March 2014

UNDER PRESSURE

WITHOUT DYNAMIC MONITORING AND CONTROL, CLOSING VENTS IS A BAD IDEA FOR RESIDENTIAL HEATING AND COOLING

EcoVent Systems, Cambridge, MA 02139

ABSTRACT

This paper discusses fundamental aspects of modifying airflow in residential heating, ventilation, and air conditioning (HVAC) systems. It finds that homeowners who close vents using a system that does not account for changes in system load, flow conditions, and system efficiency may experience increased system pressure, increased noise, inefficient air leakage, decreased comfort, and the potential for system damage and shortening of equipment life. The paper then proposes a novel method for dynamically balancing residential HVAC airflow. This process would respond to the real-time conditions affecting the home and its mechanical systems. Such a system has the potential to overcome the potentially costly and dangerous effects of indiscriminately closing air vents without dynamic real-time knowledge of the HVAC system and home environment.

INTRODUCTION

Manufacturers are introducing new products that enable homeowners to redirect airflow within their homes by utilizing internet-controlled thermostats and vents; however, not all of these systems have accounted for the delicate balancing of system pressure and flow conditions. In fact, past studies of previous-generation vent technology advise against unmonitored vent closure.[1]

It is important to note that these studies were conducted more than a decade ago and do not reflect the latest device designs and controls on the market. Even so, these results should caution homeowners against investing in vent-control systems that do not account for system safety concerns.

OVERVIEW OF TYPICAL HOME HVAC SYSTEM

A typical single-zone residential forced air HVAC system consists of several components illustrated in Figure 1 at right:

1. Heating/Cooling Unit
2. Duct Work
3. Master Unit
4. Plenum Sensor
5. Thermostat/User Display
6. Vent

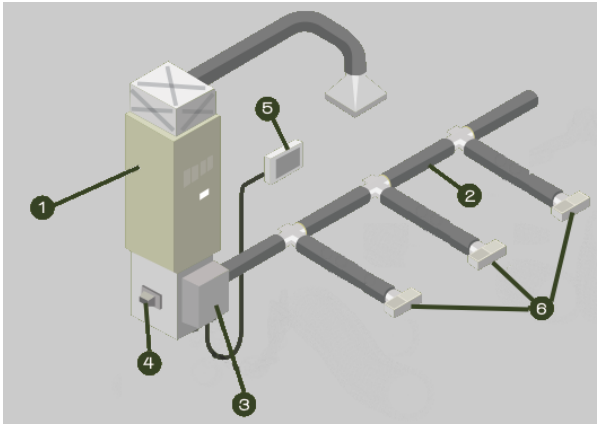

Figure 1 Traditional Residential HVAC System

The user has two primary points of control—the thermostat and the vent. He or she can change the temperature setting on the thermostat display, or alternatively, adjust the louvers to increase or reduce airflow to specific rooms or areas of the home.

Some consumers have been advised to close vents in unoccupied rooms as a way to conserve energy. In order to test this claim, the Lawrence Berkeley National Laboratory conducted a series of tests in the early 2000s, finding that vent closures had unintended effects on the health of the overall HVAC system:

[1] Walker, I. 2003. "Register Closing Effects on Forced Air Heating System Performance." LBNL Report-54005. Lawrence Berkeley National Laboratory, Berkeley, CA. http://epb.lbl.gov/publications/pdf/lbnl-54005.pdf

> *Closing registers nearer the air handler tends to increase the pressures and air leakage for the whole system. (Walker, 2003).*

The report goes on to note that excessive vent closure can lead to equipment damage and questionable effects in terms of energy efficiency. The following section describes some of the complications of unmanaged vent closure.

IMPACTS OF UNMONITORED VENT CLOSURE

In a forced air HVAC system, the distribution of air is essential to its proper functioning. Closing vents without understanding the characteristics of an individual system can cause serious damage to homeowners' HVAC systems.

