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A STUDY OF THE EFFECTIVENESS OF FIRE RESISTANT DURABLE AGENTS ON RESIDENTIAL SIDING USING THE ICAL APPARATUS

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ABSTRACT

A test protocol based on the Intermediate Scale Heat Release Calorimeter (ICAL) was developed to evaluate the potential fire retardant effects of water-based durable agents applied to wood siding. The protocol includes exposure of one meter square specimens of siding to one or more constant heat fluxes consistent with those from wildland fires. Specimens both untreated and treated with a fire-retarding gel have been evaluated in a preliminary study. Time delay to ignition of the treated specimen was the primary measured property, while mass changes prior to and during the fire exposure were also recorded. A more comprehensive study is presently underway.

INTRODUCTION

Wildland/urban interface fires are a unique problem in fire research and testing. Generally, fires in buildings begin inside, rather than outside, the structure and most standard test protocols reflect that. One exception is NFPA 268 which deals with the issue of flammability of siding in commercial buildings. In that method, specimens are exposed to a 12.5 kW/m^2 radiant flux in order to simulate proximity to another building on fire. The wildland fire environment is not normally considered in evaluating structures, especially residential housing. While "permanent" fire retardant treatments and coatings exist, it would be impractical to treat the exteriors of all houses to be resistant to wildland fires. However, temporary treatments, such as water-based fire retarding agents, have been used to protect structures during such fires.

There are two primary means of attack on a structure by a wildland fire, radiant heat and burning brands. In the case of radiant heat, a heat flux above about 25 kW/m^2 will ignite wood structures, even without a specific ignition source. Heat fluxes as low as about 15 kW/m^2 will also ignite wood siding in the presence of a suitable ignition source. Burning brands tend to collect in protected areas of a house, such as under eaves and in corners. These brands could be sufficient to start a fire along the exterior of the house. Without any protection or treatment, the wood structure would continue to burn.

Recently, durable agents and water-based gels have been used to protect homes against the threat of wildland fires[1]. 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 recent study at Omega Point Laboratories, Inc.[4], sponsored by NIST, was a preliminary program to determine the feasibility of using the ICAL test method (ASTM E1623) to characterize the efficacy of temporary, spray-on fire retardant treatments for wood siding.

TEST APPARATUS

The standard ICAL apparatus and test method (ASTM E1623) were used for this study, with certain modifications as listed below:

1) A specimen support frame was developed to permit presentation of the complete surface area of the specimen, both for treatment and for exposure to the radiant heat (see Figure 1). The specimen was held in place by clamps in each of the four corners.

