# Roof and Attic Ventilation Issues in Hot-Humid Climates


**presented by:**

**Armin Rudd**

**Building Science Corporation**


**for**

**South Florida Building Officials Association**

**14 May 2003**

# Early History of Attic Ventilation

Presentation material with permission from:

William B. Rose, Research Architect

Building Research Council-School of Architecture University of Illinois at Urbana-Champaign

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Proceedings available through NRCA

# L.V. Teesdale, 1937

Roof condensation is reported far more frequently than sidewall condensation, not necessarily because it occurs more frequently but rather because it is more likely to be seen by the occupants. For example, in a pitched roof house having, say, fill insulation in the ceiling below the attic, condensation may develop during a severe cold spell on the underside of the roof boards, forming as ice or frost. When the weather moderates, or even under a bright sun, the ice melts and drips on the attic floor, leaks through and spots the ceiling below. ... If the attic has adequate ventilation little or no trouble will occur but adequate ventilation is sometimes difficult to attain, and tends to increase the heat loss.

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# L.V. Teesdale, 1937 (continued)

- Overall recommendation was to reduce indoor humidity, and

  “For new construction it is recommended that a suitable vapor barrier be installed on the side wall studs and below the ceiling insulation and that some attic ventilation also be provided.”

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# Rogers 1938

“Architects, owners and research technicians have observed, in recent years, a small but growing number of buildings in which dampness or frost has developed in walls, roofs or attic spaces. Most of these were insulated houses, a few were winter air-conditioned. The erroneous impression has spread that insulation ‘draws’ water into the walls and roofs...Obviously, insulation is not at fault.”

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# Rogers 1938

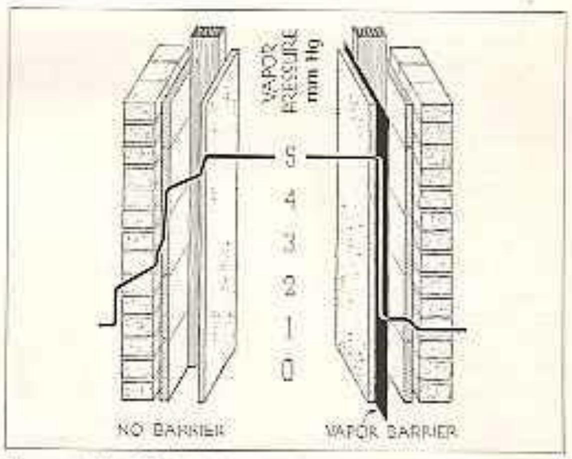
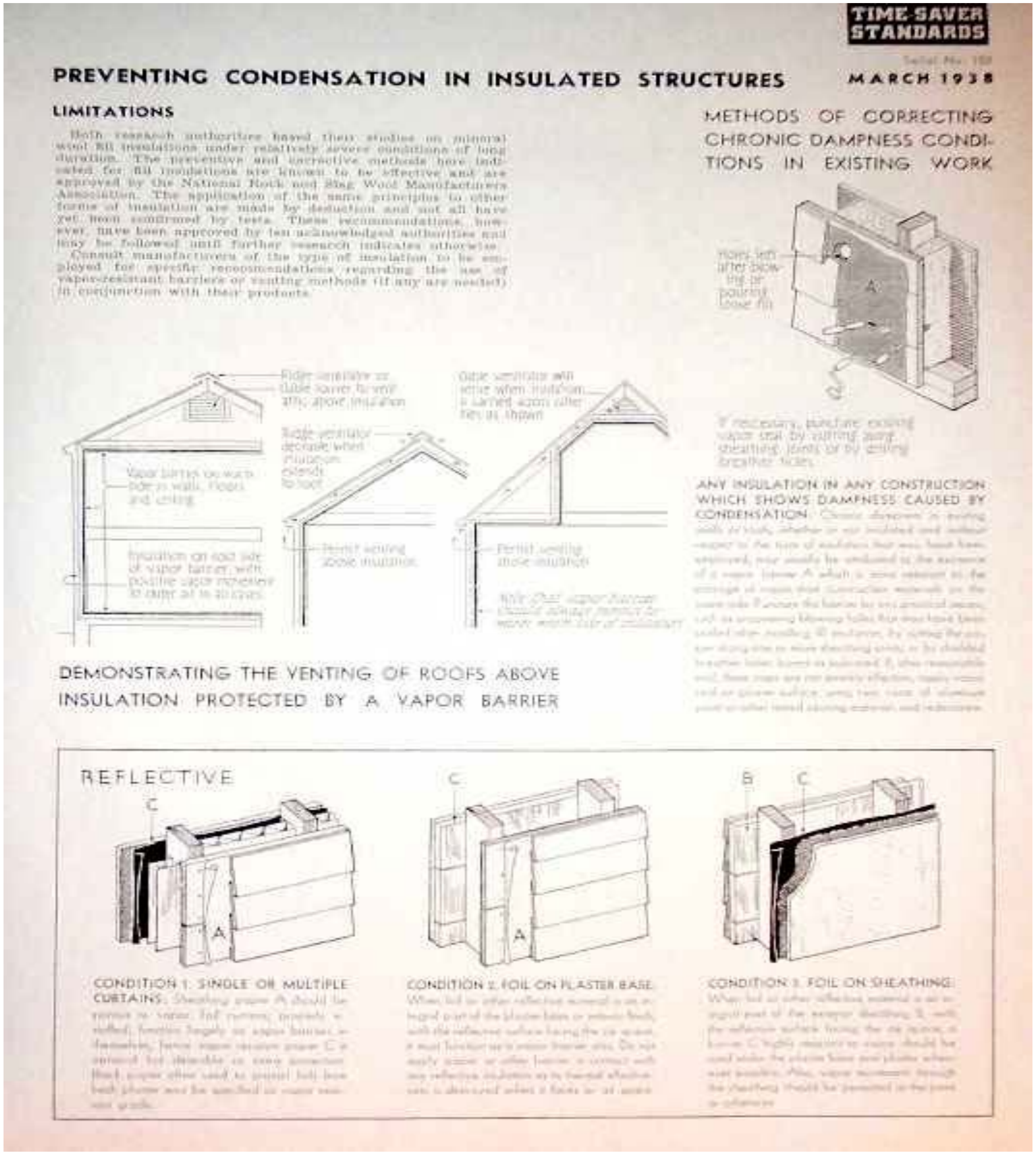



Figure 2: VAPOR PRESSURES IN WALLS. The weight of water vapor in air exerts pressure which tends to move vapor from air that has more water content to air that has less. This vapor pressure is measured in millimeters of mercury (Hg). Approximate changes in vapor pressure between the warm, humidified air usually present in occupied buildings in winter and the pressure out of doors on a typical winter day are shown above. The pressure gradient lines show also the relative rate of vapor movement. Note that a vapor barrier (at right) stops most vapor movement and reduces the pressure nearly to that of the cold outside air. Compare with the temperature gradient lines of Figure 3. (Drawings based on data from Kimberly-Clark Corporation).



