Forest&Wood Products Australia
Knowledge for a sustainable Australia

MARKET ACCESS & DEVELOPMENT

PROJECT NUMBER: PNA014-0708

APRIL 2009

Assessing the ability of a large-scale fire test to predict the performance of wood poles exposed to severe bushfires and the ability of fire retardant treatments to reduce the loss of wood poles exposed to severe bushfires

This report can also be viewed on the FWPA website

www.fwpa.com.au

FWPA Level 4, 10-16 Queen Street,
Melbourne VIC 3000, Australia
T +61 (0)3 9614 7544 F +61 (0)3 9614 6822
E info@fwpa.com.au W www.fwpa.com.au

Assessing the ability of a large-scale fire test to predict the performance of wood poles exposed to severe bushfires and the ability of fire retardant treatments to reduce the loss of wood poles exposed to severe bushfires

Prepared for

Forest & Wood Products Australia

by

W. D. Gardner and J. A. White Jr

Publication: Assessing the ability of a large-scale fire test to predict the performance of wood poles exposed to severe bushfires and the ability of fire retardant treatments to reduce the loss of wood poles exposed to severe bushfires

Project No: PNA014-0708

This work is supported by funding provided to FWPA by the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF).

ISBN: 978-1-920883-52-2

Researcher:
D. Gardner
Consultant wood technologist
33 Galahad Cres, Castle Hill, NSW 2154

J. A. White Jr
Fire Science Consultant, Western Fire Centre Inc
c/- Western Fire Center, Inc., 2204 Parrott Way, Kelso, Washington 98626

Final report received by FWPA in January, 2009

Forest & Wood Products Australia Limited
Level 4, 10-16 Queen St, Melbourne, Victoria, 3000
T +61 3 9614 7544 F +61 3 9614 6822
E info@fwpa.com.au
W www.fwpa.com.au

Executive summary

Observation shows that when wood poles are exposed to severe bushfires, copper-chrome-arsenate (CCA)-treated hardwood poles are more likely to be seriously damaged than creosote-treated hardwood poles. One way to reduce damage in bushfire-exposed CCA-treated poles is to apply a fire retardant treatment. However, the lack of an acceptable large-scale test method to assess the efficacy of available fire retardant treatments is an impediment to their use by some members of the Australian electricity supply industry.

Research was conducted to develop a large-scale test method that could be used to assess the efficacy of fire retardant treatments applied to CCA-treated poles. The method could also be used to assess the performance of poles of alternative materials and poles treated with alternative preservatives. The aim was to develop a test method that would successfully predict the 'real-life' outcome when wood poles are exposed to severe bushfires, that is, that CCA-treated hardwood poles are seriously damaged and creosote-treated hardwood poles survive with minimal damage. If a test could be developed, the efficacy of a range of commercially available fire retardant treatments would be assessed.

A large-scale test was developed – the ENA pole fire test method. Specimens tested to this method are exposed to a 60 kW/m^2 heat flux for the full ten minutes of the test and flame contact from a 40 kW ring burner for the last five minutes of the test. After the fire test exposure, specimens are subjected to a 2 m/s wind for up to three and three quarter hours. CCA-treated hardwood specimens tested to this method were seriously damaged and creosote-treated hardwood specimens survived with minimal damage. The 2 m/s wind exposure was needed to reliably result in severe damage to CCA-treated hardwood specimens. This research also demonstrated the greater susceptibility to fire damage of CCA-treated radiata pine poles, as CCA-treated radiata pine specimens were seriously damaged without being subjected to the 2 m/s wind after exposure to a 30 kW/m^2 heat flux.

Standards Australia published two large-scale fire test methods just prior to the testing being conducted. The project aims were expanded to include assessing the suitability of one test – Australian Standard (AS) 1530.8.1 *Methods for fire tests on building elements, components and structures – Tests on elements of construction for buildings exposed to simulated bushfire attack – Radiant heat and small flaming sources*, as a test for assessing the fire performance of poles exposed to bushfires.

As published, AS 1530.8.1 was not a suitable method for assessing the performance of wood poles exposed to bushfires. However, when the post-test observation period was extended and different performance criteria used, the test was found to be a suitable test for assessing the performance of wood poles exposed to bushfires.

Two large-scale test methods are recommended – a) the ENA pole fire test method for poles exposed to severe bushfires where poles are likely to be exposed to high heat fluxes and flame contact from the fire front and adjacent burning vegetation and b) a modified version of AS 1530.8.1 for poles that will be exposed to bushfires where they are unlikely to be exposed to flame contact from the fire front and will be exposed to lower heat fluxes and/or flame contact from adjacent burning vegetation.

Four commercially available fire retardant treatments were assessed. Three were applied as coatings to CCA-treated spotted gum specimens and one was impregnated by vacuum/pressure treatment into CCA-treated spotted gum specimens. One of the fire retardant coatings and the impregnated fire retardant were also applied to CCA-treated radiata pine specimens. Before testing, all fire retardant-treated specimens were subjected to the 12 weeks accelerated weathering regime of ASTM D2898 *Standard practice for accelerated weathering of fire retardant treated wood for fire testing. Method A*, with UV exposure added in the drying cycles. The fire retardant-treated specimens were tested to both the ENA pole fire test and AS 1530.8.1 methods. Three efficacy ratings were developed for the fire retardant-treated specimens - excellent, fair and poor. The efficacy of the fire retardant treatments ranged from poor to excellent. In one instance, the efficacy rating was different when the fire retardant was applied to CCA-treated hardwood and CCA-treated softwood specimens. Testing to the two methods also produced some differences in efficacy ratings for some of the fire retardant treatments.

Contents

List of figures

List of tables

1 Introduction

There are approximately five million wood power poles in Australia (Energy Networks Association, 2006). The loss of wood poles in severe bushfires has become a matter of increasing concern to the Electricity Supply Industry (ESI) in Australia. Among reported losses, one hundred poles were destroyed in the January 1, 1998 fires in Hobart, Tasmania and 900 to 1,000 in the January 18, 2003 fires in Canberra, Austalian Capital Territory (Emergency Management Australia, 2006). Up to 150 poles can be destroyed in a severe bushfire event in Western Australia (A. Seneviratne, pers. com.).

Most of the poles in service were processed from a range of hardwood species. Some were installed without preservative treatment and some were full length preservative-treated with either creosote or copper-chrome-arsenate (CCA) before installation.

Poles exposed to severe bushfires are likely to be exposed to high heat fluxes and flame contact from the fire front and adjacent burning vegetation. Experience within the ESI is that CCA-treated poles are more likely to be severely damaged or destroyed in a severe bushfire than creosote-treated poles. Creosote-treated hardwood poles have been reported to survive exposure to bushfires when untreated hardwood poles exposed to the same fire have been destroyed (Keating, 1962) and creosote-treated posts performed better than CCA-treated posts when exposed to bushfires (Dale, 1966).

Some members of the ESI have implemented strategies to reduce pole losses in severe bushfires. These include the use of steel poles in some bushfire-prone areas (WesternPower, 2005) and the treatment of poles with a fire retardant coating before they are installed (WesternPower, 2007).

The ESI considered it would be an advantage to have a large-scale fire test method that could be used to test the fire performance of poles and the efficacy of fire retardant treatments that may reduce pole damage when they are exposed to severe bushfires. Such a method could be used to evaluate:

- The effect of species (hardwood vs. softwood) on the damage to poles exposed to bushfires.
- The efficacy of fire retardant treatments.
- The performance of poles treated with alternative preservatives when exposed to severe bushfires.
- The performance of poles manufactured from alternative materials.

At the time the project was being developed, there was no large-scale Australian Standard bushfire exposure test method available. A report on the outcomes of a large-scale test of steel poles was published (BlueScope Steel, 2006). This testing was conducted in the open at a site on the New South Wales south coast and it was considered that reliance on favourable weather conditions would limit the usefulness of this facility for the testing needs outlined above. It was considered that a test that could be conducted within a fire test facility would also provide more repeatable fire exposure conditions and could be conducted at any fire test facility with the appropriate equipment.

As there was no test immediately available, the principal aim of the project was to develop a test method that would successfully reproduce the 'real-life' outcome when preservative treated hardwood poles are exposed to a severe bushfire, that is, that CCA-treated hardwood poles would be severely damaged and creosote-treated hardwood poles would survive the test with minimal damage. A large-scale test that was being developed in USA for assessing the performance of building elements exposed to wildfires was selected as the basis for the test method.

If an appropriate test could be developed that discriminated between the fire performance of CCA-treated hardwood poles and creosote-treated hardwood poles, reproducing the experience in the field, the efficacy of a range of commercially available fire retardant treatments applied to CCA-treated hardwood pole specimens would be assessed by that method. The efficacy of some fire retardant formulations applied to CCA-treated softwood pole specimens would also be assessed. All fire retardant-treated pole specimens would be subjected to a standard accelerated weathering regime before fire testing. This was considered necessary to assess the permanence and long-term efficacy of the fire retardant treatments as they would be exposed to natural weathering in service.

This project was conducted on a collaborative basis with funding and/or in-kind contributions from:

- Arch Wood Protection
- Chemco Inc.
- Energy Networks Association
- Forest and Wood Products Australia
- International Paint
- Koppers Wood Products
- Osmose
- Preschem Pty Ltd
- Forest Products Commission, Western Australian

2 Project aims

The project aims were:

- To develop a large-scale test method that would predict the real-life outcome for CCA-treated hardwood poles and creosote-treated hardwood poles exposed to severe bushfires.
- To assess the test fire performance of CCA-treated radiata pine pole specimens.
- To assess the efficacy of three fire retardant formulations applied as coatings and one fire retardant formulation applied by vacuum/pressure treatment to CCA-treated hardwood pole specimens.
- To assess the efficacy of one fire retardant formulation applied as a coating and one fire retardant formulation applied by vacuum/pressure treatment to CCA-treated softwood pole specimens.
- As two Standards Australia tests for bushfire exposure were published about the time the project testing began, the project aims were expanded to include testing all specimen types to one of these methods.

3 Materials

3.1 Pole test specimens

Both preservative-treated hardwood and preservative-treated softwood pole specimens were tested. The hardwood specimens were treated with CCA or creosote and the softwood specimens were treated with CCA. Where possible, poles that had been in service for many years were selected to ensure that they were fully seasoned and thus the moisture content of the test specimens would be typical of the moisture content of the aerial part of poles in service.

3.1.1 CCA-treated hardwood pole specimens

The CCA-treated hardwood test specimens were obtained from the aerial part of CCA-treated spotted gum *(Corimbya maculata)* poles that had been removed from service for a range of reasons, including biodeterioration, changed operational needs – e.g. longer pole needed, road widening, etc. The poles had been CCA treated between 1978 and 1989. The poles were obtained from the Integral Energy, Jamisontown depot and the Country Energy, Port Macquarie depot. The specimens were 2700 mm long, and between two and four specimens were obtained from each pole. The specimens were docked to 2150 mm prior to testing.

3.1.2 Creosote-treated hardwood pole specimens

The creosote-treated hardwood test specimens were also obtained from the aerial part of poles that had been removed from service for the same reasons as the CCA-treated spotted gum poles. The poles had been creosote treated between 1973 and 1984. The poles were sampled at the same depots as the CCA-treated spotted gum poles. The creosote-treated poles were mainly spotted gum. Creosote-treated blackbutt *(Eucalyptus pilularis)* poles were also sampled. The specimens were also 2700 mm long and three or four specimens were obtained from each pole. The specimens were docked to 2150 mm prior to testing.

3.1.3 CCA-treated softwood pole specimens

As there are very few CCA-treated softwood power poles in service, it was not possible to obtain specimens from poles that had been removed from service. The softwood test specimens were obtained from CCA-treated radiata pine *(Pinus radiata)* poles that had been CCA treated approximately two years before their sampling and had not been put into service. The poles were part of a WesternPower stock of CCA-treated softwood poles. The specimens were docked to 2150 mm prior to testing.

3.2 Fire retardant formulations

There were four fire retardant formulations tested. They were:

- Chartek 7 – an epoxy intumescent fire protective coating manufactured by International Paint. Chartek 7 is used to provide fire resistance to structural steel members.
- FireGuard – a water-based intumescent fire protective coating manufactured by Osmose. FireGuard is applied to wood poles.
- FireTard 120 – a water-based fire retardant coating manufactured by Fire Retardant Technologies. FireTard 120 is applied to timber building elements in bushfire-prone areas.

- FRX - a water-based fire retardant formulation manufactured by Chemco that is applied by vacuum/pressure impregnation. FRX is used to treat timber roofing shakes for use in bushfire-prone areas.

4 Methods

4.1 Moisture content

The moisture content of all CCA-treated specimens was determined before fire testing. A 30 mm long, 15 mm diameter core sample was taken from each specimen. The samples were oven-dried at 100 ^{o}C to constant weight.