EQUIPMENT DAMAGE

Residential HVAC systems rely on well-managed airflow to transfer heat to and from your home. If the airflow is reduced too far under the wrong conditions, the heat transfer element (coils) can freeze over entirely, limiting system function and threatening equipment. When coils freeze as illustrated in Figure 2, refrigerant can enter the compressor and contaminate the motor's oil thereby shortening the compressor lifespan. [2]

Figure 2 Frozen Coils

This dangerous reduction of airflow can be the result of a combination of closing too many vents, bad ducting, a clogged air filter, a poorly performing fan, indoor conditions, and outside weather. Most HVAC systems are designed withstand most of these conditions, but without monitoring, it is impossible to know when the system is entering a dangerous state. Closing vents without knowing the precise state of the system can aggravate a system that is already struggling and eventually cause it to fail. In a heat pump system, a similar effect to freezing coils can occur because the refrigerant gets too hot.

OVERHEATING SYSTEMS

Damage by freezing coils is not the only way a system can be harmed by unmonitored vent closures. When in heating mode, reduced airflow can lead oil, gas, or electric strip heaters to reach their high temperature limits. This causes the heating system to shut down to maintain safety. During this shutdown period, the homeowner will lose heat until the circuit resets or a technician comes out to reset it. Even though a reset can restore the unit to normal operations, repeatedly triggering high temperature limits can decrease the lifespan of the system.

[2] Image credit: MonsterVac

INCREASED NOISE

Even if closing vents without monitoring the system does not damage HVAC equipment, it has other negative effects, including increasing operating noise. Systems' fans are sized to move a certain volume of air through the home, and the system is sized to keep airspeeds in the ducts under control in order to limit noise. By reducing the exit area of the system by closing or reducing vents, the airspeed will increase and along with it, noise.

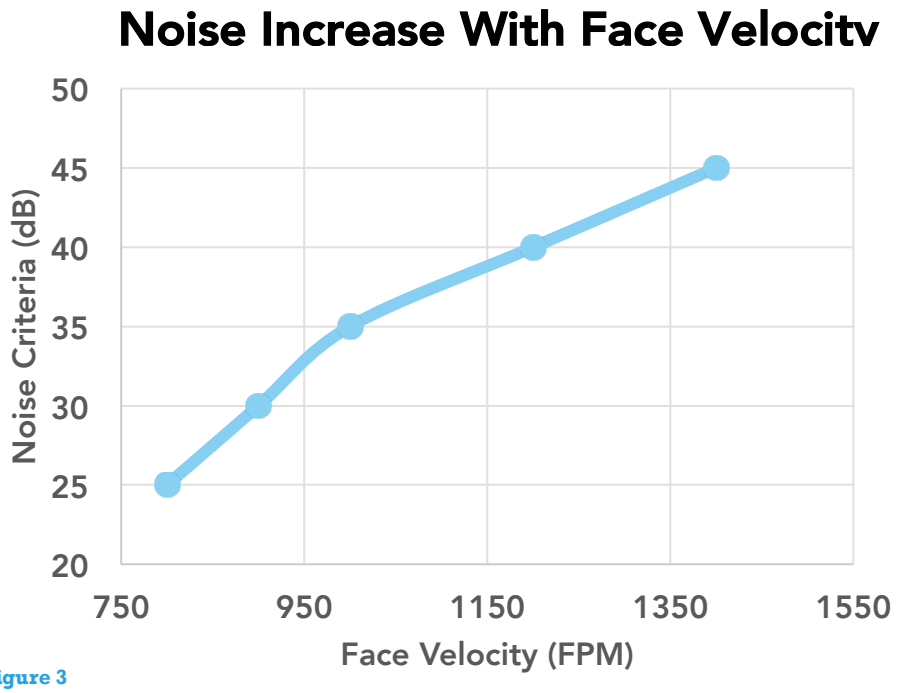

Figure 3

As air flows over sharp edges and rough surfaces it becomes turbulent. Turbulent air is noisy air. That means that vents with louvers and grilles create additional noise with increasing airspeed. Traditional louver designs also do not seal well. Small cracks and openings accelerate the air even more causing whistling and rattling. Figure 3 illustrates noise-generating surfaces in red. The potential increase in temperature comfort is overcome by the noise generated by the increased airflow in the whole home.

