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

Case Study

Just outside Kinder, Louisiana

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

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Present during most of the investigation were the homeowners, one of their invited guests (their legal consultant) and a local manufacturer's field representative. The purpose of the visit was to try to determine the possible cause(s) of the reported mold growth that appears along the marriage wall ceiling.

• HOUSE DESCRIPTION....
The house is a doublewide home. This is a 4-bedroom 2-bath dwelling enclosing approximately 1800 square feet of living space. The crawlspace skirting is not continuous, but open on either end below the marriage wall. There is not a ground cover 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 floor and is what is referred to as a perimeter system. The air conditioning compressor is located on the west side of the building near the rear bedrooms. A manually controlled exhaust fan in the utility room ceiling provides ventilation.

• OBSERVATIONS....
The air conditioner system is a 4-ton. The general condition of filters and coils appeared to be good. The condensate drainpipe from the air handler unit ends in the crawlspace below the air handler unit. It dumps the water onto the ground. The air handler unit is located in the utility room. This room acts as a return plenum when the door is closed (there is a grille in the door to allow passage of air).

Staining of the ceiling area was noted in 5 areas, all where at or very near the marriage wall. This staining appears to be either dust/dirt markings, some type of biological growth or a combination of both. Generally, the areas of staining are relatively small (less than ½ square foot of area). The pattern of the staining appeared to be very similar to what would be caused by the movement of air passing from a hole and fanning out in all directions. The exceptions are the south and central bedroom closet ceilings, which appear to be entirely discolored. The ceilings are most probably contaminated with a mold / mildew growth.

A temperature and relative humidity reading was taken at the ceiling marriage wall between the kitchen and dining room at about 1:30 in the afternoon. To get this reading, a piece of the trim was removed to place the probe in the area where it appeared that attic air might have been entering. The temperature of that air was 99degF and the relative humidity was 64%; this equates to a dewpoint temperature of about 85degF.

• 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 were recorded which provides the necessary inputs to determine the CFM50.

Blower Door Test Results
CFM50 = 2564
[C=168.6, n=0.696, r=0.991]

As a frame of reference, most new homes of today have an airtightness of approximately 0.75 to 1 CFM50 per square foot of floor area. In this case, the house is a little leakier than the normal.

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
$CFM25_{total}$ = 285
$CFM25_{out}$ = 110

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	-1.4 pa
Air handler on and master suite door closed	-1.5 pa
Air handler on and all interior doors closed except utility	-1.9 pa
Air handler on and all interior doors closed	-1.2 pa

The pressure difference was also measured across each closed door when the air handler fan was operating.

Measurement of pressure across closed doors	**Pressure differential (room wrt living room)**
Master Suite	1.3 pa
South bedroom	1.5 pa
North bedroom	2.1 pa
Center bedroom	2.1 pa
Utility room	-5.7 pa
Hall bathroom	0.5 pa

- **CONCLUSIONS....**

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

- The supply side duct leakage is significant. 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 belly pan, which leaks to the crawlspace through various holes and penetrations such as those created by electrical and piping.
- The negative pressure that exists in the building when the air handler fan operates pulls attic air into the space via various penetrations that exist in the marriage wall. The trim pieces tend to direct the airflow along the flat planes of the ceiling and walls (as noted by the patterns of

discoloration on the walls / ceiling). The entering air is at a very high dewpoint – above the temperature of the interior surfaces. The surfaces close to the entering point will tend to have a very high relative humidity, which promotes biological growth. The air entering will tend to carry small dust and dirt particles which will tend to discolor the surface and provide an additional nutrient base for the mold / mildew.

- The closet spaces with closed doors will tend to have a higher relative humidity for two reasons. First, they are connected to the attic space via cracks along the marriage wall behind the trim. As the building operates in a slight negative pressure, hot humid attic air is pulled into the closet at a slow constant rate. Secondly, the closed space will not receive cooling and dehumidification as there is not much of a pathway for airflow between the closet and the adjoining conditioned rooms.
- The utility room door is generally kept closed. When this door is closed, the utility room operates in a negative pressure. This is not a surprise, since the utility room acts as the return plenum (there is a return grille in the door). Interior air from the house is drawn through the return grille in the door and then passes through the room to the air handler unit. Outside air is pulled into the room through all of the various cracks, penetrations and holes that lead to the exterior. Some of these are intentional – such as the dryer vent, some are not – such as the ventilation fan (when not operating) without a back-draft damper.

