HVAC SYSTEM PRESSURE RELIEF

Correcting pressure imbalances in your HVAC system can result in a healthier, more efficient home.

BY PAUL H. RAYMER AND NEIL MOYER

Without central air conditioning, the South wouldn't be what it is today. Central air conditioning has made living in the South year-round a real pleasure, but it has also created its own set of problems—including the subtle but critical problem of pressures that differ from room to room.

To keep the installed costs of air conditioning down, it became common practice to put supplies into each room and use a central return, eliminating individual return runs. Rooms can serve as ducts as long as all the doors in the house stay open. As soon as doors, working as dampers, start to close, the system changes. Uneven pressures are created, and system performance and comfort are compromised causing the occupants to compensate by running the system longer or at a lower set point.

PAUL RAYMER

Neil Moyer installs a privacy insert, which enhances privacy between rooms while correcting pressure imbalances.

Complicating this problem is the fact that some rooms are pressurized and some rooms are depressurized. Air will seek to leak out of a pressurized room and leak into a depressurized room. Even though air has always leaked into and out of houses, this poses a greater problem now because of air conditioning. The leaks may be very small and the pressures tiny, but even a slow leak over the long term can cause serious damage. The pressures are as small as a couple of carbonated bubbles popping out of a soft drink. But in a house, those tiny pressure differences just don't go away. Like a small, constant drip, they can cause serious damage over time.

When a home's walls have been chilled by the air conditioning, the warm, moist outside air that leaks into the rooms under negative pressure slithers its way down from the attic or from the outside through the wall system until it strikes something that is below the dew point, where it gives up its moisture. This commonly happens behind vinyl wallpaper, which acts as a vapor barrier that moisture can't get through. So instead, the moisture slowly grows mold, which may not be noticed for a long time.

The Florida Solar Energy Center (FSEC) and my company, Tamarack Technologies, Incorporated, decided to test a variety of pressure relief solutions to see which worked best to solve these pressure problems.

Equalizing Circulation

Ideally, forced-air heating and cooling systems circulate an equal volume of return air and supply air through the conditioning system, keeping air pressure in the house neutral. Each conditioned space in the building should, ideally, be at neutral air pressure at all times. When the building is under a positive air pressure, indoor air will be pushed outward to unconditioned spaces and beyond to outside. When the building is under a negative pressure, outside air will be pulled inward, toward and into conditioned spaces.

Pressure imbalances are also created when interior doors are closed in buildings with heating and cooling systems that have only a central return air intake. Positive pressure in a closed room results when return air flow does not equal supply air flow. Conversely, negative pressure results when air leaving the space (return air) exceeds air entering the space (supply air). The resultant positive pressure in a closed room pushes air into unconditioned spaces, such as the attic and the interior and exterior walls. The negative pressure in the main body of the building pulls air from unconditioned spaces into conditioned spaces. This is known as "mechanically induced infiltration," since the negative pressure is created by the mechanical system.

If the system is balanced, there will be no pressure variations. This can be accomplished by installing dedicated returns; by the use of transoms; by undercutting the doors by approximately 3 inches; or by using one of a number of other alternatives. These include installing a jumper duct (a piece of duct that "jumps" over the partition); wall-to-wall grilles; or a baffled return air pathway (R.A.P.). The R.A.P. is a passive pressure-balancing system for use with ventilation or forced-air heating or cooling systems, where it is often impossible to provide both supply and return ducts to every room.

Styles of Pressure Relief

A jumper duct is created when a grille and collector box are installed in the ceiling on each side of the wall, and they are connected by a short section of ductwork that "jumps" over the top of the partition. The duct commonly has a 6-inch, 8-inch, or 10-inch diameter. The grilles are normally standard return air grilles. A jumper duct limits the physical connection between the rooms, providing a reasonable amount of privacy. But the common use of flexible ducting causes a substantial amount of back pressure, limiting the amount of air that can be supplied to the room.

The simplest approach to pressure relief is to cut opposing holes on either side of the wall and cover the openings with a return air grille. This is the least expensive approach, but the opening provides hardly more privacy than a hole in the wall. At the same time, if there continues to be a pressure imbalance, opening a hole to the wall cavity invites unwanted air flow into the wall cavity itself, which may be connected to other spaces.