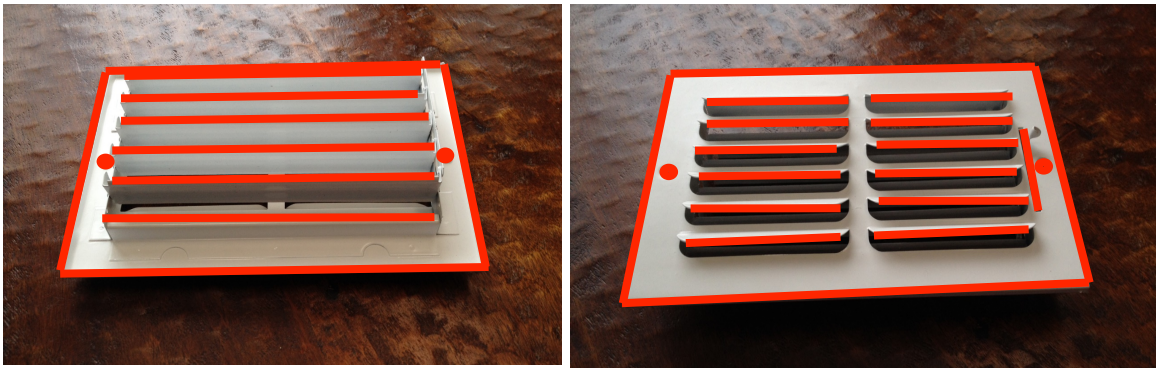

Figure 4 Noise-Generating Surfaces on Traditional Louvered Vents

AIR LEAKAGE & INFILTRATION

In addition to increasing noise, traditional louvers do not stop much of the forced air from escaping the vent, even when closed. There is still a significant amount of air leaking through the closed louvers, as Figure 5 illustrates.

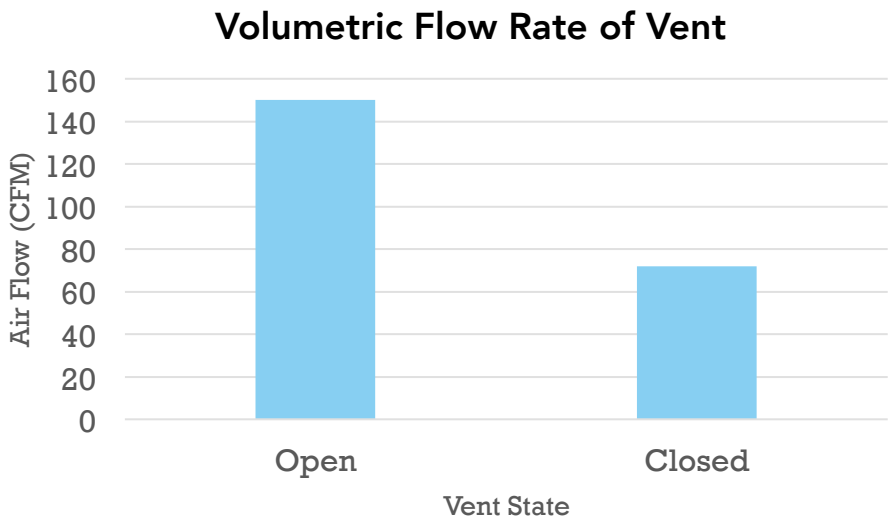

Figure 5

Another potential issue with an unmonitored HVAC system is air infiltration. A clogged filter can cause the unconditioned air around the system to be sucked into the system. Too much blockage due to bad ducting or closing vents can cause conditioned air to be forced out of the ducting into the unconditioned space. Both of these effects can reduce efficiency and increase cost if they are not taken into consideration. Systems are designed with specific losses accounted for the vents and ducts. If a vent with more pressure loss is put in place of an existing vent, the losses will begin before the vent is even closed.

REDUCED COMFORT

If the goal is to increase comfort, closing vents without knowing how the air is distributed in the system can be ineffective. There are many types of air distribution systems including branch (Figure 6a), star (Figure 6b), and perimeter loop (Figure 6c). Depending on the type of system and which vents are closed, the comfort situation in the home can be exacerbated.

As previously discussed, the fan will try to push the same volume of air and without knowing where the air from the closed vents is going, reaching an optimal balance in the home can be impossible without real time measurements.

