



## **Why Should I Worry About Moisture Problems?**

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*Moisture problems in Canadian housing are detrimental to our health and to the durability and resale value of our homes. This fact sheet shows you how to solve moisture problems, improve energy efficiency and reduce greenhouse gas emissions that contribute to climate change.*

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### *“I can’t see through these windows!”*

- Winter-long condensation and frost on windows is annoying and can damage the window frame and wall below.

### *“Our basement smells like . . . a basement.”*

- Musty odours are a symptom of dampness and mould growth. A flood, sewer backup or burst plumbing can lead to many hidden moisture problems, even after the mess has been cleaned up.

### *“Wheeze . . .”*

- Large-scale health surveys in Canada and other countries have confirmed a strong correlation between dampness and mould and respiratory disease in children.

### *“Yuck, my sweater’s ruined!”*

- Mould growth in closets, cupboards and basements can foul clothing, books, carpets, furniture and other possessions with mildew stains.



### *“But I just painted this wall!”*

- Warm, moist air leaking out through walls can condense inside the wall. Symptoms of deterioration can include peeling paint, spalling bricks and buckled or rotting siding. Repairs can be costly and ongoing.

### *“It’s not raining but my roof is leaking!”*

- Warm, moist air is probably leaking into the attic, condensing and causing problems. This can lead to rotting wood framing, wet insulation and sagging or stained ceilings.

### *“Can’t we lower these energy bills?”*

- Moisture problems are often associated with cold surfaces and air leakage, both of which mean excessive heat loss and high energy bills.

### *“Why aren’t we getting any offers?”*

- Home buyers will shy away from a house with moisture problems, even if they are minor. Resale value will be lower.

## Does My House Have a Problem?

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Start with a few basic questions:

- Is there persistent mould growth?
- Are there musty smells, particularly in the basement?
- Are windows fogged up or frosted up through much of the winter?
- Is there evidence of moisture deterioration – rotting wood, soft drywall, buckled siding or spalling bricks?
- Does frost build up in the attic?
- Has basement flooding ever occurred?
- Are humidity levels often above 55 percent in the winter?



### EnerGuide for Houses

EnerGuide for Houses of Natural Resources Canada’s (NRCan’s) Office of Energy Efficiency offers unbiased, third-party home energy evaluations by qualified and licensed energy efficiency advisors in communities across Canada. Advisors use their expertise in combination with NRCan’s energy-modelling software to prepare a report to help the homeowner plan energy efficiency renovations. The report includes an EnerGuide for Houses label and rating. To contact an agent, visit the EnerGuide for Houses Web site at [energuideforhouses.gc.ca](http://energuideforhouses.gc.ca), or call 1 800 387-2000 toll-free and ask the operator for the number of an EnerGuide for Houses representative in your area.



## What to Look For and Where

Put on some old clothes and a detective's cap, grab a flashlight and some simple tools, and go through the entire house, both inside and outside, searching for moisture damage and mould growth and their potential causes. Winter is the best time for this inspection, although basements should also be inspected in the summer. You can also do this type of inspection when you're looking to buy a home, particularly if it is an older house.

## Checking your home's humidity levels

Knowing the level of relative humidity (R.H.) in your home is very useful. Buy or borrow a hygrometer and watch the changes in R.H. that occur throughout a typical day in different rooms of the house and over the heating season.

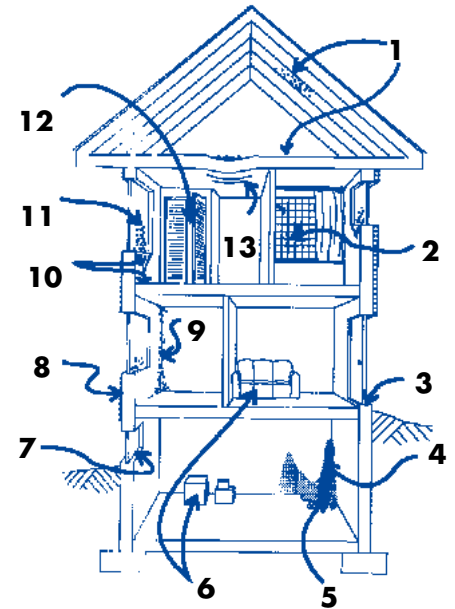
## How to Solve Moisture Problems and Save Energy

The good news is that many of the measures that you can undertake to solve moisture problems can also save energy, thereby helping to pay for themselves. This section includes some examples. For further details, refer to one of the publications listed on page 11 of this fact sheet.

