



# **BUILDING A FRAMEWORK FOR HEALTHY HOUSING**

---

## **Healthy Homes: HVAC-Related Issues for Housing Rehabilitation**

---

Joe Laquatra  
Cornell University

# The issues

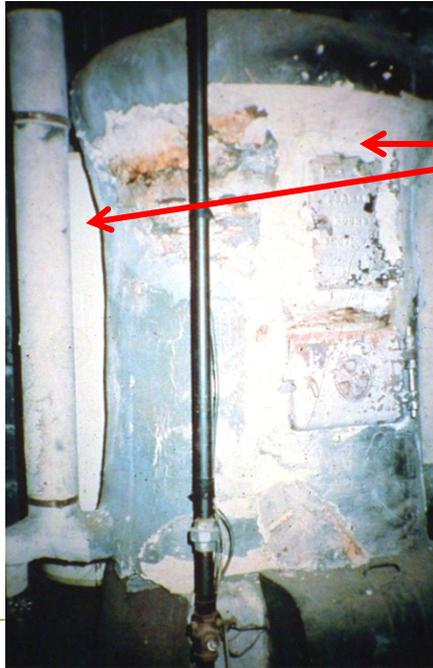
- Asbestos
- Leakage
- Backdrafting
- Contamination
- Correct sizing





# BUILDING A FRAMEWORK FOR HEALTHY HOUSING

---



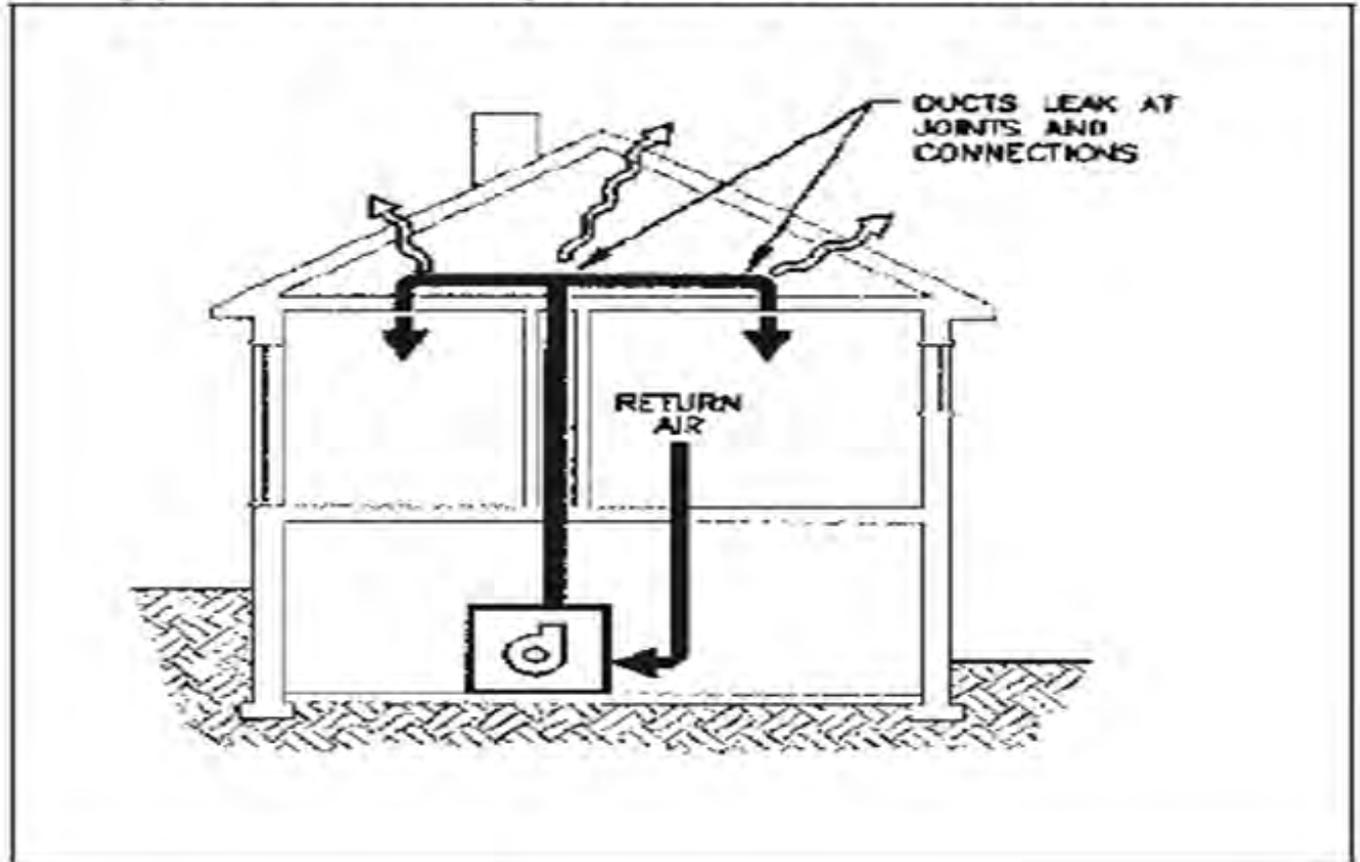
Asbestos removal from older heating systems

