Raising the Standard for Home Environments.

Building Science Basics

Introduction to Building Science Basics

Since a home is the most significant purchase most people make, and good health is priceless, knowing how to protect both is important. On average, Americans spend 65% of their time in their homes, in what is usually viewed as a safe haven. However, growing evidence suggests that some homes may be detrimental to the health of their occupants, especially those with compromised lung capacity due to age, asthma/allergies, chemical sensitivities or other respiratory conditions. Building Science Basics helps homeowners understand in simple terms the science behind how their home functions. While many problems that develop in a home require the attention of a building science expert, knowing the basic principles that govern a home's performance should help homeowners become more aware of the factors that affect the health of their home and its occupants.

A house is much more than four walls and a roof. It is an interactive system made up of many components, structure, ventilation, and filtration. Each component influences the performance of the entire system. Buildings perform in very predictable fashion. These performance characteristics are based on four simple principles of physics. Although solid design is the starting place for a healthy home, proper maintenance is important for both interior and exterior components to function as designed.

Basic Performance Principles

There are many principles at work in our homes. Here we will address four principles that will help us better understand how our homes perform. These are:

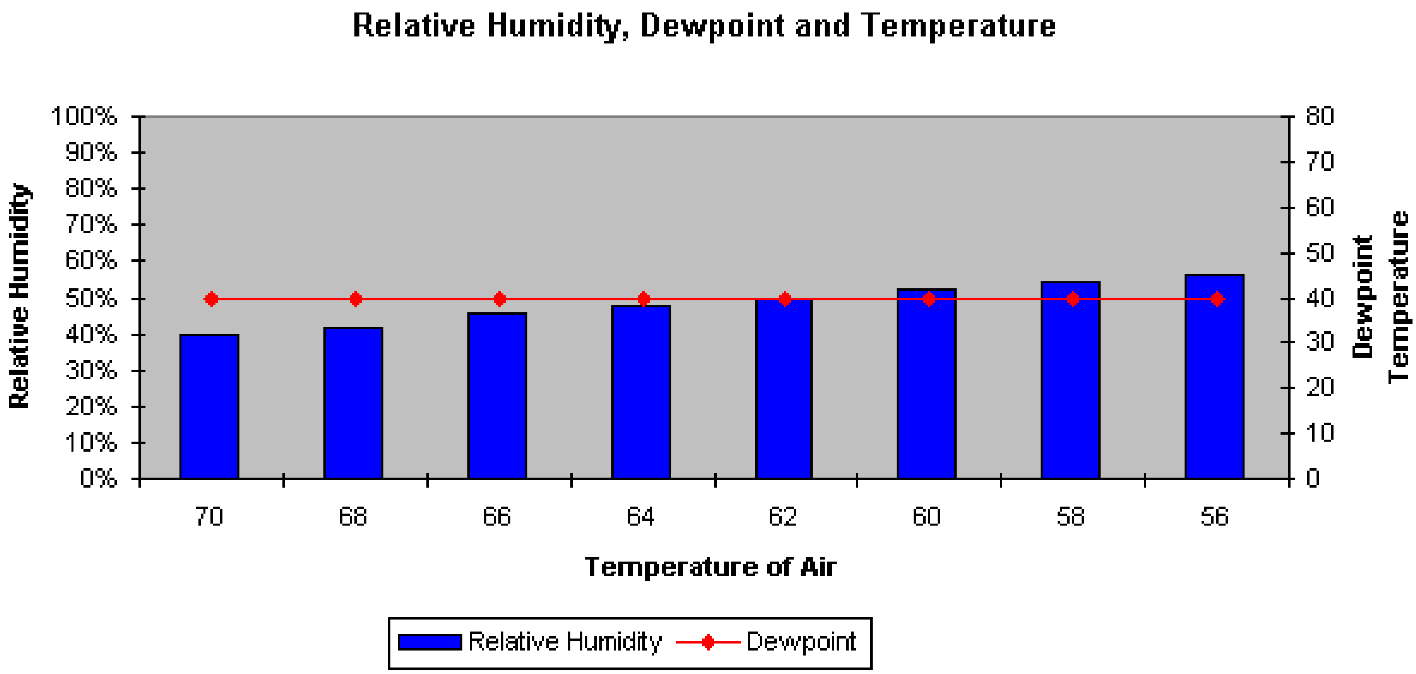
1. Moisture movement
2. Dewpoint temperatures
3. Pressures
4. Heat flow

1. Moisture mo vement: Moisture levels in a home depend on a variety of different factors such as lifestyle (showering and cooking), number of occupants, leaks, and ground/atmospheric moisture. Moisture wants to move from areas of high vapor pressure to areas of low vapor pressure. Vapor pressure is the pressure exerted by water molecules in a mixture of air. An example: when the home is being heated, moisture wants to move to the outside, and when it is being air conditioned, moisture wants to move from the outside to the inside of our homes.

   One of the most common ways we use to discuss moisture in homes is relative humidity (RH) levels. RH is a percentage that indicates the amount of moisture in the air relative to the maximum amount the air can hold at that temperature. Warm air can hold more moisture than cool air, so the RH of a sample of air will change as the temperature changes, even though the actual amount of moisture in the sample does not. If we raise the temperatures, we lower the RH and if we lower the temperature, we raise the RH.

