Interim Report for Project Entitled:

Impact of Spray Foam Insulation on Durability of Plywood and OSB Roof Decks

Performance Period: 10/14/2014 – 6/30/2015

Submitted on

February 15, 2015

DRAFT

Presented to the

Florida Building Commission
State of Florida Department of Business and Professional Regulation

by

Forrest J. Masters, Ph.D., P.E., masters@ce.ufl.edu, (352) 392-9537 x 1505, Principal Investigator
Kurtis R. Gurley, Ph.D., kgurl@ce.ufl.edu, (352) 392-9537 x 1508
David O. Prevatt, Ph.D., P.E. (MA), dprev@ce.ufl.edu, (352) 392-9537 x 1498
Trent Vogelgesang, Graduate Research Assistant

Designated Project Leader: David O. Prevatt

Engineering School for Sustainable Infrastructure & Environment

UF | UNIVERSITY of FLORIDA

Table of Contents

1. Relevant Sections of the Code (and Related Documents)

- R806.4 – Florida Building Code – Residential Buildings
- 611.7.1.2 – Florida Building Code – Existing Building
- 606.3 – Florida Building Code – Existing Building
- TAS 110 Testing Application Standard – Florida Building Code
- ICC-ES AC 377 – Acceptance Criteria for Spray Polyurethane Foam
- ASTM C1029

2. Progress Summary

The first project goal is to create a state-of the art literature review on the state-of-the-art review on the properties and field performance of spray applied foam insulations (open cell and closed cell foams), and related causes of water leakage and deterioration of wood roof decks. The research required the formation of an Advisory Panel of experts to advise the research team. A list of Advisory Panel Members and list of persons invited to the join the Panel is provided in Appendix A.

A primary question in the researchers' minds is to determine whether a reasonable concern for moisture buildup in wood decks in homes in Florida that have spray-applied foam insulations on their roof decks. Through discussion of the Advisory Panel it was felt that a survey of construction professionals (not in current scope) might be valuable tool in determining the awareness by the industry on the issues discussed. The research team has spent a great part of the time to locate and review peer-reviewed papers, and authentic reports pertinent to this topic. The researchers have preliminarily identified a list of nearly 70 peer-reviewed papers, reports and other information. Some of the recurring subjects within our literature review include:

- Properties of wood and spray foam
- Early studies on moisture movement
- Experimental Research
- Numerical Analysis of Hygrothermal Movement in Roof Decks
- Health Related Issues
- Forensic Studies of Roof Systems

Other categories will be added to the final report. A complete list of the collected documents is included in Appendix A. The literature review itself, is currently 30% complete. The Advisory Panel members continue to advise the research team and assist in identifying additional sources of literature to be considered by the Roofing TAC.

The research team held a two-day Advisory Panel Meeting in Orlando FL in 21st and 22nd January 2015 attended by 18 participants (in person and via web conferencing), to discuss the research objectives, and provide direction to the research team. Notes of meetings were circulated and the comments of the Advisory Panel members are being incorporated into the report. A second Advisory Panel Meeting was held on 12 February 2015 to review the progress and development of the experimental research plans and the work on the research team. A second project goal is to conduct field and experimental investigations into the relative drying characteristics of mock-ups of typical wood-spray foam composite structures that are used in Florida residential construction. Through discussion with the Advisory Panel, three experimental research directions are proposed:

- Relative-drying rates (see Experimental Research Plan 3a): Test parameters included type of wood deck (OSB and plywood), type of spray foam (open-cell vs. closed cell), and type of roof underlayment (1 layer, and 2-layer 30 lb building felt underlayment, and self-adhering bituminous membrane). The experimental research requires the construction of a temporary hot-box and the purchase of radiant heaters to provide the heat source for the roof specimens. The radiant heaters have been identified and will be purchased for the project by February 2015. Most of the

instrumentation for measuring relative humidity and temperatures of the specimens will be used from UF's existing inventory.

- Moisture spread from Point-Source Water Leakage (see experimental Research Plan 3b): Test parameters include type of wood deck (OSB and plywood), type of spray foam (closed cell vs. none), and type of roof underlayment (2-layer 30 lb building felt underlayment and self-adhering bituminous membrane). The experimental research requires mono-sloped roof deck specimens and water source of dripping water leak. The study will compare the se roof samples will be monitored over time to develop a relationship between the moisture spread (gravimetric weighing) and timescale respectively.
- Field Survey of roof constructions with installed spray foam insulations (see Experimental Research Plan 3c): The Advisory Panel recommended reducing this scope because given the short time available it may not be as helpful to the overall objectives. The PI proposes a modified to include few homes in the study (reduce from five to two) but still include the interviews with the homeowner/occupant as to the comfort and thermal efficiency and risk perception of the installations. The numerical modeling of hygrothermal performance may provide limited results given that some the researchers. Efforts are underway to develop a complementary numerical modeling that matches the experimental research plans described in ERP 3a and ERP 3b.

3. Description of Issues

- Survey questions of Member Associations. Work with Advisory Panel to augment list
    - FRSA (Mark Zehnal), FBHA (Arlene Stewart), ARMA (Mike Fischer)
- Further refinement of the ERPs
- Update demographics on volume of foam (board feet installed) roof deck construction in Florida and the US as a whole SPFA (Rick Duncan)was deemed crucial
- Florida Building Code review on chronology of changes related to spray foam
- Definitions of terms relating to attic roofing systems.

4. Recommendations for the Code

No recommendations at this stage

5. Deliverables

- A report providing a state of the art literature review and conclusions, including technical information on the problem background, results and implications to the FL Building Code will be submitted to the Program Manager by June 1, 2015.

