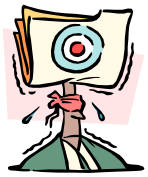

Forum on Moisture Problems in HUD Code homes in hot, humid climates

Case Study

Just a little south of Houston

FLORIDA SOLAR ENERGY CENTER
A RESEARCH INSTITUTE OF THE UNIVERSITY OF CENTRAL FLORIDA

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• HOUSE DESCRIPTION....

The house is a doublewide 4-bedroom 3-bath dwelling. The crawlspace skirting is fairly continuous, and a ground cover has not been laid down underneath the home. The major axis of the roof lays in an east-west direction that places the smallest exposed wall area to the greatest sunloading. Heating and cooling is accomplished with a centralized forced air system. A single air handler unit is located in the utility room. The duct system is located under the attic space. The air conditioning compressor is located on the north side of the building near the utility room. A manually controlled exhaust fan in the utility room ceiling provides ventilation.

• OBSERVATIONS....

There are two window air conditioning units in use, one in the south central bedroom and the other in the living room. The homeowner stated that this was the only way that they could even begin to be comfortable in their home. These units operate in conjunction with the central unit.

The interior wall of the bedroom adjacent to the showerhead of the hall bathroom has severely deformed. The most probable cause is moisture related.

The utility bill was very high – approximately $500 per month.

The homeowner mentioned that the air conditioning contractor had been there and performed a HUD code duct test (HUD 3280.715 (a)(4)) and indicated that there were no significant problems. The testing was performed with a Retrotec blower door assembly (based on the description supplied by the homeowner).

• TESTING....

The house is a system of components, parts and pieces that are put together to form a system designed to provide shelter and comfort for the occupants. When this system does not function properly, testing is required to determine the source or causes of the problem.

A blower door test was done to determine the airtightness of the building envelope. A series of building pressures and associated airflows was recorded. This provides the necessary inputs to determine the CFM50 of the house.

Blower Door Test Results
CFM50 = 3247
[C=258.4, n=0.647, r=0.998]

A duct system airtightness test was also completed. A duct tester was attached to the air handler unit. The supply registers were temporarily sealed off and the system was then depressurized to 25 pascals. The total and outside leakage flow components were measured. An airtight duct system would have zero leakage or both the $CFM25_{total}$ and $CFM25_{out}$ would be 0.

Duct Test Results
$CFM25_{total}$ = 430
$CFM25_{out}$ = 328

In addition to the duct test with a duct tester assembly, a pressure pan test was also completed. This test will indicate relative leakiness of the duct system at each register and grill. The blower door assembly depressurizes the house to 50 pascals and each register / grill is completely covered with the pressure pan. In general, the lower the number (approaching 0.0), the tighter the duct at that location and the leakier the duct, the larger the number (approaching 50.0).

Pressure Pan Test Results			
Mbath	12.8	Mbed1	8.4
Mbed2	15.0	LR	13.3
Entry	8.7	Dining	14.8
S Bed	11.4	S Bed Bath	5.8
Hall Bath	6.0	SW Bed	8.9
NW Bed	6.0	Family1	6.2
Family2	8.8	Kitchen	12.1
Laundry	17.1	RA	17.3

Pressure differential measurements were completed to determine a magnitude and direction of flow across the envelope when the air handler fan operates. Interior door closure effect was also measured when the air handler fan operated.

Condition	Pressure differential (house with reference to outside)
All fans off	-0.0 pa
Air handler on & utility room door open	-5.6 pa
Air handler on and master bedroom door closed	-7.0 pa
Air handler on and all interior doors closed	-8.0 pa

The pressure difference was also measured across each closed door when the air handler fan was operating. This is the pressure created by the supply air being pumped into the closed room and seeking a pathway out of the room. This pressure will vary from room to room based on quantity of air supplied to the space and the relative tightness of the room.

Measurement of pressure across closed doors	Pressure differential (room wrt living room)
Master Suite	8.0 pa
Central bedroom	3.8 pa
Bath	0.5 pa
Southwest bedroom	2.6 pa
Northwest bedroom	4.9 pa

Laundry	-10.3 pa

- **CONCLUSIONS....**

The building experiences extended periods of severe depressurization. This is created by a number of factors.

- The supply side duct leakage is extreme. The operation of the air handler fan causes the house to operate in a negative pressure. This is because the supply leaks dump the air into the attic space.
- The period of times that the various bedroom doors are closed (especially the master bedroom) only serves to increase the negative pressure of the main living area of the house. When the bedroom doors are closed, there is not enough opening for the air to return back to the air handler fan. This excess air is then vented through any and all holes that might exist in that room.

The moisture and energy concerns were created by…

- The wall panel that has been deformed in the south bedroom was most probably caused by the depressurization of the house. There is a pathway for crawlspace moisture to enter the wall cavity via plumbing penetrations through the rodent barrier.
- The fireplace will not vent properly when the air handler unit operates. The extremely negative pressure created by the supply side leak tries to replace lost air through the chimney.
- The excessive loss of conditioned air causes the air conditioning unit to run excessively. The operation of the air handler fan most likely causes the house to be uncomfortable. A great deal of outside and crawlspace air is drawn into the house to replace the lost air. This air contains not only the summer heat, but also high humidity. The addition of the window air conditioners provided the necessary cooling capacity required for cooling and dehumidifying the infiltrating air.

- **RECOMMENDATIONS....**

A number of factors must be considered in the proper retrofit of this home to ensure that failure does not happen again. The following should be done:

Air conditioning and heating system:

- All supply duct system leaks should be air sealed with a mastic (such as RCD#6 or equivalent). The seal must be applied to the air barrier ductwork. The main area of concern is the main supply duct line – most likely the crossover duct. It appears that it may be partially or totally disconnected.
- The return support platform should be sealed. There is a large hole in the floor of the return air platform where the refrigerant lines pass through to the outside unit.
- The closet that encloses the air handler unit operates in a negative pressure. This is mostly likely due to air handler cabinet leaks. Either the air handler cabinet should be tightened, the closet made “leakier” to the conditioned space via a grill assembly or a combination of both.
- The utility room door is normally closed. When this door is closed, the utility room acts as a return plenum. The utility room door should be removed and replaced with “bar room” type doors. This will provide adequate area for return air traveling to the air handler and provide a visual barrier to the laundry room.
- The air balance of the duct system should be checked. This should be done with all of the interior doors closed. The balance will probably include adjustment of supply air to the master bedroom and the addition of a return air grill through the wall directly to the return air plenum of the air handler unit. The pressure differentials across the various closed bedroom doors should be checked and be less than 3 pascals. The pressure differential from the living area to the outside should be 0 when the interior doors are open and no more than 3 pascals when all interior doors are closed (ideally this should also be 0 for best performance.)

Wall assembly:

- All damage wall panels should be removed and replaced. The replacement panels should be finished with a vapor permeable material to allow moisture movement to the inside. The ideal location for a vapor retarder is on the warm side of the wall. In the hot, humid climate, the warm side is the exterior (ASHRAE Fundamentals 1989, Chapter 21). The exterior plywood sheathing will act as a vapor retarder in this case. Every material located to the inside of the plywood should be at least ten times more permeable to allow for drying to the inside. The placement of a vapor barrier behind the gypsum wallboard should be avoided. This may cause condensation to occur within the wall assembly and causing the structure of the building to be damaged.

Crawlspace

- A vapor barrier ground cover would reduce the amount of moisture coming into the crawlspace from the ground. This will tend eliminate some of the moisture in this area, especially with a tighter skirting surrounding the home.