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The Wall of Fire:

Training Firefighters to Survive Fires in Vinyl-Clad Houses

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September 2009

Appendix B Not Included. Please visit the Learning Resource Center on the Web at http://www.lrc.dhs.gov/ to learn how to obtain this report in its entirety through Interlibrary Loan.

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Abstract

Most new houses in Henrico County were clad with vinyl siding. Vinyl siding presented challenges to firefighters because of its tendency to melt and burn. The problem was that no formal training was available to help firefighters (a) recognize the unique dangers presented by fires involving vinyl siding; or (b) amend their fire attack strategies accordingly. The research questions driving this effort were: (a) to what extent does vinyl siding contribute to fire growth; (b) what are the documented examples of rapid fire growth attributed to vinyl siding that resulted in firefighter maydays, loss of life, or significant property loss; and (c) what unique considerations should firefighters take when fighting fires in vinyl-clad houses.

The research concluded that when vinyl is exposed to direct flames, or intense radiant heat, it does burn and contribute to fire growth. Case studies described how fires burned rapidly up vinyl-clad walls, then entered the structures through vulnerable openings such as vinyl attic soffits. The problems identified in these cases, along with the limited amount of existing training materials for vinyl fires, were used to develop strategy and tactics training for firefighters. This “action research” method resulted in a complete Powerpoint™ presentation.

The research recommended the Henrico County Division of Fire provide the training to its members, share that training with other fire departments, and promote building code changes to reduce the vulnerability of vinyl-clad houses.

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The Wall of Fire: Training Firefighters to Survive Fires in Vinyl-Clad Houses

Introduction

According to the Henrico County, Virginia, Building Inspects Department, most new houses in the county are built with vinyl siding (R. Moore, personal communication, August 7, 2009). This weather-resistant and low-maintenance product offers aesthetic value at a relatively low cost and is very popular with both builders and homeowners (Vinyl Siding Institute [VSI], 2009). However, when combined with other combustible wall assembly members, vinyl siding allows rapid exterior fire growth and extension of fire throughout the house, endangering both residents and firefighters (Berry, 2003; Goff, 2007; Madrzykowski, Roadarmel, and DeLauter, 1997). This danger is amplified when the vinyl siding is used in combination with other lightweight construction practices (Berry, 2003), which is normally the case with new houses in Henrico County.

The problem was that no formal training was available to help firefighters (a) recognize the unique dangers presented by fires involving vinyl siding; or (b) amend their fire attack strategies accordingly. This purpose of this research was to meet that need, using "action research" to create a Power-Point™ presentation to train firefighters. The research questions driving this effort were: (a) to what extent does vinyl siding contribute to fire growth; (b) what are the documented examples of rapid fire growth attributed to vinyl siding that resulted in firefighter maydays, loss of life, or significant property loss; and (c) what unique considerations should firefighters take when fighting fires in vinyl-clad houses.

Background and Significance

In order to describe the background and significance of this problem, it is helpful to understand the basic history and make-up of the Henrico County Division of Fire. Henrico County is one of the oldest local governments in the United States, having been established as one of the eight original "Shires" of Virginia by the King of England in 1611 (Henrico County Division of Fire [HCDF], 2008). Its modern borders encompass 240 square miles, surrounding the City of Richmond on three sides. Henrico County is home to slightly more than 300,000 permanent residents and is the corporate headquarters of several fortune-500 companies, including Reynolds Metals, Altria (the former Phillip Morris), Genworth Financials, and Mead Westvaco (HCDF, 2008).

The Division of Fire was formed as a county agency in 1930. Since that time it has evolved into an all-hazards emergency services agency staffed with 518 sworn personnel who provide fire prevention and suppression, emergency medical services, environmental protection, and technical rescue. Physical resources include 20 fire stations, 20 pumper engines, five aerial tower trucks, three heavy rescue squads, and 14 advanced life support ambulances. All members are cross-trained as firefighters and emergency medical technicians, and all operational members share fire and EMS responsibilities (HCDF, 2008).

The Division of Fire's culture and doctrine regarding residential firefighting has been based on the experience of fighting fires in older homes. Traditional or "legacy" style construction methods relied on dimensional lumber, plaster and lath wall boards, and much heavier framing than is found in modern homes (Underwriters Laboratories [UL], 2009). Because of the heavier materials used to build these houses, it was

relatively safe for firefighters to conduct aggressive interior fire attack. It is less safe for firefighters to perform interior operations on newer homes built with vinyl siding and lightweight framing because these buildings burn much faster and are more likely to collapse (Berry, 2003; Bruno, 2008; Goff, 2007; Toth, 1998; UL, 2009).

Increased use of Vinyl Siding

The Henrico County Department of Building Inspections estimates that 80 percent of all new single-family homes in Henrico County are clad with vinyl siding (R. Moore, personal communication, August 7, 2009). Henrico County is not unique in this respect. Vinyl siding has become the most common type of siding product used in the United States (VSI, 2009). According to VSI, during 2008, 32% of all new homes in the United States were built with vinyl siding. Its use is even more prevalent on the northeast, where vinyl was installed on 78% of all new homes built in 2008 (the product is less popular in the western states where only 7% of new homes incorporated vinyl siding). It is interesting to note that the popularity of vinyl siding holds true across all price ranges of homes. According to 2008 U.S. Census data, vinyl siding is the most prevalent type of siding for all homes regardless of sale price (United States Census Bureau, 2009).

