## http://www.relative-humidity-sensor.com/relative-humidity.htm

## http://www.toxic-black-mold-info.com/prevent.htm#Tips

## Why Monitor/Control the Relative Humidity Levels Inside My Home or Building?

1. **To prevent the growth of mold, dust mites, bacteria, fungi, viruses and lower the rate at which chemical off-gassing occurs** from materials in the home. The optimum relative humidity range for the well being of the home and for the health of the occupants is between 30% to 50% RH.

   In this day and age, people are spending more of their time indoors (approximately 90%), so the indoor air quality is a vital factor in maintaining healthy lives. A home that is too humid or damp can promote the growth of mold and dust mites. If present at high levels indoors, these microorganisms may adversely affect the health of individuals. The most common symptoms of mold or dust mite exposure are allergic reactions such as runny nose, itchy eyes, throat irritation, headaches, etc.

**U.S. E.P.A. (Environmental Protection Agency) on controlling relative humidity indoors:**

"By controlling the relative humidity in a home, the growth of some sources of biologicals can be minimized. A relative humidity of 30-50% is generally recommended for homes. Standing water, water-damaged materials, or wet surfaces also serve as a breeding ground for molds, mildews, bacteria, and insects. House dust mites, the source of one of the most powerful biological allergens, grow in damp warm environments."

2. **Damp structures** are more susceptible to a variety of problems that will work to **damage the integrity of the home**.

   Homes that have high humidity levels are more likely to become infested with termites and carpenter-ants since these insects prefer and migrate towards moist wood, and the steel components of a home may begin to rust if the indoor relative humidity is too high.

   Excessive moisture levels in homes can significantly increase the maintenance and operating costs through damage to furnishings, wall coverings, carpets, ceilings, etc.
3. **Moisture Problems and Wood.**

   Wood is a hygroscopic material, meaning that it readily takes up and retains water. It always contains water and exchanges water vapor with the air. For example, wood will adsorb water when the relative humidity is high, and release it when the relative humidity is low. Wood swells as it adsorbs water and shrinks as it releases water, so both its moisture content and dimensions are controlled by the relative humidity of the air.

   Inside homes the relative humidity of outdoor air drawn inside is drastically altered by heating and cooling and seasonal changes. It is these extreme fluctuations in relative humidity that may disrupt the wood moisture content and cause structural damage of the wood.

## About Relative Humidity

**What is Relative Humidity (RH)?** Relative humidity is defined as the ratio of the water vapor pressure or water vapor content to the saturation vapor pressure or the maximum vapor content at the temperature of the air or gas. The saturation vapor pressure in the air varies with air temperature: the higher the temperature, the more water vapor it can hold. When saturated the relative humidity in the air is 100% RH.

According to the EPA, the relative humidity recommended for houses is between 30% and 50%. This level of humidity is not always easy to maintain, especially in certain “problem” areas of the home. A dehumidifier is often needed in basements and crawlspaces where humidity can be very high. However, in the winter months, the use of the furnace may contribute to most parts of your home suffering from the opposite problems: a lack of humidity. Therefore, monitoring RH levels in your home will allow you to maintain all areas it at the recommended levels and deal properly with seasonal variations.

**Examples of How Relative Humidity Changes Occur**

- On a 30 degree F day with an outdoor RH of 60%, the relative humidity indoors can drop to levels as low as 15% when the air is heated to 70 degrees F (as the air is heated it expands giving it the capacity to hold more moisture. If moisture is not added to the air as it is heated the RH level may drop considerably). If the outdoor temperature is 10 degrees F, the indoor relative humidity may fall to 8% or less. These are extreme levels of dryness. As a comparison, the average relative humidity in the Sahara Desert is 25%.
- Since warm air can hold more water vapor than cold air, the relative humidity of the air can be changed by simply changing its temperature. If in the winter, outside air at 20 degrees F and 65% RH is drawn inside and heated to 70F without humidification, its RH drops to about 10%. In summer, outside air at 70F and 60% RH flows into a basement at 60F causing an increase in RH up to 82%.

