bushfire CRC

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Measuring Ember Attack on Timber Deck-Joist Connections using the Mass Loss Cone Calorimeter and Methenamine as the Ignition Source

Report to
Bushfire CRC

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Executive Summary

As part of work investigating the bushfire performance of typical Australian timber decking a study of the ember attack on small scale timber deck-joist connections was undertaken. The tests were performed in the mass loss cone calorimeter using methenamine as the ignition source. The ignition source was placed on the joist in the gap between the deck boards. The majority of the work looked at the effect of moisture content, timber species, deck board thickness and ignition size on the ignition and burning of the deck-joist connection under ambient conditions (approximately 20°C and 50% RH). A smaller study was performed to investigated the influence of radiant heat on a set deck-joist connection configuration.

The results of the tests have been summarised in Figure A and Figure B.

The main points from Figure A are:

- The order of the species starting from easiest to ignite and burn were:

  Mountain Ash, Radiata Pine, Cypress Pine, Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau, Merbau, Redgum
- The thicker the deck board the easier it was to ignite. i.e. The deeper the gap between the deck boards, the more heat is generated as the edge surfaces of the deck boards are ignited.
- At 12-14% (room condition) moisture content and with a 20mm thick deck no continuous fire could be achieved. At the same moisture content but with a thicker deck both Mountain Ash and Radiata Pine achieved a continuous fire.
- At 4-7% (bushfire condition) moisture content only Mountain Ash, Radiata Pine and Cypress Pine resulted in a continuous fire in the majority of cases. Jarrah and Spotted

Gum did achieve a continuous fire but required a combination of thick deck and larger ignition source.

- At 0% (oven dry) moisture content and 20mm thick deck only Mountain Ash and Radiata Pine resulted in a continuous fire.
- At 0% (oven dry) moisture content and 50mm thick deck and larger (24 kJ) ignition source all species resulted in a continuous fire.

The main points from Figure B are:

- The order of the species starting from easiest to ignite and burn were the same as show in Figure A, ie:

  Mountain Ash, Radiata Pine, Cypress Pine, Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau, Merbau
- For the parameter set used:
  - (4-7% (bushfire condition) moisture content,
  - 20mm thick deck,
  - maximum of 3 x 0.15g methenamine ignition source)

  the best performing timbers (Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau and Merbau) required a 10-12 kW/m² radiant heat to sustain a continuous fire.