Vinyl siding is marketed as a low-maintenance, cost-effective product. The vinyl industry offers evidence that vinyl siding is the least expensive type of cladding available during new home construction (see Table 1).

Table 1

Cost of Common Exterior Siding Materials

Dollars per square	Vinyl Siding	Fiber Cement	Stucco	Wood (Cedar)	Brick	Stone
Materials	92	136	88	462	565	707
Labor	90	105	275	76	473	961
Paint/Stain	0	56	42	42	0	0
Total Cost	182	297	405	580	1,038	1,668

Note. From http://www.vinylsiding.org/aboutsiding/newsroom/dataandstats

The installation of vinyl siding on new homes in Henrico County must meet the 2006 International Residential Code, published by the International Code Council. The code requires that vinyl siding be installed over a rigid "backer board" attached to the framing of the structure (International Residential Code, 2006). While there are several acceptable options for the backer board, by far the most common product used in Henrico County is oriented strand board (OSB), according to building inspector Richard Moore (personal communication, August 7, 2009). OSB is an engineered plywood sheet consisting of layers of wood strands bound together with wax and resin. Since OSB is not weather-resistant, when it is used for exterior wall assemblies it is generally covered with a moister barrier such as Tyvek ® prior to the installation of siding (VSI, 2007).

New homes built with vinyl siding are typically trimmed with vinyl as well. The eves, or roof soffits, are constructed of a single layer of vinyl that is continuously

perforated to allow air movement through the product to support the ventilation of the attic (VSI, 2007). This method uses natural convective currents to ventilate the attic by drawing fresh air in from the soffits. The fresh air then drafts along the underside of the roof decking and is exhausted out of a continuous ridge vent installed along the highest lines of the roof (Barlow, 2008; VSI, 2007). The physics of convection assure continuous ventilation without any mechanical assistance. This energy-efficient design represents a significant departure from the ventilation design of older homes, which were typically built with sealed soffits constructed of solid wood.

Fighting Fires in Vinyl-Clad Houses

During the past 15 years there has been a building boom in Henrico County. From 1993 to 2008, the total number of housing units in the county increased 28 percent from 100,353 to 128,529 (Henrico County Planning Department, 2009). During this time the Division of Fire was increasingly exposed to fighting fires in modern, lightweight-framed houses. The Division's experiences have been similar to those published by fire departments throughout the country: lightweight framing presents serious challenges to firefighters. Compared to houses built using legacy methods, these structures burn much faster and give little warning before collapse (Berry, 2003; Bruno, 2008).

Traditional methods of fighting fires do not always apply when firefighters are confronted with exterior fires involving vinyl siding. These fires burn rapidly up the side of the structure, and quickly enter the house through vinyl windows or other vulnerable openings, or spread into the attic through ventilated soffits. This results in fire simultaneously extending through the house on multiple floors (Bossert, 2007; Prince

William County Department of Fire and Rescue [PWCFR], 2007; Loudoun County Department of Fire, Rescue, and Emergency Management [LCDFR], 2008).

The experience of firefighters in Henrico is not unique. In fact, a number of significant incidents and "close calls" have been reported in the region. On February 22, 2007, a grass fire in Raleigh, N.C., spread to an exposed townhouse that was clad in vinyl siding. The vinyl siding caught fire and quickly burned up the wall, through the soffit, and into the attic (Bossert, 2007). Bossert noted that "fed by wind, the fire spread to multiple [vinyl-clad] buildings" (p. i), eventually destroying 32 vinyl-clad townhomes.

On April 3, 2007, three firefighters in Fairfax County, Virginia, were injured while conducting interior operations in a house where the exterior vinyl siding had burned up the wall and though the vinyl soffits (Fairfax County Fire and Rescue Department [FCFR], 2007). The resulting fire and collection of gasses in the attic caused what the department determined to be a "carbon monoxide explosion," blowing all three firefighters off the second floor landing, and causing extensive damage to the home (FCFR, 2007, p.8).

Just two weeks after that incident, in neighboring Prince William County, Firefighter Kyle Wilson was killed and two other firefighters injured while conducting interior operations in a large, lightweight-framed house. The investigation revealed that the rapidly expanding exterior fire, fueled by burning vinyl siding, allowed fire to simultaneously enter the structure at multiple points and on multiple floors, including the attic (PWCFR, 2007). The fire spread was magnified by sustained wind conditions. The resulting heat build-up inside the home was spectacular and overpowering, both in terms of the speed that it occurred and the temperatures that it achieved.

On May 25, 2008, a similar situation occurred in nearby Loudon County, Virginia (albeit without the wind). Seven firefighters were injured, including four who suffered serious burns, while conducting interior operations inside a large, lightweight-framed house with vinyl siding. Again, the rapidly expanding fire on the vinyl-clad exterior entered the home at multiple points, leading to a rapid build-up of heat, a flashover, and early partial collapse of the structure while firefighters were inside (LCDFR, 2008).

