Mechanical Ventilation in Houses in the Southeast, Doing the Right Thing Not-Quite-Right

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ABSTRACT

It is becoming more common for residential structures in the hot and humid Southeast to have mechanical ventilation systems. Of particular interest is the heat recovery or energy recovery balanced ventilation equipment. In this climate, the first issue that must be addressed after one has decided to use mechanical ventilation is how best to receive the benefits of — minimize the liability of — mechanical air exchange. During the summer, cool dry inside air is exchanged for hot outside air that contains a substantial latent moisture load.

For each of the installed systems examined, there were four primary focuses: (1) the design theory of the application; (2) the physical installation; (3) the control system (planned and actual); and (4) the actual performance of the systems, including measured airflows, impacts on indoor relative humidity and CO_2, and measured enthalpy of the core.

This initial phase of the introduction of a technology into a region and to a work force has resulted in some of the problems that one would imagine. This set of examinations has at least two benefits. First, it supports again the old song that if installed equipment is not performance tested, it is a guess as to what performance will result. Second, it is hoped that this feedback will serve as an information resource to improve equipment selection, application, and installation.

Introduction

Professional writings and folk opinions over the last 100 years have made the point that humans need ventilation air in houses. In the past, when we were children, older relatives told some of us about the importance of sleeping with the window open in the bedroom. It was important, we were told, even when it was snowing. Photographs document tuberculosis sanitariums in winter with patients on cots placed under warm blankets on outdoor porches to breathe in the healing air. In spite of that history, our current knowledge, organizational recommendations for minimum ventilation, and the potential of indoor air chemical soup in modern homes, realistic provision for ventilation air has remained a stepchild in residential construction. Priorities, priorities! Shall I breathe well or would I rather spend my money to have the latest fun toys in my new house? It is possible to raise parallel questions about other parts of a residential structure that can help clarify the absurdity of wondering if residences should have ventilation air systems. Would one ask if sinks should have drains? Or could we get by with just a hole in the floor under the sink? You know the pitch — it would cost less than complete drain piping. If one were asked whether houses should have roofs, or if they should have roofs that don't leak, or don't leak too much, it is certain that there would be a solid commonality of responses. However, ventilation air systems have not yet matured in the consumer's mind into being got-to-have-it items.

Current construction industry processes like the selling of shelter or, in some cases, image, are also a problem. How shelter is positioned in the marketer's pitch and in the buyer's mind, and how it is financed, are major barriers to the widespread use of ventilation air systems in residential structures. The actual construction process and availability of equipment are problems that are present but not dominant. However, as this paper reports, there will need to be improvements in the installation of ventilation systems. As more ventilation air systems are included in southeastern houses, it is important to provide an early reflection of current practices to encourage self-correction. Thus this exploration of how some ventilation air systems are actually being installed.

Background

As with many applied building science investigations, this report on ventilation air systems began on a personal level. Because we at Advanced Energy have been advocating at least minimal ventilation strategies, it seemed important to provide better than a minimum ventilation strategy as I built my own new home. As a result of the successes and, more to the point, the failures of the system that I installed, I wondered how other installed systems were performing. Performance testing on my system led to performance testing of other systems. I am generally satisfied with my system and with the results from the testing, and I generally would make the same installation decisions again. However, the eye-opener testing result was that the measured airflow on my system at the low speed setting was twice the manufacturer's rating, 162 cfm versus 80 cfm. This was significant because the Total Recovery Efficiency (TRE) performance rating listed by the Home Ventilating Institute was for an airflow of 108 cfm. With that one discovery began an extended journey that has provided several nuggets of information. With the assistance of the equipment manufacturer, it was finally determined that the master control board that controls the blower speed was being constructed incorrectly (the quantity mismanufactured is unknown). Much to the manufacturers' credit, they continued to work with me even though they thought that the only problem was that I just could not measure airflow correctly. Also to their credit, they did acknowledge in the end that the protocols we use at Advanced Energy to measure airflow are accurate and reliable. They also provided me with information for control adjustment that, while not totally satisfactory, is functional for the short term until a more appropriate solution becomes available.

A central design consideration when initially thinking about ventilation air for southeastern residences was the dominance of the moisture or latent load that the air would contain. The November 1997 ASHRAE Journal published an article by Lewis G. Harriman III, et al., that wonderfully quantified the latent load versus the sensible load for ventilation air for an entire cooling season for many different locations. The authors proposed a ventilation load index defined as the cumulative load that would occur if one cubic foot per minute of outdoor air were treated to change it to space-neutral conditions. Space-neutral conditions are listed as 75 degrees, 50% relative humidity (65 gr/lb). If you choose to bring in 80 cfm of ventilation air in Raleigh during the cooling season, you can now calculate the latent and sensible work that will need to be done. Moisture removal will be a 5,760,000 Btu job whereas cooling will only be an 864,000 Btu job. The point is made.

