EVALUATION OF THE EFFECTIVENESS OF FIRE RESISTANT DURABLE AGENTS ON RESIDENTIAL SIDING USING AN ICAL-BASED TESTING PROTOCOL

by

Arthur F. Grand, Majid Mehrafza
Omega Point Laboratories, Inc.
Elmendorf, TX 78112-9784

Reprinted from the Fire and Materials 2001. 7th International Conference and Exhibition. Proceedings. Interscience Communications Limited. January 22-24, 2001, San Antonio, TX, 241-248 pp, 2001.

EVALUATION OF THE EFFECTIVENESS OF FIRE RESISTANT DURABLE AGENTS ON RESIDENTIAL SIDING USING AN ICAL-BASED TESTING PROTOCOL

Arthur F. Grand, Majid Mehrafza
Omega Point Laboratories, Inc.
Elmendorf, TX 78112-9784

ABSTRACT

A test protocol based on the Intermediate Scale Heat Release Calorimeter (ICAL) was developed and used to evaluate the potential fire retardant effects of temporary, water-based treatments applied to residential siding materials. Substrates included wood and plastic (vinyl) siding and wood siding with a window. The protocol, intended to simulate certain conditions of wildland fires at a wildland-urban interface, included exposure of one meter square specimens to constant heat fluxes of 15 and 25 kW/m^2 in the presence of an open-flame ignition source. The treatments extended the times to ignition of painted wood siding from around 30 seconds for untreated panels to more than 300 seconds of exposure at 25 kW/m^2. Development of the test protocol included creation of a modified specimen support and different ignition source than the standard ICAL apparatus (ASTM E1623). The gel-water systems were applied with a garden hose connected to an aspirator system intended for use by homeowners.

INTRODUCTION

Wildland/urban interface fires are a unique problem in fire research and testing because the fire exposure is from the outside of the building. Most fires in buildings start from inside the structure, so most fire test protocols are designed around that mode of exposure. Two exceptions are NFPA 268, which deals with flammability of exterior walls from another exterior fire source, and ASTM E108, which deals with flammability of roof coverings under a simulated fire originating outside the building. In the **NFPA** 268 test method, mock-up exterior wall specimens are exposed to a radiant heat **flux** of **12.5** kW/m^2. The wildland fire environment is not normally considered in problems related to buildings, especially residential housing. While "permanent" fire retardant treatments and coatings exist, it would be impractical to treat the exteriors of residences to be fire resistant. However, temporary treatments, such as water-based fire retarding agents, have been used to protect structures during wildland fires.

The two primary means of attack on a structure **by** a wildland fire are radiant heat and burning brands. In the case of radiant heat, **a** heat **flux** of 25 kW/m^2 will ignite wood structures, even without a distinct ignition source. Heat fluxes down to about 15 kW/m^2, in the presence of an ignition source, will also ignite unprotected wood. Burning brands tend to collect in protected areas, such as under eaves and against inside comers. Allowed to bum, these brands could be sufficient to start a fire along the exterior of the house.

Recently, "durable agents" and water-based "gels" have been used to protect homes against the threat of wildland fires'. Without any standards, or even very much research, it is difficult to demonstrate the efficacy of these agents. Internal research studies at BFRL/NIST[2,3] included treatment of wood **siding** and exposure to moderately high intensity fire sources. **A** preliminary study at Omega Point

Laboratories, Inc.[4], sponsored **by** NIST, was conducted to determine the feasibility of using the **ICAL** test apparatus **(ASTM** E1623) for this research.

The primary objective of the present study[5] was to develop a standard test protocol for the evaluation of water-based gels or durable agents applied to residential structures. **It** is anticipated that the results **of** this study will be important **to** the future development and testing of temporary fire retarding agents for the protection of residential structures from wildland fires.

