PREPARING THE WALL FOR INSTALLATION OF AN AIR, VAPOR, OR AIR/VAPOR BARRIER

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ABSTRACT

There are many ways to "seal" around wall penetrations. This article will attempt to describe some of these methods and provide the information necessary to make the determination as to which method is appropriate for a satisfactory air, vapor, or air/vapor barrier installation.

HISTORY

Over the years, there has been much talk about whether or not to seal the space between a window frame and the adjacent wall. Back in the days of cheap energy, in the sense of cost savings, it did not make a lot of difference whether or not all of the wall penetrations were totally sealed. Many of our ancestors spent their winter nights huddled beneath a mountain of homemade quilts while listening to the eerie sounds of the wind whistling through the gaps around the windows and doors. How often do those of you who grew up in the days of candles and lanterns recall seeing the flickering of the flames because a breeze was always blowing in the house? Aaahhh…for the good old days.

Good old days, my foot! When we did not know any better, cold and miserable was the norm. Back "in the day," most housing was simple and cheap. An early attempt at closing out the elements involved filling the gaps left during construction with mud and straw. My own grandchildren now think that a conditioned environment is a right guaranteed by our constitution.

What this article will attempt to teach is how to seal the open space around window and door frames and other types of wall penetrations to keep our living environment as pleasant as possible. As energy bills have skyrocketed in the last few decades, closing up the building envelope has become of much greater importance to owners and managers alike. By cutting the amount of air passing through wall openings that are not properly sealed, we are using less energy, thereby assisting in lowering the loads being seen by the power companies. So, by simply sealing the openings that are a part of construction, less energy is needed to maintain the indoor temperature, thereby directly affecting the amount of energy being made and consumed. The collective "carbon footprint" (the most recent politically correct term to describe man's contribution to the latest ecological calamity) is being impacted by simply controlling the flow of air through the building envelope.

AIR FLOW

Before discussing the methods used in sealing openings in the building envelope, one should first understand the mechanisms of airflow through a wall unit. There are three basic methods of airflow: diffuse, orifice, and channel.

Diffuse flow is a slow movement of air through a porous material such as concrete masonry units (CMU), fiberglass insulation, gypsum wallboard, or plywood. As air diffuses through these surfaces, condensation can occur that can result in material degradation, mildew, and mold growth. This type of flow can impact the wall assembly over a number of years and not be seen until the wall is dismantled.

Orifice flow refers to air passes unobstructed from one side of the wall to the other through some type of opening. If the rough opening for a window is too large for the frame, one often can see directly through at varying points around the frame. Although this type of flow is undesirable from many perspectives, it seldom causes long-term damage to the wall assembly. This is because the air flow is fast and does not allow time for condensation within the wall unit. Orifice flow is a major contributor to temperature and humidity variations within the structure and should be controlled whenever possible.

Channel flow refers to air flowing through channels or passages in the wall assembly. This type of flow is potentially the most damaging and often requires extensive treatment. Because the channel of flow might be altered within the wall assembly, or the speed might be changed, there is more opportunity for condensation of water vapor once it reaches its dewpoint. Channel flow typically is found at the boundaries between dissimilar materials. When looking at the penetration-to-wall interface, one sees the opportunity for both orifice and channel flow. It has been shown that air leakage, both infiltration and exfiltration, is a more effective transport mechanism for water vapor than is diffusion.

As an example, a vapor retarder with a permeance of 5 ng/Pa/sec/m² (0.088 perms) is applied to a 10 ft² surface in which the warm side is 70˚F at 30% RH and the cool side is -4˚F. After a 30-day period, the amount of water vapor diffusion through the vapor retarder due to the difference in pressure caused by the difference in ambient conditions would be about 0.21 oz. If that same vapor retarder had a 1-in² hole cut in the middle of it and was under a very low air pressure, 92,000 ft² would pass through that hole, carrying up to 494 oz of water vapor with it. If only 10% of this water vapor condenses in the wall assembly, the air leakage has deposited roughly 233 times the amount of moisture that was transported by diffusion.[1]

AIR MOVEMENT

As in air flow, there are three basic methods of creating air movement from the indoor environment to the outdoor environment and vice versa. Higher pressure on the outside drives moisture-laden air into and through the wall assembly via infiltration. Higher pressure on the inside forces air into and through the wall assembly, creating exfiltration.

