U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Technology Solutions for New and Existing Homes

Building America Case Study

Overcoming Comfort Issues Due to Reduced Flow Room Air Mixing

PROJECT INFORMATION

Project Name: Reduced Flow Room Air Mixing Risks

Location: Various U.S. areas

IBACOS, *ibacos.com*

Application: Retrofit

Component: Heating and cooling equipment

Year Tested: 2013–2014

Climate Zone: All

PERFORMANCE DATA

Modeled Load Reduction (Btu/h)

Heating Load:
Pre-Retrofit: 80,000 Btu/h
Post-Retrofit: 25,000 Btu/h

Cooling Load:
Pre-Retrofit: 30,000 Btu/h
Post-Retrofit: 12,000 Btu/h

Modeled Airflow Reduction (Total CFM)*

Pre-Retrofit: 1,580
Post-Retrofit: 720

*Totals are based on the higher of the two flows for heating and cooling.

Building America U.S. Department of Energy SM

Many energy efficiency upgrades can reduce a home's heating and cooling loads. If the load reductions are great enough and the heating, ventilation, and air conditioning (HVAC) system warrants replacement, that system often is replaced with a more efficient, lower capacity system that meets the loads of the upgraded house. This new system no longer provides sufficient mixing and thermal comfort because the original ducts are now oversized, resulting in reduced air velocity and throw from the supply register.

The U.S. Department of Energy Building America team IBACOS studied when HVAC equipment is downsized and ducts are unaltered to determine conditions that could cause a supply air delivery problem and to evaluate the feasibility of modifying the duct systems using minimally invasive strategies to improve air distribution. The team performed calculations for unaltered ducts and resulting air velocities for a two-story 1960s house and examined air velocities and pressure changes with respect to various factors. Then, the team used a mocked-up duct and register setup to measure the characteristics of isothermal air—to reduce the effects of buoyancy from the observations—passing through the duct and leaving the register. Comfort issues might arise from inadequate terminal conditions for air velocity and throw, leading to poor room air mixing. This study looked at the effects on performance when the volumetric flow rate through a typical floor register was reduced by 50%, which reduced the supply register velocity and throw below that needed for thermal comfort and air mixing. (see Figure 1).

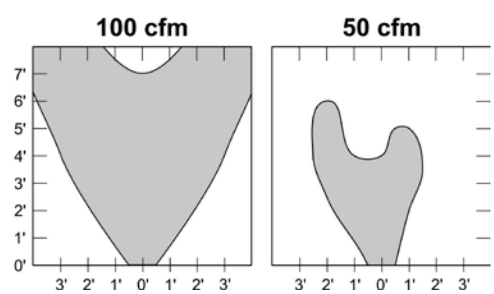

Figure 1. Throw and spread for (left) full and (right) 50% reduced volumetric flow. Shaded region represents steady state flow greater than 50 ft/min.

Increased Leakage Risk for Restricted Registers

Diminished air velocity at the tested volumetric flow rates through the original register area results in face velocity insufficient to provide adequate throw and spread. Reducing the net free area of the register by 50% increased both throw and spread. With volumetric flow of 50 cfm, reducing the net free area of the register net free area by 50% increased the face velocity to an acceptable range. Thus, the throws and spreads of the restricted register configuration improved.

The impact to duct leakage from restricting the register to increase face velocity and throw was also investigated. The team used the mocked-up duct system to simulate normal leakage and a duct with a 2-in. hole. The results indicate that restricting the register 50% resulted in a 13 Pa increase in pressure in the duct at 100 cfm. Increasing the register throw by decreasing the net free area increases the duct static pressure and could contribute to increased duct leakage.

For more Information, please see the Building America report, *Distributed and Room Air Mixing Risks to Retrofitted Homes* at: *buildingamerica.gov*

Image credit: All images were created by the IBACOS team.

For example, if a 4×8 air supply outlet is properly selected for sufficient throw and noise criteria at 500–700 ft/min face velocity when delivering 110 cfm, that same supply outlet delivering half the volumetric flow (i.e., 55 cfm) falls below the manufacturer's recommended velocity range for sufficient throw and spread to deliver room air mixing at the 50 cfm volumetric flow condition (see Figure 2). However in Figure 2B, the velocity and throw are increased by reducing the net free area of the register, an easily accomplished noninvasive solution.

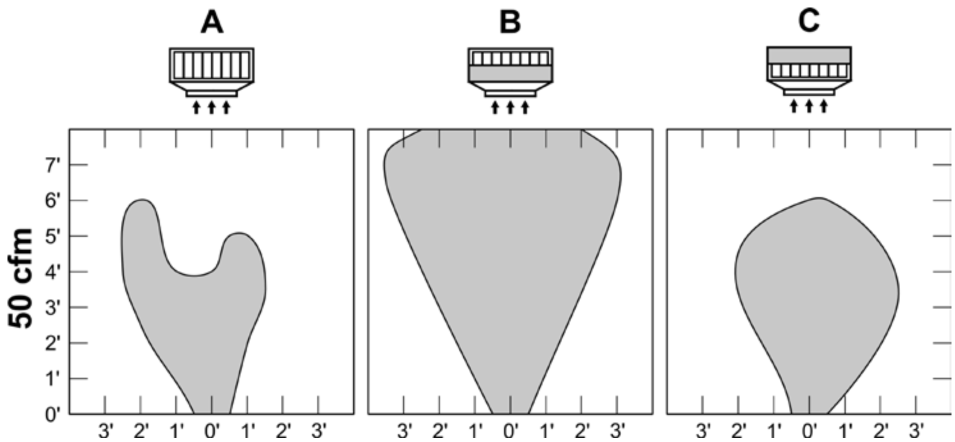

Figure 2. Comparative throw and spread characteristics with reduced net free area: A = fully open; B = 50% blocked in-board; C = 50% blocked out-board. Shaded region represents steady state flow greater than 50 ft/min.

ASHRAE Fundamentals 2009, Section 33.16 states, "Higher supply velocities produce better room air diffusion than lower velocities, but velocity is not critical in selecting these units for heating." The second half of that statement—that velocity is not critical—sometimes is used in defense of ignoring supply outlet selection. Section 33.16 of ASHRAE Fundamentals is based on University of Illinois work from the late 1950s using relatively large volumes of air for heating mode only. Even in cold climates, houses have a mixed load where the cooling load air velocities dominate the duct design and register sizing. Thus, in typical houses today, supply air velocity is important for comfort and should be considered when retrofitting a house and its HVAC system.

Lessons Learned

- The location of the reduced net free area register restriction affects performance.
- Throw and spread of the restricted register configuration improve when the register net free area is properly reduced.
- As long as the combined change in air velocity and net free area of the register generate the same or less pressure inside the duct, duct leakage will not be exacerbated.

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