Not a do-it-yourself project

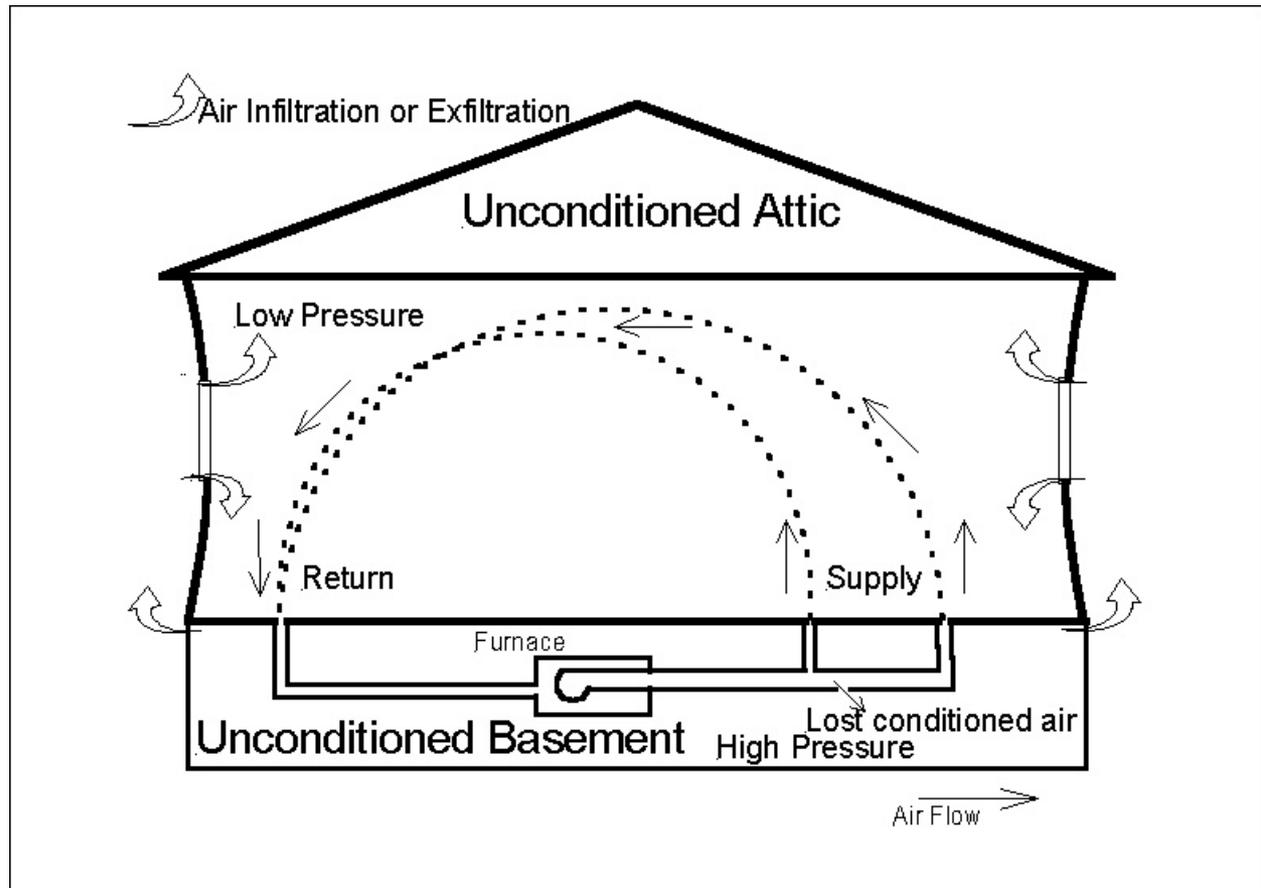


## Typical Duct Systems Leak 15% to 20%

### Supply Leaks



## Return Leaks





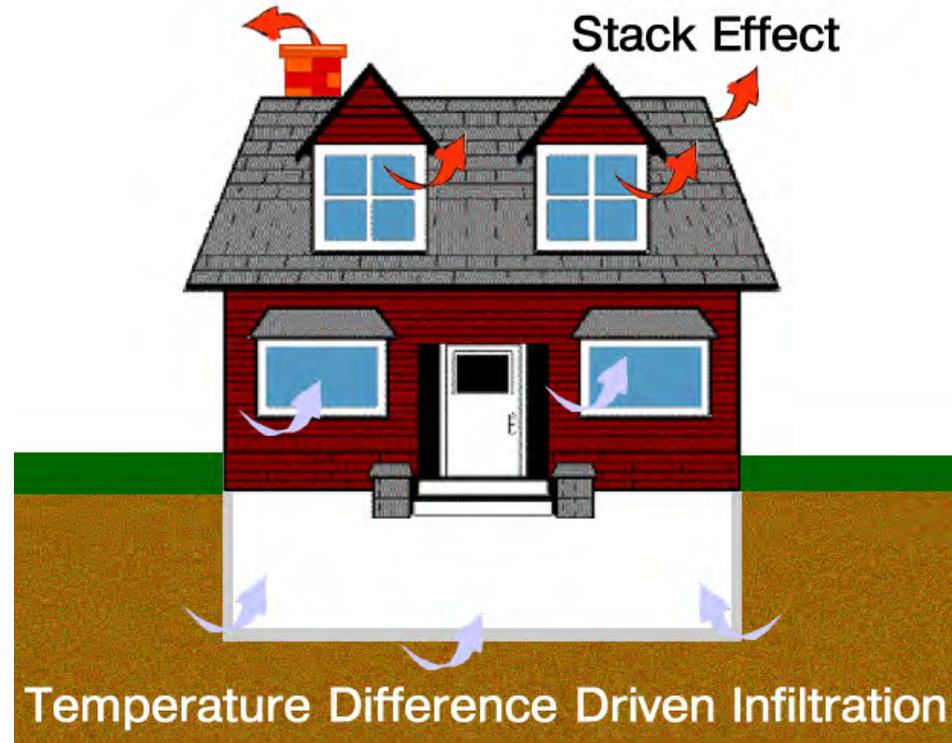
**duct blaster**

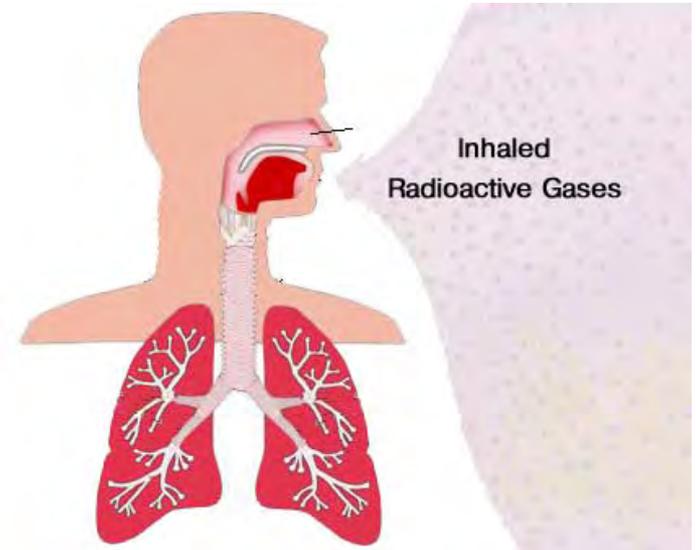
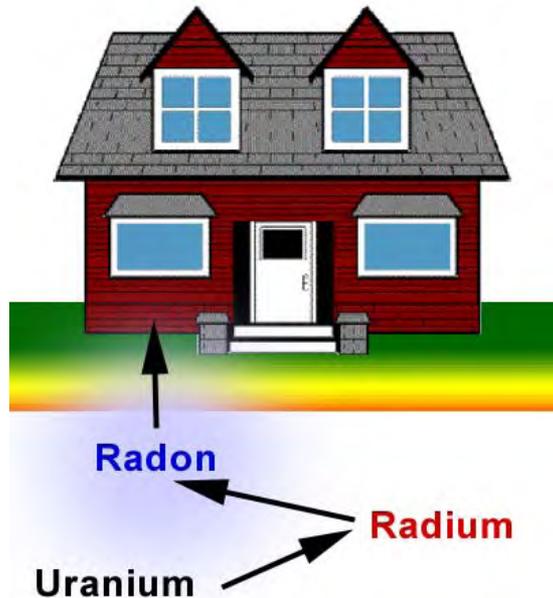
**blower door test**



