You Can Do It, Too

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Moisture Problems in the Home

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In recent years, Michigan Cooperative Extension Service staff members have reported an increase in the number of questions coming into county offices about moisture and water-related problems in the home. The complaints occur in both winter and summer, and they take a variety of forms.

Some homeowners complain about water and ice formation on interior windows in winter. Others complain about peeling exterior paint and the growth of mildew and mold inside the home. Still other homeowners report frustration over water collecting in basements or crawl spaces. Resulting odors and concerns about structural damage that could occur and the hard work and expense needed to clean and repair any damage are major concerns.

All of these problems involve one or more of the three most common types of moisture problems in Michigan homes: condensation, seepage and leakage. This publication discusses these problems and points out means to help you identify whether the problems exist in your home, determine their cause(s) and implement effective solutions as quickly as possible.

CONDENSATION

Condensation can be a problem in both winter and summer. In winter, it often appears on windows first in the form of fog or ice on window panes. In the summertime, water dripping from toilet tanks and cold water pipes and condensation on masonry or stone surfaces in basements are the major causes of frustration.

Causes of Condensation

All air contains water in the gaseous or vapor form. The temperature of the air determines how much water vapor it can hold. As air gets warmer, its capacity for holding water vapor increases. On the other hand, as air cools, its capacity for holding water vapor decreases. When air cools and its vapor-holding capacity decreases and the amount of vapor in the air stays the same, the air may eventually reach or exceed its saturation level. At this saturation point, the excess vapor from the air will begin condensing and collect as a liquid on the nearest surface that is cooler than the air. Three conditions in the home increase the chances that condensation will occur. The first of these is a relatively recent phenomenon, a side effect of the efforts many homeowners have taken to increase the energy efficiency of their homes. Many have added insulation to cut heat loss and heat gain, while others have caulked and weatherstripped around windows and doors to reduce the infiltration of cold air into their homes. The same practices that trap heat in the home also trap high levels of moisture.

A second common condition contributing to moisture problems in Michigan homes is the existence of cool surfaces with which interior moisture vapor naturally comes in contact. This problem often occurs in the homes of people who have not insulated or weatherized. In less energy efficient homes, certain locations are prime candidates for condensation problems because they commonly have cool surfaces. These include poorly weatherized and insulated windows (in winter), poorly insulated exterior walls and

TABLE 1—RECOMMENDED HOUSEHOLD RELATIVE HUMIDITY LEVELS AT VARIOUS TEMPERATURES

Inside air temp.	Outside air temperature, °F −15	−10	−5	0	5	10	15	20
70°F	15%	17%	20%	25%	30%	35%	40%	45%
75°F	18%	20%	24%	30%	35%	40%	45%	50%

Fig. 1: Typical crawl space vent
If there is any chance of floodin
the vapor retarder should be all

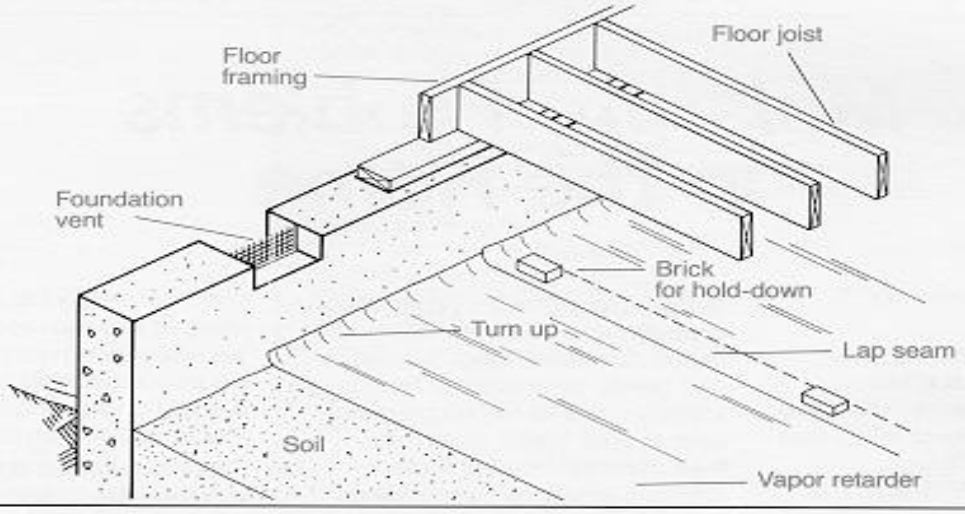
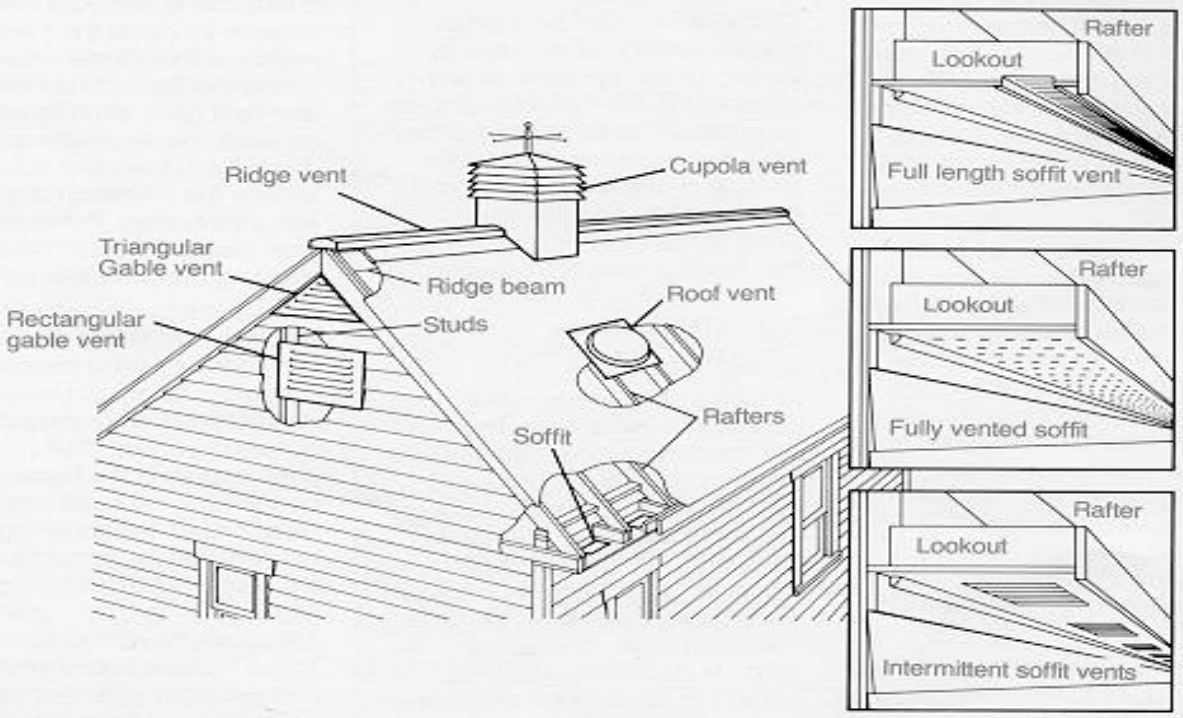