## Reduce moisture sources inside the home

Getting at the source of excess moisture makes more sense than having to rely on a lot of ventilation. Ventilation removes moisture, but it also removes heat. Here are some tips on reducing moisture sources:

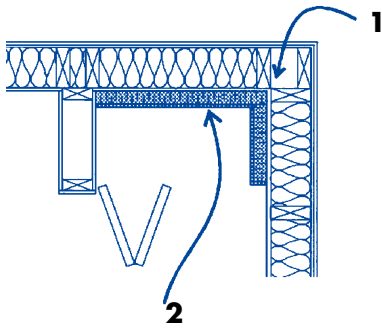
- Avoid drying clothes indoors. Vent dryers to the outside.
- Cover any exposed earth in the crawl space or basement with heavy polyethylene, sealed and weighted down.
- Slope soil away from foundations to keep the basement walls and slab dry. Patch any foundation leaks.
- Don't use humidifiers, unless humidity levels are below 30 percent R.H.



*Figure 1. Typical moisture problems*

Here are some of the key locations to check:

- 1) mould, frost or wet insulation or wood in attic
- 2) mould in the bathroom
- 3) frost on door sills
- 4) damp basement walls
- 5) water on basement floor
- 6) mould behind furniture and stored items
- 7) frost on window frames
- 8) peeling paint, deteriorating siding or efflorescence on bricks
- 9) mould in corners
- 10) wall damage and wet carpets below windows
- 11) condensation or frost on windows
- 12) mould in closets
- 13) sagging or stained ceilings



### Insulating a thermal bridge

- 1) thermal bridge at exterior corner in closet
- 2) add insulation (plus polyethylene and drywall)

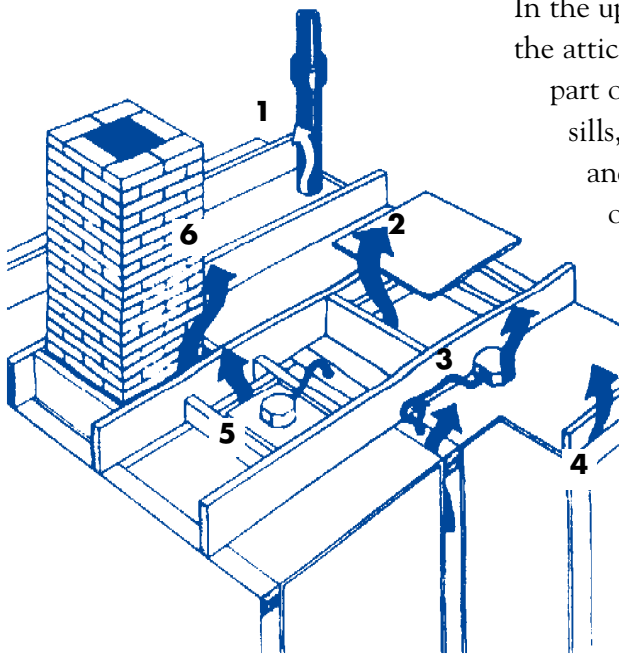
- Avoid drying firewood indoors.
- Operate bathroom exhaust fans during a bath or shower. Use a range hood exhaust when cooking. Make sure fans are vented to the outdoors.
- Avoid steam cleaning carpets in winter.

