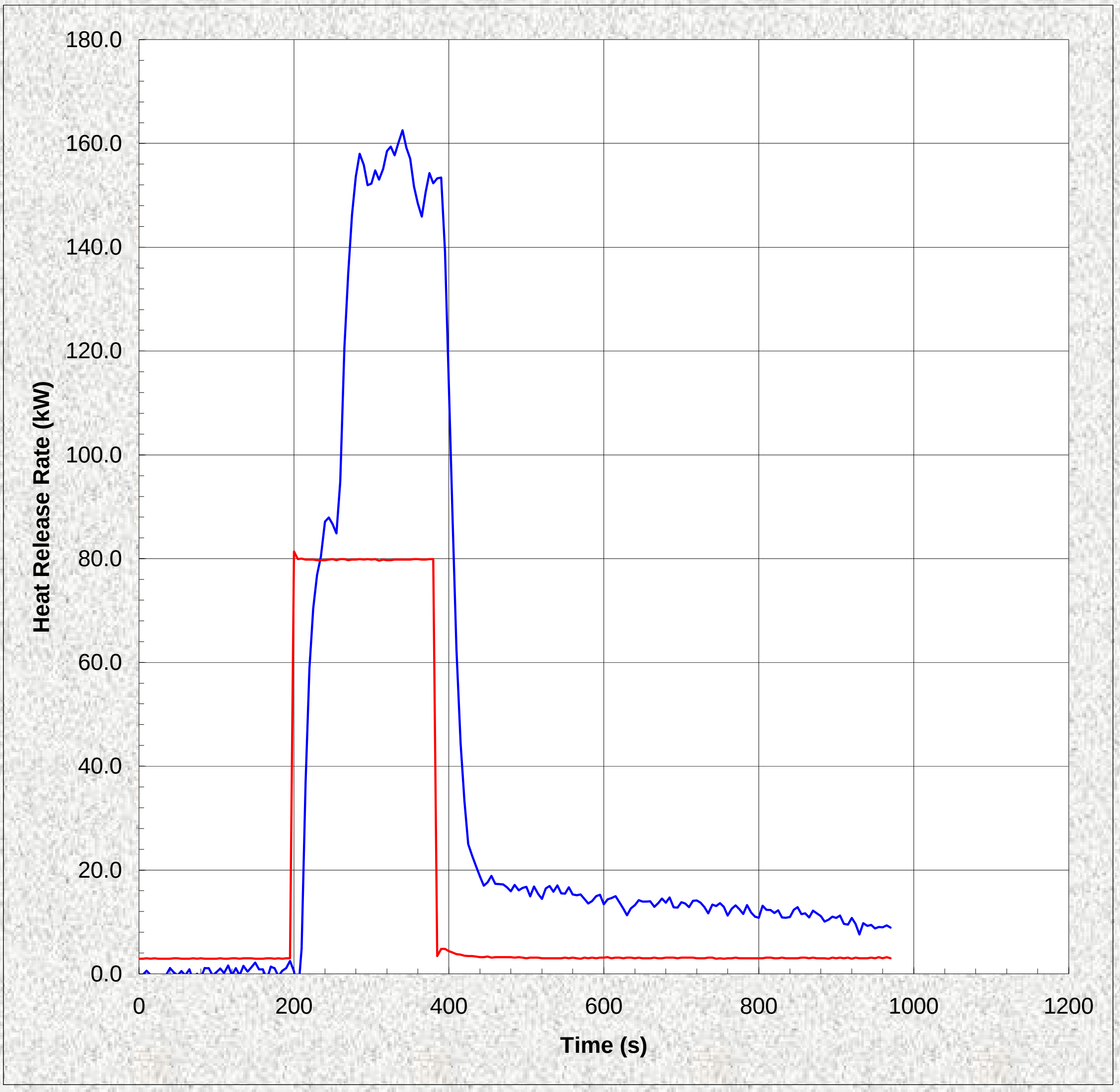
Title	Date
Under Deck Flame Test - 12-7A-5	10/Mar/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1329	**80kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.21				**163**