The moisture content was calculated as:

$$\text{Moisture content (\%)} = 100\text{x}\frac{(\text{wet weight} - \text{dry weight})}{(\text{dry weight})}$$

The moisture content of the creosote-treated pole specimens was not determined as it needed to be determined by a solvent extraction procedure that was not available in the fire test laboratory region.

4.2 Chemical analysis

One specimen from each of the CCA-treated poles sampled was analysed for copper, chromium and arsenic content. The full sapwood depth was sampled for analysis.

4.3 Fire retardant application

With the exception of the FireTard 120 formulation, all treatments were applied by representatives of the formulation manufacturers. The application rates were selected by the fire retardant treatment manufacturers.

4.3.1 Chartek 7

Chartek 7 was applied to four CCA-treated spotted gum specimens. The target coating thickness was 4 mm. The treatment was applied at the Western Fire Center Inc. laboratory, Kelso, Washington, USA.

4.3.2 FireGuard

FireGuard was applied to four CCA-treated spotted gum specimens and four CCA-treated radiata pine specimens. The formulation was applied to a target thickness of 3.2 mm (1/8 inch) on the lower 600 mm of the specimens and 1.6 mm (1/16 inch) on the rest of the specimens. The formulation was applied at the Western Fire Center laboratory.

4.3.3 FireTard 120

FireTard 120 was applied to four CCA-treated spotted gum specimens at the Western Fire Center laboratory, by Western Fire Center staff. Application was in accordance with instructions provided by the company marketing the product.

4.3.4 FRX

Four CCA-treated spotted gum and four CCA-treated radiata pine specimens were treated with FRX at Chemco's Ferndale, Washington, USA facility. The specimens were treated with FRX by a vacuum/pressure schedule and then subjected to a prescribed heating schedule. FRX retentions were calculated from weighed uptakes during treatment and the specimen diameters and sapwood thickness, and the assumption that only the sapwood of the specimens was penetrated by the FRX. The CCA-treated spotted gum specimens were treated to a mean retention of 60.9 kg/m^3 (3.8 lb/ft^3) and the CCA-treated radiata pine specimens were treated to a mean retention of 75.2 kg/m^3 (4.7 lb/ft^3), both calculated as being present in the sapwood.

4.4 Accelerated weathering

The fire retardant-treated specimens were subjected to the 12 weeks accelerated weathering regime of ASTM D2898 *Standard practice for accelerated weathering of fire retardant treated wood for fire testing. Method A.* Method A was modified to permit ultraviolet (UV) exposure. In this weathering procedure, specimens are exposed to a total of 12 weeks of accelerated weathering conditions. Each of the 12 weeks consists of four days of rain exposure and three days of heating/UV exposure. During the four-day rain exposure, the total water usage is 1711 ± 41 l/m^2 which is a heavy mist of water spray. During the three-day heating/UV cycle of each week, the accelerated weathering room temperature is maintained at 60°C and the UV is adjusted to provide a specimen irradiance of approximately 5 W/m^2. All specimens were reconditioned to a moisture content of less than 15% before fire testing. For some specimens this required an additional drying regime at 60 ^oC in the weathering facility.

4.5 Fire tests

There were two fire tests used.

The first method was based on a test procedure *Determination of fire test response characteristics of exterior wall systems* being considered for standardisation by ASTM in 2006. A modified version of the ASTM E1623 *Standard test method for determination of fire and thermal parameters of materials, products and systems using an Intermediate Scale Calorimeter (ICAL)*, shown in Figure 1, was used. The modifications involved a) replacing the sample holder illustrated in Figure 1 with a bracket to hold the pole, and b) inclusion of a ring burner at the base of the pole specimen that was ignited at five minutes into the test. This test shall be reported as the ENA pole fire test.

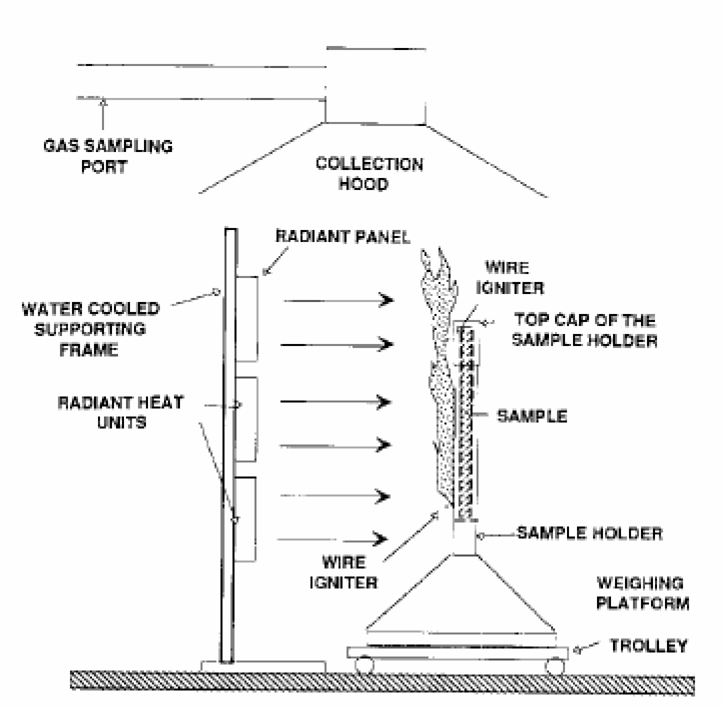

Figure 1 Illustration of ASTM E163 test apparatus

The second test was AS 1530.8.1 - 2007 *Methods for fire tests on building elements, components and structures – Tests on elements of construction for buildings exposed to simulated bushfire attack – Radiant heat and small flaming sources.*

4.5.1 ENA pole fire test

The ICAL comprised a 1500 x 1500 mm radiant panel and a gas-fired ring burner. The ring burner was located around the pole specimen level with the lower edge of the radiant panel. The radiant panel was gas fired and is capable of irradiating specimens with up to 60 kW/m^2. This test apparatus, with the exception of the ring burner and pole mounting system, is discussed in detail in ASTM E1623. Prior to a test, a pole specimen was moved to a predetermined distance from the radiant panel where previously established heat flux values (i.e., 30, 40, 50 or 60 kW/m^2) had been established.

The pole specimens were exposed to a fixed heat flux for the full ten minutes of the test and flame contact from the ring burner for the last five minutes of the test. The heat flux ranged from 30 to 60 kW/m^2. The ring burner output was 40 kW for all tests. In this test only one side of the specimens was exposed to the radiant heat flux. The test equipment was located under a collection hood. The collection hood is 4.9 x 4.9 m in size and is capable of quantifying fire sizes up to 9 MW. All of the fire gases and effluent were collected by the hood during a test. Measurements were then made of smoke production, heat release rate and carbon monoxide and carbon dioxide generation rates. Heat release rate is determined by oxygen calorimetry methodology. The procedures for measuring these parameters are described in ASTM E2067 *Fire Tests*, *Standard Practice for Full-Scale Oxygen Consumption Calorimetry.*

The test equipment is shown in Figure 2 with a CCA-treated spotted gum specimen six minutes after the start of the test and one minute after the ring burner was ignited.

Figure 2 CCA-treated spotted gum specimen six minutes after ENA pole fire test start

The following data were recorded for each test during the ten minute fire test exposure:

- Time to ignition (s).
- Ignition temperature (°C).
  The surface temperature at the mid height of the specimen surface exposed to the radiant panel was measured using a Maxline Infrared Pyrometer with M402 Sensor. The band of wavelength in which the sensor responds to the infrared radiation is 8 to 12 μm to avoid the water and carbon monoxide bands. A data acquisition system consisting of a Fujitsu laptop computer controlling a Fluke Measurement and Control Link using Labview software recorded the temperature.
- Peak heat release rate (kW/m^2).
  The heat release was measured using the data acquisition system described above.
- Total heat release (kJ).
- Maximum surface temperature (°C).
  This was the maximum temperature recorded at the mid-height of the specimen surface exposed to the radiant panel during the ten minute fire test exposure.

Following the ten minute fire test exposure the pole specimens were monitored for up to four hours after the test start. During that time the maximum surface temperature of the specimens was measured by scanning them with a Flir ThermaCAM EX 320 infrared camera, which can measure up to 1200 °C with an accuracy of ± 2 °C. Monitoring the surface temperature after the ten minute fire test exposure period was not included in the original working plan for the project. The use of the Flir ThermaCAM EX320 infrared camera was offered by Western Fire Center after one CCA-treated spotted gum and one creosote-treated spotted gum specimen had been tested at 40 kW/m^2. The maximum surface temperature was monitored until four hours after the test start or until it was less than 200 °C, whichever occurred first. The test was terminated in less than four hours if the maximum surface temperature recorded was less than 200 °C.

If there was evidence of continuing combustion – temperatures above 200 °C and/or visible smoke or glowing or flaming combustion, the specimens were retained overnight and inspected the next day, 24 hours after the test start.

At the end of the test period, the specimens were examined for damage due to the fire test exposure.

There were two variations to the method during the three and three quarter hours observation period following the ten minute fire test exposure. Specimens were either maintained under laboratory conditions after the fire test exposure or were exposed to a 2 m/s (5 mph) wind. The specimen surface exposed to the radiant panel was exposed to the 2 m/s wind.

The 2 m/s wind exposure was included because wind is a significant factor in severe bushfires and it often persists following the passage of the fire front, as illustrated by the conditions prevailing in Canberra during and following the bushfire in that city on 18 January, 2003 (Webb *et al.*, 2004).

4.5.2 AS 1530.8.1 test method

This test method was developed to assess the performance of building elements exposed to a bushfire of lower severity than that considered in the development of the ENA pole fire test method. This method is based on a bushfire exposure of heat flux from the fire front, without direct flame impingement. The method also assesses the impact of adjacent burning vegetation. The test method exposes specimens to a burning timber crib and a varying heat flux profile. The heat flux profile and crib size vary according to the category of bushfire attack that the structure will be exposed to. The categories range from medium to severe. The parameters for the severe exposure were selected.

The heat flux profile applied is given in Table 1.

Table 1 Heat flux profile applied to specimens tested to AS 1530.8.1

Time (s)	20-140	140-180	180-240	240-300	300-360	360-420	420-480	480-540	540-600
Heat flux (kW/m^2)	40	24	16	12	8.5	7	5	4	3

The largest crib - Class C was used. This was made from radiata pine, comprised three rows of nine sticks and weighed 1.25 kg. After the crib was ignited, it was placed in contact with the pole specimen on an adjacent insulated plate, within 15 seconds of the test start. The base of the crib was aligned with the lower edge of the radiant panel. The heat flux profile began 20 seconds after the test start.

The CCA-treated spotted gum specimen at one minute after the test start is shown in Figure 3.

Figure 3 CCA-treated spotted gum specimen one minute after start of AS 1530.8.1 test

The test has a 60 minute duration and there are seven performance criteria specified for this test, but it was considered that only two may be relevant to testing poles. These were:

- Flaming not permitted on the fire-exposed side at the end of the 60 minute test period.
- Radiant heat flux 250 mm from the specimen greater than 3 kW/m^2 not permitted between 20 and 60 minutes.

The AS 1530.8.1 method was amended for this research as follows:

- After the ten minute fire test exposure, the maximum surface temperature was monitored by scanning the specimen with the Flir ThermaCAM EX320 infrared camera for up to four hours after the test start, or until it was less than 200 ^{o}C, whichever occurred first.
- At four hours after the test start, if the maximum surface temperature exceeded 200 ^{o}C and/or there was visible evidence of continuing combustion, the specimen was retained in the laboratory overnight and examined 24 hours after the test start.

4.6 Test laboratory

All fire tests were conducted at Western Fire Center Inc., Kelso, Washington, USA. The fire retardant-treated specimens were subjected to the ASTM D2898 accelerated weathering at the Western Fire Center laboratory.

The non-fire-retardant-treated specimens were tested to the ENA pole fire test method in October 2007. The fire retardant-treated specimens were tested to the ENA pole fire test method in May 2008. The specimens were tested to AS 1530.8.1 in May 2008.

5 Results

5.1 Moisture content

The moisture content data for the CCA-treated spotted gum and CCA-treated radiata pine specimens are summarised in Table 2.

