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Heat disinfestation of decorative, high value wooden paneling—an alternative to fumigation

JONATHAN BANKS[1*], MARK SHEPPARD[2]

[1]*Grainsmith Pty Ltd, 10 Beltana Rd., Pialligo, ACT 2609, Australia*

ABSTRACT

Wooden paneling, installed in some reception areas in a newly constructed hospital building, was found infested with the powderpost beetle, *Lyctus brunneus*. It was necessary to eliminate this infestation rapidly to prevent further damage to the paneling and avoid delays in hand-over of the premises. Heating to equivalent of ISPM 15 (>56°C for >30 min) was used as a disinfestation measure. Panel sections were individually treated using an improvised system of hot air blowers as heat sources applied to the outer face of the panel, with heat retained using insulated plywood plenums temporarily fitted over the panel. Most infestations were eliminated in the first series of treatments, but there were three instances of survival, evidenced by continued production of wood powder borings, requiring localized retreatment. Heat treatment was chosen as the most appropriate disinfestation system available. It was sufficiently rapid and also allowed continuing construction and fit-out activities in the affected area during treatment. Localised fumigation would have been difficult to carry out effectively, with risk of loss of fumigant into lift shafts, wall cavities and other voids and workspaces. It would also have required the premises to be vacated during the treatment. Residual chemical treatment would have been too slow and uncertain and also inappropriate in the hospital setting.

Key words: Fumigation alternatives, Heat disinfestation, Rapid treatment options, Wood borers

Sheoak (*Casurina* sp.) wood panelling in a new building at an advanced stage of construction (Fiona Stanley Hospital, Perth) was found infested with wood borers (powderpost beetles (*Lyctus brunneus*(Stephens))). The panelling was made from timber sourced from the site on which the hospital was being built and was unique, valuable and decorative. It had received no insecticidal treatment from time of harvesting. Part of the decorative appeal of the panelling was the patches of light coloured wood in the predominantly darker brown sheoak wood with its characteristic oak patterning. This light coloured sapwood is a particularly infestible material.

The panelling was installed around the lift wells on four floors, with further areas behind some reception and staff areas. It is assumed that the wood was infested prior to installation and not infested *in situ*. At the time the infestation was detected, by presence of characteristic borings accumulating on the floor below the panels, the building was still in fit-out stage and had not yet been handed over for use. The insects were able to emerge directly through the multi-coat gloss finish on the external face of the panels.

The infestation had to be eliminated rapidly to avoid further damage to the panelling and to avoid any delay in building handover. The panelling had to be treated *in situ*. Removal and treatment off site was uneconomic and impractical.

Several *in situ* treatment options – fumigation, insecticide treatment, heat disinfestation and trapping - were considered for this particular situation, with disinfestation by heat treatment chosen as the most suitable. The treatment had to be both fully effective and rapid. While trapping may have been successful in the long term, it would not have halted damage and would not be rapid enough as a treatment to meet the tight handover schedule. Injection of insecticide, such as permethrin, into emergence holes or applied

[2]PEST Australia Pty Ltd, Pest Management Consulting, Australia

[*]Corresponding author e-mail: *apples3@bigpond.com*

as an insecticide-impregnated lacquer, was considered unsuitable because it was uncertain if it had been fully effective, could not be applied to the existing high grade finish of the panels and left residues possibly of concern in a hospital setting. With methyl bromide no longer allowable because of phaseout under the Montreal Protocol control measures, the only registered fumigants available were phosphine and sulphuryl fluoride. Phosphine was not regarded as suitable because of the extended exposure time required and corrosion risk to the already installed electronic controls of the lifts. Fumigation with sulphuryl fluoride would have been problematic because of difficulties with creating suitable sealed enclosures around the various lift wells and voids behind the panels over the four floors, and would also have required evacuation of the adjacent work areas during the set up and treatment.

Heat treatment could be carried out rapidly and did not interfere with continuing work in the area. Preliminary tests showed that insecticidal temperatures could be achieved without affecting the quality of the finish on the wooden panels or the panels themselves.