Table 1. Test Results for Pressure Relief Devices (at 2.5 Pa pressure difference)

CFM	Dimension (in)	Area (in²)	Type*
36	6 in dia.	28	J
41	4 x 12	48	0
42	4 x 12	48	TW, S, RAP
45	4 x 12	48	TW
46	4 x 12	48	TW, S
49	8 x 8	64	0
52	12 x 6	72	0
56	12 x 6	72	TW, S, RAP
57	8 x 8	64	TW
58	8 x 8	64	TW, S, RAP
59	8 x 8	64	TW, S
60	12 x 6	72	TW
60	12 x 6	72	TW, S
61	1 x 30	30	U
62	8 in dia.	50	J
65	1 x 32	32	U
67	8 x 8	64	0
70	8 x 14	112	0
72	12 x 12	144	0
73	1 x 36	36	U
101	8 x 14	112	TW, S, RAP
107	8 x 14	112	TW
110	8 x 14	112	TW, S
119	12 x 12	144	TW
120	12 x 12	144	TW, S
120	12 x 12	144	TW, S, RAP

* J—Jumper duct S—Sleeve
0—High/low offset RAP—Baffled return air pathway
TW—Through-the-wall U—Door undercut

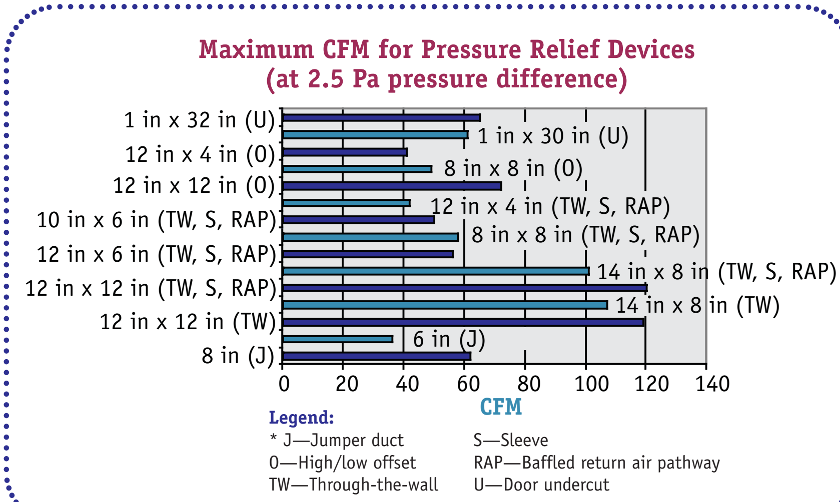


Figure 1. Using a sleeve assembly will reduce the possibility of inadvertent air flow into the wall cavity.

Adding a very short piece of rigid duct to the assembly provides a sleeve that effectively restricts the passage of air to moving from one side of the wall to the other. This reduces the unwanted flow problem, but it doesn't help much from the point of view of privacy. Adding a baffle (such as the R.A.P.) to the sleeve can reduce the transfer of light and sound and, if it is properly designed, will have little effect on the movement of air.

Another approach is to offset the holes on either side of the wall, cutting one high and one low. Like the jumper duct or the assembly with the light and sound baffle, this arrangement can enhance the privacy between the rooms. But the passage of air is limited to the dimensions of the wall cavity and, like the simple hole approach, a potential path is created for unwanted air flow into the wall cavity.

Testing

FSEC constructed a chamber that imitated the conditions of a room with an 8-ft high ceiling in order to test the different arrangements for pressure relief; testing began in May 2003. A Duct Blaster was connected to one end of the room with a flexible duct connection leading out of the room.

Tests were run for the 6-inch and 8-inch jumper ducts; four different configurations with various sizes of wall openings (straight through with and without sleeves, straight through with sleeve and privacy insert, and high/low offset using the wall cavity as a duct); and three different slots simulating three different-sized undercut doors (see Table 1 and Figure 1). The results in Table 1 are arranged in ascending maximum air flow needed to maintain the pressure differential at 2.5 Pa (0.01 inches WC). Figure 1 gives the same information in a different format.

When the performance of the slots under the door is compared to the performance of the openings with grilles, the deleterious effect of the grille becomes clear. The ratio of the CFM flow necessary to maintain a pressure difference of 2.5 Pa and the area of the opening of the slot is more than 2 to 1 (61 CFM through 30 in^2, for example), whereas with the openings with grilles it averages 0.83 to 1 (60 CFM through 72 in^2, for example). The jumper duct assemblies average 1.19 to 1.

In any calculation for the size of the through-the-wall assembly, the resistance of the grille becomes the critical factor in determining the size of the opening needed to optimize the flow. If a through-the-wall opening is to be used, to be sure that the opening is adequate to maintain no more than a 2.5 Pa pressure difference, the opening should be equal to or greater than the total air flow delivered divided by 0.83. (The following are meant as useful rules of thumb.)

