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Performance of Deck Board Materials Under Simulated Wildfire Exposures

Stephen L. Quarles, Laurence G. Cool, and Frank C. Beall

Abstract

As part of a program to assess the role of commonly used construction materials in vulnerability of structures to wildfire, University of California Forest Products Laboratory (UCFPL) researchers developed fire test protocols for attached decks. Test decks made with plastic, wood-plastic, or solid wood lumber were subjected to an under-deck fire (3-min. exposure to an 80 kW propane flame) or an above-deck exposure (an ASTM E-108 "A" brand). Deck performance was evaluated by three criteria:

1. dropping of flaming debris,
2. accelerating flaming combustion, and
3. collapse of a deck board.

Results showed that performance of the decking products depended on the cross-section form (solid, hollow, or channeled), fire exposure (under- or above-deck), and material composition (especially the plastic component). For example, channeled products, regardless of material, did poorly in the under-deck exposure tests, and the hollow products performed poorly in the above-deck exposure tests.

Quarles:
UC Cooperative Extension Advisor, Wood Durability
Cool:
Research Associate
Beall:
Professor, University of California Forest Products Laboratory, Richmond, California, USA

Introduction

The California Department of Forestry and Fire Protection's Fire and Resource Recovery Program reported an estimated 80 million acres in California at risk of wildfire destruction, potentially affecting several hundred thousand housing units in the urban wildland interface (UWI) (1). The catastrophic wildfires that have occurred in the west and southeast in recent years have generated interest in improving our understanding of propagation of wildland fires and the fire performance of building materials and structures in the UWI.

An effort is underway in California to develop performance-based codes that will help reduce the vulnerability of structures to wildfire. As part of this program, researchers at the University of California Forest Products Laboratory (UCFPL) have developed protocols by which construction materials and assemblies used on the exterior of structures can be consistently tested and evaluated. An outside review committee consisting of fire professionals in the public and private sectors oversaw this process. The protocols addressed roof coverings and assemblies (2), exterior wall claddings (3), windows (4), and attached decks (5). The foundation for the protocols was reported by Jennings (6).

Table 1. ~ *Fire exposures for construction materials and assemblies tested.*

Component/assembly	Exposure
Roof covering	"A" brand
Exterior cladding	Flame impingement
Windows	Flame impingement
Attached deck	Flame impingement and "A" brand

Figure 1. ~ *In the UWI, attached decks would be subjected to under-deck flame-impingement exposures and above-deck burning brand exposures.*

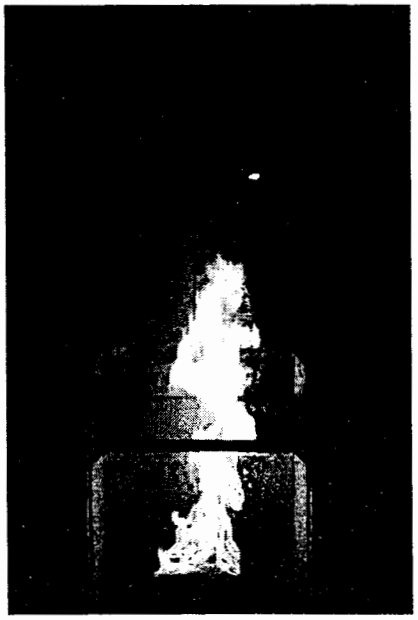

Figure 2. ~ *The test apparatus used for below-deck exposures, showing the propane sand burner and an 80 kW output.*

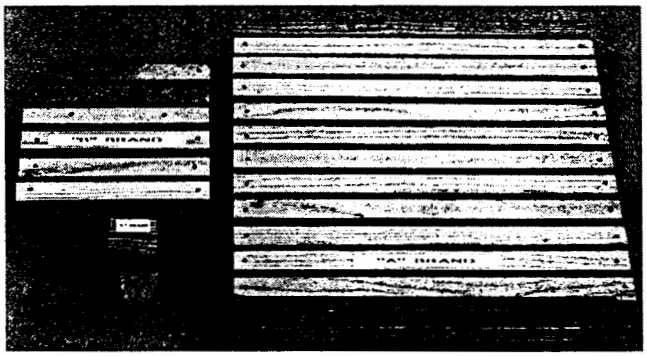

Figure 3. ~ *"A", "B", and "C" brands used to evaluate the fire performance of roof coverings and assemblies. UCFPL protocols used the "A" brand for roof and above-deck exposures.*

The protocols were designed to simulate the type of fire exposure anticipated for the installed component or assembly (**Table 1**). As seen in **Figure 1**, anticipated exposures for decks would include flaming embers (brands) from above, and a flame impingement exposure on the underside of the deck, either from an approaching ground fire or from burning stored debris.