Wind

Wind gusts for three to five seconds can exert very strong forces in excess of 50 lbs/ft² on a building. Sustained winds can exert positive pressure (infiltration) against one or more faces of a building while exerting negative pressure (exfiltration) against the opposite wall or walls. Each of these pressures can affect the inside air environment and can force moisture-laden air into the wall assembly, resulting in condensation within the wall.

Fan Pressure

When mechanical equipment (HVAC) is used to move air in either direction, pressures are exerted against the wall assemblies. When the spaces around penetrations are unsealed, the majority of the pressure differential finds its way to those unsealed areas. Free air movement at these spaces can result in uncomfortable indoor air. Overcompensation, increasing the size of the mechanical units to compensate for the net loss or gain through the openings, can be reduced by sealing the openings.

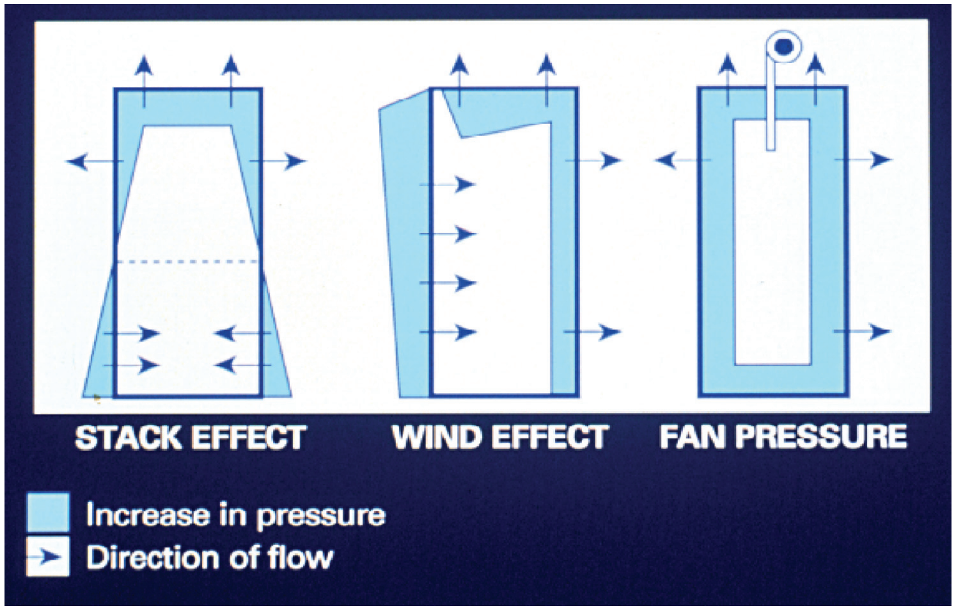

Illustration 1 – Proper sealing around all wall penetrations can reduce the amount of air flowing out of or into the building interior through stack effect. (Brian J. LeVoguer, "Beyond Air Barriers: Rubberized Membranes for the Building Envelope," The Construction Specifier, *November, 1998.)*

Stack Effect

Differences between inside and outside temperatures, coupled with the phenomenon of decreasing air pressure with increase in height, result in pressure differences affecting air flow across the building envelope. In colder climates, stack effect creates positive pressure at the lower levels of a structure (infiltration) and negative pressure at the upper levels (exfiltration). Proper sealing around all wall penetrations can reduce the amount of air flowing out of or into the building interior through stack effect. See *Illustration 1.*

SOLUTIONS

In researching for this article, the Internet provided many sources of information. Using the search words "window sealing," there were over 1.1 million hits. Hoping to narrow the search, the word "frame" was added and 100,000 hits were found. All methods discussed in the few items opened involved some type of mechanical closure at the penetration-to-wall interface. Of all the items visited, probably the simplest yet best site was that by the U.S. Department of Energy: **www.energy.gov/insulationairsealing.htm**. This site recommends that one should use caulking, sealing, or weather stripping techniques to stop air infiltration.