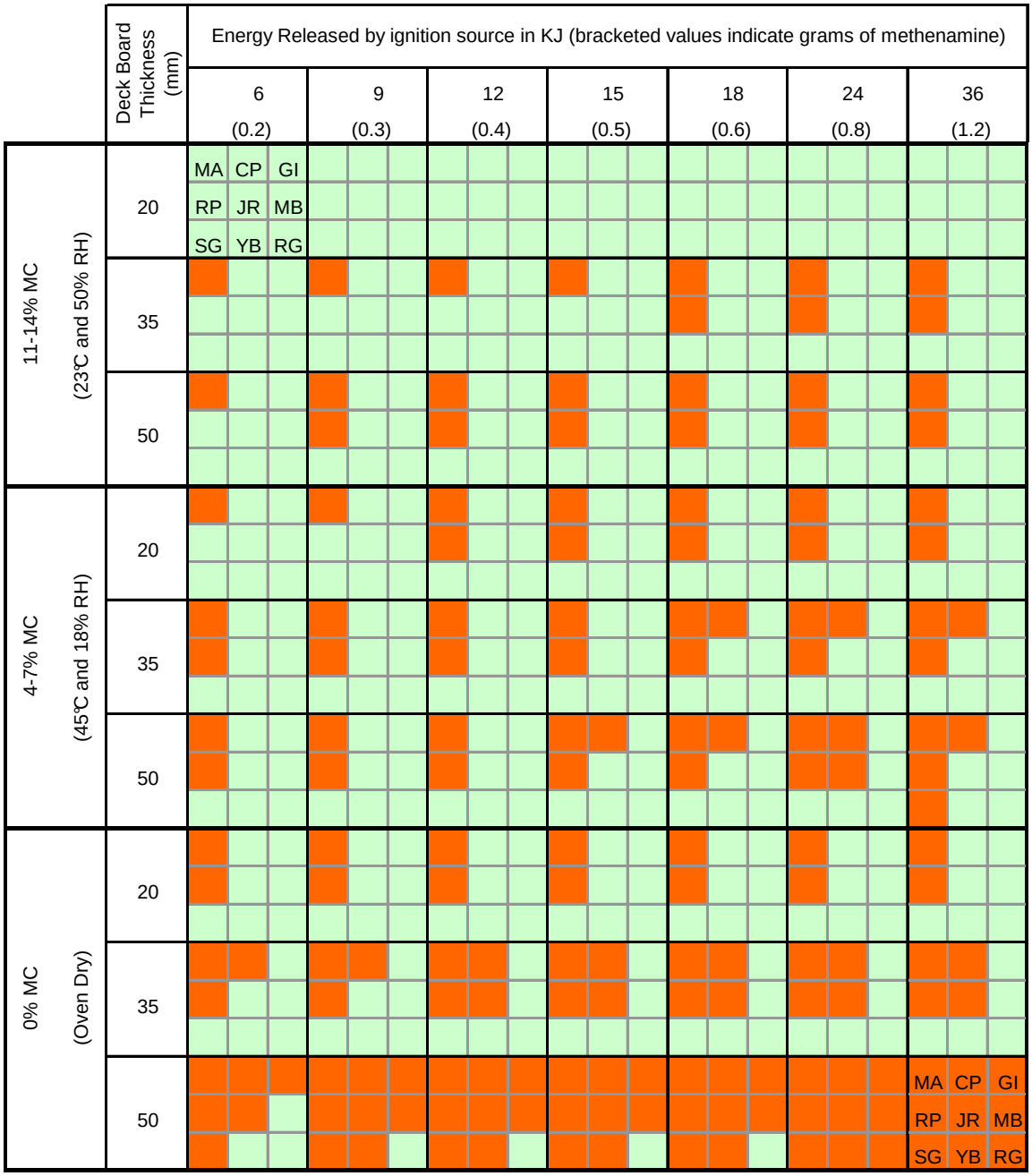

Figure A Results of ignition tests on small scale deck-joist connections

Mountain Ash 0	Cypress Pine 6	Grey Ironbark 12*
Radiata pine 0**	Jarrah 10	Merbau 12*
Spotted Gum 10*	Yellow Balau 10*	

* second ignition source used
** third ignition source used

Notes: The joist material used was Radiata Pine
Ignition source 0.15g methenamine tablet
Joist depth = 20mm
Gap in deck = 10mm
Moisture Content 4-7%

Figure B Heat Flux (kW/m²) required to cause a continuous fire in small deck-joist connections in the mass loss cone calorimeter

Contents

1. Introduction

As part of work investigating the bushfire performance of typical Australian timber decking a study of the ember attack on small scale timber deck-joist connections was undertaken. The aim was to determine the influence of the moisture content, timber species, deck board thickness, ignition size and radiant heat had in producing a continuous fire. To achieve this a program of tests were performed in the mass loss cone calorimeter using methenamine as the ignition source (see *Figure 1-1*).

This had a number of advantages:

- the ignition was repeatable and scalable
- the environment could be easily controlled eg. radiant heat, air flow, etc
- data could be easily collected eg. mass loss, heat release, etc

However there were also some disadvantages:

- airflow could not be changed. The air flows vertically up through the cone and flue so a horizontal airflow could not be investigated.
- the air temperature and relative humidity could not be varied.
- only small scale (approximately 110mm x 100mm) connections could be tested
- the methenamine burnt with a vertical flame with little heat radiating from its base. Embers are likely to have a more uniform radiation profile.

