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Unvented Roof Summary Article
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This article was written to tie together and summarize the various papers on unvented conditioned cathedralized attics found on our website. We realize that there is a wealth of information, and much of it too detailed to understand or digest in a single sitting. Furthermore, building officials might not have the time available to carefully examine the many documents on the page; this is meant to summarize the main arguments, and provide pointers to where detailed information and measured data can be found.

The articles dealing with unvented roofs are as follows (in chronological order):

From http://www.buildingscience.com/resources/resources/roofs/

"Measurement of Attic Temperatures and Cooling Energy Use In Vented and Sealed Attics in Las Vegas, Nevada" Armin F. Rudd, Joseph W. Lstiburek and Neil A. Moyer; Presented at the '96 Excellence in Building Conference, 14-17 November, and published in EEBA Excellence, The Journal Of The Energy Efficient Building Association, Spring 1997. Energy Efficient Building Association, Minneapolis, MN

"Vented and Sealed Attics In Hot Climates", A. F. Rudd and Joseph W. Lstiburek, Presented at the ASHRAE Symposium on Attics and Cathedral Ceilings, Toronto, June 1997. ASHRAE Transactions TO-98-20-3. American Society of Heating Refrigeration and Air-Conditioning Engineers, Atlanta, GA.

BSC Figures 1 and 2 (Unvented Roof Insulation and Framing Details, Air Barrier at Unvented Roof)

"Questions posed regarding unvented roofs," A. F. Rudd. 2000.

"Unvented-cathedralized attics: Where we've been and where we're going," A. F. Rudd, Joseph W. Lstiburek, and Kohta Ueno. 2000.

"Unvented Roof Systems, " Joseph W. Lstiburek, 2001.

"Unvented Roofs, Hot-Humid Climates, and Asphalt Shingles," January 2003, Joseph Lstiburek.

"Unvented Attic Discussion", Revised January 2003, Joseph Lstiburek.

Unvented Roof (Conditioned Attics): Theory and Practice

Building codes typically require attic ventilation; the origin of this requirement comes from cold climate demands to avoid ice damming and vent internally generated moisture. In hot (cooling-dominated) climates, the purpose of attic ventilation is to remove solar gain from the roof, thereby reducing the contribution of roof cooling load. In typical houses, the contribution of the roof cooling load to the total load is on the order of 10%.

However, our modeling and research has shown that the requirement for venting attics in hot-dry and hot-humid climates is of questionable validity. Our studies on houses in various locations (including Las Vegas, Tucson, and the southeastern United States) have shown that by moving the ceiling air barrier and thermal barrier to the roof plane, better building airtightness can be achieved, and that the elimination of heat gain to the attic ductwork (due to conduction and leakage) more than offsets the additional heat gain caused by not venting the attic.

Placement of the air handler and ductwork system in this conditioned attic space negates the effect of duct leakage, which is commonly 10-20% of the rated air handler flow in typical construction. For houses with tile roofs, operating temperature for this 'conditioned attic' or 'attic utility area,' has been measured at typically within 5-7° F of indoor temperatures, without any direct space conditioning (i.e., conditioned by duct leakage and conduction); this provides less harsh operating conditions for the ductwork and air handler than typical unconditioned attics.

An excellent (and entertaining) discussion of the basics is found in the article: "Unvented Attic Discussion," 1999, Joseph Lstiburek.

Detailed studies are also on the same web page: the paper that addresses both computer models and test houses is "Measurement of Attic Temperatures and Cooling Energy Use In Vented and Sealed Attics in Las Vegas, Nevada." The paper ""Questions posed regarding unvented roofs" provides a summary of typical questions on the performance and applicability of unvented roof systems.

Unvented Roof Assembly Details (Air and Thermal Barriers)

Moving the thermal and air barrier from the flat ceiling plane to the roof deck requires special detailing; since the attic is now conditioned space, it must be air sealed and insulated. Typical areas requiring draftstopping are the intersection between the 'conditioned attic' and the 'unconditioned attic' typically found over the garage or the porch. Details addressing these air barrier questions have been drawn and are enclosed here (see BSC Figures 1-4); they show the requirement for thermal barrier (i.e., insulation) and air barrier continuity around all of the conditioned space.

BSC Figure 1 details the intersection between a conditioned attic and a perpendicular ridge overframed garage attic that is not conditioned; the detailing for an unconditioned porch roof would be similar. Figure 2 shows an intersection in-line with the trusses; it requires the construction of a 'kneewall' with a rigid air barrier (such as plywood, OSB, rigid foam sheathing, or Thermo-Ply).