TIME-SAVER STANDARDS

PREVENTING CONDENSATION IN INSULATED STRUCTURES — MARCH 1938

LIMITATIONS

Both research authorities based their studies on mineral wool fill insulations under relatively severe conditions of long duration. The preventive and corrective methods here indicated for fill insulations are known to be effective and are approved by the National Rock and Slag Wool Manufacturers Association. The application of the same principles to other forms of insulation are made by deduction and not all have yet been confirmed by tests. These recommendations, however, have been approved by ten acknowledged authorities and may be followed until further research indicates otherwise.

Consult manufacturers of the type of insulation to be employed for specific recommendations regarding the use of vapor-resistant barriers or venting methods (if any are needed) in conjunction with their products.

METHODS OF CORRECTING CHRONIC DAMPNESS CONDITIONS IN EXISTING WORK

DEMONSTRATING THE VENTING OF ROOFS ABOVE INSULATION PROTECTED BY A VAPOR BARRIER

ANY INSULATION IN ANY CONSTRUCTION WHICH SHOWS DAMPNESS CAUSED BY CONDENSATION.

REFLECTIVE

CONDITION 1: SINGLE OR MULTIPLE CURTAINS.

CONDITION 2: FOIL ON PLASTER BASE.

CONDITION 3: FOIL ON SHEATHING.

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# Rogers 1938

"Venting of roof areas above insulation may be accomplished by various means, according to the construction involved. Unoccupied attics or loft spaces, above insulation installed at the ceiling below, should be vented by louvers in gable ends or side walls at the highest possible point, or by ridge ventilators or false chimneys. Wood shingle roofs applied on spaced shingle lath without vapor resistant papers provide sufficiently free vapor movement to make additional venting unnecessary, but roof decks of any kind which are covered with vapor-resistive materials should have special vents."

- 1939. Rogers became Director of Technical Publications for Owens Corning Fiberglas.

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# Rowley 1938

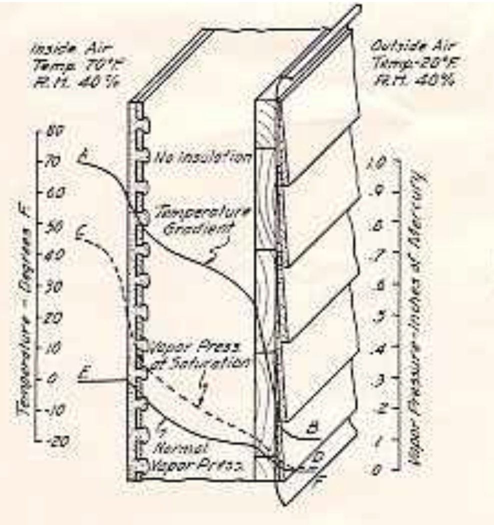



Fig. 7—Frame wall without insulation showing normal temperature and vapor pressure gradient through wall

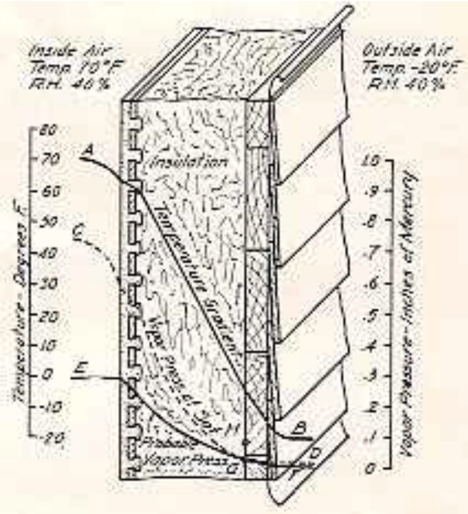
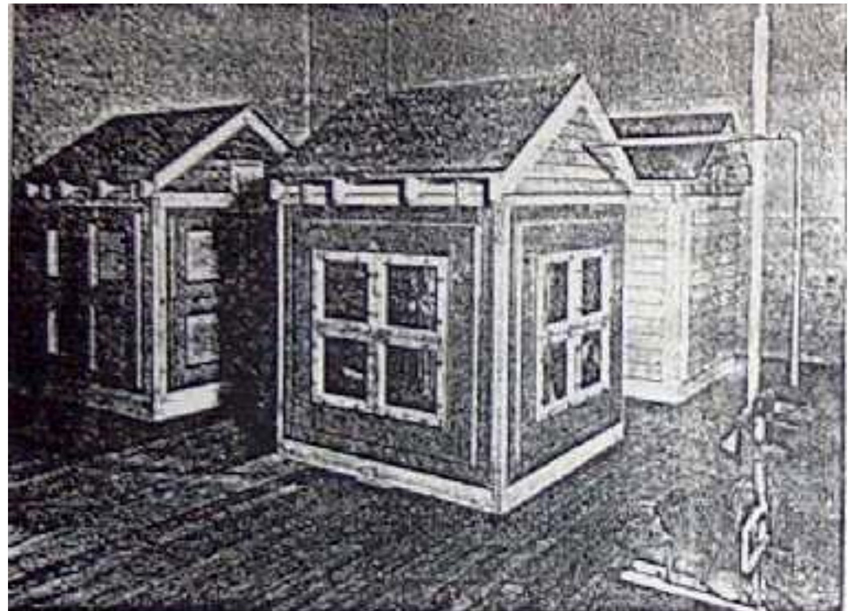



Fig. 8—Frame wall with insulation showing temperature and vapor pressure gradients as established through wall. *H* indicates vapor pressure required at inner surface of sheathing to prevent condensation. *G* indicates maximum vapor pressure allowed by temperature of sheathing



...G. 5. View of Set-up for Ventilated and Unventilated Attics. Apparatus in ...ground Used for Measuring Supply of Air to Mechanically Ventilated Attics

Table 5—Attic Ventilation

| Test No. | Period No. | Duration of Test | Outside Air Temp, Deg F | Inside Air Conditions | | No Ventilation | | Natural Ventilation | | | Mechanical Ventilation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Deg F | R. H. % | Attic Air, Temp. | Condensation[a] | Opening, sq in[b] | Attic Air Temp. | Condensation | Air Supplied, cu ft[c] | Attic Air Temp. | Condensation |
| 19 | 1 | 54 | −10.4 | 70.3 | 40.5 | 4.6 | 3.01 | 0.25 | −0.4 | 0.0 | 3.0 | 1.8 | 0.00 |
| 19 | 2–3 | 68 | −10.3 | 70.0 | 40.9 | 4.6 | 3.33 | 0.125 | 1.2 | 0.16 | 1.5 | 2.0 | 0.03 |
| 20 | 1 | 66 | +15.0 | 70.1 | 40.6 | 26.9 | 0.0 | 0.125 | 24.2 | 0.0 | 1.5 | 24.3 | 0.00 |
| 20 | 2 | 99 | +10.0 | 69.9 | 40.3 | 22.6 | 0.0 | 0.125 | 19.9 | 0.0 | 1.5 | 19.7 | 0.00 |
| 20 | 3 | 117 | +5.0 | 70.1 | 40.6 | 17.3 | 1.16 | 0.125 | 13.9 | 0.0 | 1.5 | 14.4 | 0.00 |
| 20 | 4 | 72 | +5.0 | 70.0 | 31.3 | 17.6 | 0.78 | 0.125 | 14.6 | 0.0 | 1.5 | 15.0 | 0.00 |
| 20 | 5 | 72 | +5.0 | 70.1 | 20.7 | 16.9 | −1.02 | 0.125 | 14.1 | 0.0 | 1.5 | 14.4 | 0.00 |
| 20 | 6 | 98 | +10.0 | 70.1 | 20.6 | 20.5 | −1.22 | 0.125 | 18.3 | 0.0 | 1.5 | 18.4 | 0.00 |
| 20 | 7 | 66 | +15.0 | 70.1 | 21.0 | 23.4 | 0.0 | 0.125 | 21.2 | 0.0 | 1.5 | 21.2 | 0.00 |
| 20 | 12 | 141 | 0.0 | 70.0 | 21.3 | 11.8 | 1.76 | 0.125 | 7.8 | 0.0 | 1.5 | 9.6 | 0.00 |
| 20 | 13 | 72 | −11.4 | 70.1 | 19.9 | 1.43 | 2.52 | 0.125 | −2.5 | 0.0 | 1.5 | −0.5 | 0.00 |

[a] Condensation in grams per square foot ceiling area per 24 hours.
[b] Opening in square inches per square foot ceiling area in each gable.
[c] Air supplied in cubic feet per hour per square foot ceiling area.