## Seal ducts with fiberglass mesh and mastic







**Colorless, odorless, tasteless, radioactive gas**

**Second leading cause of lung cancer**



---

## Sub-slab ventilation system

PVC pipe

4" gravel beneath slab

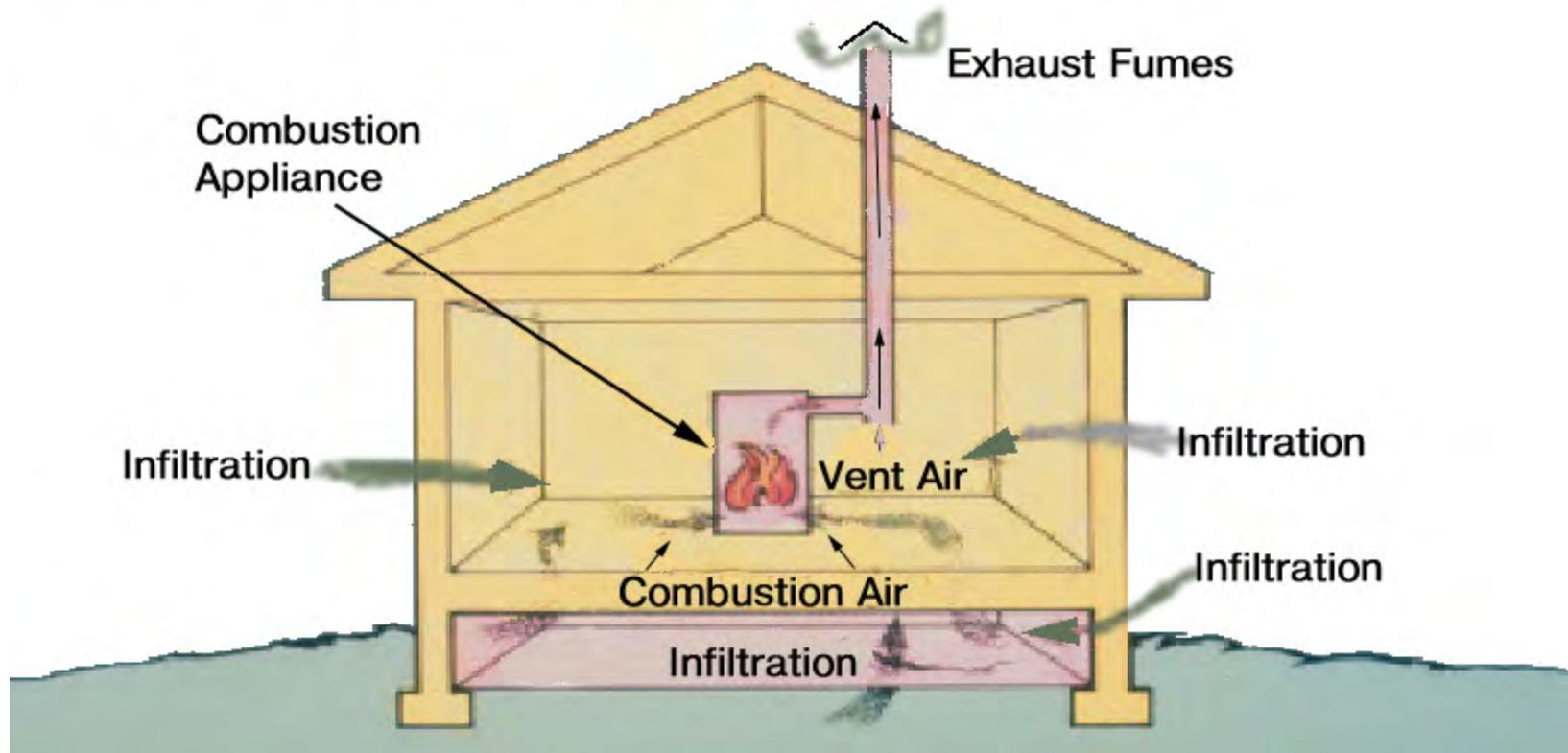




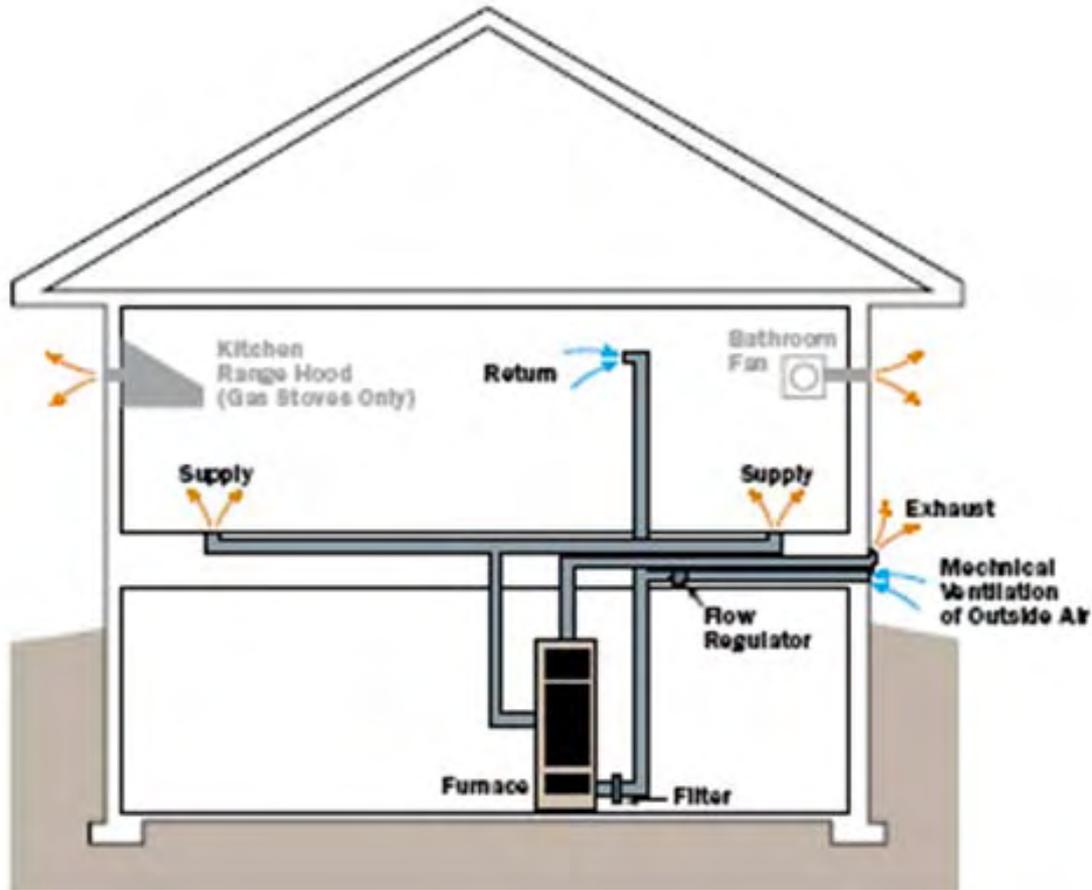
## In-line exhaust fan



# COMBUSTION AIR CONCEPTS



# Sealed Combustion



# Sizing Issues

- ACCA (Air Conditioning Contractors of America) Manual J
  - Guidance for calculating heating and cooling loads
  - Considers heat loss through walls, attics, infiltration, etc.; heat gain from sunlight, people, appliances, infiltration, etc.
- Avoid rules of thumb



# Combustion Pollutants

- Nitrogen oxides
- Sulfur dioxide
- Carbon monoxide
- Respirable particles
- Water