Finally, in addition to this prescriptive detailing, the houses should be subjected to a blower door test protocol, with the attic hatch open, which tests the airtightness of the entire building shell, including the unvented roof. This test truly determines whether the air barrier details, taken in aggregate, are effective. We recommend the airtightness goal used in the Building America program; see the web page->Building America -> Performance Targets. The airtightness goal is based on the surface area of the building, and is tighter than the majority of typical residential construction.

Of course, controlled mechanical ventilation is a recommended addition to all houses.

Unvented Roof Assembly Material Performance

One of the first questions brought up when unvented roof systems are proposed is whether it will be detrimental to the life of the building materials in the assembly. In addition to measuring the energy performance of test houses in various locations, Building Science Corporation also measured temperatures of attic air, roof sheathing (plywood/OSB), and roof tiles or shingles.
The resulting data showed that when a vented tile roof in Las Vegas was compared with an unvented cathedralized roof, the maximum roof sheathing temperature difference was 17° F (see "Questions posed regarding unvented roofs"). The maximum measured roof sheathing temperature of 154° F for the unvented attic was well within acceptable temperature limits (less than 180° F) (see "Unvented-cathedralized attics: Where we've been and where we're going").

Furthermore, Las Vegas would be among the 'worst case' locations for elevated temperatures of building materials (108° F ASHRAE 0.4% design temperature); few locations (e.g. Phoenix) have design conditions worse than that location.

The air handler and HVAC system (ductwork) are operating at much less stressful temperatures (within 3-5° F of indoor setpoint, instead of typical attic temperatures), and no ultraviolet light enters via roof vents. These factors will tend to increase lifespan of this mechanical equipment and ductwork systems in unvented roofs.

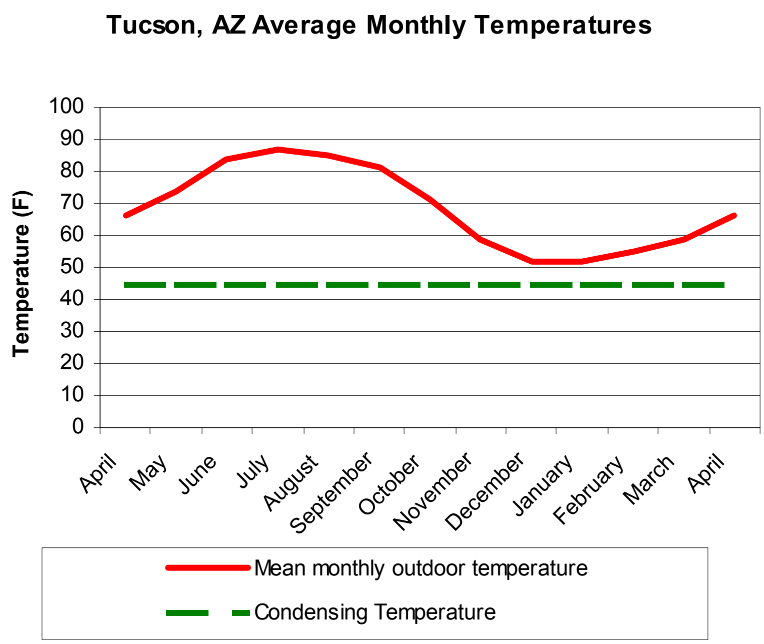
Climate Data

As mentioned in "Questions posed regarding unvented roofs," unvented attics with cathedralized insulation can be recommended in the continental US wherever the monthly average outdoor dry bulb temperature does not fall below 45° F; this coincides with the definition of a hot-dry or hot-humid climate.

This temperature limitation is a function of potential condensation problems within the roof assembly. The logic behind this decision is detailed in the web page "Unvented Roof Systems." As mentioned in that article, unvented assemblies can be built in mixed or cold climates, but further detailing is necessary.