Material	Comment
Merbau	

Heat Release Rate - Time



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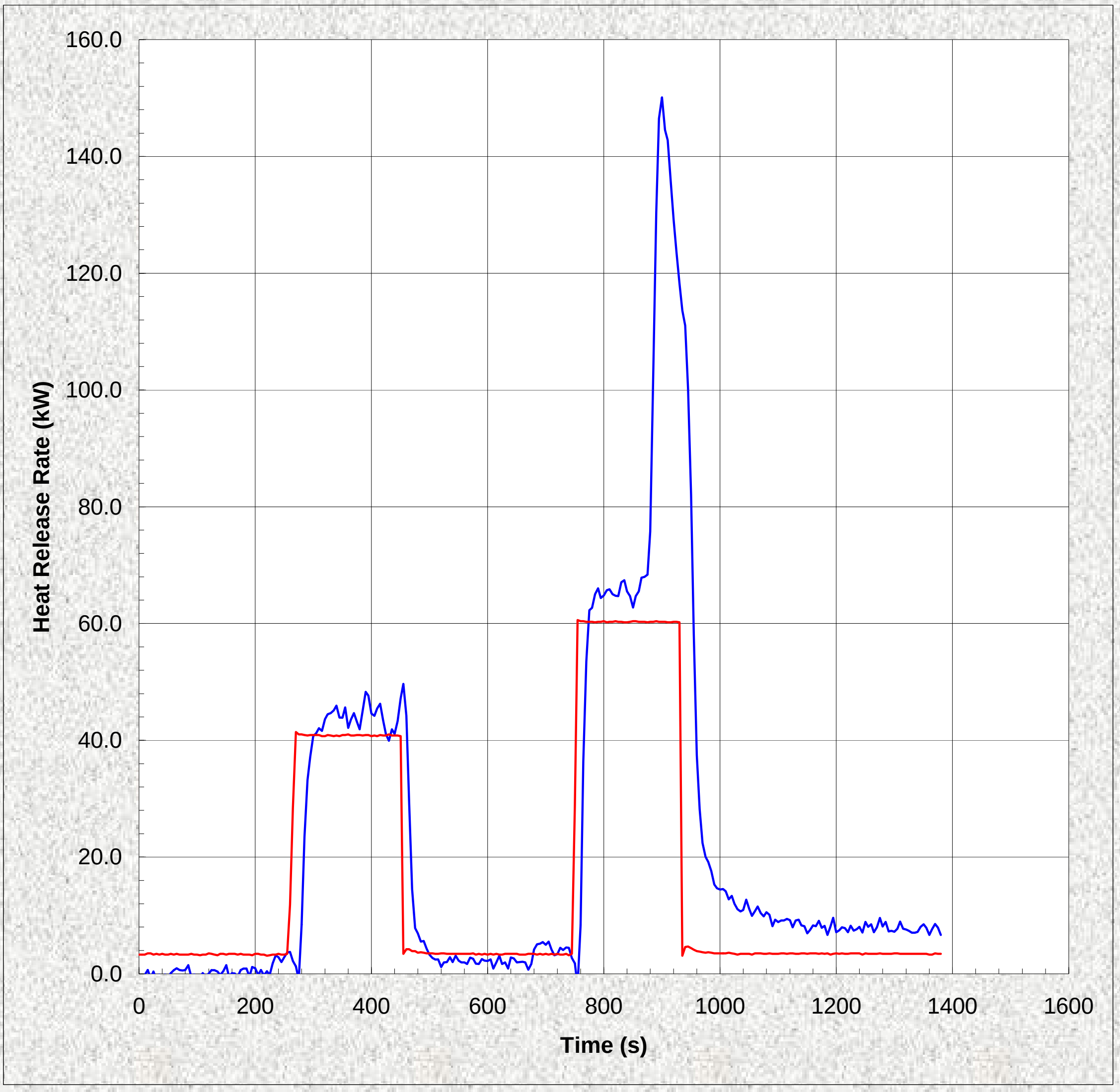
TEST RECORD SHEET

Client	**Bushfire CRC**
Test Number	**No 5**
Title	**Under Deck Flame Test - 12-7A-5**
Date	10/Mar/06
Test Code	J1331
Burner Output (kW)	**40 kW + 60kW**
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.28
Peak Heat Release (kW)	**150**
Material	**Merbau**
Comment	

Heat Release Rate - Time



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TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 6**

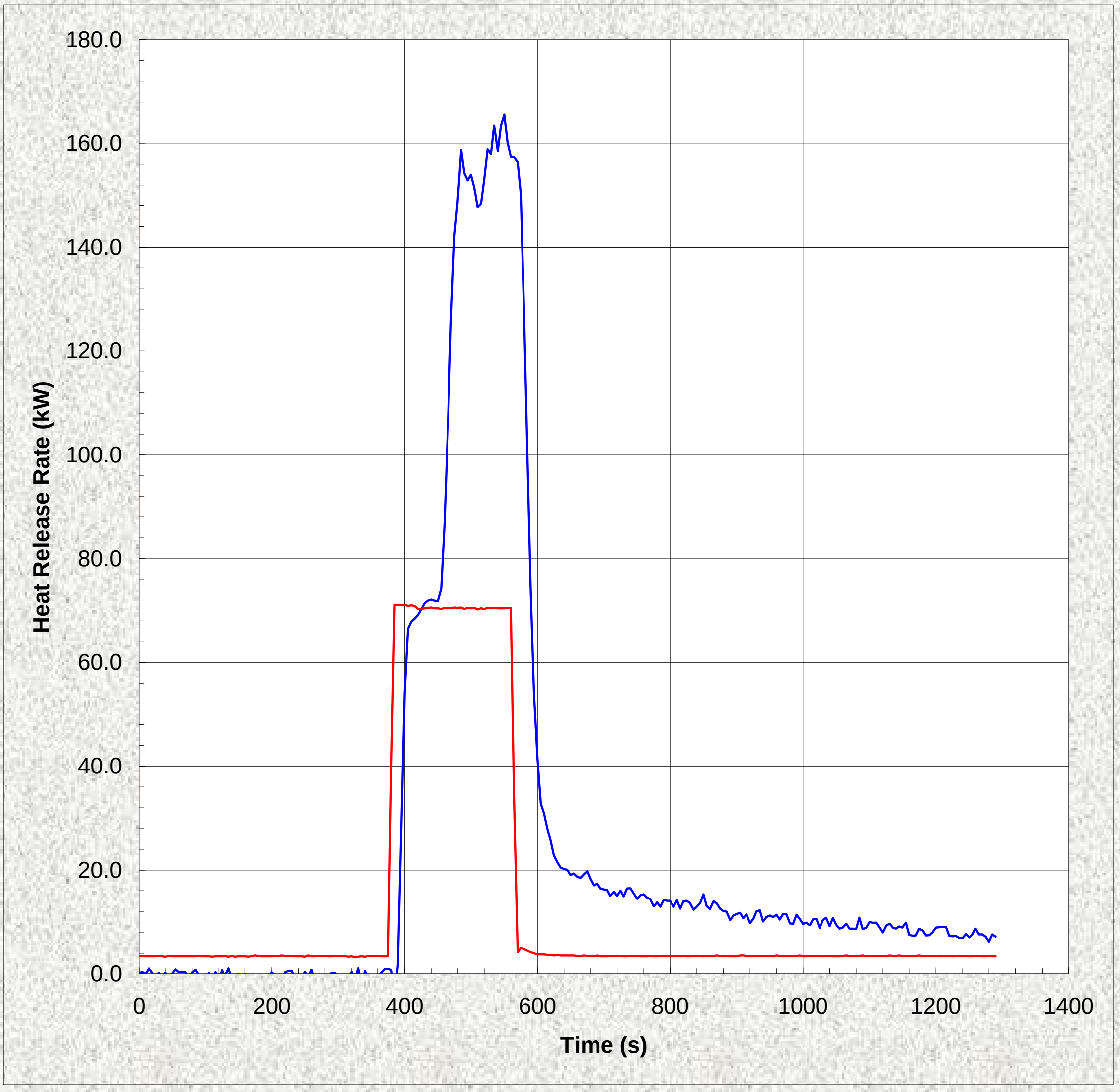
Title	Date
Under Deck Flame Test - 12-7A-5	10/Mar/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1332	**70 kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.27				**166**

