

Moisture Audit of Residential Structures

Moisture is both a blessing and a curse. When you have just what you need your health and the health of your buildings is ensured. But when you have too much, your buildings can fail in many ways that can not only damage the structure but affect your health and well-being. The information that follows is a tool to help you keep moisture in your house at acceptable and healthy levels.

When moisture is at appropriate levels, we are not even aware of it. It just does its job. But when it gets out of control it always leaves a calling card in mostly obvious places: rotting wood, rusting metal, moldy surfaces, condensation on windows, peeling paint, and spalling (surface deterioration) masonry. Depending on your sensitivities, you may experience dryness in your nose and respiratory system when moisture is insufficient, or experience allergic reactions from the molds and other allergens produced by organisms that are encouraged by too much moisture. Sometimes moisture's calling card is in a hidden crawlspace, in a wall cavity, under a carpet or under a cardboard box sitting on a basement floor and we have to do some serious exploring that involves turning things over and opening up places so we can get a better view.

One of the things you will learn from this moisture audit is that it is not always Mother Nature who does crazy things to your house. More often than not the problems can be traced to mistakes builders, contractors, building material manufacturers, and homeowners make in the creation, maintenance and use of residential living space. You have to learn how to drive a car safely; there are rules of the road that help keep you safe. Well, you have to learn how to live safely in your house as well. But accidents happen, both on the road and in your house and we have to take the "accidents" that we cause or permit with moisture in our homes and learn from them so we are less likely to cause them again. This audit is an attempt to teach you how to keep moisture from hurting your house and you.

Many moisture problems you should be able to solve yourself with just a little new knowledge and understanding. Some will require the help of a contractor; and sometimes you will need the help of a person(s) who can use diagnostic tools to help locate and solve moisture problems in your home (a specialist who can figure out how your house is interacting with Mother Nature and you). Your moisture audit will hopefully help you know when each resource is appropriate and which strategy will be the most cost effective in solving your particular moisture problem(s).

So . . . let's begin.

A moisture problem always suggests four questions:

1. Where did the moisture come from – **the source**.
2. How did the moisture get to where it caused the problem – **the path**.
3. Was the moisture a vapor, in bulk or a condensate or combination of the three – **the moisture form**.
4. Was it gravity, air pressure, capillarity, or diffusion that carried the moisture from one place to another – **the driving/pulling force**.

Most moisture problems fall into two types:

1. **A site specific moisture problem where the problem, source, and path are all close together:** the location of the problem, the source of the moisture, and the path of the moisture are all close together and easily identifiable. For example, water leaking into the corner of a basement (**form:bulk**) is likely coming in through openings in the basement wall (**path**), the water is coming from the downspout that is spilling water in this corner of the house (**source**) and gravity is carrying the water in (**driving/pulling force**). Some can be surface water and some from a broken storm drain, but it is all associated in the same area.

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2. A moisture problem where **both the moisture source and path are not obvious at all** and significant investigation is required to try and find them. For example, a cathedral ceiling roof, with many recessed lighting fixtures (**path**) creating holes between the inside of the house and the roof surface, is rotting because of all the moisture (**vapor**) these little "chimneys" have sucked out of the apparently dry basement walls (**source**) is condensing on the underside of the roof sheathing during the cold winter months.

If you have a moisture problem, where do you start?

A word of caution: never jump to immediate conclusions about what the solution to your problem may be. Finding a successful solution to one moisture problem does not mean it will always work for every other problem that appears to be like it. Deal with each problem on its own terms.

Step One: Using Moisture Audit Worksheet #1 define the problem as specifically as possible. Some examples:

- paint is peeling on the clapboard siding on the south side of the house
- some framing attached to the basement walls is covered with mold near the bottom
- the plaster under a window is falling off the wall
- mold is growing on the interior of an outside wall where it meets the ceiling
- the crawlspace in the basement has had six inches of water standing in it for a week
- a resident is having severe asthma attacks when in the house
- a resident is complaining of burning in the nose when in the house

Step Two: Using the worksheet(s) that are most applicable for your problem. Note all those factors which you think are relevant to finding the source and path of your moisture. It may be necessary to use more than one.