You can see from the above examples why it is important to measure and control relative humidity levels throughout the entire home or building, since the humidity levels in the air may change drastically through the heating and cooling processes. These processes can then lead to extreme highs or lows in the relative humidity levels indoors.

If you suspect unhealthy conditions in your home due to humidity being too high or too low, it is prudent to utilize a tool known as a digital thermo-hygrometer (a.k.a. moisture meter or humidity sensor). This handy instrument digitally calculates temperature and measures indoor relative humidity levels. It can store the minimum and maximum temperature and relative humidity as well as provide up-to-date readings of the present conditions. Using a thermo-hygrometer is the best way to learn about and understand your indoor environment. This unit allows you to evaluated the RH levels in your home and understand the RH patterns, such as highs and lows, that exist.

## Monitoring Relative Humidity

It is absolutely vital to know whether or not you have a humidity problem. Not only do you need to know "if", but you also need to know "where" (which areas or rooms) a humidity problem may exist, since the humidity level will not necessarily be consistent throughout a home or building.

Otherwise, you will not know if something needs to be done to correct the problem, or where you need to focus your efforts.

To monitor the relative humidity level throughout the home or building, you will need **relative humidity sensors**, also known as **hygrometers** or **moisture meters**.

***Places where you should monitor Relative Humidity*** *(at least periodically)**:***

- Each of the rooms (especially bathrooms)
- Attic, space between roof and ceiling

- Basements, crawl spaces, cellars
- In wall cavities
- Ductwork, especially closer to air handler (nearby where filter is installed)
- Cabinets
- Closets, food storage areas

If you do have excessive humidity, and see evidence of a mold problem, then you may need an air purifier to remove mold spores from the air.

**Ionizers** are typically better than air filters, since they can remove smaller particles from the air, and do not rely on particulate passing through them in order to remove them from the air.

## Moisture and Wood

Wood is a hygroscopic material. It always contains water and constantly exchanges water vapor with the air. Wood picks it up when atmospheric relative humidity is high, and gives it off when relative humidity is low. Since wood swells as it adsorbs water, and shrinks as it releases water, both its moisture content and its dimensions are controlled by the relative humidity of the surrounding air. Wood moisture content is equal to the weight of water contained in the wood divided by the oven dry weight of the wood, expressed as a percent.

Despite wide day-to-day fluctuations, average outdoor relative humidity actually changes little from season to season. However, inside homes the relative humidity of outdoor air drawn inside is drastically altered by heating it and cooling it without humidification or dehumidification. It is these extreme seasonal swings in relative humidity that may disrupt the wood moisture content and cause structural damage of the wood through changes in dimensions.

# Humidity Control Tips

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**Note:** Make sure that you have a humidity sensor to verify that your humidity reduction efforts result in a relative humidity level is which falls below 50-55% RH.

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## Use Dehumidifiers

Dehumidifiers remove moisture by drawing air across a cooled surface, causing condensation to occur. The water that condenses runs into a drip tray and either collects in a container or is pumped into a sink. This type of dehumidifier is economical in electrical consumption, and works well above 60-65$^{o}$F and above 60% relative humidity.

With dehumidifiers, it is **more effective to use multiple room units**, as opposed to a single large unit that attempts to dehumidify a large area. It is also affordable to include a few **small-area units** for bathrooms, closets, cabinets, etc. Dehumidifiers can reduce the humidity in the room or area where they are placed, but a single unit will not impact the humidity level beyond this area very much, if at all.