Training Deficiencies

In its investigation into the fatal 2007 incident in Prince William County, it was noted by the National Institute of Health and Safety (NIOSH) that fire departments should "ensure that firefighters are trained for . . . rapid fire progression associated with lightweight construction" (NIOSH, 2008, page 13). The department's internal report focused even more specifically on the role of vinyl siding and the need to educate firefighters about the nature of fighting fires in vinyl-clad structures. The Fairfax County report also acknowledged the unmet need to "address the characteristics and challenges for arriving officers at the scene of an exterior fire involving vinyl siding" (FCFRD, 2007, page 14).

Unfortunately, very little such training is available in the published fire service literature. Even the most prolific fire service educator on the topic of building construction, the late Dr. Francis L. Brannigan, barely mentions vinyl siding in his much-referenced textbook, *Building Construction for the Fire Service*. He states only, "vinyl siding is made to look like wood siding. It will burn as well" (Brannigan, 1992, p.120).

Henrico Fire uses the textbook, *Essentials of Firefighting and Fire Department Operations* for its recruit academies and for promotional testing. This book and its

associated test banks are validated to meet NFPA 1001 training standards under the National Board on Fire Service Professional Qualifications. The Virginia Department of Fire Programs also uses this book and its test banks for firefighter training. However, in its latest 5th edition, this text does not even mention the term vinyl siding, much less explain the significant firefighting challenges presented by exterior vinyl wall assemblies. It states only, "firefighters must be alert for fire coming from doors or windows extending to the exterior of the structure" (International Fire Service Training Association, 2008, p. 149).

This problem was selected not only because of its importance to the organization, but also because of its relevance to the National Fire Academy's Executive Analysis of Fire Service Operations in Emergency Management (EAFSOEM) curriculum. The EAFSOM course focuses heavily on the importance of the executive's role in evaluating areas of vulnerability and leading the changes necessary in the organization to address those vulnerabilities. Since fires in vinyl-sided houses have been shown to be dangerous to firefighters, and since very little or no training is being offered to prepare firefighters for this problem, this topic meets the most laudable goal of an applied research paper – to improve firefighter safety.

The topic is related to two of the U. S. Fire Administration operational objectives. The first is to "reduce the loss of life from fire of firefighters," and the other is to "respond appropriately in a timely manner to emerging issues" (USFA, 2002, ¶ 4).

Literature Review

It was apparent from a review of the literature that the topic of fires in vinyl-clad houses has received scant empirical research, especially in light of its prevalent use in

American home construction. In fact, there have been no published studies or models of fire progression in the "as built" system of vinyl/OSB exterior wall assemblies, soffits, and lightweight truss roof systems. As noted by professional engineer James Dalton, Coordinator of Research and Development for the Chicago Fire Department, "these exterior vinyl wall assemblies have no fire rating whatsoever" (personal communication, August 29, 2009).

Despite this lack of published research, there are some sources of data that describe the performance of vinyl siding under fire conditions either partially, indirectly, or in a manner that responds to the research questions in this paper.

Not surprisingly, there is some disagreement between the vinyl industry and the fire service as to the safety and performance of vinyl siding under fire conditions. According to the Vinyl Siding Institute (VSI), a trade organization representing manufacturers of vinyl siding, their product "can take the heat safely" (VSI, 2006, p.2). They list three reasons: (a) vinyl siding has a high ignition temperature; (b) vinyl siding "takes unusually high amounts of oxygen to burn and stay burning;" and (c) that flames spread slowly across the surface of vinyl (p.2).

In a web-based article, VSI representatives Dobson and Johnston (2008) noted that, "vinyl siding typically passes the radiant exposure test in NFPA 268 [National Fire Protection Association (NFPA) *Standard Test Method for Determining Ignitibility of Exterior Wall Assemblies Using a Radiant Heat Energy Source*] without exhibiting sustained flaming . . . it has to be exposed directly to flames before it will ignite" (¶ 14). These authors also note that the release of chlorine compounds from burning vinyl inhibits the chemical chain reaction required for the hydrocarbons in the product to burn,

thereby reducing the overall flammability of the siding. "This is the reason that it is extremely difficult to ignite vinyl siding by radiant energy alone" (Dobson and Johnston, 2008, ¶ 18). They summarize by stating that "[the] claim that vinyl siding contributes to the aggressive spread of a fire is a misperception" (¶ 23).

As an example of this "misperception," VSI points out that people who have "witnessed a vinyl sided home damaged by fire could perceive the damaged siding as burned, when in fact it had merely melted" (VSI, 2006, p. 2). This distinction forms the core argument of vinyl's fire safety performance. That is, that while the siding will *melt* easily, it will not *burn* easily; and melting – by itself – is not a safety concern (Dobson and Johnston, 2008). Vinyl will deform and melt at temperatures as low as 160 degrees Fahrenheit. VSI publishes a *Vinyl Siding Installation Manual* that discusses this further. It states that vinyl "will soften, sag, melt, or burn, and may thereby expose material underneath" (VSI, 2007, p. 3).

Taken together, this information suggests that while vinyl will burn on its own, it is more likely to remain burning, and will burn more quickly, once the underlying backer-board begins to burn. Because it melts and deforms easily, it allows these backer-board materials to be exposed to the ignition source.