- Moisture Audit Worksheet #2: Exterior Walls (inside and out)
- Moisture Audit Worksheet #3: Foundation Walls (inside and out)
- Moisture Audit Worksheet #4: Roof Surfaces (inside and out)
- Moisture Audit Worksheet #5: Mechanical Systems (plumbing, HVAC)
- Moisture Audit Worksheet #6: Interior Framing and Surfaces

Step Three: If the issue that is driving this audit is a health problem of one of the residents then you should use Moisture Audit Worksheet #7 to guide your search for the moisture, mold and/or any other offensive material or organism.

- Moisture Audit Worksheet # 7: Moisture Related Health Issues

Moisture Audit Worksheet #1: Defining The Problem

Describe the moisture problem as specifically as you can:

Given what you have described, try to answer as many of the following questions as possible:

- Is the problem related to the seasons of the year?
- Is the problem only evident when it rains or snow melts?
- Is the problem related to any activity by a resident?
- How many persons have been living in this residence during the course of this problem? How many before this problem?
- What repairs, replacements or additions were made to the house in the weeks/months prior to the problem's appearance?

If possible, take a photo of the problem(s) and the immediate areas around it.

Moisture Audit Worksheet #2: Exterior Walls (inside and outside)

Specifying the Problem:

1. Condition That May Be Caused By Moisture On Exterior Walls
(exterior)

- peeling paint
- deteriorated siding
- rotted window sills
- rotted window/door trim
- brick/stone/mortar damage
- rotted sheathing
- rotted framing members, including sill plates

- other: _____

(interior)

- plaster damage
- paint peeling
- wallpaper peeling
- mold on and/or behind wallpaper
- mold on walls
- rotted sheathing

- other: _____

Diagnosing The Problem:

1. Orientation of wall: (circle one): N, NE, NW, S, SE, SW, E, W.

2. Wall Details:

platform construction/ balloon construction/ brick veneer/ other

Wall composition:

exterior surface is _____

sheathing is _____

interior surface is _____

insulation in the wall made of _____

there are heat ducts/ pipes in wall

there are water service and/or waste lines in wall

siding is closer than 6" to the ground

closets on exterior walls

Window type(s) and number of each in this wall:

<input type="checkbox"/> double hung	<input type="checkbox"/> casement	<input type="checkbox"/> fixed	<input type="checkbox"/> slider	<input type="checkbox"/> other
<input type="checkbox"/> single pane	<input type="checkbox"/> double-glazed	<input type="checkbox"/> argon or other gas	<input type="checkbox"/> vinyl	<input type="checkbox"/> low-e
<input type="checkbox"/> wood	<input type="checkbox"/> wood @ ext. cladding	<input type="checkbox"/> vinyl	<input type="checkbox"/> metal	

Manufacturer of window: _____

Storm window type(s):

triple track aluminum wood other

Moisture Audit Worksheet #2: Exterior Walls

3. Possible Moisture Sources:
 - ice backup (heating climate)
 - blocked rain gutter spilling water into wall
 - wind driven rain
 - leaking heat pipes
 - leaking water/waste lines
 - blocked weep holes in storm windows
 - interior moisture level (relative humidity too high)
 - interior surface temperature below dewpoint temperature
 - leakage around windows/door

4. Possible Moisture Paths:
 - leaking through openings in walls and/or through floors
 - moisture vapor convected through wall openings
 - moisture extrusion through wall surfaces
 - moisture splashing up under siding
 - moisture via capillary action up behind siding
 - moisture via capillary action through masonry
 - condensate from humid inside air.

5. Exploratory "surgery" and testing to confirm diagnosis:
 - remove some plaster or drywall
 - remove some siding
 - spray water on side of house to see if windows/doors leak

Correcting The Problem:

1. Corrective measures:
 - a. remove (repair) moisture source:

 - b. divert moisture source:

 - c. block moisture source:

 - d. block moisture paths:

 - e. ventilate the moisture source:

 - f. control surface temperature/room temperature

2. Levels of moisture reduction to be achieved:
 - a. all leaks bringing bulk moisture into the structure are corrected
 - b. humidity controlled in the 40 % RH range on the interior

3. Older homes with too many layers of paint that most likely has lead in it may require installation of vinyl or aluminum siding.