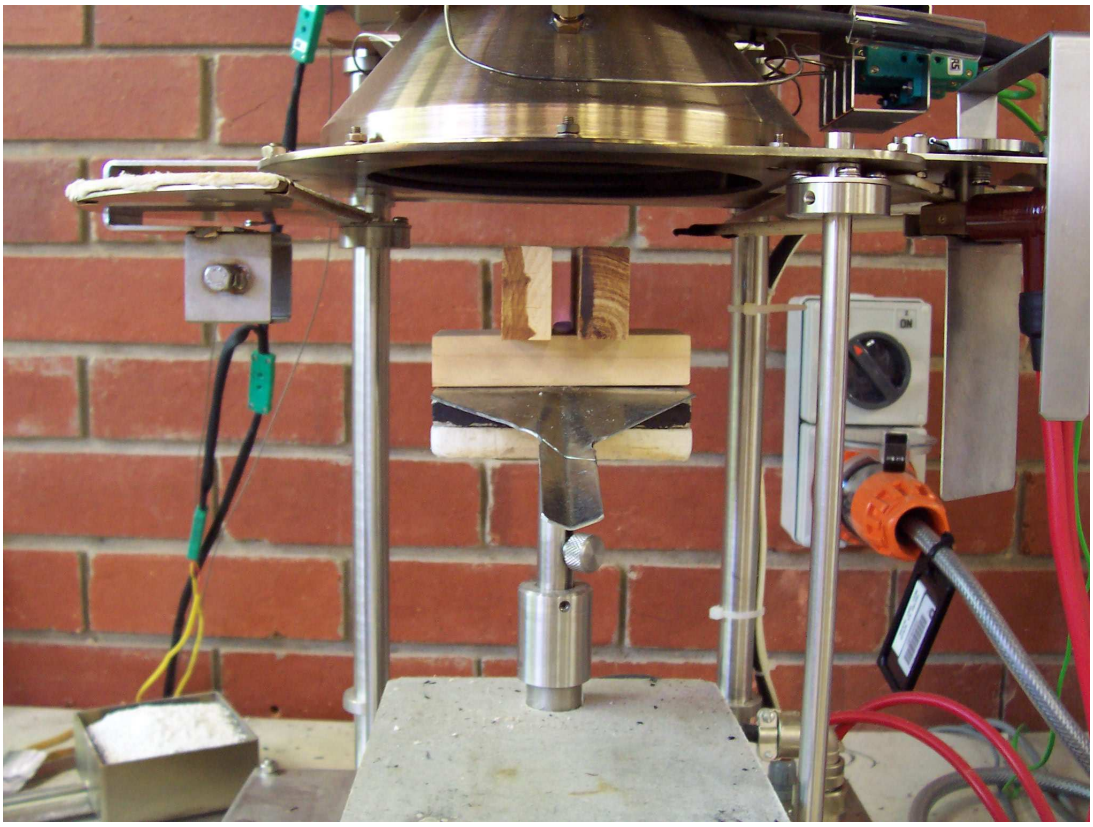

Figure 1-1 Cone calorimeter test setup

2. Material

2.1 Timbers

The timbers tested reflects the variety of timbers used for decking in Australia. The common timbers used for decking include Spotted gum, Blackbutt, Merbau, Cypress Pine, Jarrah and Treated Radiata Pine. These timbers are easy to source and are likely to be used in the future. Currently Spotted Gum, Blackbutt, Cypress Pine and Radiata Pine form the bulk of solid timber production in Australia. This is likely to continue with the current preference for Spotted gum, Blackbutt and Radiata Pine plantation development [1].

Nine timber species were selected for testing covering the range of timbers used for decking in Australia. These are listed below. Untreated radiata pine was used instead of CCA treated Radiata Pine for health and safety reasons. For Cypress Pine which has large proportions of both sapwood and heartwood initial ignition tests indicated the selection of sapwood or heartwood didn't appear critical and the material as assumed to be uniform.

Timber species tested:

Mountain ash *

Radiata Pine

Cypress Pine (White)

Jarrah *

Spotted Gum *

Grey Ironbark *

Yellow Balau

Merbau

Redgum

Some timber samples were sent to Ensis laboratories for species identification (marked above with a *). The identification of other species such as Radiata Pine, Cypress Pine, Merbau and Redgum could reasonably be assumed by appearance and industry labelling.

2.2 Methenamine

The methenamine used was obtained from two sources:

- 0.15g (6mm diameter) tablets used for textile tests manufactured by James H Heal & Co. England (see *Figure 2-1*)
- 14g fuel tablets used in bush stoves manufactured by GUMMI-NOLLER GMBH Germany under the Esbit brand (see *Figure 2-1*).

The 0.15g tablets were used for the smallest ignition source while the 14g tablets were broken up into smaller pieces (0.3g – 0.5g) and used for the larger ignition sources. The mass of the ignition source was measured using a jewellers scale. The cost of the 0.15g tablets made it expensive to use them for the large ignition sources.

Figure 2-1 Methenamine Tablets

2.4 Conditioning

All specimens were conditioned to equilibrium moisture content (EMC).

Three types of conditioning were used.

- Standard conditions of 23° C and 50% RH (resulting in a EMC of ~ 11-14 %)
- Bushfire conditions of 45° C and 18% RH (resulting in a EMC of ~ 4-7 %)
- Oven dried conditions (resulting in a EMC of ~0 %)

Samples of each species were oven dried to determine the typical EMC for each species (see Appendix A).

3. Testing

3.1 General

The testing was performed using a mass loss cone calorimeter.

This had the advantage over testing under a open hood of:

- allowing the measurement of heat release and mass loss.
- providing a environment which was consistent for all the tests
- allowed a radiant heat to be applied to the specimen if required

The specimens consisted of three pieces of 100mm x 50mm x 20mm timber arranged to represent the connection between the deck and joist in a timber deck. Three different deck thicknesses can be tested by changing the arrangement or adding a 50mm x 15mm x 10mm spacer as shown in *Figure 3-1* , *Figure 3-2* and *Figure 3-3*. Radiata pine was used for the joist and spacer. The size of specimen in plan was 100mm by 110mm which is slightly wider than the standard 100mm x 100mm sample normally used for the cone calorimeter. A 10mm gap between the deck boards was used for the following reasons.

