PREVENTING *HARM* TO THE BUILDING ENCLOSURE

The Building Enclosure's purpose is to protect the occupants and the building's construction materials from Heat, Air, Radiation, and Moisture; known within the building science community by the acronym *HARM*. Thus we have the expression, "Keep the building out of HARM's way".

The building enclosure is defined by the combination of roof, walls, windows, doors, and floors that separate the indoors from the outdoors. These surfaces totally "envelope" the building leading to the alternative term *Building Envelope*.

Component parts of the enclosure create either a *barrier*, where the intent is to prevent intrusion, or a *retarder*, where the intent is to slow intrusion. Roofs provide a barrier against the intrusion of rain and would be defective if any rain is allowed to enter the building. Insulation, on the other hand, is a retarder because it only slows the passage of heat. The use of barriers vs. retarders represents different strategies for preventing HARM.

In spite of our best efforts, buildings will leak. Accordingly, our goal in the design and construction of buildings is to minimize (not prevent) and manage leakage so that it will not cause damage. We achieve this goal first by selecting materials that can tolerate some moisture without being damaged, then by installing them so that they have the opportunity to dry before being damaged. Creating the means for water to get out of buildings is at least as important as preventing its entry in the first place.

HEAT. We control temperature primarily for occupant comfort. People can be comfortable across a range of temperatures between 70°F. and 80°F. When it is cold outside, we add heat, either by burning fossil fuel or converting electricity to heat by passing it through resistance. When it is hot outside, we remove heat with refrigeration. Both processes consume energy, so we insulate buildings to retard the flow of heat, thus conserving energy.

Heat doesn't necessarily damage building materials, but it can reduce their useful life by as much as 50% in a hot-humid climate as compared to how long they will last in cold climates.

AIR. The intrusion of cold air creates drafts, making occupants uncomfortable. Air entering from the outside at 90°F. to 100°F., on the other hand, is not uncomfortable and will usually go unnoticed by occupants, a mixed blessing. Tempering air to room temperature consumes energy, whether being heated or cooled.

More important, outside air in hot-humid climates contains moisture, which moves with the air. The infiltration of outside air is the dominant transport mechanism introducing moisture to buildings.

RADIATION. Radiation, particularly ultra-violet (UV) radiation from the sun, is harmful to both people and building materials. Opaque roofs and walls shield building occupants from the sun at the expense of absorbing the radiation themselves. Outer, exposed building enclosure surfaces must be constructed of materials that do not deteriorate when subjected to UV radiation.

Solid objects, including people, gain or lose heat by radiation to and from other objects that are cooler or warmer. This process is independent of surrounding air temperature. A classic example is sitting by a "pot belly stove" that overheats your side facing the stove, while the side away from the stove remains cold.

When radiant heat is re-radiated by solid objects, the wave length changes (lengthens) and it will no longer pass through glass, trapping the heat and preventing its escape; the so-called "greenhouse effect."

MOISTURE. Water can take the form of a solid (ice), liquid, or gas (humidity, vapor, steam). When at "equilibrium" water changes from one of these states to another in a continuous process. We refer to water in these various states collectively as *moisture*.

Fungus can grow only in the presence of liquid water. Rot in wood is a fungus, as is mold. If wood is allowed to rot, the building will deteriorate and ultimately be destroyed. Mold is hazardous to the health of building occupants. Accordingly, buildings should be kept dry.

A particularly insidious form of moisture is *interstitial condensation*, water that forms between layers of building construction materials, where the damage it causes is hidden from view.

Whether moisture enters as bulk-water rain intrusion, diffuse vapor through walls, or with infiltrating air, it is a contaminant. Moisture is arguably the contaminant that is most HARMful to buildings.

CONTROLLING MOISTURE

Good building design and construction incorporates measures to first control moisture by gravity:

- Roofs prevent water from entering the enclosure.
- Walls either prevent water from entering (barrier) or provide a means for draining water that does enter (retarder) the enclosure.
- Concrete and masonry store water until it can be evaporated by the sun.
- Claddings that allow water to enter are drained.
- Flashings divert water away from connections and openings.
- Drainage systems take water "down and out," safely away from the building.
- Artificial sources of water such as irrigation sprinklers are not allowed to impinge upon buildings.

Then, moisture that enters the enclosure material must be prevented from condensing:

- The use of vapor barriers should be avoided, except under slabs.
- Impermeable vinyl wallpaper cannot be installed on exterior walls.

As stated above, some moisture will enter the building enclosure by 1) overcoming measures to prevent it from intruding the enclosure, 2) air intentionally introduced for ventilation, 3) from processes within the building such as cooking and bathing, and 4) by evaporation from the occupants.

This water that inevitably enters buildings must be removed mechanically:

- By the air conditioning system, whose primary function is to control temperature and removes moisture only as a by-product of that function.

- By dedicated dehumidification equipment where all other measures are inadequate.

Mechanical dehumidification with refrigeration compressors is expensive, both in terms of initial capital investment and in energy consumption. It should be the last, not the first, resort to remove moisture. Only the residual moisture that cannot be prevented or removed through natural means—gravity and the heat of the sun—should be removed mechanically.

AIR CONDITIONING: DETRIMENTAL SIDE EFFECTS

Air conditioning, while intended to improve occupant air quality can have the unintended consequence of adversely affecting temperature, relative humidity, and interstitial condensation within the dwelling's wall and roof/ceiling cavities; any of which would be detrimental to the well being of the occupants and of the building.

In general, construction assemblies should be pressurized on their cooler and drier side. Accordingly, building pressure should be slightly negative in cold-dry weather; slightly positive in hot-humid weather.

Ventilation systems will not necessarily control building pressurization, but they will affect it. Factors to consider include: supply air quantity, exhaust air quantity, hours of operation, infiltration, exfiltration, outside and inside temperature and humidity, and type of construction.

In cold weather, ventilation air has to be heated, relative humidity must be maintained at an acceptable level, and positive building pressure must be avoided.

In hot-humid weather, heat and moisture present in ventilation air has to be removed, negative building pressure must be avoided, and dehumidification equipment to dry ventilation air may have to be installed.

While air conditioning may improve the health and comfort of occupants, it is generally deleterious to the health of the building because it creates artificial temperature and vapor pressure differentials, which in turn can cause condensation. Condensed moisture facilitates both rot and mold. Think of air conditioning as strong medicine, at once making occupants comfortable while slowly destroying the building.

HVAC AND BUILDING SCIENCE: INEXTRICABLY LINKED

From the foregoing discussion we can see that the building enclosure, mechanical equipment and occupants must operate as one integrated system in two simultaneous climates: the outdoor one created by Mother Nature and the indoor one created artificially for the occupants.

In our culture, we assign tasks according to the expertise and resources possessed by various construction professionals: architects, engineers, building officials, contractors, manufacturers, and skilled tradesmen.

Heating, Ventilating, and Air Conditioning (HVAC) engineering and Building Science—the study of HARM as discussed above—are generally defined as separate disciplines for purposes of analysis or job description. But the natural laws of physics and thermodynamics govern this process indiscriminately and universally, unaware of either the desired result or of our arbitrary divisions of labor. Thus HVAC and Building Science are inextricably linked.