Moisture Audit Worksheet #3: Foundation Walls (inside and outside)

Specifying The Problem:

1. Condition That May Be Caused By Moisture:

(exterior)

- holes through the wall: below grade and/or above grade
- spalling mortar joints
- deteriorating masonry surface
- paint peeling
- collapsing window well(s)
- rotted window/door sills

other: _____

(interior)

- holes through the wall: below grade and/or above grade
- horizontal and/or vertical stress cracks in foundation wall
- spalling mortar joints
- efflorescence
- spalling masonry surface and/or coating
- deteriorated/moldy wood framing on masonry wall
- deteriorated/moldy surface materials such as drywall, paneling, etc.
- general wall damp
- water flowing through wall into basement

other: _____

Diagnosing The Problem:

1. Orientation of Foundation Wall: (circle one): N, NE, NW, S, SE, SW, E, W

2. Nature of Interior Space:

- full interior basement
- crawlspace (conditioned / unconditioned)
- slab

3. Foundation Wall Details:

Wall composition:

- all brick
- all concrete block
- all poured concrete
- all stone
- combination brick and stone
- combination brick and clay tile
- combination brick and concrete block
- other: _____

Window type(s) and number of each in this wall:

- double hung awning hopper glass block
- other vent openings for crawlspace are on this wall

4. Grade Details:

- grade level is inches below the bottom edge of the siding
- basement window sills are inches above the grade
- basement windows are surrounded with window wells of masonry/ metal

Moisture Audit Worksheet #3:

- _____ there are flower beds along this wall
- _____ there is shrubbery along this wall: type _____; size _____
- _____ there is a tree(s) close to this wall: type _____; size _____
- _____ there is a _____ concrete/ _____ asphalt/ _____ gravel driveway along this wall
- _____ there is a _____ concrete/ _____ asphalt/ _____ gravel driveway along this wall
- _____ the driveway is _____ right up against the house/ _____ inches from the foundation wall
- _____ the driveway pitches toward the house
- _____ the patio pitches toward house
- _____ the sidewalk pitches toward the house
- _____ there is a side door through this wall and the threshold is _____ inches above the grade level
- _____ there are storm drain crocks for downspouts along this wall _____ (number)
- _____ storm drains _____ run to daylight/ _____ are connected to a city storm system
- _____ sewer system is _____ septic/ _____ connected to city sewer
- _____ there are _____ yard drains/ _____ driveway drains
- _____ there _____ are/ _____ are not splashblocks under the downspouts

5. Crawlspace, Basement, Slab Floor Condition

- a. crawlspace:
 - _____ dirt only
 - _____ concrete only – condition: _____ cracks/ _____ holes/ _____ spalling
 - _____ combination – concrete condition: _____ cracks/ _____ holes/ _____ spalling
- b. basement floor:
 - _____ dirt only
 - _____ concrete only – condition: _____ cracks/ _____ holes/ _____ spalling
 - _____ combination – concrete condition: _____ cracks/ _____ holes/ _____ spalling
- c. slab:
 - _____ slab condition: _____ cracks/ _____ holes/ _____ spalling

6. Possible moisture sources:

- _____ storm water spillage from gutters
- _____ clogged or broken storm drains
- _____ backed up city storm and/or sewer system
- _____ wind driven rain
- _____ storm water grading toward house
- _____ water table rising
- _____ unvented clothes dryer/hanging clothes in basement
- _____ unvented basement bath/shower

7. Possible moisture paths:

- _____ leaks through wood framing that ends up in the basement
- _____ leaks around window and door framing (especially under thresholds)
- _____ leaking through holes/cracks in foundation walls
- _____ moisture wicking through mortar joints and masonry materials
- _____ moisture carried in heating ductwork under a slab
- _____ moisture vapor from bathing, clothes, or clothes being dried in the basement
- _____ moisture vapor from soils in a crawlspace or from open top concrete block walls

