Agricultural Extension Service • University of Minnesota

FACT SHEET

AGRICULTURAL ENGINEERING NO. 19—1974

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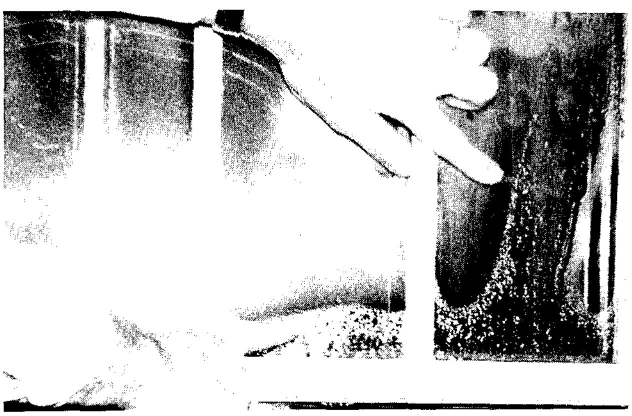
Controlling Household Humidity

Introduction

Many Minnesota residents have problems in their homes caused by relative humidities that are too high or too low. Low relative humidity may result in static electricity and physical discomforts like dry skin, nose, or throat. It may also cause excessive shrinking of wood resulting in the loosening of glue joints in furniture, loose doors or woodwork.

Many humidifiers have been installed to add moisture to homes during the heating season to relieve extreme dryness. If the relative humidity in your home is too high it will cause severe condensation on windows during cold weather with heavy accumulations of water and ice which can damage window sills and woodwork. It may also cause condensation in concealed places where you may not see it until the damage is done.

Common indications of concealed condensation are exterior paint peeling and wet areas in the ceiling or near the junction of the wall and ceiling caused by melting of ice and frost accumulations in the attic.



Serious condensation on a window is a danger signal. It indicates that the moisture level is too high. You must take steps to reduce moisture.

What relative humidity is best?

During Minnesota winters, the most desirable relative humidity for your home will be a compromise between that which causes serious condensation on windows and that which causes extreme dryness. Generally this will be a relative humidity just high enough to start condensation along the lower edge or in the lower corners of the windows. This is where the first visible condensation will occur because these are the coldest inside surfaces. Condensation forms on surfaces which are cooled below the dewpoint of the inside air. As the outside temperature drops, window temperatures get colder and condensation will occur at lower relative humidities. As a result, the maximum relative humidity that you should maintain in your home is reduced as the outside temperature drops. Table 1 gives relative humidities that usually can be maintained in homes equipped with double windows without causing window condensation.

Table 1. Allowable relative humidities to minimize condensation on windows.

Outside temperature	Inside relative humidity
°F.	percent
-20	15 to 20
-10	20 to 25
0	25 to 30
+10	30 to 35
+20	35 to 40

There is considerable variation in window construction. However, the relative humidities listed in table 1 will be satisfactory in most homes equipped with double windows. The inside surface of a double window will be warmer than the inside surface of a single window. Double windows therefore are used in colder climates to reduce heat loss and to allow for higher inside relative humidities. A relative humidity gauge may be helpful; but, regardless of what it says, window condensation must be your measure of a tolerable moisture level.

What determines the relative humidity in your home?

The relative humidity level in a home results from the balance between the moisture produced in the home and the moisture lost. In cold weather, the major moisture loss from a home is caused by air infiltration. All homes have some air exchange, cold air enters and warm air leaves taking moisture with it.

High infiltration rates will usually result in low relative humidities. One way to correct this is to install a humidifier to increase the moisture produced in the home. Another way to help is to reduce infiltration by weatherstripping the windows and doors, caulking openings, etc. (See Fact Sheet Agricultural Engineering 18, "Home Insulation and Heat Loss.")

Low infiltration rates combined with high moisture production can produce relative humidities that are too high. A common way to lower the relative humidity is to ventilate the house by running exhaust fans, partially opening windows or doors, opening the fireplace damper, and operating exhaust fans in high moisture producing areas such as bathrooms, laundry areas, kitchen stoves, etc. You may use a dehumidifier for this purpose, but it will not remove as much moisture in the winter as in the summer and the cooling coils may frost up. If your dehumidifier removes a significant amount of water and does not frost up it could be helpful. All of the electrical energy used by the dehumidifier will go to help heat the house and in addition will supply about 1,000 BTU of heat for every pint of water removed.

Moisture production in the home

Moisture is produced in the home through (1) normal household operations such as cooking, washing, bathing, etc. (2) respiration of the occupants, (3) evaporation and transpiration of growing plants, (4) humidifiers, and (5) moisture from construction. Table 2 can give you an idea of the amount of water vapor produced in a home.

Table 2. Moisture production

Source	Water vapor produced
Human respiration by an average family of four	8 to 12 pounds in 24 hours
Cooking for an average family of four (a gas stove)	5 pounds per day
Showering	1/2 pound per shower
Tub bath	1/8 pound per bath
Clothes drying (after being spin-dried)	1 pound of water per pound of dry clothes (if dried inside or drier is not vented)
Living plants	About the same as used to water the plants

In addition to the sources listed in table 2, moisture may enter the house through the basement walls and floors, crawl spaces, etc. In newly constructed homes, large quantities of water may be introduced through drying of concrete and plaster. A moisture problem in a new home may be due to this and could correct itself after the first heating season.