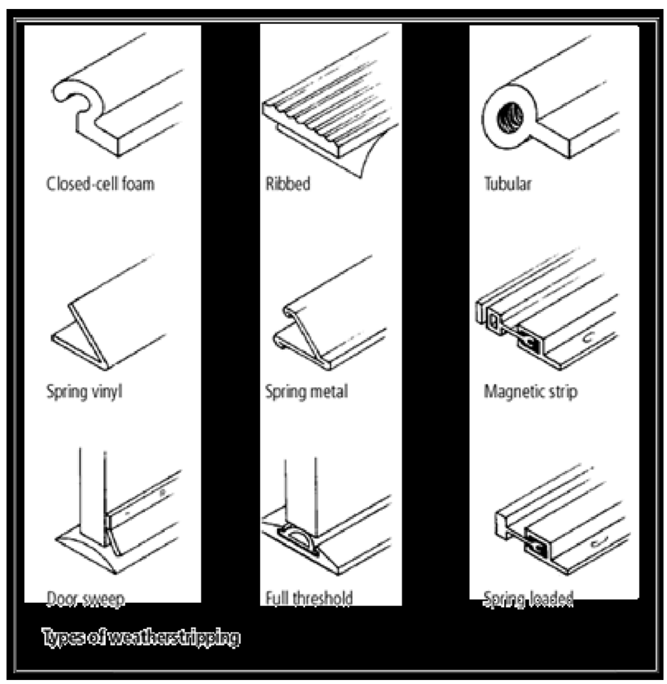

Illustration 2 – A sampling of different types of weatherstripping that are available (www.daviddarling.info/encyclopedia/W/AE_weatherstripping.html).

Caulking

Caulking is probably the least expensive thing that the average homeowner can do to seal around windows and doors. Silicone- or urethane-based caulks are the best selection for this purpose. However, the cost of caulking can be a determining factor for a homeowner. Silicone or urethane caulks generally run $3-$4 for an 11-oz tube. It takes two to three tubes of caulk to properly seal each window.

When depending on caulk as the main air-stopping medium, one must consider that the caulk will usually be exposed to the elements, since caulk is generally applied post-construction, or there is no cavity-wall construction to protect the caulk from the elements. Latex does not hold up well to water penetration, specifically at the head of the window or door. It has been suggested that when using latex caulk, the head should be sealed with silicone or urethane while the jambs and sill are done with the latex material. Silicone and urethane hold up well against water and can defend the head from water running down the face of the building. For new construction where caulk has been selected as the primary window and doorframe sealant material, silicone or urethane should always be used.

There are many good manufacturers of high-quality, silicone- or urethane-based caulks. A quick online Google search found 71 manufacturers from which to choose.

Weatherstripping

There are numerous sources for weatherstripping, whether it is to be installed on the inside face of the frame, in the middle of the frame, or on the outside face of the frame. *Illustration 2* shows just a few of the types of weatherstripping available.

Each of these offers a degree of airflow management; but, if not installed strictly in compliance with manufacturers' instructions, there is a strong possibility of air leakage, especially at the corners. Weatherstripping is probably the least effective method for stopping air migration into or from the building. In most cases, weatherstripping in conjunction with some degree of caulking can provide a better closure than either by itself.