8. Exploratory "surgery" and testing to confirm diagnosis:

- _____ temporarily remove downspouts from storm drains and run water away from house on ground
- _____ have each storm drain crock snaked to check blockage; snake main line to city storm in street
- _____ storm drains surveyed with a camera to locate leaks and condition of storm drains
- _____ if practical, fasten plastic sheeting to siding, down to the ground and out 3' on ground for just a few rainstorms to see if surface water could be the problem

Moisture Audit Worksheet #3: Foundation Walls

- _____ fill obvious holes in foundation walls with appropriate materials
- _____ tape all four sides of a one foot square piece of plastic to wall and or concrete floors to see if moisture is wicking through these surfaces or if condensate forms on outer surface of the plastic

Correcting The Problem:

1. Corrective Measures:
 - a. remove moisture source:
 - _____ Mother Nature is not likely to be cooperative
 - b. divert moisture source:
 - _____ secure and properly pitch gutters and downspouts; when possible and code permits, disconnect downspouts from storm systems and run water on ground away from structure or redesign gutter system so less of the underground storm system will be required
 - _____ avoid flower beds around the perimeter of the house
 - _____ grade soils away from the house
 - _____ "flash" soil to house with EPDM roofing materials
 - _____ install full exterior excavation and drainage system
 - _____ install interior moisture control measures including sump pumps
 - c. block moisture source:
 - _____ fill holes/cracks in masonry surfaces
 - _____ apply dampproofing materials on exterior
 - _____ avoid cementitious waterproofing coatings on interior (efflorescence can cause them to spall)
 - _____ close up subslab heating/cooling ductwork; replace heating system
 - _____ install polyethylene plastic on the surface of a dirt floor crawlspace
 - d. ventilate the moisture source:
 - _____ use a dehumidifier to reduce relative humidity in space
 - _____ vent clothes dryers directly to exterior
 - _____ vent basement baths (showers) directly to exterior
 - e. control surface temperature/room temperature with heating or insulation
 - _____ can keep condensate from forming on foundation walls giving appearance of an exterior moisture problem.
 - f. remove or protect any cellulose material from foundation walls/floors.
 - _____ use plastic shelving away from the walls to store things; when remodeling a basement, use moisture impermeable materials on walls before framing and finish materials are installed
2. Levels of moisture reduction to be achieved:
 - a. all leaks bringing bulk moisture into the structure are corrected
 - b. humidity controlled in the 40% RH range on the interior
3. Other preventive measures required to reduce possibility of moisture problems:
 - a. protect interior building materials used along foundation walls from possible moisture damage
 - b. store materials in a basement on plastic or vinyl-covered steel shelving

Moisture Audit Worksheet #4: Roof

Specifying The Problem:

1. Condition That May Be Caused By Moisture:

- roof sheathing wet, rotting, moldy
- roof rafters wet, rotting, moldy
- eaves/soffits wet, rotting, moldy

Diagnosing The Problem:

1. Roof Details:

- roof surface: asphalt/fiberglass/ wood shakes/ slate
- how many layers of roofing material
- type of sheathing: 1 x 6/ plywood/ OSB
- ice guard installed along roof edges: tucked behind gutters: yes/ no
- drip edge installed on eave edge and/or rake edge
- soffit venting: hole vents/ intermittent vents/ continuous vent
- roof venting: ridge vent/ roof vent/ gable vent/ powered vent
- other roof penetrations: chimney(s)/ plumbing stack(s)/ bath fan vents

2. Possible Moisture Sources:

- ice backup along eaves
- wind driven rain/snow blowing in
- rain leaking in
- moisture vapor from interior (see mechanical and interior framing worksheets)
- moisture vapor from exterior

3. Possible Moisture Paths/Conditions:

- ice backup leaking in along eave edge
- wind driven rain/snow via roof vents
- water leaking in through holes in roof
- water leaking in around flashings
- vapor via thermal by-passes in attic floor (recessed lights, bath fans, mechanical openings, framing openings)
- dewpoint temperature achieved in attic
- exterior moisture vapor entering via roof vent openings

4. Exploratory "surgery" and testing to confirm diagnosis:

- seal thermal bypasses into attic; replace or remove recessed light fixtures
- remove section of plaster where water leaked to better assess source

