Phase 2 Investigation of Potential Benefits from Sealing Building Cavities in Conditioned Space Used for Return Air Plenums in Existing Homes

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Research Purpose and Goal: This research proposes to continue work completed in Phase 1 (end date June 30, 2014) investigating the benefit and cost of sealing building cavities used as return air pathways that are formed by all or part of an air handler closet or other space located in the conditioned space in existing homes (McIlvaine et al. 2014). The current code provides the following definition:

> "Ducts in Conditioned Space. [Ducts located] interior to both the thermal envelope and the pressure envelop of the building." (ICC 2011)

By this definition, a return plenum located within a house's the conditioned footprint, such as the one in Figure 1, appears to meet the definition because since they are within the whole house air barrier usually formed by a combination of interior and exterior finishes and detailing. However, in operation, return plenums formed by building cavities often *are not* separated from unconditioned spaces by an air barrier as illustrated in Figure 1. When the air handler operates, unconditioned air is pulled into the return plenum. Figure 2 shows the heat signature of attic air being pulled down the wall cavity during air handler run time.

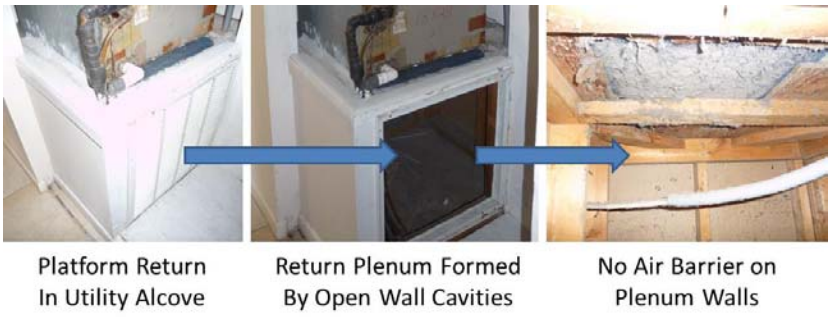

Figure 1 – Return plenum formed by unfinished frame walls and air handler support platform in a utility alcove.

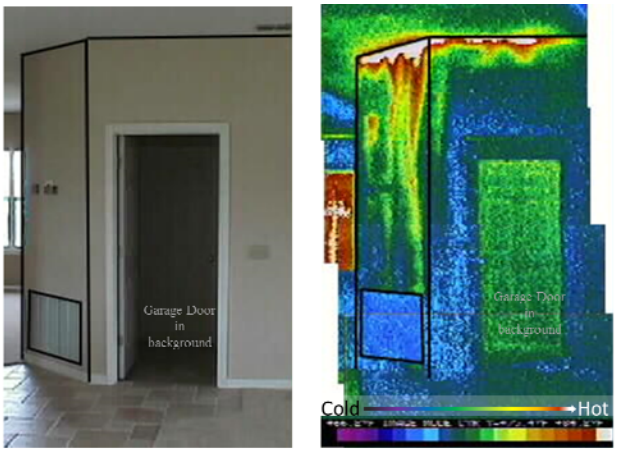

Figure 1. Left: A return plenum formed by unfinished framing under an air handler support platform is on the other side of this wall mounted return air grill in a utility room. Right: Infrared image showing hot attic air (see color scale at bottom of image) being pulled down the interior wall cavity during air handler run time (Parker, et al. 1998.).

Magnitude of Opportunity: In an FSEC field study conducted between 2009 and 2012, researchers observed a large number of unsealed return plenums and AHU closets in the conditioned space (McIlvaine et al. 2013a and 2013b). Interior air handler configurations were found in 40 out of 70 homes ranging in vintage from the 1950's to 2006. These interior air handlers generally manifested in the field study in two configurations:

1. A framed platform supporting an up-flow air handler with through-wall filter-back return grilles (Figure 3) or
2. A metal or frame air handler stand where the closet functions as the return plenum with return air pathways through louvered doors or door mounted grilles (Figure 4).

Figure 3. This air handler in an interior closet (left, top) is served by a return air plenum directly beneath (left, bottom) formed by the open, unfinished framing of the closet walls.

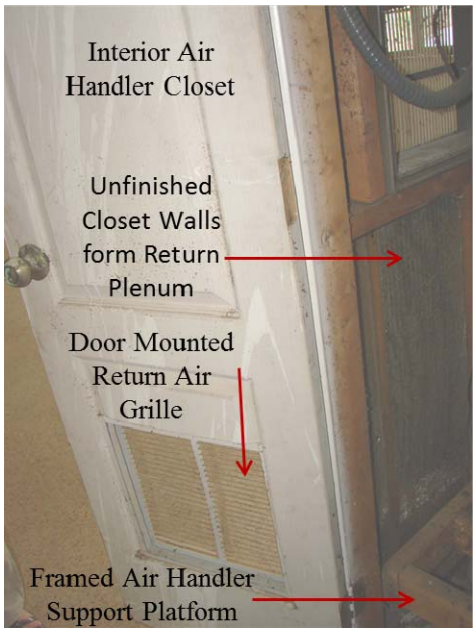

Figure 4. Interior air handler closet with no dedicated return air pathway. The unfinished closet walls (and poorly sealed ceiling) function as a return plenum.