Combustion of the deck could in turn ignite the exterior cladding or result in failure of window glass, resulting in flame entry into the structure. The 80 kW output used for the under-deck exposure is somewhat lower than the 150 kW peak output of an intermediate sized plant commonly used for landscaping vegetation around a home (**Fig. 2**) (7). For the above-deck brand exposure, the widely-accepted ASTM E-108 burning brand roof test method was used, with slight modification, since similar conditions of brand exposure would be expected for roofs and decks (8). In particular, the large "A" brand (**Fig. 3**) was used, since it has become the norm for rating roof coverings in the UWI.

The objective of this paper is to discuss the fire performance of a variety of deck board materials when tested under the protocols developed for attached decks.

Experimental

Twelve decking materials, representing the broad range of types commercially available, were purchased at retail lumberyards and tested using the established protocol. Eleven of these were plastic composite lumber, and one was Deck Heart

Table 2. ~ *Form of deck board materials tested.*

Form	Products
Solid	Rhino, SmartDeck, Trex, WeatherBest, Bedford (reinforced and unreinforced), Ecoboard, Maxituf, Redwood
Channeled	ChoiceDek, TimberTech, Eon
Hollow	Nexwood, WeatherBest, EverNew

grade redwood, which is similar to a Construction Heart grade except that some restrictions are placed on allowable slope of grain. A list of the decking materials is given in **Table 2**.

The test decks consisted of five deck boards, supported by two untreated 2 by 6 Douglas-fir joists spaced 400 mm (16 in.) on-center. Both nominal 25 mm (1 in.) thick and 50 mm (2 in.) thick material was evaluated. The overall dimension of the test deck was 600 by 700 mm (24 by 27 in.).

For the under-deck exposures, the decks were exposed to an 80 kW propane burner flame for 3 minutes. In the above-deck test, the decks were exposed to a flaming "A" brand, constructed as specified in ASTM E-108 (8) (**Fig. 3**). The test apparatus for the above-deck testing consisted of a rack to hold the deck in front of a small wind tunnel set for 20 km/hr. (12 mph) wind speed as specified in both ASTM E-108 (8) and the UCFPL protocol. The brand was ignited by 30-s exposure to a gas flame on each face (3-min. total exposure) prior to placement on the deck surface at the start of the test. On a noncombustible surface, an ignited "A" brand will sustain combustion for about 12 minutes.

Some fire officials argue that higher wind speeds should be used in tests designed to evaluate roof coverings for structures in the UWI, since winds can gust to speeds much greater than 12 mph. We examined the effect of wind speed, and concluded that lower speeds were actually more severe since at higher speeds, the brand burns out more quickly.

The fire performance of decking materials was evaluated using three criteria:

1. The propensity of the material to drop flaming debris (**Fig. 4**);
2. rapidly accelerating flaming combustion (**Fig. 5**); and
3. collapse of any deck board (**Fig. 6**).

The time at which these events occurred was recorded. The heat release rate (HRR) during the test was measured using oxygen depletion calo-

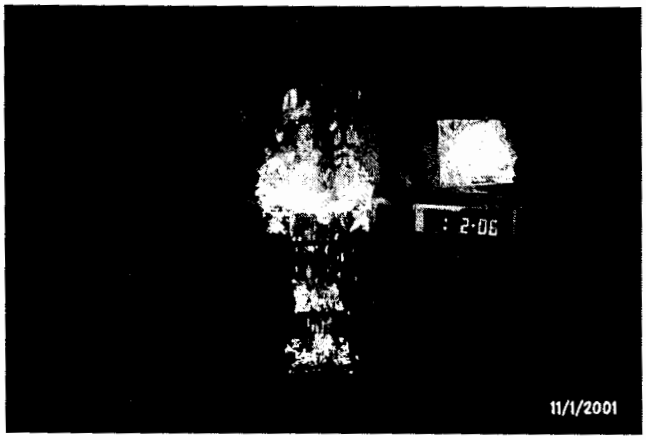

Figure 4. ~ *An example of dropping flaming debris in an under-deck exposure test.*