Material	Comment
Merbau	

Heat Release Rate - Time



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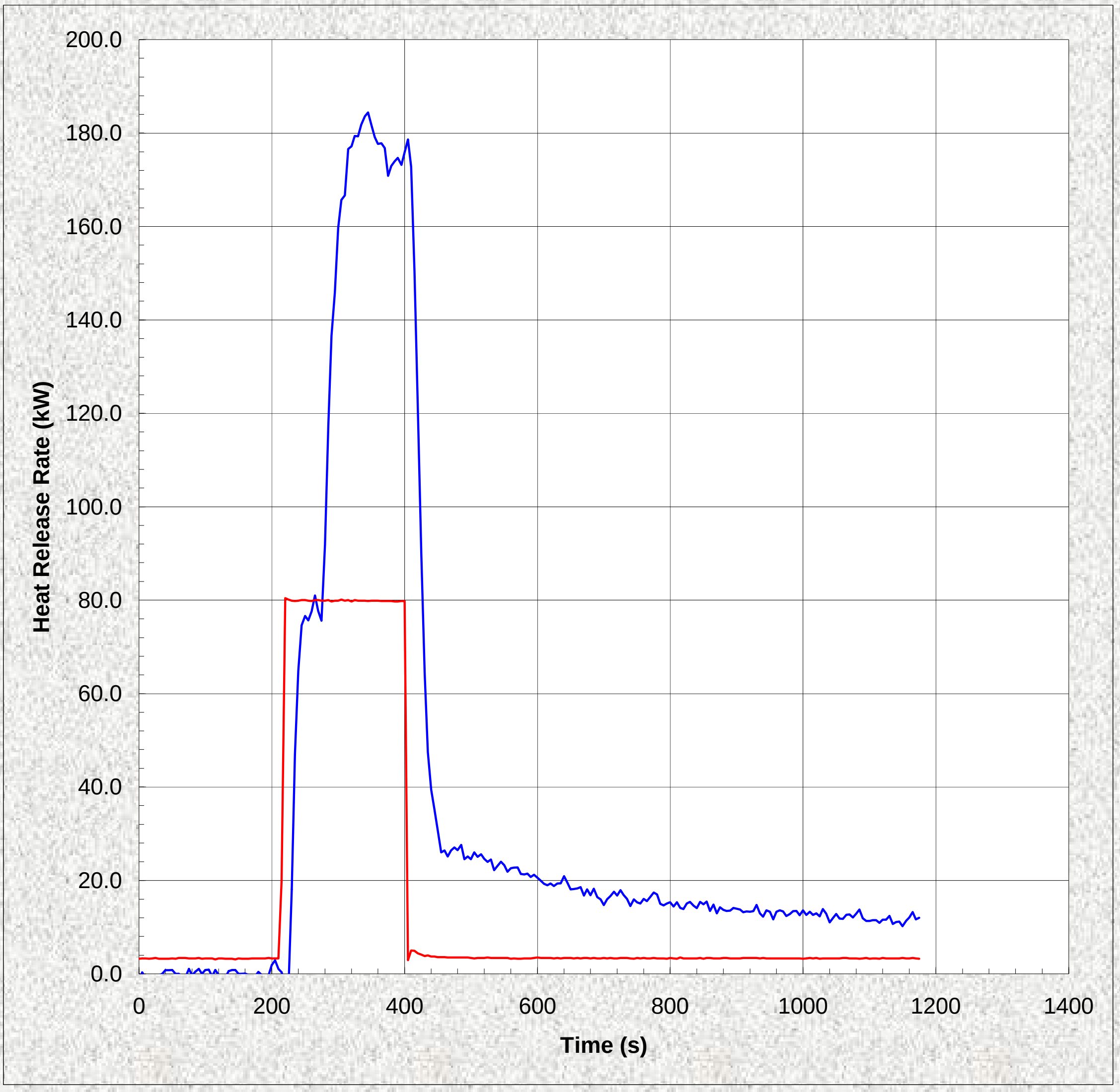
TEST RECORD SHEET

