Vulnerability of Vents to Wind-Blown Embers

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Introduction

Wind-blown embers are the principal cause of building ignitions. Although the importance of embers (also called brands or firebrands) has been understood for a number of years, the ability to evaluate them in a laboratory setting has been a relatively recent development.

Reports from the November 1961 Bel Air fire in Southern California, where 484 homes were destroyed, was an early example in North America that provided clear evidence of the importance of ember ignitions. Greenwood (1999) reported that “There was no contiguous fire boundary. Instead, there were scores of large fires scattered over a wide area, each sending thousands of brands into the air to swarm out to ravage new sections.” These isolated spot fires were caused by wind-blown embers. Steinberg (2013) also discussed the importance of embers and the specific implication to building ignitions, again as pertaining to the 1961 Bel Air fire by referring to “destroyed buildings surrounded by unconsumed vegetation.” An investigation after a January 1944 wildfire in Victoria, Australia, also clearly showed the importance of embers to building ignition and destruction. Barrow (1945) reported that “Although the damage was caused primarily by the external fire, practically all the houses ignited inside, i.e., in the roof space, in rooms, or under the floors, due to the ingress of flame, sparks, *and embers* through openings such as ventilators, eaves, and windows” (emphasis added).

Embers can ignite combustible construction materials directly and, as indicated in the Bel Air fire report already discussed, can also cause spot fires that can in turn result in a flame and/or radiant heat exposures to a building. Examples of direct ember ignitions include those resulting from a deposition of embers directly on or immediately adjacent to a combustible material. This scenario is most commonly thought of for exterior use materials such as wood shakes or shingles on a roof or combustible siding materials. Without adequate suppression capabilities, this scenario would result in fire spreading from the outside of the building inwards. A direct ember ignition scenario can also occur if a sufficient number of embers pass through a penetration in the exterior envelope, potentially resulting in a building burning from the inside out. Common examples of vulnerable penetrations include open windows and vents.

Ember entry through vents that resulted in interior (attic) fires have been discussed in post-fire reports. Maranghides et al. (2015) reported that an attic fire was successfully extinguished during the 2012 Waldo Canyon fire, indicating that ember entry into the attic was a likely scenario. Maranghides and McNamara (2011) reported evidence of attic fire with a possible source from an attic vent during the February 2011 fires in Amarillo, Texas. In a Texas Forest Service case study of the 2005 Cross Plains fire, Gray et al. (2007) reported a suspected home ignition from firebrands that entered through screened attic vents. This house was reported to have burned from the inside out. These observations support the importance of embers as a cause of building ignitions in general, and provide evidence of the vulnerability of vents to ember intrusion, with subsequent ignition of interior combustibles as one cause of building ignition.

Building codes and standards that apply to new construction and existing buildings have specific requirements for attic and sub-floor (crawl space) vents. Current editions of the International Code Council's International Wildland Urban Interface Code (ICC IWUIC, 2012) and the National Fire Protection Association (NFPA) Standard 1144 (2013) specify a minimum ¼-in. (6 mm) noncombustible mesh screen covering for vents. Chapter 7A in the California Building Code addresses new construction in designated wildfire-prone areas in the state. Chapter 7A specifies noncombustible mesh screen covers between $^{1}/_{16}$ in. (1.5 mm) and ⅛ in. (3 mm). Chapter 7A also provides a performance-based path for compliance by allowing vents that "resist the intrusion of flames and burning embers" to be used. This standard also limits the use of vents in the under-eave area. This section of the code was based on best judgement at the time the code was developed, judgement that indicated an increased vulnerability in the under-eave area.

Chapter 7A was fully implemented in 2008. In support of that standard, the California Office of the State Fire Marshal (OSFM) had developed State Fire Marshal (SFM) standard test methods to evaluate the performance of certain components, including decking and siding. However, a standard test method was not provided to evaluate the ability of a vent to "resist the intrusion of flames and burning embers" (California Building Code, 2010). A standard test method was developed through the American Society for Testing and Materials (ASTM), but not until 2014 (ASTM 2886). In the time between 2008 and the present, vents that were accepted for use by the State Fire Marshal's office did so by conducting tests at one of the commercial fire test laboratories approved by the California OSFM. The commercial fire laboratory followed the procedures of the current version of the ASTM draft standard test method.

During the 2011 wildfire experiments conducted at the IBHS Research Center, it was observed that embers readily entered through the gable end vent used in the attic of the test building. It was also observed that the number of embers passing though attic vents located in the under-eave area depended on the type of eave construction, with entry through vents in the blocking of open-eave construction exceeding entry through vents installed in a soffited-eave. At the same time that our experiments were being conducted, Manzello et al. (2011) reported on a laboratory experiment that evaluated the vulnerability of a gable end vent to ember entry. The gable end vent was reported to be vulnerable to ember entry. Results of modeling indicated that vents located in an enclosed (soffited) eave would be less vulnerable. The open-eave construction option was not modeled.

The experiments reported here expand on observations made during the 2010–2011 Wildfire Ignition Resistant Home Design (WIRHD) project where it was observed that certain vent designs were more vulnerable to ember entry. External funding for the 2013–2014 experiments was secured from a CSAA Community Safety Foundation Grant.

The objective of this study was to clarify the relative importance of vents, including style, type and location to the entry of wind-blown embers. At the time this project was conducted, three vents had been accepted for use by the California OFSM. These vents were incorporated into the experimental design.

Experimental Design

Attic vent area calculations used to determine the number and size of vents used in the test building were based on a 1:300 ratio, providing 1 ft^2 (0.1 m^2) of net free vent area for each 300 ft^2 (28 m^2) of building floor area (Beall, 1998). The test building used for these experiments had a floor area of 1,200 ft^2 (111 m^2), resulting in the need for 4 ft^2 (0.4 m^2) of total vent area. Since inlet and outlet vent areas are typically split 50:50, approximately 2 ft^2 (0.2 m^2) of net free vent area was allocated for inlet vents (always the under-eave vents) and 2 ft^2 (0.2 m^2) was allocated for outlet vents (vents that penetrated through the roof or those located in the gable end of the building). Only one type of outlet vent was installed for a given test. The experimental design enabled evaluation of the effectiveness of vent-related mitigation strategies for new and existing buildings. Four-mesh (i.e., ¼-in. [6 mm]) noncombustible screening located in a gable end vent was used as the control condition.