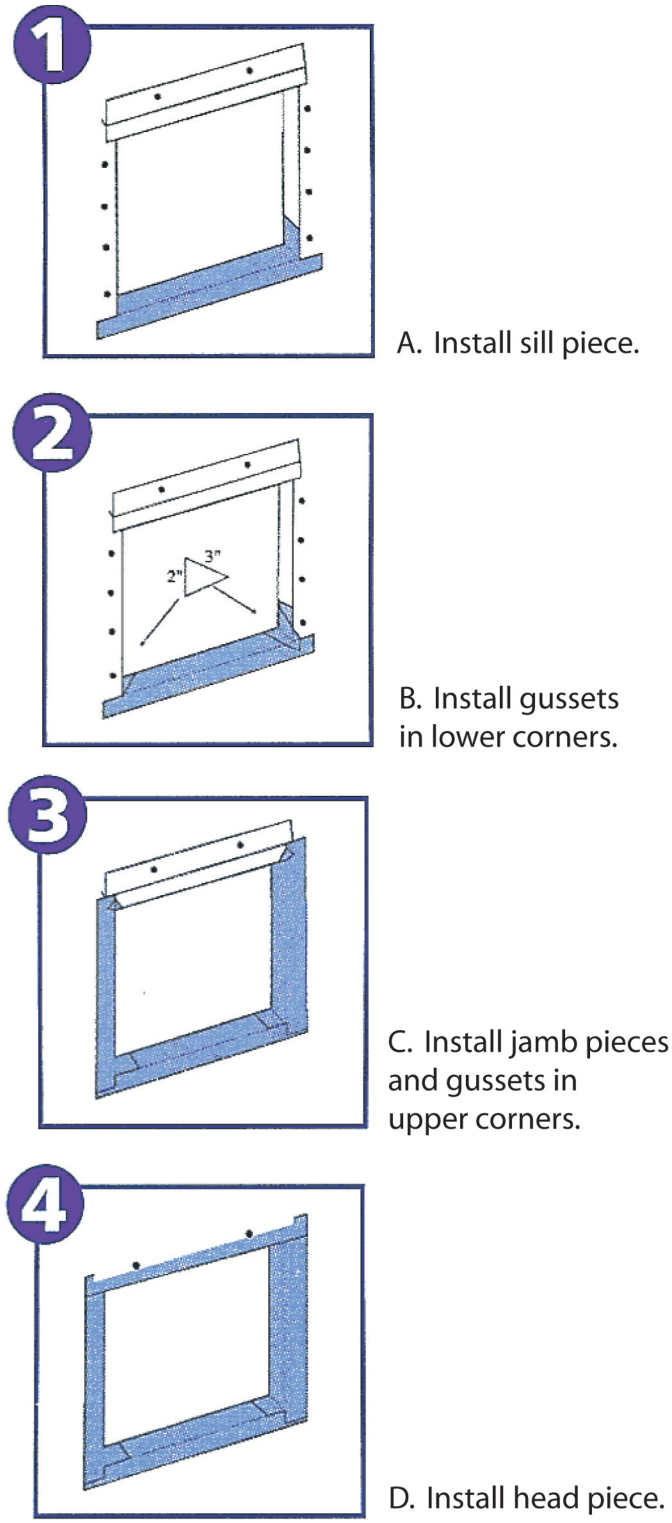

Illustration 3-1 to 3-4 – The preferred method for membrane installation at window openings. The same method can be employed at any opening in the wall except for those that are rounded. (Henry Company item number 295 REV 04/04.)

Sealing

Fairly recent innovations in self-adhered membranes have given the specifier a new way to close the building envelope to a point where mechanical conditioning of the interior environment is feasible. Self-adhered membranes can be used to seal around any penetrations through a wall assembly and to provide a permeable or nonpermeable air barrier/rain screen over the entire wall structure. Several manufacturers have stepped up to the plate and now provide excellent details to be used in closing up the building envelope.

Self-adhered sealing tapes are available in both breathable and nonbreathable versions. When used in conjunction with additional air barrier materials, a complete system can be devised that will successfully keep unwanted air and moisture out of the building. Self-adhered sealing tapes are simple to use. If not properly installed, however, they may not perform to the expectations of the specifier. The contractor should be certified by the manufacturer as a qualified installer of the self-adhered sealing tape.

There are some common threads from manufacturer to manufacturer, the most important of which is to support the membrane at all times. When applying the transition membrane (interface of two different materials), it is mandatory that some type of mechanical support be installed prior to the membrane. In most cases, the transition membrane is a nonreinforced material that is subject to deformation if left unsupported. This support can be as simple as a backer rod placed into the opening or as elaborate as a fabricated metal panel that spans an opening. If left unsupported, changes in pressure from inside to outside can cause the material to deform and possibly delaminate. Mechanical damage from subsequent trades' activity can be devastating to an unsupported membrane.

The second commonality is the need for a clean, smooth, and dry surface. Cleanliness can never be understated. Proper preparation of the surface to which the membranes are to be applied will improve the adhesion of the membrane immeasurably. Smoothness of the opening surfaces that are to receive the membrane is mandatory. A smooth surface will accept the membrane and help in the long-term performance of the membrane. Self-adhered membranes should never be installed against a wet or damp surface. The surest way of having delamination at the membrane-to-surface interface is having a moist surface.

The third commonality is the need for priming of all surfaces to receive the self-adhered membrane. It's like painting a car; before automotive paint is applied, the metal surface must first be primed. Without the primer coat, the paint would someday peel off the metal. The same holds true with self-adhered membranes. Sealing around penetrations with a self-adhered membrane without priming the surfaces first risks eventual delamination of the membrane, resulting in a clear path for air flow.

