Powered Attic Ventilators, Another Applied Building Science Nightmare and Treasure Trove

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It is important that Building Scientists become aware of the potential for many unplanned impacts on houses by powered attic ventilators. As plans are developed for new structures, as diagnosticians examine existing buildings to determine the causes of failures and as researchers try to divine recommendations for the houses of the future, an awareness of the influence of these ventilators on houses must be maintained. By introducing this information now, others can begin to add their efforts to further map and understand these interacting relationships.

The conventional wisdom for using powered attic ventilators is listed as well as some of the opposing arguments. That information is followed by a few anecdotal cases that are reviewed to explain the origin of our interest in this phenomena. To provide some direct field measurement of this issue, additional measurements were taken in houses containing powered attic ventilators that were part of a larger group of houses receiving extensive diagnostic examination. The measurements were taken to determine how many unplanned cubic feet per minute of air the ventilator could draw from the house. Problems such as combustion safety, moisture issues, higher utility bills and discomfort were listed when they could be associated with the action of the ventilator drawing air from the house rather than from outside as intended.

For this exploratory sample of houses, it was determined that, on average, powered attic ventilators draw 231 cfm of conditioned air out of the house and cause by themselves .72 air changes per hour. This loss along with the resulting problems need further documentation.

Introduction

In several regions of the United States, powered attic ventilators enjoy the pleasures of a positive reputation. They are promoted by builders, shingle manufactures, roofers, HVAC contractors, utilities, weekender material retailers, ventilation manufactures, consultants and others. Extending shingle life, protecting shingle warrantee, removing moisture from attics and reducing the air conditioning load by the removal of attic heat are their believed benefits. These regional cultures accept and sometimes expect the use of powered attic ventilators. Cash flow in their regional economic systems is saturated with their use. Those who manufacture, sell or install powered attic ventilators in these regional cultures could experience financial hardships should it be suggested that powered roof ventilators should not be used. However, that is our central theme as a result of our measurement of some of their unplanned impacts on houses.

Background

Discussions have been ongoing for years around the issue of venting attics. Debates try to determine if we should ventilate an attic, how much to vent, where to vent, and what materials or equipment should be used. That topic will not be addressed directly. What is addressed, is an unplanned outcome for one of the attic venting strategies. Powered attic ventilation is the strategy that concerns us. It is the position of some (Wolfert and Hinrichs 1974) who happen to be in favor of attic venting, that if a powered ventilator is used, more energy will be consumed by the motor than will be saved on the air conditioning bill. Our measurements will identify an additional cost penalty that could be included in their future calculations (Figure 1). Others have demonstrated that increased attic ventilation does not necessarily reduce the transfer of heat across ceiling insulation into the house (Fairey 1985).