Scope

The scope of these examinations is a narrow one within the topic of ventilation. The content of this report begins after the decision already had been made to install a balanced flow, recovery ventilator. The field activities then evaluated aspects of each installation. The report is best described as a small collection of case studies that have resulted in some specific recommendations for selecting equipment, for designing applications, and for providing quality control protocols for installations. It is not a full and formal argument to confirm that southeastern homeowners should only consider balanced flow, energy recovery (high performance for both latent load and sensible load) ventilation air systems that are installed with ducting separate from the air conditioning and heating ducting. However, the reader would not be mistaken to conclude that the author was led to support that position personally as a result of these investigations. Neither is this report a financial argument of return on the dollar for an installed system. This is about having already decided what you want and improving the probability that you will receive the benefits of your choice. It does provide a conceptual reference point by including the general perspectives and arguments that led to the formation of decisions and performance criteria. The other installations are evaluated against those criteria, their manufacturers' intended results, and the owners' desired outcomes.

An overview of the case studies is provided in Table 1. Ten pieces of equipment were examined; eight were field installations and the other two cases [2, 9] involved that same piece of equipment. That piece of equipment was procured as a resource for the Applied Building Science Center Laboratory and was performance tested without any modifications. Later, at the manufacturer's request, it was returned for investigation and possible modification. On its return from the manufacturer, it was again performance tested. Six of the eight field units are balanced flow, recovery units [1,3,4,5,6,10], one is a dehumidifier with outside air [7], and the other is an in-line fan supplying outside air to a return duct [8]. Desiccant-coated rotary wheels are the recovery core mechanism in five of the units [1,2,3,5,9], with counterflow air streams in one of those units [5]. The other recovery core mechanisms are crossflow plastic [4,6] and counterflow aluminum [10].

Of particular interest in the application design is whether the ventilation air system is ducted separately or is connected to the air conditioning and heating ducts. Separate ducting is used for five of the eight field systems [1,3,6,7,10]. For the three with connected ducting, one is the simple in-line fan that supplies air to the return duct [8]. One pulls exhaust air from the house and delivers treated outside air to the return duct [4], and the last one pulls exhaust air from the return duct and delivers treated outside air to the supply duct [5]. Two of the separately ducted systems [1,3] use multiple supplies to the house and a single exhaust. One system pulls exhaust air from four locations and provides air to the house through one large grille [10]. Three of the systems pull their exhaust from bathrooms [4,6,10].

Approaches to filtration are varied. Several units use small, minimal performance, washable filters inside the equipment box on or near the core [4,5,6,10]. The other six use pleated filters in different combinations. One pushes air into the return duct, but the air is only filtered through the deep pleated Space Gard when the air handler is on [8]. One has no recovery and only one air stream, which is continually pre-filtered and then deep pleat filtered [7]. Two systems utilize pleated filters for each air stream to clean the incoming air and also to reduce the rate of accumulation of debris in the equipment [1,3]. Those two units have a slot for a large one-inch pleated filter inside the equipment box to clean incoming outside air. One of these units has a Space Gard filter to clean incoming outside air before it reaches the equipment box or the house [3].

All but one of the units have multiple airflow speeds. The one with a single airflow [7] has the option of varying the amount of outside air that can be mixed into the main air stream. Only three of the systems do not have a humidistat designed into their controls [4,6,8]. Designed airflow, rated TRE and associated airflow, and exhaust air crossover into the supply air stream represent quite a wide range of results.

Installation of the ventilation air systems for this sample was strongly driven by the owners of these newly built homes. Another important element is that the systems were included at the design stage. Two builders included them in houses that they constructed. One was the builder's private residence [5], and the other was a production house [10]. There were several central driving forces in all these cases that resulted in the installation of ventilation air systems. Those included awareness and knowledge in the hands of the decision-maker, a desire to enhance the potential healthiness of the indoor environment, and a desire to construct a house that would meet various performance standards.

The Reference System

A description of the content of a decision matrix that can be used when making choices and picking a ventilation air system will provide a useful reference point. Personal orientations can form a point of beginning. What you want can take priority over doing the least that you can do to get by. Optimum conditions can take the place of minimum standards. Phrases like build it tight and ventilate it right can add construction focus. That can be supported with making additional construction decisions that will cause an ordinary house to reach a higher percentage of its already bought and paid for potential.

Air exchange for a residential structure can be divided into several parts. If it is reasonably tight, performance tested with a blower door to 0.25 CFM 50 per square foot of exterior surface area (no large hole allowed), then there will not be very much uncontrolled air leakage. Now you can focus on ventilation air. There are at least three ways of looking at the volume of air needed. For scuba divers, the amount of required air is minimal. They breathe small amounts of clean air once and expel it. For humans who live in controlled housing, the requirement for air is larger. One part of that equation is that humans personally exhaust pollutants in several ways and then inhale a mixture of those pollutants that is, hopefully, diluted. An additional factor, the probable indoors air chemical soup derived from construction materials and lifestyles, leads to the need for an increased volume of ventilation air for the houses in which most of us will live. Although not the first line of defense and contrary to the position of some in this industry, ventilation above that necessary for breathing is the solution to the common remaining indoor pollution. From a cost perspective, it may actually be cheaper and more practical to continue to use most current construction materials and install continuous ventilation. Of course the really bad boys like combustion by-products and auto exhaust would still be designed out of indoor air.