Condensation of Moisture, Rowley, Algren and Lund

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# Rowley's Conclusions 1938

4. It is possible to reduce the rate of condensation within a structure by ventilating to the outside. This method may be particularly effective in attics where the condensation occurs on the underside of the roof. Adequate ventilation may be obtained without serious loss of heat.

9. For cold attic spaces it is desirable to allow openings for outside air circulation through attic space as a precaution against condensation on the underside of the roof even though barriers are used in the ceiling below.

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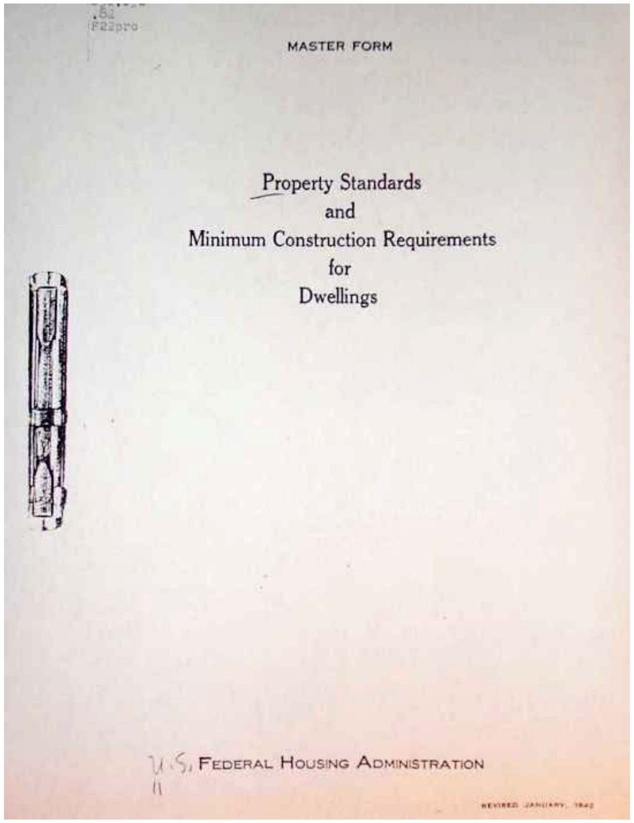
# FHA 1942

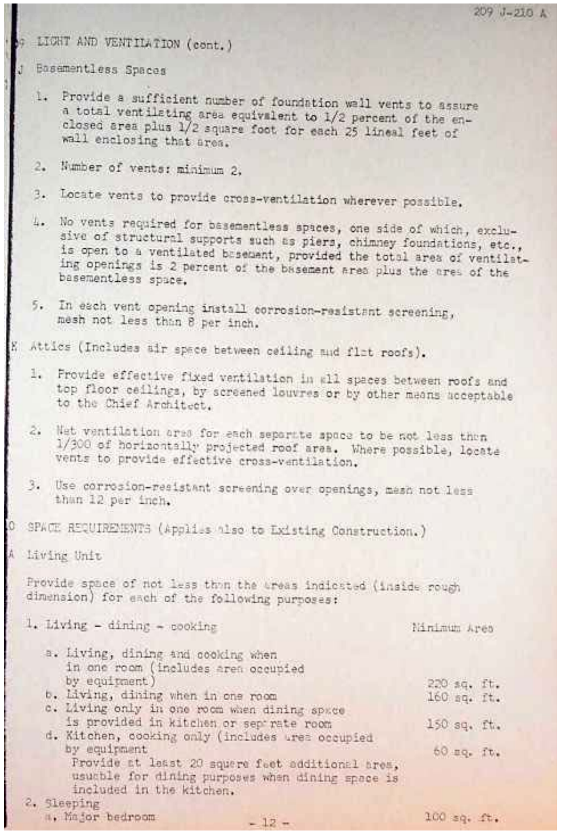
- First guidelines for “basementless space” ventilation (1/150), “loft or attic space” ventilation (1/300) and vapor barriers (1.25 grains per ft$^2$-hr-inHg) appeared. Mimeographed copy with no references or citations.



MASTER FORM

Property Standards
and
Minimum Construction Requirements
for
Dwellings

U.S. FEDERAL HOUSING ADMINISTRATION



209 J-210 A

LIGHT AND VENTILATION (cont.)

J Basementless Spaces

1. Provide a sufficient number of foundation wall vents to assure a total ventilating area equivalent to 1/2 percent of the enclosed area plus 1/2 square foot for each 25 lineal feet of wall enclosing that area.
2. Number of vents: minimum 2.
3. Locate vents to provide cross-ventilation wherever possible.
4. No vents required for basementless spaces, one side of which, exclusive of structural supports such as piers, chimney foundations, etc., is open to a ventilated basement, provided the total area of ventilating openings is 2 percent of the basement area plus the area of the basementless space.
5. In each vent opening install corrosion-resistant screening, mesh not less than 8 per inch.

K Attics (Includes air space between ceiling and flat roofs).

1. Provide effective fixed ventilation in all spaces between roofs and top floor ceilings, by screened louvres or by other means acceptable to the Chief Architect.
2. Net ventilation area for each separate space to be not less than 1/300 of horizontally projected roof area. Where possible, locate vents to provide effective cross-ventilation.
3. Use corrosion-resistant screening over openings, mesh not less than 12 per inch.

O SPACE REQUIREMENTS (Applies also to Existing Construction.)