- Summary of experimental research, objectives, methods, results and recommendations for future investigations.

- A breakdown of the number of hours or partial hours, in increments of fifteen (15) minutes, of work performed and a brief description of the work performed. The Contractor agrees to provide any additional documentation requested by the Department to satisfy audit requirements.

6. Appendices:

6.1. Appendix A: Cited Literature

Literature Review:
Impact of Spray Foam Insulation on Durability of Plywood and OSB Roof Decks
Updated: 02/11/15

1. Saber, H. H., Maref, W., Elmahdy, A. H., Swinton, M. C., and Glazer, R. (2010). "3D thermal model for predicting the thermal resistance of spray polyurethane foam wall assemblies." *National Research Council Canada*.

2. Bomberg, M. T., and Lstiburek, J. W. (1998). *Spray polyurethane foam in external envelopes of buildings*, CRC Press.

3. Booth, R. J., DeRushie, C., and Liu, K. (2002). "Protection of foam plastic thermal insulation in low sloped roofing systems." *Journal of Thermal Envelope and Building Science*, 25(4), 255-274.

4. Carll, C., and Wiedenhoeft, A. C. (2009). "Moisture-related properties of wood and the effects of moisture on wood and wood products." *Moisture control in buildings: the key factor in mold prevention, 2nd ed. West Conshohocken, PA: ASTM International*, 54-79.

5. Datin, P. L., Prevatt, D. O., and Pang, W. (2011). "Wind-uplift capacity of residential wood roof-sheathing panels retrofitted with insulating foam adhesive." *Journal of Architectural Engineering*, 17(4), 144-154.

6. Derome, D., and Fazio, P. (2000). "Large-scale testing of two flat roof assemblies insulated with cellulose." *Journal of Architectural Engineering*, 6(1), 12-23.

7. Hendron, R., Anderson, R., Reeves, P., and Hancock, E. (2002). *Thermal performance of unvented attics in hot-dry climates*, National Renewable Energy Laboratory.

8. Huang, Y.-C. T., and Tsuang, W. (2014). "Health effects associated with faulty application of spray polyurethane foam in residential homes." *Environmental Research*, 134(0), 295-300.

9. Jerman, M., and Cerny, R. (2012). "Effect of moisture content on heat and moisture transport and storage properties of thermal insulation materials." *Energy and Buildings*, 53, 39-46. `

10. Lstiburek, J. (2002). "Moisture control for buildings." *ASHRAE journal*, 44(2), 36-41.

11. Lstiburek, J. W.(1993) "Humidity control in the humid south." ,*Proc., BETEC Workshop Proceedings*, 1-14.

12. Parker, D. (2005). "Literature review of the impact and need for attic ventilation in Florida homes." *Florida Solar Energy Center-Revised Draft Report, FSECCR-1496-05, submitted to the Florida Department of Community Affairs*.

13. Prevatt, D., McBride, K., Roueche, D., and Masters, F. (2014). "Wind Uplift Capacity of Foam-Retrofitted Roof Sheathing Panels Subjected to Rainwater Intrusion." *Journal of Architectural Engineering*, B4014001.

14. Rudd, A. F., and Lstiburek, J. W. (1998). "Vented and sealed attics in hot climates." *TRANSACTIONS-AMERICAN SOCIETY OF HEATING REFRIGERATING AND AIR CONDITIONING ENGINEERS-ASHRAE*, 104, 1199-1212.

15. Smits, G. F. (1994). "Effect of cellsize reduction on polyurethane foam physical properties." *Journal of Building Physics*, 17(4), 309-329.

16. Timusk, P. C. (2008). *An investigation of the moisture sorption and permeability properties of mill-fabricated oriented strandboard*.

17. Trechsel, H. R. (1985). "MOISTURE IN BUILDINGS: AN OVERVIEW." *Building Standards*, 54(2), 3-321.

18. Wu, L., Van Gemert, J., and Camargo, R. E. "Rheology Study in Polyurethane Rigid Foams." *Huntsman Corporation*.

19. Zabel, R. A., and Morrell, J. J. (1992). *Wood microbiology: decay and its prevention*, Academic press, 249-262.

20. Salonvaara, M., Karagiozis, A., and Desjarlais, A. "Moisture Performance of Sealed Attics in Climate Zones 1 to 4.", ASHRAE, Thermal Performance of the Exterior Envelope of Whole Buildings XII International Conference

21. Gates, C., and America, B. (2013). *Byggmeister Test Home: Analysis and Initial Results of Cold Climate Wood-Framed Home Retrofit*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program.

22. Dickson, B., and America, B. (2013). *Guide to Closing and Conditioning Ventilated Crawlspaces*, US Department of Energy, Energy Efficiency & Renewable Energy.

23. Lukachko, A., Grin, A., and Bergey, D. (2013). *Hybrid Wall Construction and Quality Control Issues in Wyandotte, Michigan*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Office.

24. Zoeller, W., Shapiro, C., Vijayakumar, G., and Puttagunta, S. (2013). *Retrofitting the Southeast: The Cool Energy House*, US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program.

25. Pallin, S., Kehrer, M., and Miller, W. A. (2013). "A Hygrothermal Risk Analysis Applied to Residential Unvented Attics." Oak Ridge National Laboratory (ORNL).

26. Mayer, R., Enache-Pommer, E., Parsons, G., Mazor, M., Hansbro, J., Lastovica, J., Buck, C., and Maurer, M. (2014). "Finite element thermal modeling and correlation of various building wall assembly systems." *Energy and Buildings*, 75(0), 410-418.

27. Puttagunta, S., Grab, J., and Williamson, J. (2013). "Performance House--A Cold Climate Challenge Home." US Department of Energy, National Renewable Energy Laboratory (NREL), Golden, CO.

