Interim Report:

Field Study and Analytical Assessment of Sealed Attics Conducted for the State of Florida

Submitted to:

Florida Building Commission
Department of Business and Professional Regulations
Building Codes and Standards
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1. INTRODUCTION

Transforming residential attics into a semi-conditioned space by sealing it with open-cell spray polyurethane foam (ocSPF) or closed-cell spray polyurethane form (ccSPF) has gained approval among builders and building code officials. However, there is an educational gap in technology transfer to the builder. Field data demonstrating successful implementation in all climates are sparse. The more the support and the more the knowledge provided to the building community, the better the acceptance of code changes by the building community. The 2010 energy conservation supplement to the Florida Building Code (FBC) provided measures for putting the supply and return ducts inside the building thermal envelope (Section 403.2, 2010 of FBC). However the code change while intending to minimize risk and improve efficiency may be counterproductive.

Field studies conducted by ORNL in a hot, humid climate investigated the thermal and hygrothermal performance of ventilated attics and non-ventilated semi-conditioned attics sealed with open-cell spray polyurethane foam (ocSPF) and with closed-cell spray polyurethane foam (ccSPF) insulation[1]. In the ventilated attics the relative humidity drops as the attic air warms; however, the opposite was observed in the sealed attics. Peaks in measured relative humidity in excess of 70 to 90% were found to occur from solar noon until about 8 PM on hot, humid summer days. Moisture pin measurements made in the wood roof sheathing and absolute humidity sensor data from inside the foam and from the attic air suggest that moisture is being stored in the foam and in the sheathing of the sealed attics[2].

1.1 PURPOSE

The purpose of this project is to monitor two single-family residential structures constructed with sealed attic systems and document the air tightness of the home, the duct system and the sealed attic. An additional two homes will also be monitored using funds provided by the Florida Roofing and Sheet Metal Contractors Association (FRSA). The moisture content of the wood roof decks, the indoor ambient, outdoor ambient and attic ambient relative humidity and temperature will be recorded for a 12-month period. The data from this project will be used to check for moisture intrusion and storage in attics sealed with spray foam insulations.

The Florida Roofing and Sheet Metal Contractors Association (FRSA) has supported the Roofing Technical Advisory Committee (TAC) of the Florida Building Commission in finding interested homeowners willing to participate in the demonstration of their homes. A one-page Flyer was prepared to help advertise the campaign (see Appendix). The FRSA also made a $40,000 donation to the project through the University of Florida Foundation in order to expand the project to 4 home demonstrations and to support field acquisition and reduction of field data beyond the project end data of June 30, 2016. Acquisition will extend through the critical hot and humid summer months when moisture accumulation is expected to be most prevalent.

This Interim Report provides the status of the project. Contract between the University of Florida (UF) and the Florida Building Commission (FBC) was approved January 2016, 5 months after FBC approved the project. Subcontract between ORNL and UF was approval by the ORNL DOE office 2/17/2016. Despite contract delays, the setup of the FL homes, characterization of the home's air tightness, commissioning of the data acquisition and the reporting of some field data will be completed 06/06/2016.

[1] Miller, Railkar, Shiao and Desjarlais. 2016. "Sealed Attics exposed to two Years of Weathering in a Hot and Humid Climate." in Thermal Performance of the Exterior Envelopes of Buildings, XII, proceedings of ASHRAE THERM XII, Clearwater, FL., Dec. 2013.
[2] Lstiburek, J. 2016. Venting Vapor. ASHRAE 4 6 Journal, August 2015.

1.2 OBJECTIVE

The goal of the project is to document the risk potential and the effects upon occupant comfort in Florida homes that are sealed using ocSPF or ccSPF. Four residential field demonstrations will be setup across the state of Florida to acquire field data. The project will focus on Florida homes that have the attic sheathing, gables, eaves and soffits sealed using open-cell spray polyurethane foam (ocSPF), closed-cell spray polyurethane foam (ccSPF) insulations or similar sealed system. Attics sealed with blown fiber insulations are also candidate systems for the study. Field data will be reduced and used to assess the potential of moisture storage in the foam which can lead to structural damage to the sheathing. The storage of moisture has also been found to affect the level of the indoor relative humidity levels causing it to exceed prescription in ASHRAE Standard 55.