With an intention to use air for improving the indoor environment, a larger volume of air than normal will need to be conditioned prior to entry is required. A minimum amount of that air should come in through random holes. Both of those positions lend support for balanced airflow, recovery systems. For the volume of air during the cooling season in the Southeast, the major load is the moisture that will be in the incoming air stream. Therefore, a system should be capable of removing that latent load even when there is very little temperature difference. This volume of air could also use an outgoing air stream to precondition the incoming air stream. The ventilation air system works best when it can appropriately treat incoming air — filter, humidify, dehumidify, heat, cool, and filter exhaust air going through the equipment. There is also the perspective that a continuous airflow that is distributed to different parts of the house is beneficial.

Although the individual pieces of equipment used for balanced flow and for latent and sensible recovery are themselves complex, their installation strategy can be a simple one. Elements of the decision process that can result in getting the ventilation system that you want include separate ducting from the HVAC system; separate ducting from spot exhaust ventilation for kitchens and bathrooms; dedicated volume ventilation; plain controls for consumers; continuous operation; a full range of airflow; recognized recovery performance rating for summer conditions; quiet; double filtered; and easy to get to and easy to service. The notion that paying attention to the necessity of providing ventilation air should be achieved without increasing housing cost is questionable. Although blended, mixed, complex, interlocking, engineered, controlled systems can definitely work, the simplicity of installation is more likely to work in day-to-day construction. With a decision to meet Southeastern summer ventilation needs with a desiccant-coated rotary wheel system, it makes more sense to exclude bathroom moisture. Moist bathroom air exhausted to an Energy Recovery Ventilator [ERV — transfers both moisture and heat to the opposite air stream] will only save the moisture and return it to the house — just what you did not want to happen.

Just because some houses have no ventilation and people live in them does not necessarily mean that such a situation is most appropriate. Rather than focusing on an Energy Recovery Ventilator as an economic device, look at it as a conditioning appliance. One could just as well ask for a return on the dollar for the freezer, VCR, big screen TV, carpeting, special rugs, or chandelier.

Methodology

As mentioned earlier, this material is a set of exploratory case studies. They have a common focus of looking at and selectively performance testing some elements of installed ventilation systems. The intent is to identify some common threads of success and failure. It is hoped that a summary of this information will be a resource in the process of self-correction for this industry.

To the degree possible, the installer and the owner were interviewed and the manufacturers' literature was reviewed. These resources framed the understanding of what was intended for the installation and what outcomes and benefits were anticipated. They also served as a quick orientation to the logistics of where individual components were and how they were supposed to work.

Photographic slides were taken at each of the sites to document a selection of items for future reference. Indoor and outdoor air conditions were sampled initially and periodically throughout the site visit using a variety of instruments.

Item Measured	Instrument Used
CO_2	Teleaire Model 1050
Temperature and Relative Humidity	Vaisala HM41
Volts	A.W. Sperry DSA-400
Psychometric conversions	Trane Psychometric Chart
	Vaisala HM41
	Psycho computer program
kWh	kilowatt-hour meter for 120 power

Airflow for the systems was measured using The Energy Conservatory (TEC) duct blaster and digital pressure gauge. The protocol involved covering a supply or exhaust hood or grille with a box. The box was connected to eight feet of flex ducting and a TEC duct blaster. Using the TEC digital pressure gauge and the duct blaster controller, air was added to or taken from the box until the pressure in the box became zero with reference to the ambient space. The box then became invisible to the airflow at the hood or grille. The digital pressure gauge airflow function was selected and was used to measure the cubic feet per minute of airflow through the duct blaster. In this configuration, the duct blaster airflow was equal to the unobstructed airflow of the hood or grille.

A second configuration involved using the same setup but adding in a TEC Automated Performance Testing (APT) system and laptop computer to control the pressures by automatically controlling the duct blaster speed. We refer to this process as "cruising zero.” It allows us to change ventilation equipment airflow, and the APT makes automatic adjustments and reports the new airflow.

To prove this protocol for the measurement of airflow to the skeptics at Airxchange, the manufacturers of the Honeywell ER200, we inserted an airflow grid provided by Airxchange in-line in a duct. We then were able to independently measure airflow with the grid. Then we measured airflow simultaneously for the same air stream with the grid and duct blaster (manually and cruising zero). It demonstrated that while registering slightly high, the grid airflow measurements could be trusted when installed in a duct. A really marvelous characteristic of the TEC duct blaster protocol, in addition to its accuracy and repeatability, is that it is nondestructive and nonintrusive.

The APT system by TEC allows for the data logging of several other measurements — temperature, relative humidity, CO_2, CO, and pressure. This process was used to record over time and through different conditions the temperature and relative humidity simultaneously for each of the four air streams of a balanced airflow, recovery ventilator. In some tests, 10 separate measurements were recorded simultaneously: four temperature, four relative humidity, and two pressure. A hand- recorded event log with reference time was maintained to compare against the time-stamped data. The sensors were checked and adjusted in the field with a temperature and relative humidity sensor before data were saved. At the end of the test, the sensors were again checked against the standards to confirm that they were still in agreement.

Thorough observation was completed for each system. The physical installation of the system was examined. This included listing where the unit was placed, how it was connected to the outside and inside, where different ducts went and where they were connected, confirmation that the unit had power, and how the controls actually worked. Awareness was kept as to what else beyond the expected was going on. Additionally, how this house and system were attempting to address or had failed to address moisture issues was compared to the template of criteria held for systems in the

Southeast. The installer’s intentions and the homeowner's desires also were compared against the installation.

