ATTIC AND ROOF SLOPE VENTILATION DESIGN

1. In areas with cold climates, shed and ridge vents are likely to be covered with snow when ventilation is needed to keep the roof surface cool. Without adequate air flow, heat and moisture will accumulate in the roof slope or attic. Eventually this heat and solar gain will melt the outlet vents open; but, some icing will occur and related ice dams will start to form during the "closed" condition. The length of time it takes for them to open is related to outdoor temperatures and snow depth. The deeper the snow (and the more insulation value it provides above the roof sheathing), the more melting will occur before ventilation can start to remove heat from the underside of the roof deck.
2. Inlet and outlet ventilation areas should be properly sized to work effectively. Typical soffit and ridge vent hardware/device systems are designed to have the appropriate ratio of inlet and outlet square inches of net free area to provide code-compliant air flow; i.e., the manufacturers plan for the net free area of one foot of ridge or shed vent (outlet) to be the same as or more than the net free area of one foot of soffit vent (inlet). Refer to the code jurisdiction for your location to see how to calculate what the total net free vent area should be with respect to the roof area or the attic floor area. The use of a vapor barrier typically determines this ratio. The distribution of low-to-high (inlet to outlet) net free area is also detailed in the code. The net free area of a ventilation device is the effective flow area of the accumulated openings in the device. This area is published in the product data and usually printed on the device itself. Adding screens with tight weave spacing to louvered devices significantly reduces the net free area reported by the manufacturer.
3. Vent chutes are used to prevent the soffit from being filled with insulation and to maintain air flow from the soffit to the attic or ridge vent. The chutes should have the same net free area as the soffit and ridge vents. If the soffit is a continuous box rather than a succession of bays defined by the extension of the rafters into the overhang, intermittent large openings can successfully serve as the inlet for multiple rafter bays. If the soffit volume at the end of each rafter bay is isolated, inlets need to be appropriately sized and installed in each bay.
4. Roofs with valleys will typically have significantly more outlet area (ridge vent length/area) than inlet area (soffit vent length/area). A hip roof will have less outlet area when compared to the available inlet area provided by standard soffit vents. Complex roof configurations require careful planning to maintain the appropriate inlet-to-outlet ratio (see distribution below). Hip and valley conditions usually require more than just the area provided by conventional ridge and soffit details.
5. Dormers, skylights, chimneys, and other obstructions can prevent uniform roof surface ventilation in cathedral slopes. Inlet and outlet areas on either side of these obstructions should be increased and cross-connected to provide adequate flow above and below them.
6. Ventilation should also be evenly distributed. Isolated attic or roof areas without adequately sized or distributed inlet and outlet vent openings will create dead zones in the airflow pattern, providing little cooling or drying. Specifically, areas with only inlet or only outlet will not provide effective air flow. Don't count soffit vents that service dead end-vent chutes as inlet area – best practice is to provide both inlet and outlet for any vented roof slope area or use an unvented roof design.
7. When designing a ventilation system, don't just compare the gross inlet area and gross outlet area for the entire building. Each **local** area of the roof or attic must have adequate and balanced inlet and outlet net free areas for cooling/drying to be effective over the **entire** roof area. Remember, it is the temperature of the roof surface that determines if melting will occur in that specific area.

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Likewise, adequate flow is required to reduce moisture accumulation. If a valley is the area that is out of balance, that is where the melt will occur. Areas above valleys are the worst places to have melting as the melt water is concentrated in a narrow flow area and is therefore the most susceptible to problematic ice buildup. In attics where roof configurations or obstructions make it impossible to provide adequate local air movement, mixing is an effective strategy. This involves using fans to circulate air from well ventilated areas into the dead zones.

