Technical Letter Report //

Performance Review of Abodo Vulcan Thermally Modified Radiata Pine: Performance for the U.S. Market*

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About Jeffrey Morrell

The author is Distinguished Professor Emeritus at Oregon State University. He holds BSc and PhD degrees in Forest Biology from the State University of New York College of Environmental Science and Forestry at Syracuse and an MSc in Plant Pathology from Penn State. He joined the faculty at Oregon State in 1983 where he directed the timber durability program. He moved to Australia in 2018 to establish the National Centre for Timber Durability and Design Life at the University of the Sunshine Coast. He is active in standards, serving as Chair of the Waterborne Preservative committee for the American Wood Protection Association and Chairs Committee TM-012 for Standards Australia, which deals with timber durability.

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Background

Thermal modification was originally developed in the U.S in the 1930's by Alfred Stamm and co-workers for darkening light woods to render them more marketable in the furniture market, but it also had the ability to improve the moisture resistance of the modified timber. The process was sparingly used, but it saw a resurgence in interest when timber users sought non biocidal methods for protecting timber from decay. Thermal modification has attracted considerable interest in Europe, where regulations regarding the use of traditional wood preservatives have become increasingly restrictive. This has created a relatively robust market for thermally modified cladding and decking.

Interest in thermal modification has also developed in the North American market and several producers now offer decking and other products. However, the market remains small in comparison to traditional pressure treated timber or wood plastic composites.

There are several reasons why the development of markets for thermal modification in the U.S. differs from that in Europe. While European regulators have severely restricted the use of many biocides for consumer products, there are no regulatory drivers in the U.S. beyond the restrictions against the use of chromated copper arsenate (CCA) for residential applications. Treated timber tends to be the least expensive durable product on the market followed by traditional durable timber such as western red cedar or redwood and then by wood/plastic composites (WPC's). While durable timbers and WPC's have sizable market shares, treated timber continues to dominate these applications.

The second reason for the limited market share for thermally modified timber is the presence of subterranean termites in most of the country, especially the southern U.S (Figure 1). Numerous studies have shown that thermally modified timbers have little resistance to termite attack and, in some cases, are more susceptible. This has not completely inhibited the market, but it should be a cause for concern. The other factor that has been considered is the potential effects of the thermal processes on strength and flexural properties; however, these effects are of less concern in applications such as cladding and, to a lesser extent, decking.

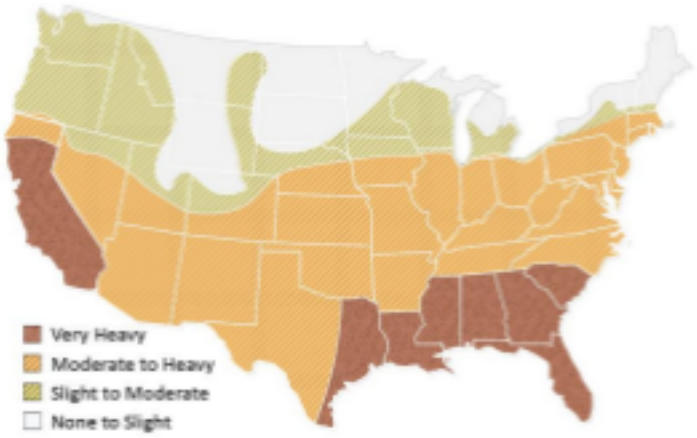

Figure 1. Risk of termite attack across the United States Source: (Building America Solution Center, U.S. Department of Energy's Building Technologies Office).

Building products such as thermally modified timber can be standardised under two systems: the American Wood Protection Association (AWPA) or the Internal Code Council Evaluation Service (ICC-ES). For practical purposes both systems use the same criteria for assessing durability aspects of these products. The AWPA has created a series of guidance documents for standardisation. The most comprehensive of these is Guidance Document A which lays out criteria for specific tests, but Guidance Document N relates to thermally modified timbers.

For the purpose of this review, the tests specified for Guidance Document N will be used along with the acceptance criteria for each of these tests as listed in Guidance Document A.

Soil Block Tests: There are a variety of laboratory tests to determine the decay resistance of thermally treated wood. While the soil block test specified in AWPA Standard E10 is commonly used in North American, the agar block test described in European Standard EN113 is an acceptable alternative.

EN113 laboratory trials of radiata pine thermally modified at 220 or 230° Celsius (°C) and exposed to two brown rot fungi (*Coniophora puteana* and *Oligoporus placenta*) showed that samples modified at 220°C experienced mass losses that would classify the wood as moderately durable while materials modified at 230°C mass losses less than 3%, which would classify it as very resistant to decay. The results indicate that Abodo Vulcan Radiata pine thermally modified at 230°C would be very durable. The results also showed that moisture contents of blocks thermally modified at 230°C were at less than half the moisture content of the untreated controls, illustrating the moisture resistance of Abodo Vulcan.