One of the most directly applicable studies of the flammability of vinyl siding was conducted by National Institute of Standards and Technology (NIST) researchers Madryzkowski, Roadarmel, and DeLauter (1997) at their Building and Fire Research Laboratory in Gaithersburg, Maryland. The purpose of their study was to evaluate the effectiveness of various types of applied foams and gels, in order to protect homes from advancing wild-land fires (Madryzkowski et al., 1997). To establish the control group,

the study first evaluated the combustibility and flame spread characteristics of three different siding materials: aluminum siding, T-1-11 (plywood) siding, and vinyl siding. In each case the siding material was applied directly to the wooden 2x4 studs of an 8-foot wall. The stud channels were filled with insulation, and the interior side of the wall was fitted with standard gypsum board. In each assembly, a soffit was provided, constructed of the same material as the siding that was tested. Each assembly was then exposed to a natural gas burner exposing "a steady-state 50kW fire for the duration of each experiment" (p. 346).

The results were interesting. A small, focused area of the aluminum siding melted after ten minutes of flame contact, at which point a smoldering fire developed inside the wall, but there was no vertical flame spread. The T-1-11 allowed burning and flame spread 200 seconds after ignition. The flames then took an average of another 80 seconds to burn to the soffit level, where the "fire was limited to the surface burning until the flames penetrated the vents in the eve and spread fire into the attic" (p. 347).

The performance of vinyl was much more dramatic than the other products. "The vinyl softened, deformed and charred prior to igniting" (p. 347). This is consistent with the assertions made by VSI: although vinyl does not easily ignite, it will burn freely once it is ignited (VSI, 2007). The NIST report continues, "less than 90 seconds after ignition, the flames began to spread upward and within another 50 seconds the flames were in the attic space" (p. 347). The researchers observed that "the [vinyl] soffit softened and dropped out leaving an open path for flame spread into the attic area" (p. 347).

In 2006 the Southwest Research Institute [SRI] in Houston, Texas, was commissioned by the Brick Industry Association to determine the actual fire-rating of

three common exterior wall assemblies (SRI, 2006). The test evaluated three different wood-framed load-bearing walls that were clad with brick veneer, fiber-cement lap siding, and insulated vinyl siding, respectively. The tests were conducted in accordance with the American Society of Testing and Materials (ASTM) E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*. The results showed significant differences in the performance of the assemblies. The brick wall easily passed the one-hour fire rating; the fiber cement wall achieved a 59-minute fire rating, but the vinyl only lasted 18 minutes (SRI, 2006). The researchers pointed out that with the vinyl assembly, the heat source (a furnace) was turned off after three minutes, but the burning vinyl and OSB sheathing continued to burn, contributing to the fire growth and heart release vertically up the wall. The vinyl wall failed completely; flames burned completely through the assembly (SRI, 2006).

It is unclear from these studies whether the vinyl by itself or the combination of vinyl and its combustible backer board is primarily responsible for the fire growth. In 2004, NIST conducted a test simulating house to house fire spread. Two external wall assemblies, clad in vinyl siding, were built six feet apart. "It took less than 80 seconds for flames exiting from a simulated house with combustible exterior walls and a window to ignite a similar house [six feet] away" (NIST, 2004, p.1), the report concluded. The researchers then constructed the same wall, but this time included a layer of fire-rated half-inch gypsum board between the vinyl and the OSB. With this fire-rated protection in place, the vinyl was consumed but the protected OSB did not ignite, even after nine minutes of continuous exposure to radiant heat from the adjacent "house." This test is only partially descriptive of the conditions firefighters might face, because it did not

assess fire spread into the house through windows, attic soffits, or other penetrations in the exterior wall. It did, however, demonstrate the difference between a structure where the outermost layers protect the wall framing, versus one where the outmost layers melt and burn quickly, exposing the framing materials to fire.

When vinyl siding burns, the fire may enter the structure without burning completely through the wall. As discussed earlier, light-weight vinyl soffits melt, burn, and fail quickly, allowing rapid fire expansion into the attic (Bossert, 2007; Madryzkowski et al., 1997). Another example of fire penetrating into the house can be found with the early failure of vinyl windows. In 1997, NIST researchers conducted a large-scale test of window breakage induced by exterior fires (Mowrer, 1997). The evaluation concluded that, "vinyl-framed windows faired poorly . . . the vinyl frames and sashes lost strength, sagged and distorted under the imposed heat fluxes, typically within minutes" (Mowrer, 1997, p. 15). Mowrer noted that the distortion in the vinyl windows frames due to heat "lead to the development of penetrations in the windows, even if the glazing remained intact. Such penetrations would permit the entry of fire brands into a building" (p. 15).

These efforts to empirically document the behavior of vinyl clad houses under fire conditions seem to support the large amount of anecdotal data in the popular fire service literature regarding vinyl siding fires. Lt. Joseph Berry of the Fire Department of New York noted in a 2003 article in *Firehouse Magazine*, that "vinyl will melt and burn when exposed to flame, exposing the OSB underneath" (Berry, 2003, p.73). He points out that "OSB has more resins per square foot than regular plywood. The small, wafer-size wood chips provide an ideal surface for fast fire consumption" (p.74). He cautions firefighters

to be on guard, because “when fire races across the combustible exterior of a building, it moves like a locomotive, consuming everything in its path” (p. 74).

Lieutenant Jared Goff of the Fairfax County Fire and Rescue Department was blunt in his analysis of vinyl siding:

> … vinyl siding, while durable and long lasting, is bad for the fire service. Its [sic] not bad enough that the contents inside the building have increased by 10,000 BTUs over the years, however, now the outside burns just as hot and quick (Goff, 2007, p.11).

