ROOF VENTILATION FOR CATHEDRALS: HOW MUCH IS SUFFICIENT.

by

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WHAT IS ROOF VENTILATION?

To truly understand how much ventilation is a sufficient amount of roof ventilation we must first ask ourselves “what is roof ventilation?” Thanks to the wonderful technology of the World Wide Web there are many different definitions of roof ventilation available. The September 2006 issue of a popular roofing magazine, *Rural Builder*, defined roof ventilation as “the process of supplying air to or removing air from attics, elevated ceilings or other enclosed spaces over which a roof assembly is installed”.

**Passive Ventilation**

The most common type of roof ventilation is passive ventilation. Passive ventilation allows air to naturally enter at the eave or lowest point of the roof and exhaust at the peak or highest point of the roof. All passive ventilation products have a net free area (NFA) value. Net free area is the portion of the opening that actually ventilates. It is the total unobstructed area through which air can enter or exhaust a non-powered or natural vent.

Warm air naturally rises and cool air naturally descends. A well balanced system takes advantage of this natural effect. Cool air enters the roof system at the eave and warm air exhausts the roof system at the ridge. In its simplest form, that is roof ventilation. However, wind also plays a role in this; when wind hits a building high pressures force air in at the eave and as wind travels over a building low pressures draw air out at the ridge. By allowing continuous air movement through a roof system the temperature of the roof is closer to the temperature of the outside air.

**Short Circuits**

Much like electrical short circuits, there can be short circuits in roof ventilation. In general, short circuits occur when something is caused to go around or away from its original path. In the case of ventilation short circuits air is diverted away from the ridge vent. A few causes include venting at the rake and installing box or power vents in the middle of the roof. In these examples air enters at the eave but
is diverted away from exhausting at the ridge by the rake, power or box vent and the remainder of the roof is not ventilated.

WHY IS ROOF VENTILATION IMPORTANT?

All Climates
Ventilation offers benefits for all types of roof systems: shingled, standing seam, tile, etc. Ventilation helps prevent moisture buildup, preserve the life of the roof and conserve energy by reducing the heat gain through the roof assembly.

Moisture
Ventilation is a key element in removing unwanted moisture in a roof system. Oak Ridge National Laboratories performed a study in Knoxville, TN regarding the amount of moisture that is in OSB (oriented strand board) sheathing and the findings were astonishing. Although the two OSBs started out with the same moisture content, after roughly 750 days the amount of moisture in the OSB on the unvented roof system was more than 3.5 times the moisture content of the OSB on the vented roof system.

Warm Climates
Heat Builds-up
The primary source of heat build-up in a roof system is direct sunlight. This occurs when solar heat is transmitted through the roofing material and radiated to the ceiling insulation. Eventually the temperature of the entire system – roof, air, insulation – rises.
When the sun goes down, the source of the heat is depleted and the roof starts a cool-down process. The heat from the roof begins to reradiate to the outside air. In some cases the heat absorbed by the materials may not be entirely depleted in the night hours. This is particularly the case when the roof system does not have sufficient ventilation, which can cause the heat to continually build up over a long stretch of warm weather. If the heat is not depleted and continues to build up it can warm the ceiling of the conditioned environment.

Continual heat buildup can cause a number of problems. Some of the major concerns include premature shingle deterioration, condensation buildup and increased cooling costs. Let’s take a closer look at each of these issues individually.

Shingles start to deteriorate at a faster rate when the temperature of the roof sheathing they are attached to is continually elevated. This can cause a significant shortening of a shingle’s life. Warmer air can also hold more water vapor than cooler air thus providing an environment for condensation buildup, mold and mildew when the heat is not depleted. If the built-up heat is not allowed to escape it can also radiate into the controlled space of the building, increasing air conditioning usage, energy consumption, service needs and eventually lead to premature replacement of the air conditioning unit. A study done by Oak Ridge National Laboratories found just that, that ventilation can reduce the heat gain through the roof assembly up to 45% when compared to an unvented system.

Cool Climates

Ice Dams
In a cool climate perhaps the largest benefit of proper roof ventilation is preventing the freeze/thaw cycle that is the most common cause of ice dams and other water damage. This illustration shows how warm air from the heating system of the controlled environment rises through the natural gaps, holes and other pathways and reaches the underside of the sheathing.
Once the underside of the roof sheathing is warm it will then melt the underside of the snow blanket on the exterior of the roof and the water runs down the slope of the roof to the eave. As it starts to run off the roof and hits the cooler air the water refreezes. The repetition of this process is what causes ice dams to occur.