## Add insulation to cold surfaces

Areas that are uninsulated or poorly insulated – such as exterior corners or foundation walls – can be improved with additional insulation. This may be expensive by itself, but can be incorporated as part of a renovation. Don't forget to install an air/vapour barrier (usually polyethylene) on the room side of the insulation to prevent hidden condensation behind the insulation.

## Reduce uncontrolled air leakage

In the upper part of your house, air leakage outward carries moisture into the attic and wall cavities, causing long-term deterioration. In the lower part of your house, air leakage inward can chill window frames and door sills, causing frost to form. Air leaking in through foundation walls and the floor can be a source of moisture. Seal all cracks, joints and openings for services and around sump pump lids. It's a good strategy to reduce this uncontrolled air leakage and rely more on controlled mechanical ventilation for fresh air. Seal hidden openings into the attic, tighten the attic hatch, weatherstrip and caulk around windows and doors, install gaskets on electrical outlets, caulk baseboards and seal the top of foundations. (Natural Resources Canada has published another fact sheet of this series entitled *Air-Leakage Control*. See page 11 to find out how to order your free copy.)



### Sealing air leakage into attic

- 1) plumbing stack
- 2) attic hatch
- 3) electric wiring
- 4) tops of partition walls
- 5) electrical boxes
- 6) chimney

## Install effective ventilation systems

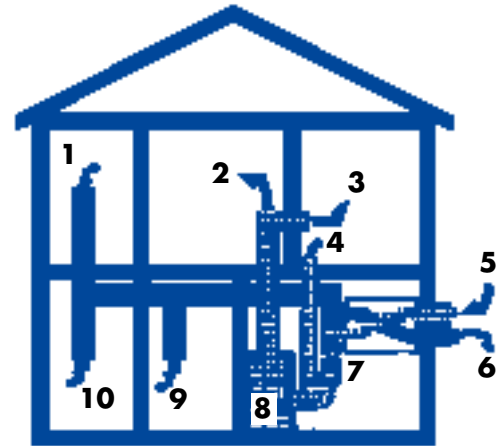
If indoor humidity levels are high and moisture sources cannot be reduced any further, increase ventilation rates. Ensuring adequate mechanical ventilation is especially important if you are airtightening your home. Ventilation has the added benefit of improving your home's indoor air quality.

Many older exhaust fans make a lot of noise but don't move much air. Replace these with more efficient (and quieter! – that is, they produce less than 53 decibels or 2 sones when working) units and use them to remove moisture from bathrooms and kitchens. Make sure the air is being exhausted to the outdoors and not into your attic! Remember to check the ductwork from the exhaust fan – it's usually hidden in the attic. The best approach is to provide a balanced ventilation system with a heat recovery ventilator (HRV). An HRV provides the opportunity for continuous ventilation without wasting a lot of energy by transferring heat from the exhaust air to preheat the fresh air.

Three additional points about ventilation are worth noting:

- 1) When outdoor conditions are mild and damp, such as in coastal areas or on a rainy day in the spring, ventilation will not be very effective at removing moisture because the outdoor air is saturated and has little drying potential.
- 2) A new house or newly renovated house needs lots of extra ventilation for the first year because construction materials – particularly wood and concrete – will be drying out.
- 3) Homes soak up moisture in the summer and gradually release it back into the air in the fall. To assist in “drying out” your house before the cold weather arrives, provide more ventilation and open up the windows on warm, dry fall days.

The use of air conditioners on muggy summer days can also help.



*Schematic of a ventilation system with an HRV*

- 1) kitchen
- 2) living room
- 3) bedroom
- 4) cold-air return
- 5) fresh air
- 6) exhaust air
- 7) HRV
- 8) furnace
- 9) bathroom
- 10) laundry



## Clean and maintain mechanical equipment

Humidifiers, dehumidifiers, air-conditioning units and filtration systems can be a source of mould growth. Regular cleaning has the added advantage of improving the equipment's efficiency.

## Upgrade or replace windows

Windows are usually the first place where you notice condensation because they are the coldest surfaces inside the home. New window technology

offers improved insulating value and can greatly reduce condensation. (But replacing your windows is not your first solution to a moisture problem. Reduce moisture sources before performing costly measures, such as replacing windows.)

