

**Table 1-1: Moisture Sources and Their Potential Contributions**

<b>Moisture Source</b>	<b>Potential Amount Pints</b>
Ground moisture	0–105 per day
Unvented combustion space heater	0.5–20 per hour
Seasonal evaporation from materials	6–19 per day
Dryers venting indoors	4–6 per load
Dish washing	1–2 per day
Cooking (meals for four persons)	2–4 per day
Showering	0.5 per shower

### 1.6.3 Symptoms of Moisture Problems

*SWS Detail: 2.02 Moisture; 2.0201 Drainage; 2.0202 Ground Vapor Retarders; 2.0203 Space Conditioning*

Condensation on windows, walls, and other cool surfaces signals high relative humidity and the need to reduce moisture sources.

During very cold weather or summer air conditioning, condensation may occur on cold surfaces. Occasional condensation isn't a major problem. However, if condensation happens frequently, take action to reduce moisture sources. Adding insulation helps eliminate cold walls, ceilings, and air-conditioning ducts where water vapor condenses.

Moisture problems arise when parts of the building become wet often and remain wet. Moisture in organic or porous building

materials reaches a threshold that allows pests like mold, dust mites, and insects to thrive. These pests can cause or trigger asthma, bronchitis, and other respiratory ailments because they produce potent biological allergens.

Rot and wood decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi and insects penetrate, soften, and destroy wood.



**DRY ROT**

**TERMITES**

**EFFLORESCENCE  
& SPALLING**

Peeling, blistering, or cracking paint may indicate that moisture is moving through a building material or assembly, damaging the paint and the materials underneath.

Corrosion, oxidation, and rust on metal are unmistakable signs of moisture problems. Deformed wooden surfaces may appear as the damp wood swells, and later warps and cracks as it dries.

Efflorescence is a white, powdery deposit left by water that moves through masonry and leaves minerals behind as it evaporates from the masonry surface. Masonry materials experience spalling with efflorescence that deteriorates their surfaces.

## 1.6.4 Solutions for Moisture Problems

*SWS Detail: 2.02 Moisture; 2.0201 Drainage; 2.0202 Ground Vapor Retarders; 2.0203 Space Conditioning; 3.0104.1 Closed Crawlspace Air Sealing; 6.0305 Dehumidification; 6.0305.1 Ventilator Dehumidifiers*

Preventing moisture problems is the best way to guarantee a building's durability and its occupant's respiratory health. However, the solutions get progressively more expensive if simple ones don't solve the problem.

## Inexpensive Moisture Solutions

If moisture source reduction isn't adequate to prevent moisture problems, try these solutions after preventive measures are in place.

- ✓ Repair plumbing leaks.
- ✓ Install a ground-moisture barrier. *See "Ground-Moisture Barriers" on page 43.*
- ✓ Provide crawl-space ventilation that complies with the requirements of the IRC and SWS.
- ✓ Verify that combustion vents, clothes dryers, exhaust fans vent to the outdoors and **not** into crawl spaces or attics.
- ✓ Seal water leaks in the foundation.



**UNVENTED  
SPACE HEATER**



**WATER POOLING**



**DUCT CONDENSATION**

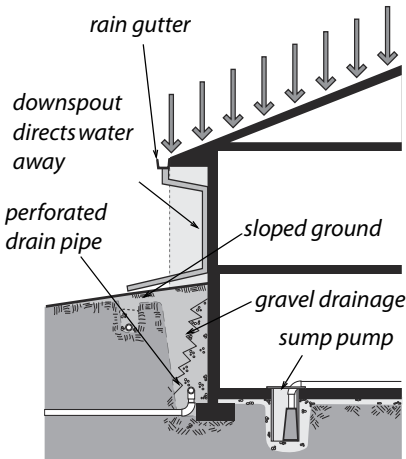
- ✓ Seal water leaks in the roof.
- ✓ Remove unvented space heaters, a major source of moisture, from the dwelling.
- ✓ Educate clients about ways to reduce moisture.

- ✓ Educate clients to avoid excessive watering around the building's perimeter. Watering lawns and plants close to the building can dampen its foundation. In moist climates, cut shrubbery back away from the foundation, allowing air to circulate near the foundation.
- ✓ Insulate air-conditioning ducts to prevent summer condensation.

## More Costly Moisture Solutions

Follow these preventive measures before trying any of the solutions in the next section.