Termite Tests: There are a variety of termite test methods that are highly dependent on the behaviour of the termite species being evaluated. The most common termite in North America is the subterranean termite (*Reticulotermes flavipes*), but the Formosan termite (*Coptotermes formosanus*) has been introduced in some areas of the southern U.S., California and Hawaii. This species is far more aggressive than the native subterranean termite and the AWPA standards explicitly require additional tests against this species.

While there are no trials against the Formosan termite, Australian field trials of Abodo Vulcan Radiata 230°C showed that *Coptotermes acinaciformis* readily attacked thermally modified wood and these results would be consistent with other studies of thermally modified timbers. This Australian species is comparable to the Formosan termite (*C. formosanus*) in terms of the ability to aggressively attack wood. The aggressive attack by *C. acinaciformis* indicates the need for some supplemental treatment to protect against termite attack.

Abodo Vulcan Radiata 230°C treated with an insecticide and exposed in the same test experienced virtually no wood attack. A second field trial produced similar results and indicated that thermally modified wood supplementally treated with insecticides was highly resistant to attack by *C. acinaciformis,* which would allow it to be classified for use in all the United States. These results indicate that thermally modified timber with a supplemental termite treatment will perform in areas with high risk of termite attack.

Above-ground Test: Thermally modified timber is most likely to be used in above ground applications such as cladding, windows and decking. The AWPA Guidance document recommends the use of the L-joint which exposes a painted mortise and tenon joint on an above ground frame, but other tests are also allowed. The Australasian Wood Preservation Committee (AWPC) recommends an above ground exposure where wood samples are exposed vertically on racks with a slight angle designed to capture and trap water as well as a second test method where deck boards are exposed above but close to the ground. The AWPA Guidance Document A requires a minimum of three years data for above ground tests in an aggressive exposure site and five years for sites in less severe environments. The data presented would meet those requirements.

Data for three tests of Abodo Vulcan Radiata 230°C were reviewed including one 11 year test of decking, lap-joints and flat panels exposed near Rotorua, New Zealand and another 67 month test near Auckland. In both cases, the untreated radiata pine sapwood control samples were destroyed, indicating that the site conditions were suitable for aggressive decay.

The 11 year trial included Abodo Vulcan Radiata 230°C along radiata pine treated with CCA, copper naphthenate, copper azole or tributyltin oxide (TBTN) and untreated Monterey pine (*Hesperocyparis macrocarpa*). The latter species is moderately resistant to decay and its performance would be similar to that of untreated Douglas-fir heartwood (*Pseudotsuga menziesii*) in an above ground exposure.

Thermally modified decking had slightly lower ratings than CCA, copper naphthenate or copper azole treated radiata pine when exposed on preservative treated joists, but was in much better condition than either TBTN treated radiata pine or untreated Monterrey cypress. The condition of thermally modified wood was similar to the preservative treated radiata pine when exposed on untreated joists.

A second above ground field test located in Auckland, New Zealand exposed Abodo Vulcan Radiata 230°C as a decking product as well as flat panels exposed on racks with a 45 ° angle that tended to trap water and induce conditions suitable for fungal growth. The thermally modified material was compared with radiata pine treated with a mixture of two organic Biocides (tebuconazole/propiconazole) or CCA for above ground exposure (equivalent to AWPA Use Category 3B). Western red cedar (*Thuja plicata*) was also included as a naturally durable timber (Table 1). The angled racks have presented a more aggressive decay environment after 67 months. Untreated radiata pine controls are nearly destroyed, while all of the treated samples as well as western red cedar heartwood are performing similarly (ratings >9). Thermally modified radiata pine is still rating 10, indicating that it remains free of visible decay.

Soil Contact Exposures: The Guidance document also lists stake tests as recommended, but not required. A five-year field stake test performed in Rotorua, New Zealand with radiata pine thermally modified at 170 to 230°C as well as untreated pine sapwood and redwood heartwood (*Sequoia sempervirens*) showed that samples thermally modified at temperatures from 170 to 210 °C had largely failed after five years, while the wood modified at 230°C were performing similarly to redwood. While thermally modified wood is most suited to above ground exposures, these tests suggest performance similar to that of New Zealand grown redwood.

Summary

Field tests of Abodo Vulcan Radiata 230°C show that performance against decay fungi is similar to that of pines treated with traditional preservatives for Use Category 3B where termites are not present. This material has little or no resistance to termite attack and must be supplementally treated with a termiticide to perform where termites are present. Abodo Vulcan Radiata 230°C should perform similarly to western red cedar in above ground applications such as cladding in terms of resistance to fungal decay.

Table 1. Comparison of durability between common naturally durable species and Abodo Vulcan 230°C

Species	Durability Class
Abodo Vulcan Radiata 230°C	UC3B (indicative)
Western Red Cedar Heart	UC3B
Coast redwood (NZ grown)	UC3A

Literature Cited

American Wood Protection Association. 2022. Guidance Document A: Data requirement guidelines for listing wood preservatives in the AWPA Standards. In: AWPA Book of Standards, AWPA, Birmingham, Alabama.

American Wood Protection Association. 2022. Guidance Document N: Data requirements for listing thermally modified wood with enhanced durability in the AWPA Standards. In: AWPA Book of Standards, AWPA, Birmingham, Alabama.