If you are thinking about replacing deteriorated windows, consider upgrading to high-performance windows, which have special "low-E" coatings and are filled with inert gases such as argon or krypton. The additional cost is usually less than 10 percent, and the energy savings are considerable. For more information on energy-efficient windows, refer to Natural Resources Canada's publication entitled *Consumer's Guide to Buying Energy-Efficient Windows and Doors*. See page 11 to find out how to order your free copy.

### Basic Facts About Moulds

Moulds (also called mildew or fungi) are parasitic micro-organisms that appear as a black, white or multi-coloured stain or "fuzz." Mould spores can cause asthma and other allergies. Some moulds also release complex chemicals into the air called mycotoxins that can cause serious health problems. There are tens of thousands of varieties of moulds, and identifying them is a difficult and expensive task, even for experts. Therefore, health officials recommend eliminating all moulds from inside your home.

Most mould spores need "free water" (in other words, condensation or damp materials) to germinate. However, once mould colonies are established, many generate their own moisture and can continue to survive even under dry conditions. Moulds also need mild temperatures and a source of food, such as house dust or drywall paper.

If your home's windows are still in good condition, consider installing some type of interior storm-window kit over the entire window and frame during the heating season. This effectively adds a layer of glazing, prevents air leakage, and brings the inner surface of the window closer to warm air currents. Condensation will be reduced or even eliminated, comfort will be improved, and energy bills and drafts will also be reduced. Thin plastic film ("shrink-wrap") kits, which are available at hardware stores, are inexpensive but must be replaced each year. Other systems, such as rigid plastic sheets, are more expensive but can be re-used for several years.

If condensation is occurring between the panes of older unsealed windows (for example, a permanent window plus a storm window or two single-glazed slider windows), try sealing the interior unit with weatherstripping. If condensation is occurring between the panes of a sealed double-glazed unit, the unit will eventually have to be replaced.

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## Doing It Right

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### Check for moisture entry from other sources

This fact sheet has focused on moisture sources leading to condensation inside the home. However, don't forget to inspect for more obvious sources of water entry. Key areas to check include the following:

- roof leaks (especially at chimneys, flashings, skylights and eavestroughing)
- wall leaks (especially at window and door flashings and sills)
- foundation leaks (especially where the ground slopes toward the foundation)
- plumbing leaks (especially at toilet bases and under sink drains)

### Keep the air circulating

Condensation and mould growth often occur in out-of-the-way areas such as closets, corners, walls behind furniture and unused rooms. Increasing air circulation to these areas will warm the cold surfaces and lower local humidity levels, reducing the potential for condensation.

- Pull furniture and stored material away from exterior walls and off basement floors.
- Leave closet doors ajar, leave bedroom doors open as much as possible and undercut doors.
- Don't block or deflect warm air registers.
- Open drapes, blinds and curtains.
- Set the furnace fan to run continuously. (This will use more electricity, but this expense can be reduced by installing a two-speed energy-efficient motor.)
- Don't close off or cut off the heating supply to unused rooms.

### Get rid of mould

Even if you eliminate condensation and lower humidity levels in your home, existing moulds will likely persist and continue to release spores. Moulds must be physically removed. Fortunately, this is not a complex or expensive procedure. Use chlorine bleach to clean mouldy surfaces and a mixture of one part chlorine bleach, two parts water and a little detergent to clean nearby surfaces. Leave for 15 minutes and then rinse well. These are harsh mixtures, so use gloves and protective glasses and remember to ventilate well. Badly mildewed carpets, furnishings and books will probably need to be replaced.