Supplemental testing was completed for a number of these houses. These performance tests were usually part of some other project and were not directly related to this ventilation report, but sometimes they provided useful insights. Measurements included the use of a blower door, a duct blaster, room pressures, series leakage, combustion safety protocols, and pressure pans.

Results

The most extensive investigations that included enthalpy data for the four air streams of a unit were collected on four systems [1,4,5,10]. Multiple and ongoing measurements of airflow were collected on the unit in the ABSC lab [2,9]. A working relationship has been maintained with the owners of four of the systems [1 (mine), 9 (lab unit), 4, 7]. Short summaries for each of the case studies follow in which positive, negative, and notable items are reviewed.

Case # 1

Advanced Energy staff members often can be heard saying, "Performance test or it is a guess." That is what was done after this ERV was installed in May 1996. The original airflow measurements using the TEC duct blaster protocol gave a range of 162-190 cfm for a unit rated to provide 80-250 cfm. Through several months of extensive discussions, parts replacements, and diagnostics with Honeywell and Airxchange staff, it finally was determined that the master control module was being manufactured defectively. It took a year to reach that conclusion. With that determination and the manufacturer's temporary fix instruction to adjust the potentiometer, the current range is 93-213 cfm. It is improbable that a regular homeowner or installer would have had this success with a manufacturer given the lack of awareness and limited resources of most individuals.

The available airflow provided by the system successfully reduced the concentration of smells given off by the building materials. Although no specialized materials were used, entering the house from outside provided, only occasionally, very slight odors from building material outgassing. Turning the system off did allow an unpleasant concentration of smells. It also allowed an overnight build-up of CO_2 from the four occupants to reach 1600 ppm from an outside background level in the mid- 400s ppm. During normal operation, the CO_2 concentration was in the 700s ppm when the airflow was at 165 cfm. Now that the airflow has been adjusted to 93 cfm, the CO_2 concentration is in the mid 800s ppm. With the system running continuously, the CO_2 concentration is near background when we return home at the end of the day. Annualized natural air exchange for this house has been estimated to be around 55 cfm. That was based on a blower door, air tightness measurement of 1180 CFM50. Excluding that varied air leakage and spot exhaust from a dryer and from bath and kitchen fans, the continuous ventilation of 165 cfm for this 1800 sq. ft. house provided a minimum air exchange rate of 0.63 per hour. The adjusted master control board now allows the system to run slower, and it usually is set at 100 cfm, which provides a minimum air exchange rate of 0.38 per hour.

Operation costs immediately leap to mind when ventilation air is discussed. With separate meters, it was determined that the standard (not frost-free) freezer used 989 kwh per year or 2.71 kwh per day running intermittently. The refrigerator with frost-free freezer also running intermittently required a total of 1531 kwh per year or 4.19 kwh per day. The continuously running ERV used 1157 kwh per year or 3.17 kwh per day for its two motors. Even with the ERV airflow out of control, the total energy required to heat, cool, and treat the natural air exchange and extra percent of untreated ventilation air was only 6509 kwh. Thus the total operation of space conditioning required 7666 kwh, an average of 21 kwh per day for this commonly constructed house. Including all the costs for providing year-round continuous ventilation at an elevated rate resulted in an estimated bill of only $9.17 per month.

During summer cooling while running at the elevated airflow, 165 cfm, the ER200 was able, depending on conditions, to remove between 14 and 29 Grains of moisture vapor per pound of dry air from the incoming ventilation air. This is not adjusted for the 12% exhaust crossover air into the incoming supply air in the ER200. The TRE rating of 79% for the ER200 assumes an airflow of 108 cfm. The elevated airflow caused a change of around five points in the indoor relative humidity. With the system turned off, the relative humidity usually measured around 53% (a low of 50%); with it on, the relative humidity would rise to around 58%. Through several cycles on different days, this shift was repeatable. On some days the five-point rise caused the indoor relative humidity to reach 60%. So the intent to have elevated ventilation air and control the latent load with a highly rated desiccant-coated wheel system was compromised because the system's controls could not provide the low-end 80 cfm as published by the manufacturer. A positive note on the desiccant technology is that substantial Grains of moisture were being rejected even at night and at other times when there was little or no temperature difference. Rejection of that moisture load is important because the dehumidification function of the air conditioner was occurring only on a limited basis.

Performance measurements during the summer of 1998 will be completed and reported during the conference presentation. With the airflow now reduced, it will be interesting to see if there is a change in the equipment's rejections of incoming latent load. Overall, the ventilation system has been a very positive experience and has provided such pleasant and comfortable indoor air without any noise that it has spoiled the whole family with regard to the indoor air at many other locations.

Case # 2

This ABSC laboratory ER200 was procured through a completely separate path from the ER200 in Case # 1. It was the workhorse for many of the diagnostics that took place over the year. It also served as a second case to verify measurements taken for the Case # 1 ER200. The original airflow range for this unit was 169-244 cfm. Numerous voltage recordings and experiments also were completed with this unit. Prior to being informed by the manufacturer, experiments in the lab had proven that the voltage required to produce a low-end airflow of 80 cfm was 55 V. This unit as delivered by the manufacturer was operating on the low end at 80.4 V. The measured volts for case # 1 ER200 was 94.4 V. Based on the accumulating Advanced Energy data, this unit was shipped back to Airxchange personnel at their request for diagnostics in August 1997.