In a 2008 editorial column, noted fire service author and contributing editor of *Firehouse Magazine* Hal Bruno echoed the sentiments of these authors. He observed that fires in houses with lightweight framing and vinyl siding “quickly spread up the exterior wall, then trapped firefighters inside the building in a flashover or floor collapse” (Bruno, 2008, p.20).

Procedures

Three research approaches were used. First, a detailed literature review was performed. The primary focus of the literature review was to identify the fire-related attributes of vinyl siding that have been demonstrated through existing research. The results of this literature review were discussed above. Second, an electronic mail message was sent to more than 700 current executive fire officer students and recent graduates soliciting from them examples of existing training programs or Standard Operating Procedures (SOPs) related to vinyl siding fires. Not a single department responded with a training programs or SOPs on this topic. It may be reasonably inferred from this lack of response that this topic has not been adequately explored by the fire

service. This inference is supported by the near complete lack of published training materials related to fighting fires in vinyl-clad houses.

Finally, each of the four regional fire departments that experienced significant vinyl-siding incidents were contacted to obtain additional information, lessons learned, and training materials that were developed as a result of their respective incidents.

All of the information was synthesized and compared to identify common variables impacting fires in vinyl-clad houses.

This research was limited by several factors. The review of fire protection literature was limited to information that was published and available in the public domain. It is plausible that additional tests on the characteristics of vinyl siding have been conducted but not disseminated outside private organizations.

Finally, it should stressed that while the analysis of case studies and their associated recommendations provides a description of the problem and possible solutions, it is not intended to describe the phenomena of external fire in a comprehensive or statistically valid manner.

Results

As noted above, the e-mail polling of executive fire officer candidates from more than 700 fire departments provided no usable data. This poor response suggests that most fire departments have not addressed this issue. This assertion is supported by the fact that the literature review revealed almost a complete absence of published information on tactics for vinyl-siding fires.

Useful information was collected from the four case studies. These cases focused on vinyl-siding fires that involved firefighter injuries or fatalities, mayday situations, or

significant property loss. These incidents occurred within 200 miles of Henrico County, took place within the past three years, and were extensively investigated. A summary of each case study is provided below.

Fairfax County Incident

In the early evening of April 3, 2007, Fairfax County (VA) Engine 415 responded for a motorcycle fire under a deck at a large vinyl-clad house (FCFRD, 2008). When the engine arrived on scene, they observed fire burning from rear deck, up the vinyl siding, and extending into the attic. The firefighters extinguished the visible fire on the outside before proceeding into the house through the front door, advancing their hose to the second floor. From the second floor landing, they were attempting to create an opening in the ceiling when "an explosion occurred, forcing one member over the railing and the other two members down the stairs to the first floor" (FCFRD, 2008, p. 3). The three firefighters were taken to the hospital, and the house suffered significant damage. The subsequent investigation revealed that "the fire, fueled by vinyl siding, extended into the attic through the soffit . . . fire gasses and carbon monoxide levels increased in this attic space. The levels reached explosive range and the gas ignited, causing the explosion" (p. 8). Figure 1 is a photo that shows the vinyl siding melting, sagging and burning, as fire approaches and enters the attic through the soffits and gable vents.

Figure 1. 4909 Fox Creek Court

Prince William County Incident

Two weeks after the Fairfax County incident, and just 26 miles away, a very similar fire occurred, but this time the outcome was tragically worse (PWCFR, 2007; NIOSH, 2008). At 6:01 am, a 911-call was received for a house fire. The first two units on scene, Prince William County Fire and Rescue Department's Wagon 512 and Tower 512, arrived seven minutes later and found a large vinyl-clad home with heavy fire visible on two sides. Two firefighters from Tower 512 entered the house to search the second floor bedrooms. Conditions quickly deteriorated, with visibility suddenly changing from clear to completely obscured. At this time a "ball of fire" was seen issuing from the second floor down the interior stairs and out the front door (PWCFR,

2007, p. 17). The members inside became separated. One member was rescued to safety, but despite numerous rescue attempts, Firefighter Kyle Wilson remained trapped on the second floor, where he perished (PWCFR, 2007; NIOSH, 2008).

After the incident, the department conducted and in-depth investigative report. While a number of issues were determined through this investigation, according to Fire Chief Kevin McGee, "two major issues rose to the top" (PWCFR, 2007, p. 2). The first was the impact of wind on fire conditions. During the incident, sustained winds accelerated the exterior fire growth and contributed to the spread of fire into and through the house. The second issue related to the role that vinyl siding played. Chief McGee writes:

> There is a disturbing trend emerging which is the increase of fires that are originating on a structure's exterior. Exterior fires spread rapidly on commonly used building construction materials. The exterior fires attack the structural support components, as there are no protective coverings to delay the fire spread. At the Marsh Overlook incident, there were no protective elements in place to stop the exterior fire from directly impinging and weakening the structural components. Lightweight building construction fires are dangerous to firefighters and in this case, deadly. The fire and rescue profession must continue to re-evaluate the operational approach to fires involving lightweight building construction (p. 3).