APPARATUS

The **ICAL** (Intermediate Scale Heat Release Calorimeter) apparatus at Omega Point Laboratories conforms to the principles of **ASTM** E1623, but differs in gas supply (propane vs. natural gas) and radiant panel details. The apparatus includes an approximately 1.5 m **x** 1.5 m propane-fired radiant panel, a calibration panel to measure heat flux across the surface of a specimen **and** as a function of distance from the panel, and a load cell on a moveable cart to hold the specimen.

A modified specimen support frame was developed for this study, **as** shown in Figure **1.**

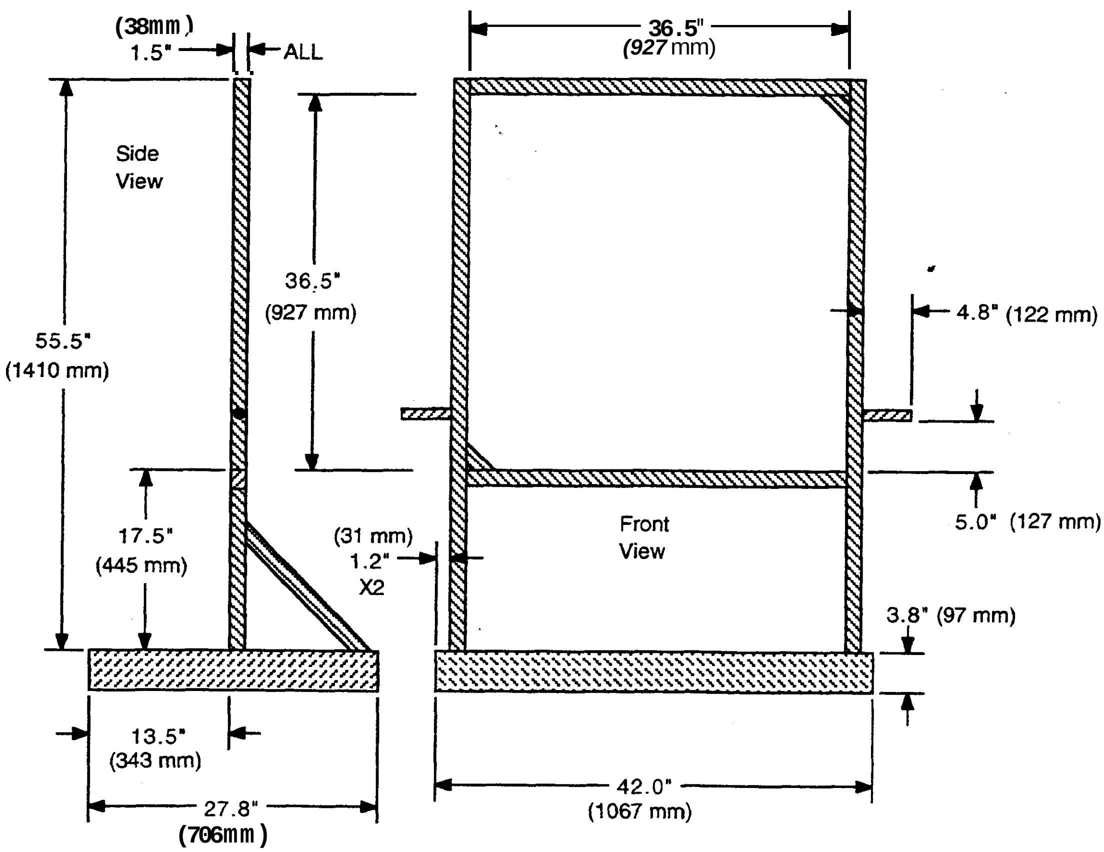

Figure 1. Specimen support frame

The modifications enabled the full specimen surface to be available for treatment and exposure (the normal ICAL specimen holder wraps around the edges). Furthermore, the new specimen frame was able to be lifted onto the load cell platform quickly and easily after the spray treatment.