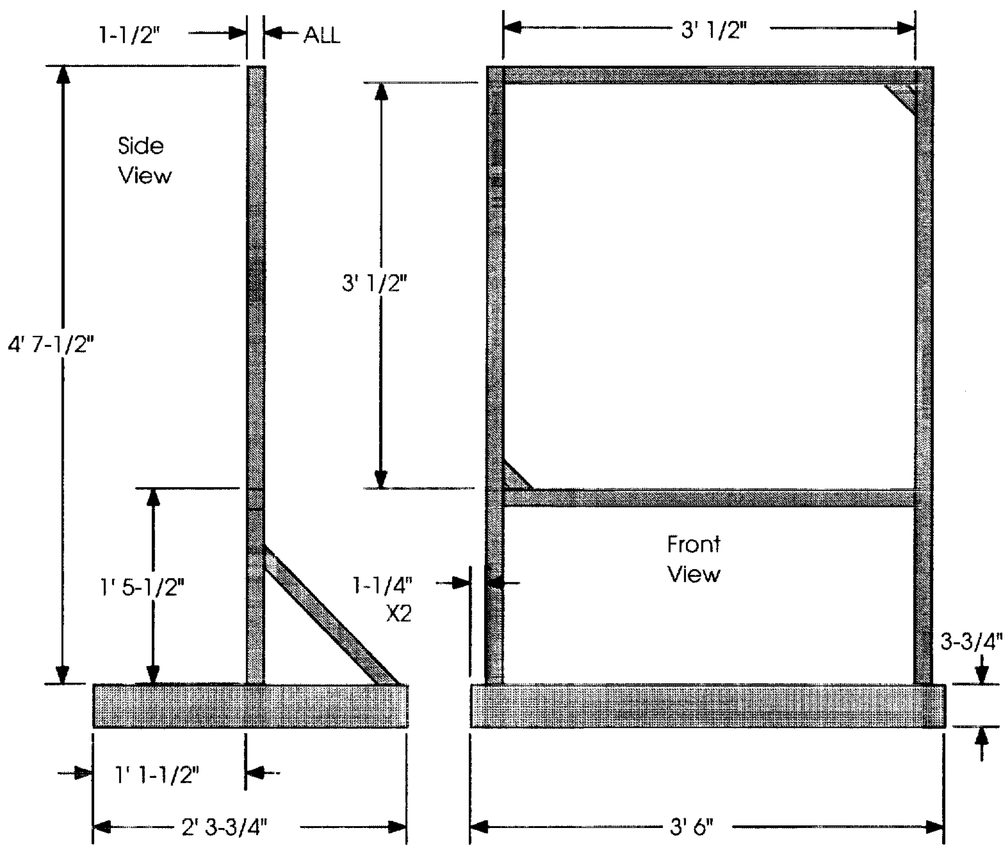

Figure 1. Specimen support frame for plywood siding

2) An open-flame burner was adapted from another test method (see below).

3) The ICAL radiant panel was calibrated to the range of heat fluxes required, from a maximum of 25 kW/m^2 to as low as "Texas summer sun" heat fluxes (ca. 1 kW/m^2).
4) The actual fire exposure was conducted for as long as necessary to evaluate the efficacy of the coating. Generally, the experiments were terminated upon ignition and continued burning of the specimen.
5) Heat release rate (HRR) was not determined in these experiments. It was reasoned that the experiment was essentially over once the HRR reached a measurable level. Mass loss was monitored prior to ignition.
6) Application of the coating and allowance for an extended drying period were performed with the radiant panel operating and open to the specimen (at heat fluxes estimated at 1-3 kW/m^2). The higher flux exposure was begun by moving the specimen to a pre-determined distance from the panel and lighting the pilot burner.

A propane "T" burner, from the mattress test method California Technical Bulletin 129, was used as the pilot ignition source. The burner was positioned approximately two inches (50 mm) from the bottom of the specimen, in the center, and approximately eight inches (200 mm) from the surface of the specimen. The pilot flames were near to, but not in direct contact with, the surface of the specimen.

The following materials were used in this study:

Plywood siding: T1-11, 10 mm (3/8 in.) thick, obtained locally (Home Depot)

Red latex exterior flat paint: obtained locally (Home Depot); a single, heavy coat was applied

"Barricade®" Fire-Blocking Gel concentrate: supplied by Fire Protection, Inc., Jupiter FL (contact person: John Bartlett, 561/575-6055)

Delivery system for the gel was a "Home Protection AtakPak": supplied by Fire Protection, Inc.; this included a nozzle, hose, eductor and quick disconnect. This equipment was used to aspirate the gel into the water stream and to deliver the mixture through an adjustable water-spray nozzle.

RESULTS AND CONCLUSIONS

The results on times to ignition for the preliminary study are summarized in Table 1. Several different treatments and two heat fluxes were tried during that series of tests. It can be seen from the data in the table that the painted and unpainted wood siding behaved similarly, except that the effect of water alone may have been greater for the unpainted wood. This could be attributed to greater water pick-up for the unpainted siding. There was relatively little control of the application rate or the ratios of the gel/water mixtures; therefore, few tests were conducted with the gel in the preliminary series. However, the potentially dramatic effects of treatment by the gel are evident from the results obtained (i.e., up to about 1000 s for ignition, compared to around 100 s for water alone).