Case # 3

A search was undertaken in order to provide another supporting data point regarding the airflow problems of the Honeywell ER200. This third ER200 was found by inquiring among the HVAC contractors with whom we work. It was purchased by the contractor through a third wholesale path roughly a year after the previous two ER200s. There were only two points of interest for this unit. First, the airflow range was measured and was found to be 228-237 cfm. Second, the measured low-end voltage was a 98.8 V. The system is ducted separately and is well filtered. No other measurements were taken at that time.

Recently, the installing contractor reported that the lowest adjustment possible of the potentiometer resulted in a low-end measurement of 73 V. The low-end exhaust airflow after the adjustment was 120 cfm. Because the installer and owner did not plan to use high-end airflow, the contractor closed the exhaust and supply dampers until the static pressure resistance provided a balanced airflow of 70 cfm.

Case # 4

This homeowner's primary motivation was to pursue decisions that would result in the control of indoor relative humidity and thus restrict mold growth and to provide energy recovery ventilation. This was important because of the owner's allergies to mold spores. The installing contractor chose an ERV with a low TRE rating and limited moisture transfer ability. The system delivers outside air from the ERV into the return duct for the heat pump. The heat pump blower is used to distribute the air throughout the house. Exhaust air was taken from bathrooms and a laundry room. The system was designed to run on low speed continually and on high speed by using timers in the bathrooms.

On our first visit we discovered that the control wiring was not connected to the unit and thus it did not run at all. This was several months after the owner had moved into the house. During the second visit we discovered that the system only ran when the timers were engaged. That helped explain why a house twice the size and with half the occupants of Case #1's house could have a higher CO_2 measurement, 788 ppm. The indoor air relative humidity was 61%, which was part of the concern that caused the owner to request a diagnostic.

The ventilation system was manually overridden to run continually, and the heat pump was cycled on its thermostat. During the recording period, the relative humidity in the house increased to 72%. When the compressor turned off, the coil was wet and the blower was still running because of the interlock with the ERV. Outdoor air leaving for the house from the ERV with 77.6 Grains of moisture mixed with return air containing 79.5 Grains. That mixed air was blown across the wet coil and delivered to the house containing 95 Grains and thus the humidification of the house. Had there been moisture-laden air from a shower returning to the ERV, some of that moisture would have also been transferred to the incoming air stream. As the house humidified during the data collection, the outdoor air did pick up a small portion of additional Grains of moisture as it passed through the ERV core.

Recently we were informed that the control wiring was corrected so that the system will run continually on low as intended. Additional controls were installed to turn the ventilation system off if humidity becomes a problem in the summer. It would be interesting to monitor how often the system would need to shut down at different settings. Shutting down, of course, means no ventilation air. We were also informed that part of the moisture problem was that the heat pump airflow had been set to high for its proper dehumidification operation during air conditioning. That is, of course, another whole story of equipment not being installed in a way that will deliver its designed performance potential.

High speed airflow for this ERV is balanced and is within the expected flow. Airflow for the intake measured 140 cfm, and 146 cfm was measured for the exhaust. The outdoor intake and exhaust hoods are located together in a deep alcove, under a low deck. It appears from the intake air data that a portion originated from the exhaust hood air.

Case # 5

This builder on his personal residence installed a Vanee 1000 Duo system, which uses desiccant-coated wheel technology. The installation was similar to Case # 4 because it was connected to the air conditioner ducting. However, it was connected to both air streams. It exhausted air from the house by taking air from the return. Air was supplied to the house by delivering air to the supply ducting for distribution. The space-conditioning blower was always on.

The Vanee 1000 Duo has a TRE rating of 61% for a balanced airflow of 120 cfm. Airflow for the intake measured 128 cfm, and 90 cfm was measured for the exhaust, an imbalanced result. The controls indicate that the owner can set the airflow at a low or high speed. Regardless of the setting, the airflow in each air stream remained at the original volumes of 128 cfm and 90 cfm. Ducting for this system was unsealed at several locations and barely stayed in place on the unit starter collars.

Once again, with the air conditioner blower running continually, operating the ERV system humidified the house. Indoor relative humidity remained in a high 60s to mid 70s percent band and cycled over a six-point range with the compressor. The capacity of the exhaust air stream in this unit to provide latent and sensible treatment of the incoming air was noticeably compromised by the 40% larger volume of incoming air. Depending upon the condition of the indoor air, the exhaust air stream picked up moisture ranging from 20 to 26 Grains. The ERV equipment could only reduce the incoming air stream moisture by seven to 10 Grains.

Case # 6

The same model equipment was used at this location as for Case # 4. This was a separately ducted system with exhausts from two bathrooms and with supplies to a master bedroom and a hall. Whoops, make that: it exhausts air from all four locations. The bathrooms' air stream is crossed in the ERV core with the air collected from the master bedroom and hall. Both air streams then are blown to outside. This is an exhaust-only setup that collectively removes 330 cfm from the house to the outside. The installers apparently found themselves in the attic at the ERV with four ducts and no notations on the ducts. The two ducts (supply and exhaust) from the house were both connected to the two intake collars on the ERV and all the air was exhausted.