A Living Unit

Provide space of not less than the areas indicated (inside rough dimension) for each of the following purposes:

| 1. Living - dining - cooking | Minimum Area |
|---|---|
| a. Living, dining and cooking when in one room (includes area occupied by equipment) | 220 sq. ft. |
| b. Living, dining when in one room | 160 sq. ft. |
| c. Living only in one room when dining space is provided in kitchen or separate room | 150 sq. ft. |
| d. Kitchen, cooking only (includes area occupied by equipment | 60 sq. ft. |
| Provide at least 20 square feet additional area, usable for dining purposes when dining space is included in the kitchen. | |
| 2. Sleeping | |
| a. Major bedroom | 100 sq. ft. |

- 12 -

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# FHA 1942

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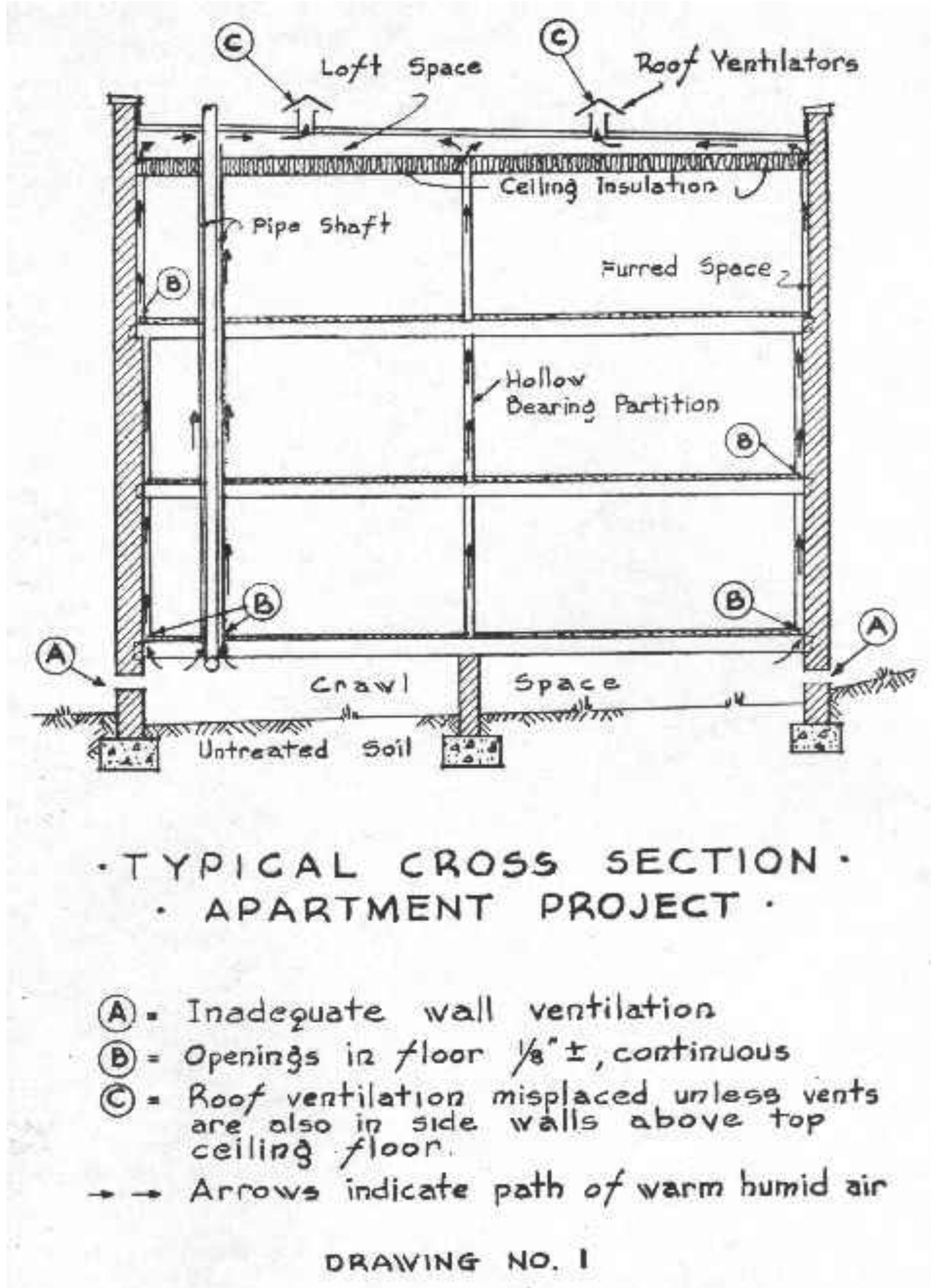
# Britton "Crawl Spaces" 1947

"Note: Where an effective vapor barrier is assured in the top-story ceiling, loft or attic space ventilation specified above may be greatly decreased. Such decrease may well be as much as 90% where controlled construction is assured and walls or crawl space do not contribute to moisture supply in the attic or loft space."

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# HHFA 1948

- Ralph Britton was the principal author of "Condensation Control", a booklet with guidance for the post-WWII housing boom. Recommended attic ventilation and vapor barriers.

**HIP ROOF, ENCLOSED RAFTERS**

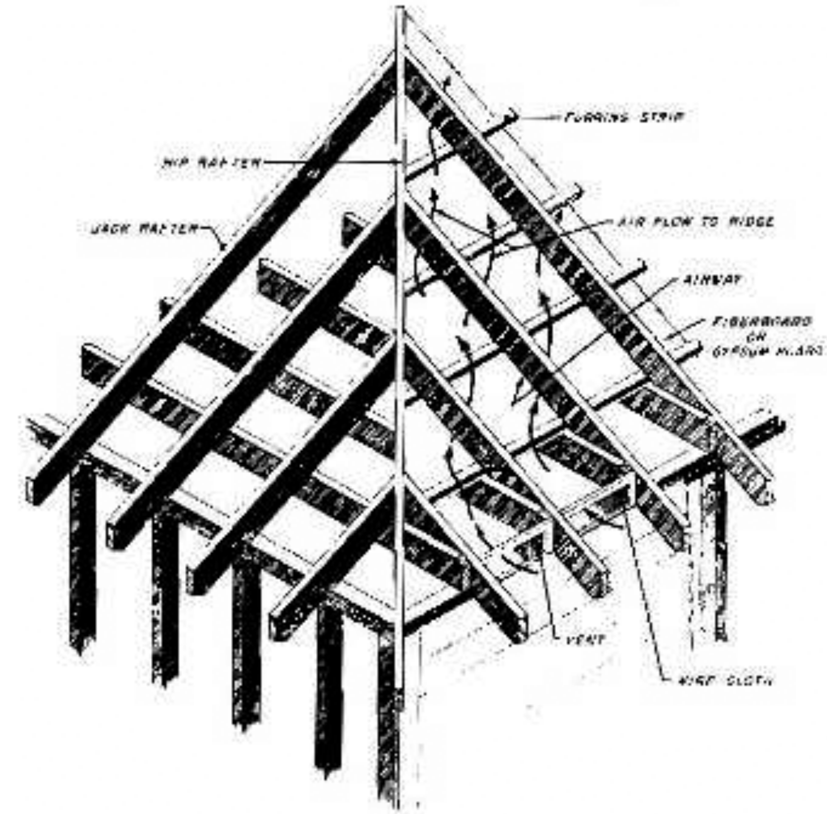


FIGURE 45. *Hip roof, enclosed rafters.* Hip-roof construction presents a special problem when it is desired to enclose or insulate the roof because of the complete closure of the spaces between the jack rafters by the hip rafter when the insulation is applied between or on the under side of the rafters. If rooms are built into the attic they should be constructed independent of the roof structure or furred in such a way that air will not be trapped in the construction. Fiberboard is used for thermal insulation and the interior surface in this detail. An inlet for fresh air is shown below the eaves and airways throughout the roof construction. Although not shown, it is assumed that an outlet will be provided to permit the discharge of air near the ridge. Figures 41, and 46 to 49 indicate how this may be done and the sizes of openings are given in "Good practice recommendations."