Correcting The Problem:

1. Corrective Measures:

- a. remove (repair) moisture source:
 - Mother Nature is not likely to be cooperative
- b. divert moisture source:
 - repair all roof surface leaks
 - replace all roof surfaces
- c. block moisture source:
 - install ice guard on eave edge of roof
 - caulk joint between roof sheathing and fascia board
 - repair flashings

Moisture Audit Worksheet #4: Roof

- d. ventilate the moisture source:
 - _____ does thermal by-pass treatment reduce need for ventilation
 - _____ do existing vents create a problem, not solve one
 - e. control surface temperature/room temperature:
 - _____ does keeping attic cooler reduce ice backup
2. Levels of Moisture Reduction To Be Achieved
- a. all leaks bringing bulk moisture into the structure are corrected
 - b. paths for vapor moisture to enter the attic from the interior are blocked, controlling RH level
3. Other preventive measures required to reduce possibility of moisture problem:

Moisture Audit Worksheet #5: Mechanical Systems (Plumbing/HVAC)

Mechanical systems can be a source of moisture, a path for moisture problems, and a solution to other moisture problems. It is important, when doing a moisture audit, to always consider how the mechanical systems may be playing a role in the problems you are investigating, even when it may not be obvious. The purpose of this worksheet is to remind you of ways mechanical systems may be **a** or **the** source of your moisture problem.

Mechanical Systems As Contributors To Moisture Problems:

1. Plumbing:

_____ Leaks:

_____ water service lines: _____ frozen pipes _____ corrosion

_____ waste stacks and lines: _____ frozen pipes _____ corrosion

_____ overflowing caused by: CARELESSNESS BROKEN FIXTURES/CONNECTION

_____ tubs _____

_____ sinks _____

_____ toilets _____

_____ water heaters _____

_____ clothes washers _____

_____ garbage disposals _____

_____ dishwashers _____

_____ Sewer/Storm Water System Failure:

_____ backup of clogged and/or broken sewer/storm water lines around house and to street

_____ sump pump fails

2. Heating/Cooling/Air Conditioning/Venting:

_____ Hot Water/Steam:

_____ leaking radiators

_____ leaking/corroded pipes

_____ Forced Air Heating:

_____ heat ducts under a slab with water leaking into them can act as a humidifier driving moisture vapor into the house

_____ heat ducts traveling through a crawlspace can pick up mold spores

_____ open cold air returns into basement can carry mold spores and moisture from basement to living spaces

_____ heat ducts in exterior walls can pick up mold spores

_____ Air/Conditioning:

_____ units are oversized and do not dehumidify effectively

_____ units are oversized and space gets too cold and condensation forms

_____ Venting:

_____ no bath fans to remove shower moisture

_____ no kitchen fan to remove cooking moisture

_____ powerful exhaust fan (such as Jenn-Aire) backdrafts furnace, hot water tank

_____ fans in place are not used regularly

Moisture Audit Worksheet #5: Mechanical Systems (Plumbing/HVAC)

- Metal or PVC Flues: condensate forms from flue gases and water drains back down the flues
 - Chimneys:
 - flues are too large for gases of higher efficiency furnaces/boilers and moisture condenses in the chimneys and wicks into the walls of the chimney, causing spalling of the chimney face and/or surfaces applied to the chimney
 - flues get clogged up with leaves and other debris and blocks the openings in them so that CO gases and moisture cannot escape
 - Unvented Gas Heaters: can off gas CO and generate large amounts of moisture when gas burns
3. Controls:
- Thermostat settings: too low a setting can cause dewpoint temperatures to be reached on walls and windows with resultant condensate forming