28. Walker, I., and Less, B. "An Assessment of Envelope Measures in Mild Climate Deep Energy Retrofits." ASHRAE, *Proc., Thermal Performance of the Exterior Envelope of Whole Buildings XII International Conference*.

29. Morse-Fortier, L. (2012). "Potential Problems Arising from the Use of Composite Foam Panels on Sloping Roofs." *Forensic Engineering 2012*, American Society of Civil Engineers, 161-168.

30. Dixon, C., Masters, F., Prevatt, D., and Gurley, K. (2012). "Investigation of the Wind Resistance of Asphalt Shingles." *Advances in Hurricane Engineering*, American Society of Civil Engineers, 517-527.

31. Badiu, E., and Brătucu, G. (2013). "RESEARCHES REGARDING THE CAUSES OF DEGRADATION OF ROOF SYSTEMS." COMEC, 353-356

32. Ojanen, T. T. (2001). "Thermal and Moisture Performance of a Sealed Cold-Roof System with a Vapor-Permeable Underlay." ASHRAE, *Thermal Performance of the Exterior Envelopes of Buildings VIII*, 1-13

33. Straube, J., Smegal, J., and Smith, J. (2010). "Moisture-Safe Unvented Wood Roof Systems." Buildingscience Corporation, 1-13

34. Grin, A., and Lstiburek, J. W. (2012). *Moisture and Structural Analysis for High Performance Hybrid Wall Assemblies*, Citeseer. US Department of Energy, Energy Efficiency & Renewable Energy, Building Technologies Program, 1-65

35. Alturkistani, A., Fazio, P., Rao, J., and Mao, Q. (2008). "A new test method to determine the relative drying capacity of building envelope panels of various configurations." *Building and Environment*, 43(12), 2203-2215.

36. Grin, A., Smegal, J., and Lstiburek, J. (2013). "Application of Spray Foam Insulation Under Plywood and Oriented Strand Board Roof Sheathing." National Renewable Energy Laboratory (NREL), Golden, CO.

37. Oustad, M., Gustavsen, A. U., and Uvslokk, S. " Calculation of Moisture and Heat Transfer in Compact Roofs and Comparison with Experimental data.", Norwegian University and NBI, 1-8

38. Lstiburek, J. W. (2014). "Cool Hand Luke Meets Attics." AMERICAN SOCIETY HEATING REFRIGERATING AIR-CONDITIONING ENG. - ASHRAE , Buliding Science Corporation, 1-6

39. Prevatt, D. O., Shreyans (2010). "Field evaluation of thermal performance and energy efficiency of ccSPF retrofitted vented residential attic." *Rep. No. UF01-10, Univ. of Florida, Gainesville, FL*.

40. Sorahan, T., and Pope, D. (1993). "Mortality and cancer morbidity of production workers in the United Kingdom flexible polyurethane foam industry." *British journal of industrial medicine*, 50(6), 528-536.

41. Lesage, J., Stanley, J., Karoly, W. J., and Lichtenberg, F. W. (2007). "Airborne Methylene Diphenyl Diisocyanate (MDI) Concentrations Associated with the Application of Polyurethane Spray Foam in Residential Construction." *Journal of Occupational and Environmental Hygiene*, 4(2), 145-155.

42. McBride, K. (2011). "WIND UPLIFT PERFORMANCE OF CCSPF-RETROFITTED ROOF SHEATHING SUBJECTED TO WATER LEAKAGE - THESIS - UNIVERSITY OF FLORIDA." D. Prevatt, ed., University of Florida.

43. Shreyans, S. (2011). "Thermal Performance of Foam Retrofitted Vented Residential Attic - THESIS - UNIVERSITY OF FLORIDA." D. Prevatt, ed., University of Florida, 1-131.

44. 44. ComPliaNce, C. "Application of Spray Foam Insulation Under Plywood and OSB Roof Sheathing.

45. Nelson, P. E., and Der Ananian, J. S. (2009). "Compact asphalt shingle roof systems: Should they be vented?" *Journal of ASTM International*, 6(4).

46. Honeywell "Energy Performance and Closed-Cell Spray Foam: A Better Building Technology." Honeywell, 1-10.

47. "Insulate with Integrity: Learn the facts about SPF & What the Experts are saying" Owens Corning, (http://ww3.owenscorning.com/insulate-with-integrity/)

48. Yuan, S., and Karagiozis, A. N. (2010). "The Hygrothermal Performance of Wood-Framed Wall Systems Using Spray Polyurethane Foam Insulations and a Smart Vapor Retarder in the Pacific Northwest."

49. Parker, D. S., Sonne, J. K., Sherwin, J. R., and Moyer, N. "Comparative evaluation of the impact of roofing systems on residential cooling energy demand in Florida." 219.

50. Straube, J., and Smegal, J. (2009). "Building America special research project: High-R walls case study analysis." *RR-0903 at www. buildingscience. com*.

51. "Vacate and Safe Re-Entry Time - SPF." Environmental Protection Agency.

52. Shafer, J. (2013). "Spray Foam Basics for the Fire Service." Green Maltese.

53. Smegal, J., and Lstiburek, J. (2013). "Hygric Redistribution in Insulated Assemblies: Retrofitting Residential Envelopes Without Creating Moisture Issues." National Renewable Energy Laboratory (NREL), Golden, CO

54. Morris, C. (2013). "Customer Letter." DPIS Engineering, LLC: The Builders Solution.

55. "What happens with a roof leak and spray foam?", Centex.