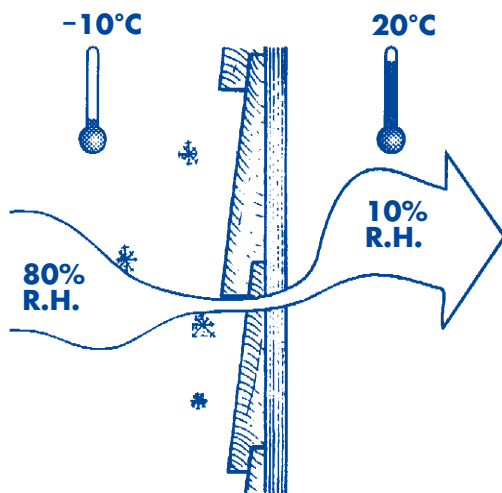
## Technical Information

If you want to learn more about how moisture behaves, this section contains technical information. If not, skip to the next section.

## Basic Facts About Moisture

Air contains moisture in the form of water vapour. The warmer the air, the more water vapour it is able to hold. Relative humidity (R.H.) is a measure of how much moisture the air holds in comparison with the maximum amount the air can hold at that temperature. For example, air at 50 percent R.H. holds half the moisture it is capable of holding.

As air is warmed, its relative humidity will decrease. For example, air leaking into a house from the outdoors in winter at 80 percent R.H. and at  $-10^{\circ}\text{C}$  will have a relative humidity of less than 10 percent once it is warmed to  $20^{\circ}\text{C}$ . That's why leaky houses can be excessively dry indoors in winter.



*Air leakage into a house*

As air is cooled, its relative humidity will increase. For example, warm, moist air at 50 percent R.H. and at  $20^{\circ}\text{C}$  leaking out of a house and into an attic in winter will reach 100 percent R.H. by the time it has cooled to  $9^{\circ}\text{C}$ . At 100 percent R.H., condensation occurs, with water or frost forming on the nearest surface. This is why air leakage outward can cause moisture problems in attics and walls.

Air doesn't need to pass into or out of the house to change its R.H. or to condense. Cold surfaces can also cause condensation. Think of the droplets of water that form on a glass of cold water on a humid summer day. The air immediately adjacent to the glass has been chilled to the point where its relative humidity is 100 percent, and condensation occurs.

Where is the coldest surface in a house during the winter? Usually, windows have the coldest surface, which explains why condensation – in the form of fogging or frost – is common on cold days. Cold surfaces can also occur at thermal bridges, which are locations where there is very little insulation or where structural members extend through the insulation from inside to outside. Examples of thermal bridges include exterior corners and wall/ceiling intersections. (See diagram on page 3.)

You may be surprised to learn that condensation caused by cold surfaces can also be a problem in the summer. Usually, in late spring or early



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# POINTS

summer, the ground has not fully warmed up from the previous winter. On warm, humid days condensation can occur on basement walls and floors that are in contact with the ground. For example, outside air at 70 percent R.H. and 25°C will condense on basement walls and floors that are cooler than 19°C. Therefore, opening basement windows won't always dry out the basement; in some cases, it can actually increase moisture problems.

The higher the indoor relative humidity, the greater the chance of condensation occurring on cold surfaces. There are many moisture sources that can contribute to elevated humidity levels in winter:

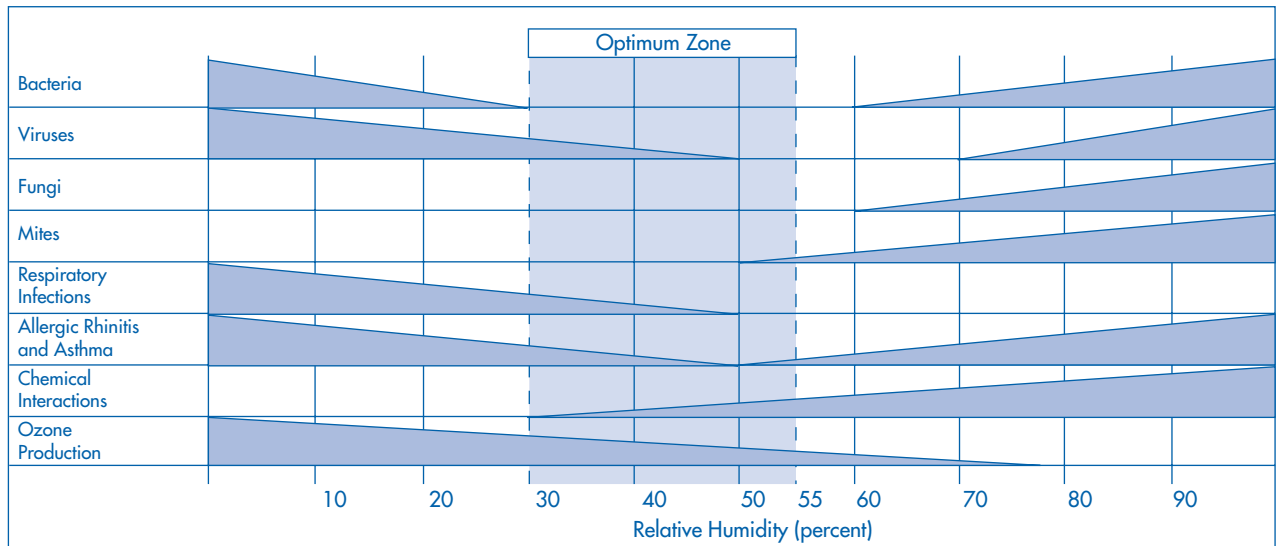
- occupants (30–40 litres/week for a family of four)
- summer moisture absorbed by house and released in fall (20–40 litres/week for about four weeks)
- drying of construction materials in a new house (25–35 litres/week for first 18 months)
- drying firewood indoors (15–30 litres/week for three cords/season)
- household activities: showering, cooking, bathing, washing (15–20 litres/week)
- damp basement, crawl space or sump pit (15–20 litres/week)
- drying clothes indoors (10–15 litres/week)
- humidifiers
- indoor pools, hot tubs, greenhouses, house plants and aquariums

Indoor humidity levels are also influenced by air exchange, which has the effect of replacing moist indoor air with drier outdoor air during winter. The rate of air exchange in a house depends on the use of mechanical ventilation, such as bathroom and kitchen exhaust fans or a heat recovery ventilator, and on natural air leakage.

The combination of indoor moisture sources, air exchange rates and cold surfaces will determine how much condensation will take place in your home.

## Keep humidity levels within a healthy range

Health Canada recommends that your home’s relative humidity be kept between 30 and 55 percent in winter. Lower levels aggravate skin allergies and respiratory infections, and higher levels increase the spread of mould, bacteria and viruses. Dust mites spread when the humidity is above 50 percent.



*Relative humidity and health effects*

Source: Health Canada

Decrease in bar width indicates decrease in effect.

## Piggyback!

If you are undertaking a major renovation, such as finishing a basement or gutting an interior, don’t lose the opportunity to “piggyback” solutions to moisture problems. Some measures – such as adding insulation, a polyethylene air/vapour barrier or a balanced ventilation system – are much easier and less expensive to implement during construction than afterward.

## Use dehumidifiers wisely

Dehumidifiers are generally not effective in winter, since they can lower humidity levels to between 50 and 60 percent only. However, running a dehumidifier in the basement on muggy summer days can be effective in reducing condensation on foundation walls and floors. Exhausting moist air from the basement may help, unless the replacement air from outside is just as moist.

## Don't Become a Statistic!

If your house has high humidity levels and no obvious moisture sources, it is essential to check any fuel-burning equipment – furnaces, hot water heaters, boilers, fireplaces and wood stoves – to ensure that they are venting properly. A blocked chimney could mean that combustion products, including large amounts of water vapour, are spilling into your house. Along with that moisture come dangerous combustion gases, such as carbon monoxide, which kill more than a dozen Canadians every year. Have heating equipment and venting systems checked by a trained service person.