Client	**Bushfire CRC**
Test Number	**No 7**
Title	**Under Deck Flame Test - 12-7A-5**
Date	10/Mar/06
Test Code	J1330
Burner Output (kW)	**80kW**
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.23
Peak Heat Release (kW)	**184**
Material	**Spotted Gum**
Comment	

Heat Release Rate - Time



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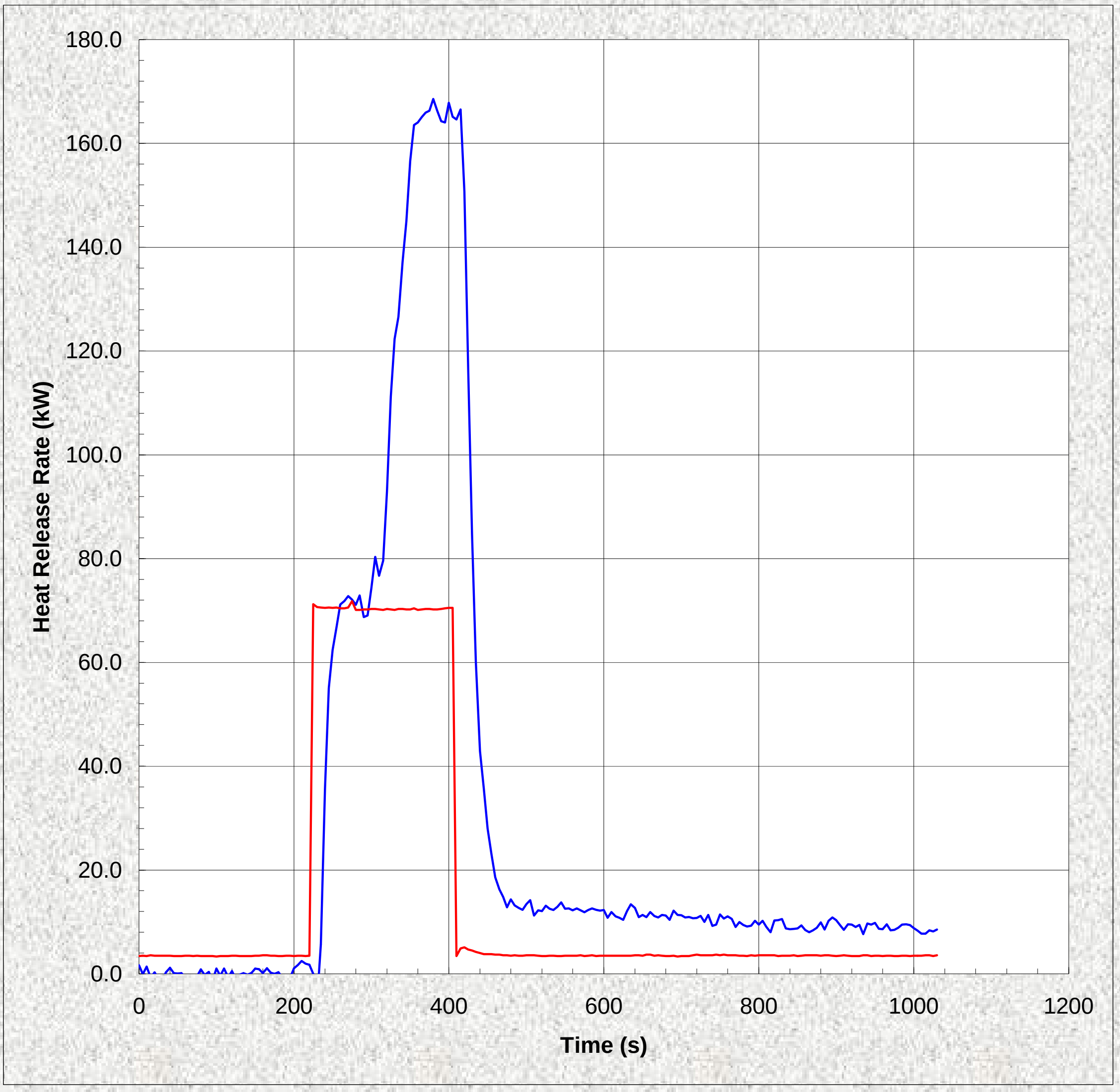
TEST RECORD SHEET

Client	Bushfire CRC
Test Number	No 8
Title	Under Deck Flame Test - 12-7A-5
Date	10/Mar/06
Test Code	J1333
Burner Output (kW)	70 kW
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.27
Peak Heat Release (kW)	169
Material	Spotted Gum
Comment	