Table 2 Moisture content of CCA-treated spotted gum and CCA-treated radiata pine specimens before fire testing

Specimen	Fire retardant treatment	Replicates	Moisture content (%)		
			Minimum	Maximum	Mean
CCA/SG[(1)]	Nil	8	12.3	19.1	15.2
CCA/SG	Chartek 7	2	11.3	12.2	11.8
CCA/SG	FireGuard	3	11.8	12.9	12.2
CCA/SG	FireTard 120	2	11.8	12.6	12.2
CCA/SG	FRX	3	9.6	11.3	10.5
CCA/RP[(2)]	Nil	2	13.1	14.2	13.6
CCA/RP	FireGuard	2	12.2	13.4	12.8
CCA/RP	FRX	2	11.4	11.9	11.7

Notes: 1 - CCA/SG=CCA-treated spotted gum
2 - CCA/RP=CCA-treated radiata pine

The moisture content of the CCA-treated spotted gum specimens tested without fire retardant treatment was typical of the above-ground moisture content for poles that had been in service for many years. For example, the mean moisture content of 20 CCA-treated spotted gum poles that were sampled after 12 to 24 years service in the Bathurst area (central west New South Wales) was 15.6% (minimum 12.5, maximum 18.4) and the mean moisture content of 20 CCA-treated spotted gum poles that were sampled after 14 to 28 years service in the Sydney metropolitan area was 15.9% (minimum 12.3, maximum 20.6) (Gardner *et al.*, 1998).

5.2 Chemical analysis

The data for the chemical analysis of the CCA-treated spotted gum and CCA-treated radiata pine specimens are summarized in Table 3. The data are reported as percent mass/mass (% m/m) of Total Active Elements (TAE). TAE is the sum of copper, chromium and arsenic present in the sample.

Table 3 Chemical analytical data for CCA-treated spotted gum and CCA-treated radiata pine specimens

Specimen	Replicates	TAE (%m/m)		
		Minimum	Maximum	Mean
CCA/SG[(1)]	9	0.71	2.06	1.20
CCA/RP[(2)]	4	1.57	2.24	1.91

Notes: 1 - CCA/SG=CCA-treated spotted gum pole
2 - CCA/RP=CCA-treated radiata pine

The minimum retention of preservatives in preservative-treated wood is specified in AS 1604 *Specification for preservative treatment Part 1 Sawn and round timber*. The relevant AS 1604 specification for CCA-treated poles (Hazard Class H5) is a minimum retention of 1.2% m/m TAE in hardwoods and 1.0% m/m TAE in softwoods. The CCA retention in five of the nine spotted gum pole specimens was below the current minimum specification. The CCA retention in all radiata pine specimens was above the current minimum specification.

5.3 Fire test data

The fire test data are reported separately for the ENA pole fire test and AS 1530.8.1.

5.3.1 ENA pole fire test data

The ENA pole fire test data are reported for the three parts of the test procedure – the ten minute fire test exposure, the post-fire exposure period of up to four hours after the test start and the inspection 24 hours after the test start.

5.3.1.1 ENA pole fire test data for ten minute fire exposure period

The following data are reported:

- Time to ignition (s).
- Ignition temperature (^{o}C).
- Peak heat release rate (kW/m^2).
- Total heat release (kJ).
- Maximum surface temperature (^{o}C).

5.3.1.1.1 Time to ignition

The time to ignition data for all specimens are summarized in Table 4.

Table 4 Time to ignition for specimens exposed to heat fluxes of 30 to 60 kW/m²

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m^2)	Time to ignition (s)		
				Minimum	Maximum	Mean
Creos/BB[1]	Nil	2	60	5	15	10
Creos/SG[2]	Nil	1	40			209
Creos/SG	Nil	1	50			149
Creos/SG	Nil	2	60	25	54	40
CCA/SG[3]	Nil	3	40	181	300	209
CCA/SG	Nil	1	50			100
CCA/SG	Nil	5	60	18	52	31
CCA/SG	Chartek 7	2	60	300	300	300
CCA/SG	FireGuard	3	60	300	345	317
CCA/SG	FireTard 120	2	60	38	48	43
CCA/SG	FRX	3	60	30	56	45
CCA/RP[4]	Nil	1	30			300
CCA/RP	Nil	1	60			17
CCA/RP	FireGuard	2	60	303	303	303
CCA/RP	FRX	2	60	147	302	225

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

The time to ignition of CCA-treated spotted gum specimens tested at 60 kW/m^2 was not influenced by the FireTard 120 or FRX fire retardant treatments. The Chartek 7 and FireGuard treatments increased the time to ignition of the CCA-treated spotted gum specimens tested at this irradiance, with ignition being delayed until after the ignition of the ring burner at five minutes after the test start.

5.3.1.1.2 Ignition temperature

The ignition temperature data for all specimens are summarized in Table 5.

Table 5 Ignition temperature for specimens exposed to heat fluxes of 30 to 60 kW/m^2

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m^2)	Ignition temperature (°C)		
				Minimum	Maximum	Mean
Creos/BB[(1)]	Nil	2	60	247	270	259
Creos/SG[(2)]	Nil	1	40			467
Creos/SG	Nil	1	50			455
Creos/SG	Nil	2	60	273	409	341
CCA/SG[(3)]	Nil	3	40	407	538	468
CCA/SG	Nil	1	50			456
CCA/SG	Nil	5	60	313	407	344
CCA/SG	Chartek 7	2	60	556	575	565
CCA/SG	FireGuard	3	60	666	686	676
CCA/SG	FireTard 120	2	60	347	388	368
CCA/SG	FRX	3	60	321	378	363
CCA/RP[(4)]	Nil	1	30			608
CCA/RP	Nil	1	60			405
CCA/RP	FRX	2	60	654	686	670
CCA/RP	FireGuard	2	60	752	756	754

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

5.3.1.1.3 Peak heat release rate

The peak heat release rate data for all specimens are summarized in Table 6.

Table 6 Peak heat release rate for specimens exposed to heat fluxes of 30 to 60 kW/m²

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m²)	Peak heat release rate (kW/m²)		
				Minimum	Maximum	Mean
Creos/BB[(1)]	Nil	2	60			236
Creos/SG[(2)]	Nil	1	40			194
Creos/SG	Nil	1	50			163
Creos/SG	Nil	2	60	172	197	185
CCA/SG[(3)]	Nil	3	40	89	126	108
CCA/SG	Nil	1	50			117
CCA/SG	Nil	5	60	94	164	116
CCA/SG	Chartek 7	2	60	84	155	120
CCA/SG	FireGuard	3	60	70	85	79
CCA/SG	FireTard 120	2	60	124	176	150
CCA/SG	FRX	3	60	86	182	145
CCA/RP[(4)]	Nil	1	30			69
CCA/RP	Nil	1	60			109
CCA/RP	FRX	2	60	81	89	85
CCA/RP	FireGuard	2	60	50	90	70

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

5.3.1.1.4 Total heat release

The total heat release data for all specimens are summarized in Table 7.

Table 7 Total heat release for specimens exposed to heat fluxes of 30 to 60 kW/m²

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m^2)	Total heat release (kJ)		
				Minimum	Maximum	Mean
Creos/BB[1]	Nil	2	60			89,720
Creos/SG[2]	Nil	1	40			43,888
Creos/SG	Nil	1	50			54,845
Creos/SG	Nil	2	60	63,517	88,539	76,028
CCA/SG[3]	Nil	3	40	21,628	22,942	22,189
CCA/SG	Nil	1	50			34,717
CCA/SG	Nil	5	60	38,776	63,364	47,128
CCA/SG	Chartek 7	2	60	7,729	26,079	16,903
CCA/SG	FireGuard	3	60	15,418	25,871	18,960
CCA/SG	FireTard 120	2	60	46,658	72,571	59,614
CCA/SG	FRX	3	60	28,343	81,820	62,217
CCA/RP[4]	Nil	1	30			14,815
CCA/RP	Nil	1	60			44,499
CCA/RP	FRX	2	60	15,780	21,529	18,655
CCA/RP	FireGuard	2	60	9,931	18,777	14,354

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

5.3.1.1.5 Maximum surface temperature

The maximum surface temperature data for all specimens are summarized in Table 8.

Table 8 Maximum surface temperature for specimens exposed to heat fluxes of 30 to 60 kW/m²

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m²)	Maximum surface temperature (°C)		
				Minimum	Maximum	Mean
Creos/BB[(1)]	Nil	2	60	832	874	853
Creos/SG[(2)]	Nil	1	40			765
Creos/SG	Nil	1	50			768
Creos/SG	Nil	2	60	782	820	801
CCA/SG[(3)]	Nil	3	40	692	719	709
CCA/SG	Nil	1	50			762
CCA/SG	Nil	5	60	715	792	748
CCA/SG	Chartek 7	2	60	708	745	727
CCA/SG	FireGuard	3	60	728	745	736
CCA/SG	Firetard 120	2	60	748	777	763
CCA/SG	FRX	3	60	737	796	761
CCA/RP[(4)]	Nil	1	30			662
CCA/RP	Nil	1	60			689
CCA/RP	FRX	2	60	736	818	777
CCA/RP	FireGuard	2	60	799	803	801

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

5.3.1.2 ENA pole fire test post-fire test exposure observations up to four hours after test start

The specimens were retained under one of two conditions after the ten minute fire test exposure, until up to four hours after the test start. The non-fire-retardant-treated specimens were retained either a) in the laboratory atmosphere or b) exposed to a 2 m/s (5 mph) wind. The fire retardant-treated specimens were all exposed to the 2 m/s wind after the fire test exposure.

The maximum surface temperature was monitored from within five minutes of the specimens being removed from the heat flux exposure until up to four hours after the test start by scanning the specimen surface with the Flir ThermaCAM EX320 infrared camera. The presence of ongoing combustion and the condition of the specimens was noted at hourly intervals until four hours after the ENA pole fire test start. The test was terminated before the end of the four hour period if the surface temperature recorded was less than 200 °C, and there was no visible evidence of flaming, glowing or smouldering combustion.

5.3.1.2.1 Maximum surface temperature recorded after the fire test exposure up to four hours after ENA pole fire test start

The maximum surface temperature at one, two, three and four hours after the test start is reported in Tables 9 to 12 respectively.

Table 9 Maximum surface temperature of specimens one hour after ENA pole fire test start

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m^2)	Wind exposure	Max. surface temperature (°C)		
					Minimum	Maximum	Mean
Creos/BB[1]	Nil	1	60	No			47
Creos/BB	Nil	1	60	Yes			24
Creos/SG[2]	Nil	1	50	No			70
Creos/SG	Nil	1	60	No			40
Creos/SG	Nil	1	60	Yes			21
CCA/SG[3]	Nil	1	40	No			542
CCA/SG	Nil	1	40	Yes			773
CCA/SG	Nil	1	50	No			416
CCA/SG	Nil	3	60	No	515	639	563
CCA/SG	Nil	2	60	Yes	681	804	743
CCA/SG	Chartek 7	2	60	Yes	26	40	33
CCA/SG	FireGuard	3	60	Yes	24	719	622
CCA/SG	FireTard 120	2	60	Yes	734	806	770
CCA/SG	FRX	3	60	Yes	470	770	613
CCA/RP[4]	Nil	1	30	No			560
CCA/RP	Nil	1	60	No			545
CCA/RP	FRX	2	60	Yes	21	27	24
CCA/RP	FireGuard	2	60	Yes	745	764	755

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine

The first specimen monitored with the Flir ThermaCAM EX 320 infrared camera was the creosote-treated spotted gum specimen tested at 50 kW/m^2. Monitoring was stopped after 25 minutes when the maximum surface temperature had dropped to 70 °C and there was no evidence of on-going combustion. In all later tests, monitoring continued for at least 45 minutes – i.e. until one hour after the ENA pole fire test start.

At one hour after the ENA pole fire test start, the maximum surface temperature of the creosote-treated spotted gum and creosote-treated blackbutt specimens that were tested at 60 kW/m^2 and not subjected to a 2 m/s wind after the ten minute fire test exposure was 40 °C and 47 °C respectively. When the specimens were exposed to the 2 m/s wind, the maximum surface temperatures one hour after the ENA pole fire test start were 21 °C and 24 °C respectively. Thus the wind exposure cooled the specimens.

For the CCA-treated spotted gum specimens tested at 40 to 60 kW/m^2 and maintained without exposure to the 2 m/s wind, maximum surface temperatures ranged from 416 °C to 639 °C at one hour after the ENA pole fire test start. When the specimens tested at these heat fluxes were exposed to the 2 m/s wind, maximum surface temperatures increased to 681 °C to 804 °C. These data demonstrate that there was on-going combustion in the

CCA-treated spotted gum specimens one hour after the test start and that the intensity of the combustion was increased by the wind exposure.

Similar maximum surface temperatures were reported one hour after the ENA pole fire test start for the CCA-treated spotted gum and CCA-treated radiata pine specimens that were tested at 60 kW/m^2 and not subjected to a 2 m/s wind.

The fire retardant-treated CCA-treated spotted gum specimens were all exposed to the 2 m/s wind. One hour after the ENA pole fire test start the maximum surface temperature for the CCA-treated spotted gum specimens was reduced by the Chartek 7 treatment. By that time all combustion had ceased in both Chartek 7 CCA-treated specimens.