Also, if your moisture remedial work or energy retrofit includes extensive air sealing, ensure that all fuel-burning equipment has an adequate supply of combustion air. Advanced equipment such as high-efficiency furnaces have their own air supplies and exhaust fans. However, conventional equipment may rely on house air for combustion and on “natural draft” to move combustion products up the chimney flue. If starved for air or overpowered by a powerful exhaust fan somewhere else in the house, such equipment can spill combustion gases indoors. Examples of combustion spillage include stains near the vent of a gas water heater, smoke entering the room from a wood-burning fireplace or stove, and pilot lights being blown out.

### Where Can I Get More Information?

This fact sheet is meant only to give you an introduction to the importance of moisture problems and how to solve them. The following publications contain more detailed information.

*Air-Leakage Control*

*Consumer's Guide to Buying Energy-Efficient Windows and Doors*

*Improving Window Energy Efficiency*

*Keeping the Heat In*

*Operating and Maintaining Your Heat Recovery Ventilator (HRV)*

To obtain additional copies of this or other free publications on energy efficiency, contact

Energy Publications

Office of Energy Efficiency

Natural Resources Canada

c/o S.J.D.S.

Ottawa ON K1G 6S3

Tel.: 1 800 387-2000 (toll-free)

(613) 995-2943 (in the National Capital Region)

Fax: (819) 779-2833

Web site: oee.nrcan.gc.ca

*About Your House: Hiring a Contractor*

*Clean-Up Procedures for Mold in Houses*

*Investigating, Diagnosing & Treating Your Damp Basement*

Canada Mortgage and Housing Corporation (CMHC)

Canadian Housing Information Centre

700 Montreal Road

Ottawa ON K1A 0P7

Telephone: 1 800 668-2642

Fax: (613) 748-4069

Web site: www.cmhc-schl.gc.ca

## Renovation Contractors

If you want to hire a contractor to help solve moisture problems, read CMHC's publication *About Your House: Hiring a Contractor* before you start. Make sure the contractor has a sound understanding of the causes of moisture problems. Supply a copy of this fact sheet and ask if the contractor has read any of the publications listed above or has taken a training course on moisture problems. If you have had basement flooding, look for a professional in the Yellow Pages™ under “Water Damage.”

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*Leading Canadians to Energy Efficiency at Home, at Work and on the Road*

The Office of Energy Efficiency of Natural Resources Canada  
strengthens and expands Canada's commitment to energy efficiency  
in order to help address the challenges of climate change.

Canada<sup>!</sup>



# CONDENSATION

## WHAT IS CONDENSATION?

Condensation is the passing of a substance from a lighter to a denser physical state. In this instance, water passes from a gaseous (vapour) state to the denser liquid one. Because it is caused by too much humidity, condensation is also the symptom of a more serious problem - excessive moisture at work in your home's atmosphere.

In seeking cooler, drier outside air, water vapour exerts pressure and forces its way through most building materials. Wood, brick, and drywall are too porous to stop moisture from migrating to the outside. But because window glass is denser and its surface colder than the surrounding walls, vapour is stopped by glass and condenses on it. While glass - the coldest, least porous (and most visible) material in a building - may show condensation first, it may also be noticed on exposed nail heads and other metal surfaces.

## WHY DOES CONDENSATION OCCUR?

Problems arise because air can hold only a limited amount of water vapour, varying with the temperature. Condensation is related to two conditions always present in the atmosphere inside your home. It is likely to form whenever there is an improper balance between:

### Relative Humidity

A ratio between the water vapour in the air compared to the maximum amount that air can hold at a given temperature. For example, 50% means the air is carrying 1/2 of the total water vapour it is capable of holding at that temperature.

### Temperature

A particular temperature where the relative humidity becomes 100%, called the "dew point" (see chart). At the dew point, the air is saturated with moisture and begins to lose it in the form of condensation.

Relative Humidity	Dew Point (Celsius)
20%	-4°
30%	2°
40%	6°
50%	10°

\*Above chart at 20°C

## WHERE DOES CONDENSATION OCCUR?

In practice, condensation will occur first over the lower part of the window because glass surface temperatures are not uniform, being lower at the bottom than at the top. Windows with a metal sash usually have more severe problems at the base and sides. Occasionally, it may occur on cold spots, such as nail heads and in corners of outside walls and closets where insulation value is reduced.