- while a number of deck design guides [2,3] recommend a smaller gap of around 5mm, some guides [4,5] also recommend using a 10-12mm gap where pedestrians are unlikely to wear high heels and a degree of self clean of litter is required to prevent decay.
- a larger gap may be a worse case scenario as it would allow a bigger build up of debris and larger embers to take hold.
- a 5mm gap restricts the air flow around the methenamine ignition source making it more difficult to keep alight.

Figure 3-1 Test Specimen for 20mm thick deck

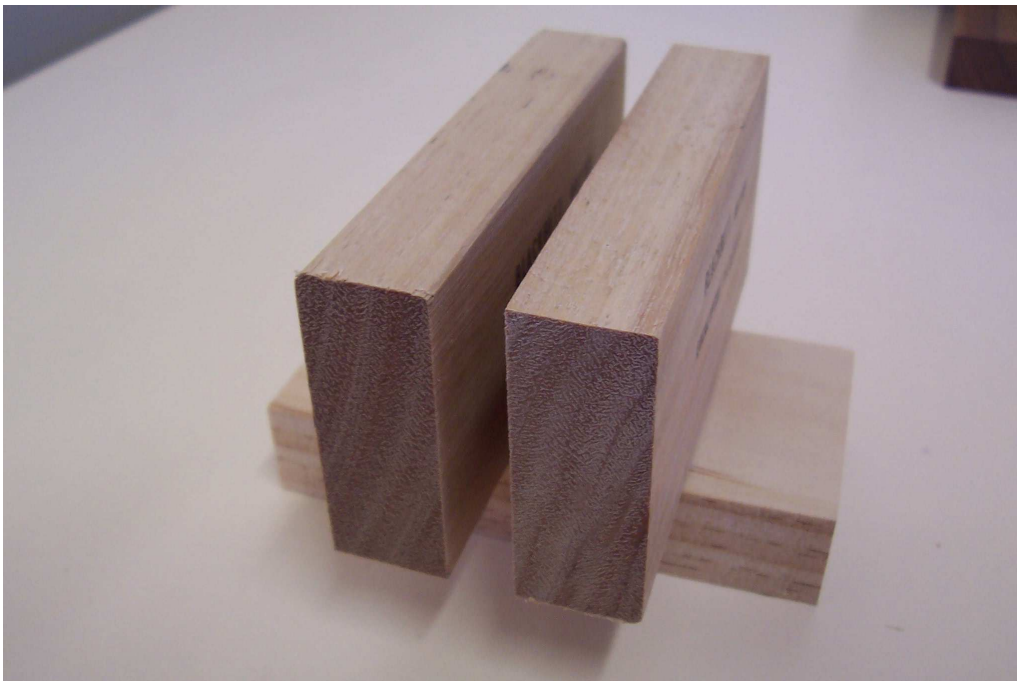

Figure 3-2 Test Specimen for 50mm thick deck

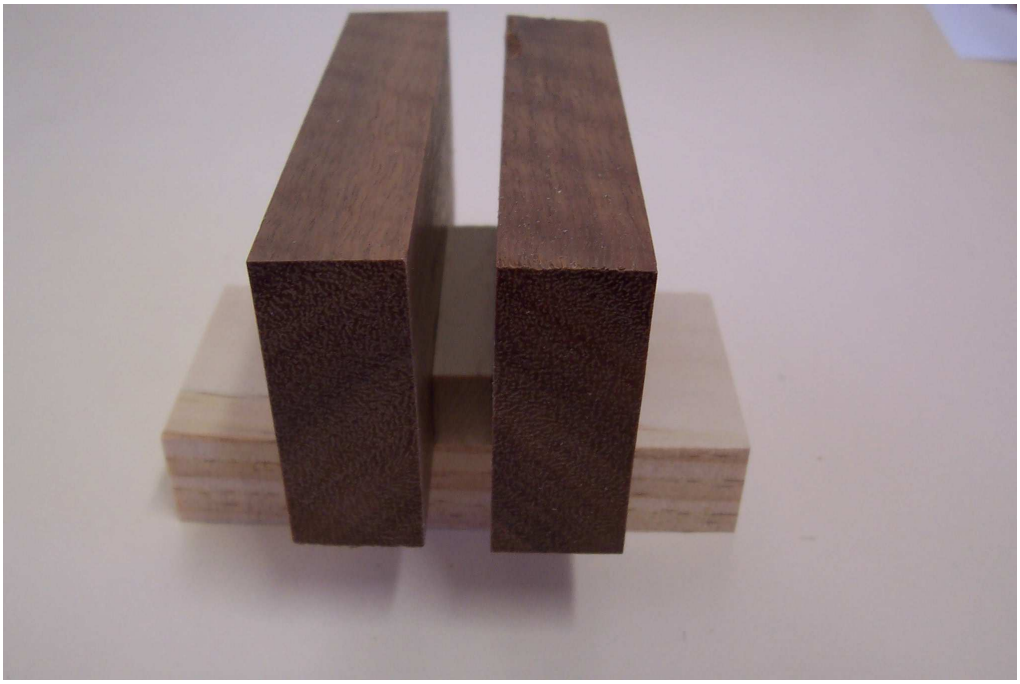

Figure 3-3 Test Specimen for 35mm thick deck using a 15mm deep spacer

3.2 Test Method

- Prior to testing the specimens are conditioned at the required temperature and humidity until EMC is obtained.
- Cone calorimeter radiation is set to the required heat flux and the data acquisition is started.
- The specimen is placed on a flat steel tray and the weighted amount of methenamine is placed in the middle of the gap between the deck and ignited using a match.
- The specimen is then placed in the cone calorimeter so that the top of the deck boards are 25mm below the base of the cone (*Figure 3-4*).
- Observation and data recording is continued until the flame goes out or the fire becomes continuous (i.e. so large it will engulf the whole specimen, see *Figure 3-5*).
- The specimen is removed and the fire extinguished.
- For some tests the burnt ignition source was replaced and the test continued to extend the time of the ignition without increasing the ignition source size.