Two types of under-eave (inlet air) vents were used. These included (1) open-eave vents that are incorporated into the solid-wood blocking inserted between roof rafters (or trusses), and (2) vents that are incorporated into the soffit material in “boxed-in” construction, as shown in Figures 1 and 2, respectively. A standard overhang width of 18 in. (460 mm) was used on all sides of the test building. An interior attic partition was constructed to separate the two inlet vent sections of the test building (i.e., the open-eave and soffited-eave sections) used for these experiments (Figure 3).

Figure 1. *Vents located in between-rafter blocking in the under-eave area of a building that used open-eave construction.*

Figure 2. *A strip vent located in the soffit of a building that used soffited-eave construction.*

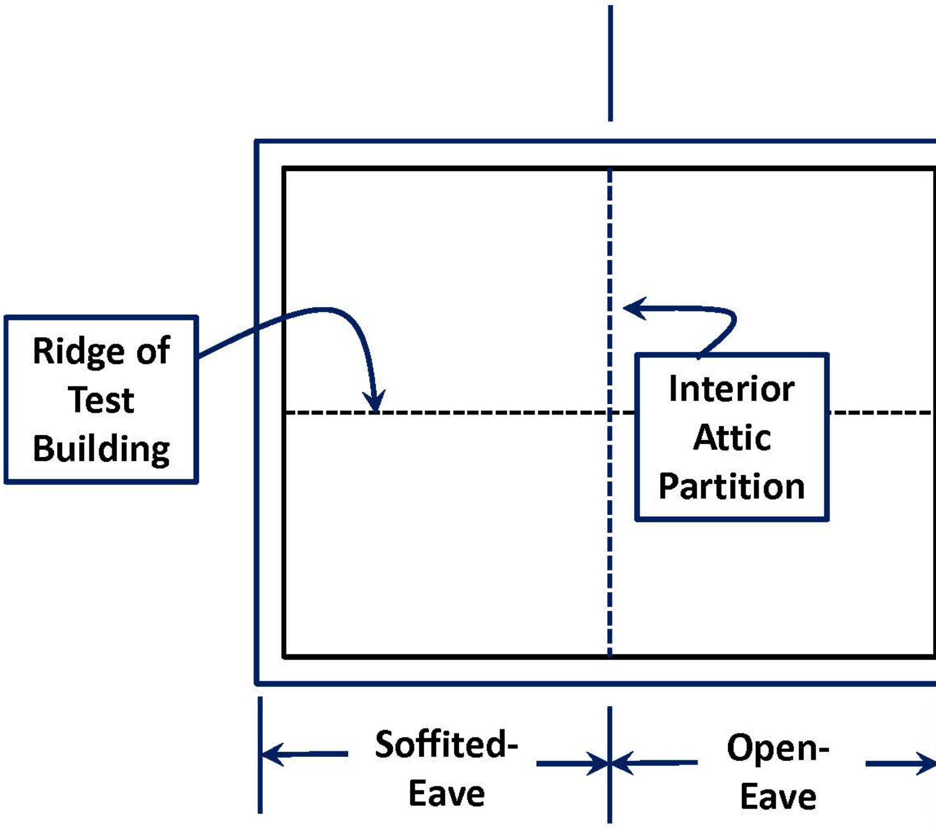

Figure 3. *A plan view diagram of the test building showing the location of the two types of inlet (under-eave) vents used in this series of experiments.*

The three types of outlet vents were evaluated during these experiments. Only one outlet vent type was evaluated at a time. Outlet vent type and products included:

1. **Gable end vent.** During these experiments, the gable end vent was covered with one of four different mesh screens—¼-in. (6 mm), ⅛-in. (3 mm) or $^{1}/_{16}$-in. (1.5 mm) square mesh, or ⅛-in. (3 mm) diamond mesh—or a vent that had been accepted for use by the California OSFM at the time these experiments were conducted. These vents had been accepted[1] for use because the vent manufacturers had provided sufficient testing information, conducted by an OSFM-approved commercial fire testing laboratory, to demonstrate resistance to

[1]The term "accepted" is used because at the time these experiments were conducted, there was no approved standard test method for evaluating the ability of a vent to resist the intrusion of embers and flames and therefore no way to "approve" a vent for use. The California OSFM was accepting these vents for use on construction projects they managed. Authorities having jurisdiction (AHJs) in other jurisdictions could do the same based on the procedure developed and used by the OSFM. Now there is an accepted method to evaluate the performance of vents—ASTM E2886, Standard Test Method for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement.

the entry of wind-blown embers and flames. The accepted vents used in this study included (1) a vent that incorporated a baffle construction and a ⅛-in. diamond mesh screen in the design, and (2) a vent that incorporated an intumescent-coated honeycomb mesh material and $^{1}/_{16}$-in. mesh screening.

2. **Off-ridge vent.** During these experiments, one of three different off-ridge vents were installed—a turbine vent, a flat-faced vent covered with ¼-in. diamond mesh screening, or an off-ridge California OSFM-accepted ember- and flame-resistant vent that incorporated a steel wool fill in the vent design.

3. **Ridge vent.** During these experiments, a Miami-Dade wind-driven-rain-rated vent (complying with Testing Application Standard [TAS] 100A), or this vent modified by removing the external baffle, was installed (Figure 4).

A diagram showing the locations of the outlet vents is given in Figure 5. As indicated, only one outlet vent was used during any individual test.