2. SCOPE OF WORK

- Select two homes identified as having sealed attics. Preference is to find sites across the ASHRAE climate zones 1 and 2 in Florida.
- Conduct homeowner's survey to document their experience with sealed attics.
- Develop test plan for documenting and conducting each field demonstration
- Develop a list of activities for homeowners to understand work conducted at their residence and conduct blower door and duct blaster tests to determine the air exchange rate for the home, the duct and the attic.
- Determine homeowner occupancy habits through questionnaire administered by UF.
- Install mini-data logger in attic complete with instrument and internet connections

2.1 <u>Task 1: Conduct Survey of FL Homes and Select Candidate Field Sites</u>

Milestone:

- Develop questionnaire.
- Survey of homes in Florida identified with sealed attics. Results of homeowners' survey documented and used for selecting demonstration sites.
- Select four demonstration homes across the ASHRAE climate zones 1 and 2 in Florida.

Deliverable:

- Report: Survey of homeowners identified with homes fitted with sealed attics. Climate, salient features of the home, sealed attic characteristics, HVAC features and heat pump tonnage and the homeowner habits including indoor comfort settings for the thermostat will be reported.

Progress To Date:

- Candidate homes identified for field study:
    - Homeowner#1: Gainseville, FL
    - Homeowner #2: Orlando, FL
    - Builder: Tampabay, FL; 2 adjacent homes;
        - House #3: ocSPF insulation,
        - House #4: ccSPF insulation
    - Homeowner #5: Bartow, FL
    - Homeowner #6: Monticello, FL
    - Homeowner #7: Venice, FL
    - Homeowner #8: Lakeland, FL

Remaining Tasks:
- FRSA and ORNL will finalize the selection of 2 homes for field testing
- Prepare report on the selected homes

2.2 Task 2: Setup Four Field Demonstrations and Collect Field Data

Thermistors, absolute humidity probes and moisture pins will be installed on the adjacent roof decks to analyze the in situ performance of the attics. The sensors will be placed in a near-identical pattern as possible for each home to provide consistent comparisons among the attics under field study. Figure 1 shows the placement of sensors. Absolute (temperature and humidity probes placed in vapor permeable sack)[3] will measure the outdoor, the indoor and the attic ambient temperature and relative humidity. Absolute probes will also be placed on the foam's surface and attached to the underside of the roof sheathing. Data will be acquired by a Campbell Scientific data logger and the data retrieved by wireless modem router (Table 1.0). ORNL is well versed in the setup of field demonstrations for measuring the thermal and hygrothermal performance of building enclosures, will fabricate instruments, procure the DAS systems and will share their techniques with UF as an educational benefit to students.

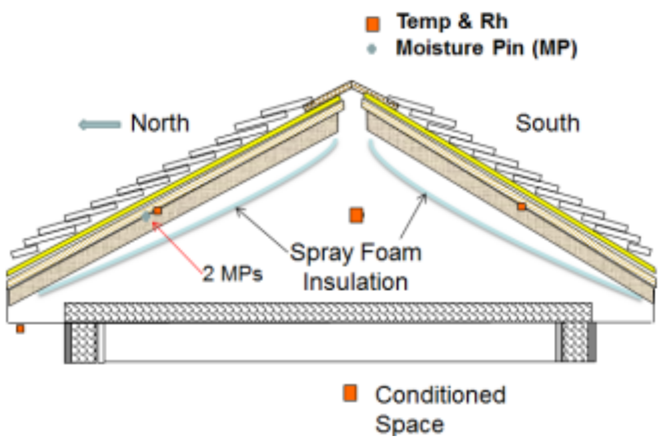

Figure 1: Cross-Section of sealed attic showing placement of thermistors, relative humidity sensors and moisture pins in demonstration homes. Spray foam applied to all interior surfaces of the attic.

Table 1. Instrument list for Data Acquisition System.

Instrument	Description	Number	Max Signal
Thermistor	Honeywell model 192-103-LET-A01)	5	10 Vdc
Relative humidity	Honeywell HIH-4000 Series	5	0.2 Vdc
Moisture pin	Shop fabrication	2	1 MΩ
Data Acquisition System	**Description**	**Number**	
Data Logger	Campbell Scientific Model CR6	1	
Ethernet to Wireless Adapter	Netgear N300	1	

[3] Straube, J., Onysko, D. and Schumacher, C. 2002. "Methodology and Design of Field Experiments for Monitoring the Hygrothermal POerformance of Wood Frame Enclosures," Journal of Building Physics, 2002, v.26:123. Web: http://jen.sagepub.com/content/26/2/123

Milestone:

- Develop test plan for documenting and conducting each field demonstration
- Develop a list of activities for homeowners to understand work conducted at their residence Conduct blower door and duct blaster tests to determine the air exchange rate for the home, the duct and the attic.
- Determine homeowner occupancy habits through questionnaire administered by UF
- Install mini-data logger in attic complete with instrument and internet connection.