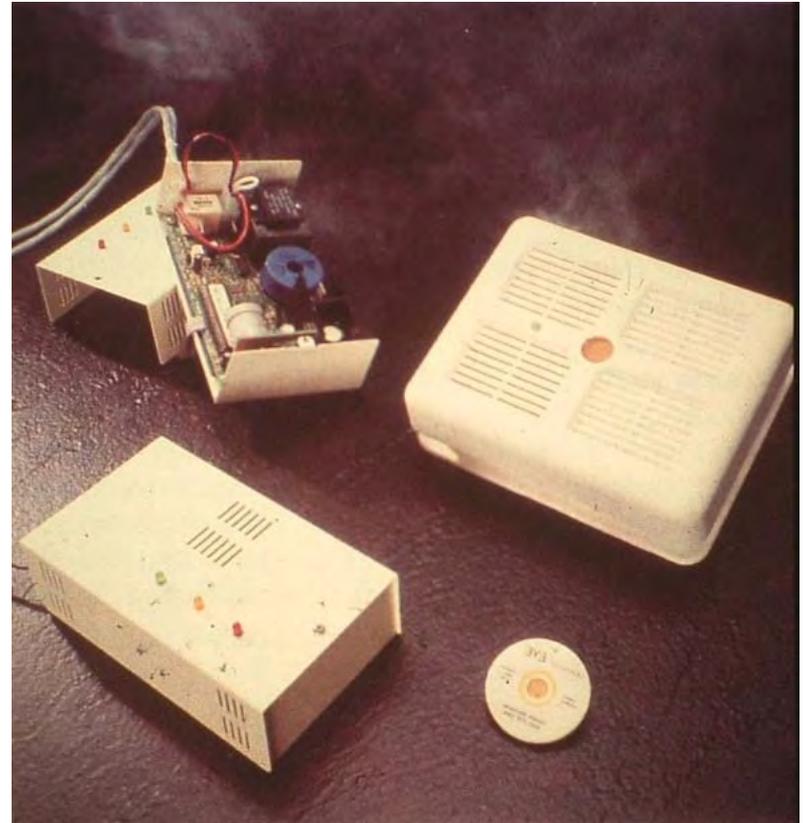
# Avoid combustion pollutants

- No unvented, fuel-fired space heaters
- Heating system maintenance
- No smoking in the home
- Exhaust fan over gas stoves



# Carbon Monoxide Detectors

No substitute for  
heating system  
maintenance



# HVAC Filters



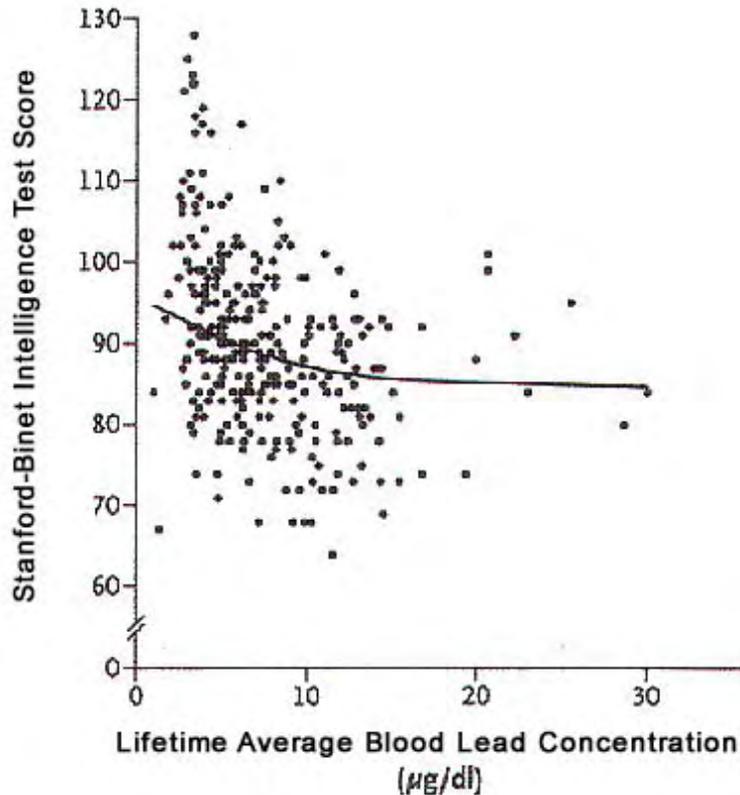
Minimum Efficiency Reporting Value (MERV):  
Range = 1 - 20  
 $\geq 7$  to reduce small dust particles in air

Dust Spot Efficiency  $\geq 25\%$

To affect allergies, MERV 10-12



# Lead: another concern in housing rehabilitation



BLL < 10 µg/dL a serious concern

Source: Canfield *et al.*, 2003; Jusko *et al.*, 2007.



# Clothes Dryer Safety

- Clothes Dryer Fires
    - 12,700 residential fires
    - 15 deaths
    - 300 injuries
- annually
- Failure to clean – leading cause



# Clothes Dryer Safety

- Remodeling projects
  - Trends place washer and dryer in hazardous locations
    - Away from outside walls
    - Bedrooms, second floor hallways, bathrooms, kitchens



# Clothes Dryer Fires

<b>Causes of Fires</b>	<b>Electrical Failures</b>	<b>First Fuel Ignited</b>
Failure to Clean 30%	Short Due to Wire Insulation 4%	Dryer Contents 45%
Electrical Failure 21%	Short circuit 4%	Lint 24%
Mechanical Failure 19%	Automatic Controls 5%	Wire Insulation 9%
Other 30%	Other 8%	Other 22%

NFPA: U.S. Home Product Report, Appliances & Equipment, November 2005.



# Loss measures for clothes dryer fires in homes

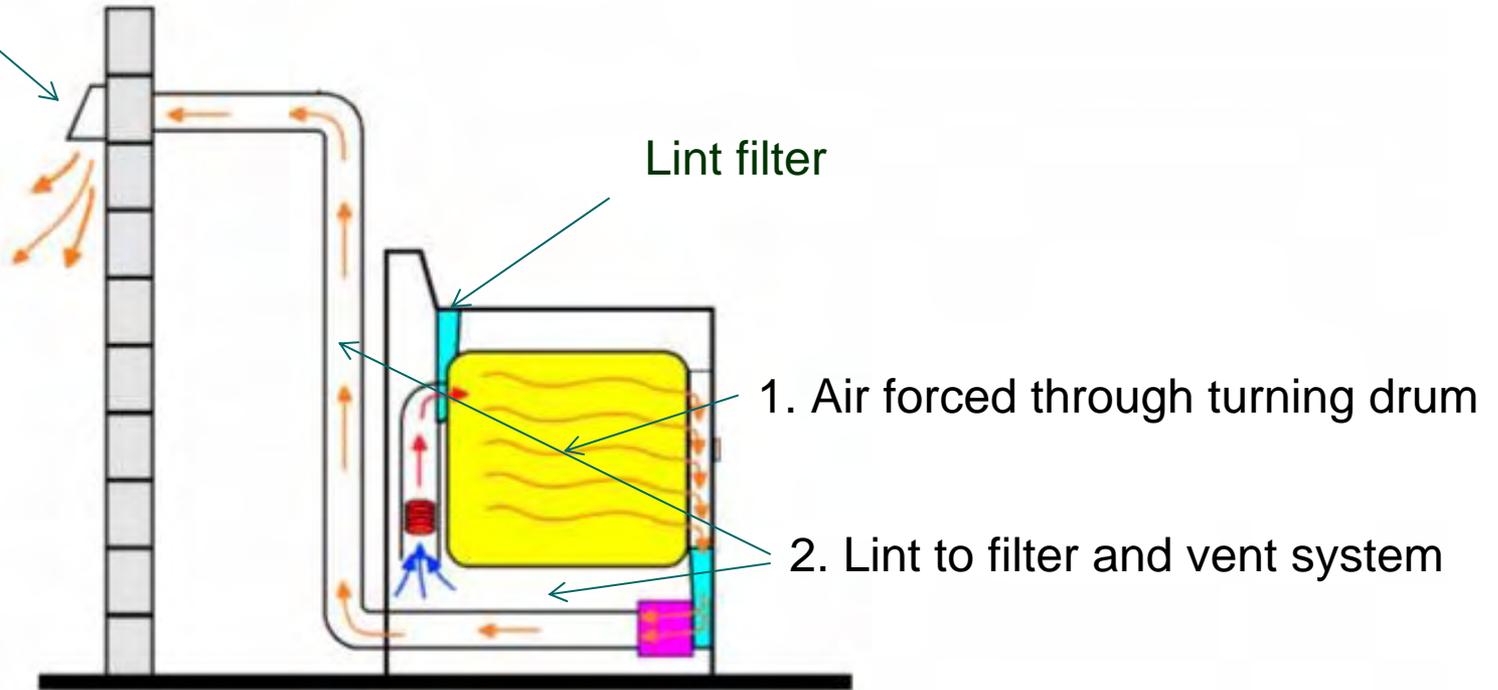
Measure	
Loss per fire	\$9,176
Injuries per 1,000 fires	33.0
Deaths per 100 fires	1.2

Source: National Fire Institute Reporting System, in FEMA (2007). *Topical Fire Research Series, Clothes dryer fires in residential buildings*. 7(1).