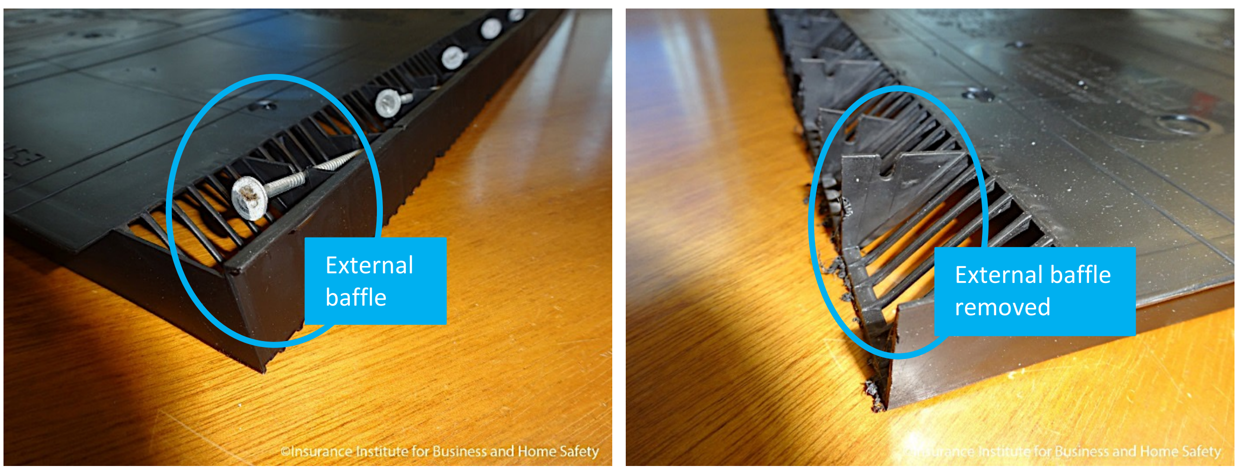

Figure 4. *A Miami-Dade wind-driven-rain-compliant ridge vent (left) and the same vent modified by removing the external baffle (right).*

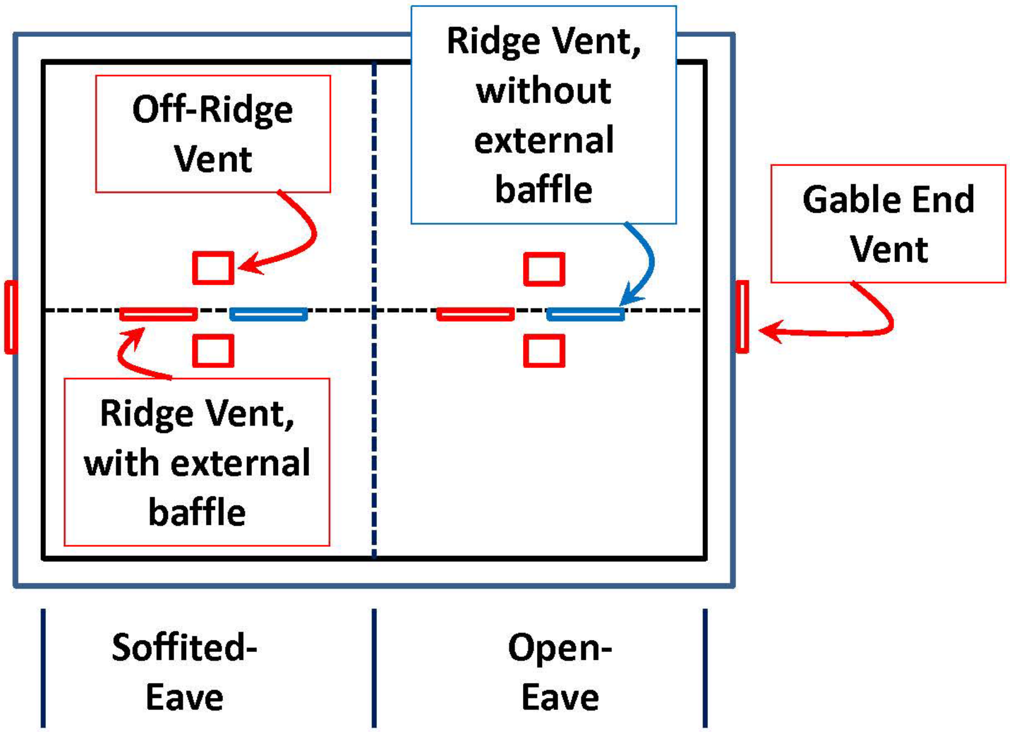

Figure 5. *Locations of gable end, ridge, and off-ridge vents. Only one of these vent types was installed during a given experimental series.*

Three fluctuating wind speed records (Figure 6) were used to evaluate the influence of wind speed on ember entry through vents for selected wind directions. Wind speed records were nominally labeled low, medium and high. The low-level wind speeds ranged from 16 to 20 miles per hour (mph) [7–9 m/s]. Medium speeds ranged from 25 to 31 mph (11–14 m/s) and high speeds ranged from 45 to 60 mph (20–27 m/s). The low and high wind speed records were scaled based on the medium record. The low record was 0.85 of the medium wind record and high was 1.75 of the medium wind record. Building orientations used to assess the effect of wind direction on ember entry are shown in Figure 7.

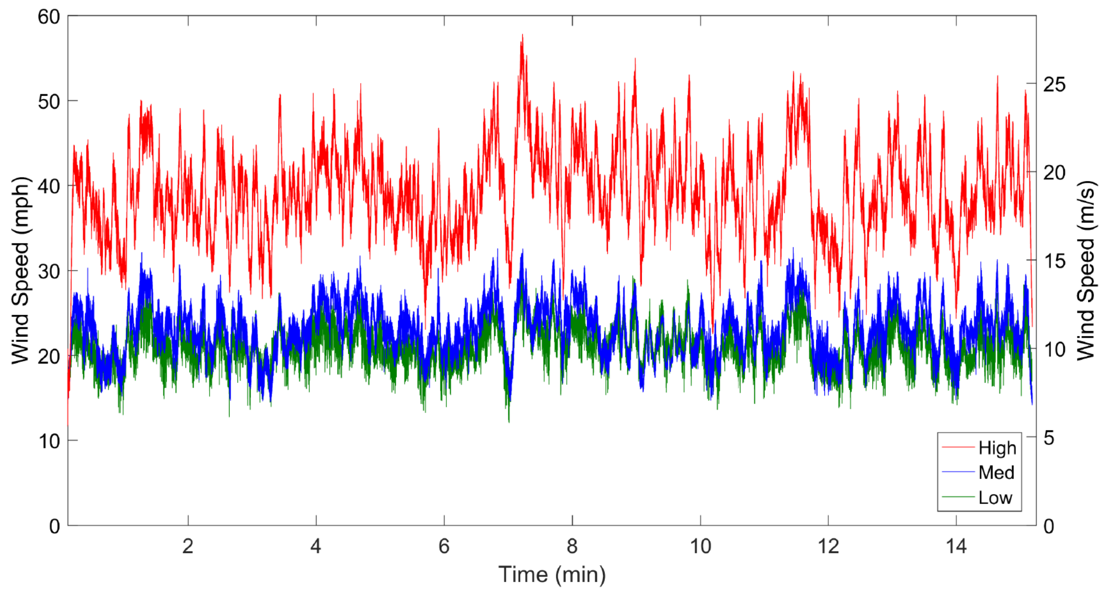

Figure 6. *The first nine minutes of the three fluctuating wind speed records used in these experiments.*

