



Moisture Condensation at the Windows

Housing Fact Sheets

This fact sheet discusses the causes of and remedies for wintertime condensation problems that occur on windows, glass, and other glazing materials in residences. This is the most common example of *surface condensation* in the house. For a discussion of concealed condensation and other aspects of moisture control in residences, see the fact sheet listed at the end.

Why Condensation Occurs

Water vapor condensation most often occurs because the indoor relative humidity is high. Since cold air holds less water vapor than warm air, the excess water vapor will condense when the temperature of the air decreases. Saturation, or 100% relative humidity, occurs when the air cools to the "dew point temperature". Air movement in the house which carries the water vapor with it is the most important means for transporting water vapor to the window.

In a typical home windows are places where air moves in and out of the building. Therefore, moisture-laden air is constantly moving around the cold glass surface providing an increased opportunity for condensation. Windows in poor condition or those which are poorly designed with high air infiltration allow large quantities of potentially moisture-laden air to leave the building.

Finally, condensation occurs at windows because the temperature of the glass surface is low. Glass is a poor insulator. The R value (Resistance to heat flow) of a single glazed window is approximately 1; a double glazed window is approximately 2. Compared to a typical adjacent wall with an R ranging from 11-20, the window is cold. Indoor air passing by the window is cooled and if the dew point temperature occurs, the water vapor condenses on the glass.

The degree of window condensation can be slight and merely a nuisance or extensive enough to lead to major maintenance and repair. *Slight condensation* (water or frost) on

the inside glass surface is usually observed on single glazed windows in wet rooms of the house (kitchen, bath, laundry). The condition is annoying. Damage to window and adjacent materials not likely, especially when condensation occurs only at times when the room is being used. It is usually caused by an increase in the indoor relative humidity from the 'wet' activity, such as cooking or drying clothes.

Moderate condensation on double glazed windows not near 'wet' areas of the house and *excessive condensation* on single glazed windows in wet rooms is a concern. The condition is both annoying and potentially damaging to the window and other building materials. Daily melting and dripping of water onto the sill may cause paint and structural damage. Furthermore, window condensation of this degree is an indication of potential concealed condensation; that is, condensation in the attic or inside the walls of the house. Check also for other surface condensation such as behind furniture, inside closets, and on other cold surfaces of the house.

In older and recently constructed homes all three factors usually cause window condensation. A combination of the remedial measures outlined in this fact sheet are necessary to reduce or eliminate the problem. In superinsulated homes or homes with low air infiltration rates (.5-1.0 air changes/hour) the best remedy is reduction of water vapor or mechanical ventilation of moisture-laden air, such as with an air-to-air heat exchanger.

Condensation will often occur on windows when shades or draperies are closed because most window treatments separate the cold glass from the warm room air, allowing the glass to further cool below the dew point temperature. These are two approaches to solving this condensation problem: one, prevent any condensation by covering the window with tightly sealed, interior movable insulation; or, acknowledge that condensation may occur with conventional window treatment but prevent the condensation from building up by opening the treatment during the day.

Condensation on the inside surface of exterior storm windows or any second layer of glazing is caused when moisture-laden air passes through cracks and gaps in the primary window. As the air cools, the moisture condenses on the exterior layer of glazing which is cold. Slight or moderate condensation is annoying. Daily melting and dripping onto a wooden frame may cause paint and structural damage. Excessive condensation indicates potential concealed condensation in the building structure.

REMEDIAL MEASURES

In order to reduce or eliminate window condensation problems it is necessary to accomplish some or all of the following points:

1. Reduce water vapor production
2. Remove moisture-laden air from the house by ventilation

3. Improve the thermal quality of the window(s) where condensation occurs.

It is also important to use vapor barriers correctly in the floor, walls, and ceiling of the house in order to prevent concealed condensation. For more information on vapor barriers, see fact sheet #12:6.

Methods for achieving these three goals are listed below. It may be necessary to use several techniques or changes in order to solve one condensation problem.

MOISTURE CONDENSATION AT WINDOWS

GOAL 1: Reduce water vapor production.

