Mold and Moisture Ventilation

John Davies, Building Performance Center Opportunity Council – Bellingham, WA
Acknowledgements

• Rich Prill, Washington State University
  – illustrations
• Kenneth Hellevang, North Dakota State University
  – Illustrations
• Mike Vogel, Montana State University
  – DOE mold curriculum
Why Mold Training?

Effective November 12, 2004, the U.S. Department of Energy issued *Weatherization Program Notice 05-1*

Section 5.14 of WPN 05-1 titled **Energy-Related Mold and Moisture Impacts** require that “weatherization crews receive specialized training in the recognition of conditions that promote mold growth they may encounter in their weatherization work and how best to prevent creating new mold conditions. At the same time, crews need training in how to treat less extensive mold conditions they may encounter in certain homes”.

This training is provided by DOE to meet the training needs of Section 5.14
DOE GUIDANCE regarding “Mold-Related Weatherization”

WPN 05-1 - November 12, 2004

5.14 Energy-Related Mold and Moisture Impacts – cont.

“DOE funds may be used to correct energy-related conditions to allow for effective weatherization work and/or to assure the immediate health of workers and clients.”
Summary of Mold Guidance

• Training
  – Understanding of conditions that promote mold growth
  – Prevention of mold
  – Treatment options

• Assessment
  – Client notification or disclaimer

• Health of Workers and Clients

• State Protocol
  – Each State will develop a protocol with specific policy.
Energy-Related Mold and Moisture

... awareness and impacts for weatherization

Why Are Molds a Concern?

- While dormant mold spores are always present inside a home, active mold growth indoors is not normal.

- Molds can present health risks for crews and clients.

- Uncontrolled mold growth can cause severe and permanent structural problems.

- Failure to recognize conditions of mold growth may worsen existing mold cases or cause molds to actively grow.
Energy-Related Mold and Moisture

... awareness and impacts for weatherization

- molds background and health effects
Hidden Home Molds

Mold behind a tub-surround.

Mold inside a furnace cabinet

Mold growing on the back side of wallpaper.
Mold - Why Today?

- Always outside “background” levels of mold
- Building Tightness?
  - (reduced infiltration, reduced ventilation)
- Poor construction practices
- Improper use of building materials
- More media and public awareness
Conditions that Promote Mold Growth

- Clues to Mold Control -

- 4 conditions of mold growth:

1. Mold spores present – they are everywhere
2. Food (organic materials) cellulose, paper, wood, jute
3. Temperature Mold does well in the same temps we like
4. Moisture

5. Plus one

1. Lack of home occupant knowledge & maintenance
Mold Growth

• Mold spore + Mold food + Proper temperature + Moisture = MOLD
1. **Mold spores present**
   - Fungi consists of approximately 25% of earth’s biomass – spores are everywhere
   - Estimated fungi species exceed 1.5 million
   - Dormant spores can survive for many years without germinating and spreading

**Bottom line ...**

*fungi spores will be in the homes you audit and weatherize!*
Mold Growth

**ORGANIC MATERIAL** – Nutrient Source
Molds secrete digestive fluids that decompose the material substrate, making nutrients available

- processed wood/cellulose (sheetrock & insulation paper)
- natural fibers such as cotton and wool (carpet, rugs, upholstery)
- “dirty” water (i.e. sewage water) is full of organic material
Nutrient Source

Example

**Organic material** *(organic jute-backing on carpet and padding liner)* – check out the mold

**Inorganic material** *(rubber and synthetic carpet)* – No mold!
Mold Growth

**TEMPERATURE**
Molds like the same temps we do

Molds germinate and grow best in warm temperatures
77 degree F to 88 degree F

At cooler temps (below 50 degrees) some molds will germinate but grow slower
What we know

Mold spore is everywhere
Mold food….wood, drywall, organic debris
Mold lives at the same temp we do 65-80
Add moisture and mold becomes a concern
What conditions can we control

• Moisture is the factor we can most realistically control
Moisture Rules

- Moisture moves from **warm** to **cold**
- Moisture flows from **more** to **less**
- Moisture hitchhikes with air: **high pressure** to **low pressure**
- **Gravity pulls water down**
- **Water wicks up**
- **Drainage is critical**
Moisture movement

- Liquid flow
  - Condensation
- Capillary flow
- Air movement
- Vapor diffusion
Mold food
Site Drainage
Roof Leaks
Capillary Flow

- Liquid water creates a suction of its own as it moves through tiny spaces within and between building materials.