Deliverable:

- Report: Test Setup and Reduced Data for Florida Homes Studied for Thermal and Hygrothermal Performance of Sealed Attic.

Progress To Date:

- Information gathered on wireless linked data acquisition system
- Students at University of Florida have worked with ORNL to learn about conducting the blower door and duct blaster tests (see Appendix).
- Instrumentation options identified by University of Students through assistance of ORNL

Remaining Tasks:

- Final Report due on 30 June 2016.

Revised Project Milestones

Task	*Milestone*	*Completion Date*
Task 1. – Conduct Survey of FL Homes and Select Candidate Field Sites		
	Select 4 homes across the various climate zones in Florida	**March, 2016**
Task 2. – Setup 2 Field Demonstrations and Collect Field Data		
	Determine air exchange rate for home, duct and attic	**April, 2016**
	Commission data acquisition system per home	**April, 2016**

Task	*Deliverables*	*Completion Date*
Task 0. – Contract Approved by ORNL and UF For Collaborative Work		
	Signed Research Contract submitted to FBC	**Pending**
Task 1. – Conduct Survey of FL Homes and Select Candidate Field Sites		
	Interim Report describing the salient features of homes identified with sealed attics	**March 30, 2016**
Task 2. – Setup Field Demonstrations and Collect Field Data		
	Preliminary report on Field Setup and Reduced Field Data for the 1st Two Monitoring Sites **Preliminary report on Field Setup and Reduced Field Data for the 2nd Two Monitoring Sites** **Final Report**	**April 30, 2016** **May 15, 2016** **June 13, 2016**

3. OUTCOME

A Go/noGo decision will be made based on the results of the field study by the FBC upon recommendation of the Roofing TAC. A Go decision will provide the opportunity to exercise a computer toolkit (developed by ORNL) to compare analytical models against empirical findings of moisture accumulation, thereby validating the ORNL compute toolkit.

Field Study and Analytical Assessment of Sealed Attics Conducted By ORNL and UF for the State of Florida

4. OPPORTUNITY

Florida homeowners whose homes have the attic sealed with spray polyurethane foam or blown fiber insulation are welcome to participate in a 1-year field study with the University of Florida (UF) and the Oak Ridge National Laboratory (ORNL). In return, the homeowners will receive valuable information documenting the efficiency of their home. An assessment of the Home Energy Rating Score (HERS) will be provided as well as the results of blower door tests, the results of guarded blower door tests and duct blaster tests. These tests will reveal the air tightness of the home, the air tightness of the sealed attic and the air tightness of the duct system. Portable data loggers will be installed in each sealed attic. The loggers will measure air temperature and relative humidity of the outdoor ambient, the indoor ambient and the attic. The roof sheathing temperature and humidity and roof sheathing moisture content will also be recorded hourly for the duration of the study, Figure 1. All findings will be documented in a report that each participating homeowner can use to make informed economic decisions for improving the efficiency of their home**.**

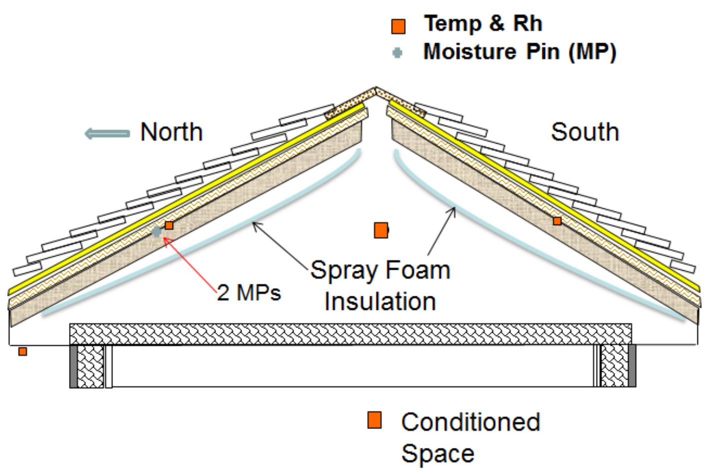

Figure 1. Cross-section of sealed attic showing placement of instruments in demonstration homes where the attic is sealed with spray foam insulation.