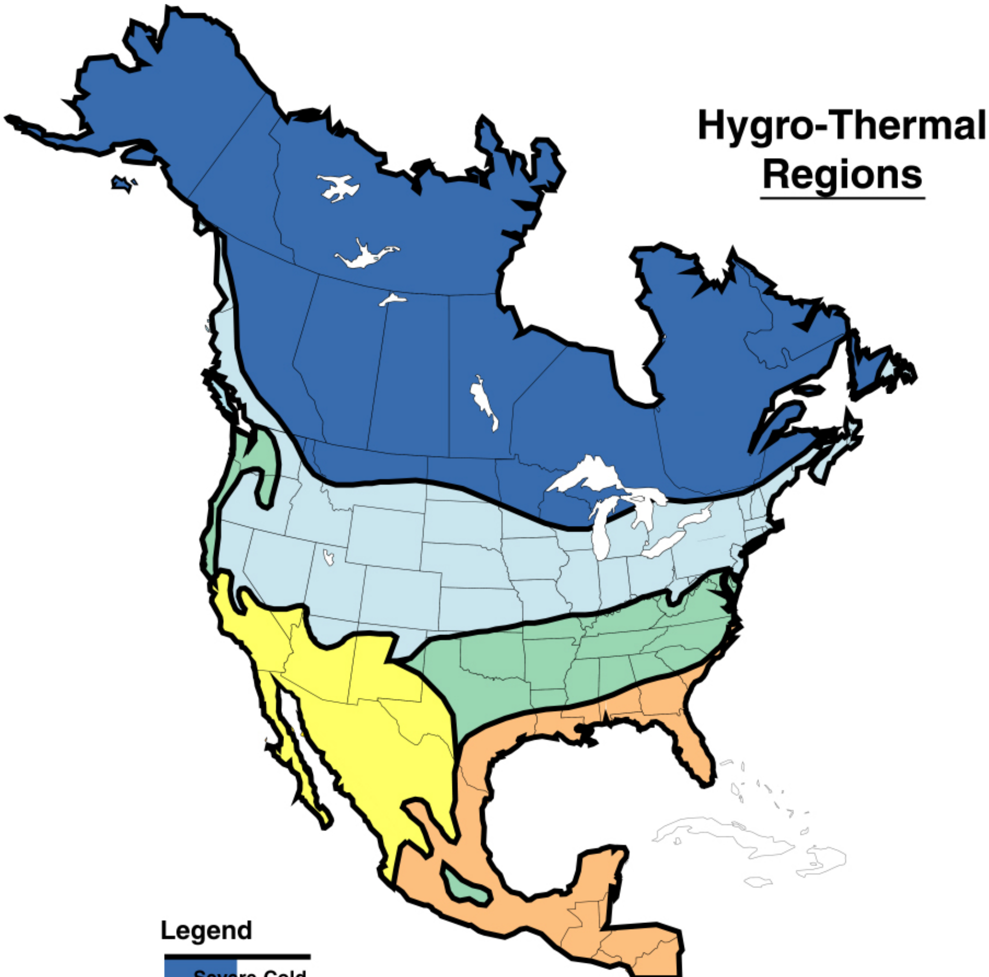
At www.weather.com (The Weather Channel Web Site), monthly average temperature information is available, in order to determine climate location (cold, mixed, or hot zone). Data for Tucson, AZ is shown below; it shows a lowest monthly temperature averaging above 45° F:

Tucson, AZ	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Mean outdoor temp (F)	66	74	84	87	85	81	71	59	52	52	55	59	66



In addition, this data includes average precipitation records, which will allow the differentiation between humid and dry climate zones (i.e., over 20 inches/year or under). Tucson's historical data shows an average precipitation per year of ~13 inches (hot dry zone).

Appendix I: Hygro-Thermal Regions Map



Legend

Severe-Cold
A severe-cold climate is defined as a region with approximately 8,000 heating degree days or greater

Cold
A cold climate is defined as a region with approximately 4,500 heating degree days or greater and less than approximately 8,000 heating degree days

Mixed-Humid
A mixed-humid climate is defined as a region that receives more than 20 inches of annual precipitation, has approximately 4,500 heating degree days or less and where the monthly average outdoor temperature drops below 45°F during the winter months

Hot-Humid
A hot-humid climate is defined as a region that receives more than 20 inches of annual precipitation and where the monthly average outdoor temperature remains above 45°F throughout the year*

Hot-Dry/Mixed-Dry
A hot-dry climate is defined as a region that receives less than 20 inches of annual precipitation and where the monthly average outdoor temperature remains above 45°F throughout the year;

A mixed-dry climate is defined as a region that receives less than 20 inches of annual precipitation, has approximately 4,500 heating degree days or less and where the monthly average outdoor temperature drops below 45° during the winter months