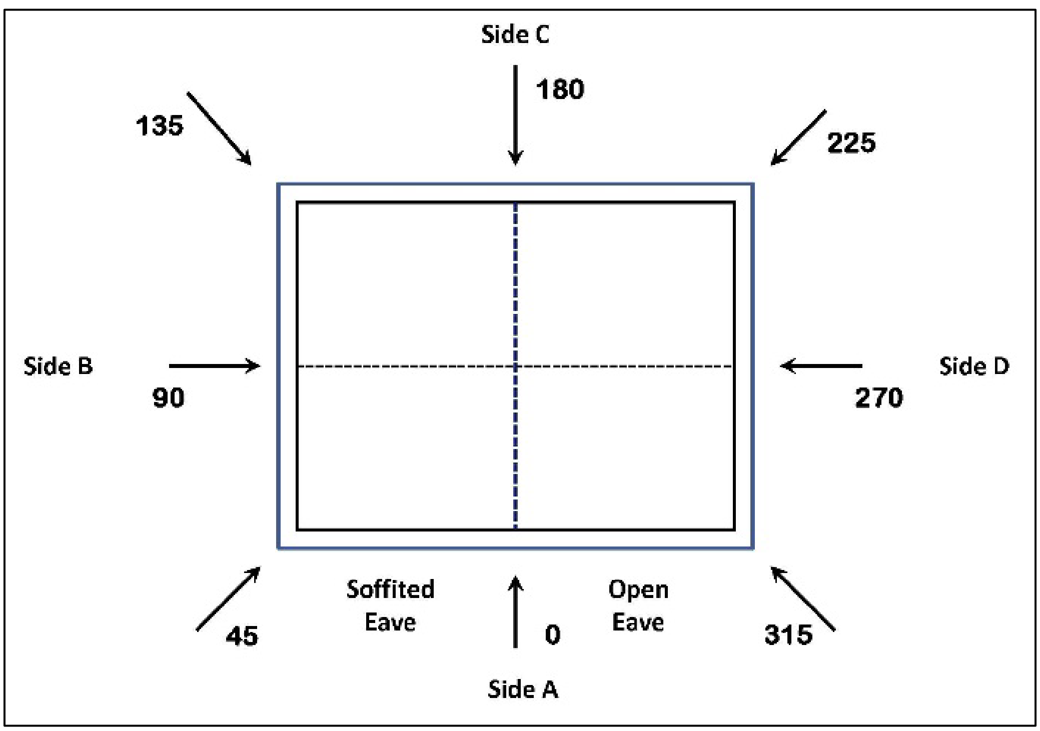

Figure 7. *Building orientations used to evaluate the effect of wind direction on ember entry through attic vents.*

One of the seven ember generators used in this study is shown in Figure 8. Each generator consisted of a cylindrical burn chamber and a raw material hopper. An auger feed screw conveyed the wood-based feed stock for the generators out of the hopper and into a chute that dropped the feed stock onto a metal mesh screen positioned just above a natural gas burner located near the bottom of the burn chamber. The gas burner ignited the raw material that accumulated on the metal screen.

The raw material used to generate embers was locally sourced southern yellow pine wood chips and commercially available hardwood (typically birch) dowels. The wood chips were dried in a dehumidification kiln located at the IBHS Research Center prior to use. The targeted ratio of chips to dowels was 85:15 (by weight). Each test was 15 minutes in duration. Longer tests could be run by intermittently reloading the raw material storage hoppers.

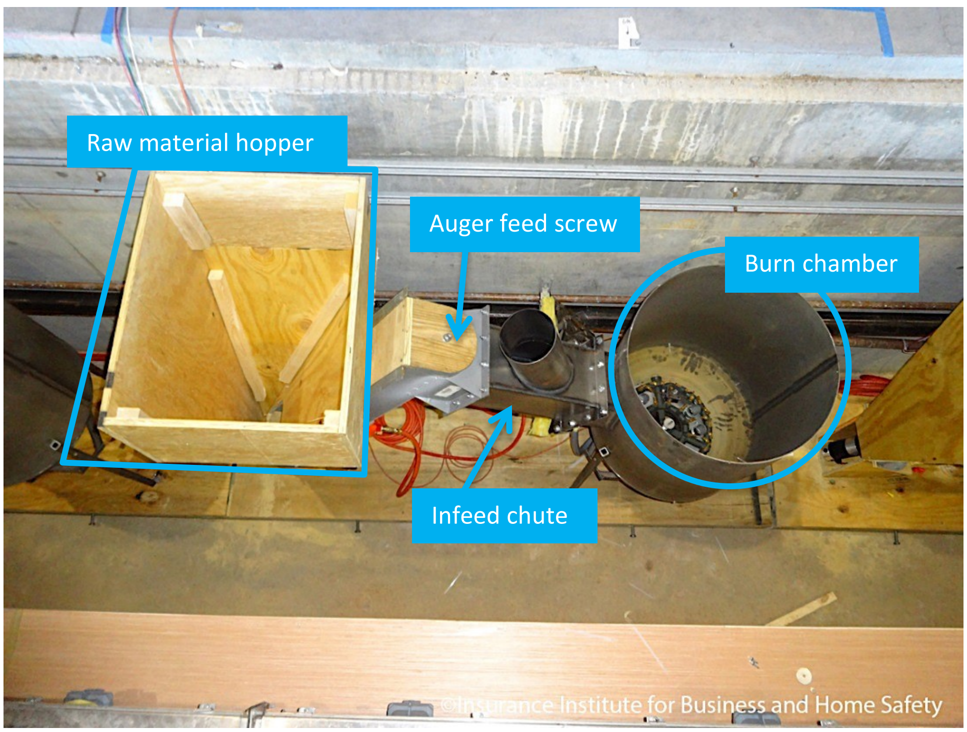

Figure 8. *The ember generation system consisted of the raw material storage hopper (left) and a burn chamber (right). An auger feed screw delivered the raw material to the burn chamber through an in-feed chute. These components of the ember generation and delivery system were located below grade in a trench.*