56. Anderson, J. (2011). "SPF Guidelines for Re-occupancy." Insulation Contracting Association of America, 1-44.

57. Holladay, M. (2014). "Open-Cell Spray Foam and Damp Roof Sheathing." Green Building Advisor, 1-8.

58. Bailes, A. (2014). "Will open-cell spray foam insulation really rot your roof?"Green Building Advisor.

59. (2009). "Water vapor permeance of wood sheathing panels and wood wall construction." *Number J450*, APA - The Engineered Wood Association.

60. (2011). "Wood moisture content and the importance of drying in wood building systems." APA – The Engineered Wood Association, 1-3.

61. Schumacher, C. J. (2008). "Hygrothermal performance of insulated, sloped, wood-framed roof assemblies."1-165

62. C.A.S.M.A (2013). ""Hot Roof" Designs: Technical Bulletin."

63. Santos, S. "Solving the Air Barrier Riddle: Permeable or Impermeable? ." Building Envelope Forum, 1-8.

64. Hubbs, B., and Hircock, M. "Building envelope performance monitoring."

65. Icynene (2013). "Open-cell spray foam & what every contractor should know ", 1-6.

66. BSC (2008). "Building Science Corporation: Unvented Roofs, Hot-Humid Climates, and Asphalt Roofing Shingles " *Research Report*.

67. Datin, P., Prevatt, D., and Pang, W. (2010). "Wind-Uplift Capacity of Residential Wood Roof-Sheathing Panels Retrofitted with Insulating Foam Adhesive." *Journal of Architectural Engineering*, 17(4), 144-154.

68. Prevatt, D. O. (2007). "Improving the Wind Uplift Capacity of Wood Roof Panels Retrofitted with ccSPF Adhesives , submitted to NCFI ."

6.2. Appendix B: Advisory Panel Members

Advisory Panel Member	Organization
Scott Kriner	Metal Construction Association
Jason Hoerter	NCFI Polyurethanes
Mark Zehnal	Florida's Association of Roofing Professionals (FRSA)
Todd Wishneski	BASF Polyurethanes
Mike Fischer	Asphalt Roofing Manufacturers Association (ARMA)
Mike Ennis	Single Ply Roofing Industry (SPRI)
Marcin Pazera	Owens Corning
John Broniek	Icynene
David Roodvoets	DLR Consultants
Tim Smail	Federal Alliance for Safe Homes
Eric Vaughn	Federal Alliance for Safe Homes
Jaime Gascon	Miami-Dade Regulatory and Economic Resources (RER)
Rick Olson	Tile Roofing Institute
Sean O'Brien	Simpson Gumpertz & Heger (SGH)
David Brandon	Brandon Construction Company
Yuh Chin T. Huang	Duke University
Bill Coulbourne	Applied Technology Council (ATC)
Arlene Stewart	AZS Consulting Inc
Tim Reinhold	Insurance Institute for Business & Home Safety
Mo Mandani	Florida Building Commission
Rick Duncan	Spray Polyurethane Foam Alliance (SPFA)
Paul Coats	American Wood Council
BJ Yeh	Engineered Wood Association

Other Invited Participants	Organization
Philip Fairey	Florida Solar Energy Center
Robin Vieira	Florida Solar Energy Center
John Straube	Building Science Consulting
Kurt Koch	Huber Engineered Woods LLC
William (Bill) Miller	Oak Ridge National Laboratories
Pamela Dixon	Homeowner
Michael Goolsby	Miami Dade County Department of Regulatory and Economic Resources
Peter Parmenter	Cedar Shake & Shingle Bureau

6.3. Appendix C: Changes to Florida Building Code
2010 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2010 Florida Energy Conservation Code

Definitions

CONDITIONED SPACE. An area or room within a building being heated or cooled, containing uninsulated ducts, or with a fixed opening directly into an adjacent *conditioned space*. See "Space."

SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

1. Conditioned space: a cooled space, heated space, or indirectly conditioned space or unvented attic assembly defined as follows.

a. Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h•ft^2 of floor area.

b. Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h•ft^2.

c. Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semi-heated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding 3 air changes per hour (ACH) (e.g., atria).

d. Unvented attic assembly: as defined in Section R806.4 of the *Florida Building Code, Residential*. These spaces shall not require supply or return outlets.

2. Semiheated space: an enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h•ft^2 of floor area but is not a conditioned space.

3. Unconditioned space: an enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

405.6.3 Installation criteria for homes using the unvented attic assembly option.
The unvented attic assembly option may be used if the criteria in Section R806.4 of the *Florida Building Code, Residential* have been met.

2010 Florida Residential Code

NON-HIGH VELOCITY

R806.4 Unvented attic assemblies.
Unvented attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) shall be permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum $^1/_4$ inch (6 mm) vented air space separates the shingles or shakes and the roofing underlayment above the structural sheathing.
4. Either Items 4.1, 4.2 or 4.3 shall be met, depending on the air permeability of the insulation directly under the structural roof sheathing.
4.1 Air-impermeable insulation only. Insulation shall be applied in direct contact with the underside of the structural roof sheathing.
4.2 Air-permeable insulation only. In addition to the air-permeable installed directly below the structural sheathing, rigid board or sheet insulation shall be installed directly above the structural roof sheathing as specified in Table R806.4 for condensation control.
4.3 Air-impermeable and air-permeable insulation. The air-impermeable insulation shall be applied in direct contact with the underside of the structural roof sheathing as specified in Table R806.4 for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

TABLE R806.4 INSULATION FOR CONDENSATION CONTROL

CLIMATE ZONE	MINIMUM RIGID BOARD ON AIR-IMPERMEABLE INSULATION *R*-VALUE[a]
1, 2 (All Florida)	R-5

a.Contributes to but does not supersede requirements of the *Florida Building Code, Energy Conservation.*

High Velocity Hurricane Zone (Miami-Dade & Broward Counties)

R4409.13.3.2.5 Unvented attic assemblies.