8. In cathedral roof slopes that are larger than typical residential roofs, soffit-to-ridge vent runs are longer. The longer the roof run, the more total area there is in each rafter bay. More area means there is more heat and moisture that the ventilation air must carry away. For this reason, the size of the ventilation passages must be increased, and the inlet and outlet net free areas must be increased to provide adequate flow to keep the ventilation air below freezing by the time it reaches the end/top of the vent chute. Most soffit and ridge vent systems are designed for average-sized residential roofs. An example would be to use a double row of soffit vent strips, a full-width 2" air passage in each rafter bay, and a ridge vent design with a larger net free area.
9. Even larger ridge vents are ineffective when snow covers the roof. In attics, use gable vents and evenly spaced cupolas or vent hoods with outlets that are above the local design snow depth (aka snow load). In cases where adequate inlet and outlet net free areas cannot provide adequate passive air flow, mechanical ventilation may be required. A combination of downdraft inlet fans with distribution ducting and balanced outlet cupolas is an effective strategy. Significant depressuization or pressurization of the attic can increase air leakage into or out of the conditioned space. In cathedral slopes, high-rise ridge vent caps that have outlets above the design snow depth are effective, but often are objectionable aesthetically. Another approach is to frame the roof so that the tops of the vent chutes terminate in a duct or gallery immediately under the ridge. This allows the ventilation air to flow along the ridge to gable end vents or evenly spaced outlet cupolas or vent hoods that are not susceptible to closure by snow on the roof. One product designed to allow this framing configuration is the SnowVENT™ system which is a system of brackets that make a structural connection at the top of the rafters while maintaining a continuous air passage along the length of the ridge.
10. Keep in mind that maintaining adequate roof and attic inlet and outlet ventilation provisions without an adequate air barrier system can actually promote roof warming, moisture accumulation, melt, and icing. This occurs when exterior (wind) and interior building pressures (from stack effect and/or mechanical systems) tend to force some or all of the airflow into the attic or cathedral slope vent chutes from the interior conditioned (warm, moist) spaces. For increased ventilation to be an effective ice dam or moisture remediation strategy, air sealing must be completed first.
11. Another hidden problem that can plague roof ventilation systems is external heat sources. Through-wall exhaust systems, south-facing walls, and leaky wall-to-roof air barrier transitions can be sources of warm air that flows up and into soffit vents, warming and wetting the roof sheathing instead of keeping it cool and dry. Localized heat/moisture sources immediately below ventilation system inlets can require closing the soffit vents and proving alternate sources of inlet ventilation air.
12. An alternate strategy to ventilation in cathedral slopes is to increase the R-value and eliminate venting altogether. Remember that the roof insulation values that are necessary to prevent melt vary significantly with climate zone, local snow depths, roof configurations, pitch, wind/drifting, and solar exposure. Lee sides of roofs, transition walls, and dormers pile up snow to depths that may require as much as R=80 or more to avoid melt completely. Low-pitch roofs hold more snow per square foot than steep slopes. Snow tends to stay on low-pitch shingled roofs longer than steep

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metal roofs which may allow snow to slide off the roof in straight roof configurations (except in valleys or above dormers and skylights). The deeper the snow cover, the more R-value the snow has, and the higher the roof insulation R-value has to be to keep temperatures in the snow pack at the roof-to-snow interface below freezing. The National Weather Service has information on the typical design snow depth for each weather station area in the U.S. The U.S. Cold Regions Research Environmental Laboratories has studied the R-value required to prevent melt for a given snow depth and documents the means of calculating the given R-value required for a given design snow load. They present two R-values for any given snow depth - one for unvented roofs and one for vented roofs. The R-value for unvented roofs is always higher than for vented roofs as the ventilation can remove some of the heat that escapes due to lower R-values. Of course, higher R-values mean less wasted energy. Unvented roofs are also relatively immune to warming caused by air leakage as there is no easy path (the vent chutes) for air to escape through. If an effective air barrier is not possible due to access limitations, increasing the higher R-value and eliminating the vents can be a successful approach for remediation projects. Of course this is always an option for the original design of the roofs in new buildings.

13. Comments:
    a. Designers must consider all of these issues when designing vented attics and cathedral roof systems. Unvented cathedral roof designs only require selecting the proper R-value for the design snow load for the building's location.
    b. I am often asked if "rule-of-thumb" ventilation net free areas are adequate to provide the necessary cooling and drying. My experience indicates that the answer is yes if "connections" between the interior space and the attic and/or insulated roof slope vent spaces are eliminated and insulation values are adequate. Most ice dam failures occur where air leakage into the vent spaces is prevalent. Ventilation cannot overcome air leakage as more ventilation generally increases the air leakage. The second most common cause is inadequate R-values. When air leakage-specific melting is not evident in localized areas of the roof, ice dams are usually due to melting that occurs more or less uniformly over the entire roof surface due to inadequate R-values. Ventilation is basically a bandaid for either excessive vapor diffusion or heat loss due to inadequate insulation.
    c. Ice dams usually indicate problems in roof areas <u>above</u> where the ice actually forms. Ice forms where the roof is cold, melt occurs where the roof is warm. Melt water runs downhill.

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