- Examples: Capillary action can also move liquid water into a home through damp soil and a porous concrete slab or stem concrete wall.
Capillary action

• Break

No Break
We build buildings out of “Mold Food”
= Keep these materials dry
New “self-composting” building
Air Movement

• Air movement carries water vapor into and out of the building and it’s cavities
WARM AIR RISES
Pathways
Underside of roof sheathing

QuickTime™ and a decompressor are needed to see this picture.
Cups inverted into water

A = solid cup

B = hole in bottom
Ceiling Mold

Check for moisture from these sources:

1. Ice damming
2. Insulation drift
3. No insulation
4. Improper attic or exhaust venting
5. Roof leak
6. AC Condensation
Ice Dam

QuickTime™ and a decompressor are needed to see this picture.
Moisture and control

Moisture Sources:
1. Excessive Humidity
2. Water Intrusion
Managing moisture and condensation in homes

- Reduce or eliminate the source
- Warm the surfaces
WX Building Assessment

General examination of building

✓ Examine structure, maintenance activities, occupancy patterns
✓ Visually look for mold and water staining
✓ Look for evidence of standing water
✓ Look for evidence of condensation
✓ Check basement or crawl space and attic for proper venting and exhaust
WX Building Assessment – Outdoors

✓ Soil grade or drainage toward foundation
✓ Standing water adjacent to foundation
✓ Wall and roof damage allowing water intrusion
✓ Missing or blocked rain gutters
✓ No downspout extensions
✓ Firewood stacked adjacent to house
✓ Excessive shrubbery around foundation
WX Building Assessment -

**Occupied Space**

- Plumbing leaks
- Water stains on walls, ceilings and around windows
- Musty odor
- Surface Condensation (especially during mild weather)
- Mold on Carpeting
- Humidifiers
- Window Air Conditioners
- Lack of bathroom, kitchen exhaust
- Clothes dryer not vented to outside
- Firewood stored indoors
- Wet clothes drying indoors
WX Building Assessment –

**HVAC System**

- Air intakes: debris (organic) vs. clean air
- Filters: dirty, damp, poor type
- Heat exchangers: dirty & damp coils, condensate pans, drainage, stagnant water
- Ducts: contamination, moisture
An average family of four can generate over six gallons of moisture per day.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Moisture Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shower (excludes towels &amp; spillage)</td>
<td>1.0 pt / 10 minute shower</td>
</tr>
<tr>
<td>Clothes drying (vented indoors)</td>
<td>5.0 pt/ load</td>
</tr>
<tr>
<td>Combustion (unvented space heater)</td>
<td>7.6 pt/ gallon of kerosene</td>
</tr>
<tr>
<td>Cooking dinner (family of four)</td>
<td>1.2 pt(1.6 if gas cooking)</td>
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<tr>
<td>Floor mopping</td>
<td>1.5 pt/ 50 sq. ft.</td>
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<tr>
<td>Respiration (family of four)</td>
<td>0.4 pt/ hour</td>
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<td>Desorption of materials: seasonal</td>
<td>6 to 17 pt/ day</td>
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<tr>
<td>New construction</td>
<td>10+ pt/day</td>
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<tr>
<td>Ground moisture migration</td>
<td>Up to 100 pt/day</td>
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</tbody>
</table>

1.0 pint can increase the RH by about 8% in a 1,500 sq. ft. single floor home.
Dryer vents

5 pints per load
Ground source can add up to 100 pints/day
Point and shoot

1 pint H2O/10 minute shower
Products of combustion

7.6 pints H2O/gallon kerosene burned
Mold Growth

MOISTURE – Excessive Humidity

- Humidity is Water Vapor
- water vapor with cool surfaces is combo for creating condensation (dew-point)
- Water Vapor moves into walls and ceilings via. diffusion and air leaks

Humid air + cold surface = condensation
In cold climates maintain 35-50% RH.