Fig. 2: Attic vent variations.



ceilings (winter), masonry or concrete surfaces (summer), toilet tanks (summer) and cold water pipes

(summer).
A third condition contributing to household condensation problems is excessively high humidity levels in the air within the home. Humidity levels are expressed as percentages and can be measured somewhat accurately with inexpensive gauges purchased at local hardware stores. The normal indoor humidity range in winter is 15 to 50 percent. In the summer, the humidity range may be higher because of the higher outdoor humidity levels we sometimes experience then.

High Humidity Level Problems
Because high household humidity levels can cause problems in both energy-efficient and less energy-efficient homes, the first step to be taken in attempting to control condensation problems is simply to reduce the level of humidity in the inside air.
During the winter, the humidity level you will want to attempt to achieve in your home will depend on the outside temperature. As outside temperatures drop, you need to lower inside relative humidity levels to minimize condensation (see Table 1). Monitor the interior surfaces of double pane windows during winter. If running water (condensation) is apparent on them, the interior relative humidity level is too high and should be lowered. Levels to achieve in summer are somewhat more arbitrary-they depend mainly on how uncomfortable you are in high humidity conditions.

Summer Problems !
During the summer, one of the major functions of an air conditioner, in addition to cooling warm interior air, is removing humidity from the home. A second alternative available to lower
summer time humidity levels is to purchase and operate a dehumidifier.
If humidity levels remain high in winter, you may need to run it then,
too. A dehumidifier uses mechanical
means to provide a cool surface where condensation can occur. A container located below the condensation coils catches and collects the condensed water for eventual disposal down a drain. Though both air conditioners and dehumidifiers are effective solutions to excessive moisture problems, they are relatively expensive to buy and costly to operate. Expect increases in your electricity bills during the months you use them.

Houses on Crawl Spaces !
In homes built on crawl spaces, evaporation of moisture from the earth is a major source of household humidity The high levels of humidity in crawl spaces can be a problem in both summer and winter. Foul odors in the home or crawl space, mold and mildew growth in the interior of the home (especially in closets) and growth of fungi in the crawl space itself are signs of the problem. Covering the crawl space ground with a vapor retarder (polyethylene or heavy plastic sheets available at lumberyards) is crucial in preventing moisture problems in crawl space homes (see Fig. 1).

In addition to a vapor retarder covering the ground, crawl spaces should be provided with adequate natural ventilation to facilitate air movement throughout the space. If a vapor retarder is present in the crawl space, 1 square foot of free vent area is required for every 1,500 square feet of crawl space ground area. Without a vapor retarder present, 1
square foot of free vent area is required for every 150 square feet of crawl space ground area. Most crawl space vents include louvers and/or screens to prevent the entry of insects and small animals. These coverings slow air circulation and cut down on the vent's effectiveness. Thus, you will need to double the amount of ventilation needed in most cases to compensate for this reduction. For example, a 1,500 square foot crawl space would require 1 square foot of free
vent area if a vapor retarder was present on the ground. If the vents used had screens or louvers, 2 square feet of vent area would be needed to vent the crawl space adequately. Locate vents near corners and across from one another to facilitate air movement through the crawl space.

Attic Ventilation !
Adequate natural ventilation is important in the attics of homes as well. If a vapor retarder is not present in the ceiling to slow migration of moisture from the home's interior into the attic, attics require 1 square foot of free vent area for each 150 square feet of attic area.

An exception occurs when the attic vents are located in a high/low configuration (i.e., half of the vent area in the eave/soffit area and the other half in the roof ridge area). In that case, 1 square foot for each 300 square feet is adequate. If a vapor retarder is present in the ceiling, attics require 1 square foot of free vent area for each 300 square feet of attic area.