Heat Release Rate - Time



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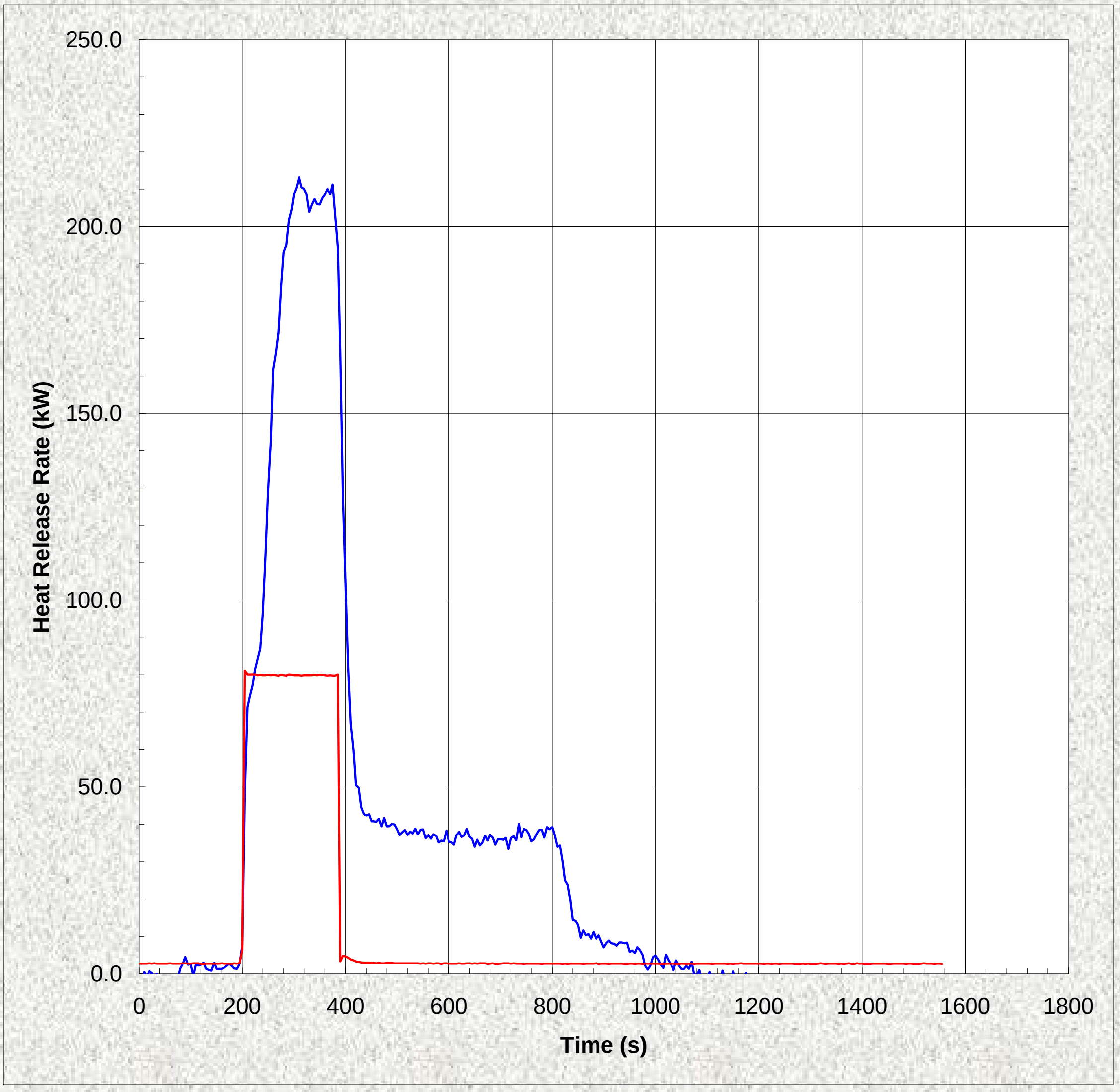
TEST RECORD SHEET

Client	Bushfire CRC
Test Number	No 9
Title	Under Deck Flame Test - 12-7A-5
Date	10/Mar/06
Test Code	J1336
Burner Output (kW)	80kW
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.25
Peak Heat Release (kW)	213
Material	Spotted Gum
Comment	Fire Extinguished at 800s