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# BOCA 1948

SEC. 115.3 ATTIC SPACES All attic spaces and unoccupied spaces between roofs and top floor ceilings shall be ventilated by not less than two (2) opposite louvres or vents with a total clear area of opening not less than one-third (1/3) of one (1) per cent of the horizontally projected roof area.

SEC. 115.4 CRAWL SPACES Access spaces under grade floor construction and wherever wood, gypsum, metal or other floor construction subject to corrosion or deterioration is installed above the

-79-

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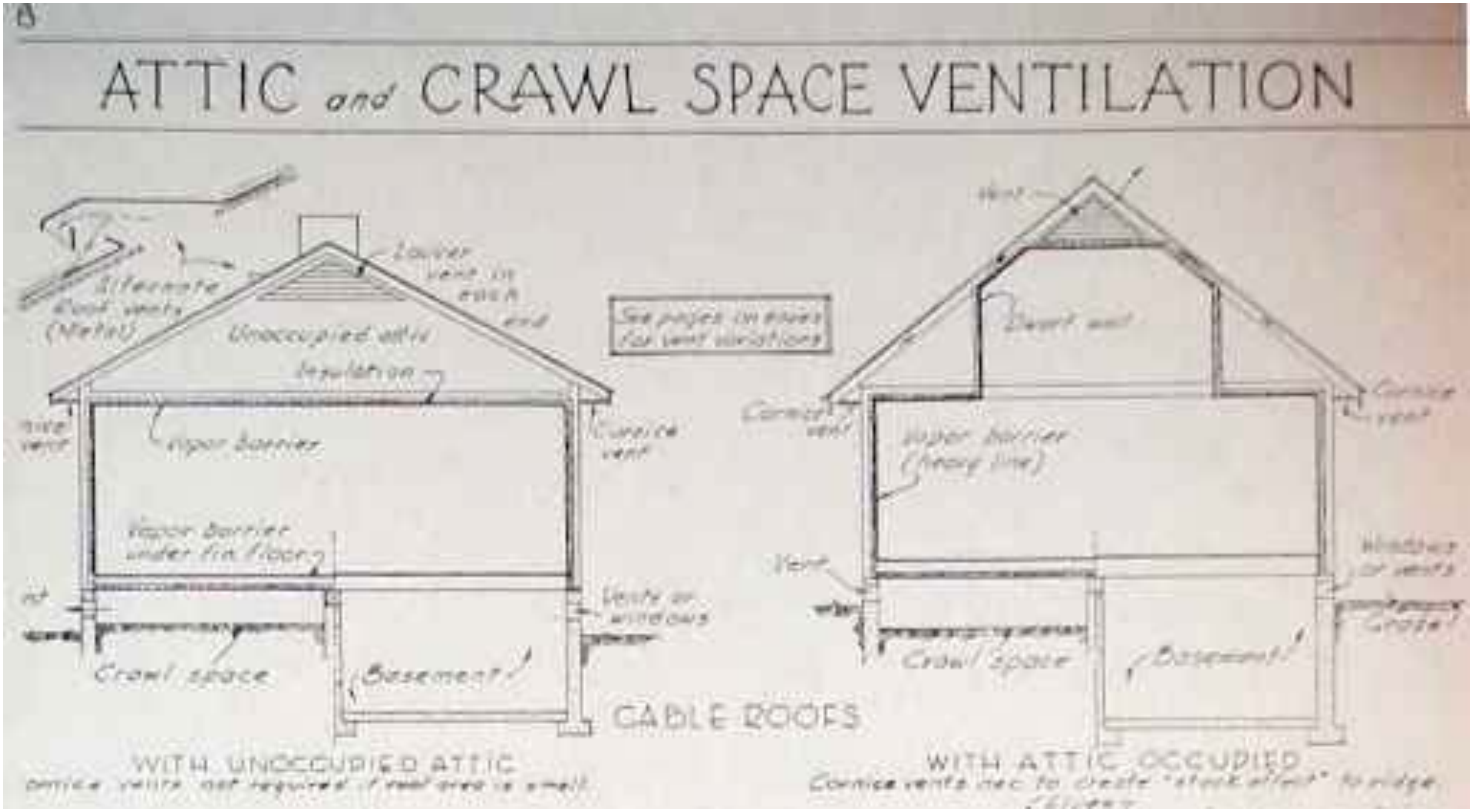
# Architectural Graphic Standards 1951

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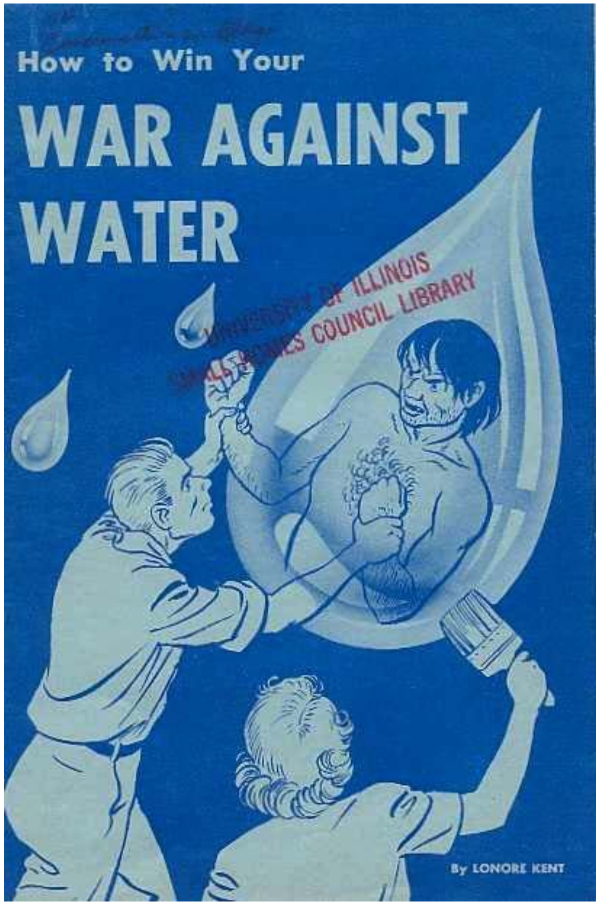
# National Paint and Varnish Association
# 1952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# Condensation Conference 1952, Tyler Rogers, opening remarks


"…with new materials and techniques and designs we have new things to blame for the faults in our buildings. It is never in fashion to blame ourselves, of course; it is always some other Joe who caused the trouble. So paint failures were at first blamed on insulation and condensation; and condensation was itself blamed on insulation, until the insulation industry, in self defense, had to undertake research to establish its innocence...

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# Condensation Conference: Rogers

...While this research and similar work by the paint industry was going on, there was a great deal of buck-passing. The insulation men blamed the paints or the wet lumber and some painters retaliated by refusing to paint an insulated house. Then the building paper manufacturers got caught in the middle; their new sheathing papers were blamed for causing condensation instead of shielding a building from dampness. The foils were soon in the ring with the papers, while architects, builders, building owners and the general public watched this battle royal and wondered if any of the fighters was worth betting on."

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# Condensation Conference, Frank Rowley, 1952

"Another point brought up by Mr. Teesdale is this question of attic ventilation. I think most people have had some experience with attic ventilation in trying to get good distribution of air around the attic. ... Too much ventilation may even cause damage by cooling off the top of the insulation. We have taken cases where excess ventilation will cool the top surface of the insulating material…So too much ventilation may be dangerous just as well as too little."