A number of types of vents are available to provide attic ventilation (see Fig. 2), As with crawl space vents, most include louvers or screens to prevent the entry of insects and rodents, and these coverings slow air circulation. Therefore, twice the amount of ventilation is needed in most cases to compensate for this reduction. For example, a 1,500 square foot attic would normally require 10 square feet of vent area if a vapor retarder was not present in the ceiling assembly. If the vents used had screens and louvers, 20 square feet of vent area would be necessary to vent the attic adequately. With or without a vapor retarder, circulation of the air throughout the attic space would be more effective if the vent openings were distributed equally between low areas (eave and soffit) and high areas (roof ridge).

Mechanical Ventilation A final method to reduce interior humidity levels is to control inhome sources of moisture vapor generation. Fig. 3 shows some of the significant sources of water vapor in the home. The kitchen, bath, laundry and utility room are primary moisture generation locations. Consider installing exhaust fans or vents in both the kitchen and the bathroom if they are not present. The vents should be ducted directly to the exterior of the home rather than to an attic

Additional Moisture

Three additional sources of moisture periodically cause problems for homeowners: humidifiers, new construction or, remodeling, and malfunctioning combustion appliances.

Humidifiers

Many homeowners use humidifiers to add moisture to their homes in winter. In the past, when homes were leaky and so less energy efficient, much of the moisture generated inside the home went out with the warm air escaping around and through windows and doors.

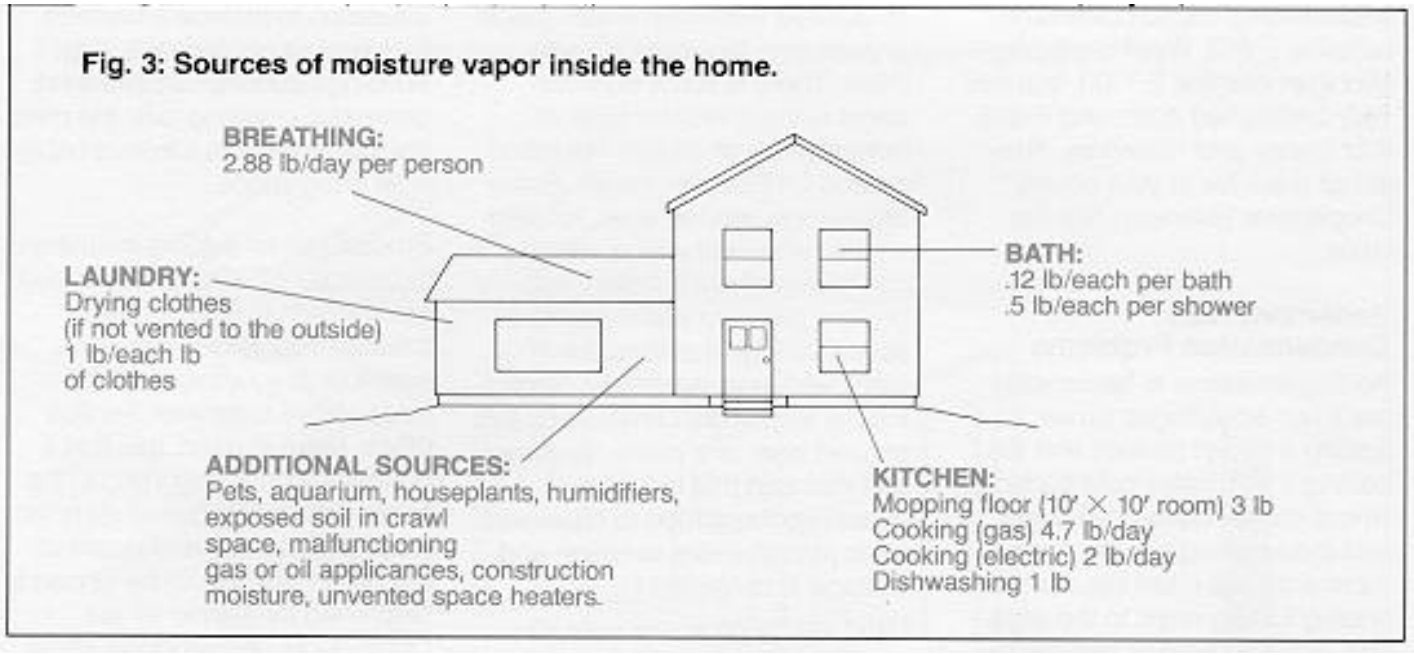
Overly dry air was common, and people experienced static electricity buildup on carpets and clothes, breathing difficulties due to, dry, nasal passages and somewhat destructive overdrying of furniture. To combat this dryness, they commonly used humidifiers. Some were incorporated directly into forced air heating systems, and moisture was circulated in the home along with heated air. A second type of humidifier, the free-standing model, is portable and can be. moved freely around the home to provide moisture where it is most needed. Whether you have extensively weatherized your home or not, experiencing condensation problems means you should not use a humidifier.

Construction Moisture

Homeowners who move into a newly constructed home or complete remodeling projects often experience high moisture levels in the interior as the building materials and systems dry. If it is necessary to close the house because of cold weather, the problem may seem excessively serious. Over time, the building materials will dry and a form of equilibrium will be established. In the meantime airing the house when you can and using exhaust fans will help to move the moist air to the outside.

Malfunctioning Combustion- Appliances

Oil- or gas-fired heating appliances that are not functioning properly or unvented heating units can cause a buildup of moisture, in a dwelling. If you suspect any combustion appliance in your home is not functioning correctly, have a repair person inspect it. Heating systems in particular should be regularly inspected and adjusted by a heating contractor. Oil-fired furnaces need annual inspections. Gas fired systems, depending on their age, can be inspected less frequently, though three years is the maximum time a gas-fired unit should go without being serviced. If you use unvented space heaters in the home, follow the manufacturer's use and maintenance instructions carefully.



or some interior space. Clothes dryers should always be vented to the outside as well. Removing moisture and depositing it outside is an effective way to control condensation problems in both winter and summer months.