Not only are all of these negative effects possible or likely when closing vents without checking the resulting system state, but also they are dynamic. The changes in the system with time of day, day of year, and current heat load change how these effects manifest themselves such that constant monitoring when changing the airflow characteristics of a system is necessary to succeed in improving the system.

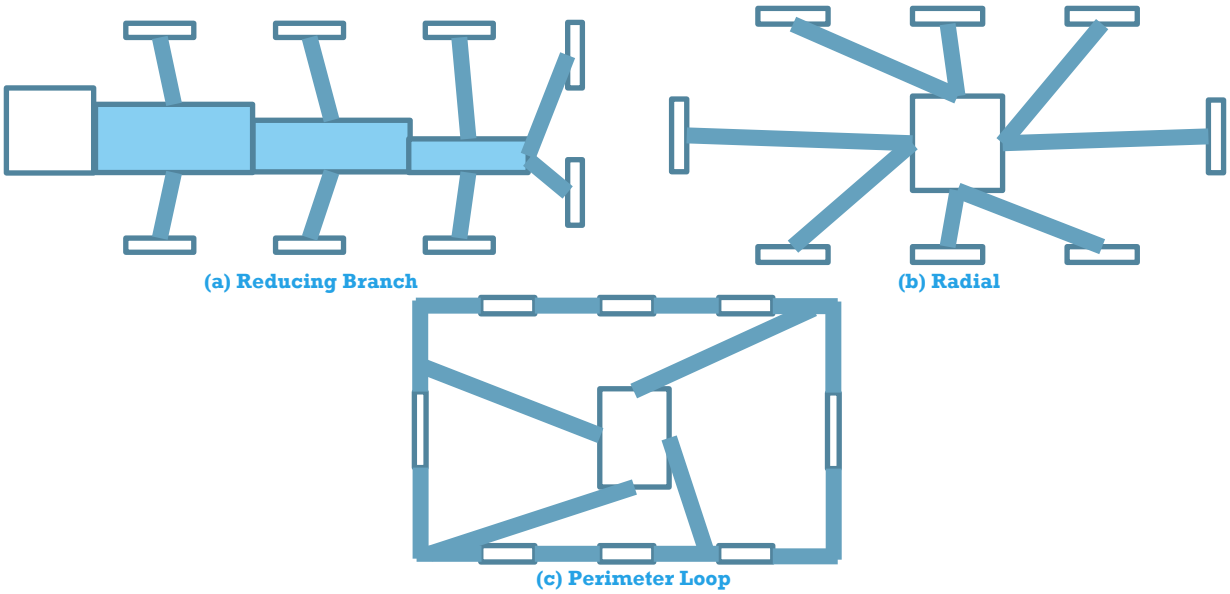

Figure 6 Air Distribution System Designs

BYPASS BAN UNDER CONSIDERATION

A common method for alleviating pressure problems is the use of bypass ducts in home HVAC systems. In addition to being inefficient, these bypass systems may soon be out of code in major states, like California. Citing energy efficiency concerns, the California Energy Commission recently proposed a code change that would prohibit the use of bypass ducts in zoned heating and cooling systems. According to *Air Conditioning, Heating, and Refrigeration News*:

> *The code change could largely affect manufacturers who specialize in the production of bypass ducts and zoning systems, distributors who sell the units, and contractors who install them.*[3]

Clearly there is a need for a better way to manage system pressure.

CONCLUSION

Although each of these issues poses problems for traditional HVAC system designs, each of them can be overcome with a combination of advanced software and hardware. Existing solutions that enable zoned heating and cooling can cost tens of thousands of dollars, more than most homeowners are willing to pay. Other, newer wireless vent solutions are less expensive, but have yet to incorporate dynamic sensing into their designs. Still others are seeking the right combination of cost, control, and system flexibility.

May the most efficient, responsive, and smartest system win.

---

[3] Woerpel, Herb "California Proposes Bypass Duct Ban" to *Air Conditioning, Heating, and Refrigeration News* March 5, 2012 http://www.achrnews.com/articles/119497-california-proposes-bypass-duct-ban