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# In Conclusion of the Historical Perspective

- Attic venting issues all started surrounding problems with cold climate roof condensation and siding paint failure after houses began to be insulated

  – Before insulation, the houses were leaky but the attics were warm due to heat loss from the living space.

  – After insulation, the houses were still leaky but the attics were colder.

  – Roof condensation was due to moisture that was carried by air leakage from the living space, or wet crawl spaces and basements to the underside of the cold roof deck.

This was a problem that Miami-Dade County does not have.

- So why was roof/attic venting universally required in hot-humid climates?

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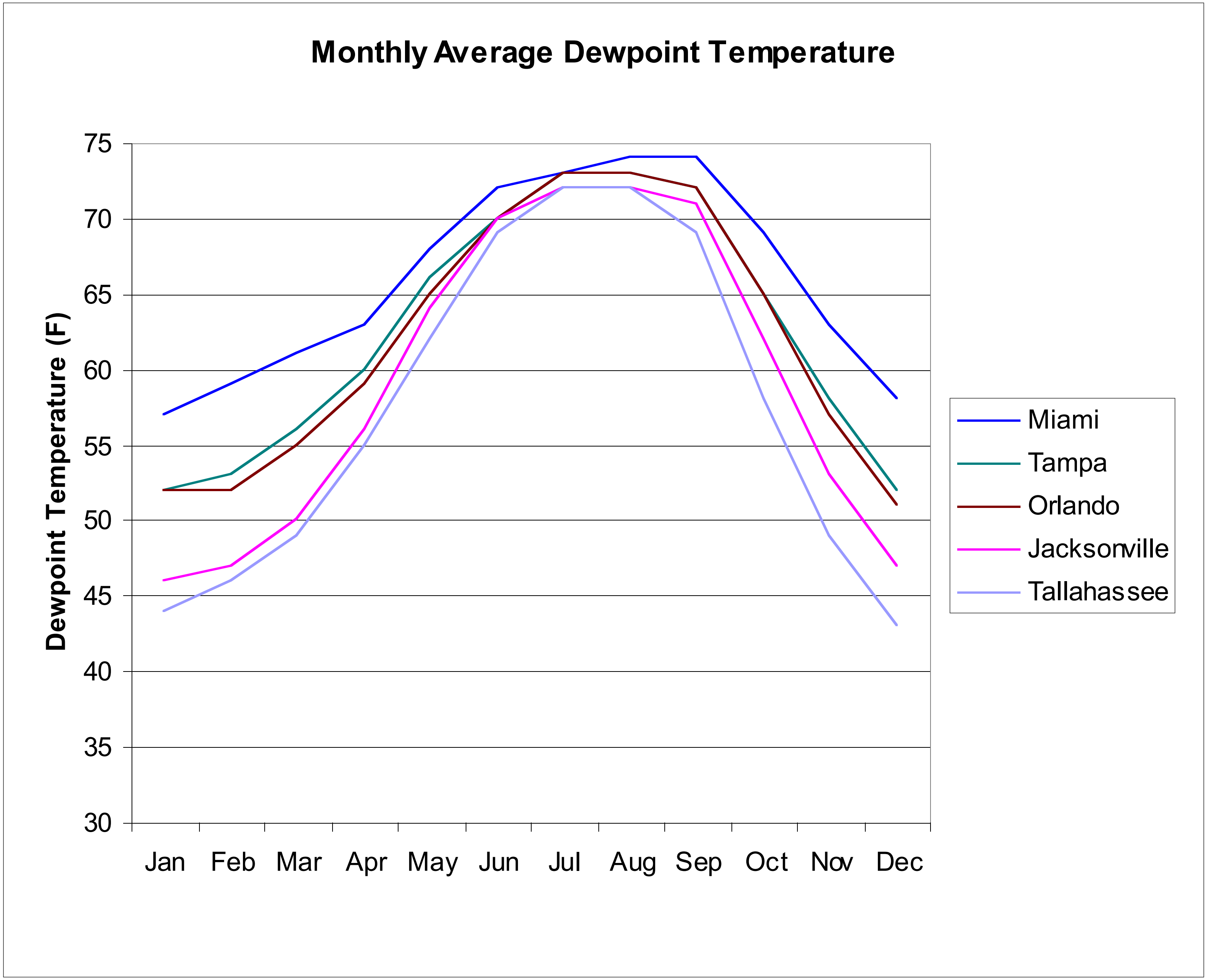
- So why was roof/attic venting universally required in hot-humid climates?
  - Outdoor temperatures do not go low enough in the winter in South Florida to cause a roof condensation problem
  - And, the greatest moisture source is always from the outside, not the inside.
    - For cooled buildings in Miami-Dade County, the drying potential is always to the inside due to moisture removal by the cooling coil


Monthly Average Dewpoint Temperature
Dewpoint Temperature (F)
75
70
65
60
55
50
45
40
35
30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Miami
Tampa
Orlando
Jacksonville
Tallahassee

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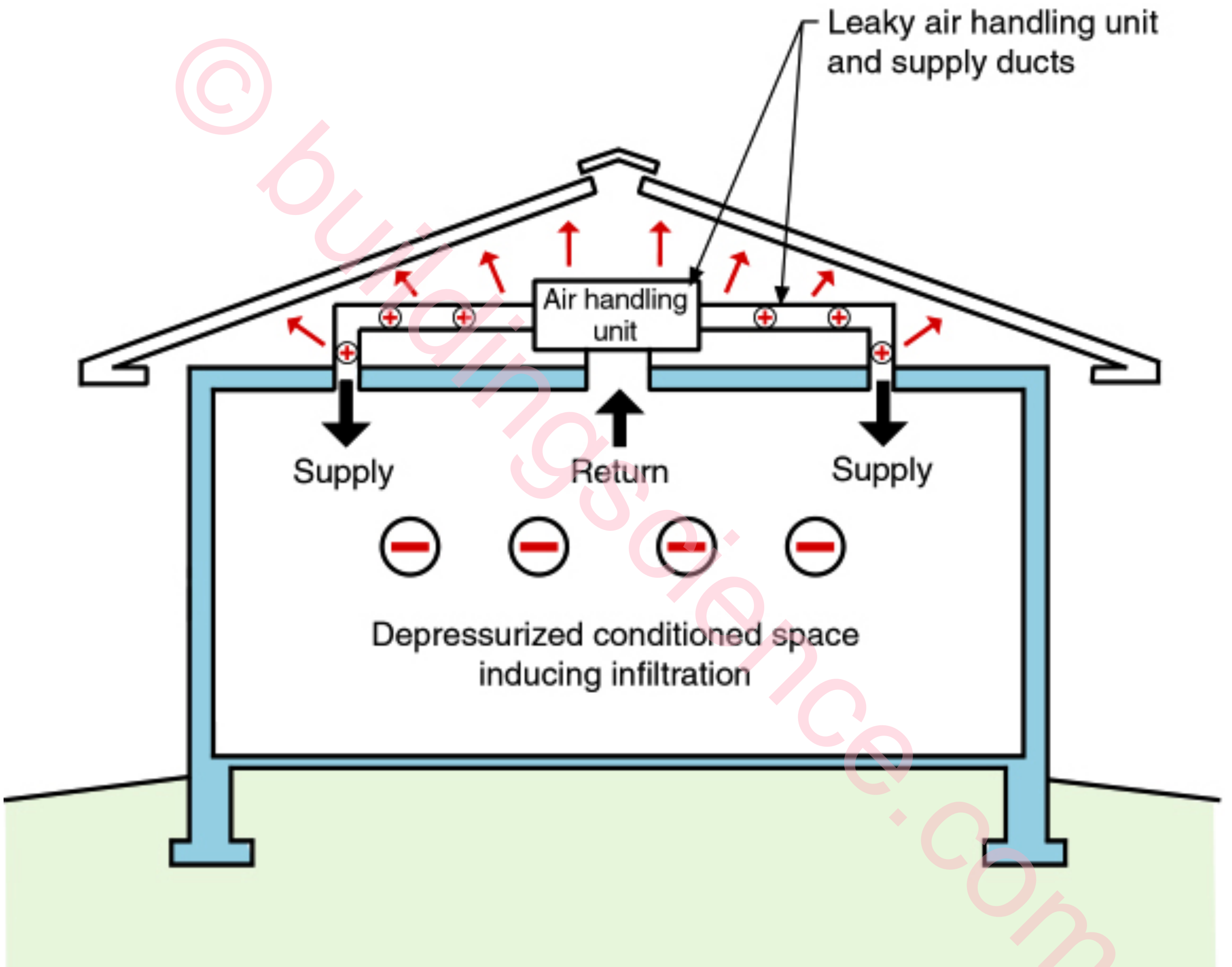
  - And, it must not be primarily for energy conservation since the IRC 2000 Chapter 11 on Energy Conservation is silent on attic venting