Cool Surface Condensation Problems

In less energy-efficient homes, cool surfaces are readily available for water vapor to condense and collect on. Warming these surfaces by adding insulation or cutting down on the amount of cold air that can get to them by caulking and weatherstripping will lessen condensation problems.

Window Surface Problems

Condensation on window surfaces in cool or cold months can be controlled by adding layers of glass in the form of storm windows or using double- or triple glazed window units, installing a plastic film on the outside or inside of the window frame (a less expensive way to add storm window protection), repairing broken glass, and sealing any leaks in and around the window with weatherstripping and caulking on both the inside and outside (see Fig. 4).

A number of bulletins available at your county Cooperative Extension Service office provide information on caulking and weatherstripping procedures. Ask for Extension bulletins E-1104, *Weatherstripping your Doors and Windows* (covers weatherstripping, caulking, adding storm windows); E-1573, *Caulking and Weatherstripping,* and E-954, *Replacing Broken Window Glass.*

Exterior Peeling Paint and Ceiling/Wall Discoloration Problems

Peeling exterior paint and discolored interior walls and ceilings (usually in the form of mold or mildew growth) are good indications that condensation is occurring inside wall cavities and attics. During winter, cold outside air collects in these areas and can cool attic, ceiling, wall cavity and interior wall surfaces to the point where condensation occurs. Adding insulation to these areas will warm these surfaces and thus help prevent condensation. Vapor retarders should be used in conjunction with the added insulation to prevent the migration of vapor into these areas from the interior of the home. Note: specially formulated vapor retarder paints are available on the market. They seem to be the least expensive and the easiest way to create a vapor retarder on the winter warm side of the ceiling or wall when insulation is added to these areas.

Sealing Interior Cracks and Holes

When you add insulation, be sure to repair, caulk or weatherstrip any holes or cracks in ceilings, walls and floors and along baseboards These are prime areas for moisture migration to occur (see Fig. 5). Moisture vapor moves with air, and any cracks or holes that allow air to flow freely through them are potential trouble spots. Recent findings indicate that the sealing of these small, often overlooked areas can be a major factor in solving moisture problems occurring in attics and wall cavities. For additional information on weatherizing, consult Extension bulletins E-813, *Weatherproofing Michigan Homes;* E-1103, *Insulate Your Unfinished Attic;* and E-816, *Wall Repair and Fasteners.* They are all available at your county

Cooperative Extension Service office.

Basement Wall Condensation Problems

Adding insulation to basement walls has advantages similar to adding it to wall cavities and the ceiling: it eliminates cold surfaces where condensation can occur, and it cuts energy costs. Basement walls are often insulated by adding furring strips to the walls and installing rigid or batt insulation between the furring strips. If you use batt insulation, install a vapor retarder such as polyethylene film on the winter warm side of the batt insulation to prevent future moisture migration into it.

To achieve a finished effect, place drywall over the vapor retarder. (Note: There is some question about using a second layer of polyethylene when batt insulation is used on basement walls. Some believe this second layer, located on the basement wall or winter cold side of the insulation, will prevent moisture that migrates or seeps through the concrete or block wall from eventually damaging the insulation. Others think this second layer is a waste of money and maintain that insulation should not be added to basement walls until all water seepage and leakage is corrected.)

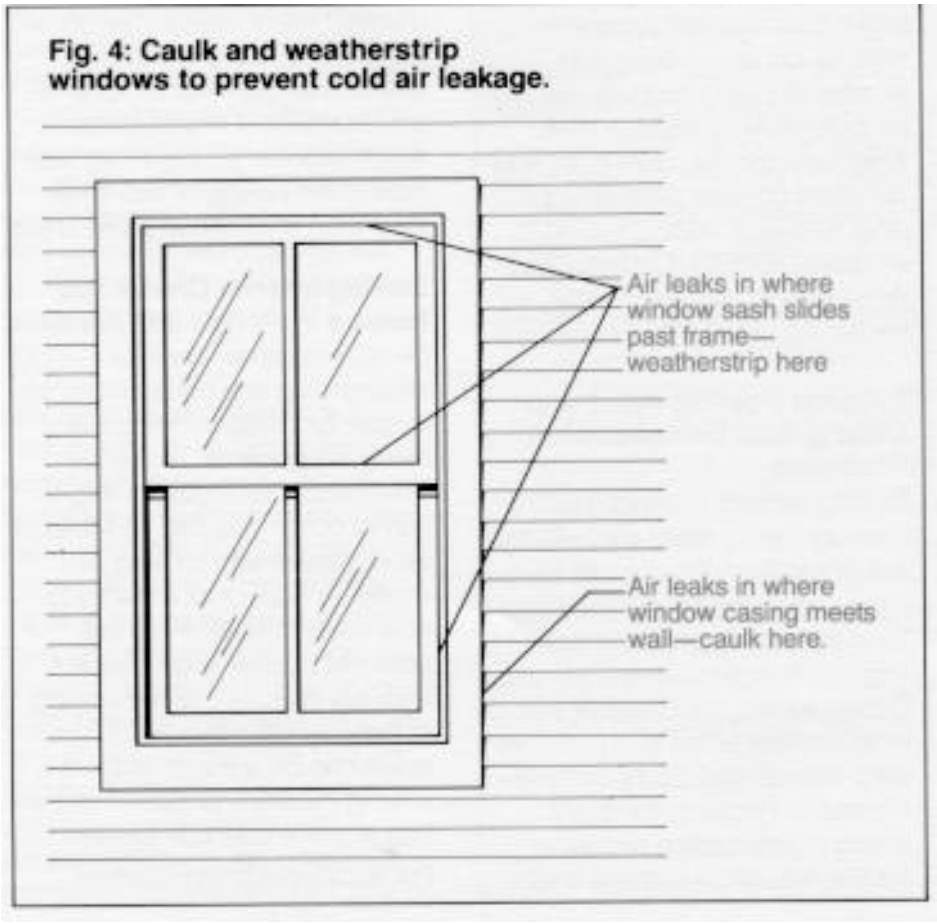
Rigid insulation is relatively impervious to water and moisture vapor damage. Therefore, it does not require the addition of a vapor retarder over or behind it when it is added to basement walls. As with batt insulation, drywall can and should be used over rigid insulation to provide a finished look and, in accordance with building codes, to provide a fire protective covering over the material that separates it from a habitable living space.