The controls were supposed to provide continuous low-speed ventilation and high-speed flow when timers were activated in either of the bathrooms. In the as-found condition, the system only ran when the timers were engaged. That setting was the only time that the variable speed controller in the master bedroom could adjust the fan speed. Relative humidity in this house remained around 60% throughout the site visit. The moisture load is most likely associated with the air conditioning performance because the ventilation system was not running. No additional ventilation measurements were taken.

Case # 7

An Ultra-Aire unit was installed to suppress moisture in the unconditioned basement of this 70-year-old house. The basement is connected to the sealed crawlspace, and the ground is covered with sealed plastic. The Ultra-Aire succeeded in maintaining a basement relative humidity of 40%. The system has very effective pleated filtration. Unexpectedly, the children who live in the house experienced substantial reduction and elimination of allergy symptoms. The system was installed with an outdoor air intake to mix with the basement air stream. This portion of the system was included to suppress and dilute an already low radon measurement. The success or failure of that function is still under review. Total airflow for the unit was 237 cfm, which is very good when compared to the maximum available of 255 cfm without any ducting. Intake air measured 76 cfm, and basement air measured 161 cfm.

Case # 8

This owner had a ventilation system and believed it to be a balanced flow, recovery system. During the site visit it was quickly determined that the ventilation system was a Fan Tech in-line fan that blew air through a four-inch duct into the heat pump return. The fan working alone at the customer's normal mid-range setting delivered 19 cfm of ventilation air into the return. When the heat pump blower cycled on, the additional suction on the four-inch duct increased the airflow to 37 cfm. The variable speed controller did function as planned. The fan transmitted a low vibration sound through the floor framing into the house. No additional ventilation measurements were taken.

Case # 9

This ER 200 unit was returned from the manufacturer and was prepared for performance testing. The measurements included the voltage of the motor and airflow as determined by both Airxchange grid and duct blaster protocols. The design volts for the designed airflow of 80 cfm was 55 V. Additional adjustments were made to the potentiometer, and follow-up measurements were completed. It was learned that the unit was returned with a low-end setting of 61.2 V, grid airflow of 106 cfm, and duct blaster airflow of 98 cfm. The high-end airflow was 242 cfm for the grid and 227 cfm for the duct blaster. When the low-end volts were set to produce the published airflow of 80 cfm, the motor would not run at all when the high-speed windings were controlled to the minimum setting. The unit's potentiometer was reset to 62.9 V to allow the unit to run at all speed settings.

There is apparently a need for an upgraded electrical design that can deliver the published airflow range. Alternately, the published airflow range could be changed. The solution could include a combination of those approaches.

Case # 10

This Nutone unit was examined during the heating season. The Nutone was a Heat Recovery Ventilator (HRV) and was a separately ducted system. Its TRE rating was 28% at 68 cfm of airflow with almost zero ability to transfer moisture. The intent was to remove humid air from bathrooms, kitchen, and laundry areas and to provide ventilation air mechanically to the house.

The ducting was insulated flex duct that was well sealed. The only filtration in the system was the small washable filter on each inlet side of the HRV core. The manufacturer's literature recommended that for exhaust grilles in a kitchen, a grease filter should be used. None was present. The bathroom exhausts were placed in the floor, minimizing the hot moist air that would be captured. Outdoor air conditioned by the HRV was delivered to the living room through one grille that blew air onto the end of a couch. The owner reported that during cold snaps it is uncomfortable in that location.

The outdoor intake and exhaust hoods are located near each other under a low deck. Those location characteristics lend themselves to allowing exhaust air to pass into the intake. Condensation would be formed in this unit under some conditions. The installed condensate drain did not have the required p trap.

No controls were accessible to the owner. The option was available to the installer but was not used. Not allowing owners to manage their environment can be viewed as a mistake. The controls were on the side of the unit, which is located in the crawlspace. A dehumidistat was part of that control package and was set on 40% relative humidity. It was designed to flip the blower motor into high speed and flush moisture out of the house. During the cooling season when the indoor air exceeds that set point, a certainty, the unit would then blow large volumes of very humid air into the house. The dehumidistat should be turned off during the cooling season.

The installer had selected a motor speed of two from a set of four. The system exhausted 123 cfm of air from the house and supplied 115 cfm of pretreated air into the house. This volume of airflow met the standards the builder had applied to the house and provided a minimum air exchange rate of 0.27 per hour. Eight channels of data sensing the temperature and relative humidity of the four air streams of the HRV were recorded. Interpretation of the data provided an Apparent Sensible Effectiveness of 70% at 48 degrees, which is reasonably close to the Nutone rating of 71% at 32 degrees. The temperature of air delivered into the house during the test was only six degrees colder than inside air. Unfortunately it was all in one location. The data also confirmed that this style HRV does not transfer moisture between air streams.

Conclusions

As a result of personal and professional interests, we looked at ventilation systems that were being installed. Besides looking, a variety of performance measurements were taken. Preliminary discussions pricked the interest of several parties. Some were seriously enough interested in learning about the state of the technology as installed in the field to provide funds for these diagnostics.

We found that all eight balanced flow systems had problems (see Table 2). Some, like the Honeywell ER200, were manufacturing problems that caused high airflow that in turn reduced the equipment's performance and increased indoor latent load. Some were installation design mistakes, in that the air conditioner blower was continuously operated for the ventilator and resulted in humidifying the indoor air of Cases # 4 and # 5. Several had controls that were installed inadequately. One did not have controls available to the owners and also blew air on them and made them uncomfortable. One installation contractor turned the balanced flow ventilator into an exhaust-only fan by connecting the ducting to the wrong ports. A final owner learned that the ventilation system was not balance flow with recovery, but just an in-line fan.