The report specifically identifies the issues presented by vinyl as part of this lightweight construction method. The report notes that "the fire rapidly consumed the vinyl siding up to the eves and soffit areas [and] photo and video documentation indicate

. . . fire extending into the attic with sections of the roof compromised at 0615 hours" (p. 43). The authors conclude that in homes with combustible exterior walls, "firefighters must anticipate rapid fire spread and extension into the attic areas, fire attacking structural members, and fire penetrating other interior spaces at more than one point" (p. 42).

Figure 2 is a photo of the house in which Firefighter Wilson died. This photo shows how the vinyl siding on three sides of the house was consumed, leaving only the brick veneer on the front intact.

Figure 2. 15474 Marsh Overlook

Loudon County Incident

On May 25, 2008, seven firefighters from Loudon County, Virginia, were injured while fighting a fire in a large, vinyl-clad home (LCDFR, 2008). Four of the injured firefighters received significant burns. Firefighters had responded to a report of a house fire, and arrived on scene eight minutes after the first 911 call. The first arriving

companies observed heavy fire from the rear of the structure extending into the attic. They initiated an interior attack, advancing the hose to the second floor. Within eight minutes of arriving on scene, these firefighters initiated a mayday, reporting a partial roof collapse with firefighters trapped on the second floor. As fire conditions continued to worsen, the firefighters on the second floor were able to escape using ground ladders that had been positioned to the windows.

In the investigation that ensued, Loudon County Fire Chief Joseph Pozzo concluded that "the challenge of rapid fire spread is exacerbated by the use of lightweight roof trusses, vinyl siding, and combustible sheathing" (LCDFR, 2008, p. 3). The report went on to specifically discuss the role played by vinyl siding, "the construction features and building materials, in particular the vinyl siding and combustible sheathing, contributed to the rapid spread of the fire" (p. 43). In a now too-familiar pattern, the report noted, "fire spread along the vinyl siding and combustible sheathing and traveled up through the vented soffits into the continuous attic space" (p. 88).

Figure 3 shows an aerial image of the house after the fire. The pattern of vinyl-clad walls consumed, and the roof burned away, is similar to the other case studies.

Figure 3. 43238 Meadowood Court

City of Raleigh, N.C., Incident

On February 22, 2007, a fast-moving fire destroyed 32 townhomes in the Pine Knoll Townhomes subdivision in Raleigh, North Carolina. A grass fire, fanned by strong winds, quickly ignited the vinyl siding of one townhouse. The fire quickly extended up the vinyl siding, entering the attic through the vinyl soffits (Bossert, 2007). Since the fire was on the exterior of the structures, the fire-rated walls that separated the units failed to stop the spread of fire from unit to unit. As burning brands issued into the sky and fell on neighboring properties, the size of the fire quickly grew (Bossert, 2007).

After the fire, the City of Raleigh hired an independent professional engineering firm to evaluate the causes of the fire. The report concluded that "the effect of combustible soffits was a major influence to fire spread . . . vinyl soffits melted and exposed combustible attics" (Bossert, p. i). The report continues on to note that "once

fire entered the attics, the roof shielded firefighting efforts, and the units were consumed" (p. 19). As a direct result of this incident, on April 5, 2007, the North Carolina Building Code Council issued an emergency rule change to the residential code, requiring "non-combustible materials for soffit construction" (Bossert, 2007, p. 22).

Figure 4. Pine Knoll Townhome Fire

As noted earlier, there is very little published training material to aid firefighters in preparing to recognize the unique hazards of vinyl siding. However, the after-action reports for the incidents described above do provide some general guidance, taken in context with the overall findings of the reports. The investigative team from the Fairfax County incident stressed the importance of completing a thorough risk-benefit analysis before committing personnel to interior fire attack positions, and also recommended maintaining a firefighter on the exterior of the structure to monitor changes in fire

conditions, including fire progression along exterior assemblies (FCFRD, 2008). The Fairfax report recognizes the need for additional training to "address the characteristics and challenges for the arriving officers at the scene of an exterior fire involving vinyl siding" (p. 14).

The authors of the Prince William incident offered two primary considerations for firefighters. First, as part of their situational awareness, and in evaluating the level of risk, firefighters need to beware of the potential for wind conditions to quickly spread exterior fires, and to blow fire from the exterior assemblies into the house in a "blowtorch effect" (PWCFR, 2007, p. 2). The second consideration was that firefighters need to be aware of the danger posed by combustible exterior assemblies, especially when used in combination with lightweight construction practices.

After the Fox Creek incident, Fairfax County Fire and Rescue Department initiated a field training program for its members on residential structure fires, with a focus on exterior fires. This training program provided students with an in-depth review of the building construction practices using vinyl siding, soffits and trim, and it explained how fire can progress from exterior to interior (Barlow, 2008). It describes vinyl soffits and overhangs as "the doorway to freedom for a fire . . . the intake for the large vented attic space" (p.15). Any fire that threatens to penetrate the soffits is described as a "huge priority" (p. 15).