Here are **factors** to consider with **dehumidifiers**:

- Water extraction (measured in pints)
- Automatic tank shut off (when tank is full)

- Air filtration
- Anti-frost sensor
- Efficient air flow
- Water pumped out of room/home
- LCD screen
- Fan speeds
- Energy consumption
- Chassis material
- Lowest temperature at which it can operate
- Noise level

## Use of Humidity Sensors

Humidity sensors allow you to determine whether or not you have a humidity problem by measuring the relative humidity in the area where you place it. This way you not only know *if* you have a problem, but to a degree you can pinpoint *where* you have a problem. Anything above 50-55% RH (relative humidity) is considered excessive, and could lead to mold, dust mite, and other microorganism growth inside.

## Ventilation

Proper ventilation can reduce moisture in the home. Keeping the **air pressure** in the home or building at a *slightly* higher level than the air pressure outside will help to ensure proper ventilation. Slightly positive air pressure forces moisture and contaminates outside.

If the air pressurization is the other way around (negative), where the air pressure is higher outside, then it **will force moisture and pollutants back into the home** or building.

**Avoid over-pressurization** though (too much of a positive air pressure), since it will cause moisture to be forced into walls and structural cavities, compounding the moisture level inside, and potentially damaging the home or building.

In order to achieve a slightly positive air pressure, adjust the supply ventilation slightly higher than the exhaust ventilation.

Also, combustion appliances and bathroom/kitchen fans should bed vented outside if possible. Combustion appliances include space heaters, ranges, ovens, stoves, furnaces, fireplaces, water heaters, and clothes dryers.

## Keep Crawl Spaces Dry

Put a plastic cover over dirt in crawlspaces to prevent moisture from coming in from the ground. Be sure crawlspaces are well ventilated with good cross ventilation under the house so air will circulate freely. Make sure all vents are unobstructed and repair any torn vent screens. If you don't have sufficient vents, add more.

## Keep Basement Dry

In general, basements have the highest humidity level in the home. If you allow the basement to remain humid, mold and dust mites can begin to colonize, and spread to other parts of the home. As a result, you may need to use a dehumidifier in the basement. You should also make sure the foundation walls are well-insulated, and that the basement is well-ventilated.

There are also things that can be done during the construction phase, such as applying a dampproof coating on the below grade portion of the foundation wall.

The basement floor can be a significant source of moisture. To reduce water absorption, the concrete slab should be poured on top of three to four inches of washed aggregate, with a sheet of polyethylene installed beneath the

aggregate. Insulating the floor slab saves energy and improves comfort; it also reduces basement condensation in the summer.

## Check for Leaking Pipes

Many pipe leaks occur without the home owner realizing they are happening. As a result, the water damage occurs before they are detected, and the humidity level in the home increased, perhaps to a level that is unhealthy (50-55% relative humidity or higher).

***Signs that you may have leaking pipes:***

1. You can hear running water sounds when nothing is turned on.

2. Musty odors that seem to originate from walls or floors.

3. Running toilets and dripping faucets.

4. Abnormally high water bills.

5. A water meter reading that changes when you aren't using any water for an hour.

6. Discolored or damaged walls.

7. A cracked or damp foundation or slab.

8. Warm spots on concrete slab floors, mildew, or excess moisture under carpets.

9. Regular sewer backups.

10. Areas in the yard that are too wet and with unusual plant or grass growth.

## Prevent Water Intrusion through the Foundation

The most important thing you can do is making sure the ground slopes away from the foundation. If necessary, you may want to apply a waterproofing sealant to the foundation.

## Prevent Water Intrusion through the Roof

Inspect your roof at least twice a year. Especially proceeding harsh weather conditions and between seasons.

Roofs will weather under the heat/sunlight. It can essentially be "baked" and become dry and brittle (alligatoring), hence it is more likely to split and eventually leak. Metal components of the roof can rust and corrode, and asphalt-based plastic cement used for seals around pipes, vents, and other penetrations may deteriorate over time and leak. You can apply a coating to some roofs to create a layer of waterproof protection.

Also, make sure the attic is well-insulated.

## Seal Windows

Condensation on or around the window is the sign of a excessive moisture. If this is happening, use a sealant around the window to make sure that it is completely air tight.