# Clothes Dryer Issues

Inspect for blockage



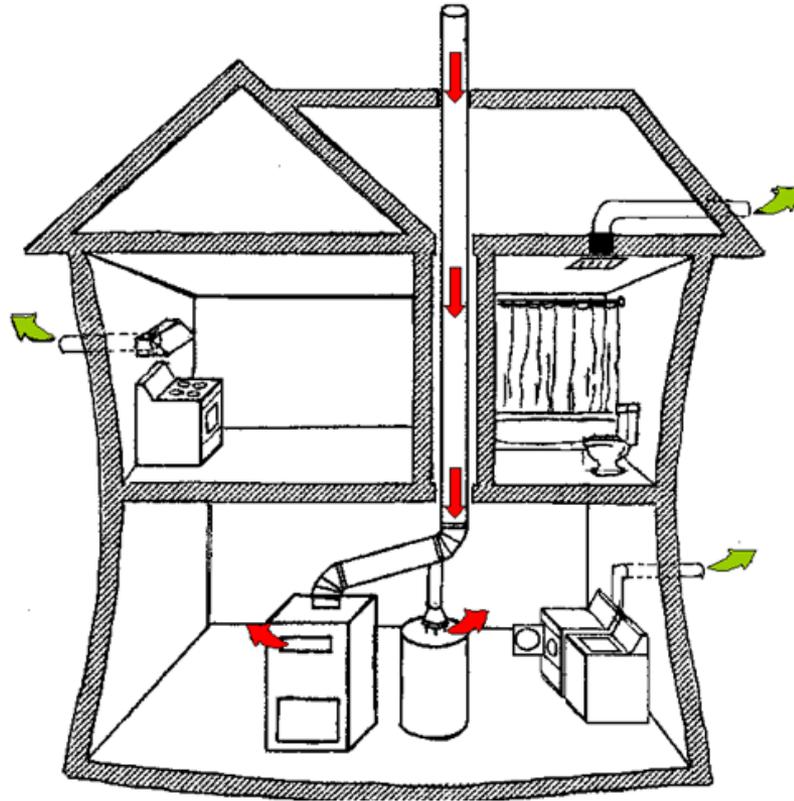
# Clogged Dryer Vent



# Clean the Dryer Vent



# Avoid Negative Pressure



# Accidental Ventilation



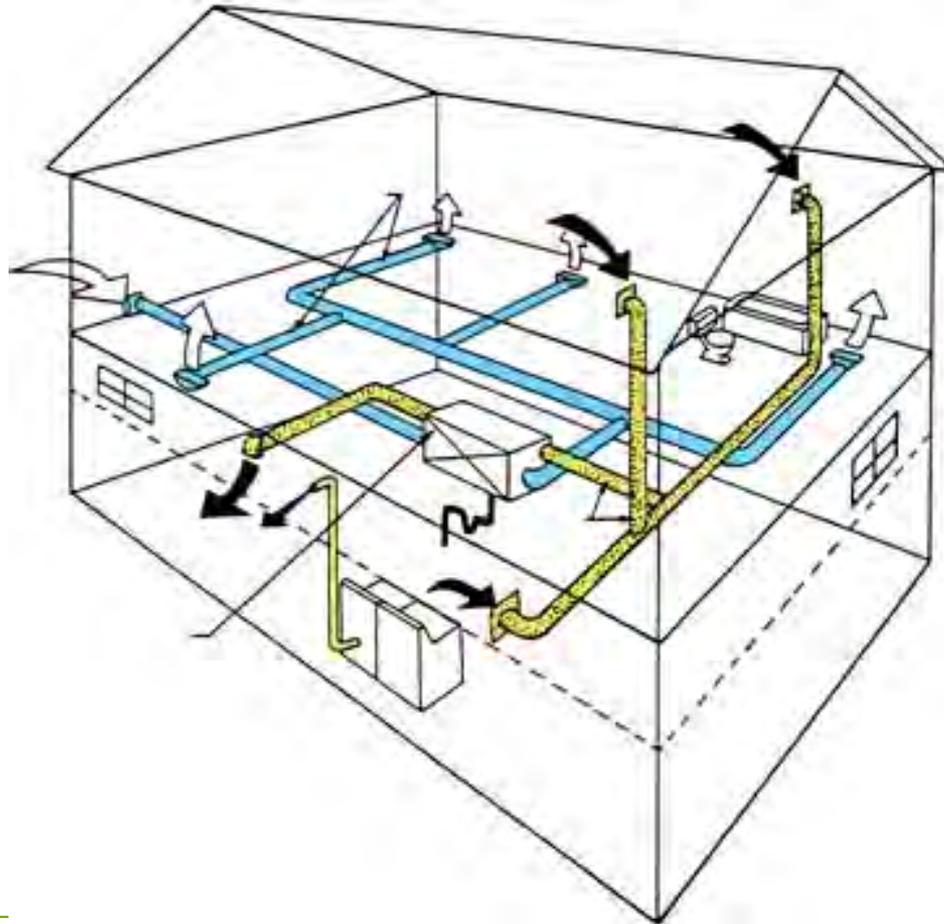
# Spot Ventilation



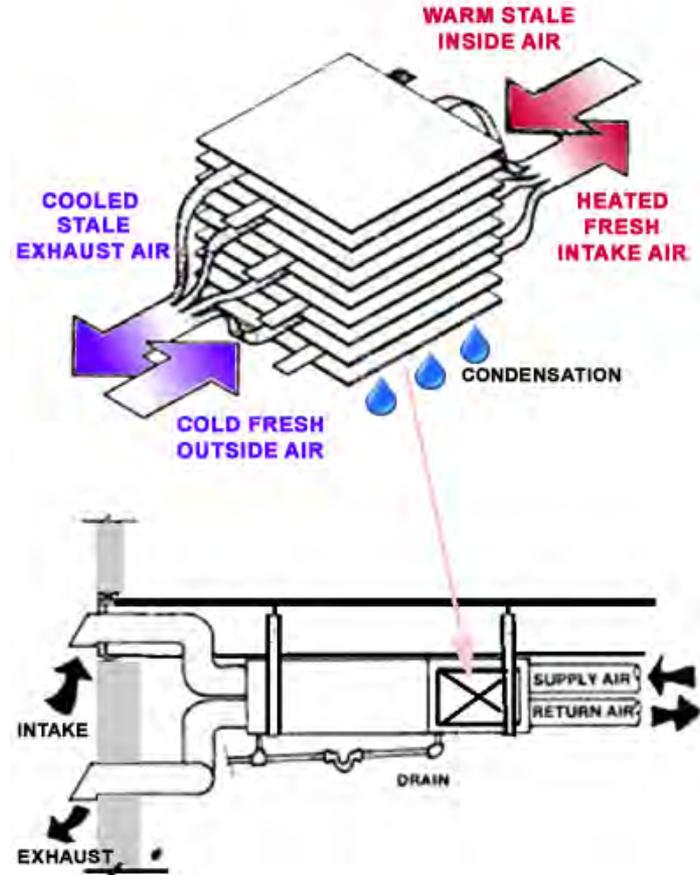
# Makeup Air Inlets



# Whole House Ventilation



# Air-to-Air-Heat Exchanger





# **BUILDING A FRAMEWORK FOR HEALTHY HOUSING**

---

## **Managing Building Moisture**

---

Kenneth Hellevang, Ph.D., PE  
Professor, Engineer  
Ag & Biosystems Engineering  
North Dakota State University