In 2008, an organizational called the "Fire and Rescue Departments of Northern Virginia (FRDNV)" issued a multi-volume *Emergency Operations Manual* (referred to as the *NOVa Manual*) to standardize firefighting efforts in a metropolitan area that relies heavily on automatic mutual aid. This organization includes fire departments from

Arlington County, City of Alexandria, City of Fairfax, Fairfax County, Fort Belvoir, Fort Myer, Prince William County, and the Metropolitan Airports Authority. The document includes a section focusing on "exterior fires extending into the dwelling" (FRDNV, 2008, p. 31). According to one of the authors, Captain Scott Kraut from Fairfax County, this manual contains the first, if not only, documented strategy for exterior vinyl fires (personal communication, September 2, 2009). The "mandatory" tactics called for in this manual include the following:

> The first hoseline is deployed to the fire location on the exterior of the structure to perform a quick knockdown of the fire in a sweeping fashion. Crews must use caution not to flow water into windows or doors whenever hoselines are operated from the exterior. This tactic may force fire and the products of combustion into the dwelling toward the occupants.
>
> Once the first hoseline is in place and operating effectively, the second line should be deployed to the interior of the dwelling. The crew must inspect the ceiling area and the floor condition at the point of entry. The use of a thermal imaging camera is highly recommended. This line will extinguish any fire within the dwelling and protect the occupants and the companies operating on the interior. In order to be successful more than one hand line may be required.
>
> Once fire is knocked down on the exterior of the dwelling, the hoseline may be re-deployed to the interior to assist the interior line or progress to upper floors to attack any fire.

> The coordination of tactics and operations between the first engine and the special service units or additional engine companies must be completed before the special service units can enter the building. (p. 32)

The Fairfax County field training presentation refers to these steps as "the combination attack" (Barlow, 2008, p. 48) and stresses that because of the complexity and danger of these fires, first-arriving company officers "need to take a few extra moments to assess building and fire conditions" (p. 47).

Barlow notes that this combination attack requires adequate staffing in order to simultaneously attack the exterior fire while preparing for an interior attack, using multiple hose lines and ensuring back-up personnel are in position. He suggests utilization of fire-department EMS crews, engine drivers, and truck or rescue personnel to place hose-lines if needed, rather than assigning these personnel to their traditional roles. This change in deployment represents the realization that this type of combination attack is different from the traditional interior attack evolution, and requires different tactical thinking (Barlow, 2008). This approach requires "discipline, good analysis of situation, communications and coordination, and a rapid deployment of resources" (p. 53).

Discussion

This research focused on three questions: (a) to what extent does vinyl siding contribute to fire growth; (b) what are the documented examples of rapid fire growth attributed to vinyl siding that resulted in firefighter maydays, loss of life, or significant property loss; and (c) what unique considerations should firefighters take when fighting fires in vinyl-clad houses.

Research Question 1: To What Extent Does Vinyl Siding Contribute to Fire Growth?

The vinyl industry, through its national trade organization, asserts that vinyl is a safe product due to its high ignition temperature and slow-burn characteristics (VSI, 2006). Testing by NIST researchers supported the notion that vinyl resisted ignition and that it would melt and distort prior to catching on fire, but the same evaluation also demonstrated that at certain temperatures vinyl would begin flaming and would continue to burn from its own heat release (Madrzykowski et al., 1997). Further testing by NIST in 2004 demonstrated that vinyl siding would ignite from a radiant heat source, although was more likely to continue burning when the underlying structural components were also ignited (NIST, 2004). Through multiple studies, NIST researchers observed vinyl siding fires progress from the exterior of the structure into the interior compartments through attic soffits (Madrzykowski et al., 1997; NIST, 2004) and through failures of vinyl window assemblies (Mowrer, 1997). These results were supported by private research conducted on behalf of the Brick Industry Association (SRI, 2006), in which a vinyl exterior wall failed and allowed fire penetration into the simulated structure in just 18 minutes.

None of these evaluations were conducted in a manner that simulated actual fire conditions on “as-built” construction with full height exterior wall assemblies, windows, soffits, and actual attic spaces. However, taken together, these tests describe a consistent manner of fire behavior and fire spread that has been observed many times in published and anecdotal reports of major fires in vinyl-clad structures.

In each of the case studies, fire extended up the exterior vinyl siding, penetrating into the structure through windows, attic soffits, or other vulnerable areas. In each case,

the fire grew quickly and almost without limitation, attacking the framing members, and exposing firefighters to dangerous, rapidly changing conditions.

The assertion by VSI that vinyl is safe because it tends to melt rather than ignite is false comfort. When the siding melts, it exposes the underlying framing to ignition. Since the building code in Virginia (and much of the United States) does not require fire-rated materials to be applied behind the siding, this research supports the assertion that the melting and distortion of the siding represents a significant failure of the product because it increases the vulnerability of the structure to fire. Further, the published research and the case studies demonstrate clearly, that when vinyl is exposed to direct flame impingement, or intense radiant heat, it does in fact burn and contributes directly to fire growth and propagation.

The use of vinyl components to protect the attic soffits is cited in multiple sources as a serious vulnerability (Bossert, 2007; FCFR, 2007; Madrzykowski et al., 1997; PWCFR, 2007). The decision of the North Carolina Building Code Council to require non-combustible soffit materials speaks directly to the seriousness of this concern (Bossert, 2007).

Research Question 2: What are the Documented Examples of Rapid Fire Growth Attributed to Vinyl Siding That Resulted in Firefighter Maydays, Loss of Life, or Significant Property Loss?