MATERIALS AND METHODS

Situation to be treated: The decorative panels were composed of sheoak (*Casurina*sp.) wood blocks of width 120 mm, various lengths, typically around 220 mm, and thickness 8 mm. These were located over 4 floors of the building, around the lift well entrances and in some public areas close by (Fig. 1). The largest panels were about 5.5 m^2 and smallest about 0.9 m^2, with a treated area of 278 m^2 over 76 panels in total.

The sheoak panelling was supported on plywood (15 mm) backing. The plywood was fixed on metal battens on a full concrete wall. The exterior surface of the panelling had been coated with a gloss multi-coat finish, probably urethane-based. It was assumed that the plywood was not infestible by the powderpost beetles, though much of it was probably treated during the treatment of the sheoak panels.

Treatment schedule: Treatment aimed to produce a temperature of at least 56°C throughout each panel for at least 30 min, and preferably for 1 h. There are no applicable Australian Standards for heat disinfestation of wood in structures and decorative materials. The version of the International Standard ISPM 15 on treatment of wooden packaging material in international trade, current at the time these treatments (IPPC, 2009), specifies 56°C core temperature shall be maintained for at least 30 min. This is for elimination of infestation of all stages of wood-destroying insects, including both adult insects and developmental stages. This International Standard was taken as advisory in the present treatment. It is noteworthy that the first version of ISPM 15 (FAO, 2002) did make

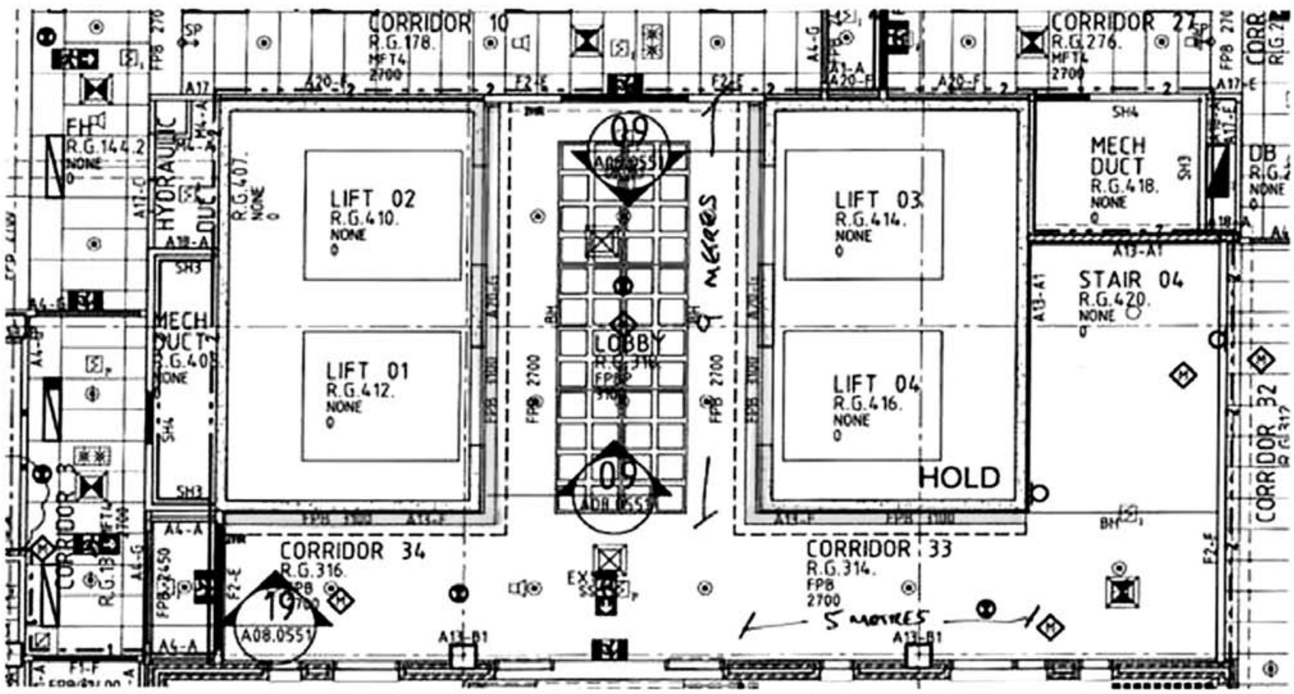

Fig. 1. Floor plan, lift area, ground floor, with position of panelling indicated by green shading

the comment that some Lyctidae were exceptions to the 56°C/30 min schedule, presumably requiring somewhat higher heat dosage.