4.1 OBJECTIVE

UF and the ORNL will field test 4 homes located in northern, central and southern Florida. The homes will have the attic sealed using open-cell spray polyurethane foam (ocSPF), closed-cell spray polyurethane foam (ccSPF) or blown fiber insulations. A key goal of this study is to document the thermal and hygrothermal performance of the sealed attics for the purpose of improving the cost effectiveness, durability, moisture resistance and efficiency of home construction. Results of the study will provide information for the Florida Building Commission (FBC) to use in strengthening the Florida building code.

4.2 BACKGROUND

The Florida Roofing and Sheet Metal Contractors Association (FRSA) is an alliance of companies actively engaged in upholding excellence in the roofing contracting business in the State of Florida. The FRSA and the Florida Building Commission (FBC) are sponsoring the UF and the ORNL to setup four Florida homes as field demonstrations to highlight and improve workmanship in residential construction.

5. APPENDIX B

5.1 Blower Door Test

The blower door test is used to quantify the air leakage (airflow) that occurs through a building envelope system of a house or commercial structure. Typically, blower door tests are performed with all doors and windows closed, and with air vents sealed. A blower or fan is used to slightly depressurize the house which measurements are taken of the airflow rate (in CFM). The airflow rate is then related to the square footage (area of the conditioned space) and the overall volume of the house.

The blower door apparatus consists of metal frame and nylon panel sized to fit into and seal an exterior door opening, a blower or fan set within the nylon panel, two flow rings and a DG-700 air flow gauge and a differential pressure gauge. The blower is operated with the fan on to generate between 30 to 50 Pascals. The airflow rate is measured at constant pressure. The blower door also allows the user to locate and identify gross areas of leakage in the house, but feeling the air flow at or near cracks and joints through the building envelope.

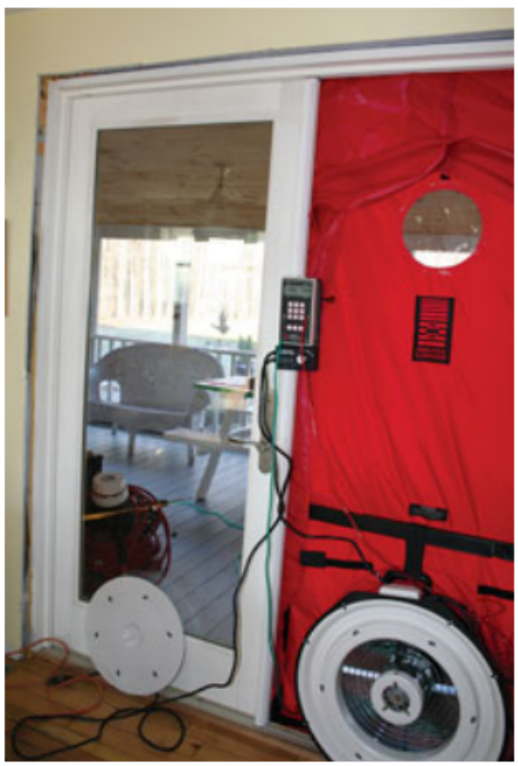

Figure 3: Blower Door Test

5.2 Duct Blaster Test

Studies suggest air duct leakage account for as much as 25% of total house energy loss, and in many cases has a greater impact on energy use than air infiltration. Leaks can cause conditioned air to be dumped directly outside or in the attic or crawlspace rather than delivered to the building. The impact on a particular building will depend on the size of the air duct leak, its location and whether or not the leak is connected to the outside.

The Duct Blaster test apparatus consists of a Duct blaster fan, a DG-700 Digital Pressure Gauge and a flexible duct. The DG-700 gauge has two separate measurement channels which allows to simultaneously monitor and display the duct system pressure and the airflow through the Duct Blaster fan during the duct airtightness test. The Duct Blaster fan is controlled by a variable fan speed controller. The 12 ft long flexible extension duct is used to connect the Duct Blaster fan to the duct system of the building.

The round transition piece connects to either the fan exhaust flange (pressurization testing) or the fan inlet flange (depressurization testing), while the square transition piece can be attached directly to the air handler cabinet. The extension duct allows the Duct Blaster fan air flow to be easily directed to the duct system.
The Total Leakage Pressurization Test is used to measure the duct leakage rate in the entire duct system when the duct system is subjected to a uniform test pressure. The Total Leakage Pressurization Test measures both duct leakage to the outside of the building (e.g. leaks to attics, crawlspaces, garages and other zones that are open to the outside). The air flow through the Duct Blaster fan required to pressurize the duct system to the test pressure is the measured total duct leakage rate.

Figure 4. Minneapolis Duct Blaster System

6. REFERENCES

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