An overview photograph of the seven ember generators is shown in Figure 9. This figure shows the vertical ducts that carry the burning (glowing) embers from the burn chamber into the wind stream of the test chamber. It also shows one-half of the air supply and distribution system used for the generators. Another air supply and distribution system was located on the opposite side of the chamber. The air supply system served two purposes: (1) to deliver air to an opening in the bottom of each generator, thereby providing the force needed to push the lofting embers out of the burn chamber and out of the vertical duct, and (2) to deliver air to the top of the infeed chute, which provided sufficient positive pressure to confine the fire to the burn chamber, and keep it from moving up the infeed chute and into the raw material hopper.

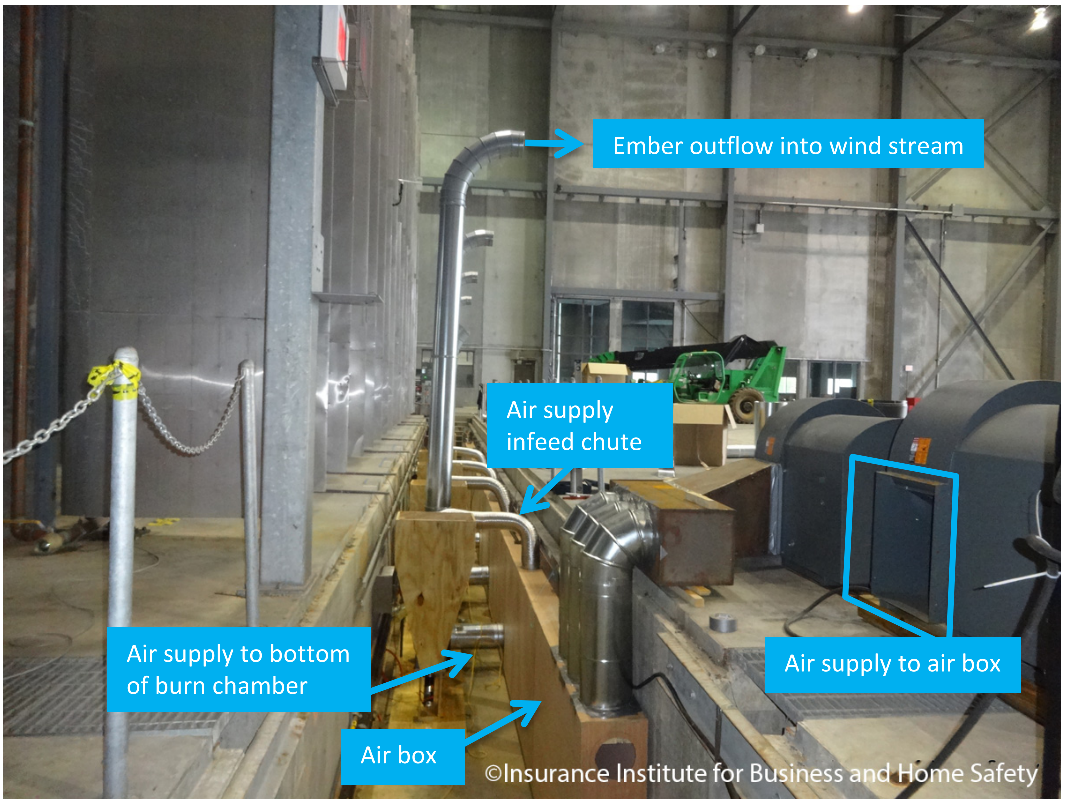

Figure 9. *Overview of ember generation system. The charged air box supplied air to bottom of burn chamber (pushing lofting embers into vertical ducts and then into wind stream of wind tunnel fans) and to the top of the infeed chute (minimizing heat exchange between burn chamber and raw material hoppers).*

All seven ember generators were run during each test. A representative photograph of these generators is shown in Figure 10.