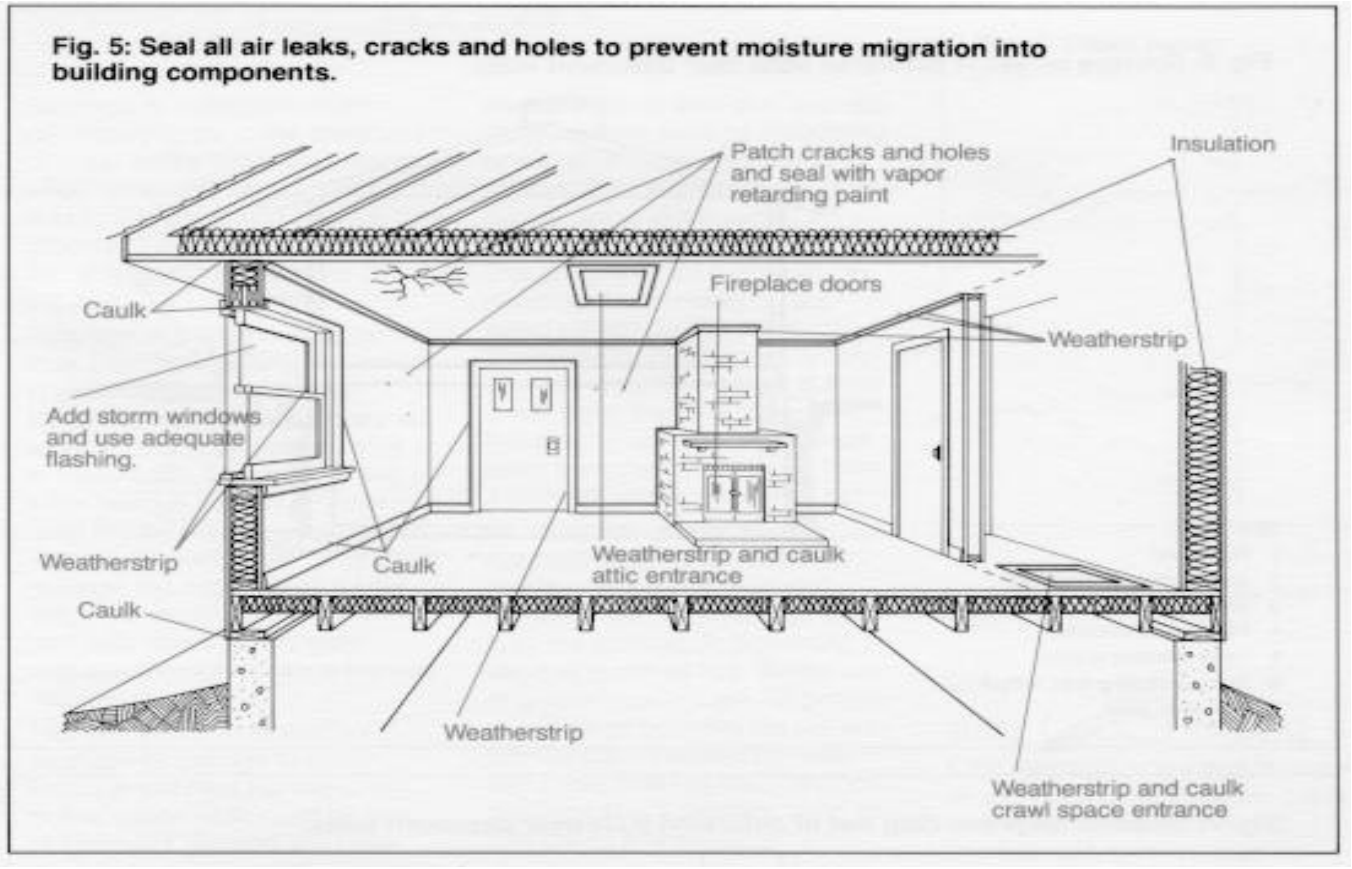
Procedures for adding insulation to basement walls are described in Extension bulletin E-1 105, Insulate *Your Basement Walls,* available at your local county Cooperative Extension Service office. Keep in mind, too, that if condensation is occurring in the basement during humid summer weather, windows and doors to the basement should be closed to help keep the humid air out. Open doors and windows when outside humidity levels are low to introduce dry air into the basement.

Toilet Tank and Water Pipe Surfaces

Toilet tank surfaces are another common place for condensation to occur, particularly during warm, humid months. Warm toilet tank surfaces by either installing rigid waterproof insulation on the inside of the tank or adding a mixing valve to the cold water supply line. This introduces hot water into the tank water supply and can help warm the tank to a level that prevents condensation. Install tubular or wrap insulation around water pipes to prevent condensation there.