Ice dams can not only damage the roof and structure of the building due to the weight of them, they are also dangerous to any life or property below them and can cause water damage due to the pooling water they create. The easiest and most effective way to prevent ice dams is with proper roof ventilation. Ventilation helps to maintain a consistent temperature underneath the roof covering and minimize the temperature differential between the airspace of the roofing system and outside air. It does this by bringing in cool air at the eave and allowing it to exhaust at the ridge, thus helping to prevent the freeze/thaw cycle that leads to ice dams.

**The Green Factor**

When it comes to roof ventilation there is no exception, it too plays a part in today’s world of going ‘Green’. As it relates to roof ventilation ‘Green’ is “a roofing system that is designed, constructed, maintained, rehabilitated and demolished with an emphasis throughout its life cycle on using natural resources efficiently and preserving the global environment”. How does ventilating a building’s roof system do all this?

- It conserve energy by minimizing the temperature difference between the controlled environment in the building, the airspace of the roofing system and the outside air, thus reducing the demand on the air conditioning system and ultimately reducing energy consumption.
- It also extends the lifespan of your roof by minimizing the temperature difference in both the summer time and winter time. Thus minimizing moisture content in the roofing system, helping to prevent shingles from premature shingle deterioration and eliminating ice dams.
- In turn it minimizes the burden on the environment by reducing not only the amount of roofing materials but also the amount of insulation and other construction materials that are sent to landfills due to premature repair and replacement.

**THE INTERNATIONAL BUILDING CODE**

Section 1203 ‘Ventilation’ of the International Building Code (IBC) pertains to attic spaces. It states that “The net free ventilating area shall not be less than 1/150 of the area of the space ventilated with 50 percent of the required ventilating area provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet above eave or cornice vents with the balance of the required ventilation provided by eave or cornice vents.” There is an exception to the code where “The minimum required net free
ventilating area shall be 1/300 of the area of the space ventilated, provided a vapor retarder having a transmission rate not exceeding 1 perm in accordance with ASTM E 96 is installed on the warm side of the attic insulation and provided 50 percent of the required ventilating area provided by ventilators located in the upper portion of the space to be ventilated at least 3 feet above eave or cornice vents, with the balance of the required ventilation provided by eave or cornice vents.” In its simplest form this means that for every 300 square feet of attic floor space 1 square inch of ventilation is needed, provided a vapor retarder is used. There is not however a section for cathedral style roof ventilation in the IBC.

CATHEDRAL ROOF VENTILATION

The word cathedral is most commonly used as a noun or adjective in the phase ‘cathedral church’. So how did cathedral roof ventilation come about? For centuries cathedrals (or cathedral churches) have had vaulted ceiling serve as a distinct architectural feature. Today cathedral ceiling has become an interchangeable phase with vaulted ceiling. Therefore, a building with a vaulted ceiling has a cathedral roof.

Cathedral roof ventilation is different than that of attic ventilation in the simple fact that it is ventilating what is typically a small space directly below the roof sheathing in which both the materials above and below the ventilated space are pitched. Whereas with attic ventilation the material above the ventilated space is pitched but the material below it is horizontal.

Vented Nailbase
The most common way to create a ventilation space in a cathedral roof is through a product called a vented nailbase. A vented nailbase consists of an insulation board, spacers of some sort creating an air channel and roof sheathing, whether it is OSB or plywood. Vented nailbases allow for a continuous channel for air to flow from the eave to the ridge. Manufactured vented nailbases are available in 4’ x 8’ panels that come with all three components sandwiched together.

The Study
To help predict how air flows through a vented nailbase air channel, a study was commissioned by Metal-Era, Inc. Metal-Era is a Wisconsin based commercial manufacture of low-slope roof edge and steep-slope roof ventilation products. CPP, Inc., a Colorado based consulting firm that specializes in wind engineering and air quality, conducted the study. The study analyzed the air flow rates and the viscosity through the airspace, the heat transfer and conductance of the insulation and the radiation and the emittance off the roofing material.