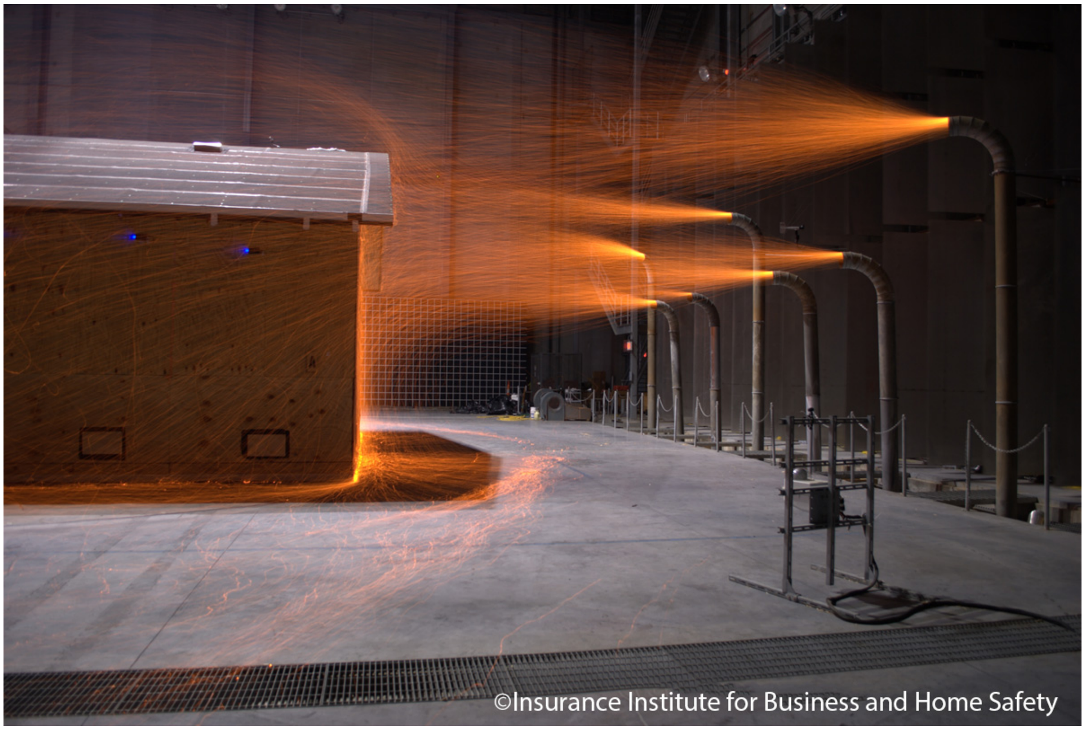

Figure 10. *Ember generators operating during a test.*

Analysis

Video- and non-video-based measurements were used to evaluate the ability of a given vent to resist the intrusion of wind-blown embers. For each test, cameras were positioned at interior location(s) to capture video of embers that entered through one or more vent openings. In the case of inlet (under-eave) vents, the field of view of a given video camera was sufficient to capture entry through two or three vent openings. For gable end and through-roof vents, cameras were only able to capture ember entry for an individual vent. A post-processing procedure using a particle tracking algorithm was used to count embers. Typical camera setups are shown in Figures 11 and 12.

Figure 11. *Typical video camera setup used to evaluate ember entry through the gable end vent.*

Figure 12. *Typical video camera setup used to evaluate ember entry into a through-roof vent.*

During the gable end vent tests, a 3 ft x 8 ft (0.9 m x 2.4 m) section of a wood-based panel was placed below the inlet of the vent (Figure 13). After each test, the embers that landed on the panel were collected and weighed.

During gable end and through-roof vents tests, a cotton pad was placed on a horizontal surface near (under) the entry area for the vent. In the case of the gable end vent, the cotton was placed on the panel previously mentioned (Figure 14). In the case of other through-roof vents, the cotton was placed on an elevated platform (Figure 12). The cotton was used to evaluate the ability of embers to ignite fine fuels in an attic space. Cotton served as a surrogate for all combustible fine fuels that could be in an attic space. Cotton was selected because it was the combustible materials selected for use in the ASTM standard test method to evaluate the performance of vents (ASTM E2886). Cotton is also used in other ASTM fire test standards. This standard evaluates vent performance by evaluating the ability of embers that pass through a given vent to ignite the cotton substrate.

Figure 13. *Embers that landed on the 3 ft by 8 ft (0.9 m x 2.4 m) panel (blocked in blue) were collected and weighed after each test. This technique provided means to quantify ember entry through the gable end vent. Note that embers (the black particles) landed on and off the panel. Only embers that landed and accumulated on the panel were weighed.*

Figure 14. *A cotton pad was placed on a horizontal surface, near the entrance of gable end and all through-roof vents to evaluate the ability of entering embers to ignite a combustible material.*

Results and Discussion

Common types of attic vents were evaluated during these tests. Inlet vents were always in the under-eave area. Outlet vents were located either on the gable end wall or on the roof. A summary of types of vents, their location and relative vulnerability to ember entry is given in Table 1. Relative vulnerability is based on a composite of the methods used to evaluate performance (i.e., post-processing of video footage, visual observations and notes made during a given test, weighing of accumulated embers on the panel, and observations made of ember strikes on the cotton pad).

As indicated in Table 1, vents that provided a vertical face to the wind were more vulnerable to the entry of wind-blown embers. These included all gable end vents, the generic through-roof off-ridge vent, and vents in the blocking of open-eave construction. In each of these cases, wind flow was perpendicular to the vertical face of the vent. The number of embers that ultimately entered through a given vent depended on the location and size of the vent opening and other design features built into the vent that have a positive influence on reducing entry. Gable end vents are installed in the vertical triangular wall of the attic at a gable end. They are limited in number and therefore tend to have a larger surface area compared to through-roof outlet vents. The vertical face and large area alone make the gable end vent location more vulnerable to ember entry than other outlet vent locations. Vent design features and smaller mesh sizes will reduce the size and number of embers that enter through a gable end vent. While gable end vents are designed to provide an outlet for hot attic air, they allow the free flow of air into and out of the attic. Consequently, when the vent is on a windward face, wind, embers and wind-driven rain can also enter through the vent.

For vents in the under-eave area, ember entry increased with increasing wind speed. Vents located in the soffit were less vulnerable to ember entry than those located in between trusses/rafters (truss bay or rafter bay blocking) in open-eave construction. The vent opening in the soffited-eave locations was parallel to the wind flow; however, recirculation of the wind in the under-eave area allowed for some ember entry to occur. The number of embers passing from the enclosed portion of the eave to the attic space (i.e., to the space above the occupied portion of the building) also increased with increasing wind speed. This relationship was reversed for ridge and turbine vents, where ember entry decreased with increasing wind speed.

Table 1. Description of vents evaluated in this series of experiments and their relative performance in terms of ability to resist the entry of wind-blown embers.

Vent Function	Location	Vent Type	Vent Description	Relative Performance
Inlet	Under-eave	Open-eave	¼-in. square mesh screening	Poor
		Soffit	⅛-in. square mesh screening[1]	Best
Outlet	Gable end	Mesh	¼-in. square mesh screening	Poor
			⅛-in. square mesh screening	Fair
			⅛-in. diamond mesh screening	Fair
			$^{1}/_{16}$-in. square mesh screening	Good
		Wildfire-resistant vent	Baffled-design wildfire -resistant vent with ⅛-in. diamond mesh backing	Good
			Honeycomb mesh, wildfire -resistant vent with $^{1}/_{16}$-in. square mesh backing	Good
	Through-roof off-ridge	Generic	¼-in. square mesh screening	Poor
		Turbine	No screen	Good
		Wildfire-resistant vent	Louvers and steel wool fill	Best
	Through-roof ridge	Miami-Dade wind-driven-rain-compliant	External baffles present	Best
		Non-Miami-Dade wind-driven-rain-compliant	External baffles removed	Fair

[1] Soffited construction is best. Though this study used ¼-in. mesh, ⅛-in. mesh is recommended.