● **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 of the duct. The areas that should be addressed include the supply register under the master bathroom vanity and all connections of the supply duct to the floor registers.
- The negative pressure that exists in the utility room when the utility room door is closed should be reduced to as close to a neutral pressure as possible. Adding additional return air pathways to the utility room can do this. Pathways for return air can include a combination of strategies; removal of the utility room door, increasing the free air area of the current return air grille, adding additional through the wall returns or hard ducting the return air from the air handler unit to the hallway.
- The condensate drain line from the air handler unit needs to be redirected to deposit the condensate to the outside, away from the crawlspace.

Ventilation:

- The ventilation system used in this home is an exhaust only type. This will cause a depressurization of the home which will cause outside and attic air to be drawn into the space. This type of ventilation system should not be used in a hot, humid climate as a general rule. The best approach would be to install a positive pressure ventilation system that preconditions the air prior to entering the conditioned space. This preconditioning would include filtration, temperature adjustment and moisture removal.
- A low cost alternative would be to install a fresh air duct to the return side of the air handler unit. When the air handler operates, outside air would be drawn into the air handler where filtration, cooling and dehumidification would occur. [This type of positive ventilation system works marginally in the hot and humid climate. The problem is that a conventional cooling system is not designed to handle much of a latent loading (dehumidification).]

Wall / ceiling assembly:

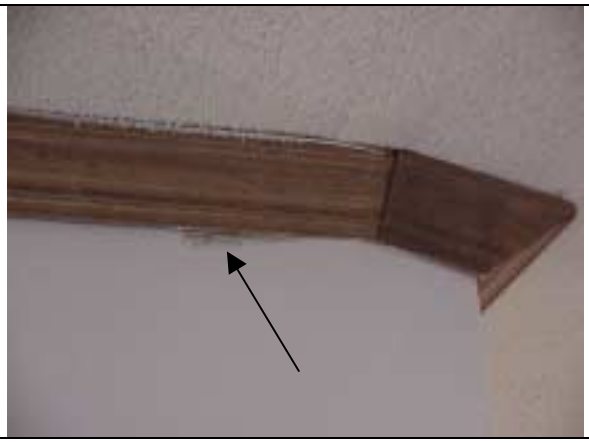
- All damaged ceiling panels (center and southwest bedrooms) should be removed and replaced.
- All of the other areas that show mold/mildew growth should be mitigated. This will require that the

sources of airflow from the attic space along the marriage wall be eliminated. The mold/mildew areas should be cleaned or disinfected with a mildewcide or chorine beach solution.

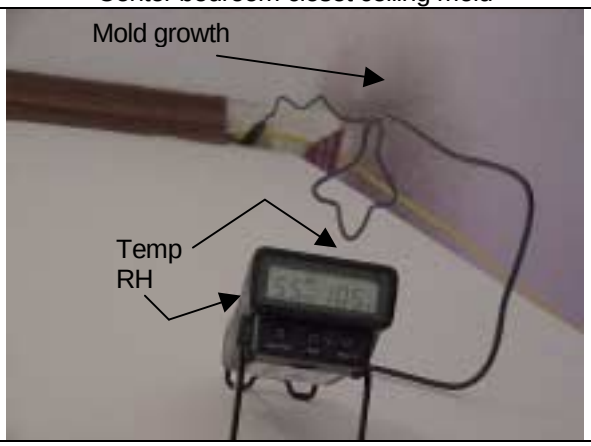
- **PICTURES....**

	
Exterior view - front	Exterior view - rear
	
View of AHU in utility room	Electrical penetrations in crawlspace
	
Ventilation fan (utility room and msbath)	Crawlspace under west end bedrooms

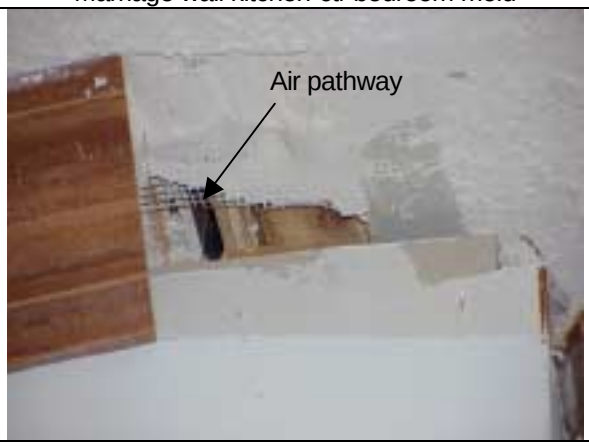
Center bedroom closet ceiling mold



Marriage wall kitchen-ctr bedroom mold



Temp - RH in marriage wall kit / dining



Marriage wall w/trim removed

Compressor unit on west end of home

Typical floor register