In planning a ventilation strategy for your home in this and similar climates, it is critically important to design in order to control the latent load of the incoming air. Other useful perspectives include the simplistic installation of complex equipment. Beneficial aspects like filtration (of both air streams), optimum airflow, range of airflow, practical independent air distribution, sound levels, and the equipment's TRE rating can improve the installation. Finally, measurement of the different air streams is very important, as is balancing the airflow through the equipment recovery core. You should physically confirm that the controls really do work as you were told that they do, and they should be located conveniently. Investigate twice to confirm that the system is not planned for a dry or heating climate. You do not want a humidity sensor to kick the unit up into high speed during the summer. Nor do you want a humidistat to turn your ventilator off as a method to control incoming latent load. Find an installer who will provide performance tests to you in writing and will explain them.

Finally, what is the plan for maintenance? Filters (pleated work well) should be used on both sides of the unit and changed as necessary. Currently the size of pleated filters in relationship to the airflow allows me to change mine every three months. The outside air intake screen is cleaned at the same time. Annually at the end of the air conditioning season, who is going to remove and clean the core and clean the blower wheels?

It has been my experience that ventilation systems are important but are seldom working correctly. It has also been my experience that a ventilation system done well is a pleasure, a comfort, and not expensive to operate. Obviously, there can be more than one method used to achieve an end result. However, the premises contained in this report do work, are not expensive, and are simple. I look forward to improvements in this approach and to alternative approaches.

More measurements of ventilation systems will be completed during the summer of 1998. Hopefully some of that additional data will be available by the time of the conference.

Table 1: Airflow Case Studies, Equipment, and Installation Details

Site	Ventilation Equipment Brand and Model	Testing Date or Period	Type Recovery Core Mechanism	Ducted Air Paths Between Equipment and House	Equipment Location	Controls
1	Honeywell ER 200	6/96 to Present	Desiccant-Coated Rotary Wheel	Separate Ducts, Multiple, Low Supplies Central High Exhaust	Sealed Crawlspace	Variable Speed Low & High Range Humidistat
2	Honeywell ER 200	12/96 to 8/97	Desiccant-Coated Rotary Wheel	N/A Variable According to Testing Needs	N/A	Variable Speed Low & High Range Humidistat
3	Honeywell ER 200	7/97 to Present	Desiccant-Coated Rotary Wheel	Separate Ducts, 4 High Supplies (3 in bed, 1 in common area) Central High Exhaust	Attic	Variable Speed Low & High Range Humidistat
4	Carrier VL3AAA020	8/97	Cross Flow Plastic	ERV Air Into Return, 4 Ceiling Exhausts, (Master Bath, Toilet, Laundry, Hall Bath)	Sealed Crawlspace	Low Speed Continous; A/H Blower on, High Speed/ with Timer
5	Vanee 1000 Duo	9/97	Desiccant-Coated Counter Flow Rotary Wheel	ERV Air into Supply Exhaust Air from Return	Vented Crawlspace	High, Low, Intermittent, Humidistat
6	Carrier VL3AAA020	9/97	Cross Flow Plastic	Separate Ducts 2 High Supplies (Bedroom, Hall) 2 High Exhausts (Baths)	Attic	Low Continous; High with Timer Variable Speed
7	Therma-stor Ultra-Aire APD	9/97	N/A Dehumidifer	Separate Ducts 1/3 Outdoor Air 2/3 Basement Air	Sealed Basement / Crawlspace	Air Continuous or with Compressor Cycling on Humidistat
8	Fan Tech In-Line Fan (Owner thought it was an HRV)	12/97	N/A In-Line Fan	Fan Duct Blows Air into Return	Semi-Conditioned Basement	Off or Variable Speed
9	Honeywell ER 200	12/97 to Present	Desiccant-Coated Rotary Wheel	N/A Variable According to Testing Needs	N/A	Variable Speed Low & High Range Humidistat
10	Nutone HRV 155	1/98	Counter Flow Aluminum	Separate Ducts 1 Low Supply, Near Return 4 Floor Exhausts (2 Baths, Laundry, Kitchen)	Vented Crawlspace	No Occupant Control, 4 Speeds on Equipment Humidistat

Table 1: Airflow Case Studies, Equipment, and Installation Details (Continued)