The variables in the study that change project per project are the length of run from the eave to ridge on the slope, the roof pitch, the eave to ridge ratio, the R-value of the insulation, the roofing covering material and the outside temperature.
The constants in the study are the inside the building temperature of 70 degrees Fahrenheit and the wind speed of 0 mph. As noted previously the pressures from the wind push air into a building at the eave and pull air out of a building at the ridge; however, we cannot predict how windy it will be, so for the sake of this study the conservative side was taken.

The conclusions of the study were as follows:
- ventilation performance rapidly degrades with runs over 20 feet when the air gap height is 1 ¼ inches or less
- longer runs negatively impact venting performance as the air has a further distance to travel
- hipped roofs with an eave to ridge ratio of under .2 choke off ventilation performance as there is not enough ridge to adequately exhaust all the air that is coming in
- steeper slopes are easier to ventilate as air naturally rises

VENTILATED ROOF SYSTEM CALCULATOR

Based on the results of the study a calculator was creates to identify how much roof ventilation is sufficient for a cathedral style roof. The calculator runs on a five node model in which the variables for a specific project are inputted and the results come in the form of a graph indicating the temperature at given points up the roof run. The ideal situation to use this calculator would be in design phase. It can however still be effective in other situations, one of which being a reroof situation. In either case a designer can input the desired variables based on their design for their specific project and see if the results are satisfactory. In the event that they are not satisfactory changes could still be made to the design. In most cases the most effective and easiest way to improve the results is by changing the airspace in the vented nailbase.
Looking at the actual calculator itself above is a snap shot of the calculator input variables, which include:

- pitch on 12
- length of passage from eave vent to ridge vent
- thickness of OSB/plywood
- height of gap
- ridge length
- eave length
- roofing composition
- ceiling/wall insulation R-value
- outside temperature

**Example Project**

Taking a look at a specific project in design phase, this building has:

- a 6/12 roof pitch
- a 30 foot length of passage
- a ½ inch thick sheathing
- 120 feet of ridge
- 285 feet of eave
- dark shingles
- a R-value of 19

**Winter Time Situation**

On the top right is a graph with the results of this specific project in a winter time situation with a 1 inch airspace in the vented nailbase. This graph shows that at 0 feet, representing the eave of the building, air enters the airspace at the outside temperature of 22 degrees Fahrenheit. As the air travels through the airspace and up the slope of the roof the temperature rises. At roughly 18 feet up the run of the roof the temperature goes above freezing point, thus causing the snow on the roof to melt. The water then runs down the slope of the roof and refreezes as it hits the colder outside air. In this situation ice dams would be forming at the eave of the building. As mentioned the easiest and most effective way to help eliminate ice dams is by adding ventilation. Because this project is in design phase a ½ inch airspace can be added to the vented nailbase making the temperature at the end of the run, the ridge, 31 degrees (see bottom graph). In which case snow is not melting, it is staying on the roof, and there are not ice dams on the building.
**Summer Time Situation**

On the top right is a graph with the results of this specific project in a summer time situation with a 1 inch airspace in the vented nailbase. This graph shows that at 0 feet, representing the eave of the building, air enters the airspace at the outside temperature of 85 degrees. As the air travels through the airspace and up the slope of the roof the temperature rises. At the end of the run, the ridge, the temperature is 134.7 degrees. If the airspace in the vented nailbase is changed to 1 ½ inches, the airspace that works for this building in the summer time, the temperature at the end of the run is now 129.5 degrees (see bottom graph). By adding that ½ inch of airspace the roof is now 14.2 degrees cooler every day, all summer long.

**The Calculator**

This calculator is available for public use on a number of professional websites including, Atlas Roofing Corporation’s, [www.atlasroofing.com](http://www.atlasroofing.com), Hunter Panels’, [www.hpanels.com](http://www.hpanels.com) and Metal-Era’s, [www.metalera.com](http://www.metalera.com). A full copy of the final study report can also be found on Metal-Era’s website.

**ADEQUATE VENTILATION**

With these graphs and guidelines designers have the ability to make educated decisions on how much is a sufficient amount of ventilation for individual cathedral roof projects. The most important key to roof ventilation is having a balanced system that works together from the intake, to the vented nailbase and ultimately the exhaust. This study and calculator help to determine what the airspace in a vented nailbase should be for individual projects; however, a designer needs to make sure that the products that are selected for the intake and exhaust can accommodate the NFA of the vented nailbase airspace. When it comes to roof ventilation **NO** one of those components can work effectively without the other two.