Heat Release Rate - Time



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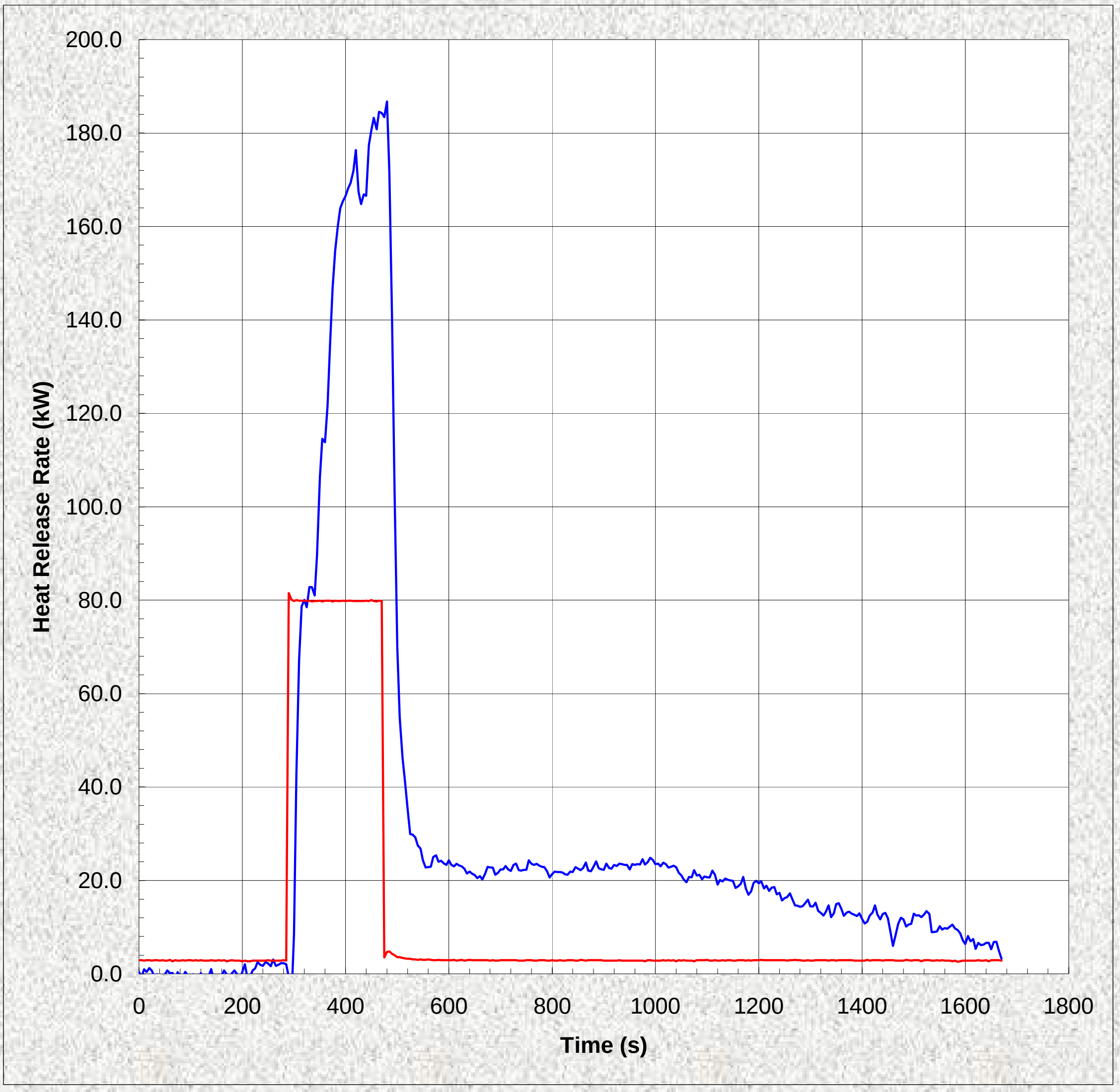
TEST RECORD SHEET

Client	**Bushfire CRC**
Test Number	**No 10**
Title	**Under Deck Flame Test - 12-7A-5**
Date	10/Mar/06
Test Code	J1327
Burner Output (kW)	**80kW**
Sampling Interval (s)	5
Baseline Interval (s)	100
Ignition Time (s)	0
A M Fraction H20	0.014
Exist. Calib. Factor	1
Av Flow Rate (m3/s)	1.26
Peak Heat Release (kW)	**187**
Material	**Spotted Gum**
Comment	

Heat Release Rate - Time



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TEST RECORD SHEET

Client	Test Number
Bushfire CRC	No 11

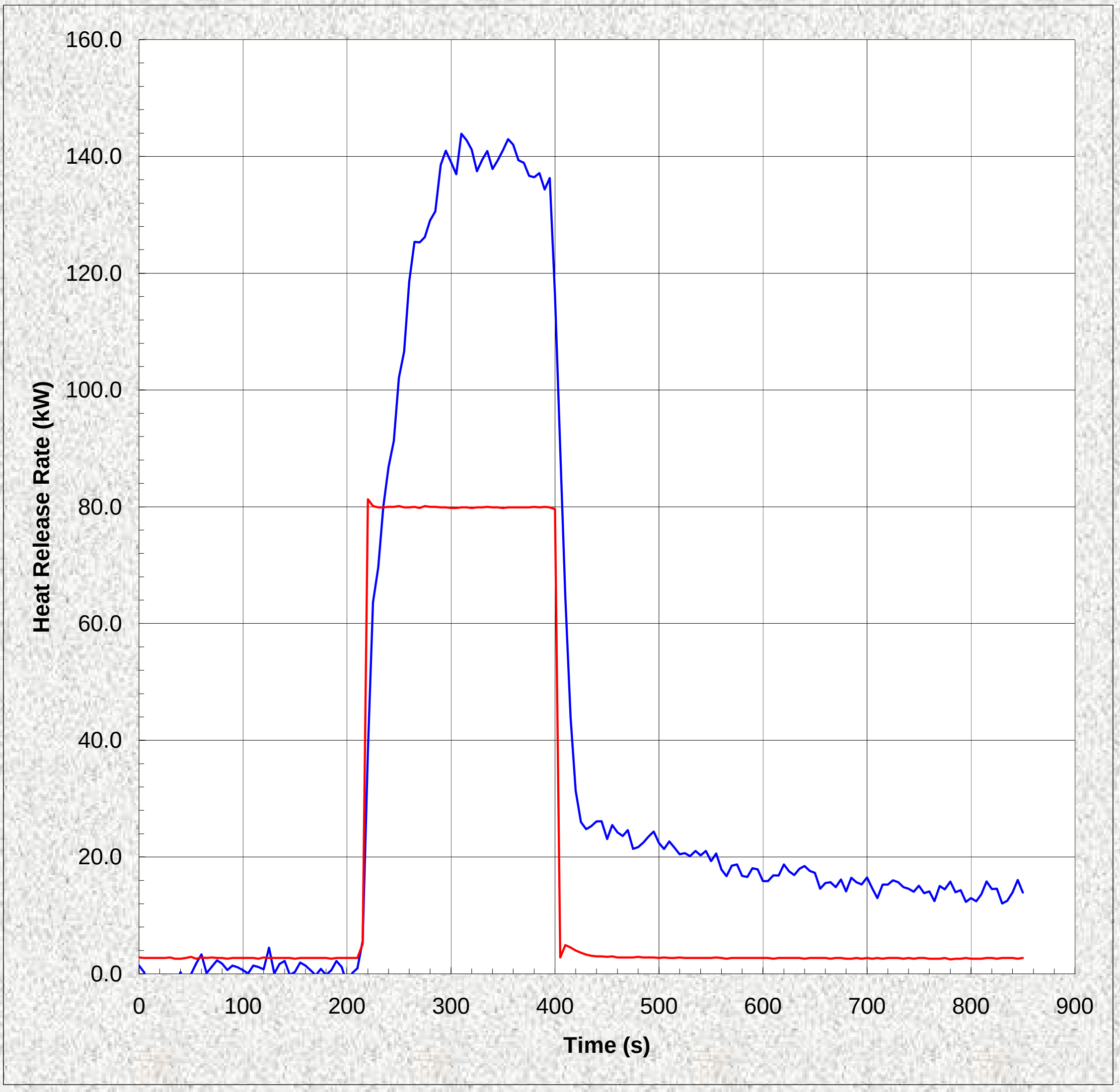
Title	Date
Under Deck Flame Test - 12-7A-5	12/May/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1369	80kW	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.24				144