Site	Designed Air Flow cfm	Total Recovery Efficiency TRE*	Exhaust Air Crossover to Supply Air	Filtration Strategy to Protect Equipment and/or People	Reason for Installation	Age of Home at Installation
1	80-250	79% @ 108 cfm	12% @ 50 Pa.	1" Pleated in Equipment for Outdoor Air Intake 1" Pleated at Central Exhaust	Owner Request Air to Breathe Pollution Dilution, Surpress Moisture Load	New
2	80-250	79% @ 108 cfm	12% @ 50 Pa.	N/A	N/A	N/A
3	80-250	79% @ 108 cfm	12% @ 50 Pa.	Space Gard Deep Pleated for Outdoor Air Intake; 1" Standard at Central Exhaust	Owner Request Perceived Importance to Meet Exemplary Home Standards	New
4	117-180	36% @ 117 cfm 29% @ 180 cfm	6% @ 100 Pa.	Thin Foam Filters in Equipment Box at Intake Side for Each Air Stream	Owner Request to Meet Exemplary Home Standards, Perceived as important, Suppress Humidity	New
5	64-120	69% @ 66 cfm 61% @ 120 cfm	2% @ 100 Pa.	Thin Foam Filters in Equipment Box at Intake Side for Each Air Stream	Owner /Builder Installation Educated to Importance	New
6	117-180	36% @ 117 cfm 29% @ 180 cfm	6% @ 100 Pa.	Thin Foam Filters in Equipment Box at Intake Side for Each Air Stream	Owner Request Perceived as Important Building Healthy Home	New
7	255 with No External Ducting	N/A	N/A	Pleated Pre-Filter Deep Pleated Filter for Total Air Flow	Suppress—Basement Humidity, Mold Spores and Radon	70 YRS.
8	0-90 with No External Ducting	N/A	N/A	When A/H Is on Air Travels to Space Gard Deep Pleated Filter in Return Path	Owner Request Perceived as Important to Meet Exemplary Home Standards	New
9	80-250	79% @ 108 cfm	12% @ 50 Pa.	N/A	N/A	N/A
10	Up to 169 on High Speed	28% @ 68 cfm	2% @ 50 Pa.	Thin Washable Filters Clipped to Each Intake Side of Core	Meet Builder-Marketed "Healthier Home" Standards	New

* Home Ventilating Institute (HVI) Measurement Protocols

Conditions: Outdoor Air +95°F, 50% RH, 124 Grains, 42.6 Enthalpy
Indoor Air +75°F, 50% RH, 65 Grains, 28.1 Enthalpy

Table 2: Summary of Findings

SITE	EQUIPMENT	SCORING DETAIL *(+ Positive, - Negative, o Neutral)*
1	Honeywell ER 200	-Mismanufactured speed control; +Good TRE rating; +Separate ducting; +Both air paths filtered -1" pleated; +Continuous Airflow; +Balanced air flow; +Quiet; +Diluted VOC smells; +Economical to use; -Slightly elevated RH% due to high air flow; +Rejects moisture even during cool periods; +Intake and exhaust hoods accessible for cleaning; +Humidity override can be turned off for summer
2	Honeywell ER 200	-Mismanufactured speed control; o lab unit
3	Honeywell ER 200	-Low/high range switch did not work; -Mismanufactured speed control; +Good TRE; +Separate ducting; +Both air paths filtered [deep pleated for outdoor air]; +Continuous airflow; +Balanced airflow; +Quiet; +Economical to use; +Rejects moisture even during cool periods; -Intake and exhaust hoods *not* accessible for cleaning; +Humidity override can be turned off for summer
4	Carrier VL3AAA020	-In-field wiring failed to provide continuous low speed operation; -Heat pump blower delivering ERV air across wet coil humidified house; -Low TRE rating; -,+Minimal equipment filters [ERV air deep pleat filtered at return]; +Balance air flow when operating; +Quiet; -Exhaust hood location feeds air to intake hood; +Intake and exhaust hoods accessible for cleaning; -Humidity override shuts down ventilation
5	Vanee 1000 Duo	-In-field wiring failed to provide selection for speed of operation; -Heat Pump blower delivering ERV air across wet coil humidified house; +Good TRE rating; -Ducting barely connected; -Minimal filters; +Continuous airflow; -Very imbalanced air flow; +Quiet; +Could reject moisture during cool periods; +Intake and exhaust hoods accessible for cleaning
6	Carrier VL3AAA020	-In-field wiring failed to provide continuous low speed operation; -low TRE rating; +Separate ducting; -Minimal filters; -Connecting of ducts to ERV provided exhaust only ventilation; +Quiet; +Economical to use; Intake and exhaust hoods *not* accessible for cleaning
7	Therma-Stor Ultra-Aire APD	+Dehumidified unconditioned basement and sealed crawlspace; +Highly filtered; o Compressor noisy, but unnoticed in house; +Economical to operate; +Achieved owners' goals plus improved children's health; +Intake hood accessible for cleaning
8	Fan Tech In-line Fan	-Blows humid air into cool basement with condensing surfaces; -,+Air is only filtered when heat pump is operating; o owners informed that they did not have ERV; -fan vibration sound through floor; -Fan as operated provide limited air to house; -Tight weave insect screening on intake hood
9	Honeywell ER 200	-Mismanufactured speed control; o Lab unit; -, +Potentiometer adjusted to alter speed control to a limited degree
10	Nutone HRV 155	+Husband praised dilution of his wife's smoking; -No controls in house, owner must go into crawlspace to adjust unit; -P trap not installed for liquid; -Low TRE rating; +Separate ducting; -Minimal filtration; +Continuous air flow; +Quiet; -Exhaust hood location feeds air to intake hood; -Intake and exhuast hoods accessibility restricted by low porch deck; +Balanced air flow; -Humidity override will increase moisture load in summer; +Economical to use; -Location of central supply and 4 exhausts

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Synopsis

Analyze the method by which homes in the Southeast can maximize the benefits and minimixe the liability of air exchange when installing mechanical ventilation systems.