The non-fire-retardant-treated CCA-treated radiata pine specimens were not tested with the 2 m/s wind exposure as the specimen combusted to destruction over 24 hours when tested at 60 kW/m^2 without wind exposure. One hour after the ENA pole fire test start the maximum surface temperature of the FireGaurd CCA-treated radiata pine specimens was similar to that of the CCA-treated spotted gum specimens without fire retardant treatment tested at 60 kW/m^2 and exposed to a 2 m/s wind. All combustion had ceased in the FRX CCA-treated radiata pine specimens by that time.

The surface temperature of specimens that recorded a maximum surface temperature of less than 200 ^{o}C at one hour was not monitored after one hour.

Table 10 Maximum surface temperature of specimens two hours after ENA pole fire test start

Specimen	Fire retardant treatment	Replicates	Heat flux (kW/m^2)	Wind exposure	Max. surface temperature (^{o}C)		
					Minimum	Maximum	Mean
Creos/BB[1]	Nil	1	60	No			TT1[5]
Creos/BB	Nil	1	60	Yes			TT1
Creos/SG[2]	Nil	1	50	No			TT1
Creos/SG	Nil	1	60	No			TT1
Creos/SG	Nil	1	60	Yes			TT1
CCA/SG[3]	Nil	1	40	No			525
CCA/SG	Nil	1	40	Yes			882
CCA/SG	Nil	1	50	No			45
CCA/SG	Nil	3	60	No	463	622	523
CCA/SG	Nil	2	60	Yes	762	811	787
CCA/SG	Chartek 7	2	60	Yes			TT1
CCA/SG	FireGuard	2	60	Yes	732	855	794
CCA/SG	FireTard 120	2	60	Yes	747	799	773
CCA/SG	FRX	2	60	Yes	567	778	673
CCA/RP[4]	Nil	1	30	No			538
CCA/RP	Nil	1	60	No			531
CCA/RP	FRX	2	60	Yes			TT1
CCA/RP	FireGuard	2	60	Yes			TT1

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine
5 - TT1 = test terminated at one hour

By two hours after the start of the ENA pole fire test, combustion had ceased in the CCA-treated spotted gum specimen tested at 50 kW/m^2 and not exposed to the 2 m/s wind.

The test of one FRX CCA-treated spotted gum specimen was terminated at one and one quarter hours after the test start because of significant flaming combustion at the top of the specimen. This was considered to be an artifact of the test. Barrel checking at the ends of the fire retardant-treated CCA-treated spotted gum specimens was increased in some specimens as a result of the alternating wetting and drying schedules in the ASTM D2898 accelerated weathering. This allowed access of hot gases and flames to the interior and top surface of the specimens that would not have occurred if the specimen had been significantly longer. The maximum surface temperature was less than 200 ^{o}C on the specimen below the top edge combustion.

The FireGuard CCA-treated radiata pine specimen tests were terminated at one hour as the specimens were flaming strongly and would obviously have been seriously damaged had the tests continued for another three hours.

Table 11 Maximum surface temperature of specimens three hours after ENA pole fire test start

Specimen	Fire retardant treatment	Replicates	Irradiance (kW/m^2)	Wind exposure	Max. surface temperature (^{o}C)		
					Minimum	Maximum	Mean
Creos/BB(1)	Nil	1	60	No			TT1(5)
Creos/BB	Nil	1	60	Yes			TT1
Creos/SG(2)	Nil	1	50	No			TT1
Creos/SG	Nil	1	60	No			TT1
Creos/SG	Nil	1	60	Yes			TT1
CCA/SG(3)	Nil	1	40	No			510
CCA/SG	Nil	1	40	Yes			870
CCA/SG	Nil	1	50	No			TT2(6)
CCA/SG	Nil	3	60	No	63	465	314
CCA/SG	Nil	2	60	Yes	765	807	786
CCA/SG	Chartek 7	2	60	Yes			TT1
CCA/SG	FireGuard	2	60	Yes	840	845	843
CCA/SG	FireTard 120	2	60	Yes	714	771	743
CCA/SG	FRX	2	60	Yes	561	682	622
CCA/RP(4)	Nil	1	30	No			599
CCA/RP	Nil	1	60	No			648
CCA/RP	FRX	2	60	Yes			TT1
CCA/RP	FireGuard	2	60	Yes			TT1

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine
5 - TT1 = test terminated at one hour
6 - TT2 = test terminated at two hours

The maximum surface temperature of one of the three replicates of the CCA-treated spotted gum specimens tested at 60 kW/m^2 without the 2 m/s wind exposure was less than 200 ^{o}C at three hours after the test start.

Table 12 Maximum surface temperature of specimens four hours after ENA pole fire test start

Specimen	Fire retardant treatment	Replicates	Irradiance (kW/m^2)	Wind exposure	Max. surface temperature (°C)		
					Minimum	Maximum	Mean
Creos/BB[(1)]	Nil	1	60	No			TT1[(5)]
Creos/BB	Nil	1	60	Yes			TT1
Creos/SG[(2)]	Nil	1	50	No			TT1
Creos/SG	Nil	1	60	No			TT1
Creos/SG	Nil	1	60	Yes			TT1
CCA/SG[(3)]	Nil	1	40	No			516
CCA/SG	Nil	1	40	Yes			837
CCA/SG	Nil	1	50	No			TT2[(6)]
CCA/SG	Nil	2	60	No	370	513	442
CCA/SG	Nil	2	60	Yes	850	920	885
CCA/SG	Chartek 7	2	60	Yes			TT1
CCA/SG	FireGuard	2	60	Yes	745	772	759
CCA/SG	FireTard 120	1	60	Yes			738
CCA/SG	FRX	2	60	Yes	453	778	616
CCA/RP[(4)]	Nil	1	30	No			538
CCA/RP	Nil	1	60	No			531
CCA/RP	FRX	2	60	Yes			TT1
CCA/RP	FireGuard	2	60	Yes			TT1

Notes: 1 - Creos/BB = creosote-treated blackbutt
2 - Creos/SG = creosote-treated spotted gum
3 - CCA/SG = CCA-treated spotted gum
4 - CCA/RP = CCA-treated radiata pine
5 - TT1 = test terminated at one hour
6 - TT2 = test terminated at two hours

The test of one FireTard 120 CCA-treated spotted gum specimen was terminated at three hours because the specimen burnt through and collapsed.

The maximum surface temperature of the CCA-treated spotted gum specimen exposed to 40 kW/m^2 without the 2 m/s wind exposure was less than 200 °C five hours after the ENA pole fire test start.

5.3.1.2.2 Specimen condition four hours after ENA pole fire test start

All specimens were inspected four hours after the ENA pole fire test start to determine a) whether there was evidence of on-going combustion and b) the type and extent of damage that had resulted from the testing. Evidence of combustion was the evolution of smoke and/or presence of flaming or glowing combustion and/or a maximum surface temperature greater than 200 °C.

5.3.1.2.2.1 Condition of creosote-treated blackbutt and creosote-treated spotted gum specimens four hours after ENA pole fire test start

All creosote-treated specimens had self-extinguished within one hour of the ENA pole fire test start. For all specimens the damage was limited to surface charring of 3 to 5 mm depth on the specimen surface exposed to the radiant panel.

5.3.1.2.2.2 Condition of CCA-treated spotted gum specimens four hours after ENA pole fire test start

The condition of the CCA-treated spotted gum specimens four hours after the ENA pole fire test start was mainly influenced by the application of the 2 m/s wind exposure.

One CCA-treated spotted gum specimen tested at 40 kW/m^2 and the specimen tested at 50 kW/m^2, both with no subsequent 2 m/s wind exposure, had ceased combusting within four hours of the ENA pole fire test start. The second CCA-treated spotted gum specimen tested at 40 kW/m^2 and no subsequent 2 m/s wind exposure was still combusting four hours after the ENA pole fire test start, but had extinguished by five hours after the ENA pole fire test start. One CCA-treated spotted gum specimen tested at 60 kW/m^2 and no subsequent 2 m/s wind exposure was still combusting four hours after the ENA pole fire test start.

The damage to CCA-treated spotted gum specimens tested at 40 and 50 kW/m^2 and no subsequent 2 m/s wind exposure was limited to charring to a depth of 4 mm on the specimen surface exposed to the radiant panel.

The condition of specimens tested at 60 kW/m^2 and no subsequent 2 m/s wind exposure was more variable. Of three replicates, one was charred to a depth of 4 mm, the second was similarly charred but was also charred to the full sapwood depth (25 mm) in one place, about 50 mm in diameter, and the third specimen was charred to the full depth of the sapwood (25 mm) on the fire-exposed face.

Specimens tested at 40 and 60 kW/m^2 and subjected to a 2 m/s wind exposure were almost completely destroyed by four hours after the ENA pole fire test start. Specimen four hours after testing at 60 kW/m^2 and a 2 m/s wind is shown in Figure 4.

Figure 4 CCA-treated spotted gum specimen four hours after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.3 Condition of CCA-treated radiata pine specimens four hours after ENA pole fire test start

The radiata pine specimens tested at 30 and 60 kW/m^2 without a subsequent 2 m/s wind exposure were significantly charred in four hours and the specimens were strongly involved in glowing and flaming combustion. The radiata pine specimen tested at 60 kW/m^2 without a subsequent wind exposure is shown in Figure 5.

Figure 5 CCA-treated radiata pine specimen four hours after testing at 60 kW/m^2 without a subsequent 2 m/s wind exposure

5.3.1.2.2.4 Condition of fire retardant-treated CCA-treated spotted gum specimens four hours after ENA pole fire test start

5.3.1.2.2.4.1 Condition of Chartek 7 CCA-treated spotted gum specimens four hours after ENA pole fire test start

The Chartek 7 CCA-treated spotted gum specimens self-extinguished within the first hour after the ENA pole fire test start. The Chartek 7 coating intumesced on the specimen surface exposed to the radiant panel and remained intact during the fire test exposure for both specimens tested – see Figure 6. The CCA-treated spotted gum specimen under the coating was not damaged by the fire test exposure.

Figure 6 Chartek 7 CCA-treated spotted gum specimen four hours after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.4.2 Condition of FireGuard CCA-treated spotted gum specimens four hours after ENA pole fire test start

Three FireGuard CCA-treated spotted gum specimens were tested.

Combustion in one FireGuard CCA-treated spotted gum specimen ceased within one hour of the test start. The FireGuard coating on this specimen was intact at the end of the ten minute 60 kW/m^2 fire test exposure and charring of this specimen was limited to a depth of 4 mm under the coating on the surface exposed to the radiant panel.

There was on-going combustion in the other two FireGuard CCA-treated spotted gum specimens. The FireGuard coating on these specimens became detached on part of the surface exposed to the radiant panel during the ten minute fire test exposure and combustion proceeded at these places when the specimens were exposed to the 2 m/s wind. After four hours there was damage to the upper sections of the fire-exposed face of these specimens – see Figure 7. Some of the damage to the top of the specimens was considered to be due to the test top edge effect discussed for a FRX CCA-treated spotted gum specimen in 5.3.1.2.1 above.

Figure 7 FireGuard CCA-treated spotted gum specimen four hours after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.4.3 Condition of FireTard 120 CCA-treated spotted gum specimens four hours after ENA pole fire test start

There were two FireTard 120 CCA-treated spotted gum specimens tested. Both FireTard 120 specimens were severely damaged by four hours after the ENA pole fire test start. One specimen had burnt through near its base and collapsed after three hours and was extinguished at that time. There was on-going combustion in the second specimen four hours after the ENA pole fire test start and it was severely damaged – see Figure 8.

Figure 8 FireTard 120 CCA-treated spotted gum specimen four hours after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.4.4 Condition of FRX CCA-treated spotted gum specimens four hours after ENA pole fire test start

There were three FRX CCA-treated spotted gum specimens tested.

For the first specimen, combustion proceeded after the ten minute fire test exposure at one position near the location of the ring burner. This self-extingusished after two and one half hours and resulted in a charred area of approximately 80 x 100 mm and 80 mm deep. The rest of the specimen surface exposed to the radiant panel was charred to a depth of 4 mm.

Combustion continued at the top of the second specimen. There was no evidence of combustion at any other place on the specimen. The flaming at the top of the specimen was considered to be due to a top edge effect (see Figure 9) and it was extinguished after one hour.

The third specimen was still combusting four hours after the test start and was more severely damaged generally than either of the other two FRX-treated replicates.

Figure 9 Combustion at top of FRX CCA-treated spotted gum specimen one hour after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.5 Condition of fire retardant-treated CCA-treated radiata pine specimens four hours after ENA pole fire test start

5.3.1.2.2.5.1 Condition of FireGuard CCA-treated radiata pine specimens four hours after ENA pole fire test start

There were two FireGuard CCA-treated radiata pine specimens tested.