**NDSU**  
**Extension Service**

# WHY? >90% of Problems

- Decay
- Corrosion
- Mold



**NDSU**  
Extension Service



BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING

# Health Effect



Scientific evidence links mold and other factors related to damp conditions in buildings to:

- Asthma symptoms in those with the chronic disorder
- Coughing, wheezing, and upper respiratory symptoms in otherwise healthy individuals
- Hypersensitivity Pneumonitis in susceptible people
- Lower respiratory illness in children

Institute of Medicine of the National Academies 2004





# Canadian Department of Health

- Mould cell walls contain a compound with inflammatory properties
- Mould spores and mycelial fragments contain allergens
- Spores of some species contain chemicals that have toxic properties.

March 12, 2007



BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING

**NDSU**  
Extension Service

# Vapor Retarder Problem



**NDSU**  
Extension Service



**BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING**

# Mold on Back of Wallboard



Ice Dam Problem

**NDSU**  
Extension Service



BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING

# Mold in Crawlspace



**NDSU**  
Extension Service



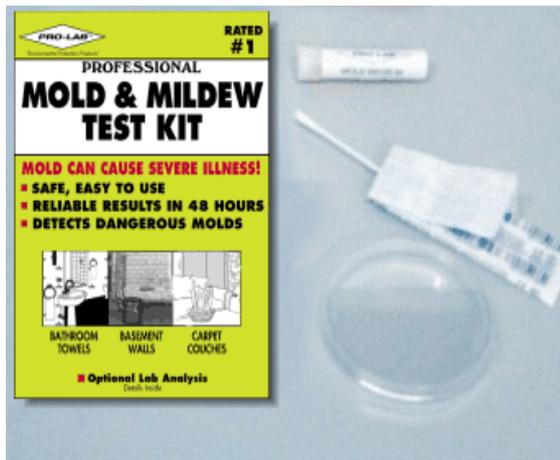
**BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING**

# Mold



# Testing for Mold

- No acceptable or unacceptable level or level of action
- Compare quantity and types at various locations
- Expensive
- Not normally recommended



## Mold Investigator

- Mold ecology
- Medical
- Building Science
- Experience



# Eliminating Mold

- **Remove Mold and Clean Surfaces**
  - People react to active, dormant and dead mold
  - Biocides are not adequate!
- **Dry**
- **Correct Moisture Problem**



# REMOVAL OF EXISTING CONTAMINATION

- **Non-porous surfaces**
  - Vacuum with HEPA filters
  - Wash with a detergent (biocide) solution
  - Thorough drying
- **Porous Materials**  
(ceiling tiles, carpeting, upholstered furniture, wallboard)
  - Remove and replace
- **Semi-porous** (floor joist, sill plates)
  - Remove mold, HEPA filter, biocide?, dry



# Microbial Remediation

- Area “MUST” be Contained
- Negative Pressurization
- Minimize Dispersal

HVAC System

HEPA Vacuum – contain surface

Bagging

Control Tracking

Control Equipment

- Trained Personnel



**NDSU**  
Extension Service



BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING

# GUIDELINES AND RECOMMENDATIONS

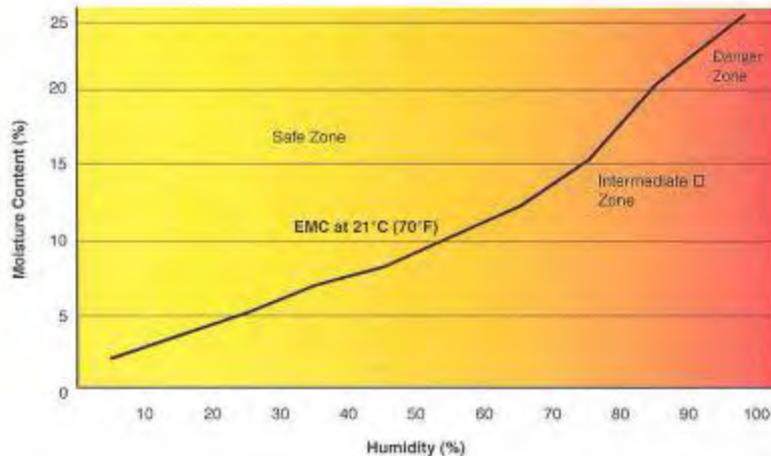
- New York City Department of Health  
“Guidelines on Assessment and Recommendation of Fungi in Indoor Environment”
- American Conference of Governmental Industrial Hygienists (ACGIH);  
“Bioaerosols: Assessment and Control”
- The Institute for Inspection, Cleaning, and Remedial Certification (IICRC) IICRC S520  
“Standard and Reference Guide for Professional Mold Remediation”
- EPA Remedial Guidelines



# During Construction

Inspect for mold – reject moldy material

Figure 4: Moisture Content vs. Humidity and the Risk of Mold Growth



Grows on wood at MC > 16% (Lstiburek)

Do not enclose wet/damp materials



# Moisture Meters



# Water Management

- Deflection – Control entry
- Drainage
  - Site – Slope all components and vary elevation to carry water away
  - Roof water away from the building
  - Assemblies – Drainage and ventilation planes
  - Window & door openings – Flashing, shingle air/water barrier - Do not rely on sealants
  - Foundation
- Design and build to permit drying