Fig. 4: Caulk and weatherstrip windows to prevent cold air leakage.





Weatherization - Related Humidity Problems

In homes where moisture problems become common after extensive energy conservation efforts, the procedures described in previous sections will help solve the problems. They are briefly noted here.

Controlling the source of excess moisture is extremely important. Place vapor retarders over crawl space dirt. Limit use of humidifiers and keep fossil fuel-fired heating equipment in good condition.

Use mechanical ventilation to remove moisture. Use exhaust fans in kitchens and baths when moisture-generated activities occur in these areas. These fans should be vented directly to the outside. In winter, some heated air will obviously be lost through these fans as they remove humidity from the home. Studies indicate, however, that the cost to make up for this loss is not excessive.

Using natural ventilation and vapor retarder paint on ceilings and walls will help control a significant amount of the moisture vapor that migrated into these areas. It is especially important to repair or seal all holes, cracks, or leaks that allow air to migrate through the ceiling or walls. Finally, it may be wise to open the house periodically on milder winter days to let in cooler, drier exterior air. This may be especially important in a newly constructed or remodeled home.

SEEPAGE AND LEAKAGE

Seepage or leakage problems commonly occur in the basement or crawl space in the early spring when snow and ice are melting and frost is beginning to leave the ground. They can also occur in the spring, summer and fall during and after heavy rains.

Seepage in a basement is the slow (non-pressurized) movement of groundwater through the basement walls. It may appear as a damp spot in an isolated area or in many spots. Leakage, on the other hand, is the fast (pressurized) movement of groundwater through the wall. In the case of leakage, the entry routes for the water are cracks or joints in the wall; with seepage, the water migrates through pores in the wall material.

Two conditions must exist for seepage or leakage to occur. First, the soil near the basement or foundation walls must be wet or saturated. Second, the basement or foundation wall must have a weak spot where water infiltration can occur.

Soil Saturation

Wet or saturated soil near basement walls can have several causes (see Fig. 6): improper disposal of roof water runoff, poor surface drainage away from the house, separation between the basement or foundation wall and the soil surrounding it (this crack acts like a funnel), window wells collecting rain water, lawn sprinklers located too close to the house, an inadequate belowground footing drain system or a high water table.

Once the soil is wet or saturated, cracks, weak joints or pores in the masonry provide a route through the basement or foundation wall. Alleviate wet or saturated soil near the basement walls by minimizing or eliminating the moisture at its source. The installation, repair and maintenance of the gutter, downspouts and eavestrough discharge system are necessary to minimize the ponding of roof water runoff close to the foundation (see Fig. 7). Eavestrough discharges should terminate at least 3 feet away from the basement/ foundation wall and gently slope away from the foundation at least 1 inch per foot of discharge run.

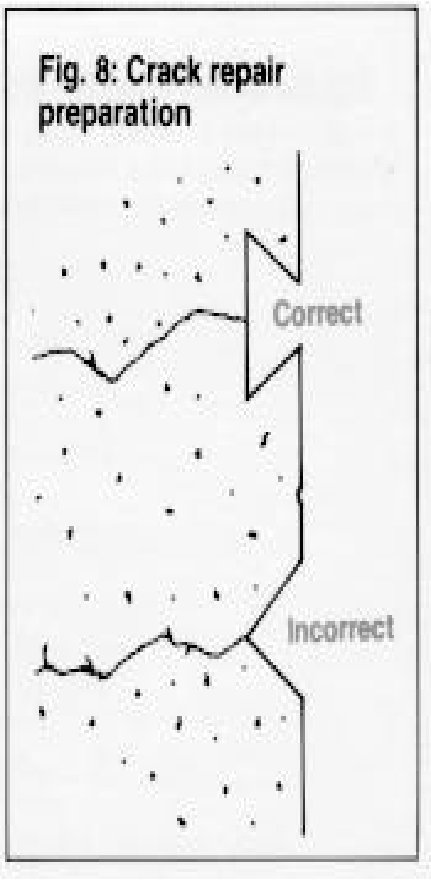
An adequate ground slope away from the basement/foundation wall is needed to ensure that rainwater will be distributed away from the foundation. Generally, a slope of 6 inches in a 10-foot run of ground is adequate. All pockets or openings between the soil and the foundation should be filled with clean material that has good drainage characteristics, such as pea gravel and sandy soil.

Window well covers should be installed so that rain-water will not collect in the wells. Locate lawn sprinklers so they don't sprinkle the walls.

A sump pump can be attached to the footing drain tile (a building contractor will be needed for this unless you are an experienced do-it-yourselfer) to drain excess groundwater away from the tile system and discharge it into a sump well set in the basement floor. In turn, the sump can then pump the waste water into the storm sewer system or to a ground area adjacent to the house. Choose a spot where the water will not damage the foundation or any adjoining property.
Contact your local township or city building officials for specific guidelines on where to dispose of sump pump discharge.