Wall opening with grilles: CFM = 0.83 x area (in^2)

Slot (no grilles): CFM = 2 x area (in^2)

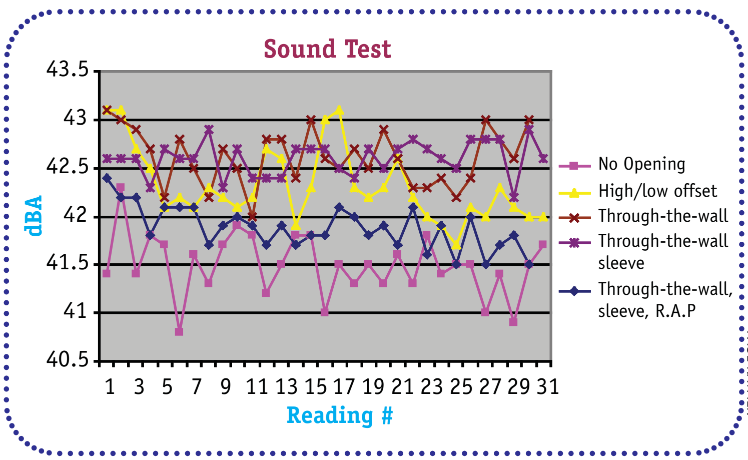
Flexible jumper duct with grilles: CFM = diameter^2

Although there appears to be no significant improvement in flow when a sleeve is used, a sleeve assembly will reduce the possibility of inadvertent air flow to and from the wall cavity itself. The high/low grille assembly using the wall cavity as a duct reaches its maximum flow at 72 CFM flow because it is limited by the cavity itself. Assuming a 3 $^1/_2$ inch x 14 $^1/_2$ inch wall cavity, increasing the opening of each grille beyond 112 in^2 does not significantly increase the flow of air through the assembly.

The best method to use at various air flows can be determined by calculating various air flows while maintaining the pressure difference at 2.5 Pa. Knowing how much air is delivered to the room tells us which method would be most suitable. For example, an 8-inch jumper duct could be used at air flows up to 60 CFM.

PAUL RAYMER

Pressure measurements were made using an inexpensive digital manometer.



PAUL RAYMER

Figure 2. This graph shows the comparative sound attenuating performance of four pressure approaches to a baseline noise level with no openings in the walls of the test room.

Since these transfer methods are additive, combining a 6-inch jumper duct with a 1-inch crack under a 30-inch door will allow a flow of 95 CFM to be delivered at 2.5 Pa, or combining a 12 inch x 12 inch R.A.P. with a 1-inch undercut would allow up to 181 CFM to be delivered. It should be noted that door undercuts are under builder, not HVAC, control, and that the actual dimensions of the cut are greatly affected by the thickness of the floor coverings.

If the designed flow of air to the room is unknown, an approximation can be made. If the grilles are rectangular or square, the CFM delivered to the room will be approximately twice the area of the grilles. (A 4 inch x 12 inch grille, for example, is likely to be designed to deliver about 100 CFM.) If the grille is round, square the diameter and double it. (An 8-inch round register, for example, is likely to have been designed to deliver approximately 130 CFM.)

Sound Solutions

For sound testing, we tuned a radio inside the test chamber to effectively create a standardized level of white noise of 57 dBA with the "door" closed. A sound meter was located outside the chamber on a stand 4 ft above the floor and 20 inches from the middle of the chamber wall surface.

Interior wall structures and hollow-core doors are marginally effective in masking average sound levels in a room. Consequently, none of these approaches could dramatically reduce the sound through the walls of the room. For example, the 30-second average white-noise sound through the walls of the room with no opening was 41.5 dBA. The 30-second average white noise sound through an 8 inch x 14 inch opening with a wall sleeve, grilles, and a

Neil Moyer installs the grille to test its performance.

sound-attenuating (baffled) insert was 41.9 dBA (see Figure 2).

Overall, slots under the door proved to be the worst for sound transfer and the through-the-wall installations with a privacy insert the best—better than the grilles offset in the wall (wall cavity) or the jumper duct approach.

Privacy is also affected by light transfer, even just enough transfer to indicate whether the light in the room is on or off. The wall cavity, jumper duct, and through-the-wall with baffled insert offer the most effective approaches to light attenuation. Again, the slot under the door is the worst.

Simple Solutions

Although the problem may seem complex, these pressure relief solutions are reasonably simple. And once the correct solution is installed, the HVAC system will perform better, the occupants will be more comfortable, and the risk of mold or deterioration in the walls of the house will be reduced. It's a small cost for a lot of benefit.

Both occupant comfort and building durability should be considered in determining the best approach. The simplest approach—cutting a hole and installing grilles on both sides of the wall—may result in occupant complaints and long-term building deterioration problems. The Florida code specifies a pressure difference of less than 2.5 Pa. There are many devices currently available (such as Bachrach draft-rite, Magnehelic, and Dwyer 460 Air Meter) that measure pressure differences at this level, and several of them can be purchased for less than $20. Equipped with such basic gear, an inspector should be able to determine if an acceptable level of pressure relief has been achieved.

Paul Raymer is the president of Tamarack Technologies, Incorporated, which is a principal team member of DOE's Building America Program and a member of the Home Ventilating Institute (HVI). The R.A.P. is a product manufactured by Tamarack Technologies, Incorporated.

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FOR MORE INFORMATION:

To learn more about the R.A.P. go to www.tamtech.com.

To learn more about FSEC and its buildings research, go to www.fsec.ucf.edu/bldg/BAIHP/index.htm.