In absence of data for the inaccessible interface between the back of the sheoak panel and supporting ply, maintenance of a surface temperature of >60°C for 70 min (or equivalent) was used as an operational standard objective to achieve 56°C/30 min or more throughout the sheoak.

Treatment methodology: Prior to treatment, most potentially heat sensitive electrical and electronic components were removed. This included lift indicators, various sensors and switches, and communication devices and their connections. Lift control electronics were left in place, but given some protection from excessive heat by wrapping in sarking.Sarking was also used to cover any holes in the panelling that remained after removal of switches, indicators, communication equipment and the like.

All sheoak panels on each floor, were individually heat treated to insecticidal temperatures. Individual panels were enclosed with a plenum (heating enclosure) fitted to the outer surface of each panel. Each plenum, 150 mm deep, was constructed on a light timber framework with either 3 ply wood or 3 mm MDF panels. Fig. 2 shows a plenum in place on a panel, with heating and monitoring equipment.

Various plenums (enclosures) were made to suit the different panel widths and ceiling heights or location, such as above the lift entrances. Some were made in two sections where required in order to be able to fit the enclosure against the panelling under the recessed lighting structure in the ceiling on some floors.

The inner surface of each plenum was lined with aluminium foil sarking (Silverwrap, R = 1.3, aluminium

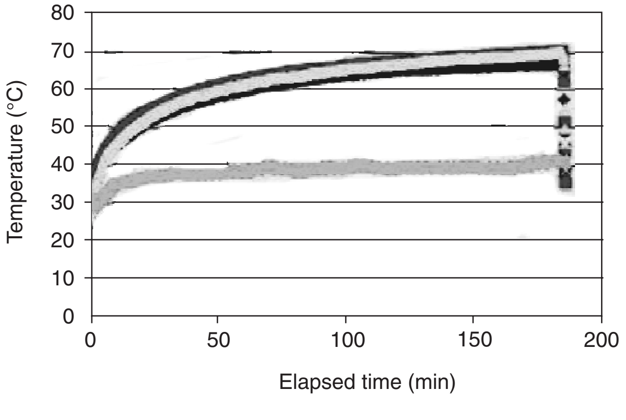

Fig. 2. Typical temperature rise at three points on panel surface during heating, with external temperature of plenum (lowest line).

surface inward) to provide a heat reflectant insulation, retaining heat within the plenum. The enclosures, where they contacted the panelling, were edged with self adhesive foam strips. This provided a resilient seal that was not gastight but was sufficient to retain the heated air within the enclosure while allowing some loss to the outside, thus heating the periphery of the panels.

In a few instances, the available plenum was not sufficiently wide to cover the whole panel under treatment. In these cases, the panel was treated in two sections. In other situations, close to lift wells, the plenum was too wide. Open areas around the back of the plenum were covered with sarking and cloth-backed adhesive tape as appropriate, to retain heat sufficiently to meet treatment requirements.

The plenums were moved between adjacent similar panels after completion of heat treatment on one panel. A smaller version of the plenums was made for spot treatment of infestations that survived the initial series of treatments.

Heat supply and monitoring: Heat was introduced into each plenum using temperature controlled heat guns (Bosch model PHG 630DCE) rated at 0.5 m^3 min^{-1} and set at 150°C output. Larger panels (> 3.5 m^2) were heated using five of these heat guns (Fig. 2), with input through holes in the side of the plenum, spaced approximately equally along the vertical edge of the plenum. Smaller panels were heated with two, three or four heat guns as appropriate. Some large panels required additional heat input to achieve target temperatures in a timely fashion. This was supplied, as needed, by a 1.5 kW electrical fan heater (Microfurnace), ducted into one of the lower ports in the plenum. Heat input was reduced by switching off one or more guns if surface temperatures of the panelling under treatment became excessive (>80°C).