For both specimens, part of the FireGuard coating on the specimen surface exposed to the radiant panel became detached during the ten minute fire test exposure. The FireGuard CCA-treated radiata pine specimens combusted vigorously during the first hour of the 2 m/s wind exposure. The tests were terminated at one hour for both specimens to avoid their probable complete oxidation to ash and the associated containment issues. A FireGuard CCA-treated radiata pine specimen one hour after the ENA pole fire test start is shown in Figure 10.

Figure 10 FireGuard CCA-treated radiata pine specimen one hour after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.2.5.2 Condition of FRX CCA-treated radiata pine specimens four hours after ENA pole fire test start

There were two FRX CCA-treated radiata pine specimens tested. Both specimens self-extingusished within one hour of the ENA pole fire test start. The fire test exposed face of both specimens was charred to a maximum depth of 10 mm – see Figure 11.

Figure 11 FRX CCA-treated radiata pine specimen four hours after testing at 60 kW/m^2 and being subjected to a 2 m/s wind

5.3.1.2.3 Specimen condition 24 hours after ENA pole fire test start

Specimens that were still showing evidence of combustion at the end of the wind exposure period (four hours after test start) were re-inspected after an additional 20 hours – i.e. 24 hours after the test start.

5.3.1.2.3.1 Condition of CCA-treated spotted gum specimens 24 hours after ENA pole fire test start

One CCA-treated spotted gum specimen that was tested at 60 kW/m^2 without a 2 m/s wind exposure continued to combust significantly beyond the four hour inspection. The specimen was still smouldering 24 hours after the ENA pole fire test start. The specimen was severely damaged 24 hours after the ENA pole fire test start – see Figure 12.

Figure 12 CCA-treated spotted gum specimen 24 hours after testing at 60 kW/m^2 without being subjected to a 2 m/s wind exposure

The CCA-treated specimens tested at 40 and 60 kW/m^2 with subsequent 2 m/s wind exposure continued to combust after the wind exposure was stopped, resulting in severely damaged specimens at 24 hours after the ENA pole fire test start. The effect of the wind exposure is illustrated in Figure 13, where specimens tested at 60 kW/m^2 and classified as seriously damaged, both with and without 2 m/s wind exposure, are shown.

Figure 13 CCA-treated spotted gum specimens 24 hours after testing at 60 kW/m^2 without subsequent 2 m/s wind exposure (L) and with subsequent 2 m/s wind exposure (R)

5.3.1.2.3.2 Condition of CCA-treated radiata pine specimens 24 hours after ENA pole fire test start

Both CCA-treated radiata pine specimens that were tested without 2 m/s wind exposure were completely combusted to ash 24 hours after the ENA pole fire test start – see Figure 14.

Figure 14 CCA-treated radiata pine specimen 24 hours after testing at 60 kW/m^2 without subsequent 2 m/s wind exposure

5.3.1.2.3.3 Condition of fire retardant-treated CCA-treated spotted gum specimens 24 hours after ENA pole fire test start

5.3.1.2.3.3.1 Condition of Chartek 7 CCA-treated spotted gum specimens 24 hours after ENA pole fire test start

The condition of the Chartek 7 CCA-treated spotted gum specimens was as reported for their condition after four hours.

5.3.1.2.3.3.2 Condition of FireGuard CCA-treated spotted gum specimens 24 hours after ENA pole fire test start

The condition of the two FireGuard CCA-treated spotted gum specimens that were still combusting at the end of the 2 m/s wind exposure did not change significantly in the following 20 hours.

5.3.1.2.3.3.3 Condition of FireTard 120 CCA-treated spotted gum specimens 24 hours after ENA pole fire test start

The FireTard 120 CCA-treated spotted gum specimen that was still combusting four hours after the ENA pole fire test start continued to combust and it collapsed before the end of the 24 hour period.

5.3.1.2.3.4 Condition of fire retardant-treated CCA-treated radiata pine specimens 24 hours after ENA pole fire test start

As none of the fire retardant-treated CCA-treated radiata pine specimens were combusting four hours after the ENA pole fire test start, their condition at the 24 hour inspection was unchanged from that reported for four hours after the ENA pole fire test start.

5.3.2 AS 1530.8.1 test data

5.3.2.1 Time to ignition and ignition temperature

The time to ignition and ignition temperature data are summarized in Table 13 for all specimens tested except the CCA-treated radiata pine, for which the data were not collected.

Table 13 Time to ignition and ignition temperature for specimens tested to AS 1530.8.1

Specimen	Fire retardant treatment	Time to ignition (s)	Ignition temperature (^{0}C)
Creos/SG(1)	Nil	38	557
CCA/SG(2)	Nil	48	338
CCA/SG	Chartek 7	45	335
CCA/SG	FireGuard	63	476
CCA/SG	FireTard 120	46	327
CCA/SG	FRX	50	441
CCA/RP(3)	FireGuard	83	517
CCA/RP`	FRX	50	473

Notes: 1 - Creos/SG = creosote-treated spotted gum
2 - CCA/SG = CCA-treated spotted gum
3 - CCA/RP = CCA-treated radiata pine

5.3.2.2 Compliance with AS 1530.8.1 performance criteria

Compliance with the AS 1530.8.1 requirements for a) an absence of flaming on the fire-exposed side of the specimens at 60 minutes after the AS 1530.8.1 test start and b) a maximum radiant heat flux 250 mm from the specimen of 3 kW/m^2 between 20 and 60 minutes after the AS 1530.8.1 test start, are summarized in Table 14 for all specimens tested, except the CCA-treated radiata pine, for which the data were not collected.

Table 14 Compliance with AS 1530.8.1 absence of flaming and maximum radiant heat performance criteria

Specimen	Fire retardant treatment	No flaming at 60 minutes	Radiant heat less than 3 kW/m^2
Creos/SG[(1)]	Nil	Pass	Pass
CCA/SG[(2)]	Nil	Pass[(4)]	Fail (30 min)
CCA/SG	Chartek 7	Pass	Fail (24 min)
CCA/SG	FireGuard	Pass	Fail (22 min)
CCA/SG	FireTard 120	Pass[(4)]	Fail (37 min)
CCA/SG	FRX	Pass[(4)]	Pass
CCA/RP[(3)]	FireGuard	Pass	Pass
CCA/RP`	FRX	Pass	Fail (25 min)

Notes: 1 - Creos/SG = creosote-treated spotted gum
2 - CCA/SG = CCA-treated spotted gum
3 - CCA/RP = CCA-treated radiata pine
4 - Specimen not flaming but still smouldering at 60 minutes

The CCA-treated spotted gum, FireTard 120 CCA-treated spotted gum and FRX CCA-treated spotted gum specimens satisfied the requirement for no flaming 60 minutes after the test start, but smoke was being emitted from these specimens indicating smouldering combustion was still occurring. The time at which the emitted radiant heat reached 3 kW/m^2 for those specimens that failed this performance criteria is given in parenthesis beside the "Fail" notation for each specimen.

5.3.2.3 Maximum surface temperature at one, two, three and four hours after AS 1530.8.1 test start

The maximum surface temperature recorded for each specimen at one, two, three and four hours after the AS 1530.8.1 test start is given in Table 15.

Table 15 Maximum surface temperature at one, two, three and four hours after AS 1530.8.1 test start

Specimen	Fire retardant treatment	Maximum surface temperature (°C) at			
		One hour	Two hours	Three hours	Four hours
Creos/SG[(1)]	Nil	153			
CCA/SG[(2)]	Nil	520	440	438	470
CCA/SG	Chartek 7	260	78		
CCA/SG	FireGuard	373	47		
CCA/SG	FireTard 120	573	563	581	592
CCA/SG	FRX	500	539	499	485
CCA/RP[(3)]	FireGuard	260	193		
CCA/RP	FRX	523	354	256	112

Notes: 1 - Creos/SG = creosote-treated spotted gum
2 - CCA/SG = CCA-treated spotted gum
3 - CCA/RP = CCA-treated radiata pine

The maximum surface temperature for most specimens was recorded adjacent to the position where the crib was mounted.

The maximum surface temperature was less than 200 ^{o}C:

- At one hour after the AS 1530.8.1 test start for the creosote-treated spotted gum specimen.
- At two hours after the AS 1530.8.1 test start for the Chartek 7 CCA-treated spotted gum, FireGuard CCA-treated spotted gum and FRX CCA-treated radiata pine specimens.
- At four hours after the AS 1530.8.1 test start for the FRX CCA-treated radiata pine specimen.

5.3.3 Specimen condition four hours after AS 1530.8.1 test start

5.3.3.1 Condition of creosote-treated spotted gum specimen four hours after AS 1530.8.1 test start

The creosote-treated spotted gum specimen self-extinguished within the first hour after the AS 1530.8.1 test start. The specimen was charred to a depth of 2 mm over the fire-exposed surface. There was also charring to a depth of 15 mm over an area of approximately 250 x 100 mm adjacent to where the crib was placed - see Figure 15.

Figure 15 Creosote-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.2 Condition of CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

There was well established glowing combustion adjacent to where the crib was placed – see Figure 16. The specimen was charred over the fire-exposed surface.

Figure 16 CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.3 Condition of CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

There was well established glowing combustion adjacent to where the crib was placed and at several positions higher on the specimen surface exposed to the radiant panel. The specimen was charred over the fire-exposed surface.

5.3.3.4 Condition of fire retardant-treated CCA-treated spotted gum specimens four hours after AS 1530.8.1 test start

5.3.3.4.1 Condition of Chartek 7 CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

The Chartek 7 CCA-treated spotted gum specimen had self-extingusished within two hours after the AS 1530.8.1 test start. The Chartek 7 formulation had intumesced and remained intact on the fire-exposed surface. The specimen surface under the Chartek 7 coating was not charred, except for an area of approximately 170 x 100 mm adjacent to where the crib was placed, where there was charring to a depth of 20 mm. – see Figure 17.

Figure 17 Chartek 7 CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.4.2 Condition of FireGuard CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

The FireGuard CCA-treated spotted gum specimen had self-extinguished within two hours after the test start. The FireGuard formulation had intumesced and remained intact on the fire-exposed surface. The specimen surface under the FireGuard coating was lightly scorched and there was charring to a depth of 12 mm over an area of approximately 170 x 100 mm adjacent to where the crib was placed – see Figure 18.

Figure 18 FireGuard CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.4.3 Condition of FireTard 120 CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

There was significant glowing combustion established in the FireTard 120 CCA-treated spotted gum specimen adjacent to the crib position and at several positions higher up the specimen surface exposed to the radiant panel – see Figure 19.

Figure 19 FireTard 120 CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.4.4 Condition of FRX CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

There was significant glowing combustion established in the FRX CCA-treated spotted gum specimen adjacent to the crib position – see Figure 20.

Figure 20 FRX CCA-treated spotted gum specimen four hours after AS 1530.8.1 test start

5.3.3.5 Condition of fire retardant-treated CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

5.3.3.5.1 Condition of FireGuard CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

The FireGuard CCA-treated radiata pine specimen had self-extingusished within two hours after the AS 1530.8.1 test start. The FireGuard formulation had intumesced and remained intact on the fire-exposed surface. The specimen surface under the FireGuard coating was lightly scorched and there was charring to a depth of 18 mm over an area of approximately 300 x 75 mm adjacent to where the crib was placed – see Figure 21.

Figure 21 FireGuard CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

5.3.3.5.2 Condition of FRX CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

The FRX CCA-treated radiata pine specimen had self-extingusished within four hours after the AS 1530.8.1 test start. The specimen surface exposed to the radiant panel was charred to a depth of 4mm and there was charring to a depth of 45 mm over an area of approximately 250 x 125 mm adjacent to where the crib was placed – see Figure 22.

Figure 22 FRX CCA-treated radiata pine specimen four hours after AS 1530.8.1 test start

5.3.3.6 Condition of specimens 24 hours after AS 1530.8.1 test start

5.3.3.6.1 Condition of CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

The CCA-treated spotted gum specimen was still combusting after 24 hours and was severely damaged – see Figure 23.

Figure 23 CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

5.3.3.6.2 Condition of fire retardant-treated CCA-treated spotted gum specimens 24 hours after AS 1530.8.1 test start

5.3.3.6.2.1 Condition of Chartek 7 CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

The condition of the Chartek 7 CCA-treated spotted gum specimen did not change from its condition reported at four hours after the AS 1530.8.1 test start.

5.3.3.6.2.2 Condition of FireGuard CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

The condition of the FireGuard CCA-treated spotted gum specimen did not change from its condition reported at four hours after the AS 1530.8.1 test start.