# Air Distribution System in Attic






Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.


5 4 '98

# Benefits of Unvented Attic with Spray Foam Insulation

- Building air tightening
  - Greatly reduces air infiltration which causes comfort problems and high space conditioning energy bills
  - It is hard to build the ceiling air tight due to changing ceiling heights, soffits, coffered ceilings, dropped ceilings, and mechanical chases

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- Eliminates moisture carried in by outside air
  - Eliminate condensation on cool duct and ceiling drywall surfaces (attic dewpoint temperature can be up to 85 F)
  - Eliminate moist air pulled down interstitial wall cavities by mechanical depressurization, often resulting in mold on drywall

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  - Eliminate moist air pulled down interstitial wall cavities by mechanical depressurization, often resulting in mold on drywall
- Improved indoor air quality
  - Less dust, dirt, and pollen gets into the house
  - Less hospitable environment for bugs and insects who like the moisture

# Benefits of Unvented Attic with Spray Foam Insulation (continued)

- Energy efficiency
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  - Less pressure buffeting in high winds
- Increased fire resistance
  - Less air supply due to stack effect

# Association of Heating, Refrigeration, and Air Conditioning Engineers

2001 ASHRAE Fundamentals Handbook, page 24.8

**Attics and Cathedral Ceilings**

The commonly stated rules for attic and cathedral ceiling construction —ventilation and vapor retarder toward the inside—pertain to cold climates and not to warm, humid climates with indoor air conditioning. Common sense suggests that venting with relatively humid outdoor air means higher levels of moisture in the attic or cathedral ceiling. Higher moisture levels in vented attics in hot, humid climates do not lead to moisture damage in sheathing or framing. However, higher moisture levels in attic cavities may affect chilled surfaces of the ceiling and cold surfaces of mechanical equipment. When cooling ducts are located in the attic space, attic ventilation with humid outdoor air may increase the chance of condensation on the ducts.

As in all climates, airtight construction is desirable. In warm, humid climates, airtight construction usually reduces the latent load. Insulation and interior finishes should be selected and installed with an understanding that vapor diffusion is primarily inward.

Icynene samples were removed to inspect roof sheathing of 6-month old house in North Florida
Sheathing was in perfect condition and moisture content was normal

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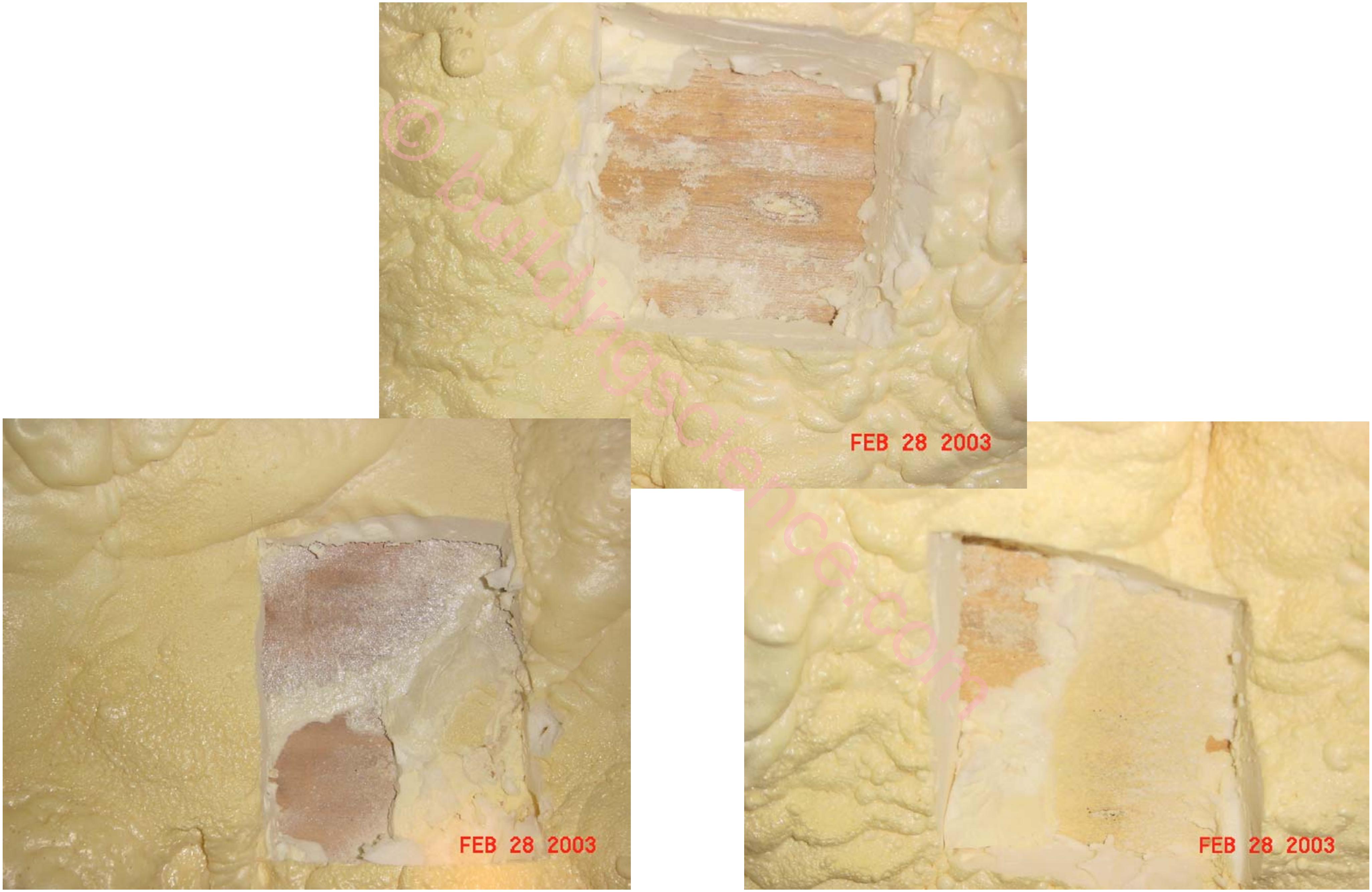
# Icynene samples were removed to inspect roof sheathing of a 3-year old house in North Florida Sheathing was in perfect condition and moisture content was normal