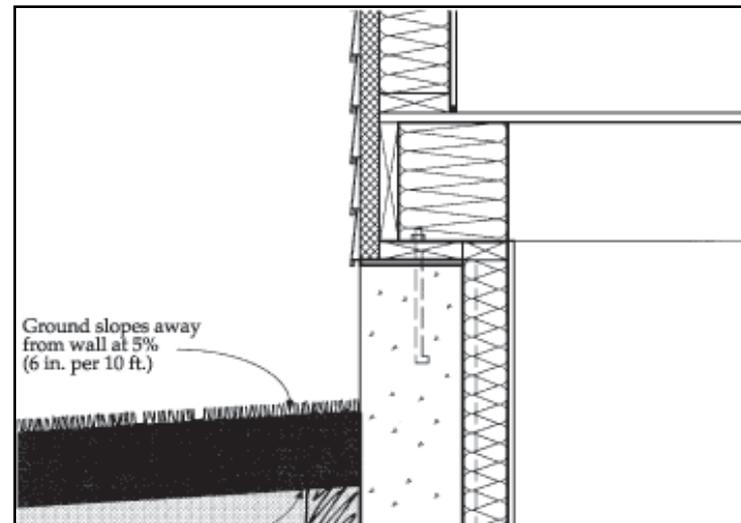


# Water Control

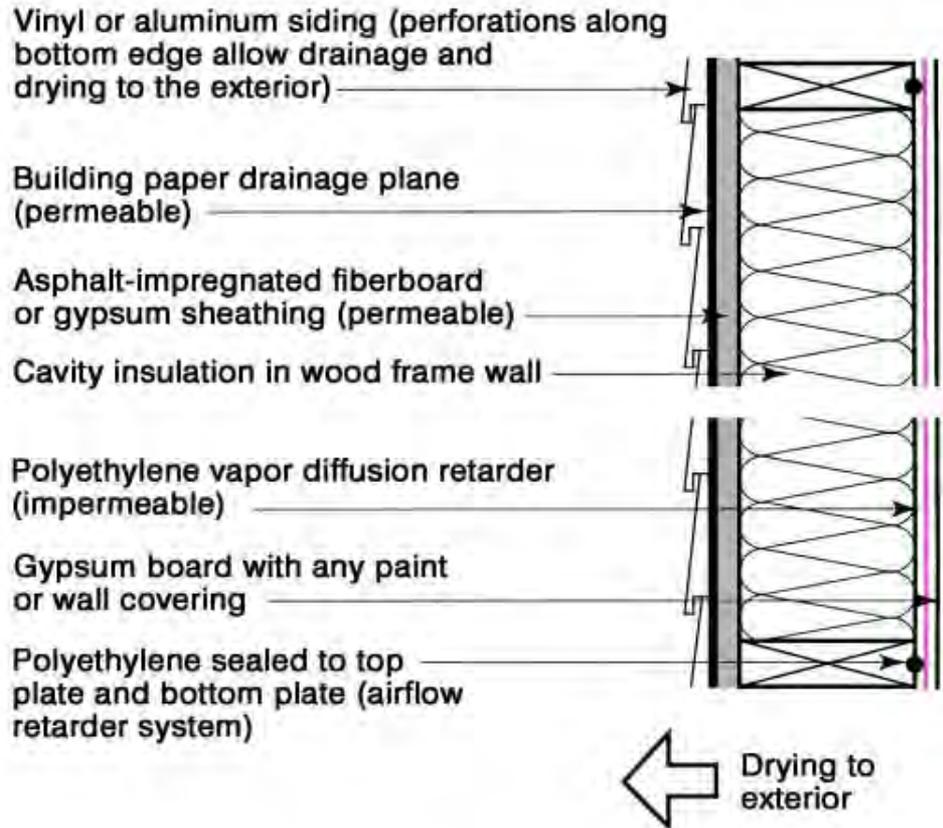
**1 inch of rain on 1,000 sq. ft. = 623 gallons**

**Extend down spouts**

**Slope ground 1 inch per foot away from the house**



# Recommended Wall Section



- Vapor diffusion retarder to the interior (Cold Climate)
- Airflow retarder to the interior
- Permeable exterior sheathing and permeable building paper drainage plane
- Ventilation provides air change (dilution) and also limits the interior moisture levels



# Proper Flashing

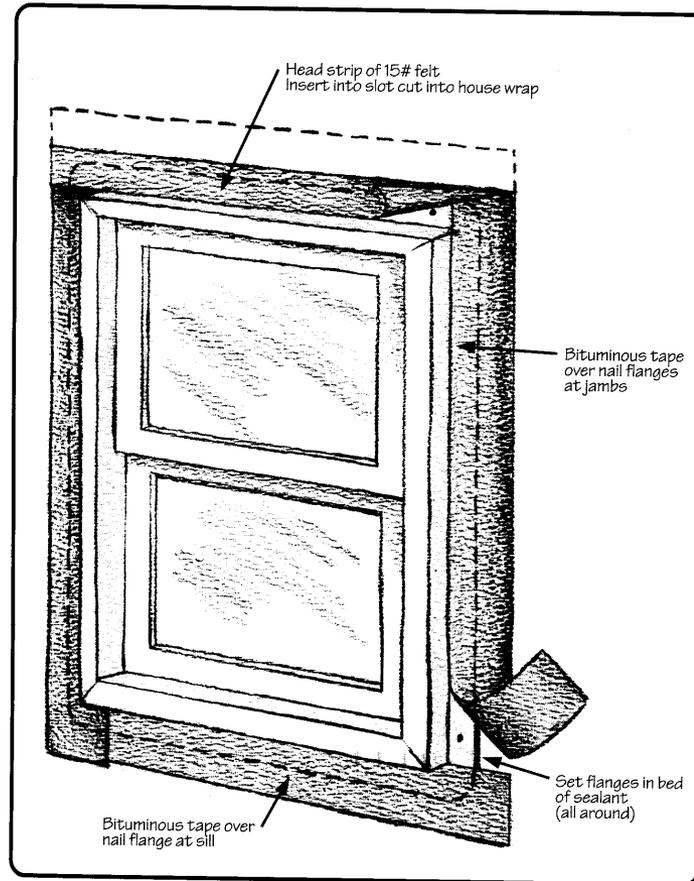


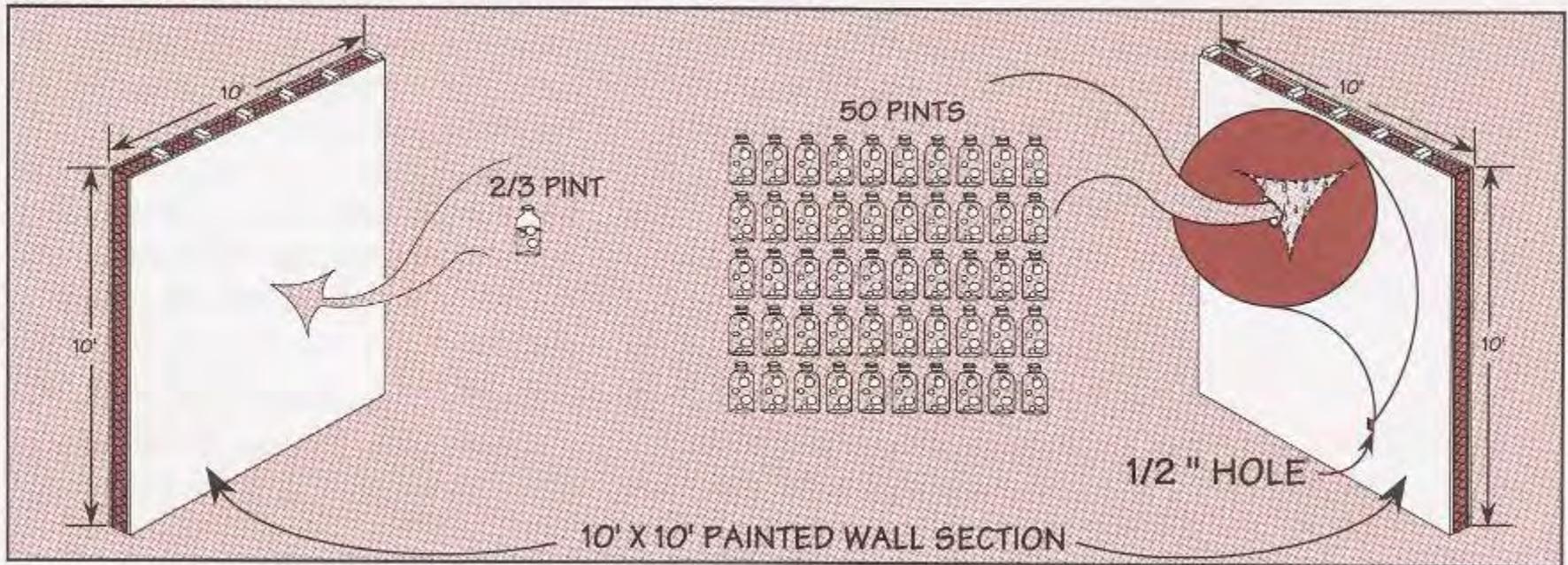
Figure 4.12 - Window Flashing for Severe Weather  
(areas subject to frequent wind-driven rain)