The four case studies provided valuable insight to common problems encountered during fires in vinyl-clad structures. In each case the fire started on the exterior of the house by melting, distorting, and igniting the vinyl, which burned up along the exterior sheathing. As the siding failed, the underlying wood and framing was exposed and

ignited, further fueling the vertical fire growth. As the fire approached windows, overhangs, and soffits, it found points of entry into the unprotected areas of the structure. In particular, in all four cases the fire entered into unprotected attic spaces, which allowed for rapid and uncontrolled fire growth across the top of living spaces, with deadly consequences for anyone still inside the house.

The impact of wind was a factor in both the Prince William case and in the Raleigh incident. In each of these instances the wind contributed to much faster fire spread along the exterior wall, and once the fire found penetrations into the structure, the wind caused a "blow torch" effect that increased fire spread.

The lightweight framing practices in each of the four cases contributed to the resulting disasters. However, the common denominator affecting the initial fire growth, and the greatest vulnerability of the structures identified in each of the four cases was the vinyl siding.

Research Question 3: What Unique Considerations Should Firefighters Take When Fighting Fires in Vinyl-Clad Houses?

Using the analysis of vinyl siding's contribution to fire spread, it was possible to identify the unique aspects of fire behavior seen in these structures. Extrapolating from that information, the following topics should be included in the training program:

1. Review the burn characteristics of vinyl siding as demonstrated by various tests reviewed above.
2. Review how the melting and distortion of vinyl exposes the combustible framing of the structure to fire.

3. Review how the combustible wall sheathing behind the vinyl siding adds to the fuel load for external fires.
4. Explain how fire spreads into the house through vinyl windows, soffits, and other openings.
5. Explain how fire spreads quickly up and across vertical vinyl-clad surfaces.
6. Review how exterior vinyl fires can spread to open, unprotected attic spaces.

The second source of data for the training program was the case study analysis. In reviewing these cases, there were common findings that describe unique considerations when dealing with vinyl siding fires (PWCFR, 2007; LCFD, 2007; FCFD, 2008). These common themes included the following:

1. It is critically important to conduct a thorough size-up of the structure and the fire condition before committing personnel into the structure. This includes the need to conduct a complete "lap" around the structure.
2. Firefighters should control the exterior fire before entering the structure.
3. Wind is a major concern when firefighters are confronted with combustible exterior fires. The presence of wind should dictate a higher measure of caution before committing crews into a structure.
4. Due to the potential for exterior fires to enter the structure on multiple floors and locations, firefighters should continuously check for extension below and above their operating position, and not work in advance of the hose-line, even during search operations.

5. If the exterior vinyl fire threatened the attic soffits, crews should make checking the attic for fire extension a priority.

The third source of information was existing training resources that have been developed to prepare firefighters for vinyl siding fires. Very little such material was available for review. The lack of response to the e-mail survey suggests that few fire departments have developed this type of training. The one exception was found in Northern Virginia, where the collaborative efforts of several fire departments resulted in a unique set of recommendations included in the 2008 edition of the *NOVa Manual* (FRDNV, 2008). Fairfax County's in-service training program (Barlow, 2008) supported and expanded upon the points made in the *NOVa Manual*. These points include the following:

1. A "combination attack" should be employed, whereupon the first hose-line is stretched to knock down the exterior fire, while the second line is prepared for an interior attack.
2. The change in mode from exterior fire attack to interior fire attack must be carefully coordinated.
3. Crews that enter the structure must check for extension in the ceiling and the floor as they advance.

Taken together, these considerations form the basis for a training program that will provide firefighters with an understanding of the building construction issues, how

the fire spreads, how the fire spread endangers them, and how to adjust their tactics for the safest and most effective fire attack method.

Recommendations

Based on this research effort, the following recommendations are made to the Henrico County Division of Fire.

Recommendation 1: The Division of Fire Should Provide Formal Training to all Members Regarding the Unique Aspects and Dangers of Fires Involving Vinyl Siding.

The Division's Training Section should develop a "train-the-trainer" program that will allow the organization to present this training to all personnel during regularly scheduled in-service training. Battalion chiefs should ensure all personnel within their battalions receive the training. The Powerpoint™ presentation (attached as Appendix B) may be used for this purpose. The training should be enhanced with practical training at the Division's fire training center during the semi-annual company in-service training evolutions.

Recommendation 2: The Division of Fire Should Make its Training Program Available to Other Fire Departments.

Since information on vinyl siding fires is difficult to locate in the fire service media, and since there are few training programs available on the subject, it is the obligation of the Division of Fire to promote this information to other fire departments, preferably in a nationally-published journal, or any other means that will ensure its widespread distribution.

Recommendation 3: The Division of Fire Should Work with the State Fire Marshal to Amend the Building Code to Address the Vulnerabilities of Vinyl Siding.

Given the recent firefighter fatality, firefighter injuries, and significant property loss attributed to vinyl siding fires, the Henrico County Fire Marshal should assess the potential of a code change (at the State level) that would require non-combustible components added to the exterior of houses to reduce the likelihood of such events from occurring. Special focus should be given to following North Carolina's example in requiring non-combustible materials be used in construction of attic soffits.

By enacting these recommendations the Division will be taking proactive steps to protect both residents and firefighters, while honoring the sacrifice of those whose loss and suffering allowed us to realize the magnitude of this problem.

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Appendix A

Dedication

This research is dedicated in memory of

Technician I Kyle Wilson

Prince William County Department of Fire and Rescue

Died in the line of duty on April 16, 2007, while fighting a fire in a vinyl-clad house