- ✓ Install or improve air barriers and vapor barriers to prevent air leakage and vapor diffusion from transporting moisture into building cavities. *See page 549.*



**Stopping water intrusion:**  
Take all necessary steps to protect homes from water intrusion.

- ✓ Add insulation to the walls, floor, and ceiling of a building to keep the indoor surfaces warmer and less vulnerable to winter condensation. During cold weather, well-insulated homes can tolerate higher humidity without condensation than can poorly insulated homes.
- ✓ Ventilate the dwelling with drier outdoor air to dilute the more humid indoor air. Ventilation is only effective when

the outdoor air is drier than the inside air, such as in winter. In summer, outdoor air may be more or less humid than indoor air depending on climate, time of day, and whether the dwelling is air conditioned. *See "Ventilation" on page 419.*

## 1.6.5 Ground-Water Drainage

*SWS Detail: 2.0201.1 Gutters; 2.0201.2 Downspouts; 2.0201.3 Grading; 2.0201.4 Sump Pumps*

Inadequate drainage is an important moisture problem for many buildings. Finish the following tasks before air sealing the floor or installing underfloor insulation, **as allowed under DOE guidelines or with non-DOE funds.**

Observe these specifications for gutters, downspouts, grading, and sump pumps.

### Rain Gutters

Comply with these specifications when installing or repairing rain gutters.

- ✓ Install or repair rain gutters as necessary, and verify that downspouts discharge rainwater at least 6 feet away from the building.
- ✓ Size gutters appropriately for the roof area they drain.
- ✓ Attach gutters with screws through fascia into sub-fascia or rafter tails.
- ✓ Fasten gutter sections together with mechanical fasteners, such as sheet-metal screws or pop rivets.
- ✓ Slope all gutters toward downspouts a minimum of  $\frac{1}{4}$  inch per 10 feet.
- ✓ Make all seams watertight using a compatible sealant, such as a butyl caulk.

- ✓ When replacing whole sections of rain gutters, prefer continuous rain gutters.

## Repair or Install Downspouts

Comply with these specifications when installing or repairing downspouts.

- ✓ Plan the size and number of downspouts, according to the area drained.
- ✓ Attach downspouts to gutters with mechanical fasteners, such as sheet-metal screws or pop rivets.
- ✓ Attach downspouts to dwellings a minimum of every 4 feet of their length with appropriate hardware and fasteners.
- ✓ Assemble downspout sections so that the upper section fits inside the lower section.
- ✓ Drain downspouts a minimum of 6 feet away from the structure.



**Gutter hangers:** Reinforced gutter hangers prevent snow and ice from detaching gutters from the building.



**Downspout terminations:** A variety of fittings like this one can drain rain water 6 feet from the building.

## Grading

Comply with these specifications when you can repair grading problems.

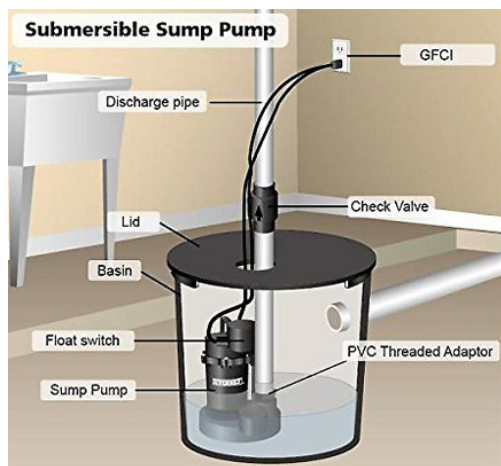
- ✓ Verify that the ground outside the building slopes away from the foundation.

- ✓ If the ground slopes toward the foundation or water puddles near the building, use topsoil, clean fill, and/or masonry materials, slope ground away from the building at least 6 inches per 10 feet.
- ✓ Clear all vegetation within 3 feet of the building or trim all vegetation to 1 foot clearance from the building.

### Install Sump Pumps, only if necessary

A sump pump is the most effective remedy when ground water continually seeps into a basement or crawl space and collects there as standing water. Persistent ground-water seepage may only be solved by connecting an interior perimeter drain to the sump.

- ✓ Suggest a sump pump for crawl spaces or basements with a history of flooding.
- ✓ Select a sump pump that meets the flow requirements of the home.
- ✓ Select the most energy efficient pump available. Prefer electrically commutated motors (ECM) when possible.
- ✓ Locate the sump pump where it collects water from the entire below-grade area and pumps it away from the foundation a minimum of 10 feet.
- ✓ The sump cover must not interfere with drainage and must be accessible and rigid.
- ✓ Install sump pumps according to the manufacturer's instructions.



**Sump pump:** Pumps water out of a sump or basin where water collects in a basement or crawlspace.

- ✓ Install a check valve to prevent pumped water from reentering the sump well.
- ✓ Verify safe operation, and ensure that floats and float switches function correctly.
- ✓ Provide resident with manufacturer's operation-and-maintenance instructions.