Photo 1 – Air barrier system being installed at the Iowa State University Bio-Sciences Building. The properly detailed window opening uses a UV-stable transition membrane. Note that the wallboard joints have yet to be sealed.

Proper sealing of the opening should follow a logical path of sill (*Illustration 3-1*), sill corners (*3-2*), jambs (*3-3*), head corners (3-2), and head (*3-4*). By installing the transition membrane in this manner, the opportunity for water to get behind the membrane is minimized. *Photo 1* shows a properly detailed window opening using a UV-stable transition membrane. Note that the wallboard joints have yet to be sealed.

Photo 2 – Air barrier system being installed at Shared Medical Systems, Great Valley, PA. Some would think of this as a good detailing of the opening, but it obviously is not. This usually occurs as a result of starting the project with no assistance from the manufacturer.

Photo 2 shows what some think of as a good detailing of the opening. It is obvious that this is not a good installation. As in other materials, the contractor felt that more was better. This particular project was rejected in its entirety, and all the openings were detailed properly before the air barrier was installed.

Photo 3 is of a properly prepared wall with subsequent installation of the primary air barrier membrane proceeding up the wall in a logical sequence.

Photo 3 – Project near completion showing a properly prepared wall with subsequent installation of the primary air barrier membrane proceeding up the wall in a logical sequence.

PIPE PENETRATIONS

Pipes, wires, cables, and any other circular units that pass through the wall must be properly sealed to preclude any flow of air through the assembly. Flexible pipe should never be used where an air barrier is to be installed. With pipes of large diameter that have fluids flowing at a high rate of speed resulting in vibrations, the generally accepted method of closure is mechanical. These pipes generally pass through a sleeve that was placed when the wall was poured or built. The most commonly known mechanical closure is a compressive type that employs a rubber ring that fits around the circumference of a pipe and is compressed so that the rubber fills the gap between the sleeve and the pipe. These penetrations most often occur below the wall that is to receive the air barrier, but should be considered as a part of the overall building envelope.

Any circular penetration that is integral with the wall assembly can be sealed in a manner similar to that used for a window. The primary difference would be that the seal is a two-piece construction employing self-adhered transition membrane. The first piece would be approximately 8 inches wide by the circumference of the circular penetration plus 1 inch or 10% – whichever is greater. Strike a line down the center of the 8-inch dimension of the transition membrane. Cut “fingers” into the membrane that extends from the scribed line to one edge. Remove the backing paper and position the piece so that the solid portion wraps around the pipe and the ”fingered” portion attaches to the wall. Follow this step with a “target patch,” which is a second piece of membrane, either round or square, that will extend beyond the “fingers” at least 2 inches. In the middle of the second sheet, cut a hole that is the same diameter as the penetration. Slide the “target patch” over the penetration and position against the wall. Remove the backing paper and secure the “target patch” in place. Roll the completed assembly with a laminate roller to assure solid attachment to all surfaces. Apply a bead of caulking at the base of the penetration and at the outside edge of the membrane on the pipe.

DISSIMILAR MATERIALS

All across the faces of a structure there are numerous places where dissimilar materials meet to form an interface. In building construction, steel, CMU, concrete, wood, plywood, gypsum wallboard, aluminum, and other types of material can be found on the outside face of the building. At each point where any two or more of these materials come together, an interface that could allow for orifice or channel flow to occur is formed. The simplest method for sealing these interfaces is to apply a transition membrane that extends a minimum of 3 inches on either side of the interface. If the manufacturer recommends a primer to prepare the surface before installing the transition membrane, it is important that the primer be properly applied.

When using gypsum building board for the substrate for the air barrier, all joints in the board must be sealed. There are several self-adhering tapes that are available for this purpose. Placing of the sealing tape should be such that there is no bucking of water at the junctions of the sealing tape.

ROOF KNOWLEDGE ASSESSMENT

Test your knowledge with the following questions on psychrometry, developed by Donald E. Bush Sr., RRC, FRCI, PE, chairman of the RRC Examination Development Subcommittee.