2. Dewpoint temperatures: Dewpoint is the temperature where water vapor will change to liquid water. This is a function of both temperatures and the amount of moisture in the air. If we have a dewpoint of 40 degrees, any surface in the home that reaches this temperature will have liquid water on it. To prevent this condensation, we can either raise the surface temperature or lower the relative humidity.

   The following graph helps explain dewpoint and relative humidity data as they apply to our homes. Assuming we have a dewpoint temperature of 40 degrees and start with an interior temperature of 70



   degrees and 40% relative humidity, our home would not see any condensation on surfaces. If we start to lower the temperature, our RH goes up, and at about 62 degrees we would start to see condensation, let's say on our windows. We could then raise the temperature or lower the relative humidity to get the window surfaces above the dewpoint, and eliminate the window condensation.

3. Pressures: Pressure moves from areas of high pressure to areas of low pressure. Pressure and holes are one of the biggest concerns in residential construction, and they are tied into much of what we need to understand about how our homes function. Pressures can be caused by external conditions (wind and temperature), internal conditions (exhaust fans, air handlers, chimneys and vents, and clothes dryers). In order for pressures to influence how a house performs, there needs to be either an intentional or unintentional hole associated with pressure. If you feel cold air entering your house, this is a result of both a hole and pressure. If you take either of these away, the hole or the pressure, the air will not move. An important point to remember is that cold air entering your home may be replacing warm air leaving your home. In other words, we tend not to notice air leaking out of our home as much as air leaking into our homes, although they can be equal amounts. Air leaking out can generate problems with attic and wall condensation in cold climates and ice dams in climates with heavier snow loads.

   We need to look at two control strategies here, holes and pressures. For any given hole, the amount of air moving through will be a function of the characteristics of the hole and pressures. And remember, if we stop the air from leaving our home, we will automatically reduce the air we feel entering our home. Forced air heating systems use pressure to move air across a heat exchanger, and into our conditioned spaces. The same system creates pressure across a furnace filter drawing air through the filter, which in turn catches the particles in the air. If the forced air system were not operating, a home would not have any filtration no matter how efficient the filter.

4. Heat flow: Heat moves from areas of higher temperature to areas of lower temperature. When heating, your home's warm air is escaping to the outside, and while cooling the opposite is happening. Insulation is designed to resist heat flow, so the higher the R-value (R-value is the resistance to heat flow: the higher the number, the better an insulation material is able to slow heat flow), the slower heat will move into or out of a home. To understand how we slow heat movement in our homes, we need to discuss the mechanisms of heat flow. There are basically three types of heat flow we need to be concerned with.

    Conduction = is the transfer of heat energy between objects that are in contact (touching a hot iron is one form of conduction)
    Convection = is a mechanism for heat transfer in gases and liquids; it requires air or liquid movement to transfer heat (a hair dryer moves heat this way)
    Radiation = is the transfer of heat in the infrared spectrum, and will occur even in the vacuum of space (that's how the sun's warmth reaches us)

Remember pressure and holes? Even with insulation, if we have a hole and pressure across the hole, we can move an enormous amount of heat through insulation (convection). These same holes and pressures can move substantial amounts of moisture through the insulation. Remember dewpoints? If we try to move moist air through insulation, the dewpoint and the resulting condensation can occur in closed wall or ceiling systems. Unlike window condensation, this will not be as obvious and may result in ceiling staining, biological contamination (e.g. mold), and in severe cases, structural degradation.

Moisture Issues

Moisture problems are the number one source of residential concerns. Interior relative humidity (RH) is what is most frequently discussed. Relative humidity is a percentage that indicates the amount of moisture in the air relative to the maximum amount the air can hold at that temperature. Based on both building and occupant characteristics, optimum RH levels may be quite different. For the building, depending on climate, windows may start showing heavy condensation at interior RH levels as low as 25%, while hardwood floors may start showing gaps between boards below 35% RH. For homeowner comfort, levels of 40%-60% are generally recommended, although on a seasonal basis controls to maintain 40%-50% RH would be ideal.

Dewpoint is another important consideration when discussing relative humidity. Simply stated, dew point is the temperature at which water vapor starts to condense into liquid water. Most frequently, this is seen on windows of a home in cold weather conditions. This also occurs in walls and attic systems, although this is not as readily visible as on windows. When it starts getting cold outside, and windows are starting to show signs of water condensing on the interior surface, this can be a problem.

Here are ways to resolve these problems. First deal with the issue of dewpoint. Every relative humidity has a dewpoint. For this example, use a relative humidity of 48%, standard window glass of an R-2 and a dewpoint of 40 degrees F. With these values, we would expect to see condensation forming on the glass when the outside temperate goes to 0 degrees, with condensation getting heavier as the outside temperature gets colder. As we cannot realistically change the outside temperature, we must lower the relative humidity or raise the temperature of the glass. Here are two simple tips to solving condensation on windows, an annoying winter problem:

• Operating a ventilation system, even a small bathroom fan, will decrease the relative humidity.
• Putting tight fit plastic over the interior surface of the glass will raise the temperature of that surface.

