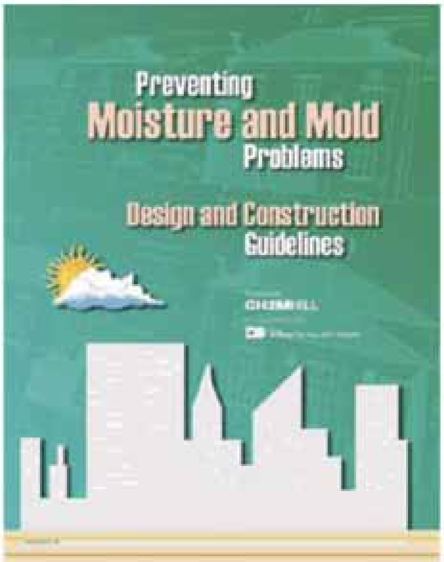

Avoiding Moisture and Mold Problems in Florida Buildings:
Design and Construction Guidelines

By J. David Odom, Liberty Building Diagnostics Group

Just months after occupying their new, multimillion-dollar municipal building, employees of a Florida county began complaining of chronic sinus problems, allergy attacks, headaches and asthma—classic signs of sick-building syndrome and building-related illness. The architects, engineers, and microbiologists tasked with finding the cause of these symptoms identified a problem that is becoming widespread nationwide: severe microbial contamination.

Mold and mildew were growing unchecked throughout the building's heating, ventilation and air-conditioning (HVAC) system and in many spaces within the building. The excess moisture was the direct result of a combination of rainwater leaks and an HVAC system that pulled moist outside air into the building during the hours when the cooling system had cycled off. Once the HVAC system became infected, it dispersed spores throughout the building.

So, only a few years after opening, the building underwent a major overhaul. Ultimately, repairs and other associated costs would exceed $20 million.

Unfortunately, this problem is not an isolated one. Rainwater leaks occur in every climate, and in this case, the leaks alone would probably have led to significant microbial contamination and building evacuation. The real devastation arose from the less obvious cause: improper interaction between the building envelope and the HVAC system.

In essence, IAQ problems are symptoms of a broken process. The complexity of the building-construction process and the failure to recognize interrelationships between different disciplines often worsens existing problems.

Key factors in the schematic design of the mechanical side of building systems in humid climates are as follows:

- Maintaining building pressurization through proper control of exhaust, makeup air and ventilation.
- Properly selecting HVAC and control systems for adequate dehumidification and filtration.

Pressurization

During hot, humid months, outside air with a large moisture load can be drawn into a building through the wall system and into the interior space. Because airflow always follows the path of least resistance, air can be carried down interior walls of a space if they are connected to the exterior envelope. As air flows through, moisture condenses and is deposited in wallboard and other building materials. Moisture accumulation increases with decreasing interior temperatures and with increased negative pressures. Figure 1 shows that pressure differentials in hot, humid areas—even one negative Pascal, which many consider insignificant—can create a problem in a building with an average envelope and an interior temperature of 74°F.

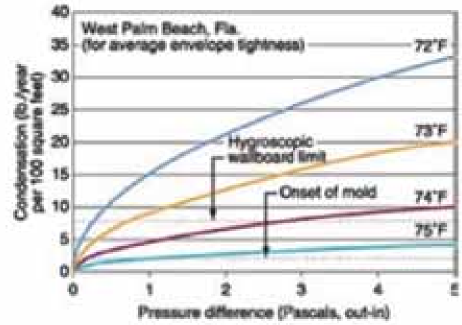

Figure 1 - Moisture and Pressurization

Building performance is a function of not just pressure differential, but envelope tightness and interior temperature. Just a little negative pressure can lead to building failures because of mold and mildew as the potential for moisture accumulation increases with decreasing interior temperatures.

The following considerations must be addressed to ensure proper building pressurization:

- Control of mechanically induced depressurization.
- Proper distribution of makeup air within the building spaces.
- Building designs that overcome any depressurization from stack, wind and fan effect.

The design team must also consider how exhaust-air systems affect space pressures. For example, a toilet-exhaust system should be viewed as a method of addressing odor and localized moisture only, not as a method of drawing outside air into a building. Typically, exhaust rates exceed those required to handle odor problems. Ventilation to control problems with air-quality degradation should be achieved by designing and installing a makeup-air system. Any air that is exhausted from a space must be supplemented with conditioned air from a makeup-air supply system (see Figure 2). Makeup air should never be supplied by infiltration of outside air.

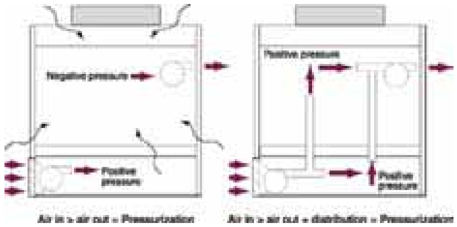

Figure 2 - Effects of Positive Pressurization
An important consideration in achieving positive pressurization is that interior building partitions not adversely affect the distribution of air.

The way buildings operate today is as a multitude of pressure vessels: interstitial spaces in an exterior wall; plenums; dropped ceilings; rooms that typically have doors closed between them. These different pressure relationships—some of which are very well connected to the supply air, some that are not—include pressure-starved areas and some pressure-excessive areas.

Ventilation

Most building codes establish minimum ventilation requirements in relation to occupancy or space function. These requirements are usually based on ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality." This standard specifies the minimum acceptable outdoor air requirements for occupied spaces.

Providing conditioned outside air not only helps pressurize a building but also dilutes chemicals or particulate pollutants generated in the space. Outside air can also be induced in the space by the HVAC system as ventilation air. If the HVAC system introduces air into the space, the system must continuously dehumidify the air. Of course, adequate dehumidification should not be sacrificed for adequate ventilation.