1. **“Psychrometrics” or “psychrometry” are terms used to describe the field of engineering concerned with the determination of physical and thermodynamic properties of gas-vapor mixtures. What is the most common system of interest for psychrometry?**
2. **Why is psychrometric ratio an important property in the area of psychrometrics?**
3. **What thermophysical properties are found on most psychrometric charts?**
4. **In order to use a particular psychrometric chart for a given air pressure or elevation, how many of the six independent properties must be known (dry bulb temperature, wet bulb temperature, relative humidity, humidity ratio, specific enthalpy, and specific volume)?**
5. **What is the meaning of “specific enthalpy?”**
6. **What is the most common psychrometric chart used by practitioners and students alike?**

Answers on page 30

ROOF KNOWLEDGE ASSESSMENT

Answers to questions from page 29:

1. **Mixtures of water vapor and air.**
2. **Because it relates the absolute humidity and saturation humidity to the difference between the dry bulb temperature and the adiabatic saturation temperature.**
3. **Dry bulb temperature, wet bulb temperature, dew point temperature, relative humidity, humidity ratio, specific enthalpy, and specific volume.**
4. **At least two.**
5. **It is the sum of the internal energy of a thermodynamic system. It is symbolized by "h" and also called "heat content per unit mass."**
6. **The (omega-t) chart in which the dry bulb temperature (DBT) appears horizontally as the abscissa and the humidity ratios appear as the ordinates.**

Reference: **Wikipedia, the free encyclopedia. Subject: psychrometrics**

CONCLUSION

Man has been trying to make his environment as comfortable as possible throughout history. As newer and better methods for accomplishing this are developed, they are just as quickly being implemented. Air barriers are the latest tools being used in this quest. Closing of all airflow through the building envelope is instrumental in the proper use of air barrier technology. It is the opinion of this writer that the single best method available to the design professional for sealing the openings is with polymer-modified sealing tapes. Simple and easy to use, these self-adhered membrane seals will provide the specifier with a high level of confidence that the overall air barrier installation is the best system possible.

In drawing up the specifications for an air barrier system, the details at all openings and transition points must be properly drawn. Any left out or missing details can result in a less than satisfactory final product. The design professional should take advantage of the many manufacturers of air barrier products who have developed excellent details that can easily be customized to be job specific. The manufacturer should also offer to attend pre-job conferences and supply on-site inspections during the installation of the air barrier products. It is best to use only one manufacturer for a project so that all the materials will be compatible.

REFERENCES

1. LeVoguer, Brian J., "Beyond Air Barriers; Rubberized Membranes for the Building Envelope," *Construction Specifier*, November 1998.

Charles E. Mills, RRO, CDT

Charles E. Mills, RRO, has been a building envelope specialist with the Henry Company, eastern U.S., for the past eight years. His responsibilities include training, contractor approval, and warranty approvals in roofing, waterproofing, and air barriers. He has over 22 years of experience in all types of roof systems. Prior to joining Henry, he held certifications in multiple disciplines of nondestructive examination, including building thermography by CPW and USDOE. Charles is an active member of RCI and CSI, serving on the Education and Building Envelope Committees with RCI and as programs chairman with the CSI Tampa Chapter. Charles has been a member of RCI for nine years and CSI for 12 years.

BC Insurers Won't Cover Green Roofs

The British Columbia Homeowner Protection Office (HPO) has warned all municipalities in the province that local insurance companies are balking at covering green roofs on multifamily housing. The notice has prompted the city of Vancouver to reverse its requirement that the Olympic Village in False Creek include green roofs. Ken Cameron, CEO of HPO, called for a May 29 conference to discuss the issue among insurers, builders, and municipalities.

The unprecedented move is apparently a reaction to the leaking condominium debacle recently faced in the province. Cameron wrote, "There are some issues that should be considered in the particular context of British Columbia before further application of green-roof systems in residential developments proceeds, in order to avoid another potential systemic building envelope failure."

Steven Peck, president of Green Roofs for Healthy Cities, headquartered in Toronto, called the issue "…unfounded and strange" and said, "One of the foremost green-roof research facilities in North America is in Vancouver [The Institute of Technology's Centre for the Advancement of Green Roof Technology]…it seems to me the insurance industry in B.C. has a lack of technical sophistication." He noted that millions of square feet of green roofs have been installed in Europe with no sign of problems beyond what any roof might have. In fact, he added, German insurance firms give buildings with green roofs better ratings due to reduced fire risk in such structures.