Unvented attic assemblies shall be permitted if all the following conditions are met:
1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarder is installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum continuous $^1/_4$ inch (6 mm) vented air space separates the shingles or shakes from the roofing underlayment.
4. One of the following shall be met, depending on the air permeability of the insulation under the structural roof sheathing:
a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.
b. Air-permeable insulation only. In addition to air-permeable insulation installed

directly below the structural sheathing, at least R-5 rigid board or sheet insulation shall be installed directly above the structural roof sheathing for condensation control.
c. Air-impermeable and air-permeable insulation. At least R-5 air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

2007 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2007 Florida Building Code: Energy

Chapter Subchapter 13-2 – Definitions

CONDITIONED SPACE. See "Space, (a) conditioned space.

SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

(a) **Conditioned space:** A cooled space, heated space, indirectly conditioned space or unvented attic assembly defined as follows:
(1) Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area.
(2) Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft^2.
(3) Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding three air changes per hour (ACH) (e.g., atria).
(4) Unvented attic assembly: as defined in Section R806.4 of the *Florida Building Code, Residential*. These spaces shall not require supply or return outlets.
(b) **Semiheated space:** An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area but is not a conditioned space.
(c) **Unconditioned space:** An enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

13-604.A.5 Installation criteria for homes using the unvented attic assembly option. The unvented attic assembly option may be used in EnergyGauge USA Fla/Res if the criteria in Section R806.4 of the *Florida Building Code, Residential,* have been met.

R806.4 Unvented attic assemblies. Unvented attic assemblies shall be permitted if all the following conditions are met:

1. The unvented attic space is completely contained within the building thermal envelope.
2. No interior vapor retarder is installed on the ceiling side (attic floor) of the unvented attic assembly.
3. Where wood shingles or shakes are used, a minimum continuous $^{1}/_{4}$ inch (6 mm) vented air space separates the shingles or shakes from the roofing underlayment.
4. One of the following shall be met, depending on the air permeability of the insulation under the structural roof sheathing:

a. Air-impermeable insulation only. Insulation shall be applied in direct contact to the underside of the structural roof sheathing.

b. Air-permeable insulation only. In addition to air-permeable insulation installed directly below the structural sheathing, at least R-5 rigid board or sheet insulation shall be installed directly above the structural roof sheathing for condensation control.

c. Air-impermeable and air-permeable insulation. At least R-5 air-impermeable insulation shall be applied in direct contact to the underside of the structural roof sheathing for condensation control. The air-permeable insulation shall be installed directly under the air-impermeable insulation.

2004 FLORIDA BUILDING CODE

UNVENTED ATTIC CODE REFERENCES

2004 FLORIDA BUILDING CODE: BUILDING

Chapter 13 - Energy Efficiency

Section 13-202. DEFINITIONS

CONDITIONED SPACE. That volume of a structure which is either mechanically heated, cooled, or both heated and cooled by direct means. Spaces within the thermal envelope that are not directly conditioned shall be considered buffered unconditioned space. Such spaces may include, but are not limited to, mechanical rooms, stairwells, and unducted spaces beneath roofs and between floors. Air leakage into dropped ceiling cavities does not constitute conditioned space (see "Space.")
SPACE. An enclosed space within a building. The classifications of spaces are as follows for the purpose of determining building envelope requirements.

(a) **Conditioned space:** A cooled space, heated space, or indirectly conditioned space defined as follows.

(1) Cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^{2} of floor area.

(2) Heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to 5 Btu/h·ft$^{2.}$

(3) Indirectly conditioned space: an enclosed space within a building that is not a heated space or a cooled space, which is heated or cooled indirectly by being connected to adjacent space(s) provided (a) the product of the *U*-factor(s) and surface area(s) of the space adjacent to connected space(s) exceeds

the combined sum of the product of the *U*-factor(s) and surface area(s) of the space adjoining the outdoors, unconditioned spaces, and to or from semiheated spaces (e.g., corridors) or (b) that air from heated or cooled spaces is intentionally transferred (naturally or mechanically) into the space at a rate exceeding three air changes per hour (ACH) (e.g., atria).

(b) **Semiheated space:** An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area but is not a conditioned space.

(c) **Unconditioned space:** An enclosed space within a building that is not a conditioned space or a semiheated space. Crawl spaces, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

2004 Florida Building Code: Residential

Chapter 8 - Roof-Ceiling Construction

R806.4 Conditioned attic assemblies.

Unvented conditioned attic assemblies (spaces between the ceiling joists of the top story and the roof rafters) are permitted under the following conditions:

Chapter 8, Section R806, (4)(ab1)
1. No interior vapor retarders are installed on the ceiling side (attic floor) of the unvented attic assembly.

Chapter 8, Section R806, (4)(ac2)
2. An air-impermeable insulation is applied in direct contact to the underside/interior of the structural roof deck. “Air-impermeable” shall be defined by ASTM E 283.

Chapter 8, Section R806, (4)(ad3)
3. Shingles shall be installed as shown:

Chapter 8, Section R806, (4)(3)(a)
a. For asphalt roofing shingles: A 1-perm (57.4 mg/s · m^2 · Pa) or less vapor retarder (determined using Procedure B of ASTM E 96) is placed to the exterior of the structural roof deck; i.e. just above the roof structural sheathing.

Chapter 8, Section R806, (4)(3)(b)
b. For wood shingles and shakes: A minimum continuous ¼-inch (6 mm) vented air space separates the shingles/shakes and the roofing felt placed over the structural sheathing.