A propane "T" burner (ASTM E1537, Cal. T.B. 129) was used as the igniter for these experiments. The burner was positioned and adjusted so that the flames were near, but not in direct contact with, the surface of the specimen (see Figure 2).

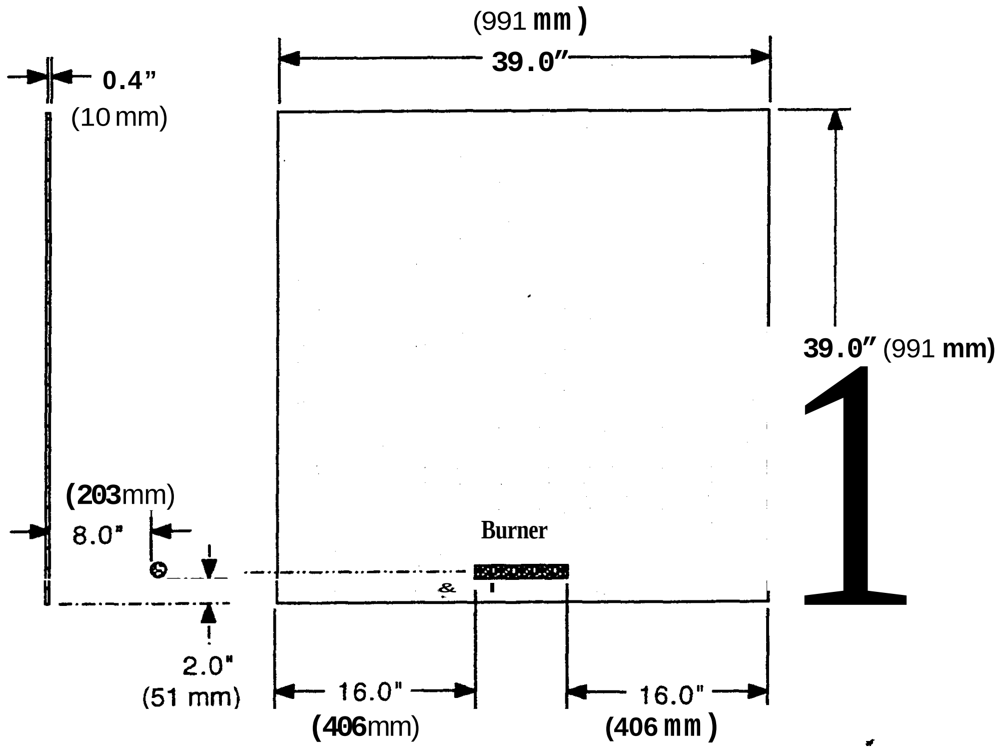

Figure 2. Location of ignition burner with respect to specimen, side view (left) and front view (right)

TEST PROCEDURE

The specimen substrates were plywood T1-11 siding, 1 m x 1 m. A single, heavy, coat of red latex paint was applied to each panel and allowed to dry.

The ICAL radiant panel was calibrated for heat flux as a function of the distance between the panel face and the specimen surface. Specimens were exposed to heat flux exposures of 15 and 25 kW/m^2. A heat flux of approximately 1 kW/m^2 constituted "drying" conditions (this was calculated as the approximate intensity of a hot summer day in the southern U.S.).

The support frame was weighed alone and with the specimen in place. Then the specimen was sprayed and the frame and specimen were weighed again. The weight of the specimen was recorded at five minute intervals during the drying period, if applicable, and every 15 seconds during exposure to **high** heat conditions (15 or 25 kW/m^2). The spraying was achieved by an aspirator system attached to a garden hose. Water delivery was set to 10 gpm at 50 **psi.**

The two gel products used in this study were as follows:

- "Barricade@" Fire-Blocking Gel concentrate: supplied by Fire Protection, Inc., Jupiter FL (contact: John Bartlett, 561 / 575-6055)
- "Nochar" LE112 Thermal Barrier Concentrated Gel: supplied **by** Nochar Inc., Indianapolis, IN (contact: Dennis Campbell 317 / 613-3046)

RESULTS AND DISCUSSION

Table 1 contains a summary of ignition delay times on painted wood specimens, including untreated, water-treated and two different gel-water treatments at both 25 and 15 kW/m². Individual run results are shown to illustrate the range of values (quite large in some cases), with an average and standard deviation for the data shown.