Strategies To Help Make Mechanical Systems Work For You, Not Against You

1. Plumbing:
- keep all water and waste lines inside the conditioned space, so they cannot freeze
 - carefully and fully insulate any water/waste line that must pass through unconditioned spaces
 - address leaking plumbing fixtures immediately, lest the moisture contribute to mold growth and/or destroy critical structural components of the structure
 - keep sewer and storm system lines snaked out; if residence is subject to city sewer and storm water backup, consider installing check valves on these lines to reduce this backup
2. Heating/Cooling/Air Conditioning/Venting:
- address leaking pipes that may be carrying hot water or steam for heating
 - seal off a failed sub-slab ductwork forced air system and replace it with an above grade heating system
 - seal all accessible duct joints on a forced air system with a mastic to keep moisture and mold spores from entering the system or being carried somewhere else by the system
 - cold air returns for forced air systems must be connected directly to the furnace and the air should not travel through any area not regularly used for living space
 - when installing any new piping or ductwork, it should always be within the conditioned space and not in the walls or other unconditioned spaces
 - bath and kitchen ventilation fans must vent directly to the exterior
 - to encourage fan usage, connecting the fan to the light switch in the bathrooms means it will be on whenever someone has turned on the light to use the bathroom
 - use **no** unvented gas appliances (including natural gas, kerosene, etc)
 - keep wire screens on top of chimney flues to keep debris and critters out
 - whenever new heating equipment is installed be sure it is sized properly, is properly vented, and whenever possible, it is a unit that gets its combustion air from outside the residence and ventilates the flue gases directly to the exterior
 - whenever new air conditioning units are installed, be sure they are properly sized and that the condensate formed by these units is properly drained away
 - check chimney cleanouts and be sure chimney is not blocked in any way by debris

Moisture Audit Worksheet #6: Interior Framing and Surfaces: Some Moisture Paths

How your house is put together on the inside and how many holes are put into the surfaces that are exposed to the exterior can create some serious moisture paths in your home. Some of these places are a bit hard to get to, but often are not costly to fix and you may be able to do it yourself. But some of these paths can be very difficult to find and you will need the help of professionals with diagnostic equipment that can help detect how moist air is moving through your house. The following is a checklist of things to consider:

1. The ceiling between the interior and the unconditioned attic spaces:
 - _____ bath fan venting directly into the attic (moisture can condense on the cold roof sheathing)
 - _____ recessed light fixtures into the attic
 - _____ mechanical system holes through this surface including:
 - _____ around light fixtures
 - _____ around plumbing stacks that eventually go through the roof
 - _____ doors and hatch openings into the attic space

2. Interior framing:
 - _____ opening between chimney(s) and wood framing around them
 - _____ balloon construction framing open from the basement all the way to the attic
 - _____ chases in which mechanical lines or ducts are run and may be open from the basement to the attic
 - _____ soffits over kitchen cabinets and other places which may be open to side walls and floors on outside walls

3. Corrective Measures:

The primary remedial measure with these moisture paths is to block or close them off so no moisture can move through them to where it can do damage.

 - _____ around non-heat generating openings (such as recessed and other light fixtures and chimney collars) you are blocking or closing off in the attic, seal openings with plastic sheeting, caulk, foams
 - _____ around heat generating openings follow specifications of light fixture manufacturers; around chimney collars create a metal flashing from coil stock that is secured to the chimney and framing with adhesive caulk
 - _____ openings in framing in the basement can be blocked or closed off with styrofoam insulation cut to fit the openings and sealed around the perimeter with caulk or foams compatible with styrofoam

Moisture Audit #7: Moisture Related Health Issues

Moisture problems can underlie a number of housing-related health hazards:

- ❑ **Lead paint failure** is often caused by moisture problems. It results in loose and flaking paint that contaminates household dust on the interior and soil on the exterior.
- ❑ A number of **allergic asthma triggers** are associated with excess moisture, including house dust mites, mold and cockroaches.
- ❑ **Outgassing** of some volatile chemicals found in building products, such as bonding agents, is increased by higher building relative humidity.
- ❑ **Mold** growth from excessive moisture may have allergenic or toxic health affects.

Factors to consider:

Have medical tests identified things that the residents are allergic to? If so, are they allergens related to excess moisture?

Do the residents with the health complaints experience discomfort only while in the residence? Is there a particular place in the residence where they are most uncomfortable?

Can you connect the moisture problem identified with an exposure pathway? (For example, foundation wall water intrusion may result in toxic mold growth in the basement. A cold air return that opens into the basement and is not connected to the furnace can provide mold spore exposure pathway to an infant who's crib is near the cold air return in an upper bedroom.)