Table 1. Summary of Times to Ignition Results for Various Treatments and Substrates

Heat Flux (kW/m^2)	Condition or Treatment[a]	t_{ig} (s)[b] Unpainted	t_{ig} (s)[b] Painted
25	no treatment, no pilot	614	525
25	no treatment	74	82
25	water spray	125	91
25	gel (light), 60 min. dry	211	
25	gel (heavy)	1092[c]	923[c], 941[c]
15	no treatment, pilot	221	134
15	water spray	200	171
15	water spray, dry 60 min.	85	

a) pilot burner present unless otherwise noted

b) T_{ig} = time to ignition (sustained for at least 10 s, unless otherwise noted)

c) ignition was achieved, but flames went out quickly and never progressed to flaming across the surface of the specimen, as in the other cases

Mass determinations were conducted to determine the water or gel/water pick up prior to the test and the mass loss during the preliminary exposure of the specimen (i.e., up to ignition). These results confirmed the high dose of the gel in some experiments (up to 5 lbs/ft^2) and the greater pick up of water by the unpainted wood (approximately 0.1 – 0.2 $lbs./ft^2$) compared to the painted wood (0.05 $lbs./ft^2$). The high pick up of the water in the gel mixture was evident by the mass data, compared to the water spray alone. Mass loss rates for the specimens prior to ignition were also measured.

The primary result of the studies to date are that the ICAL apparatus appears to be suitable for evaluating the response to heat and flame of wood siding with certain applied, temporary surface treatments, including a water-based durable agent and water alone. Satisfactory tests were conducted at both 25 kW/m^2 and 15 kW/m^2 heat flux. The repeatability of ignition of common plywood siding with or without a pilot burner was acceptable under the preliminary protocol. As a result, we generally were able to observe a delaying effect of water treatment alone on the ignition of wood paneling. Although this effect was small, it opens the possibility for a simple internal laboratory calibration test as part of a final protocol.

The "Barricade" gel treatment applied to wood siding in the preliminary study yielded promising results in terms of delayed ignition, even at a heat flux of 25 kW/m^2. Further evaluation of this and other treatments is underway in the current study.

Drying under low heat flux conditions, prior to a higher heat flux exposure, was achievable using this experimental setup.

PRESENT STUDIES

A number of issues are being addressed in the study currently underway. Measurement and control of the mixing of the concentrated agent and water must be improved over that in the preliminary study. Such information will permit establishment of comparable application rates for various coatings and to evaluate the performance of any given coating at various applications.

Both higher and lower heat fluxes than the 25 kW/m^2 will be examined for both screening and standard testing purposes. An applied heat flux of 25 kW/m^2 was sufficient to ignite wood without a pilot flame and seems suitable for evaluating most agents. Shorter duration, high flux exposures will be used to characterize the performance of certain better quality agents, while lower flux exposures may help in the development of research data to potentially improve the performance of marginally acceptable agents.

In addition to wood siding, other substrates will include plastic siding and glass windows in a wood framework. The ability of the coating to adhere to these substrates and the ultimate performance of the coating on surfaces other than wood will be considered.

Various water-based coatings will be exposed to lengthy periods of drying under "summer sun" conditions in order to determine the effect of drying on fire performance. Such atmospheric conditions are realistic and are expected to play a role in the suitability of temporary coatings.

Thermocouples will be placed between the gel coating and the wood surface for selected experiments in order to provide input for modeling and for prediction of the efficacy of the coating as a function of coating thickness. Calculation of an effective thermal conductivity for the coating should be possible.

In order to measure any significant heat release rate over that of the combined HRR of the radiant panel and the igniter, the specimen would have to be burning vigorously and the coating has failed. This is easy to detect visually and generally signifies the end of the test. Therefore, measurement of HRR, while always an option, need not be done for these experiments. Mass loss measurements could always be used to estimate rate of burning, if needed. Several potential fire scenarios can be simulated by the modified ICAL radiant panel method described herein. These include the following: burning brands up against the siding (e.g., 20 kW/m^2, with pilot burner), burning shrubbery near the house (e.g., 25-35 kW/m^2, with pilot burner), mild to moderate radiant heat from a wildland fire (10-20 kW/m^2, without pilot burner), intense radiation for a relatively brief duration (up to 50 kW/m^2, with or without the pilot burner).

Criteria for acceptability will be considered, based on the results of this study. Such criteria might include delay in times to ignition at a fixed heat flux, reduction in the extent of burning across the surface once ignition occurs, protection of the substrate to short intervals of higher heat flux, and extended protection of the substrate to longer duration exposures at moderate heat fluxes.

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