It is evident from the data in Table 1 that the gel-water treatments extended the time to ignition by a substantial amount. Untreated wood specimens ignited at around 32 seconds at 25 kW/m²; whereas the gel-water treated specimens ranged from 316 seconds to over 900 seconds (with an average for all runs around 550 s). There were no significant differences in ignition delay times between the two types of **gel** treatments (Barricade and Nochar). Water treatment increased the ignition delay from approximately 32 seconds to around 58 seconds; but it was not as effective as the gel-water treatments.

Table 1. Treatment vs. No Treatment on Painted Wood
25 kW/m² and 15 kW/m² with Igniter

25 kW/m² Run No.	Treatment	Ignition Delay (s)	15 kW/m² Run No.	Treatment	Ignition Delay (s)
4	None	35			
5	None	33	46	None	175
6	None	28	47	None	166
Average (3)	***None***	*32±4*	***Average*** (2)	***None***	*171±6*
7	Water	58			
8	Water	57			
Average (2)	*Water*	*58±1*			
9	Barricade	460			
10	Barricade	***603***			
22	Barricade	905	21	Barricade	806
23	Barricade	425	48	Barricade	732
52	Barricade	390	***50***	Barricade	688
Average *(5)*	***Barricade***	*557±211*	***Average*** *(3)*	***Barricade***	*742±60*
11	Nochar	316			
12	Nochar	370			
24	Nochar	836			
25	Nochar	436	49	Nochar	295
53	Nochar	730	51	Nochar	673
Average (5)	***Nochar***	*538±231*	*Average (2)*	***Nochar***	*484±267*

Similar results were obtained for the exposures at 15 kW/m^2 (also Table 1). In these cases, the times to ignition of the untreated wood were longer than for the higher heat flux (approximately 170 s average), while the gel-water treatments ranged from 295 seconds to 806 seconds (for an overall average of 640 s).

The effects of the "drying" period (either 60 or 120 min. at about 1 kW/m^2) on the performance of the coatings are shown in Table 2. These experiments were important because there would be some delay between spraying and exposure in real-life scenarios. Average ignition delay times and the range of values are shown (some of the results are from Table 1). In some cases, drying decreased the average ignition delay times when compared to specimens tested immediately after spraying. However, it is unclear whether or not the drying period significantly reduced the times to ignition because of the wide range of test results. Treated specimens after drying still showed ignition delay times of around 400 s at 25 kW/m^2 and 400 to almost 700 s at 15 kW/m^2.

Table 2. Effects of Drying
Treated, Painted Wood
25 kW/m^2 and 15 kW/m^2 with Igniter

Test Condition and Number of Runs″	Treatment	Drying Period[b] (min.)	Ignition Delay ± S.D. (s)	Range (s)
Average of 2	Water	None	58±1	(57-58)
Average of 2	Water	60	99±73	(47-150)
Average of 5	Barricade	None	5572211	(390-905)
Average of 2	Barricade	60	3842332	(149-619)
Average of 5	Nochar	None	538±231	(316-836)
Averageof2	Nochar	60	395±91	(330-459)
15 kW/m^2				
Averageof3	Barricade	None	742±60	(688-806)
#27 (one only)	Barricade	60	443	
#34 (one only)	Barricade	120	421	
Average of 2	Nochar	None	484±267	(295-673)
#29 (one only)	Nochar	60	683	
#35 (one only)	Nochar	120	620	

Notes: a) Some averages taken from Table 1
b) Drying performed at ca. I kW/m^2

Figure 3 contains a graph of mass vs. time for four experiments on painted wood specimens. In this graph, "zero" time represents the start of the 25 kW/m^2 radiant exposure, with the ignition burner present. The apparent rates of mass loss for the four specimens (untreated wood, water-treated, gel-treated and gel-treated with drying) are nearly the same. The linear best-fit slopes of the curves were, respectively, 0.0093, 0.0074, 0.0071 and 0.0071 kg/s. Thus, the gel-water treated specimens showed longer times to ignition, but lost mass at the same rate as wood specimens treated by water only.

