

# Research Report



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## Condensation

- Reducing the amount of moisture from indoor and outdoor sources will reduce the potential for condensation
- Condensation is caused when moist air comes into contact with cooler surfaces, such as
  - > Hot and humid air entering a wall or building in the summer
  - > Indoor air entering a wall and condensing during the winter
  - > Condensation on cold spots of walls in the winter
- Reward iForms reduce the potential for condensation on and within walls because they have a uniform insulation layer, low air infiltration, thermal mass, and no wall cavities
- To further reduce the potential for condensation, provide adequate heat and ventilation in the winter, and adequate dehumidification and ventilation in the summer

**Condensation** on walls can cause unsightly problems and damage to the building and its contents. Even more undesirable is the condensation of moisture within a building wall where it is not readily noticed until damage has occurred. Moisture accumulation can cause wood to rot and metal to corrode.

Fungi and biological growth such as molds have the potential to grow in the presence of moisture or at relative humidities on the wall surface of 70% or higher<sup>1</sup>. Spores are always available in indoor and outdoor air. Although the components of the Reward iForm™ (concrete and EPS insulation) do not provide nutrients for biological growth, nutrients are generally readily available. So, the primary method in controlling biological growth is to avoid high humidities and surface condensation. Relative humidities generally should be kept below 50%.

**Sources of Moisture.** Moisture can enter building walls from the interior, exterior, soil, or the building materials themselves. Reducing the amount of moisture from these sources will reduce the potential for condensation.

**Indoor sources** of moisture include people, plants, cooking, and bathing. The average person produces 2.6 pints of moisture per day through breathing and perspiration. This amount increases with physical activity. Almost all water used for indoor plants evaporates and enters the indoor air. Five to seven small plants release 1 pint per day of water. A shower can contribute 0.3 pints per minute (12 pints per day for 10-minute showers for a family of four). Cooking in a kitchen can contribute 5 pints per day for a family of four.

**Outdoor sources** include precipitation and infiltration. Rain and melting snow cause problems when the ground against walls is not pitched to move water away, or when plants that require frequent watering are located near walls. Primary and secondary defenses should be employed to reduce the risk. For instance if caulk is used to prevent precipitation from entering a wall around doors and windows, flashing should be provided behind the caulk to keep out moisture should the caulk

<sup>1</sup> *Moisture Control in Buildings*, ASTM Manual Series MNL 18, Heinz Trechsel, editor, ASTM, West Conshohocken, PA, 1994, p.321. www.astm.org



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deteriorate. Near the foundation wall, landscaping materials that require little or no watering help prevent moisture from entering the walls.

Infiltration of moist air comes from several sources. Due to the stack effect in buildings, especially two-story or higher, rising warmer air causes outdoor air to enter through leaks near the bottom of the building and exits near the top. A significant amount of this leakage occurs around doors and windows. Heating and cooling systems that depressurize buildings cause infiltration also. Providing high efficiency systems that use outside air minimizes this potential problem.

**Soil** provides moisture that moves through slabs and foundations. Capillary breaks between the foundation and above-grade walls and vapor retarders under slabs can reduce this potential. Soil should be sloped away from the building to provide adequate drainage. As land becomes more scarce and costly, more buildings are being built on less desirable sites that previously ponded water; drainage design is particularly important in these areas. Vapor retarders should be installed beneath all concrete floor slabs in direct contact with the concrete to prevent moisture from moving up into the building. The vapor retarder should be installed above a granular subbase layer and directly beneath the concrete slab.

**Building materials** contribute significantly to moisture inside buildings, known as "moisture of construction", during the first years after construction. Exposed concrete surfaces contribute up to 15 pints per day, until concrete surfaces reach equilibrium with the indoor air. Wood and materials that have been stored outdoors are also contributors. Many buildings have noticeable condensation the first year after construction but this subsides in subsequent years. Dehumidification and adequate ventilation can help alleviate condensation due to the moisture of construction.

**Condensation within Walls.** The "vapor retarder" and "air barrier" research reports explain how the Reward iForm wall system reduces the potential for condensation within walls. Low permeance interior or exterior finishes on the wall should be avoided. On the interior, a vapor retarder is not recommended in the continental U.S. Vinyl wallpaper should be avoided. Low permeance and unvented exterior finish materials should also be avoided. Brick veneer should be vented and/or have weep holes. Vinyl siding or other exterior finish materials should be vented or have a permeance greater than 1.0 perms.

**Condensation on Surfaces.** Condensation on surfaces occurs most frequently due to cool indoor surface temperatures or high indoor humidity levels. Some of these can be avoided by using the Reward iForm:

1. Insufficient, damaged, or wet fiberglass insulation can cause localized cool surfaces. This may be a problem in wood or steel frame walls but not Reward iForm walls.
2. Thermal bridges, or areas of the wall that are not insulated as well as others, can also produce cooler surface temperatures. These occur any place wood, metal, concrete, or a highly conductive material penetrates an insulation layer. This often appears as "shadowing" or a dark band at the location of wood or steel studs. This is generally not a problem in Reward iForm walls



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because it provides a continuous uniform layer of insulation. Also, the thermal mass in the concrete helps moderate temperature extremes, so Reward iForm walls will not get as cold as frame walls with similar thermal resistances.

3. Cold air from air-conditioners blowing in the region of warm humid air can cause condensation on indoor surfaces. This is generally a problem in buildings with leaky walls that allow warm humid air to enter. This is generally not a problem in Reward iForm walls because of its low air infiltration.