Moisture removed by infiltration

The quantity of water vapor removed by air infiltration depends on the inside and outside temperatures and relative humidities and the rate of air exchange. A house of average construction and tightness may have an infiltration rate of about one air change per hour. A loose house may have infiltration rates as high as two air changes per hour, and one of tight construction a rate of 1/2 air change per hour, or less. The volume of the basement is not normally included when determining the volume of infiltration air.

Table 3 gives the water vapor lost from a home due to air infiltration at various rates and inside relative humidities. The table is based on a 1,300 square foot, single story house with an inside temperature of 70°F. The outside temperature is assumed to be 0°F. or lower. At these temperatures, the moisture contained in the outside air is not significant. The volume of the house is 10,000 cubic feet. This would be the volume of air exchanged in one hour for an infiltration rate of one air change per hour.

Table 3. Moisture lost through infiltration, inside temperature 70°F., outside temperature 0°F.

Inside relative humidity	Air changes per hour: 1/4 (Very tight)	1/2 (Tight)	1 (Average)	2 (Loose)
percent	pounds of water lost per 24 hours			
10	6	12	23	45
20	13	25	50	100
30	18	36	78	156
40	26	53	106	212

Examples of moisture balance in a house

Assume a family of four is living in a 1,300 square foot, single story house, loosely constructed with poorly fitting windows and doors. This family will produce about 25 pounds of water vapor in a 24-hour period. Table 3 shows a "loose" house will lose 45 pounds of water per day in below zero weather when the inside relative humidity is 10 percent. Since the total water produced in the house is only 25 pounds per day, the inside relative humidity must balance out considerably below 10 percent. The family will likely experience extreme dryness due to this low moisture level.

Table 1 indicates that a relative humidity of 20 percent may be reasonable in below zero weather. At 20 percent relative humidity this home will loose 100 pounds of water (table 3). Since this family produces only 25 pounds per day, an additional 75 pounds (9 gallons) must be added by humidifier. The house could very likely be tightened up to reduce the infiltration rate. This would increase the relative humidity (without a humidifier) and also save heat (see Fact Sheet Ag. Engineering 18). At one air change per hour the relative humidity would balance out slightly over 10 percent. To maintain 20 percent at this exchange rate would require only an additional moisture input of 25 pounds per day (3 gallons) by a humidifier.

While you cannot measure infiltration it is unlikely that a rate of 1/2 air change per hour could be achieved in an older home.

Fluctuating relative humidities

The moisture input to a home is not constant. During periods of high moisture input the relative humidity will increase and condensation and fogging may appear on windows. As soon as the moisture input is stopped, this condensation will be reduced. Four pounds of water added at one time to the home in table 3 would increase the relative humidity from 20 percent to almost 40 percent. A house has some averaging effect, it absorbs moisture during periods of high relative humidity and releases it during drier periods. This helps reduce extreme relative humidity fluctuations.

Concealed condensation

Concealed condensation occurs when water vapor moves through a permeable wall or ceiling and condenses when it reaches its dewpoint in a colder region nearer the outside. This type of condensation can be far more serious than visible condensation on windows. Concealed condensation can be minimized in new construction by installing vapor barriers on the warm side of the insulation. (See Fact Sheet Ag. Engineering 18). When condensation occurs in the attic space above an insulated ceiling, the best solution is to increase the attic ventilation rate by installing additional louvers and ventilators.

Ventilation of the stud space on the outside of the wall will help minimize condensation in the wall. On existing walls you can install small air vents through the outside wall into each stud space. This may help but it is not likely to completely solve the problem. A vapor barrier on the inside is the best. On existing walls you can provide a reasonably good vapor barrier by applying two coats of good quality oil or rubber-base paint.

If the relative humidities shown in table 1 are not exceeded, problems of concealed condensation will be minimized unless the walls and ceiling are extremely permeable to water vapor.

Solving the low relative humidity problem — Summary

Should your house be extremely dry, likely it is also quite loose allowing a high infiltration rate. A practical way to deal with this problem is to make the house tighter. Make sure you close the fireplace dampers when not in use and operate exhaust fans only when necessary. This will also save heating fuel. When a house is tight and there is not enough moisture production to keep the relative humidity at the desired level, it will be necessary to install a humidifier to add water vapor.

Solving the high relative humidity problem — Summary

Where there is excessive condensation on windows, you can lower the relative humidity by reducing the moisture input to the house and/or by increasing the ventilation rate. Be sure the clothes drier is vented outside. Operate exhaust fans in areas of high moisture input such as over the stove when cooking and in the bathroom during showers and baths. Increase the ventilation rate by partially opening the fireplace damper. **If you have a humidifier, turn it off or reduce the setting.**

With a forced warm-air furnace, you can provide additional ventilation by installing a 6- or 8-inch outside air intake duct into the cold-air return of the heating system. Be sure to install a damper in this duct so you can regulate the amount of air brought into the house to give the proper relative humidity.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture. Roland H. Abraham, Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101. We offer our programs and facilities to all people without regard to race, creed, color, sex, or national origin.