## Foundation:

To prevent water from collecting around the foundation, and seeping up through the walls, make sure the **ground slopes away** from the foundation.

Here are some **additional tips** in preventing water seepage through the foundation:

1. Ensure the floor is well ventilated and walls are properly sealed against moisture entry. Polythene put over damp ground can help prevent dampness rising into the house.

2. Insulate your home properly. In the winter, insulated ceilings, walls and floors have temperatures similar to those of the warmer air inside the home, therefore condensation is less likely to form.

3. Prevent rising damp from entering a foundation wall by improving your home's perimeter drainage. Direct all surface rainwater away from the home through drainpipes, culverts, French drains, etc.

4. If no other methods are feasible, a last resort would be to install either a physical or chemical horizontal damp-proof course.

## Roof:

***1. Ways to Inspect for a Roof Leak.***

A **common cause** of leaks is from **cracked or damaged chimneys**. Look for loose brick, cracked mortar joints, and a solid metal or concrete cap on top.

Look for **water stains on the inside ceiling**, and on the beams in an attic. Beams that have been exposed to water will become weakened and cause a sag in the roof.

Look for any **visible damage** such as cracks, tears, splits. These will most likely lead to leaking.

Closely inspect all **roof penetrations** (i.e. skylights, chimneys, vents, etc). Look for signs that the cement is separating from the surface, especially at a vertical penetration of the roof.

Check areas **where different materials meet** such as metal to brick, shingles to metal, etc. These surfaces expand and contract at varying rates and will pull away from each other. Make sure the seals between materials are tight, not loose.

You can attempt to find a leak from the inside by using a flashlight and tracing the leak uphill.

***2. How to Protect/Maintain the Roof.***

Inspect your roof at least twice a year. Especially proceeding harsh weather conditions and between seasons.

Roofs will weather under the heat/sunlight. It can essentially be "baked" and become dry and brittle (alligatoring), hence it is more likely to split and eventually leak. Metal components of the roof can rust and corrode, and asphalt-based plastic cement used for seals around pipes, vents, and other penetrations may deteriorate over time and leak. You can apply a coating to some roofs to create a layer of waterproof protection.

***3. Ice Dams and Leaks.***

Leaks caused by ice dams occur when warm, heated air from the home begins to migrate through the insulation and into the attic area of the house. Without proper ventilation, this warm air collects in the attic area and may warm the underside of the roof decking.

Cold outside temperatures keep the top outside layer of moisture frozen and the warm decking melts the bottom layer of ice turning into liquid water. This water will run down the shingles until it meets the "dam" at the gutter

line. With no escape route, the water pools, then backs up underneath the shingles and enters the attic area through nail holes and seams in the roof decking

***4. Ways to Minimize the Occurrence of Ice Dams.***

Keep the attic adequately insulated.

Do not cover the attic soffit air intake vents with insulation (add these to your home if you don't have any).

Ensure attic has sufficient air exhaust outlets and airflow is distributed evenly throughout the attic (peak mounted ridgevents maximize air flow).

An ice and water shield can be installed at the eaves of the home and under the shingles to prevent water from entering the home.

Install electric heat tapes in the gutter system.

## Windows:

Condensation on or around the window is the sign of a excessive moisture. If this is happening, use a **sealant** around the window to make sure that it is completely air tight.

## Walls:

Taking measures to **reduce water leakage** through the **roof**, leaky **pipes**, and the **foundation** (see above for each of these), as well as through the **gutters** (below) will go a long way in keeping the walls from collecting too much moisture.

In addition to this, make sure that the **air pressure is not too high** on the **positive side** (see Ventilation tips below). However, you do want the air pressure inside to be slightly positive.

Also, make sure that the **relative humidity level is below 55%** to prevent your walls from taking in too much moisture (Relative Humidity Sensor Buying Guide). Use dehumidifiers if necessary.