5.3.3.6.2.3 Condition of FireTard 120 CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

The FireTard 120 CCA-treated spotted gum specimen was still combusting after 24 hours and had burnt through completely in the vicinity of the crib position – see Figure 24.

Figure 24 FireTard 120 CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

5.3.3.6.2.4 Condition of FRX CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

The FRX CCA-treated spotted gum specimen was still combusting 24 hours after the AS 1530.8.1 test start and had burnt through completely in the vicinity of the crib position – see Figure 25.

Figure 25 FRX CCA-treated spotted gum specimen 24 hours after AS 1530.8.1 test start

5.3.3.6.3 Condition of CCA-treated radiata pine specimen 24 hours after AS 1530.8.1 test start

The CCA-treated radiata pine specimen was severely damaged and almost completely converted to ash, as occurred with the specimen after the ENA pole fire test – see Figure 14.

5.3.3.6.4 Condition of fire retardant-treated CCA-treated radiata pine specimens 24 hours after AS 1530.8.1 test start

The condition of the FireGuard CCA-treated radiata pine and FRX CCA-treated radiata pine specimens did not change from their condition reported at four hours after the AS 1530.8.1 test start.

6 Discussion

From the results of the experimental program the following matters need to be considered:

- The development of the ENA pole fire test method.
- A comparison of the ENA pole fire test method and AS 1530.8.1.
- Relevance of the ENA pole fire test method and AS 1530.8.1.
- Efficacy of the fire retardant treatments that were tested.

6.1 Development of the ENA pole fire test method

The aim in developing the method was to have a test that would predict the outcome observed in the field when preservative-treated hardwood poles are exposed to a severe bushfire, that is, that CCA-treated hardwood poles are likely to be seriously damaged and creosote-treated hardwood poles are likely to survive with minimal damage. The original intent was to use three of the factors that contribute to a severe bushfire exposure on a wood pole in service – a) high heat fluxes, b) flame contact from the fire font and adjacent burning vegetation and c) a wind that accompanies the passage of the fire front and persists for some time thereafter.

It is also evident from experience and anecdote that the damage to CCA-treated hardwood poles can be due to continuing combustion of the poles for a significant period following the passage of the fire front. Poles that were assessed as only lightly damaged immediately after the passage of a bushfire were found to be seriously damaged when re-inspected the next day (D. Price, pers. com.). For this reason, specimens were to be observed for up to four hours after the start of the fire test exposure, and if there was still evidence of combustion at that stage, they would be retained without wind exposure overnight and inspected 24 hours after the test start.

It was decided early in the project planning that imposing a wind on the specimens during the fire test exposure would not be possible with the equipment configuration that would be used. It was also decided that the testing would be easier to manage if the three and three quarter hour observation period after the fire test exposure was conducted in a normal laboratory atmosphere rather than with the specimen being exposed to a specified wind.

The test schedule was to firstly determine whether the desired outcome – successful reproduction of field observation of serious damage to CCA-treated hardwood poles and minimal damage to creosote-treated hardwood poles - could be achieved without exposing the specimens to a wind exposure for three and three quarter hours after the ten minute fire test exposure. If the desired outcome could not be achieved without wind exposure, a wind exposure would be introduced. The heat flux would remain constant for each test. Heat flux would start at 40 kW/m^2 and increase to a maximum of 60 kW/m^2. Poon (2002) proposed 60 kW/m^2 as a test heat flux for extreme exposures and 40 kW/m^2 is specified as the initial heat flux in AS 1530.8.1 for testing to severe bushfire exposures.

6.1.1 ENA pole fire test outcomes without wind exposure for specimens without fire retardant treatment

Testing without wind exposure was limited to the specimens without fire retardant treatment. The test outcomes varied between specimen types – creosote-treated blackbutt, creosote-treated spotted gum, CCA-treated spotted gum and CCA-treated radiata pine.

Creosote-treated spotted gum specimens were tested at heat fluxes of 40, 50 and 60 kW/m^2 without a subsequent four hour wind exposure. Flaming ceased on all specimens in less than 90 seconds after the end of the fire test exposure. Flaming also ceased on the creosote-treated blackbutt specimens in less than 90 seconds after the end of the ten minute 60 kW/m^2 test exposure.

CCA-treated spotted gum specimens were exposed to heat fluxes of 40, 50 and 60 kW/m^2 without a subsequent wind exposure. Flaming ceased on all specimens in less than 25 seconds after the end of the ten minute fire test exposure. One of three specimens tested at 60 kW/m^2 continued to combust in glowing and smouldering modes and was severely damaged 24 hours after the test start.

Two CCA-treated radiata pine specimens were tested without wind exposure. The first was tested at 60 kW/m^2 heat flux and the second at 30 kW/m^2 heat flux. Flaming ceased on both specimens in less than 40 seconds after the end of the fire test exposure. Both specimens subsequently continued to combust in glowing and flaming modes and were severely damaged 24 hours after the test start.

The testing without wind exposure demonstrated a difference in the susceptibility to fire damage of creosote-treated hardwood, CCA-treated hardwood and CCA-treated radiata pine specimens. The creosote-treated blackbutt tested at 60 kW/m^2 heat flux and creosote-treated spotted gum specimens tested at 50 and 60 kW/m^2 heat fluxes survived the test with minimal damage. All CCA-treated spotted gum specimens tested at 40 and 50 kW/m^2 heat fluxes and two of three replicates of CCA-treated spotted gum tested at 60 kW/m^2 heat flux survived with minimal damage. The third CCA-treated spotted gum specimen tested at 60 kW/m^2 heat flux was seriously damaged. The radiata pine specimens tested at 30 and 60 kW/m^2 heat fluxes were seriously damaged.

As the test criterion required that duplicate specimens achieved the test outcome, and two of three CCA-treated spotted gum replicates survived the test with minimal damage, testing at a heat flux of 60 kW/m^2 without wind exposure was not an adequate method for assessing the fire test performance of wood poles.

6.1.2 Maximum surface temperature in four hour period after ENA pole fire test start for specimens without a subsequent wind exposure

After the ten minute fire test exposure, the maximum temperature of all specimens, after the second test in the series, was monitored by scanning with a Flir ThermaCAM EX 320 infrared camera. The data provided an insight into the inherent difference in performance of CCA-treated and creosote-treated hardwood poles in service.

The maximum surface temperature of the creosote-treated specimens was less than 150 ^{o}C 15 minutes after the end of the ten minute fire test exposure and these temperatures reduced with time. The maximum surface temperature of the CCA-treated spotted gum and CCA-treated radiata pine specimens ranged from 486 ^{o}C to 566 ^{o}C 15 minutes after the end of the fire test exposure. These temperatures were generally recorded in very small areas on the specimen surface and there was often no visible evidence of combustion – visible smoke and/or glowing or flaming combustion. Thus there was evidence from the infrared imaging of glowing combustion on all CCA-treated specimens 15 minutes after they were removed from the ten minute fire test exposure, and many of these glowing combustions were not visible to the naked eye. An infrared image of a glowing combustion in CCA-treated spotted gum is shown in Figure 26.

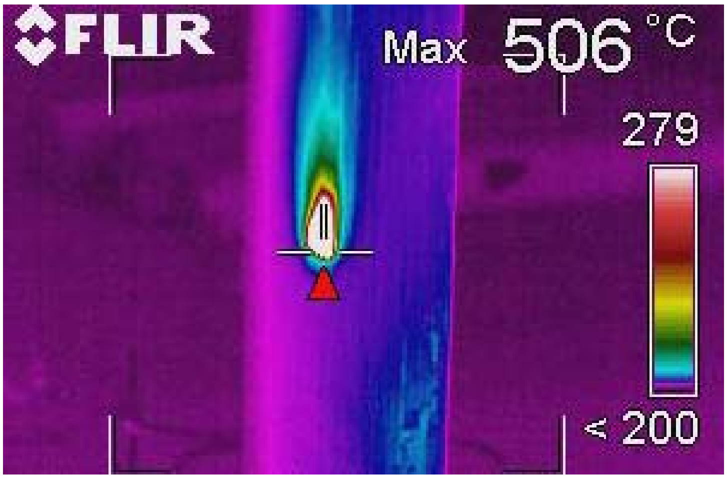

Figure 26 Infrared image of glowing combustion in CCA-treated spotted gum

These glowing combustions are evidence of the afterglow phenomenon in CCA-treated softwood and hardwood specimens. Without wind exposure, these glowing combustions self-extingusished in all CCA-treated spotted gum specimens, with the exception of one tested at 60 kW/m^2 heat flux. In both CCA-treated radiata pine specimens these glowing combustions continued and developed into flaming combustion and resulted in the destruction of both specimens.

6.1.3 ENA pole fire test outcomes with 2 m/s wind exposure for specimens without fire retardant treatment

After the ten minute fire test exposure, specimens without fire retardant treatment were subjected to a 2 m/s wind exposure on the surface exposed to the radiant panel because testing without a wind exposure failed to produce the test outcome required – CCA-treated spotted gum specimens severely damaged and creosote-treated blackbutt and creosote-treated spotted gum specimens suffering minimal damage.

The creosote-treated blackbutt and creosote-treated spotted gum specimens were cooled by the 2 m/s wind exposure – i.e. the maximum surface temperature after the fire test exposure reduced more rapidly when the specimens were exposed to wind than when they were not.

The glowing combustion in the CCA-treated spotted gum specimens was accelerated by the 2 m/s wind exposure and progressed to flaming combustion. This resulted in all CCA-treated spotted gum specimens being severely damaged during the three and three quarter hours 2 m/s wind exposure. Maximum surface temperatures were higher during the three and three quarter hours post-fire test exposure period for the CCA-treated spotted gum specimens exposed to the 2 m/s wind than those that were not exposed to wind. The resultant damage to CCA-treated spotted gum specimens was greater 24 hours after the ENA pole fire test start when they were subjected to a 2 m/s wind exposure.

The CCA-treated radiata pine specimens were not subjected to a 2 m/s wind exposure as they were seriously damaged during testing without a wind exposure.

As testing with a 2 m/s wind exposure resulted in serious damage to CCA-treated spotted gum specimens and minimal damage to creosote-treated blackbutt and creosote-treated spotted gum specimens, testing with a 2 m/s wind exposure was used for assessing the efficacy of fire retardant treatments.

6.2 Comparison of ENA pole fire test and AS 1530.8.1 methods

The ENA pole fire test and AS 1530.8.1 methods vary in four ways:

- The ENA pole fire test method allows for non-piloted ignition of specimens before the ring burner is ignited. Ignition in the AS 1530.8.1 test will be piloted because of the presence of the burning crib from the start of the test.
- The radiant energy impressed on the specimens varies considerably. The energy incident on the ENA pole fire test specimen is 36 MJ/m^2 when an exposure flux of 60 kW/m^2 is used. Specimens are subjected to 9 MJ/m^2 during the AS 1530.8.1 test.
- The energy output also varies between the ring burner in the ENA pole fire test and the AS 1530.8.1 Class C crib. The energy output from the ENA pole fire test ring burner is 1.2 MJ and it is 18.75MJ from the AS 1530.8.1 Class C crib. However, in the AS 1530.8.1 test, only the face of the crib adjacent to the specimen and its top radiate to the specimen. Radiation from the other faces of the crib is lost which is not the case with the ring burner of the ENA pole fire test. While not measured in this set of tests, flux from the AS 1530.8.1 crib to a specimen could be as high as 80 kW/m2 compared to the ENA ring burner which produces a flux of about 8-10 kW/m2 because of its thin flame optical thickness. Because radiation is additive, the total exposure in the ENA pole fire test could be as high as 70 kW/m^2 whereas in the AS 1530.8.1 test it might be in the order of 90 or 100 kW/m^2.
- The ENA pole fire test includes subjecting the specimens to a 2 m/s wind and specimens tested to AS 1530.8.1 are not subjected to any wind exposure.

The results obtained by testing specimens to the two methods can vary according to the assessment criteria. The criteria selected for this research are:

- Specimen condition when combustion has ceased or condition at 24 hours after test start, whichever occurs first. These criteria can be applied to both test methods.
- Cessation of flaming by 60 minutes and radiant heat flux 250 mm from the specimen not greater than 3 kW/m^2 between 20 and 60 minutes. These criteria apply to AS 1530.8.1 only.

6.2.1 Comparative results from ENA pole fire test and AS 1530.8.1 methods when final specimen condition is the assessment criterion

When the assessment criteria were the condition of the specimen when there was no evidence of on-going combustion, or specimen condition 24 hours after test start, whichever occurred first, the AS 1530.8.1 method provided the same basic test outcomes for specimens that were not fire retardant treated as the ENA pole fire test, when the latter test was conducted at 60 kW/m^2 heat flux with a subsequent 2 m/s wind exposure i.e. the CCA-treated spotted gum specimen was seriously damaged and the creosote-treated spotted gum specimen survived the test with minimal damage. CCA-treated radiata pine specimens were seriously damaged by both methods, and that was achieved without the 2 m/s wind exposure in the ENA pole fire test method.