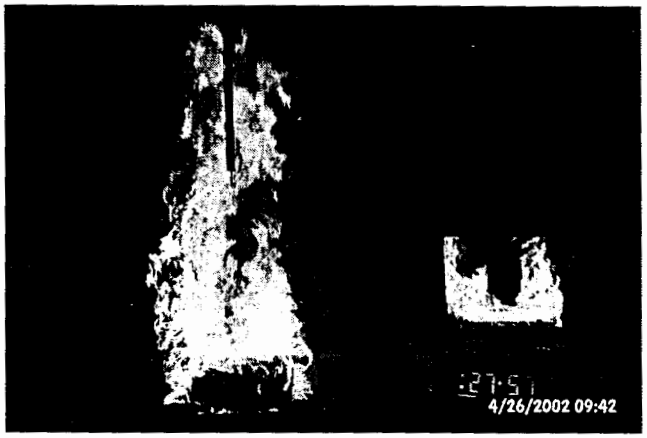

Figure 5. ~ *An example of accelerating flaming combustion in an under-deck exposure test.*

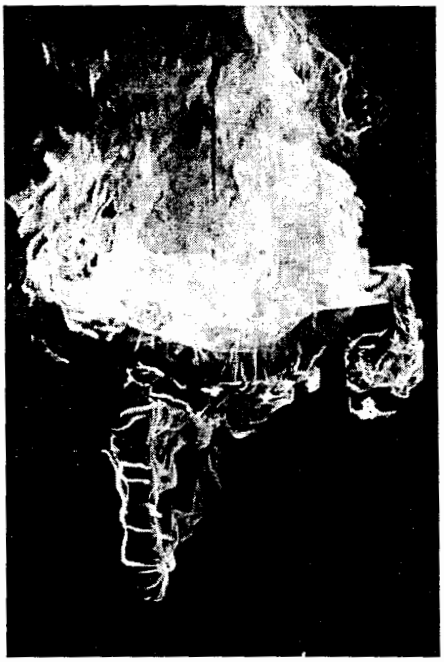

Figure 6. ~ *An example of deck board collapse in an under-deck exposure test.*

Table 3. ~ *Results of under-deck exposure tests, showing the time each degradation effect was observed. "N" signifies that the degradation effect was not observed during the test. The form of a given product is abbreviated by "ch" (channeled), "h" hollow, and "s" solid.*

Product (form)	Dropping flaming debris	Deck board collapse	Accelerated combustion
	(min.)		
Eon (ch)	1	N	2
Maxituf (s)	1	N	4
Evernew (h)	N	3	N
TimberTech (ch)	3	7	5
ChoiceDek (ch)	4	12	8
Nexwood (h)	7	13	N
Bedford, unreinforced (s)	1	N	17
Ecoboard (s)	1	N	22
Trex (s)	22	N	N
Rhino Deck (s)	N	21	N
SmartDeck (s)	N	N	N
Weatherbest (s)	N	N	N
Weatherbest (h)	N	N	N
Bedford, reinforced (s)	N	N	N
Redwood (s)	N	N	N

Table 4. ~ *Results of above-deck exposure tests, showing the time each degradation effect was observed. "N" signifies that the degradation effect was not observed during the test. Eon, Maxituf, EverNew, and ChoiceDeck were not tested under this protocol.*

Product (form)	Dropping flaming debris	Deck board collapse	Accelerated combustion
	(min.)		
Rhino Deck	15	18	N
Ecoboard	5	N	20
Nexwood	10	23	N
Trex	17	25	N
SmartDeck	25	30	N
Weatherbest, hollow	N	35	N
Bedford, unreinforced	5	N	N
Bedford, reinforced	N	N	N
Weatherbest, solid	N	N	N
Redwood	N	N	N
TimberTech	N	N	N

rimetry (9). Tests were stopped if board collapse or accelerating combustion (net HRR greater than 400 kW) occurred ("fail"), if combustion stopped, or if 40 minute elapsed (both "pass").