Vents are designated “inlet” or “outlet” vents based on air flow into and out of the attic space under natural convection conditions. Under the elevated wind speed scenarios used in this tests (and typically present during wildfires), all under-eave and the non-turbine off-ridge vents on the windward side of the building were inlet vents (Figure 15), and those on the leeward side of the building were outlet vents (Figure 16), regardless of their nominal designation. The ridge (Miami-Dade-compliant and non-Miami-Dade-complaint) and turbine vents were consistently outlet vents (Figure 17).

Figure 15. As indicated by the action of the ribbons, on the windward side of the building, the off-ridge through-roof vent (left) and open-eave vent (right) were inlet vents.

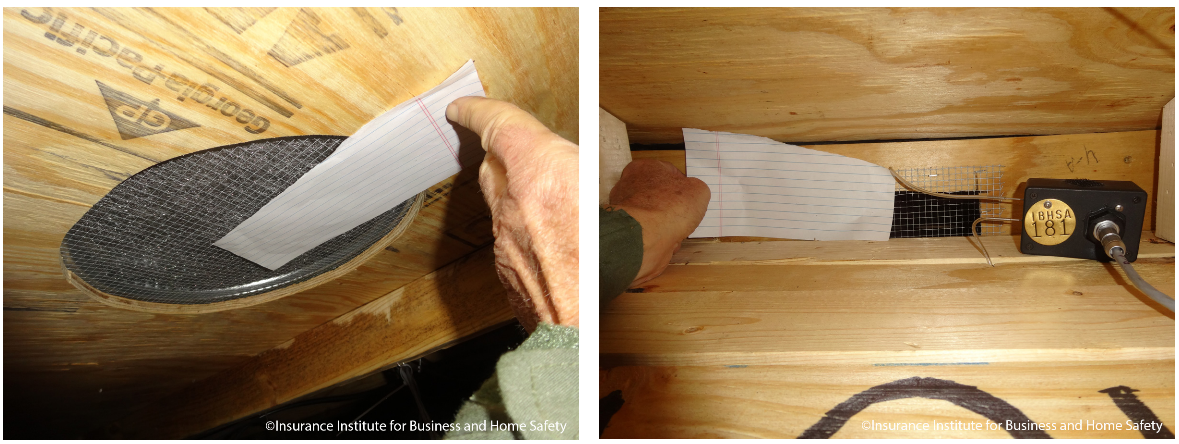

Figure 16. As indicated by the action of the ribbons, on the leeward side of the building, the off-ridge through-roof vent (left) and open-eave vent (right) were outlet vents.

***Figure 17.** As indicated by the action of the ribbons, the ridge vent (left) and turbine vent (right) were consistently outlet vents.*

In these series of experiments, the external baffle on the Miami-Dade-compliant ridge vent was effective in eliminating ember entry into the attic space. The response of the non-Miami-Dade-compliant ridge vent and the turbine vent to wind speed (i.e., always an outlet vent) explained their response to ember entry, where increased wind speed increased their effectiveness as outlet vents. The momentum of the ember entering the vent resulted in embers being carried across the opening of the attic space to the vent exit. This is graphically depicted for the ridge vent in Figure 18. At higher wind speeds, ember entry into the attic space was minimal. At lower wind speeds, smaller embers would be carried across the opening and through the exit on the opposite side. Larger, heavier embers would drip into the attic. Because lower wind speeds will likely occur during wildfires, attaching ⅛-in. metal mesh screening to the roof sheathing under these vents would be an additional precaution to reduce the number of embers that enter the attic space. For turbine vents, it would also be important to ensure they are in good working order (i.e., they spin freely). All commercially available ridge vents (Miami-Dade-compliant and non-Miami-Dade-compliant) are made of plastic materials. The greatest vulnerability to these vents could be the ember ignition of vegetative debris (e.g., pine needles) that can accumulate at the inlet of the vent, and the subsequent flaming exposure to the plastic components that would result.

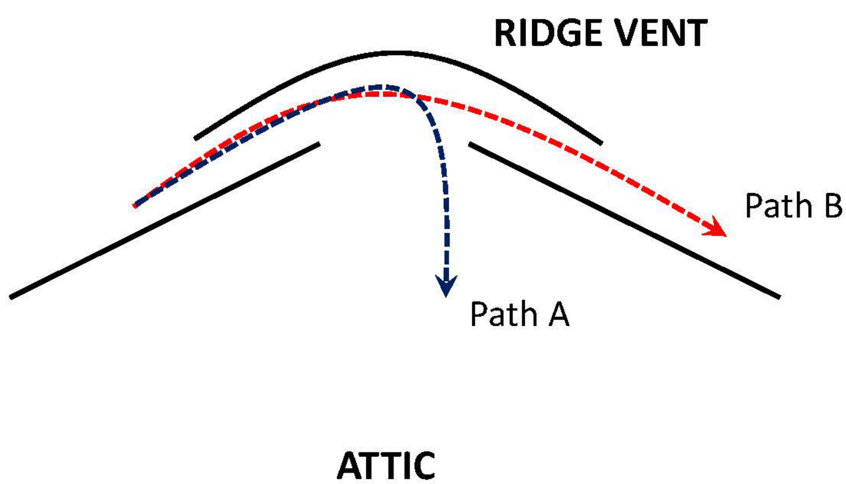

Figure 18. *A diagram depicting a non-Miami-Dade-compliant ridge vent. At higher wind speeds, embers that entered the vent would be carried over the opening to the attic and through the exit on the opposite side (Path B). At lower wind speeds, the heavier embers would drop out of the air stream and into the attic space (Path A).*

Three vents that were accepted for use in California were incorporated into the experimental design. These vents were the “wildfire-resistant vents” listed in Table 1. The wording in the California Building Code required vents that resisted the entry of burning (typically glowing) embers *and* flames. Our experiment focused only on ember resistance. Whereas the embers entering the attic space through the $^{1}/_{16}$-in. (1.5 mm) mesh of the “screened wildfire” vent were smaller than those that passed through the vent that incorporated a baffle design and ⅛-in. (3 mm) diamond mesh, the number of embers entering the attic through each of these vents was less than those passing through the $^{1}/_{16}$-in. and ⅛-in. diamond mesh alone, respectively. Note that the camera used to count embers was placed close to the entrance inside the attic space. It was observed that the smaller embers, those passing through the $^{1}/_{16}$-in. (1.5 mm) mesh screening in particular, would self-extinguish before reaching the floor of the attic. In the case of the vent with the baffle design, the baffle itself had a positive influence in resisting ember entry, possibly due to increased retention time in the vent or mechanical damage to the embers when passing through the vent. The screened wildfire vent also incorporated an intumescent paint–coated honeycomb mesh material, approximately 1-in. thick, and louvers. Whereas the primary function of the honeycomb mesh material was for flame resistance, the thickness of the mesh and possibly the use of louvers on the outside of the vent could have had a positive effect on reducing the entry of wind-blown embers. The steel wool infill used in the off-ridge through-roof vent was effective in minimizing ember entry into the attic space.