## 1.6.6 Drying Buildings with Dehumidifiers

*SWS Detail: 2.0203.1 Stand-Alone Dehumidifier Installation; 3.0104.1 Closed Crawlspace Air Sealing; 6.0305 Dehumidification; 6.0305.1 Ventilator Dehumidifiers*

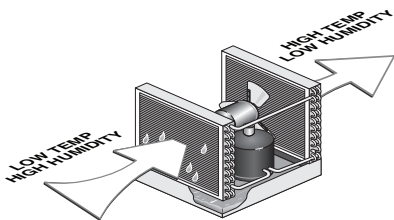
As a last resort, remove moisture from indoor air by cooling the air to below its dew point with dehumidifiers in winter and air conditioners in summer. Using dehumidifiers and air conditioners for drying a building is the most expensive solution. Try all the moisture solutions discussed previously before resorting to a dehumidifier.

### Dehumidifier Specifications

The dehumidifier should meet these specifications.



- ✓ Must be ENERGY STAR or more efficient.
- ✓ Must have a fan-off option.
- ✓ Must retain automatic settings after power interruption.
- ✓ Must be rated for low temperature operation if located in a basement or crawl space.
- ✓ Must have features that control both peak power and energy use.



**Dehumidifiers:** In damp climates, dehumidifiers protect homes from excessive moisture.

## Dehumidifier Installation

When you install a dehumidifier, observe these requirements.

- ✓ Choose a dehumidifier with automatic controls to limit energy and power.
- ✓ Evaluate the dehumidifier for compatibility with the space where you install it. Read the specs.
- ✓ Install the dehumidifier in a location that allows free air-flow around it.
- ✓ Pipe the dehumidifier's collected water to a plumbing drain in a code-approved way.
- ✓ Seal any penetrations to the exterior of the home created by the dehumidifier's installation.
- ✓ Verify that the dehumidifier functions as designed.
- ✓ Measure the relative humidity in the space before and after completing the installation. Relative humidity should decrease after a few hours of operation.

- ✓ Verify that the dehumidifier's relative-humidity measurement is accurate, using a secondary independent measurement.
- ✓ Give the resident the user guide and warranty information, and explain how to use the dehumidifier.
- ✓ Show the occupant how to clean or change the filter and how to clean the condensate drain.
- ✓ Permanently remove old appliance from job site and recycle or dispose of removed appliance and its refrigerant to comply with local and federal law (EPA Section 608 of Clean Air Act of 1990).

## 1.6.7 Ground-Moisture Barriers

*SWS Detail: 2.0202 Ground Vapor Retarders; 2.0202.1 Un-Vented Subspaces - Ground Cover; 2.0202.2 Vented Subspaces - Ground Cover; 2.0202.3 Pier and Skirting Foundations - Ground Cover*

Air, water vapor, liquid water, and pollutants move through soil and into crawl spaces and dirt-floor basements. Even if soil's surface seems tight and dry, the soil may allow a lot of water vapor and soil gases to enter a dwelling.

Cover the ground with an airtight moisture barrier to prevent the movement of moisture and soil gases from the ground into the crawl space. Use these procedures.

### Prepare the Ground

- ✓ The crawl space should have an access hatch or door that is sized adequately for a worker or a resident to enter and exit.
- ✓ Remove biodegradable matter, such as vegetation, wood, and cardboard, from the crawl space.

- ✓ Remove all debris that can cause injury or puncture ground-moisture barrier, such as nails, wood debris, and sheet metal screws.
- ✓ Provide negative pressure in the crawl space with reference to the building when dust or vapors might migrate into the living area from the crawl space during weatherization.

## Install the Ground-Moisture Barrier

- ✓ Cover the ground completely with a ground-moisture barrier at least 6-mil polyethylene with less than 0.1 perm where little or no foot traffic exists. Install reinforced or cross-linked polyethylene where the barrier experiences foot traffic, such as when residents store belongings in the crawl space.
- ✓ Seams must overlap at least 12 inches. Seal the edges and seams with acoustical sealant, butyl caulking, or construction tape to create an airtight seal between the crawl space and the ground underneath.



**Ground-moisture barrier:**  
An airtight ground-moisture barrier blocks water vapor and gases coming up from the ground.

- ✓ The edges of the barrier should run at least 6 inches up the foundation walls and internal supporting structures. Fasten the barrier with wood strips, masonry fasteners, and sealant., such as polyurethane adhesive or acoustical sealant to a clean and flat masonry surface.

- ✓ To avoid trapping moisture against wood surfaces, ground-moisture barriers must not touch wood structural members, such as posts, mud sills, or floor joists.
- ✓ The ground vapor retarder must not interfere with the established drainage features such as sump pits or French drains.
- ✓ Fasten ground vapor retarder to ground with durable fasteners or ballasts when installed on sloping ground, or when people access the space for routine maintenance or storage.

### Post a Crawl-Space Sign

Install a durable (minimum of 10-year service life), easily seen sign, sized a minimum of 8.5" x 11" at each access to the space.

Sign must include these items.

- ✓ Warning to prohibit storage of hazardous and flammable materials.
- ✓ Caution residents not to damage the ground-moisture barrier, air barrier, insulation, or mechanical components specific to the space.
- ✓ Specify that immediate repairs are necessary in the case of damage.