Surface temperatures of panelling under treatment were measured with Type K thermocouples. These were either read from time to time using a hand-held monitor (OneTemp thermometer 303P) or were logged electronically with a 4-channel thermocouple logger (Onset Hobo UX120-014M). Representative surface temperatures were indicated from thermocouples held to the outer panelling surface at various points using adhesive cloth tape. Typically, larger panels had three or more sampling points while the smaller panels only had two points monitored. Where access was possible, a thermocouple was inserted immediately behind the wood panel, in front of the backing board, to indicate penetration of the heating through the panel.

RESULTS

Heating curves: Typically, heat treatment took 3.5 h, with about 2 h or less taken to achieve 60°C at all monitored points and at least 70 min heat soak at that temperature to raise internal temperatures throughout the sheoak wood to >56°C for >30 min. A typical successful heating curve is shown in Fig. 3.

On a few occasions it was possible to insert a thermocouple behind the sheoak panel, between the sheoak and backing plywood. Removal of the lift indicator sometimes revealed an accessible cut surface with the groves at the back of the sheoak providing a channel where it was partly glued to the backing ply.

Observations from an embedded thermocouple supported the assumption that heating and maintaining the outer surface to >60°C led to adequate heat dosage at the rear of the panel of >56°C for an adequate period (Fig. 4).

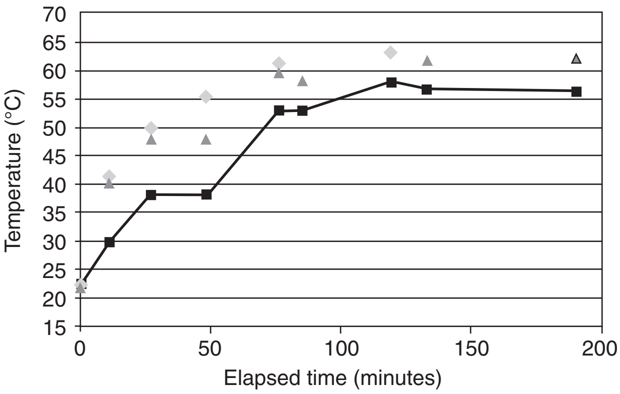

Fig. 3. Heat treatment - Panel 4, Ground floor, showing heat penetration into sheoak wood panelling. Bottom line (pink) shows rise in temperature to >56°C behind the panelling while surface points (data points without line) indicate >60°C.

Fig. 4. Heating enclosure (plenum) in place on Panel 16, First floor, showing installed heat guns and datalogger

Heating results: Detailed assessment of results of the heating obtained for each of the 74 panels treated. in given in Table 1. Treatments for most individual panels exceeded target specifications of a surface temperature of >60°C for 70 min or were slightly below this temperature but for longer.Thus all panels are likely to have received a heat dosage exceeding the ISPM15 specification of > 56°C for >30 min.

Post treatment inspection: New borings were observed from the corner areas of three of the treated panels about 5 days after completion of the first series of treatments. These areas were retreated with heat using small plenums to contain the heat over the localised infestation (Fig. 5). No further infestation was observed. The quality and finish of the wood block panels was unaffected by the treatment as assessed visually.

DISCUSSION

The results provided a practical demonstration of use of heat as an insecticidal treatment, carried out under difficult circumstances and, in this case, providing an alternative to fumigation. The treatments were carried out using inexpensive and readily available equipment, with minimal disruption to continuing building work