Other potential problems can be avoided by supplying adequate ventilation:

1. Inadequate heating and ventilation can result in cooler surface temperatures near the bottom of walls. Heating must be provided near floor level or with enough circulation to heat the lower portion of rooms.
2. Furniture or partitions placed up against walls may prevent adequate heating or air flow and produce cool surfaces.
3. Closets, which are rarely conditioned, can also have inadequate ventilation and cool surfaces. Large walk-in closets may benefit from a separate vent for conditioned air.
4. High humidity caused by cooking, bathing, hot tubs, swimming pools, or industrial processes can cause condensation on indoor surfaces. Exhaust fans should be located in kitchens and bathrooms, and special design considerations need to be followed for indoor hot tubs and swimming pools.

Since residential construction with Reward iForm walls has low infiltration and reduced heating and cooling loads, an air-to-air heat exchanger (heat recovery ventilation system) is recommended to bring in fresh air, remove moisture, and keep relative humidity in the air less than 50%. Requirements in ASHRAE Standard 62.2-2003<sup>2</sup>

should be implemented. Relative humidities in nonresidential buildings should also be less than 50%, and requirements in ASHRAE 62.1<sup>3</sup> should be implemented.

In general, condensation on interior room surfaces can be controlled both by suitable construction and by precautions such as:

- In warm climates or in the summertime, reducing the interior RH or dew point temperature by dehumidification equipment and providing adequate ventilation.
- In cold climates or in the wintertime, raising the temperatures of interior surfaces that are below the dew point, generally by use of insulation, double glazing, or circulating warm air over the surfaces. The Reward iForm raises interior surface temperatures by providing a continuous uniform layer of insulation.

**Special applications.** Buildings or areas with particularly high humidities have special design needs. These include indoor swimming pools, hot tubs, gymnasiums, ice rinks, or storage areas with moist items such as firewood. A Reward iForm wall or other low permeance vapor retarder system is often needed to separate indoor swimming pools or other special applications from the rest of the building.

<sup>2</sup> ASHRAE Standard 62.2, *Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*, ASHRAE, Atlanta, GA. [www.ASHRAE.org](http://www.ASHRAE.org).

<sup>3</sup> ASHRAE Standard 62.1, *Ventilation and Acceptable Indoor Air Quality in Buildings Except Low-Rise Residential Buildings*, ASHRAE, Atlanta, GA. [www.ASHRAE.org](http://www.ASHRAE.org).

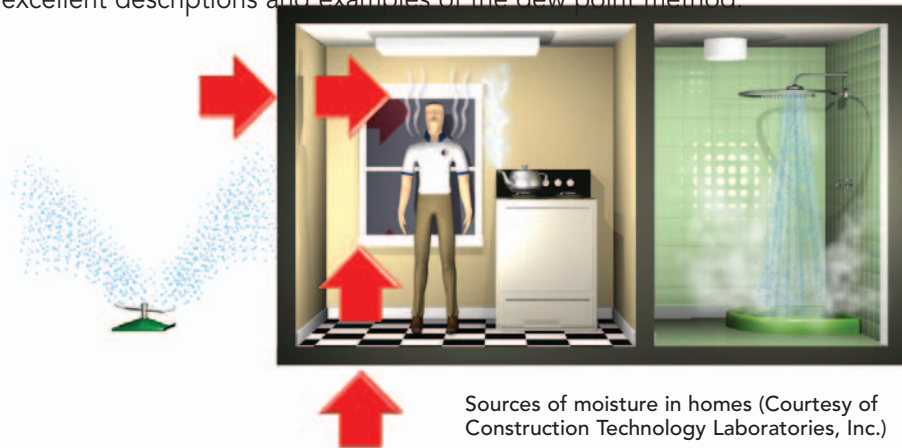


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**Analysis methods.** In any building with additional sources of moisture, an analysis using actual conditions should be performed. An analysis is also advisable for very cold climates or where experience is not available to indicate how a wall will perform. Condensation occurs on surfaces inside buildings when the surface temperature is less than the dew point of the indoor air. The dew point of the air depends on its relative humidity, with more humid air having a higher dew point. It is important to determine whether and where the temperature within the wall or roof system will fall below the dew point temperature.

The potential for condensation can be determined using simple analyses or complex calculations. ASTM publishes an excellent book on moisture models.<sup>4</sup> These models predict moisture and temperature conditions in wall and roof assemblies for particular climate and indoor design conditions. Use of these models requires knowledge of building physics, material properties, and the model limitations.

Historically, a simplified method known as the dew point method has been used to identify potential condensation problems. This is a steady-state analysis that has many limitations; however, it is a good indicator of the potential for moisture problems. The *ASHRAE Handbook of Fundamentals*<sup>5</sup> and ASTM C755<sup>6</sup> provide excellent descriptions and examples of the dew point method.



Due to manufacturing processes, EPS thickness, EPS type and the uniqueness of the Reward iForm, this analysis, information and report is only to be used with Reward iForm and is not to be used with any other ICF system



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4 Treschsel, Heinz, *Moisture Analysis and Condensation Control in Building Envelopes*, Publication No. MNL 40, ASTM, West Conshohocken, PA. [www.ASTM.org](http://www.ASTM.org)

5 *ASHRAE Handbook of Fundamentals*, Atlanta, GA, 2001 [www.ASHRAE.org](http://www.ASHRAE.org)

6 ASTM C755, "Standard Practice for Selection of Vapor Retarders for Thermal Insulation," ASTM, West Conshohocken, PA. [www.ASTM.org](http://www.ASTM.org)