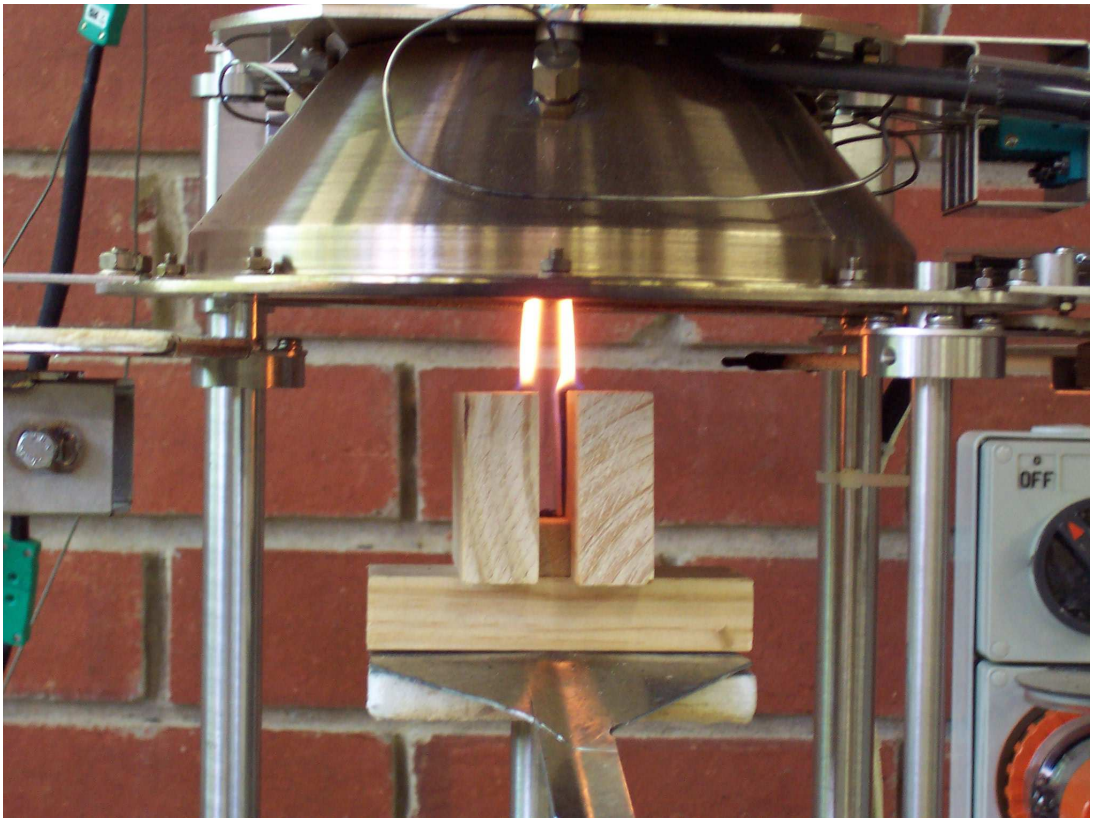

Figure 3-4 Test specimen positioned 25mm under cone element

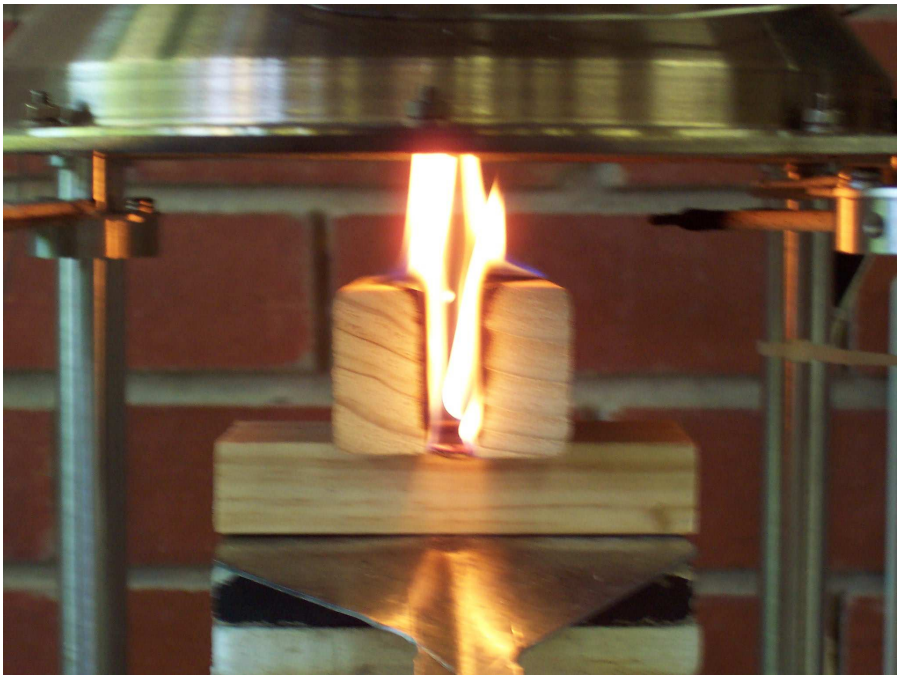

Figure 3-5 Fire continuous

3.2 Test Program

Two sets of tests were carried out. For the first series of tests the cone element was turned off. That is no external radiation was applied to the specimens. For the second series of tests the cone element was used allowing different levels of radiation to be applied to the specimens.

The aim of the first series of tests was to determine the relative effect of various parameters on the ignition and fire spread at the deck/joist connection. The parameters varied were:

- Timber species
- The conditioning environment/moisture content of the specimens
- Thickness of the deck board
- Size of methenamine ignition source

The aim of the second series of tests was to determine for a typical configuration what level of external radiation was required to result in a continuous fire. The configuration used for this was:

- 20mm deck thickness
- specimens conditioned at 45° C and 18% RH (resulting in a EMC of ~ 4-7 %)
- 0.15g methenamine ignition source

This configuration was chosen for the following reasons:

- 20mm deck thickness is typically used around domestic housing.
- 45° C and 18% RH represent typical bushfire conditions
- the 0.15g methenamine ignition source was convenient to use because of its size and tablet form. After the initial tablet had burnt out it was replaced once or twice if required to extend the ignition source burn time. This was useful to ensure the specimen had adequate time (up to 9 minutes) to heat up and ignite while keeping the ignition source at a roughly constant level. Each 0.15g tablet took approximately 3 minutes to burn out.

4. Results

4.1 Comparison of parameters

The results from the first series of tests investigating the relative effect of various parameters on the ignition and fire spread at the deck/joist connection have been summarised

in *Figure 4-1*.

The main points from *Figure 4-1* are:

- The order of the species starting from easiest to ignite and burn were:

  Mountain Ash, Radiata Pine, Cypress Pine, Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau, Merbau , Redgum
- The thicker the deck board the easier it was to ignite. . i.e. The deeper the gap between the deck boards, the more heat is generated as the edge surfaces of the deck boards are ignited.
- At 12-14% (room condition) moisture content and with a 20mm thick deck no continuous fire could be achieved. At the same moisture content but with a thicker deck both Mountain Ash and Radiata Pine achieved a continuous fire.
- At 4-7% (bushfire condition) moisture content only Mountain Ash, Radiata Pine, Cypress Pine resulted in a continuous fire in the majority of cases. Jarrah and Spotted Gum did achieved a continuous fire but required a combination of thick deck and larger ignition source.
- At 0% (oven dry) moisture content and 20mm thick deck only Mountain Ash and Radiata Pine resulted in a continuous fire.
- At 0% (oven dry) moisture content and 50mm thick deck and larger (24 kJ) ignition source all species resulted in a continuous fire.