The outcomes were not so consistent for the fire retardant-treated specimens. For some specimens the same outcomes were achieved. The Chartek 7 CCA-treated spotted gum and FRX CCA-treated radiata pine specimens survived both tests with minimal damage.

The FireTard 120 CCA-treated spotted gum specimens were seriously damaged when tested by both methods.

For some fire retardant treatments different test outcomes were achieved with the two test methods. FireGuard CCA-treated radiata pine was seriously damaged during the ENA pole fire test but survived the AS 1530.8.1 test with damage limited to the position of the crib. The FireGuard CCA-treated spotted gum specimen survived the AS 1530.8.1 test with damage limited to the position of the crib while two out of three replicates tested by the ENA pole fire test method were more seriously damaged than the creosote-treated spotted gum benchmark specimens. The FRX CCA-treated spotted gum specimen tested to AS 1530.8.1 was more seriously damaged than specimens tested to the ENA pole fire test method.

6.2.2 Comparative results when specified AS 1530.8.1 performance specifications and final specimen condition after AS 1530.8.1 testing are the assessment criteria

The selected AS 1530.8.1 criteria are:

- Cessation of flaming by 60 minutes.
- Radiant heat flux 250 mm from the specimen not greater than 3 kW/m^2 between 20 and 60 minutes for AS 1530.8.1.

The test outcomes vary greatly for specimens when they are assessed a) by the above criteria and b) by their condition 24 hours after the AS 1530.8.1 test start.

The AS 1530.8.1 data are summarized in Table 14.

All specimens tested satisfied the requirement for flaming to have ceased by 60 minutes, but three specimens - CCA-treated spotted gum, FireTard 120 CCA-treated spotted gum and FRX CCA-treated spotted gum were still smouldering at 60 minutes. If smouldering combustion is allowed, considering there was no evidence of flaming from the specimens, these three specimens would have satisfied this test criterion. As these specimens were seriously damaged 23 hours later - i.e. 24 hours after the AS 1530.8.1 test start, the observation of flaming cessation at 60 minutes was not a reliable indicator of final specimen condition.

Only three specimens satisfied the requirement that radiant heat flux 250 mm from the specimen is not greater than 3 kW/m^2 between 20 and 60 minutes – creosote-treated spotted gum, FRX CCA-treated spotted gum and FireGuard CCA-treated radiata pine. This would be an acceptable outcome for the creosote-treated spotted gum and FireGuard CCA-treated radiata pine specimens as both these specimens had suffered minimal damage when they were assessed 24 hours after the AS 1530.8.1 test start. However, the FRX CCA-treated spotted gum specimen was severely damaged when assessed 24 hours after the test start. Three specimens that failed to meet this criterion – Chartek 7 CCA-treated spotted gum, FireGuard CCA-treated spotted gum and FRX CCA-treated radiata pine, had also suffered minimal damage when assessed 24 hours after the AS 1530.8.1 test start.

The specimens that failed to meet either one or both of the test criteria would have been deemed to fail the test. This would have been a correct outcome for the CCA-treated spotted gum and the FireTard 120 CCA-treated spotted gum specimens which were seriously damaged at 24 hours after the AS 1530.8.1 test start but an incorrect outcome for the Chartek 7 CCA-treated spotted gum, FireGuard CCA-treated spotted gum, and FRX CCA-treated radiata pine specimens which had suffered minimal damage when assessed 24 hours after the AS 1530.8.1 test start.

These data demonstrate that the AS 1530.8.1 performance criteria that were selected could not reliably predict the final condition of the specimens 24 hours after the AS 1530.8.1 test start.

6.3 Relevance of the ENA pole fire test and AS 1530.8.1 methods

6.3.1 Relevance of the ENA pole fire test method

The criteria for a large-scale fire test method being an acceptable predictor of the fate of wood poles exposed to a severe bushfire is that the test will result in CCA-treated hardwood specimens being severely damaged and creosote-treated hardwood specimens suffering minimal damage, as observed in field situations. The test must also predict this outcome for poles several hours, and up to 24 hours, after the fire test exposure. This was needed because in real fire situations, CCA-treated poles have continued to combust, and the level of damage increase, for periods well in excess of the time they were exposed to the passage of the fire front.

The ENA pole fire test developed in this project – 60 kW/m^2 heat flux for the full ten minutes of the test and flame contact from a 40 kW ring burner for the last five minutes of the test, followed by a 2 m/s wind exposure to the specimen surface exposed to the radiant panel for up to four hours after the test start, satisfies the criteria for an acceptable large-scale test for wood poles. It could be argued that the ten minute exposure to 60 kW/m^2 heat flux is excessive. Poon (2002) recommends exposing specimens tested to the extreme bushfire hazard to the equivalent of four minutes at 60 kW/m^2 heat flux. As creosote-treated spotted gum specimens were not seriously damaged after ten minutes exposure to 60 kW/m^2 heat flux, the ten minute exposure is considered to be relevant. At this heat flux a subsequent 2 m/s wind exposure was needed to reliably result in severe damage to CCA-treated spotted gum specimens. A CCA-treated spotted gum specimen was seriously damaged after exposure to 40 kW/m^2 heat flux and a subsequent 2 m/s wind exposure, but the higher heat flux (60 kW/m^2) was selected because creosote-treated blackbutt and creosote-treated spotted gum specimens survived this heat flux with minimal damage. Testing at 60 kW/m^2 heat flux with a subsequent 2 m/s wind exposure will identify specimens that perform up to the level of creosote-treated hardwoods. Testing at 40 kW/m^2 heat flux and a subsequent 2 m/s wind exposure would have identified specimens that perform better than CCA-treated hardwoods. It is possible that some of the fire retardant treatments that performed poorly or variably when tested to the ENA pole fire test method may have performed better if tested at 40 kW/m^2 heat flux.

The inclusion of a 2 m/s wind exposure in the ENA pole fire test method is also reflecting reality. This research has demonstrated that a subsequent wind exposure is needed to reliably cause serious damage in CCA-treated spotted gum specimens when they are exposed to a heat flux that has been proposed (Poon (2002)) for testing to extreme bushfire hazard.

The ENA pole fire test method is considered to be a relevant method for assessing the performance of poles exposed to a severe bushfire because:

- It includes all the factors relevant to exposure from a severe bushfire – high heat flux, flame contact from the ring burner simulating flame contact from the flame front and adjacent burning vegetation and a wind that persists for a period following the passage of the fire front and
- It also results in test outcomes that are seen in real life – serious damage to CCA-treated hardwood poles and minimal damage to creosote-treated hardwood poles.

6.3.2 Relevance of the AS 1530.8.1 test method

There are several factors that need to be considered with this test method:

- Due to the lower heat flux from the radiant panel, this test method is less severe on fire retardant treatments that rely on coatings for efficacy. This was illustrated with the FireGuard fire retardant treatment. The FireGuard coating failed on the specimen surface exposed to the radiant panel, to varying degrees, after about six minutes in the ENA pole fire test allowing small glowing ignitions to be established on the underlying pole surface, resulting in specimens being damaged during the subsequent wind exposure. Except for the specimen surface adjacent to the timber crib, the coating remained intact during the AS 1530.8.1 testing and damage was limited to charring at the crib position.
- The AS 1530.8.1 Class C timber crib is a more severe exposure simulating the impact of adjacent burning vegetation than the 40 kW ring burner used in the ENA pole fire test. This is demonstrated by the greater char depth (15 mm) on the benchmark creosote-treated spotted gum specimen adjacent to the AS 1530.8.1 crib compared to the char depth (5 mm) adjacent to the ring burner in the ENA pole fire test. It is also illustrated by the fact that non-fire-retardant-treated CCA-treated spotted gum specimens were seriously damaged after testing to AS 1530.8.1 (with a maximum heat flux of 40 kW/m^2) but required a 2 m/s wind exposure to effect serious damage after testing at 40 kW/m^2 by the ENA pole fire test method.
- The test has a 60 minute duration. If the test was terminated at this time, specimen damage would have been limited to small amounts of charring on some specimens on the surface exposed to the radiant panel and charring to greater depths on all specimens adjacent to the crib position. The condition of some specimens continued to deteriorate over the next 23 hours due to on-going combustion.

In its current form, the AS 1530.8.1 test method is not a suitable method for assessing the fire performance of preservative-treated wood poles and fire retardant treatments.

The following amendments to the method are recommended to make it a relevant fire test method for assessing the fire performance of poles and fire retardant treatments exposed to bushfires of lower categories i.e. when poles are unlikely to be exposed to flame contact from the fire front and will be exposed to lower heat fluxes and/or flame contact from adjacent burning vegetation.

- Extend the term of the test to a maximum of 24 hours, in accordance with the requirements specified in the ENA pole fire test method.
- Apply the same specimen assessment criteria as those specified in the ENA pole fire test method.

6.4 Efficacy of the fire retardant treatments

The final condition of the fire retardant-treated specimens determines the efficacy of the fire retardant treatments. The aim of the research was to identify fire retardant treatments that would allow fire retardant-treated CCA-treated specimens to perform as well in the fire test as creosote-treated spotted gum specimens.

The test program demonstrated that there were varying degrees of protection provided by the fire retardant treatments. Therefore, the following classifications of efficacy have been used to cover the range of protection provided by the fire retardant treatments:

- Excellent – fire retardant treatment provides sufficient protection to CCA-treated hardwood specimens to limit fire test damage to the same, or less, than that suffered by creosote-treated spotted gum specimens. Because of their higher charring rates, greater char depths are acceptable in fire retardant-treated CCA-treated softwood specimens.
- Fair – fire retardant CCA-treated specimens are more severely damaged by the fire test than creosote-treated spotted gum, but much less seriously damaged than CCA-treated hardwood specimens tested without fire retardant treatment. If it was considered that a CCA-treated pole in service would not fail if it suffered similar damage from exposure to a severe bushfire, the fire retardant treatment efficacy was classified as fair.
- Poor – fire retardant CCA-treated specimens are severely damaged by the fire test. That damage would be similar to that suffered by CCA-treated hardwood specimens without fire retardant treatment. If it was considered that a CCA-treated pole in service would fail if it suffered similar damage from exposure to a severe bushfire, the fire retardant treatment efficacy was classified as poor.

The assessment of fire retardant efficacy sometimes vaied with the fire test method that was used.

6.4.1 Efficacy of Chartek 7

Chartek 7 was applied to CCA-treated spotted gum and tested by the ENA pole fire test and AS 1530.8.1 methods. The efficacy was assessed as excellent from both tests

6.4.2 Efficacy of FireGuard

FireGuard was applied to CCA-treated spotted gum and CCA-treated radiata pine specimens and was tested by the ENA pole fire test and AS 1530.8.1 methods. The efficacy assessment of this fire retardant treatment varied between fire test methods.

6.4.2.1 Efficacy of FireGuard when tested by ENA pole fire test method

The FireGuard efficacy was assessed as fair when applied to CCA-treated spotted gum specimens tested by the ENA pole fire test method. Of three specimens tested, one suffered only surface charring. The remaining two specimens were more severely damaged but the damage did not increase after the 2 m/s wind exposure was stopped, four hours after the ENA pole fire test start.

The FireGuard efficacy was assessed as poor when applied to CCA-treated radiata pine specimens tested by the ENA pole fire test method. Two FireGuard CCA-treated radiata pine specimens were tested and both tests were terminated after one hour.

6.4.2.2 Efficacy of FireGuard when tested by AS 1530.8.1

The efficacy of FireGuard was assessed as excellent when applied to both CCA-treated spotted gum and CCA-treated radiata pine specimens and tested by the AS 1530.8.1 method.

6.4.3 Efficacy of FireTard 120

The efficacy of FireTard 120 was assessed as poor when applied to CCA-treated spotted gum and tested by the ENA pole fire test and AS 1530.8.1 methods.

6.4.4 Efficacy of FRX

FRX was applied to CCA-treated spotted gum and CCA-treated radiata pine specimens and was tested by the ENA pole fire test and AS 1530.8.1 methods. The efficacy assessment of this fire retardant treatment varied between fire tests.

6.4.4.1 Efficacy of FRX when tested by ENA pole fire test method

The efficacy of FRX was assessed as fair when applied to CCA-treated spotted gum and excellent when applied to CCA-treated radiata pine specimens and tested by the ENA pole fire test method.

6.4.4.2 Efficacy of FRX when tested by AS 1530.8.1

The efficacy of FRX was assessed as poor when applied to CCA-treated spotted gum and excellent when applied to CCA-treated radiata pine specimens and tested by the AS 1530.8.1 method.