Wall Repair and Conditioning

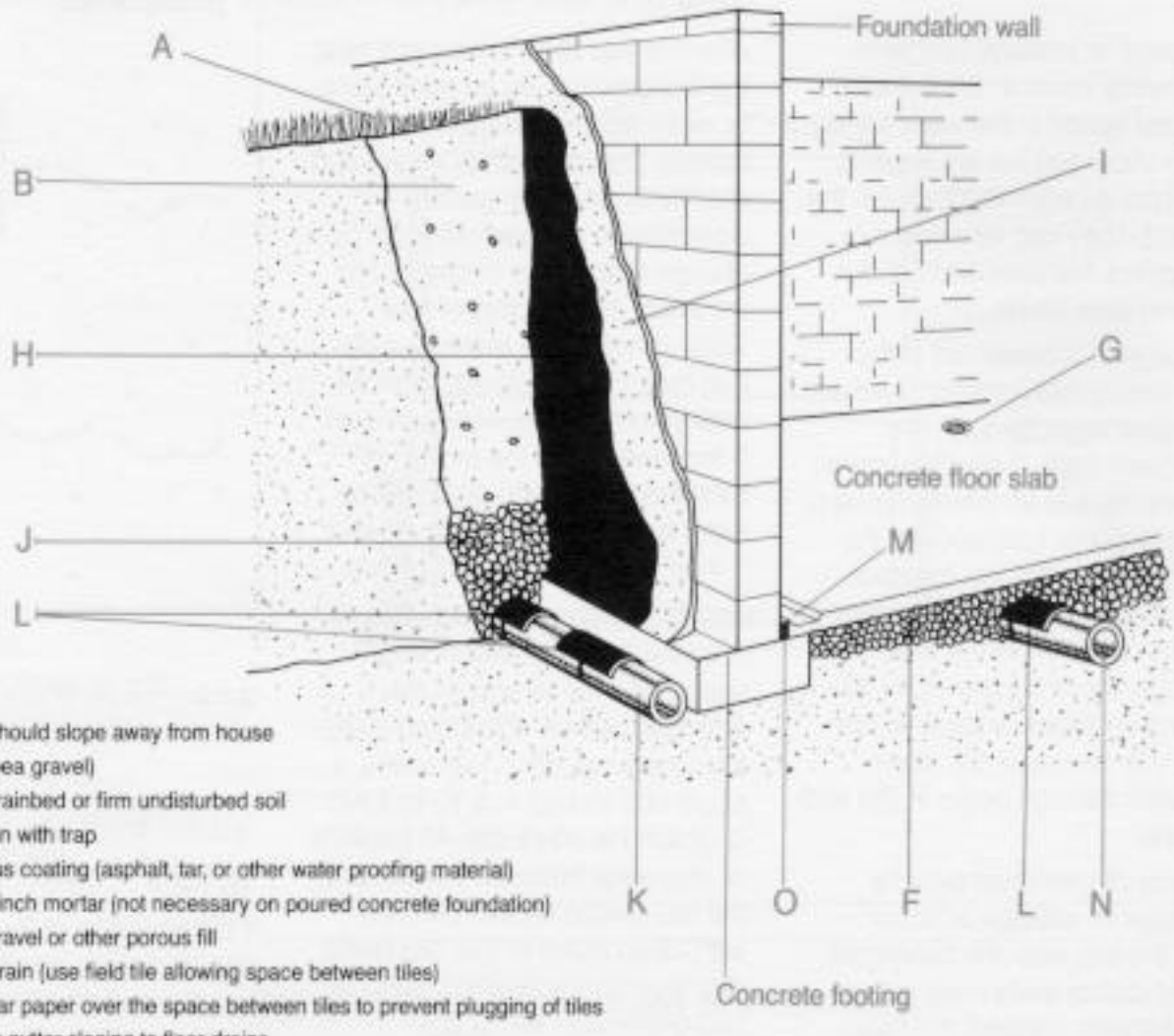
If the seepage or leakage is occurring through a small, visible crack, use a wire brush to clean the crack and fill it with mortar cement or hydraulic cement. For larger cracks, chisel out a dovetail groove (see Fig. 8) and clean and fill the groove with either mortar or hydraulic cement. If leakage is heavy or under pressure, you may need to install weep pipes to direct the leakage to a sump pump or



drain. A professional may have to be hired to help with these methods.

An additional solution for serious basement moisture seepage/ leakage problems is installing a footing drain tile system around the exterior walls. While this is being done, the exterior side of the foundation walls should be waterproofed (see Fig. 9 for a method commonly used). This solution involves excavating the soil around the exterior walls, installing a footing drain tile system, waterproofing the wall, backfilling with clean and porous material, and sloping the backfill away from the walls. Contact your

Fig. 9: Footing drain tile and waterproofing system.



KEY:

A Ground should slope away from house
B Backfill (pea gravel)
F Porous drainbed or firm undisturbed soil
G Floor drain with trap
H Bituminous coating (asphalt, tar, or other water proofing material)
I One-half inch mortar (not necessary on poured concrete foundation)
J Coarse gravel or other porous fill
K Footing drain (use field tile allowing space between tiles)
L Building tar paper over the space between tiles to prevent plugging of tiles
M Perimeter gutter sloping to floor drains
N Underfloor drain laid in gravel
O Hot tar or asphalt poured in joint

local township or city building official to secure information about discharge of footing drain tile water. The addition of a footing drain tile, weep pipes and the procedures involved in attaching an existing footing drain tile to a sump pump are expensive and time consuming. Consult an experienced building contractor, engineer or architect before attempting these solutions. Before you hire anyone to do such a job, look for background information about these people. How long have they been in business in or near your community? What type of reputation do they have with local banks, savings and loans associations, or lumberyards? Are they licensed with the state of Michigan? The State Licensing and Regulation Department can tell you. Contact it at (517) 335-1669 or 337-0678. Ask for the names of at least three references who have had work similar to yours done by the individuals or their companies. Ask these people if they were satisfied that their problems were correctly identified and solved. Finally, determine if working arrangements and business dealings between the references and the contractor were comfortably and professionally handled.

CONCLUSION

Finding solutions to moisture problems, be they condensation or water problems, is often a difficult, time-consuming and expensive undertaking. The first step in any situation is to identify the source of the problem. This may not be easy because two and often more things may be working together to create the problem.