## Gutters:

Clogged or faulty rain gutters can cause excessive water leakage through the walls, roof, and foundation of the home. You can **clean your rain gutters** with a light broom, a garden hose with a controllable-spray nozzle, or by using one of many gutter-cleaning devices on the market.

Adding **perforated covers** over your rain gutters will cut down on the frequency of cleaning. Rainwater and some dirt/small debris can permeate the cover but large debris, such as large leaves and twigs, cannot. These covers can typically be found in a local hardware store for only a couple of dollars for about every 4-feet of length.

Make sure your gutters' **downspouts** are properly cleaned too. Spray water into the gutter or the top of the downspout to ensure it drains freely and with no obstructions. Water must also be diverted away from your home's foundation.

If you don't have a spout going directly into a drain system in your yard and toward the street or a drainage basin, use **splash blocks**. These relatively small devices will channel the water from your downspout and away from your home and only cost a couple of dollars.

## Basements/Crawl Spaces:

Click here for more on basements and crawls spaces.

## Basements / Crawl Spaces

1. Put a **plastic cover** over dirt in **crawlspaces** to prevent moisture from coming in from the ground. Be sure crawlspaces/basements are **well ventilated** with good cross ventilation under the house so air will circulate freely. Make sure all vents are unobstructed and repair any torn vent screens. If you don't have sufficient vents, add more.

2. Get your basement **waterproofed** through a professional service:

http://www.basements.com/ http://www.housingzone.com/topics/kocht/cmaterials/koc01cv006.asp
http://www.xypex.com/

3. Building construction practices to prevent moisture in a new home, particularly in the basement:

**Site selection.** The first and perhaps most important step is to select a suitable site. Moisture problems are greatly reduced if a home is built on a site with a high water table.

**Surface drainage.** Landscaping should be graded/sloped to direct rainwater and melting snow away from the foundation. At least six inches over the first ten feet from the foundation wall.

**Dampproofing.** A dampproof coating on the below grade portion of the foundation wall. Tell your builder you want a high quality, durable waterproofing. A thin dampproof coating is vulnerable to damage during construction.

**Floor slab.** The basement floor can be a significant source of moisture. To reduce water absorption, the concrete slab should be poured on top of three to four inches of washed aggregate, with a sheet of polyethylene installed beneath the aggregate. Insulating the floor slab saves energy and improves comfort; it also reduces basement condensation in the summer.

**Drainage system.** An effective exterior drainage system drains bulk water away from the foundation. A channel of coarse rock or drainage tile may be used. The drainage system must be installed on the outside, and near the bottom of the footing

**Foundation wall insulation.** Foundation insulation may be placed on the exterior wall, be an integral part of the wall, or placed on the interior of the foundation wall. Regardless of where the insulation is placed, a moisture barrier is required to reduce outdoor moisture from coming through the foundation wall. In the case of insulation placed on the interior side of the foundation wall, both sides of the insulation must be protected. A moisture barrier is required between the insulation and the wall from floor to grade, and a vapor retarder is required on the interior side of the insulation.

4. To keep water out of crawlspaces, **dig ditches** around the sides of the house down to the footing. Install **gravel and drain lines** that are sloped about 2 inches per 10 feet to carry water away from the house. Direct the water to a natural drainage, to the street, or a French drain. Before backfilling, place waterproof membranes against the foundation wall. Also, ensure water from downspouts is directed away from the house.

## Ductwork / HVAC System

### Sanitize Cooling Coils

Make sure you periodically wipe any biological growth from the coils. Condensation is continually dripping off the coils when the HVAC system is running. This condensation provides a perfect place for mold to grow.

In which case, **disinfectant** should be periodically applied to the coils. You can also use an **in-duct ultraviolet (UV) light air purifier**, installed near the coil, to destroy mold before it has a change to grow. It will also destroy mold and other microbes that are caught in the filter.

**In-duct ultraviolet (UV) light air purifiers** are now being **specified by the U.S. government's General Services Administration (GSA)**, to be used in the ductwork (near the cooling coil and drain pan) of all new federal buildings. Their standards document concerning this reads:

"Ultraviolet light (C band) emitters shall be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer."