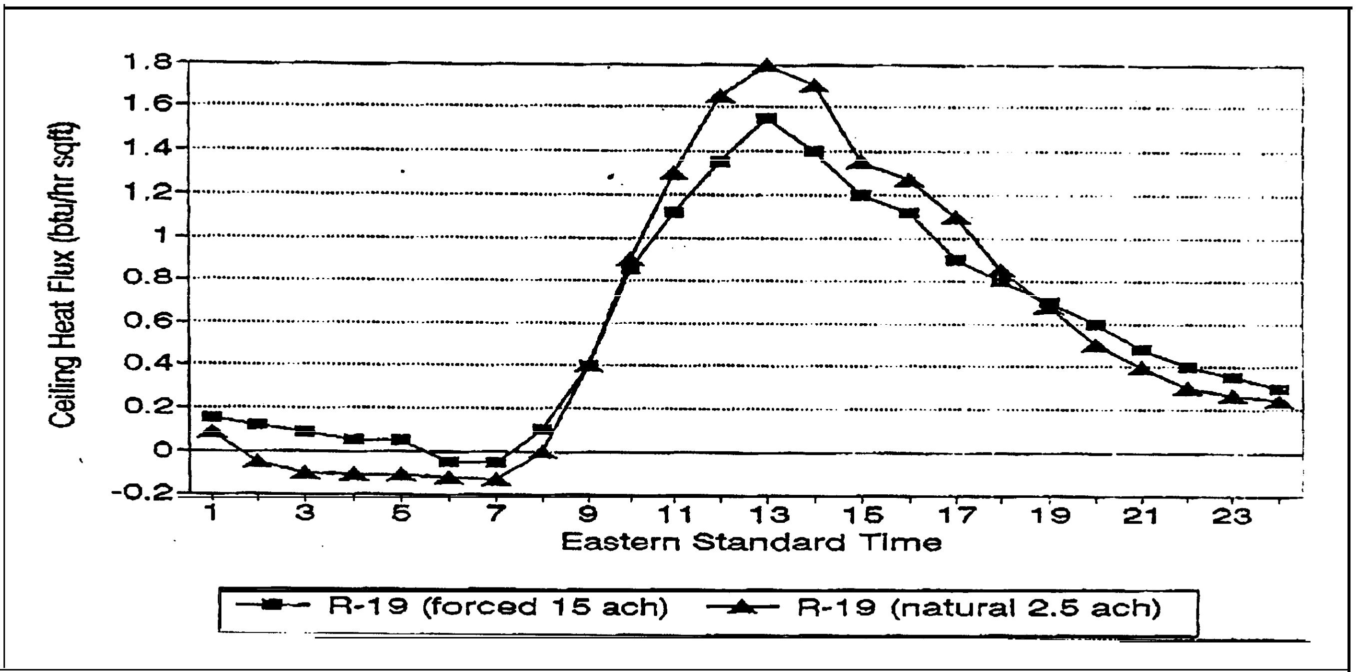

Figure 1. Ventilation Test

Motivation

Three years ago the issue of the unplanned impacts of powered attic ventilators was first brought to our attention by Jim Fitzgerald (personal communication Summer, 1991). Since that time we have continued to discuss the topic and recently, we reviewed the topic at length for inclusion in this report (personal communication March, 1994).

Case #1, July 1991, Nebraska: Following the installation of a sub-slab radon suction system, a house worst case test was performed. This test uses exhaust fans, the furnace blower and closing interior doors to create the greatest possible negative pressure in the house with reference to outside. Under this condition the sub-slab suction system worked and kept that area at a -5.0 Pascals with reference to the house. It was then noticed that they had failed to include the powered attic ventilator in the test. When it was added to the test, the subslab area became +1.0 Pascal with reference to the house and radon could once again enter the house.

Case #2, November, 1991, Minnesota: A client requested assistance because of a moisture problem. They had recently purchased a new roof and the roofing contractor had installed a powered attic ventilator as part of the package. The client mentioned that they had disconnected the unit because when it operated, it pulled the wood smoke from the fireplace into the house. The house was a 2-story over a basement. The combustion appliance zone containing the furnace and water heater was in the basement. When only the powered attic ventilator was turned on, the combustion zone became -8.0 Pascals with reference to outside.

Case #3, Minnesota: A 20,000 cubic feet house has a ventilator that by itself causes the combustion appliance zone to become -3.5 Pascals. The water heater is producing 900 ppm carbon monoxide. While testing the water heater, the door to the combustion appliance zone was closed causing a furnace duct system return leak to further repressurize the zone to a total of -6.5 Pascals. The whole house became saturated to 75 ppm carbon monoxide within 10 minutes. Based on calculations that included volume, time and concentration, it is estimated that the carbon monoxide production spilling out into the house jumped to between 10,000 and 20,000 ppm.

In a recent discussion with Rob DeKeiffer I received a report from Colorado similar to case #3 above. A family of three died when their ventilator caused backdrafting, creating high carbon monoxide production and their furnace delivered the combustion products throughout the house. At the time that they were discovered there was still 1000 ppm carbon monoxide ambient in the house (personal communication, Spring, 1994).

The above cases along with our continual diagnostic testing and recording of similar phenomena lead us to set up a more formal measuring process for the eight houses reported here. By introducing our initial measurements to other Building Scientists now, others can begin to add their efforts to further document, map and understand these interacting relationships.

Methodology

To expand the building diagnostic skills of a group of HVAC contractors, a dispersed sample of available houses in the Research Triangle Park area of North Carolina were being used to demonstrate a variety of pressure and flow measurement procedures. A subset of those houses contained powered attic ventilators. For that subset, specific pressure and flow measurements were taken and observations were made to characterize the impacts that resulted from operation of the powered attic ventilator. Attics of the sample houses contained various combinations of passive ventilation in addition to the ventilator. The measurements were taken during the period from July, 1993 through September, 1993.

Each house was prepared for a standard depressurization blower door test. The volume of each house was calculated and recorded. Using an Energy Conservatory digital manometer to measure pressure, the ventilator was turned on and off several times. A measurement could then be made of the magnitude of the pressure impact on the house caused by the ventilator. House pressure with reference to (WRT) outside was recorded with the digital manometer set on the 1/10 Pascal scale. A minimum of a five point blower door depressurization test was then performed. A calculation was completed to establish, for each house, what cubic feet per minute (cfm) flow would be necessary to cause the pressure difference that was recorded when the ventilator was operated. A calculation was also completed to represent the flow at each house in air changes per hour (Table 1).

Results

All the houses experienced some level of depressurization when the ventilator was operated. The magnitude of negative pressure, house WRT outside, ranged from -0.5 to -2.5 Pascals. The flow from the house to the attic averaged 231 cfm and measured from a low of 104 to a high of 646 cfm. The high cfm flow occurred in a house that had two ventilators and contained several noticeable air leakage paths between the house and the attic. For the sample, an average of 0.72 air changes per hour resulted.

