



BUILDING AMERICA TOP INNOVATIONS HALL OF FAME PROFILE

INNOVATIONS CATEGORY:

- 2. House-as-a-System Solutions
- 2.1 New Homes with Whole-House Packages

Moisture and Ventilation Solutions in Hot, Humid Climates: Florida Manufactured Housing

Duct leakage was a key factor in moisture damage in manufactured homes in humid climates.

Building America researchers visited 24 manufactured home factories between 1996 and 2003 and substantially mitigated moisture problems while improving energy efficiency. One manufacturer reported zero moisture-related issues in 35,000 homes built after implementing Building America recommendations.



BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science – The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

Research by Building America diagnosed the causes and prescribed a cure that dramatically reduced moisture problems in manufactured housing in Florida.

In the late 1990s, Building America researchers at the Florida Solar Energy Center (FSEC) worked with manufactured home builders to diagnose moisture problems in homes in Florida. Moisture issues were so severe that in some homes researchers could push their fingers through the saturated drywall. Using a whole-house diagnostic approach, researchers determined that the primary source of the moisture was humid air that was drawn into the home through leaky ducts located under the floor or in uninsulated, vented attics.

Between 1996 and 2003 researchers made 39 visits to 24 factories of six HUD code home manufacturers interested in improving the energy efficiency of the homes. Researchers measured total duct leakage and/or duct leakage to the outside in 101 houses representing 190 floors (some homes were double wide consisting of two floors). Most homes had mastic-sealed ducts but one-third of the duct systems were sealed with tape. Results of the studies showed that the duct leakage goal of $\leq 6\%$ total duct leakage was achieved by a much higher percentage of homes with mastic-sealed ducts than with tape-sealed ducts. The researchers observed that mastic provided a much more durable seal than did tape.

The researchers identified several issues with duct installation at the factories: leaky supply and return plenums, misalignment of ducts and openings, sloppy free-hand cutting of holes in duct board and sheet metal, insufficient connection area at joints, mastic applied to sawdust-covered surfaces, insufficient or missing mastic, loose tie straps on flex duct connections, incomplete tabbing of fittings, and improperly applied tape.

“Based on research with Building America, Palm Harbor Homes implemented duct system testing and increased return air pathways from bedrooms to 50 inches² per 100 cfm of supply air company wide. Since this implementation started, Palm Harbor has manufactured 35,000 homes and has had no incidents of moisture-related issues in homes installed in hot-humid climates. Additionally, air flow issues have been all but eliminated.”

Bert Kessler, Vice President of Engineering,
Palm Harbor Homes

The researchers made several recommendations regarding the ducts: set a duct tightness target of $\leq 6\%$ total duct leakage or $\leq 3\%$ duct leakage to the outside, seal all joints with mastic, accurately cut holes and fully bend all tabs at collar and boot connections, tighten strap ties with a strap-tightening tool, and provide return air pathways from bedrooms to main living areas. Researchers also provided the manufacturers with recommendations regarding HVAC system efficiency, improved windows, adding insulation, and air sealing, especially at the marriage line of double-wide units.

When the recommendations were implemented in two homes in a demonstration of four homes, the two homes that were mastic sealed had less than half the air leakage of those sealed with tape (McIlvaine et al. 2003).

Duct Tightness Results in Demonstration

Home	CFM25 Total
Control Home	118
Control Home	126
Energy Home	51
Healthy Home	79

In addition to providing these research findings and recommendations, Building America followed through with the manufacturers, providing technical assistance with implementing the changes and conducting return visits to see that recommendations were implemented properly.

The manufacturers noticed several benefits from the duct system improvements. The moisture problems disappeared, indoor air quality was improved, and utility bills were reduced. Homeowners could also expect longer lasting mechanical equipment, more durable homes, and reduced home maintenance. Manufacturers could expect reduced callbacks and warranty issues, and higher customer satisfaction. One manufacturer, Palm Harbor, reported zero moisture-related issues in 35,000 homes built after implementing the recommendations. Palm Harbor continues to implement these and other energy-efficiency improvements in its homes meeting ENERGY STAR, LEED, and other green-built program national and regional program requirements in many parts of the country.



FSEC shared the lessons learned in manufactured housing with site builders including Tommy Williams Homes of Gainesville, Florida, who implemented measures like mastic sealing ducts, installing properly sized high-efficiency HVAC, thoroughly air sealing the building envelope, using water-resistant exterior finishes, and implementing positive pressure ventilation to keep out humid air.

REFERENCES

McIlvaine, J. D Beal, N Moyer, D Chasar, and S Chandra. 2003. *Achieving Airtight Ducts in Manufactured Housing*, FSEC-GP-234-03, Florida Solar Energy Center, www.fsec.ucf.edu/en/publications/pdf/FSEC-GP-234-03.pdf

Moyer, N, D Beal, D Chasar, J McIlvaine, C Withers, and S Chandra. 2001. *Moisture Problems in Manufactured Housing: Probable Cause and Cures*, FSEC-GP-212-01, Florida Solar Energy Center, www.fsec.ucf.edu/en/publications/pdf/FSEC-GP-212-01.pdf