4.2 Effect of external radiation

The results from the second series of tests investigating what level of external radiation is required to result in a continuous fire has been summarised in *Figure 4-2*.

The main points from *Figure 4-2* are:

- The order of the species starting from easiest to ignite and burn were the same as shown in *Figure 4-1*, ie:

  Mountain Ash, Radiata Pine, Cypress Pine, Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau, Merbau

- For the parameter set used (4-7% (bushfire condition) moisture content, 20mm thick deck, maximum of 3 x 0.15g methenamine ignition source) the best performing timbers (Jarrah, Spotted Gum, Grey Ironbark, Yellow Balau and Merbau) required a 10-12 kW/m² radiant heat to sustain a continuous fire.

4.3 Other observations

- The combination of the vertical air flow up through the cone and way the methenamine burns with a vertical flame meant in the initial stages only the deck timber ignites and burns leaving the joist largely untouched. This is shown in

  Figure 4-3 and *Figure 4-4*.

- Due to the small size of the fire the mass loss readings provided a better indication of how the fire was progressing than the heat release values.

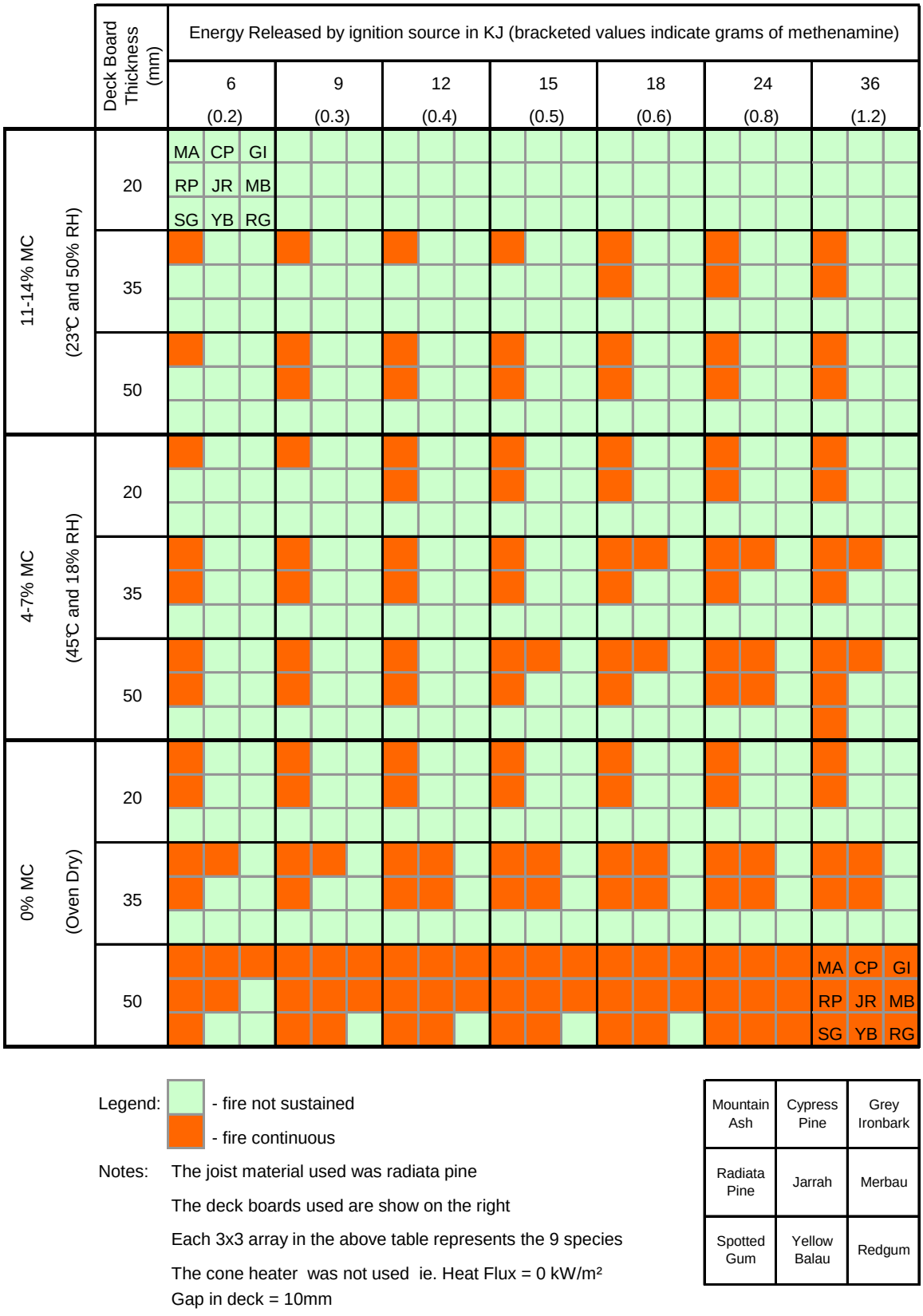

Figure 4-1 Results of ignition tests on small scale deck-joist connections

Mountain Ash 0	Cypress Pine 6	Grey Ironbark 12*
Radiata pine 0**	Jarrah 10	Merbau 12*
Spotted Gum 10*	Yellow Balau 10*	