The plastic component of pure plastic and composite materials was evaluated using pyrolysis gas chromatography.

Results and Discussion

The results of the under- and above-deck exposure tests are given in **Tables 3 and 4**. The performance of the plastic composite materials depended primarily on the plastic used in the composite, the presence or absence of fiber reinforcement, and the cross-section shape or form (**Fig. 7**). The effect of other factors, such as additives, was not examined.

Our chemical analyses of the plastic-containing products showed that in most of them, the plastic component was high-density polyethylene, often with a proportion of low-density polyethylene. All fiber-reinforced decks were polyethylene-based. Most reinforced boards had wood fibers, but one

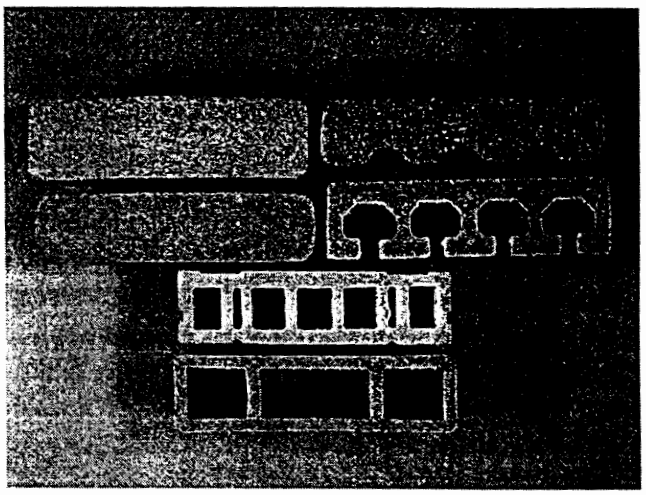

Figure 7. ~ *Examples of solid (above left), channeled (above left), and hollow (below center) construction in plastic composite deck boards.*

reportedly contained processed rice hulls (Nexwood) and one contained glass fiber (Bedford reinforced.) We tested several all-plastic decks consisting of polyethylene (Bedford unreinforced, Ecoboard, and Maxituf). Evernew was made of polyvinyl chloride (PVC), and Eon appeared to consist of poly(α-methyl styrene). Evernew, the PVC deck, though it collapsed quickly, did not sus-

tain combustion when the ignition source was removed. The Eon deck burned very readily, and combustion accelerated rapidly. Polyethylene-based composites varied in their performance though most solid form products passed the test, they did sustain combustion after the flame source was removed, and one (Maxituf) accelerated rapidly.

Fiber reinforcement clearly improved the fire performance of the polyethylene-based deck boards. Thus the unreinforced solid plastic products Maxituf, Ecoboard, and Bedford all failed by accelerating combustion, while none of the products reinforced with glass fiber (Bedford) or wood fiber (Trex, Rhino Deck, Smart Deck, Weatherbest solid) failed in this way.

Redwood, the most common deck board material used in California, was the only solid wood material evaluated in this series of tests. In both the below- and above-deck exposures, redwood performed as well as any of the other materials tested.

A number of plastic lumber products have a light-weight channeled or hollow configuration (**Fig. 7**). The below-deck exposure tests demonstrated that channels on the underside invariably made the deck vulnerable to flame exposure, which led to board collapse and/or runaway combustion. In contrast, all boards with a hollow construction collapsed in an above-deck "A" brand exposure, though combustion did not accelerate.

Summary and Conclusions

Testing of twelve commercially available decking materials showed that fire performance was mainly dependent on material (type of plastic or solid wood), presence of reinforcing fiber, and form (solid, channeled, or hollow). Decking produced with channels on the underside consistently performed poorly with under-deck flame impingement exposure, with combustion accelerating rapidly. The hollow form boards consistently failed the above-deck "A" brand exposure by board collapse, though combustion did not accelerate.

Though plastic lumber composite decking has many desirable features, particularly reduced maintenance requirements and resistance to biological degradation, the vulnerability of some of these products to wildfire exposures should be a consideration for homes in the UWI.

Acknowledgments

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Forest Products Society
2801 Marshall Court
Madison, WI 53705-2295
phone: 608-231-1361
fax: 608-231-2152
www.forestprod.org