If the air is not continuously and adequately dehumidified, the moisture added to the space might be greater than the HVAC system's ability to remove it. This moisture source normally results in moisture-related mildew problems on the interior surfaces of the building (that is, interior finishes and the surface of furnishings).

Airflow Dehumidification

To provide proper dehumidification, an HVAC system must:

- Fully dehumidify the air that flows across the cooling coil.
- Provide sufficient run time to remove moisture from the interior air despite the satisfaction of interior temperatures.

To fully dehumidify the airflow across the coil, cooling coils must be sized properly to meet the sensible load (load associated with dry-bulb temperature) and latent load (moisture in air associated with wet-bulb temperature). This includes the combination of both outside air and return air. This air must be brought to a temperature that causes the moisture in the air to condense for latent heat (or latent energy) removal. Simultaneously, the cooling coil is reducing the sensible temperature of the air to offset the sensible energy generated in the space (lights, solar, people, equipment, etc.). A common range of temperature for the cooling of this air is between 50°F and 55°F. At this temperature, most HVAC system airflows will be at 100% relative humidity (RH) and will effectively condense moisture from the air. Air provided to a space under these conditions has the best chance of maintaining interior conditions of 75°F dry-bulb (°Fdb) and 60% RH.

Dehumidification Run Time

If the system cannot provide sufficient dehumidification while it reacts to temperature control alone, it must continue moisture removal without affecting interior temperatures and occupant comfort. This can be accomplished by reheating—a form of simultaneously cooling and heating to continue dehumidification while not overcooling the occupants.

Methods of reheating include direct or indirect gas-fired heating; hot-water heating; hot-gas reheating for refrigeration-based units; and for parts of the country that allow it—electric.

Devices added to the equipment, such as wraparound coils, can also provide a means of reheating. Wraparound coils simply transfer energy from the incoming cooling coil air stream to the exiting cooling coil air stream. These coils are available in a passive refrigeration-based unit or as a water-based system that uses pumps to move the water through the system.

In conventional HVAC systems, two dehumidification methods are used. The first is a cooling-based system cooling air below its dewpoint. Moisture condenses on the cooling surface and is removed from the air. For example, a cooling-based system can cool an outside air stream from 95°Fdb (55% RH) to 77°Fdb. At 77°Fdb the air is at 100 percent RH. If it is cooled below 77°Fdb to 55°Fdb, 68 grains of moisture per pound of dry air are condensed out of the air and onto the cooling coil.

The second method involves the use of a desiccant that attracts moisture to its surface by introducing a low vapor pressure at the desiccant surface. The vapor pressure of the moisture in the air is higher, so moisture travels from

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Interaction Between the Building Envelope and the HVAC Systems

A/E Interaction	Positive Building Pressurization	Negative Building Pressurization
Correct Wall Construction*	Mildew/moisture problems unlikely in wall systems and occupied space	Possible mildew/moisture problems in wall system and occupied space
Incorrect Wall Construction	Possible mildew/moisture unlikely problems in problems in wall system; occupied space	Probable mildew/moisture problems in wall system and occupied space

* Wall construction refers to vapor retarders and air and rainwater barriers. Building envelope and HVAC system design must interact to reduce the potential of moisture and mildew formation.

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the air to the desiccant. The desiccant then must be recharged through a heating process, allowing the moisture to be driven from the desiccant and discharged to another location besides the cooling air stream.

One of the best strategies is a combination of desiccant and cooling systems, particularly for 100% outside air streams such as makeup air systems. Since air exits a cooling-based system at saturation, it only moves to a lower RH once it mixes with the room air and heat is added to it. The desiccant, on the other hand, enters the space with very low RH, and its RH increases to the room's RH level once the two air streams reach equilibrium.

Behind the Book

In assembling his book, *Commissioning Buildings in Hot, Humid Climates: Design and Construction Guidelines*, co-author J. David Odom and LBDG hoped to literally fill in key gaps missing in many reference manuals. "It is not everything you need to know about designing buildings in hot, humid climates, but a pathway to crystallizing key issues that are not picked up by other manuals like [the American Society of Heating, Refrigerating and Air-Conditioning Engineers] ASHRAE Handbook: Fundamentals." Its second aspect, likened by Odom to a Windows-like computer operating system, is to facilitate access and direct readers to other documents. The biggest gap the firm feels it has identified is lack of detail in prescriptive vs. performance language. ASHRAE Fundamentals, for example, talks in terms of performance language he says. "It doesn't say you must have constant pressurization, it says 'infiltration must be minimized.' What does that mean?" says Odom. To an architect, it means take out a caulk gun and fill up holes. "Using performance language may work fine in a more forgiving environment, but there are some things that you need to get into very prescriptive language—Do this, don't do that." ■

About the Author: J. David Odom has been a moisture and mold forensics specialist with CH2M HILL since 1978 during which time he has managed some of the largest and most complex moisture and mold problems in the country including the recent $60M construction defect claim at the Hilton Hawaiian Village in Honolulu and the $20M claim at the Martin County (FL) Courthouse.

In 1998, he was named by IAQ Publications as IAQ Person of the Year and in 1999 he was recognized as one of the 50 Most Influential People in the IAQ field. He has published 3 manuals and over 50 technical articles, including a recent monograph on moisture and mold for the National Council of Architectural Registration Boards (NCARB). This article was reprinted by permission from "Sealing the Cracks in IAQ" in the September 1999 issue of *Consulting-Specifying Engineer.*

***Commissioning Buildings in Hot, Humid Climates: Design and Construction Guidelines,* which has been successfully field-tested in over $2 billion in new construction since 1990 and is available by reaching David at 407-697-7227 or d.odom@lpdg.net.**