Building America Case Study

Mockup Small-Diameter Air Distribution System

PROJECT INFORMATION

Small-diameter home-run heating, ventilating, and air-conditioning manifold system for low-load homes

Testing Location: IBACOS lab

Capacity: 1–2.5 tons

Climate Zone: Any

PERFORMANCE DATA

Total airflow: 160–180 CFM

Average airflow per duct: 18 CFM

Power: 25–40 watts

Static pressure: 40–55 Pa

Duct diameter: 2 in.

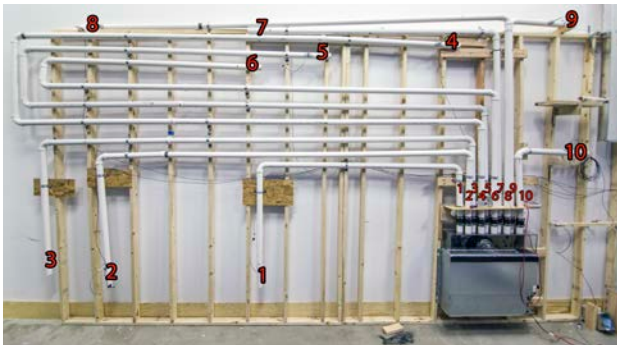
Minimum duct length: 5 ft

Maximum duct length: 36 ft

The U.S. Department of Energy's Building America research team IBACOS explored the performance of a small-diameter modular air distribution system with home-run ductwork. The team studied the airflow characteristics of a mockup duct system connected to a commercial ducted mini-split heat pump in the IBACOS Pittsburgh lab. The system used small-diameter plastic ductwork to provide a low-resistance airflow channel; the ductwork was easy to assemble and reduced duct leakage. Static pressure in the manifold chamber helped to provide balanced airflow out of each duct run.

Previous work by IBACOS and other Building America teams has shown that for all but the simplest house geometries it is necessary to supply conditioned air to each thermal zone of the house. Homebuilders and heating, ventilating, and air-conditioning system installers need a way to reliably supply the correct amount of conditioned air to individual rooms without performing complex duct system design calculations.

Current practices for designing and installing air delivery systems have many possible failure modes and comfort problems, which include errors in load calculation and system design and incorrect system installation and commissioning. To determine if the home-run manifold system can reduce the risk of some of these failure modes and comfort issues, IBACOS measured the air velocity, static pressure, and power draw of the mockup duct system.



This mockup of the small-diameter modular air distribution system that would be found in the chosen floor plan (upper left diagram on this page) contains the correct number and location of 90° bends, as well as the proper length of ductwork to fit the dimensions of the floor plan.

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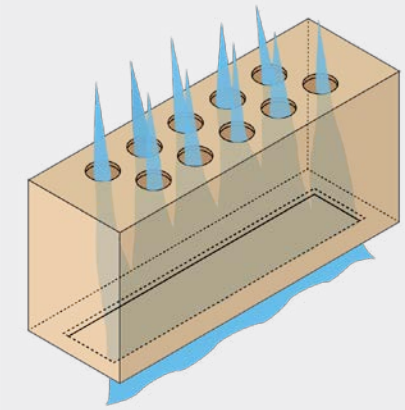
Mockup House Characteristics

- International Energy Conservation Code Climate Zone 2
- Number of thermal zones studied: 5
- Square footage studied: 1,493 ft^2 (second floor only)
- Heating load: 8,280 Btu/h
- Cooling load: 10,913 Btu/h
- Zero Energy Ready Home:
  - R-30 attic
  - R-13 walls
  - U-0.35 windows.

Test Box Geometry and Hole Location

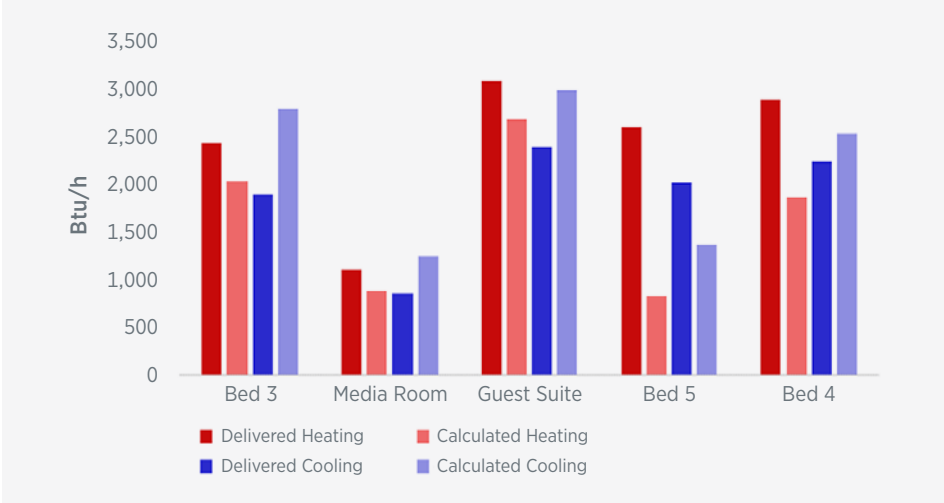
The study began with 10 mockup box configurations, and the team chose the optimum box geometry and hole locations for analysis. The box geometry shown below has a wide inlet to match the layout of the outlet holes. Measured results with equal-length duct runs show that the airflow differences through each hole are ±5%. When a mockup duct layout is connected, the airflow differences range from +34% to –18%.



For more Information see the Building America report *Performance Analysis of a Modular Small-Diameter Air Distribution System* at *buildingamerica.gov*.

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

A mockup duct system was designed to fit the floor plan, which represents the second floor of a 3,600-ft^2 home built on a slab in a hot climate. Measured data from the mockup system indicate that sufficient airflow can be achieved using the manifold system. In a low-load home, this system can provide the necessary heating and cooling airflows while making it easy to bring the ductwork into conditioned space. In the design method of additive airflow calculation, the designer determines the airflow needed to meet the thermal load and then simply picks the number of set cubic-feet-per-minute (CFM) duct runs to meet that airflow. This method can provide a reasonable range of airflow values.



Using measurements obtained from the mockup setup, delivered heating and cooling were obtained as shown in the graph above. Demanded heating and cooling were determined using Wrightsoft Version 13.0.10. The graph shows a breakdown of the delivered and demanded heating and cooling for each heating temperature rise through the coil of 50°F and a cooling temperature change of 25°F.

Lessons Learned

- The Air Conditioning Contractors of America Manual D overestimates resistance when using smooth plastic pipe for ducts.
- Short and compact duct layouts result in an efficient system for small-diameter ductwork.
- Box geometry and hole location can have a significant impact on the balance of the system. The box for the mockup case used the optimum geometry and hole location that provided the most uniform airflow through each duct.
- Commercially available ducted mini-split heat pump blowers may provide adequate airflow through the duct system but should be oversized to accommodate increased static pressure.

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