6.4. Appendix D: ERP #2: Field Survey

Experimental Research Plan
Task #2: Field Survey Existing Roofs with Spray Foam Insulation

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

1. Objective

Conduct field survey of roof constructions of five single-family residential buildings with wood roof decks insulated with spray foam insulation. Install temperature and relative humidity measuring devices in the attic, the exterior and interior of houses. Interview the homeowner/occupants as to the comfort and thermal efficiency, costs and risk perception of these installations. The original objective was to provide a

2. Approach

Instrument the homes with temperature and relative humidity sensors that currently have SPF installed on the underside of roof sheathing for comparative full-scale testing. Use wireless download technique to capture bi-weekly data without disturbing residents.

We have identified two homes for this study (Lynch and Brandon) and with the Advisory Panel's suggestion the project scope is reduced from 5 to 2 homes because of lack of useful results. We will work with the FBC to modify the project scope if needed.

Interview homeowners regarding roofing and foam installation.
Questions for interview:

(i) Owner perceptions of spray foam insulation: comfort and energy savings.
(ii) Age of roofing, age of home and orientation
(iii) Type of insulation: retrofit versus new construction
(iv) Material and Geometry
(v) Type of wood
(vi) Problems or Roof Repairs

2.2. Instrumentation

- HOBO Temperature and Relative Humidity data nodes (http://bit.ly/17FoneD) – per house to record temperature and RH of unvented attic system. Record temperature and relative humidity at 15 minute intervals.
- HOBO Wireless Data Receiver (http://bit.ly/1DWh7p1) to extract data from nodes onto laptop every 20 days. 1 Receiver needed for all homes.

Figure 1: HOBO Wireless Data Node

Figure 2: HOBO Wireless Data Receiver

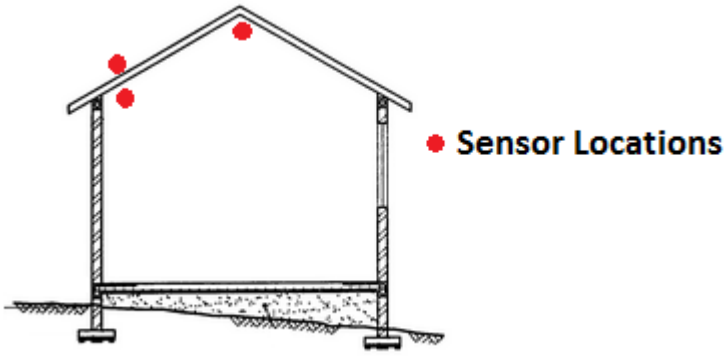


Figure 3: Sensor Locations

6.5. Appendix E: Task 3a: Comparative Drying Rate Test

Experimental Research Plan

Task #3a: Comparative Drying Rate Tests on Wood Deck-Spray Foam Samples

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

3. Objective

The objectives of this research are to: determine relative drying rates of wood roof deck configurations with various foam insulation characteristics of the systems. The results will serve as preliminary study.

4. Motivation

Small-scale proof of concept experiment is needed to confirm an approach for monitoring roof deck drying rates. Experiment will be used as precursor to more elaborate testing, if this is justified by results.

5. Approach

Fabricate 36, 12" x 12", flat roof specimens and measure the 1-D comparative drying rates through wood roof cross-sections having a) traditional (no insulation), b) open-cell and c) closed-cell spray foam insulation. Measure interior and exterior climate for 3 months. Interior conditions will be representative of a conditioned space. Exterior conditions will artificially simulate a hot/humid climate via heat lamps and humidifiers. This will create a vapor drive with hygrothermal properties typical of Climate zone 1. Roof sheathing will be water-soaked at start of experiment up to a moisture content exceeding threshold for decay of 20%.

Testing Matrix			
Underlayment	(A) 30 lb felt - 1 layer, (B) 30 lb felt - 2 layers , (C) Peel and Stick		
Foam Type	No Foam	ocSPF	ccSPF
Plywood - A	X	X	X
Plywood - B	X	X	X
OSB - A	X	X	X
OSB - B	X	X	X

Note: This matrix shows different foam and sheathing types will repeat 3 times for each underlayment type. 12 Specimens x 3 = 36 total roof specimens.

Figure 4: Isometric view of Test Hut

Moisture content will be monitored via gravimetric weighing per ASTM D4442 of removable roof specimens. Relative humidity and temperature of interior and exterior space monitored with LogTag sensors.

6. Interior – Specimen

The interior space houses our 36 roof specimens in a grid like manner and consists of 2 x 4 framing with 5/8 sheathing and is approximately 11' x 5' x 6' (LxWxD). These specimens are carefully installed to provide 1-D moisture movement occurs by ensuring the roof sheathing does not come in contact with "dry" framing and is varnished along its edges. This space will not be insulated in order to acclimate to the conditions of the lab. The temperature and relative humidity will be monitored in this space.

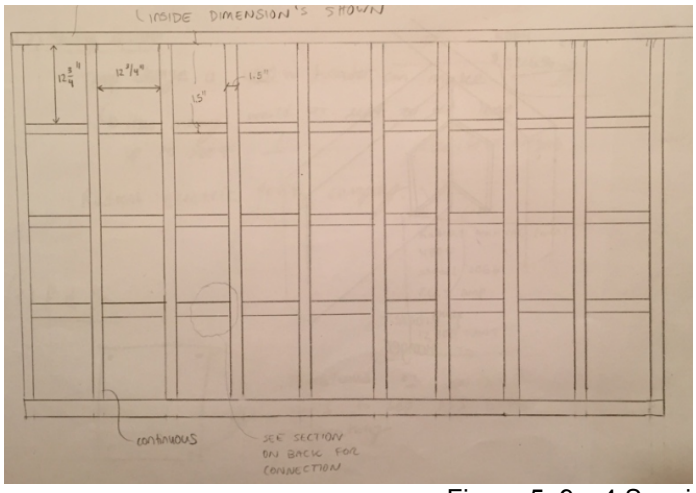


Figure 5: 9 x 4 Specimen Grid

7. Exterior Hot Box

The insulated exterior hotbox is an enclosed room with radiant heaters installed to maintain constant temperature above 150 degrees Fahrenheit. The exterior covering will be reprehensive of the hot/humid climate of Florida by introducing heat lamps and forced ventilation in the system. The hotbox insulation will consist of R19 batt insulation and 2 in in. thick rigid polystyrene board. This space will include heaters (specifications below).