### Drain Pan

This is where the condensation from the cooling coils drips. If you have a flat drain pan, the stagnant water will become infested with mold growth. In which case, a **sloped drain pan** should be used, so the water runs off to the proper location. You also need to check to make sure that **drain lines** are flowing properly.

In addition, the drain pan should be cleaned with a **disinfectant** on occasion, and should be replaced when **corrosion** becomes significant.

### Filters

Change your HVAC filters on a regular basis. If this is not done, the filter itself can become a **fertile breeding ground** for all the molds and other biological contaminates that are collected. Once this happens, the **spores from the mold will multiply**, and will be **circulated** throughout the home or building through the ductwork.

### Insulation

If you have **insulation lining the interior** of the ductwork, then it should be **removed**, so you are left with bare sheet metal. The fiber glass insulation collects a lot of dirt and dust, which provides a good habitat for mold colonies. Once the mold begins to grow inside the ductwork, the mold spores will be spread throughout the house when the HVAC system is running.

Cleaning Mold in the HVAC System

## New Construction

In many cases, mold problems can be avoided or caused during the construction of a home or building. In which case, you can take precautions during this phase to save yourself mold headaches down the road.

First, **review many of the tips on this page** to make sure that the house is built in such a way that as many of these as possible can be put into place.

In addition, **avoid using moldy materials**, ensure that any fake stucco that is used is installed 100% properly, since this is a common cause for mold growth in exterior wall cavities. If you are really adamant about preventing potential mold problems, then you may want to avoid using fake stucco altogether.

## Dirt / Dust Removal

An environment that is "dirty" or "dusty" is far more conducive to mold problems than a clean environment. Dirt, dust, and grime are often composed of **organic material**, which is a staple of the the **toxic "black" mold diet**.

House dust also serves as a **means for locomotion** for mold spores, enabling them to spread throughout the home more effectively.

## Ventilation

Proper ventilation can reduce moisture in the home. Keeping the **air pressure** in the home or building at a *slightly* higher level than the air pressure outside will help to ensure proper ventilation. Slightly positive air pressure forces moisture and contaminates outside.

If the air pressurization is the other way around (negative), where the air pressure is higher outside, then it **will force moisture and pollutants back into the home** or building.

**Avoid over-pressurization** though (too much of a positive air pressure), since it will cause moisture to be forced into walls and structural cavities, compounding the moisture level inside, and potentially damaging the home or building.

In order to achieve a slightly positive air pressure, adjust the supply ventilation slightly higher than the exhaust ventilation.

Also, try to ventilate appliances and bathroom/kitchen fans outside if possible.

## Properly Vent Combustion Appliances

Combustion appliances include space heaters, ranges, ovens, stoves, furnaces, fireplaces, water heaters, and clothes dryers.

Typically these appliances are safe. However, the combustion process always **produces water vapor**, if the appliance is not properly vented, it can lead to increased amounts of moisture in the home and provide an ideal environment for mold growth.

**Examples of properly venting combustion appliances** include equipping ranges with hood fans that are exhausted to the outside, keeping doors open to rooms where these appliances are operating, making sure that the vents are connected and unblocked, and that there are no holes or cracks in the ventilation systems. Finally, make sure that you follow manufacturer instructions when installing and using combustion appliances.

## Keep Firewood Indoors

Firewood often has a little mold growth on it before being brought indoors, since it contains nutrients for mold to grow and thrive. This is not a problem if kept outdoors, but the mold growth can really progress if the firewood is kept in contained areas.

## Shower Curtains

**Replace** shower curtains when mold begins to become visible.

## Air Purification

You may want to use an **air purifier** to minimize the airborne particulate, which allows mold spores to disperse to other areas of the home or building.

**Ionizers** are typically better than air filters, since they can remove smaller particles from the air, and do not rely on particulate passing through them in order to remove them from the air.