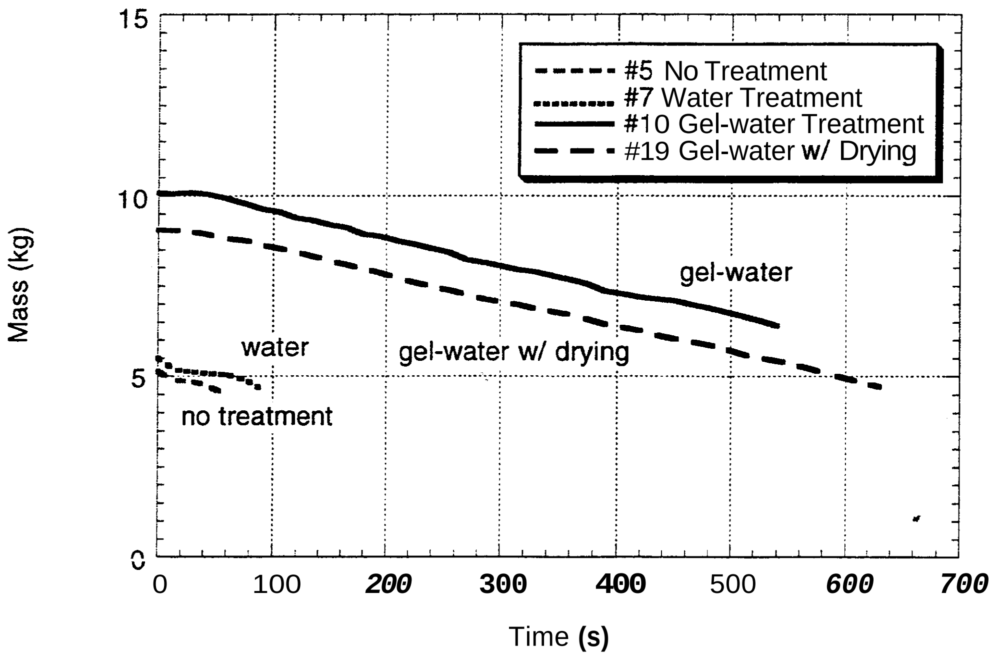

Figure 3.Typical mass loss results, up to ignition, at 25 kW/m^2

In Table 3, results are presented for a brief study on different substrates. Painted wood was the specimen used for all of the previous experiments reported. Two other substrates included vinyl siding mounted on top of unpainted wood, and a painted wood panel containing a small window in the center. The gel-water treatments provided some protection to the vinyl siding (ignition delays of 130 to 520 s, compared to **45** s for the untreated vinyl). On the other hand, the vinyl defeated some benefits of the coating by sagging and melting when exposed to the heat flux. This action carried the coating off the specimen surface with the vinyl, exposing the wood siding.

Small, aluminum-frame windows (12 in. x 24 in., 305 mm x 610 mm) were mounted in the center of certain painted wood specimens. These were protected to a significant degree by the spray coating. Untreated windows cracked after about 20 seconds **of** exposure at 25 kW/m^2, while the siding surrounding the window ignited after 90 to 122 seconds. The gel-water-treated windows cracked at various times ranging from **82** s to 715 s, and the surrounding wood panels ignited in 419 to 696 seconds. The coatings generally adhered to the glass surfaces and apparently provided some thermal protection.