# Ventilation and shingle warranties?

- With information provided so far, first manufacturer warranties requiring code-level ventilation appeared in mid 1980s.
- 1984 version of 1974 "Principles of Attic Ventilation" (AirVent, Inc.): "Also, the remodeling industry is increasingly aware of the importance of proper ventilation to assure roof shingle durability and performance."
- ARMA Asphalt Roofing Manual 1988: "Proper ventilation of the attic areas is a little understood but very helpful method of not only controlling heating and cooling costs, but also getting maximum service life out of the building materials used in the roof assembly."

# Ventilation and shingle warranties? (continued)

- Asphalt roof shingle manufacturers didn't start to adjust warranties until the 1980's, and some have not.

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  - Our simulations and measurements have shown that asphalt shingles applied over <u>vented</u> roofs in hot-dry climates operate warmer than the same asphalt shingles applied over <u>unvented</u> roofs in hot-humid climates.
    - To our knowledge, there have been no shingle warranty adjustments for Las Vegas versus Orlando, and that difference in location is more significant in regards to shingle temperature than vented versus unvented.

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    - To our knowledge, there have been no shingle warranty adjustments for Las Vegas versus Orlando, and that difference in location is more significant in regards to shingle temperature than vented versus unvented.
  - The difference in color choice from white to black is more significant in regards to shingle temperature than vented versus unvented.

Miami, FL  MONTHLY AVERAGE TEMPERATURES AS A FUNCTION OF HOUR OF THE DAY

| HOUR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 0 | 65.2 | 66.1 | 68.1 | 73.2 | 75.6 | 78.4 | 79.5 | 80.0 | 77.7 | 74.4 | 71.2 | 65.8 | 73.0 |
| 1 | 64.7 | 66.0 | 67.5 | 72.5 | 75.3 | 77.9 | 79.1 | 79.4 | 77.4 | 74.0 | 70.7 | 65.5 | 72.5 |
| 2 | 63.9 | 65.7 | 67.2 | 72.0 | 74.8 | 77.6 | 78.9 | 79.3 | 77.0 | 73.6 | 70.3 | 65.1 | 72.1 |
| 3 | 63.5 | 65.6 | 67.0 | 71.4 | 74.3 | 77.2 | 78.8 | 78.8 | 76.6 | 73.3 | 70.0 | 64.7 | 71.8 |
| 4 | 63.1 | 65.2 | 66.6 | 70.8 | 73.8 | 76.9 | 78.2 | 78.6 | 76.4 | 73.2 | 69.5 | 64.2 | 71.4 |
| 5 | 62.6 | 64.7 | 66.2 | 70.5 | 73.6 | 76.6 | 78.4 | 78.4 | 76.4 | 72.9 | 69.4 | 63.8 | 71.2 |
| 6 | 62.4 | 64.6 | 66.2 | 71.1 | 74.8 | 77.1 | 79.8 | 78.7 | 77.0 | 72.8 | 69.5 | 63.2 | 71.5 |
| 7 | 62.7 | 65.6 | 68.0 | 73.7 | 77.1 | 79.9 | 82.4 | 80.8 | 80.1 | 75.0 | 70.6 | 66.0 | 73.5 |
| 8 | 65.9 | 68.9 | 70.3 | 76.3 | 79.1 | 82.3 | 84.1 | 82.7 | 82.5 | 77.3 | 73.4 | 68.7 | 76.0 |
| 9 | 68.8 | 71.2 | 72.1 | 78.4 | 80.9 | 83.8 | 85.3 | 84.0 | 83.9 | 79.6 | 76.2 | 71.5 | 78.0 |
| 10 | 71.1 | 72.9 | 73.4 | 80.0 | 82.4 | 85.2 | 86.2 | 85.3 | 85.0 | 80.4 | 77.5 | 72.9 | 79.4 |
| 11 | 72.8 | 74.1 | 74.0 | 80.9 | 82.6 | 85.6 | 86.2 | 85.6 | 85.5 | 81.2 | 78.7 | 74.0 | 80.1 |
| 12 | 73.8 | 74.6 | 74.8 | 81.3 | 83.3 | 85.1 | 86.4 | 85.9 | 85.3 | 81.9 | 78.9 | 75.5 | 80.6 |
| 13 | 74.3 | 75.1 | 75.6 | 81.3 | 83.9 | 85.1 | 86.6 | 86.1 | 84.8 | 81.7 | 79.1 | 75.2 | 80.8 |
| 14 | 74.3 | 74.7 | 75.9 | 80.9 | 83.3 | 85.3 | 85.6 | 85.9 | 83.4 | 81.4 | 78.9 | 74.8 | 80.4 |
| 15 | 73.8 | 74.5 | 76.0 | 80.5 | 82.1 | 84.4 | 84.9 | 84.9 | 83.8 | 81.1 | 78.2 | 74.6 | 79.9 |
| 16 | 72.6 | 73.3 | 75.2 | 80.0 | 80.9 | 84.0 | 85.2 | 84.6 | 82.6 | 80.0 | 77.2 | 73.0 | 79.1 |
| 17 | 71.0 | 72.2 | 73.6 | 78.5 | 80.2 | 83.2 | 83.7 | 84.1 | 81.7 | 79.1 | 75.9 | 71.6 | 77.9 |
| 18 | 69.6 | 70.7 | 72.3 | 77.3 | 79.0 | 82.2 | 82.4 | 82.8 | 80.5 | 78.0 | 74.6 | 70.0 | 76.6 |
| 19 | 68.7 | 69.6 | 71.3 | 76.2 | 77.8 | 81.1 | 81.5 | 82.0 | 79.8 | 77.3 | 73.6 | 69.3 | 75.7 |
| 20 | 67.8 | 68.4 | 70.9 | 75.5 | 77.4 | 80.4 | 81.2 | 81.9 | 79.1 | 76.5 | 73.0 | 68.5 | 75.1 |
| 21 | 66.8 | 67.7 | 70.0 | 75.0 | 76.8 | 79.8 | 80.8 | 81.5 | 78.3 | 75.7 | 72.2 | 67.7 | 74.4 |
| 22 | 66.2 | 67.4 | 69.4 | 74.4 | 76.7 | 79.3 | 80.2 | 80.9 | 77.7 | 75.3 | 71.5 | 67.1 | 73.9 |
| 23 | 65.7 | 66.9 | 68.8 | 73.8 | 76.2 | 79.0 | 80.0 | 80.5 | 77.8 | 74.8 | 71.2 | 66.6 | 73.5 |