In hot-humid climates maintain 40-60 % RH.
FACT:
Warm Air Can Hold More Moisture Than Cold Air

TEMP. R.H.
Pyschrometrics

Indoors

• 70 degree air
• 60% Relative Humidity
• Dew point 54 degrees
• 66 grains of moisture/pound of air

outdoors

• 40 degree air
• 90% Relative Humidity
• Dew Point 36 degrees
• 33 grains of moisture/pound of air
1/2 air change

- 1/2 the volume has 66 grains/lb
- 1/2 the volume has 33 grains/lb
- Mixed together air has 50 grains/lb

- 50 grains/lb at 70 degrees =? RH

= 45 %Relative Humidity
# Outdoor-indoor Relative Humidity Conversion Chart

(Figures in chart are percentages.)

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<th>Outdoor Relative Humidity</th>
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<th>-10°</th>
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</table>
Buildings can be dried out by ventilating with cool outside air, even when outdoor relative humidity is high.
COLD OUTSIDE

High relative humidity on and near cool surfaces

Cool window surface
Bedroom space

Closet on exterior wall

Reduced surface temperature causes higher relative humidity, permitting mold and mildew to form

Solution: raise closet temperature

50°F
70% R.H.

70°F
35% R.H.
Condensation or leak?
Basement Mold

Why the mold?
• Cold surfaces causing condensation?
• Exterior water source?

Do not insulate or cover until moisture problem is dealt with!
Moisture Flows...

WARM → MORE → COLD → less
Mold Growth

**MOISTURE – Excessive Humidity**

Warm Humid air + cold surface = condensation

**Hot Climate**
outside warm humid air + cold surface on inside wall

**Cold Climate**
inside warm moist air + cold surface on outside wall
High Humidity – Window Condensation

The lower the window R-value the cooler the inside surface and greater chance of condensation.
High humidity – Poor/No Ventilation

Is the exhaust fan working properly?

Is the exhaust fan vented to the outside?

Is the fan operating long enough to remove moisture?
Mold Growth

4. Building Tightness

Since the mid 1970’s homes are built tighter, better weatherized and save energy!

Without controlled ventilation ...
...tighter = less air exchange
...tighter = less moisture evaporation
...tighter = less pollutant dilution
...tighter = greater chance of mold growth
Mold Growth

Building Tightness

How tight is too tight?
Use Blower Door and Consider:

- number of occupants
- volume of air conditioned area
- mechanical ventilation
Mold Growth

*Home Occupant Awareness*

Alert occupants of home mold growth and possible conditions that may create moisture problems and mold growth.
Assessing the problem

- Pollutants
- Pathways
- Driving Forces
Moisture as a pollutant
Pathways
Crawlspace / attic connection

Molds and Fungi
Leaky Ducts
Avoid negative pressures in the south (hot and humid)

Infiltration of warm, humid air:
- Into walls
- Through chases
- Into rooms

Condensation on cool surfaces
WX Building Assessment

FOLLOW YOUR NOSE!
FOLLOW YOUR EYES!

If you can see it or smell it, molds are likely present.
Tools

QuickTime™ and a decompressor are needed to see this picture.
Moisture content
Humidity and Temp
MOISTURE ASSESSMENT FINDINGS
INDIANA WEATHERIZATION PROGRAM

Client Name: 
Address: 

The purpose of the Indiana Weatherization Assistance Program is to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential expenditures, and improve the health and safety of the building and its occupants. This moisture assessment, as part of overall building analyses, documents existing moisture issues before weatherization was performed and identifies issues that must be addressed by the property owner before work can begin on the dwelling.

Items checked on this form have been identified as potential issues in your home.