Table 3. Comparison of Treatment vs. No Treatment on Painted Wood, Vinyl and Windows 25 kW/m^2 with Igniter, No Drying Period

Run No.	Siding*	Ign. Delay (s)	Notes & Observations
Avg. (3)	Painted Wood	32	
39	Vinyl	45	Plastic sagged/melted
30	Small Window	122	1st crack *22* s
43	Small Window	**90**	1st crack 20 s
Barricade Treatment			
Avg. (5)	Painted Wood	557	
40	Vinyl	130	Plastic sagged/melted
33	Small Window	491	1st crack **230** s
44	Small Window	564	1st crack 715 s
Nochar Treatment			
Avg. (5)	Painted Wood	538	
41	Vinyl	521	Plastic sagged/melted
32	Small Window	696	1st crack 291 s
45	Small Window	419	1st crack *82* s

*Notes:

"Painted" T1-11 wood siding
"Vinyl" installed on top of unpainted wood siding
"Window" installed in center of painted wood siding
Averages from Table 1

CONCLUSIONS

The following conclusions were developed as a result of this investigation:

1. Two commercial gel-water treatments performed similarly in their protection of wood siding to heat fluxes as high as 25 kW/m^2.

2. Times to ignition of painted wood siding specimens were extended from around 30 seconds for untreated panels to more than 300 seconds for treated panels at *25* kW/m^2 (the average of all coated specimens **at** this heat flux was more than 500 *s).* Similar extensions of times to ignition were obtained for treated specimens subjected to 15 kW/m^2.

3. Drying the treated panels for up to 120 minutes at approximately 1 kW/m^2 generally had little effect on the subsequent times to ignition of the specimens, compared to no drying.

4. The gel-water treatments protected small windows mounted in the wood panels, extending the times to cracking and breakage.

5. The gel-water treatments were successfully applied to vinyl siding; however, the vinyl defeated part of the action of the gel treatment by sagging and melting, thereby exposing the wood substrate.

6. The open flame igniter, adapted from California T.B. 129, performed suitably.

7. The gel-water treatments under consideration in this study performed well in their primary objective of providing a temporary fire retardant treatment to wood siding.

8. Based on mass loss data during radiant heat exposure, it appears that the mechanism **of** fire-retardant action of these gels is to retain large quantities of water.

ACKNOWLEDGEMENT

The authors and Omega Point Laboratories, Inc., gratefully acknowledge contributions to this study by the following individuals and organizations. Financial **support** for the study was provided by the National Institute of Standards and Technology, under U. **S.** DOC Award No. 60NANB9D0105. The technical monitor was Dan Madrzykowski. The fire retardant gels were provided **by** John Bartlett, Fire Protection, Inc., and by Dennis Campbell, Nochar Inc.

REFERENCES

1. Madrzykowski, D., NIST, and Bartlett, J., Fire Protection Inc., personal communications, March-April 1999.

2. Madrzykowski, D., "Durable Agents for Exposure Protection in Wildland/Urban Interface Conflagrations," studies conducted at NIST, presentation at **UJNR** meeting.

3. Madrzykowski, D., "Study of the Ignition Inhibiting Properties of Compressed Air Foam," NISTIR 88-3880, October 1988.

4. Grand, A. F., "Study to Utilize the ICAL Apparatus for the Determination of the Effectiveness **of** Fire Resistant Durable Agents," Final Report, Omega Point Laboratories, Inc., Project Number 15933-103926, U. **S.** DOC Award Number 60NANB8D0091, April 27,1999; available through NTIS as NIST/GCR-99-774.

5. Grand, **A.** F., "An Investigation of the Effectiveness of Fire Resistant Durable Agents on Residential Siding Using and ICAL-Based Testing Protocol" Final Report, Omega Point Laboratories, Inc., Project Number 15933-105840, **U. S.** DOC Award Number 60NANB9D0105, May 2000; available through NTIS as NIST/GCR-00-792.