Material	Comment
Spotted Gum	

Heat Release Rate - Time



Under Deck Flame Test 24-1-2007.trd

CSIRO

Manufacturing & Infrastructure Technology

Fire Science and Technology Laboratory

Graham Road, (PO Box 56), Highett, Vic. 3190, Australia

Phone: (03) 9252 6000 Fax: (03) 9252 6244

TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 12**

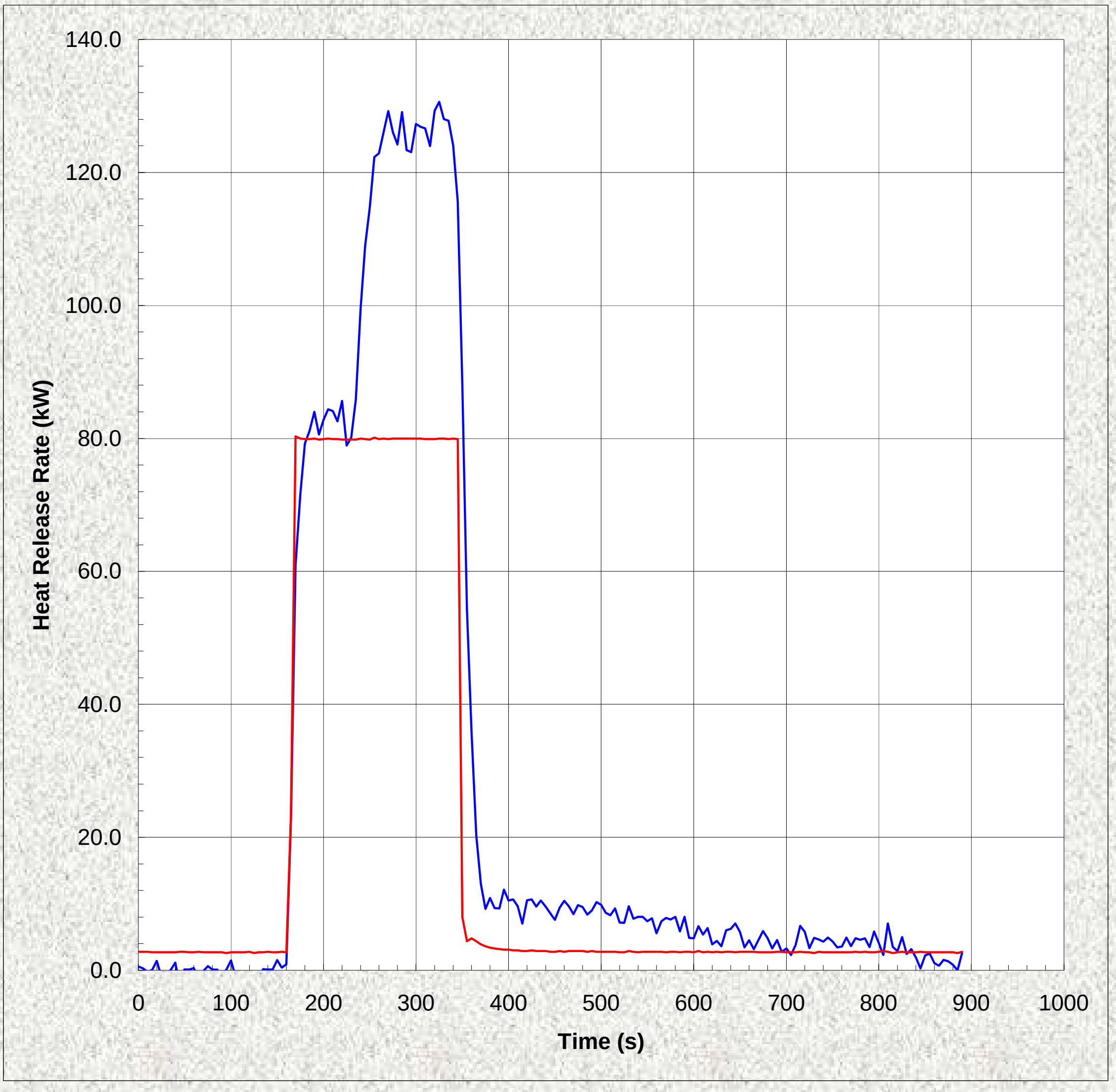
Title	Date
Under Deck Flame Test - 12-7A-5	12/May/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1367	**80kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.25				**131**