6.5 Summary of efficacy classifications for fire retardant treatments when tested by the ENA pole fire test and AS 1530.8.1 methods

The efficacies of the fire retardant treatments when determined by testing to the ENA pole fire test and AS 1530.8.1 methods are summarized in Table 16.

Table 16 Efficacies of fire retardant treatments determined by testing to ENA pole fire test and AS 1530.8.1 methods

Fire retardant	Pole specimen	Rating	
		ENA pole fire test	AS 1530.8.1
Chartek 7	CCA SG(1)	Excellent	Excellent
FireGuard	CCA SG	Fair	Excellent
FireGuard	CCA RP(2)	Poor	Excellent
FireTard 120	CCA SG	Poor	Poor
FRX	CCA SG	Fair	Poor
FRX	CCA RP	Excellent	Excellent

Notes: 1 - CCA/SG = CCA-treated spotted gum
2 - CCA/RP = CCA-treated radiata pine

For the six combinations of fire retardant and pole specimen type tested, the ENA pole fire test and the amended AS 1530.8.1 methods classified the performance of the specimens as the same in three cases and different in three cases.

The combinations classified the same by both methods were the Chatek 7 CCA-treated spotted gum and FRX CCA-treated radiata pine specimens, which were both classified as excellent and the FireTard 120 CCA-treated spotted gum specimens which were classified as poor when tested by both methods.

The combinations classified differently when tested by both methods were the FireGuard CCA-treated spotted gum, FireGuard CCA-treated radiata pine and the FRX CCA-treated spotted gum. Possible reasons for the different test outcomes are:

- The FireGuard CCA-treated spotted gum and FireGuard CCA-treated radiata pine specimens were classified better when tested to AS 1530.8.1 than to the ENA pole fire test method. This was due to the FireGuard coating remaining intact during the AS 1530.8.1 testing, except adjacent to where the crib was placed. While there was significant combustion in the FireGuard-coated specimens adjacent to the crib position, on-going combustion away from this point was probably limited by oxygen being excluded by the intact FireGuard coating on the rest of the specimen surface. The FireGuard coating became detached in some areas on specimens after about six minutes exposure to the radiant heat flux in the ENA pole fire test.
- The poorer performance of the FRX CCA-treated spotted gum specimen, when tested to AS 1530.8.1 rather than the ENA pole fire test, was probably due to the very severe impact of the Class C crib. This is illustrated by the performance of non-fire-retardant-treated CCA-treated spotted gum when it was tested to AS 1530.8.1 and when it was tested during the development of the ENA pole fire test method. When non-fire-retardant-treated CCA-treated spotted gum was exposed to 40 kW/m^2 and the ring burner and no subsequent wind exposure during development of the ENA pole fire test, glowing ignitions were established but they had self-extinguished in five hours resulting in the specimen suffering minimal damage. When non-fire-retardant-treated CCA-treated spotted gum was tested to AS 1530.8.1 the specimen was severely damaged, even though the total heat flux from the radiant panel was much less than that from the radiant panel when the specimen was exposed to 40 kW/m^2 and no subsequent wind exposure during development of the ENA pole fire test. Thus the FRX was a) providing protection to the CCA-treated spotted gum specimens against the initiation and development of the smaller glowing ignitions in the ENA pole fire test, even when their development was encouraged by exposure to the 2 m/s wind but b) did not provide adequate protection for the CCA-treated spotted gum specimen against the more severe combustion established by the AS 1530.8.1 Class C crib.

The better performance of the FRX CCA-treated radiata pine specimens in both the ENA pole fire and AS 1530.8.1 tests, compared to that of the FRX CCA-treated spotted gum specimens, may be due to two factors. The FRX only penetrated the sapwood of both the CCA-treated spotted gum and CCA-treated radiata pine specimens. The maximum sapwood thickness in the CCA-treated spotted gum specimens was 30 mm and it ranged from 70 to 160 mm in the CCA-treated radiata pine specimens. Thus a much greater depth of specimen was protected in the FRX CCA-treated radiata pine specimens. The mean FRX retention in the sapwood of the FRX CCA-treated radiata pine specimens was also higher (75.2 kg/m^3) than in the sapwood of the FRX CCA-treated spotted gum specimens (60.9). The lower FRX retention in the FRX CCA-treated spotted gum specimens may have contributed to their poorer performance, compared to FRX CCA-treated radiata pine specimens, when tested to both the ENA pole fire test and AS 1530.8.1 methods.

7 Recommendations

7.1 Recommended fire test methods

The following test methods are recommended.

7.1.1 ENA pole fire test method

The ENA pole fire test method is recommended as a method for assessing a) the performance of poles subjected to severe bushfire attack where exposure to high heat fluxes and flame contact from the fire front and adjacent burning vegetation are likely and b) the efficacy of fire retardant treatments that may be used to reduce damage to poles exposed to a severe bushfire.

The method is:

- Specimens shall be of typical pole diameter and a minimum length of 2 m.
- All fire retardant-treated specimens shall be subjected to ASTM D2898 accelerated weathering regime with UV exposure added during the drying cycle prior to testing. Specimens shall be reconditioned to a moisture content less than 15% following ASTM D2898 weathering.
- When fire retardant treatments are being assessed, they shall be applied to CCA-treated specimens with preservative retentions typical of poles in service.
- When fire retardant treatments, or novel preservative formulations, are being assessed, they shall be applied to the timber type (hardwood or softwood) that they would be applied to in service.
- Specimens are exposed to 60 kW/m^2 heat flux for ten minutes.
- A 40 kW output ring burner is ignited at five minutes into the ENA pole fire test and maintained for five minutes.
- Maximum surface temperature of specimens is monitored by scanning them with an infra red camera following the fire test exposure and up to a maximum of four hours after the ENA pole fire test start.
- Specimens are exposed to a 2 m/s wind within five minutes following the ENA pole fire test exposure. The 2 m/s wind exposure is maintained until four hours after the ENA pole fire test start, unless the test is terminated within that time.
- Ignitions on the specimen above the level of the top of the radiant panel shall be extinguished during the 2 m/s wind exposure.
- Unless the test has been terminated by four hours after the test start, specimens will be retained in the laboratory and examined 24 hours after the test start.
- The test shall be terminated when:
  a) There is no evidence of combustion and the maximum surface temperature is less than 200 ^{o}C, or
  b) The specimen is so severely damaged it is considered likely to collapse, or
  c) Twenty four hours have elapsed after the test start, whichever occurs first.
- Specimens shall be inspected after test termination and rated for performance. Specimens shall be rated:
  a) Excellent, if damage is limited to surface charring of less than 5 mm depth for hardwoods and 10 mm for softwoods.
  b) Fair, if damage exceeds the criteria for excellent, but the damage is considered to be insufficient to cause structural failure if it were present in a pole in service.

c) Poor – if the specimen is severely damaged and the damage is considered to be sufficient to cause structural failure if it were present in a pole in service.

- A minimum of two and a maximum of three specimens shall be tested. Duplicate results shall be required for a test outcome.

7.1.2 AS 1530.8.1

AS 1530.8.1 is recommended as a method for assessing a) the performance of poles subjected to bushfire attack where they are unlikely to be exposed to flame contact from the fire front but where exposure to lower heat fluxes and/or flame contact from adjacent burning vegetation is likely and b) the efficacy of fire retardant treatments that may be used to reduce damage to poles exposed to these bushfire hazards.

The method is:

- Specimens shall be of typical pole diameter and a minimum length of 2 m.
- All fire retardant-treated specimens shall be subjected to ASTM D2898 accelerated weathering regime with UV exposure added during the drying cycle prior to testing. Specimens shall be reconditioned to a moisture content less than 15% following ASTM D2898 weathering.
- When fire retardant treatments are being assessed, they shall be applied to CCA-treated specimens with preservative retentions typical of poles in service.
- When fire retardant treatments, or novel preservative formulations, are being assessed, they shall be applied to the timber type (hardwood or softwood) that they would be applied to in service.
- Specimens are exposed to the AS 1530.8.1 heat flux profile for severe bushfire exposure – i.e. heat flux profile starts at 40 kW/m^2 and reduces to 3 kW/m^2 over the test period.
- A Class C timber crib is used.
- Maximum surface temperature of specimens is monitored by scanning them with an infrared camera following the fire test exposure and up to a maximum of four hours after the AS 1530.8.1 test start.
- Unless the test has been terminated at or before four hours after the AS 1530.8.1 test start, specimens will be retained in the laboratory and examined 24 hours after the test start.
- The test shall be terminated when:
  a) There is no evidence of combustion and the maximum surface temperature is less than 200 ^oC, or
  b) The specimen is so severely damaged it is considered likely to collapse, or
  c) Twenty-four hours have elapsed after the test start, whichever occurs first.
- Specimens shall be inspected after test termination and rated for performance. Specimens shall be rated:
  a) Excellent, if damage is limited to charring of less than 5 mm depth for hardwoods and 10 mm for softwoods generally on the fire-exposed face of the specimen. Charring to a depth of 20 mm for hardwoods and 50 mm for softwoods shall be permitted adjacent to the crib position.
  b) Fair, if damage exceeds the criteria for excellent, but the damage is considered to be insufficient to cause structural failure if it were present in a pole in service.
  c) Poor – if the specimen is severely damaged and the damage is considered to be sufficient to cause structural failure if it were present in a pole in service.
- A minimum of two and a maximum of three specimens shall be tested. Duplicate results shall be required for a test outcome.

8 Conclusions

A fire test method – ENA pole fire test method - has been developed that is suitable for assessing the performance of poles exposed to severe bushfires, where poles are likely to be exposed to high heat fluxes and flame contact from the fire front and adjacent burning vegetation. The method is also suitable for determining the ability of fire retardant treatments to protect poles exposed to severe bushfires.

The research also demonstrated that the susceptibility of preservative-treated wood poles to damage from severe bushfires will be influenced by the wood species and preservative treatment, with CCA-treated radiata pine being the most susceptible followed by CCA-treated spotted gum, with creosote-treated hardwoods being resistant to fire damage.

The efficacy of four fire retardants applied to CCA-treated spotted gum specimens and two applied to CCA-treated radiata pine specimens was assessed by this method. The efficacy of the fire retardants ranged from ratings of poor to excellent and in one case the efficacy rating varied depending whether the fire retardant was applied to CCA-treated hardwood or CCA-treated softwood specimens.

A recently published Standards Australia test method – AS 1530.8.1, was also assessed to determine its suitability for assessing the performance of poles exposed to bushfires. Two AS 1530.8.1 performance criteria were selected for the testing but were found to be not relevant for the testing of wood poles. Recommendations for amendments to the method have been made to make it suitable as a test for poles and fire retardant treatments exposed to bushfires where the hazard is unlikely to include flame contact from the fire front and will involve lower heat fluxes and/or flame contact from adjacent burning vegetation.

9 Literature references

BlueScope Steel. CSIRO tests confirm rural advantages for SURELINE. BlueScope Steel. 2006.

Dale F.A. Fence posts and fire. Forest Products Newsletter Number 328. CSIRO Division of Forest Products. April 1966.

Emergency Management Australia. Emergency Management Australia Disasters database. Emergency Management Australia. Attorney General's Department. Australian Government, 2006.

Energy Networks Association. Australian timber pole resources for energy networks – a review. Energy Networks Association, Australia 2006.

Gardner W.D., Page L.G. and Marchant J.F. Survey of the performance of preservative-treated blackbutt and spotted gum poles in New South Wales. Unpublished report. Forest Research and Development Division, State Forests of New South Wales. July 1998.

Keating W.G. The behaviour of pressure-creosote poles in bushfires. CSIRO Forest Products Newsletter Number 286. CSIRO Division of Forest Products. June 1962.

Poon L. Literature review of bushfire construction materials and proposed test protocols for performance assessment. WFRA Project 20551. Warrington Fire Research 2002.

Webb R., Davis C.J. and. Lellyet S. Meteorological aspects of the ACT bushfires of January 2003. Bushfire 2004 Conference Proceedings. Adelaide. May 2004.

WesternPower. New program to introduce steel poles. Media update. 23 November 2005.

WesternPower. Fire retardant paint to increase reliability. Media update. 10 December 2007.

10 Acknowledgements

The funding and/or in-kind support of Arch Wood Protection, Chemco Inc., Energy Networks Association, Forest and Wood Products Australia, International Paint, Koppers Wood Products, Osmose, Preschem Pty Ltd and Forest Products Commission, Western Australian is acknowledged.

The authors acknowledge the assistance provided by Integral Energy and Country Energy in providing poles and assisting in specimen preparation.

The authors acknowledge the cooperation and professional input of Mike White and the staff at Western Fire Center, which were key factors in the successful outcome of the project.