1. MOISTURE AREAS

   Existing conditions (check all that apply)
   - Damp atmosphere in house
   - Client complaint of allergy-like symptoms
   - Visible mold growth (if yes - go to #2)
   - Evidence of water penetrating the home (stains, moist areas)
   - Evidence of conditions that might allow water into the home (poor grading, bad flashing, bad/missing gutters)
   - Actual construction defect or deterioration that allows water into the home (roof, decks, window concrete slabs, lack of vapor barrier)
   - Plumbing defects (leaking drains, pipes or toilet seals, missing caulk on sinks or tubs)
   - HVAC problems (dirty, must filters, poor condensation drainage)
   - Dryer vented indoors, inadequate ventilation for a kitchen, bath or other high moisture area
   - Any source of condensation

2. MOLD/MILDEW AREAS

<table>
<thead>
<tr>
<th>Room/Type</th>
<th>Existing Mold/Mildew</th>
<th>Sq Ft of area</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary bath</td>
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<tr>
<td>Second bath</td>
<td></td>
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<tr>
<td>Kitchen</td>
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<tr>
<td>Laundry area</td>
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<tr>
<td>Basement walls</td>
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<tr>
<td>Basement shower stall</td>
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<td>Crawlspace</td>
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<tr>
<td>Exterior walls</td>
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<tr>
<td>Attic/Dellaings</td>
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<tr>
<td>Other</td>
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</tbody>
</table>

3. UNSANITARY CONDITIONS (may cause odors, viruses or bacteria in house)

<table>
<thead>
<tr>
<th>Condition</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insect pests in work area</td>
<td></td>
</tr>
<tr>
<td>Excessive animal feces/carcasses in work area</td>
<td></td>
</tr>
<tr>
<td>Excessive bird/bat feces/carcasses in attic</td>
<td></td>
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<tr>
<td>Raw sewage in house/basement/crawlspace</td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments: 

These are the existing conditions as of the date below. Weatherization will not be able to proceed due to items identified on this form.

Client Signature 

Agency Representative 

Agency Phone Number 

The moisture assessment findings completed by the Building Analyst on ________ do/don't reflect current moisture issues found in the dwelling on ________. Any changes to the original assessment have been noted and initialed by the appropriate Building Technician.

Certified Building Technician 

Date 

Testing for Mold

*let clients know ...*

- No Federal Threshold Mold Limits or Standards
- No criteria or requirements for inspectors
- False negative evaluation
  - Compare quantity and types at various locations
  - Compare to outside types and levels
- **Quality** mold testing requires special training, special equipment, is expensive AND is not the job of weatherization
During cleanup protect yourself

- When cleaning up rodent waste and habitat always use a HEPA vacuum
- Wear personal protection and cleanup as you go
Personal Protection Equipment

• Less than 10 sq. ft.
  – N-95 respirator, gloves, goggles

• Between 10 and 100 sq. ft.
  – N-95 or half face respirator with HEPA filter, gloves, disposable overalls, goggles

• Greater than 100 sq. ft.
  – Full-face respirator with HEPA filter, gloves, disposable full body clothing, head gear, foot coverings and containment
Persistent Mold Growth
Typical Eave Vents
Attic Eave Vent
= “wind washing of insulation”

Cold ceiling surface in room below
The case of the toilet and the rotting floor

- 70 degree air
- 55 % RH
- Dew point 54 degrees
- Water temp 50 degrees
Solution

• Warm the water???
• Insulate the tank
• Lower the humidity
  – Exhaust fan with low flow continuous with a bumb
Case Study: Michigan City, Indiana

- 850 ft.$^2$, two bedroom, one bath house
- Four occupants
- No existing mechanical ventilation
- 125,000 btu/h draft hood equipped furnace located in a basement
- Pre-Wx: 1100CFM50
- Wx Auditor called for a new 90% efficient furnace and for mechanical ventilation to be installed in the
The digital meter displays the following readings:

- Temperature: 56.7°C
- Dew Point: 43.5°F
- Humidity: 50.7%
A better mousetrap

QuickTime™ and a decompressor are needed to see this picture.
Hazards of smoking