- Do not operate humidifier or other moisture-producing devices in cold weather.
- Restrict watering of house plants; take shorter showers; and change other behavioral patterns.
- Vent clothes dryer outdoors.
- Dehumidifiers in electrically heated homes have proven to be more energy-efficient for removing excess water vapor than the indiscriminate operation of ventilating fans, which exhaust heat as well as moisture.
- Reduce moisture from crawl space or basement by grading lot correctly and providing good drainage; use of gutters, downspouts, and overhangs to divert water; repair of cracks in foundation walls; and by covering the floor of the crawl space with 4 or 6 ml. polyethylene film.

GOAL 2: Remove moisture-laden air from the house by ventilation.

- Increase room ventilation. Install fan or mechanical device in kitchen, laundry, bath. Since moisture removal by fans also exhausts heat, operating time should be controlled by timer, humidistat, or both. In room(s) where moisture problem occurs keep doors open as much as possible. Move draperies, shades, and other interior window treatments away from the window(s) during the day.
- Increase ventilation in the attic and whole house. For houses without ceiling vapor barrier, vent ratio to attic floor area is 1 sq. ft. vent area per 150 sq. ft. floor area. See fact sheet #12-C:1 for other requirements. For houses with ceiling vapor barrier, vent to attic floor area ratio is 1 sq. ft. vent area per 300 sq. ft. attic floor area.
- Proper attic ventilation draws moisture-laden air from the entire house by diffusion through materials and through cracks and holes in the building construction. This reduces the relative humidity of the air and thus, the tendency for water vapor to condense. Whole house ventilation with an air-to-air heat exchanger (some models)

will remove moisture while retaining a portion of the heat from air which is exhausted from the house.

GOAL 3: Improve the thermal quality of the window(s) where condensation is present.

- Add second layer of glazing. This may be either an exterior mounted or interior mounted "storm window", or insulating glass. See fact sheet #12-B:3 for more information on storm windows and doors.
- Seal interior layer of glazing. If exterior mounted storm, seal primary window by adding weatherstripping around all sides of operable sash. If interior mounted storm, seal storm to interior window frame or adjacent wall using: closed-cell foam, V-strip, felt, or magnetic weatherstripping in a continuous strip around the edge. If nonopenable, the innermost window can be permanently caulked.
- Caulk/weatherstrip existing windows. This reduces air infiltration through/around window. Also, repair/replace putty around glazing. Caulking and weatherstripping should be done even when an interior mounted storm window is added and is essential when adding an exterior mounted storm window.
- Add dessicant between glazing layers. Some dessicants "recycle" water, alternately absorbing and then releasing it when the relative humidity of the air decreases. Use silica gel or alumina, which can be found in craft stores, flower shops, and scientific supply stores. Follow manufacturer's directions for use.
- Caulk/weatherstrip exterior wall adjacent to window. Moisture-laden air passes through cracks in the wall: sill plate, electrical outlets, around windows and doors, top plate. In tightly sealed houses, moisture may pass through window frames (the path of least resistance) and cause condensation.
- Add moveable insulation with R4 or greater. Insulation over interior surface of windows must be tightly sealed to window frame and between operable sections.

Summary

Moisture condensation on windows is controlled by reducing the indoor relative humidity or by improving the thermal quality of the window(s) where condensation occurs. The indoor relative humidity can be reduced by controlling the amount of water vapor produced in the house and/or by ventilating the moisture-laden air.

If the methods listed to reduce the indoor relative humidity do not solve the window condensation problem, then increase the temperature of the room or house. Indoor temperatures are reduced in order to save heating fuel.

However, at lower temperatures the air can hold less moisture. Household activities which formerly did not produce excessive relative humidity may now do so and cause

condensation problems. Increasing the temperature of the room or house is a remedial measure which should only be used last because it does not help achieve the overall objective to reduce heat loss and lower fuel consumption.

The following Cornell housing fact sheets will provide additional information.

- 11:C Weatherstripping
- 11:D Caulking Materials
- 14:A Household Moisture Problems in the Wintertime
- 14:B How to Prevent Mildew
- 14:C How to Remove Mildew
- 14:D Selecting a Dehumidifier
- 14:E Selecting a Humidifier
- 14:F Vapor Barriers in Residential Buildings

Written by Gwen Cukierski, Extension Associate, Department of Design and Environmental Analysis, Cornell University

Reviewed and revised by Mark Pierce, Extension Associate, Department of Design and Environmental Analysis, Cornell University, 1999.