In general we need to consider four sources of moisture in a home. These include:

1. Homeowner generated moisture (water vapor)
2. Building generated moisture (water vapor)
3. Soil generated moisture (water vapor)
4. Bulk water (liquid water)

• Homeowner generated moisture is produced by bathing, cooking, breathing and wet cleaning. Although variable, this can be as much as 6-10 pints per day.
• Building generated moisture is produced both by new building components drying out and seasonal drying of building components. This can be as much as 2-5 gallons per day.
• Soil generated moisture can enter as a water vapor from air movement into the home from the surrounding soil, and capillary movement through the slab or foundation walls.
• Bulk water can enter from both below ground and through building components such as windows, flashings and roof components. This can be as much as 20-100's gallons per occurrence.

Ventilation

Household air can contain high levels of pollutants and irritants, including dust, pet dander and chemicals as well as high moisture levels. These can have a serious health impact on your family, along with causing problems for the house itself. Homes need effective ventilation for the occupants and the building. Effective ventilation means both a controlled ventilation rate and a means of distributing the fresh air to habitable spaces where people live. Ventilation systems are used to expel stale and polluted air from the house and bring fresh air into the home. There are many different types of ventilation, as well as different installation techniques for each type of ventilation.

- Natural ventilation: Homes that rely on windows and natural airflow through cracks in the building. Even though a home may be drafty, it may not be a reliable source of fresh air, since natural ventilation depends on factors such as temperature and wind. Since you can't control natural ventilation, there is no way to ensure that fresh air is coming in.
- Spot or source point ventilation: This form of ventilation uses bathroom and kitchen exhaust fans. These are generally operated on an intermittent basis for cooking and bathing, and are not necessarily a substitute for occupant ventilation.
- Balanced ventilation: This type system requires both a ventilation fan to remove moist and polluted air and a fan for fresh air to replace the air being vented. This can be achieved with or without heat recovery as part of the system.
- Exhaust ventilation: This system uses an exhaust fan to remove air from the home. An equal amount of make-up air enters either by way of intentional openings or through random holes in the structure of the home. This type of ventilation maybe preferred to other systems during months requiring home heating.
- Supply ventilation: This system uses either a supply fan or a forced air heating/cooling fan to deliver fresh air into a home, and in some cases can pressurize the home. This type of system maybe preferred to other systems during months requiring home cooling.

These systems either use neutral pressure, negative pressure or positive pressure techniques to provide ventilation. Depressurization of your home can cause problems with combustion appliances backdrafting. Backdrafting is the term used to describe the unwanted flow of combustion gases into your home by vented combustion appliances. Pressurization of your home can promote moisture movement out of the home during heating seasons. Careful considerations of the type of ventilation, as it relates to pressures, should be made prior to choosing a system for your home.

The ventilation rate should be sized so each person in the house has a minimum ventilation rate of 15 cubic feet per minute (CFM). This ventilation rate should be continuous when the home is occupied. For all ventilation strategies, there are considerations such as the sound rating of the equipment, efficiency of the equipment and energy or heat recovery of the equipment. For continuously operated fans, sound ratings of 1 sone (a linear unit of measurement used to express sound intensity) or less are appropriate. The higher the rate of ventilation, in CFM, the more important heat or energy recovery would be. A heat or energy recovery unit is a device capable of transferring heat and sometimes moisture between two airstreams.

Filtration

Filtration is another important aspect of good indoor air quality. The purpose of most conventional furnace filters is to protect the fan motor from dust particles. Particles, including mold, dust and pollen, should be removed from indoor air. Not only are there several standards that are used to rate filter efficacy, each home may have unique requirements for filtration. These requirements may include:

- What particle size we are concerned with
- What existing system is in place to provide filtration
- What sources of particles are present
- What level of filtration we want

Filter Types

In addition to the above issues, considerations in filter selection should include the efficiency of the filter, life of the filter, maintenance of the filter and filter costs. When comparing costs, filter efficiency and filter life need to be considered so as to ensure we look at life cycle costs rather than first costs alone.

The preferred method of rating filters is the American Society of Heating and Refrigeration Engineers (ASHRAE) Standard 52.2. This standard provides guidance on filtration with consideration given to particle size in the rating process. In general, the smaller the particle size the more potential for respiratory irritations. A good starting point for most systems would be 35% efficacy at > 3 microns.

Although there is much more to understanding building basics than can be conveyed here, these simple explanations should help homeowners evaluate some conditions that may affect performance issues or indoor air quality concerns in their home. For severe or complicated problems, homeowners should consult building science professionals, and professional assistance may be required to identify and fix some of the problems described above.

For further assistance , contact 1-877-521-1491 or visit our web site (http://www.HealthHouse.org).

Other resources:

Environmental Protection Agency: http://www.epa.gov/iaq/
American Lung Association: http://www.lungusa.org
Local Health Department
Local University or Extension Service
Minnesota Department of Commerce: http://www.commerce.state.mn.us