As previously indicated, a cotton pad was used during these experiments to evaluate the ability of entering embers to ignite an easily combustible material. The cotton pads were dried in an oven with a temperature set point of 212°F (100°C) for 24 hours prior to the test. Although the ember strikes were often sufficient to result in short-term smoldering combustion of cotton pads, particularly with the coarser mesh screens in the gable end vents, in no case did combustion transition to flaming. A cotton pad after a gable end test with ¼-in. (6 mm) mesh screening is shown in Figure 19.

Figure 19. *A cotton pad positioned on the attic floor at the base of a gable end vent showing numerous ember strikes. The cotton exhibited short-term smoldering combustion, but always self-extinguished without transitioning to flaming combustion.*

Testing that was conducted during the development of the ASTM standard to evaluate the ember resistance of vents (ASTM E2886, 2012) demonstrated that a cotton pad (and a shredded paper fine fuel) could easily be ignited by embers that passed through ⅛-in. (3 mm) mesh screening. This information was reported in the Appendix (ASTM E2886, 2012). During these tests, three different apparatuses were being evaluated: one where the generated embers flowed vertically through the vent and onto the target materials, and two others where the embers flowed horizontally to the vent. Modifications, such as baffles or other materials that directed the embers to a pre-determined location, were made to each apparatus to maximize the number of embers that impacted the target material. During the experiments reported here, the embers that passed through the vent were allowed to follow air currents in the attic space (Figure 20). Baffles or other materials to direct the embers to a pre-determined location *were not* installed in the attic space. As a result, embers that entered the attic space followed the fluctuating wind currents and patterns inside the attic. This resulted in a greater dispersion of embers and the resulting inability to reach sufficient deposition rate on the cotton pad to result in flaming combustion. From a practical perspective, this means that combustible materials that can be stored in the attic should be stored at a distance from a vent. Cardboard boxes stored adjacent to a vent, for example, could stop embers and allow them to accumulate on the attic floor next to the box. This could result in flaming ignition of the box, and other nearby materials.

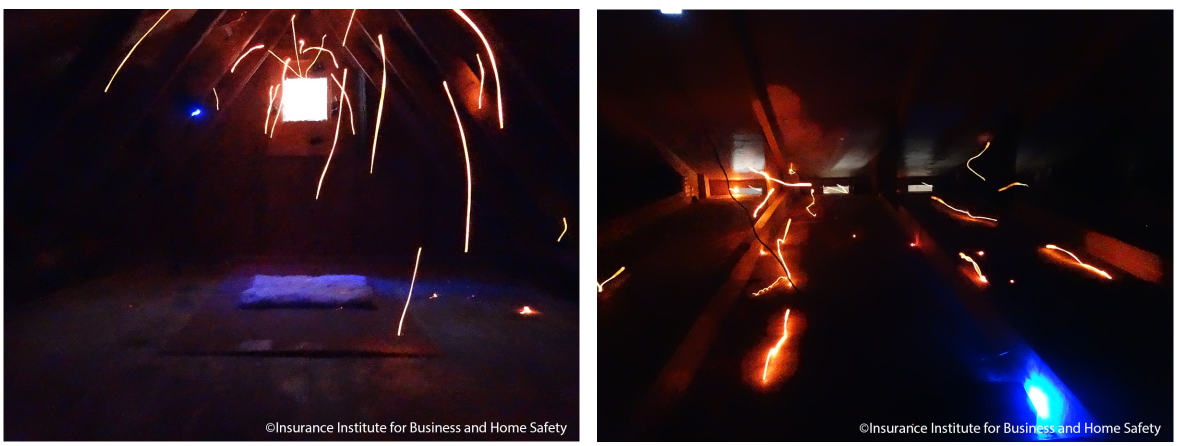

Figure 20. *The bright streaks are embers that entered the attic space through a gable end vent (left) and vents in open-eave blocking (right). They did not congregate in any concentrated area on the attic floor.*

Summary of Findings

1. There are two options for inlet vents, both located in the under-eave area. These include vents in the between-rafter blocking in open-eave construction and vents in the soffit material in soffited-eave construction. Vents located in soffited-eave construction were shown to limit ember entry and should therefore be the preferred construction type.

2. ¼-in. (6 mm) mesh screening should not be used to cover any vent. Finer mesh sizes of ⅛-in. (3 mm) or $^{1}/_{16}$-in. (1.5 mm) would be preferred. The finer $^{1}/_{16}$-in. mesh screen will require more cleaning-related maintenance to remove the debris that can accumulate on the screen surface.

3. The wildfire-resistant vents used in the gable end location performed better than the respective backing screen mesh alone.

4. Due to the relatively large size and vertical orientation of gable end vents, they should be avoided. If alternatives are not possible, a wildfire-resistant gable vent that has passed ASTM E2886 should be used.

5. Avoid using non-wildfire-resistant off-ridge and ridge vents. Of the ridge and off-ridge outlet vent options, the following performed well:
    - Miami-Dade wind-driven-rain-compliant ridge vent
    - Wildfire-resistant (steel wool fill) off-ridge vent
    - Turbine (off-ridge) vent

6. Wind-blown vegetative debris must be removed from the inlet of all ridge and off-ridge vents, paying particular attention to vents with plastic components. Plastic components are commonly used in ridge vents.

References

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