All the houses are listed as having the problem of wasted energy because of the volume of flow of treated air into the attic. Two houses are listed as having combustion safety problems resulting from the operation of the ventilator in conjunction with other mechanical equipment. In particular, at Site #1 the water heater stayed in a complete backdraft mode when the ventilators were operated in conjunction with the other mechanical equipment. The water heater was located inside the conditioned space of the house. During the seven minutes of the testing cycle the area containing the water heater reached 40 ppm carbon monoxide and at five minutes the water heater flue strength of carbon monoxide was 700 ppm.

Two houses were identified as having moisture problems resulting from the ventilator induced negative pressures. At Site #4 an interesting chain of events occurred. Prior to our visit, HVAC contractors had determined that the existing duct system had a large return leak. They very successfully repaired the return side air leakage. A large portion on the sheet metal supply duct was located in the framing cavity between the first and second floors and was uninsulated. The temperature of the supply air was now colder because hot, outside air was no longer entering the system. Following the repairs, the owner complained that moisture stains were starting to appear in the ceiling sheetrock of the first floor. The advice given was to increase the powered attic ventilation and turn on bath fans to remove moisture from the structure. In a short time span after complying with the instructions, a large section of ceiling sheetrock became saturated with moisture and fell to the floor. At this point in time our site visit occurred and we made the following conclusions. The increased pressure caused by using more fans, continually, simply moved more humid, outside air through the building cavities and into contact with the colder sheet metal resulting in a flood of water onto the sheetrock. Once the sheetrock was saturated by the condensation dripping from the duct, it fell. The problem was solved by sealing air pathways between the duct cavity and the outside that were accessible, turning off the powered ventilators and using the bath fans as normal spot ventilation. Follow up contact confirmed that the problem was not reoccurring. Discomfort was noted in two houses that were listed previously, one each under safety and moisture.

Conclusions

Confirming the hypothesis that powered attic ventilators draw conditioned air from houses is important to applied building science. Once that is well established, it is important to fully describe the multiple impacts of ventilators on the house system. The interactions cover combustion safety, occupant health, building durability, space conditioning equipment operation, occupant comfort and house thermal efficiency. To gain some perspective on what it means for a ventilator to, on average, draw 231 cfm from a house the following calculation is offered. A ventilator is typically activated by attic temperature. In general they will turn on around 10:00 A.M. and will run until 7:00 P. M., a total of 9 hours of operation during the Summer and shoulder season months. The calculation is 231 cfm times 60 minutes times 9 hours equals 124,740 cubic feet of conditioned air each day drawn from the house. What does that do? What does that cost?

Table 1. House Data

Site #	House Volume (cu. ft.)	House Pressure Caused by Ventilator	Flow from House to Attic (cfm)	Air Changes Per Hour	Problems
1	32,258	-2.5	646	1.2	Safety Comfort Dollars
2	13,184	-0.6	104	0.47	Dollars
3	15,000	-0.5	116	0.46	Dollars
4	18,000	-1.5	298	0.99	Moisture Comfort Dollars
5	18,000	-0.8	114	0.38	Dollars
6	14,000	-0.5	147	0.63	Dollars
7	18,688	-1.0	216	0.69	Safety Dollars
8	13,600	-0.5	204	0.90	Moisture Dollars
Average			231	0.72	

A review of some of the important issues includes the following:

1. Ventilators can cause negative pressures in combustion appliance zones. By themselves or in conjunction with other negative pressures they can cause backdrafting.

2. Ventilators run during electric utilities peak demand period and can become a peak demand problem.

3. Ventilators can draw conditioned air out of houses and cause the air conditioner to run more.

   A. They can cause increased latent load that air conditioners must remove.

   B. They can increase the cost for air conditioning for the homeowner.

   C. They can cause temperature discomfort, hot areas, that homeowners try to solve by increasing cooling through closing some supply registers which can cause additional problems.

4. Ventilators can be an unexpected and undocumented source of increased infiltration rates in houses.

5. Examination of this unplanned, exhaust only ventilation, which is occurring in many houses during air conditioning, may give an indication of how much intentional exhaust Southeastern houses can tolerate without developing moisture problems. This information will be very useful when an exhaust only ventilation system is chosen as the approach to ventilate conditioned space in the Southeastern region.

At a minimum, it is recommended that if a powered attic ventilator is chosen as part of an attic ventilation strategy, the following guidelines should be provided. The installer should provide a good air barrier between the house and the attic and adequate, net free, vent area should be provialed. Confirmation of safe operation is provided by measuring not by ignoring, guessing, or hoping.

Acknowledgements

The Duct Diagnostics and Repair Training Program budget of the Applied Building Science Center which is part of the North Carolina Alternative Energy Corporation is the primary source of funds that made it possible for these field measurements to be acquired.

References

Wolfert, C. K., and H. S. Hinrichs. 1974. *Fundamentals of Residential Attic Ventilation.* H. C. Products Co., Princeville, IL.

Fairey, Philip. 1985. “The Measured, Side-by-Side Performance of Attic Radiant Barrier Systems in Hot-Humid Climates.” Nineteenth International Thermal Conductivity Conference, October, 1985. Cookville, TN.