* second ignition source used
** third ignition source used

Notes: The joist material used was Radiata Pine
Ignition source 0.15g methenamine tablet
Joist depth = 20mm
Gap in deck = 10mm
Moisture Content 4-7%

Figure 4-2 Heat Flux (kW/m^2) required to cause a continuous fire in small deck-joist connections

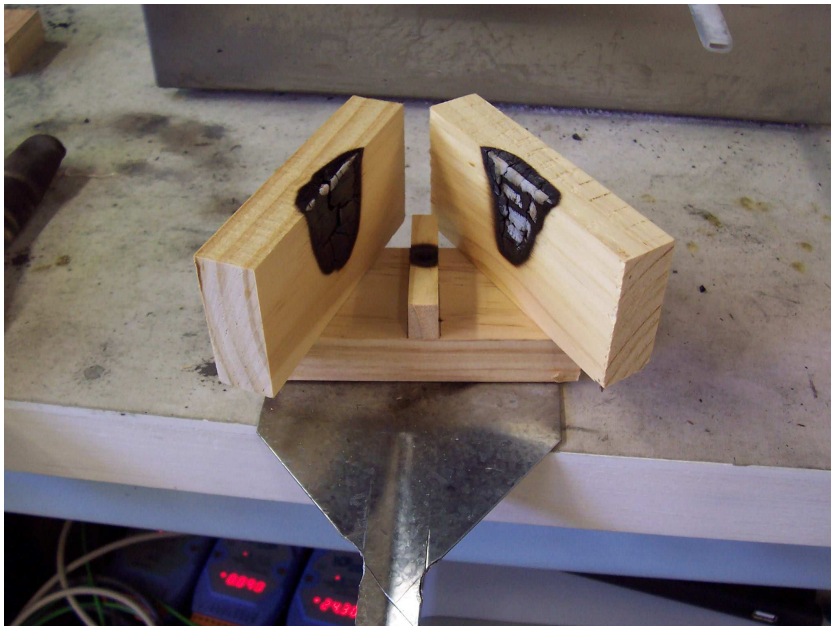

Figure 4-3 In the initial stages only the deck boards ignite and burn

Figure 4-4 Flame from methenamine ignition source

5. Conclusions

Based on the tests conducted, for ember attack alone to cause a timber deck to catch alight and burn requires some or all of the following:

- Easy to ignite timber species such as Mountain Ash or Radiata Pine
- Low moisture content
- A radiation level of the order of 10-12 kW/m²
- Large deck board thickness and large ignition source

Other parameters not covered were:

- Air temperature, humidity direction and speed
- Behaviour of real embers, i.e. radiation/time characteristics
- Other timber connection in or adjacent to timber decks, e.g. corners

Finally it is probable that the presence of secondary ignition points (e.g. debris) will provide a sufficient time-heat/radiation profile to cause any of the timber decks tested to burn even if they didn't ignite from ember attack alone.

6. References

1. Queensland Department of Primary Industries and Fisheries – Tree Species for Hardwood Plantations, http://www.dpi.qld.gov.au/hardwoodsqld/1816.html

2. National Association of Forest Industries (2004) – Timber Decks, Commercial Industrial Marine. Timber Datafile SS4

3. Timber Development Association – Domestic decks, Application Guide

4. Gatton Sawmilling Company (1998) - Boardwalk Design Guide

5. Outdoor Structures Australia Deckwood Selection Guide. *www.outdoorstructures.com.au*.

APPENDIX A – Material Properties

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

Species	Density (kg/m^3)	MC (%)
Cypress Pine	650	11
Grey Ironbark	1200	14
Jarrah	950	11
Merbau	950	12-14*
Mountain Ash	600	11
Radiata Pine	550	13
Redgum	1000	14
Spotted Gum	1050	12-14*

* material from a number of sources.

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

Species	MC (%)
Cypress Pine	5.0
Grey Ironbark	7.0
Jarrah	5.0
Merbau	5.5
Mountain Ash	4.5
Radiata Pine	4.5
Redgum	6.0
Spotted Gum	6.0