## SOURCES OF MOISTURE

The humidity level in a house during the winter will depend on both the moisture added to the air through family living habits (see chart) and the rate at which this moisture is removed by ventilation or condensation.

## QUANTITY OF MOISTURE ADDED TO THE AIR THROUGH NORMAL HOUSEHOLD ACTIVITIES

Activity (for a family of four)	Moisture in Litres each week
Cooking (3 meals per day for 1 week)	6.3
Dishwashing (3 times per day for 1 week)	3.2
Bathing (.2 litres per shower) (.05 litres per bath)	2.4
Clothes washing	1.8
Clothes drying indoors, or using an unvented dryer	10
Floor mopping (per 9.3m)	1.3
Occupants	38
Total Moisture Production per Week	63

In addition to the above sources of humidity, such things as gas appliances, dryers vented inside, plants (which put out almost as much water as they receive), pets, humidifiers, damp basements, etc., all increase the humidity level in a home.

*\* Note: A new home has significant quantities of moisture because of the water used in various areas of construction (700 gallons of water are used in plastering alone for a six-room house). This will be eliminated after a period of time.*

## CONDENSATION (CONTINUED)

### SOLUTIONS AND FACTS ABOUT HUMIDITY

#### Solutions

- Turn off all humidifiers, particularly in homes with forced-air heating.
- Move plants away from windows (where water vapour will be released directly onto glass).
- Vent the clothes dryer and gas appliances outside.
- Do not dry firewood indoors.
- Ensure kitchens and bathrooms are well ventilated by windows or exhaust fans.
- Ensure that basement walls are kept as dry as possible since they will act as humidifiers when wet.
- A de-humidifier may have to be installed (Note: a de-humidifier alone cannot eliminate the problem).
- Do not cover windows with heavy curtains since this will restrict air flow over glass.
- Produce less moisture inside the house.

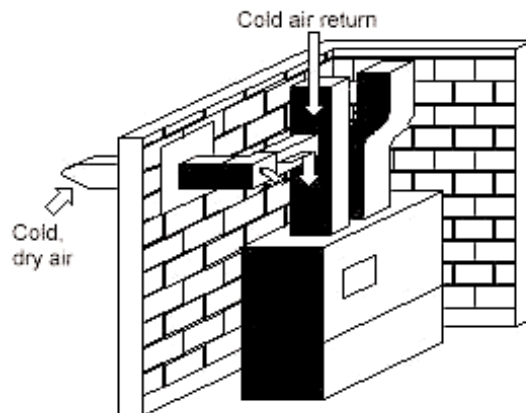
#### Facts

- Unless indoor humidities are kept below 10%, it is impossible to avoid some condensation.
- Lower outside temperatures require lower inside humidity levels (see chart).
- Electrically heated homes are difficult to rectify because there is very little movement of air.
- Ventilation is generally the most effective means available to reduce humidity and can be done by opening windows, operating exhaust fans and/or installing a ventilator from outside into the cold air return plenum of a forced air heating system (see following diagram).

### MAXIMUM ALLOWABLE RELATIVE HUMIDITY LEVELS TO CONTROL WINDOW CONDENSATION

Celsius	Single Glazed	Double Glazed	Triple Glazed
0 °C	32%	60%	70%
-5 °C	23%	53%	67%
-10 °C	18%	47%	62%
-15 °C	9%	40%	59%
-20 °C	-	37%	54%
-25 °C	-	31%	49%
-30 °C	-	29%	43%
-35 °C	-	24%	41%

### REDUCING HUMIDITY LEVELS WITH A FORCED-AIR FURNACE



### SOURCES FOR INFORMATION

Ontario Ministry of Municipal Affairs and Housing  
Canadian General Standards Board  
National Research Council (Division of Building Research)  
Rolscreen Company (Pella Windows)