Once you know the source, rethink the basics about condensation and/or water problems discussed in this bulletin. What are the no-cost or low-cost solutions you can try first? Can the solution(s) attempted help you in other ways in addition to solving the moisture problem? The addition of storm windows, for example, can cut heating costs as well as help prevent fogging or icing of windows. In some cases, the cost of the solution may be well justified. In some cases, you may find you have to rely on outside help, such as contractors, engineers or architects. Do look into the backgrounds of these people to ensure that you are getting the best help available and that the solutions they offer will indeed solve the problems.

SOURCES

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Merrill, John. *Moisture Problems in the Home,* B3371. Madison, Wis.: Cooperative Extension Service, University of Wisconsin, 1986.

National Center for Appropriate Technology *Moisture and Home Energy Conservation: How to Detect, Solve and Avoid Related Problems.* GPO 061-000-00615-0. Washington, D.C.: Government Printing Office, 1983.

Small Homes Council-Building Research Council. *Moisture Condensation,* F6.2. Champaign, Ill.: University of Illinois, 1975.

Many other Extension publications are available on housing, home maintenance/care and energy conservation. Call, write or visit the Cooperative Extension Service Office in your county for more information. Following is a list of related publications available there or by writing to the MSU Bulletin Office, P.O. Box 6640, East Lansing, MI 48826-6640.

Energy Conservation

E-0953, *Replacing and Repairing Screens* (free)
E-0954, *Replacing Broken Window Glass* (free)
E-1103, *Insulate your Unfinished Attic* (free)
E-1104, *Weatherstrip your Doors and Windows* (free)
E-1105, *Insulate your Basement Walls* (free)
E-1141, *Window Treatments for Thermal Comfort* (free)
E-1196, *Low Cost Weatherproofing* (free)
E-1301, *Low Cost Ways to Reduce your Fuel Bills* (free)
E-1302, *Save Fuel: Check your Heating Systems* (free)
E-1384, *A Checklist for Energy-Saving Homes* (free)
E-1521, *Maintaining Your Septic System* (free)
E-1573, *Caulking and Weatherstripping* (free)
E-1771, *Energy Conscious Interior Design* (free)
E-1798, *Increase Insulation Value/Stud Frame Wall Construction* (free)

Heating Systems

E-1387, *Chimneys* (free)
E-1388, *The Creosote Problem—Chimney Fires/Chimney Cleaning* (free)
E-1389, *Smoke Problems and Their Cures* (free)
E-1390, *Wood Stove Installation and Safety* (free)
E-1391, *Fireplace Safety* (free)
E-1392, *Fireplaces—Types and How They Work* (free)
E-2110, *Maintaining Conventional Residential Gas-Fired Heating Systems* (available July 1988)
E-2111, *Maintaining Conventional Residential Oil-Fired Heating Systems* (available July 1988)
NRM 16, *The Wood Heat Primer* ($1.00, for sale only)

Home Repair

E-0810, *Electrical Repairs You Can Do* (free)
E-0811, *Get Rid of the Drip in Your House* (free)
E-0812, *Flush Tank Problems* (free)
E-0813, *Weatherproofing Michigan Houses* (free)
E-0816, *Wall Repair and Fasteners* (free)
E-0817, *Interior Painting* (free)
E-1111, *Locks and Doors* (free)
E-1813, *Guidelines for Use of Chemically Treated Wood—Farm/Home* (free)
E-2090, *Structural Components of a Home* (free)
E-2091, *Exterior Structural Items of a Home* (free)
E-2092, *Interior Structural Items and Outside Areas of a Home* (free)
E-2093, *Home Space Conditioning Systems* (free)
E-2094, *Home Plumbing Systems* (free)
NCR132, *Finishing Exterior Plywood, Hardboard and Particleboard* (free)
NCR133, *Paint Failure Problems and Their Cure* (free)
NCR134, *Discoloration of House Paint—Causes and Cures* (free)
NCR135, *Selection and Application of Exterior Finishes for Wood* ($.40)
NCR136, *Finishing and Maintaining Wood Floors* ($.40)
PA1034S, *(Spanish) Cosas Simples que usted Puede Reparar en Su Casa* ($.50, for sale only)
PA1192, *Water Conservation Checklist for the Home* (free)
RCD 07, *Home Heating in an Emergency* (free)
WQ 14, *What to do if Your Septic Tank Fails* (free)
WQ 15, *Find Out About Water/Septic Systems if You Buy/Sell a Home* (free)
WQ 16, *How to Conserve Water in Your Home and Yard* (free)

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Housing

E-0795, *Buying a Mobile Home* ($.35)
E-0796, *Selecting a Mobile Home Site* (free)
E-0951, *Choosing a Homesite* ($.50)
E-1140, *Getting into Country Living* ($1.00, for sale only)
E-1167, *House-Buying Guide: A Checklist* (free)
E-1358, *House Buying—Professional Assistance—What to Expect* (free)
E-1359, *Forms of Housing Ownership* (free)
E-1360, *Renting vs. Buying Shelter in Michigan Communities* (free)
E-1361, *Factory Built Housing—Viable Alternatives for Michigan Families* (free)

Computer Programs

CP 09, *Home Maintenance and Repair—floppy disk version* ($100.00, for sale only)
CP 10, *Home Maintenance and Repair—hard disk version* ($100.00, for sale only)
CP10LD, *Home Maintenance and Repair—laser disk* ($50.00, for sale only)

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New 6:88-5M-KMF-SP, Price $1.00, For Sale Only (Home Maintenance & Improvement)