RADIANT ELECTRIC HEAT

COVE HEATER SUBMITTAL SHEET

ceramicircuit

Date: 11 Feb 2015

Project: University of Florida - FBC Roofing Project

Architect:

Engineer:

Contractor:

Submitted by:

Approved by:

HEATERS

QTY	MODEL #	VOLTS	WATTS	CUSTOM FEATURES
2	945C	120	1,000	CL - Flush Mount Ceiling Brackets

ACCESSORIES & CONTROLS

QTY	CAT. NO.	DESCRIPTION

(06/11)

www.electricheat.com

RADIANT
ELECTRIC HEAT

N112W14600 Mequon Road
Germantown, WI 53022
www.electricheat.com

ARCHITECT'S AND ENGINEER'S SPECIFICATIONS

Furnish and install where indicated on the Drawings, "High Efficiency Ceramic Infrared Panel" heaters manufactured by Radiant Electric Heat. Germantown, Wisconsin. Heaters shall be UL listed.

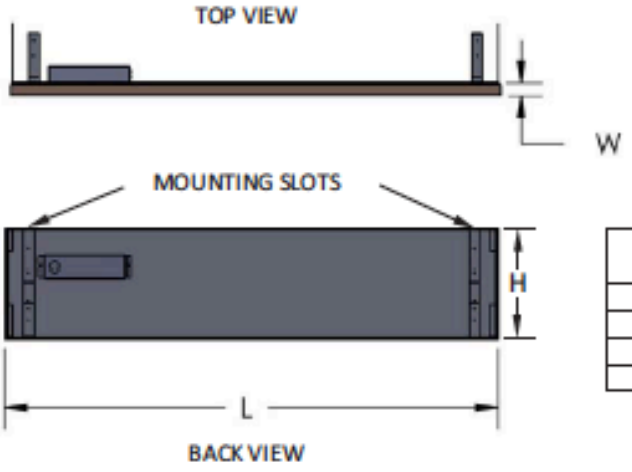
CONSTRUCTION

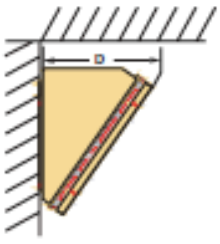
Heating Elements: Porcelain enamel coated 18 gauge steel plate, with energizing ceramic circuit on internal face of heating element; minimum 2.3 Watts per square inch of emissive surface area.
Heater Body: 20 gauge steel, high-temperature resistant powder coating. Provided with manufacturer's standard 7/8 inch knockouts for power feed.
Accessories: Provide as indicated, thermostat, NEMA 1 Enclosure control panel, and mounting brackets for models specified.
Installation: Install heating units where indicated, in accordance with manufacturer's written instructions, applicable requirements of IEC, in compliance with recognized industry practices to ensure products fulfill requirements. Secure in place with mounting brackets. Top of heater unit and trim shall be level. Where heating units are mounted adjacent to each other, the top edges shall be at the same height.

ACCESSORIES & CONTROLS

MODEL	INSTALLATION	WATTS	VOLTAGE	AMPS	SHIPPING WEIGHT
632C	CEILING COVE	585	**120 240 208 277**		14 lbs
645C	CEILING COVE	825	120 240 208 277		17 lbs
945C	CEILING COVE	1,000	120 240 208 277		22 lbs
1445C	CEILING COVE	1,500	120 240 208 277	12.5	40 lbs

*RADIANT ELECTRIC HEAT RESERVES THE RIGHT TO CHANGE SPECIFICATIONS WITHOUT PRIOR NOTICE.





Cove Model	Watts	L	H	W	D
632C	585	33"	7"	1.125"	5.5"
645C	825	46"	7"	1.125"	5.5"
945C	1000	46"	10"	1.125"	7.5"
1445C	1500	46"	15"	1.125"	10"

6.6. Appendix F: ERP 3b: Point-source wetting and moisture spread

Experimental Research Plan

Task #3b: Time variation in moisture from Point-source Water Leakage in Wood Roof Decks

David O. Prevatt [a], Trent Vogelgesang [b],
[a] Associate Professor, [b] Graduate Research Assistant
Department of Civil and Coastal Engineering, University of Florida

1. Objective

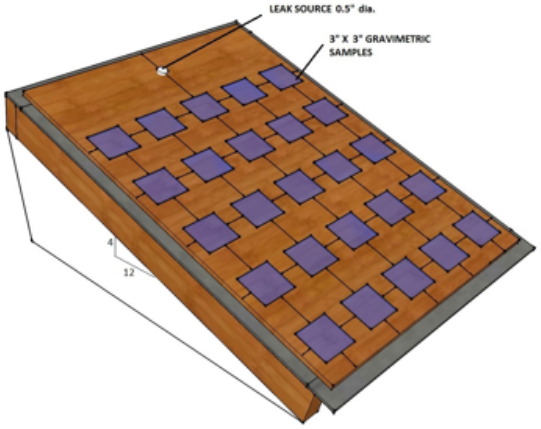
The objectives of this research are to determine: (i) the rate of moisture spread in plywood and OSB roof decking from a point leak source; (ii) if a non-destructive method of detecting moisture due to a roof leak is feasible. The results will serve as a preliminary study.