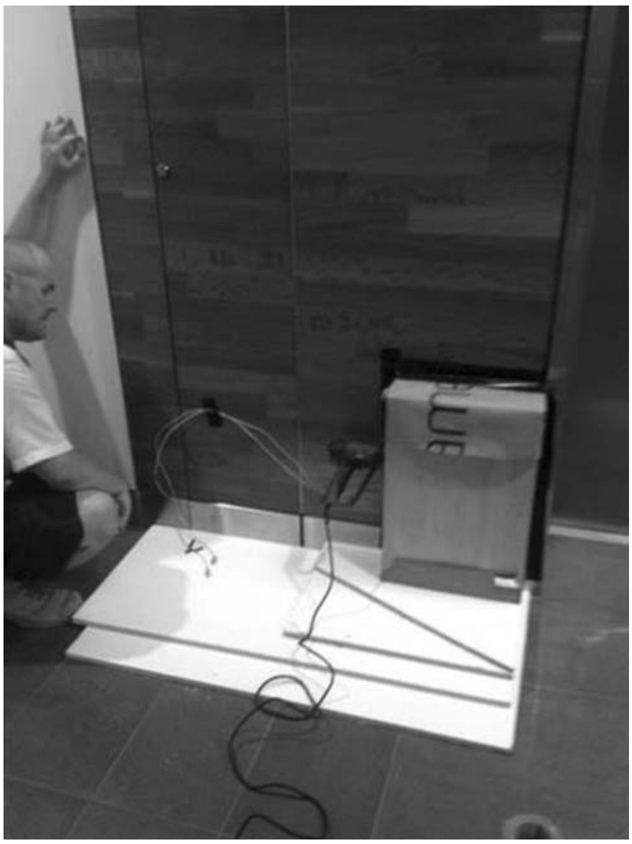

Fig. 5. Small plenum and heat gun in place for retreatment of infestation surviving first treatment series

Table 1 Heat treatment results for individual sheoak panels

Panel location	Panel No.	Panel area (m^2)	Comment	Assessment
Lower ground floor	1	4.52	All points >60ºC for at least 60 min, likely longer	OK
	2	2.57	Two surface points >60ºC for >85 min, point behind panel >56ºC for >30 min	OK
	3	5.36	Temperatures above 56ºC for 150 min	Probably OK
	4	2.57	Temperatures exceeded or much exceeded 60ºC for > 60 min, probably > 80 min	OK
	5	3.52	Two points >60ºC for 70 min, one point >57ºC for 70 min and >60ºC for 47 min	Probably OK
	6	3.52	All points >60ºC for >70 min in total	OK
	7	2.57	Single surface monitoring point exceeded 60ºC for 110 min	OK
	8	5.36	All points >60 for >140 min	OK
	9	2.57	All recorded points > 60ºC for 108 min, point 2 behind panel >56ºC for 60 min	OK
	10	4.52	Temperatures exceeded 60ºC for >100 min	OK
	11	5.53	All points >60ºC for >70 min in total	OK
	12	5.53	All points >60ºC for >130 min in total	OK
	13	5.53	All points >60ºC for more than 70 min	OK
Ground floor	1	4.87	Exceeded 60ºC at all points for at least 60 min, probably much longer (>160 min)	OK retreated
	2	4.87	> 60ºC at 3 of 4 points for >70 min, with remaining point > 56ºC for > 60 min and > 60ºC at end of treatment	Probably OK
	3	4.87	Exceeded 60ºC surface temperatures at all 3 points monitored for > 90 min	OK
	4	4.01	All points likely >56ºC for 4 h, with some exceeding 60 for >3 h	OK
	5	1.81	All lines >56ºC for 1 h, including 2 at depth.	OK
	6	4.72	Treated >3.5 h	OK
	7	1.81	All lines >60ºC for 70 min	OK
	8	3.27	All surface lines had >2 h at >57ºC	Probably OK
	9	3.27	Likely all measured points > 60ºC for 70 min, first panel treated	OK
	10	1.81	Line 2 at >55ºC for 1 h, others >59ºC for 1 h	Probably OK
	11	4.72	Likely all points >62ºC for >60 min	OK
	12	1.81	All surface lines >59ºC for >1 h 50 min, depth line > 56ºC for >70 min	OK
	13	4.01	All points >57ºC for at least 60 min, with >60ºC at end of treatment.	Probably OK
	14	4.87	Likely all points >60ºC for 70 min	OK
	15	4.87	All 4 points >64ºC for >60 min	OK
	16	4.87	All points exceeded 60ºC for >160 min	OK
	1	4.81	All surface points (2) >62ºC for >110 min	OK
First floor	2	4.81	All points >60ºC for >80 min	OK
	3	4.81	All points >61ºC for >70 min	OK
	4	4.01	All points >60ºC for >90 min	OK
	5	1.81	Single point monitored reliably >60ºC for >120 min	OK
	6	4.72	Heating prolonged to allow lowest point to be above 56ºC for >2.5 h, others >60ºC for >2 h	OK