* The definition characterizes a region that is almost identical to the ASHRAE definition of hot-humid climates where one or both of the following occur:

- a 67°F of higher wet bulb temperature for 3,000 or more hours during the warmest six consecutive months of the year; or
- a 73°F or higher wet bulb temperature for 1,500 or more hours during the warmest six consecutive months of the year

Based on Herbertson's Thermal Regions, a modified Koppen classification, the ASHRAE definition of hot-humid climates and average annual precipitation from the U.S. Department of Agriculture and Environment Canada

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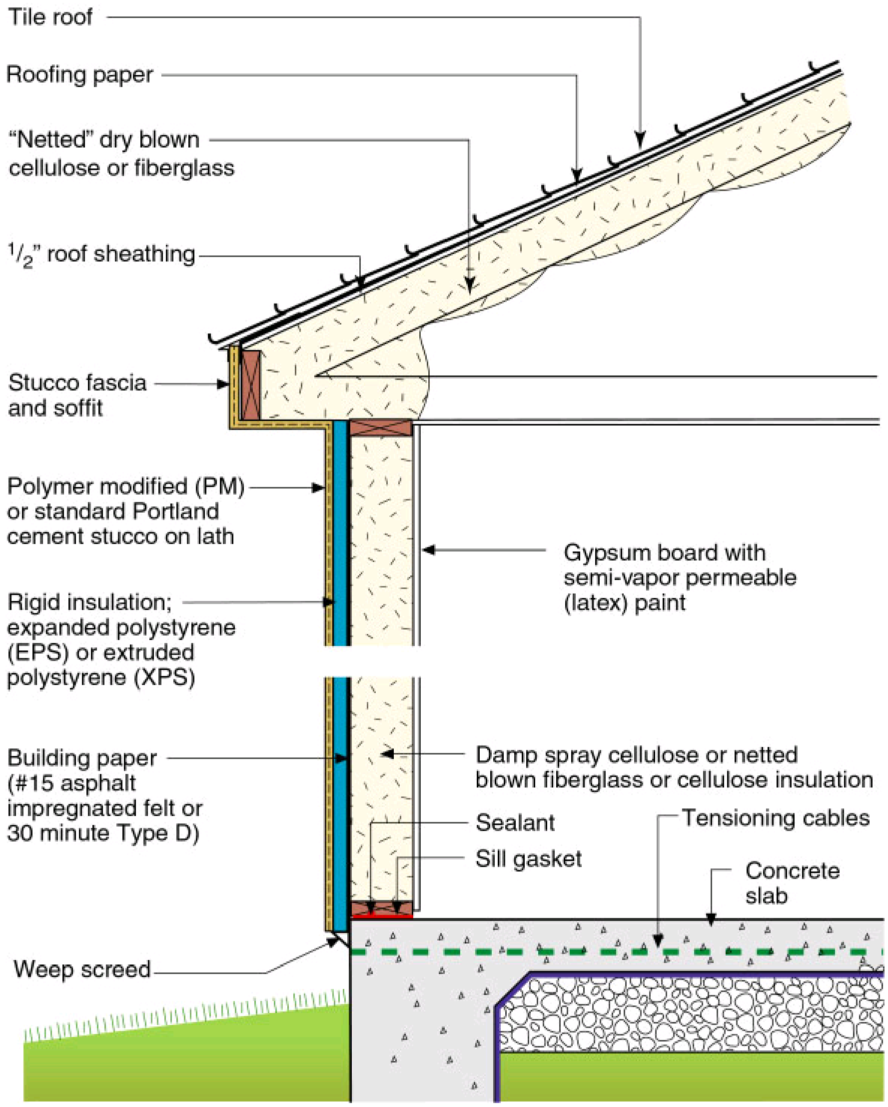
Appendix II: Hot-Dry Wall Assembly

From http://www.buildingscience.com/housesthatwork/hotdry/default.htm



- Materials – 2 x 6 wood frame covered with one layer of building paper (#15 asphalt impregnated felt or 30 minute Type D), sheathed with one inch of expanded polystyrene and covered with stucco lath and 2-coat stucco.

- Framing – 2 x 6 wood framing, 24 inches on center; for detailed information on advanced framing click here. (Shear load can be handled in any of several ways: diagonal bracing, OSB sheathing beneath the foam sheathing.)

- Moisture Control – drainage plane continuity; flashing of penetrations and control of moisture laden airflow

- Flashing – windows and doors should be flashed as shown in Figures 4-7.