Phase 1 Research Summary: The technical approach focused on open-frame platform returns and whole closet return plenums located in the conditioned space, and consisted of duct system testing in four homes as follows:

- Pre-retrofit testing: measure total duct leakage and leakage to outside conditioned spaces first for the entire as-found air distribution system and then for just the return side
- Observe and document HVAC contractor's standard treatment of the return plenum
- Pre-retrofit testing: repeat all tests
- Compare pre- and post-retrofit return side leakage to characterize the relative success of the contractor's approach
- Use test results to model the impact of return sealing whole house and space conditioning in a single base case house to facilitate comparison of a range of improvement results.

Phase 1 test results showed that the contractors' standard approach achieved post-retrofit return plenum air tightness on par with Florida new construction by constructing and sealing a dedicated return air path using duct board (Figure 5). Test results (Figure 6) show that contractors successfully isolated the return plenum from unconditioned space with normalized duct leakage outside conditioned space (Qn,out) of 0.03 to 0.01 and in one case below the measurement threshold of the test equipment.

Figure 5-plenums Completed Phase 1 return plenums.

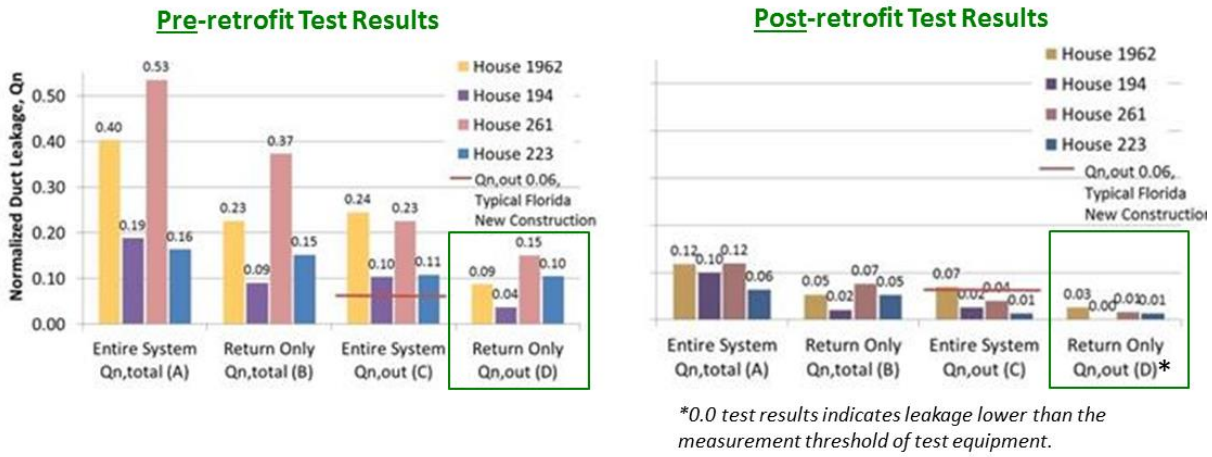

Figure 6 Phase 1 duct testing at pre-retrofit (left) and post-retrofit (right) show vast improvement.

Contractors reported material costs ranging from $ 75.00 - $130.00. Simulation analysis indicates that the forfeited savings if the returns had not been repaired ranged from $16 - $69. Based on this, simple pay back for the *materials (not including labor)* ranged from 1.8 – 4.9 years.

Intangible performance benefits relate to combustion safety, indoor air quality, and comfort associated with improved air flow control and indoor humidity levels (Cummings, et al. (1998, 2012). Beal, et al. (2011)). Return leakage can be at extreme temperature and humidity conditions as well as dusty. It often bypasses the filter, fouling equipment components, degrading equipment performance, and eroding equipment life.

Approach to Phase 2 Research: Based on Phase 1 feedback received from the Energy Technical Advisory Committee during the TAC meeting on June 26, 2013 researchers will add six or more homes to the Phase 1 data set with a concerted effort to include homes with an air handler mounted on metal stand in a utility room in the conditioned space and homes with a second-floor air handler. Test results will again be used to model the repairs and associated

hypothetical scenarios in a one or two story (as appropriate) base case house to evaluate the effect of various return plenum treatments manifested in the study houses.

Feedback from TAC also mentioned assessing the impact of return plenum sealing on HVAC peak load calculations for system sizing. Researchers will use the Manual J, Version 8 software to examine the impact of return leakage reduction. Manual J software calculates heating and cooling loads for individual components of the house, including the return duct system. In these softwares duct leakage is expressed as CFM of leakage per square foot of duct at operating pressure. By measuring the area of the return plenum and using the isolated return leakage numbers a better estimation of the impact of the return plenum repair can be had. Since these numbers are made at 25 Pascals they should underestimate the savings potential as the operating pressures in return plenums are often higher than 25 Pascals.

Expected Outcome and Impact on the Code: The outcome of Phase 2 research will be a report, similar to the Phase 1 report, describing the impact of sealing return plenums formed by building cavities (or indoor rooms in the case of utility rooms) in the conditioned space and associated cost. It is anticipated that the results from this research will inform discussions about duct sealing requirements for existing homes.

Estimated Budget for Phase 2: $48,872 (9/15/14-5/30/14)
Estimate includes recruitment of houses, field work, simulations, cost data collection, and analysis for 6 or more houses, interim report, final report, and presentation to the Energy TAC.

References:

ICC. (2011). “Florida Building Code 2010: Energy Conservation.” Washington, D.C.: International Code Council.

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