(*continued*)

(Table 1 *continued*)

Panel location	Panel No.	Panel area (m^2)	Comment	Assessment
	7	1.81	Single recorded point >75ºC for 120 min	OK
	8	3.66	All points >60ºC for >80 min	OK
	9	3.66	All points >60ºC for >70 min	OK
	10	1.81	Single point shows >70ºC for >70 min	OK
	11	4.72	Two points >60°C for >2.5 h, one point likely >56ºC for 3h	OK
	12	1.81	All points >64ºC for >100 min, with some temperatures >80ºC	OK
	13	4.01	Both operational points >60ºC for >120 min	OK
	14	4.81	Likely all points >60ºC for >70 min	OK
	15	4.81	Treated >3.5 h	OK
	16	4.81	Treated >3.5 h	OK
	17	0.89	Likely to have exceeded 60ºC for at least 70 min, and probably exceeded 65ºC for 40 min	OK
	18	0.89	All points exceeded or much exceeded 60°C for >70 min	OK
First floor	19	3.83	All points >60ºC for >80 min	OK
reception	20	3.83	All points >64ºC for >60 min	OK
	21	3.83	All points > 62ºC for > 80 min	OK
	22	3.83	All points > 61ºC for > 80 min	OK
	23	3.83	Panel 23 treated in two sections to complete reception wall treatment	OK
First floor	24	3.53	All points >60ºC for >70 min	OK retreated
staff base	25	3.53	All points >60ºC for >100 min	OK
	26	3.58	Treated in 2 parts. Part 1 - all points >64oC for >60 min. Part 2 - final readings indicate >62°C for >60 min	OK
Second floor	1	4.78	Treated >3.5 h, no temperature record	OK
	2	4.78	Treated >3.5 h, no temperature record	OK
	3	4.78	Treated >3.5 h, no temperature record	OK
	4	4.01	Treated >3.5 h, no temperature record	OK
	5	1.81	All two monitored points likely to be >70 for >90 min	OK
	6	4.72	Treated >3.5 h, no temperature record	OK
	7	1.81	All two points >62°C for >90 min	OK
	8	3.66	Likely all points >60°C for >70 min	OK
	9	3.66	Treated >3.5 h	OK retreated
	10	1.81	All points >70°C for >60 min	OK
	11	4.72	Treated >3.5 h	OK
	12	1.81	All points >65°C for at least 70 min	OK
	13	4.01	Two points >65°C for >110 min, other >56°C for >60 min	Probably OK
	14	4.87	Both operational points >60°C for at least 90 min	OK
	15	4.87	All points >60°C for at least 70 min	OK
	16	4.87	All points >60°C for at least 70 min	OK
	17	0.89	All points exceeded 60°C for 67 min, and exceeded 65°C for 40 min	OK
	18	0.89	All points exceeded 58°C for at least 100 min	OK
Second floor	19	3.105	Both monitoring points >60°C for >70 min	OK
satellite	20	3.105	All points (2) >60°C for >70 min	OK
reception	21	3.105	Exceeded 60°C at both points for >90 min	OK

being undertaken in the area.

There appeared to be no accepted heat treatment dosage standard available for the particular situation encountered – presence of wood-destroying pests (beetles) in timber in buildings. While there is much data available on the effects of heat on stored product and timber pests at the research level (Beckett et al., 2007) and specific quarantine treatments using heat (USDA 2016, IPPC 2009), there is little that is generally applicable to the situation encountered here.

A compilation of recognised effective and practical heat treatment schedules for stored products and structures would be most welcome.

ACKNOWLEDGEMENT

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