Material	Comment
Spotted Gum	

Heat Release Rate - Time



Under Deck Flame Test 24-1-2007.trd

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TEST RECORD SHEET

Client	Test Number
Bushfire CRC	**No 13**

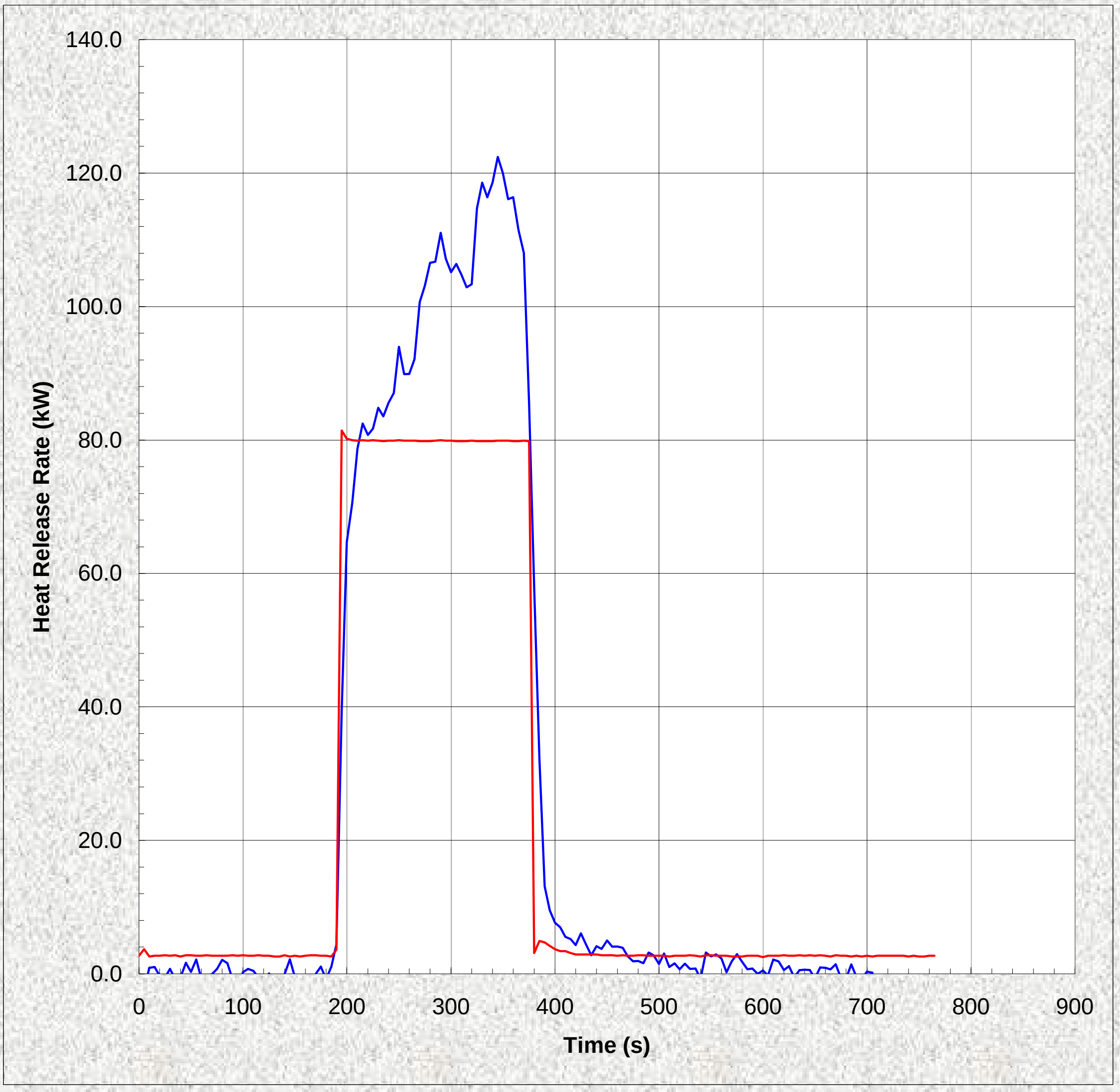
Title	Date
Under Deck Flame Test - 12-7A-5	12/May/06

Test Code	Burner Output (kW)	Sampling Interval (s)	Baseline Interval (s)	Ignition Time (s)	A M Fraction H20
J1368	**80kW**	5	100	0	0.014

Exist. Calib. Factor	Av Flow Rate (m3/s)				Peak Heat Release (kW)
1	1.26				**122**

Material	Comment
Spotted Gum	

Heat Release Rate - Time



Under Deck Flame Test 24-1-2007.trd

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