2. Motivation

To determine the moisture spreading effect over time that spray foam and roof sheathing have when subjected to a typical roof failure and leakage scenario. The purpose is to perform comparative testing to existing homes with roof damage and spray foam.

3. Approach

Fabricate 48, 3'x4', test samples with 4 and 12 mono-sloped south-facing roof pitch installed with spray foam insulation to determine the mitigation of moisture from a point source leak. The south orientation yields the highest moisture contents (Prevatt et al. 2014) and the constant roof slope is typical of one side of a roof assembly. Variables can be seen in the test matrix below. The methodology for the point source leakage is from (Prevatt et al. 2014) in which a series of sprinklers will provide continuous wetting. The moisture accumulation over time will be monitored via gravimetric sampling of 3" x 3" roof samples per ASTM D4442 and LogTag sensors will be installed to monitor relative humidity and temperature. These moisture contents will be plotted versus time to develop contour plots to show the spread of moisture throughout sheathing. This will answer: (A) Does P/S limit absorption of moisture into wood? and (B) Does having 2 vapor retarders (top-underlayment, bottom- SPF) limit drying of moisture?



Impact of Spray Foam Insulation on the Durability of Plywood and OSB roof sheathing				
Prepared by: Trent Vogelgesang		Date Modified: 02/11/15		
Perform Test Matrix for both Plywood and OSB Roof Sheathing				
Underlayment	#30 Felt - 1 layer		Peel and Stick	
Foam Type	No Foam	ccSPF	No Foam	ccSPF
Duration of Time				
Start	X	X	X	X
1 week	X	X	X	X
2 week	X	X	X	X
4 week	X	X	X	X
6 week	X	X	X	X
12 week	X	X	X	X

Figure 6: Point Source Induced Leakage

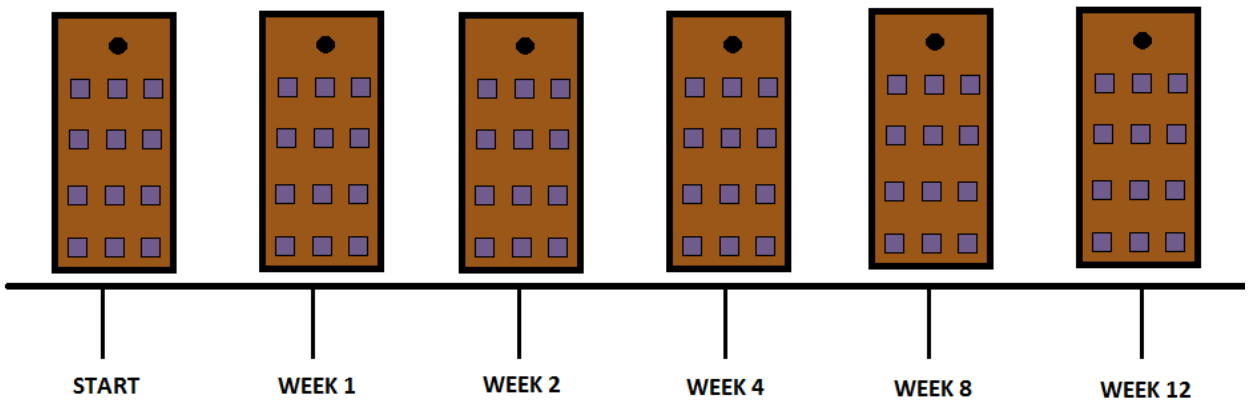


Figure 7: Time-table for gravimetric weighing

Note: Gravimetric samples will be cut out and weighed at time scales above to determine change in Moisture content over time per ASTM D4442.

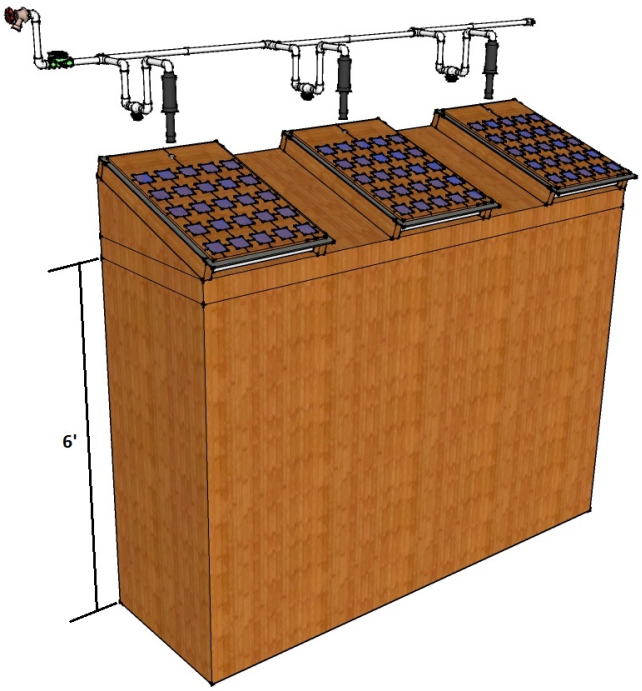


Figure 8: Isometric View of Test Setup

References:

Prevatt, D., McBride, K., Roueche, D., and Masters, F. (2014). "Wind Uplift Capacity of Foam-Retrofitted Roof Sheathing Panels Subjected to Rainwater Intrusion." Journal of Architectural Engineering, B4014001.