**NDSU**  
Extension Service



# Seal Air Leaks

Figure 2.26 *Moisture Transport via Diffusion versus Air Leakage*



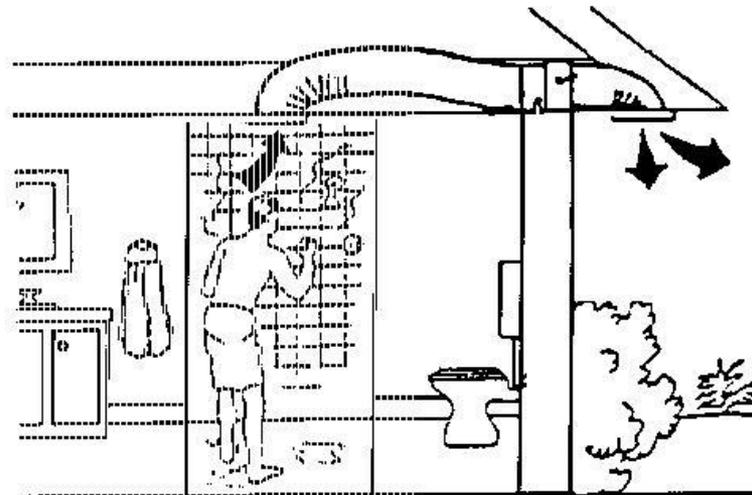
Northern Comfort, Alaska Craftsman Home Program





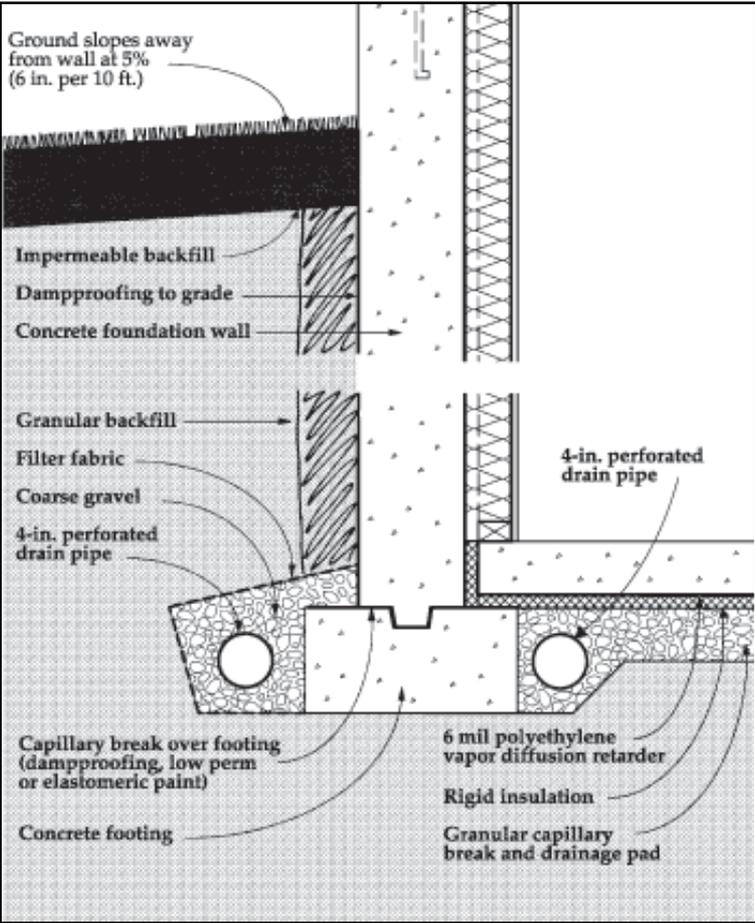
# Recommended Ventilation

- 0.35 ACH or 15 cfm/person
- Bathroom 50 cfm (intermittent)
- Kitchen 100 cfm (intermittent)





# Basement Drainage



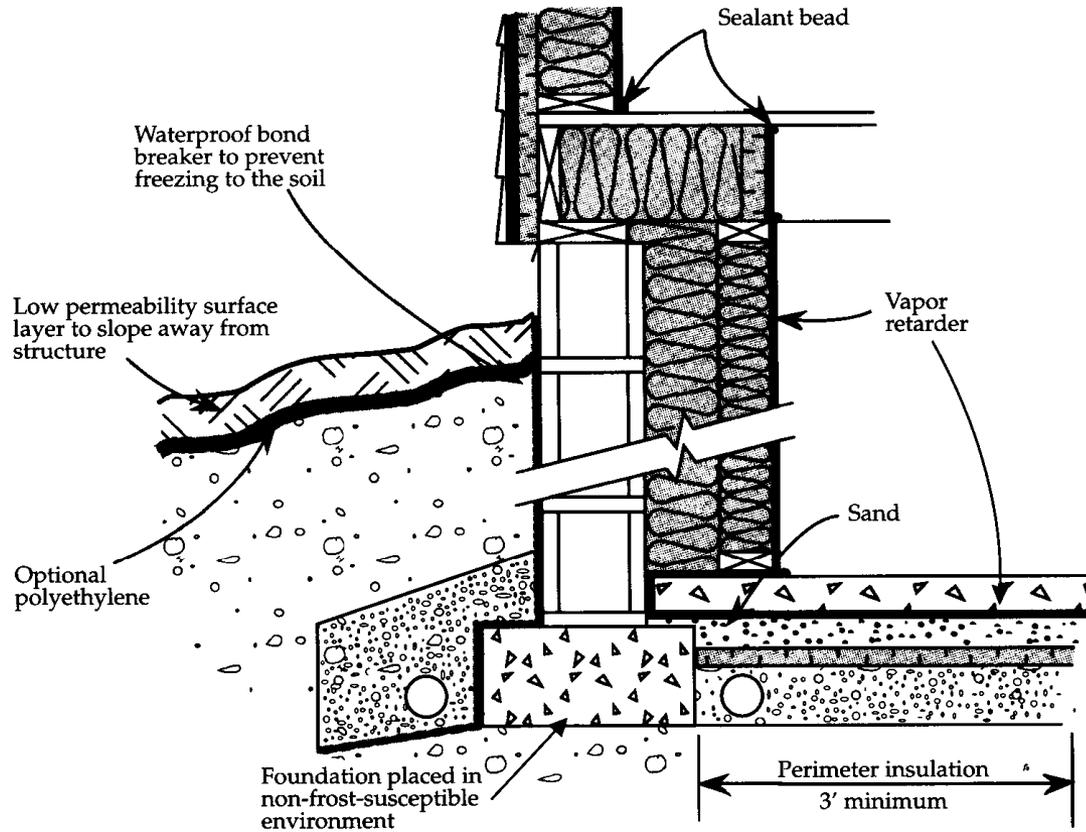
**NDSU**  
Extension Service



# Crawl Space



[www.pathnet.org](http://www.pathnet.org)



# Crawl Space Moisture Control

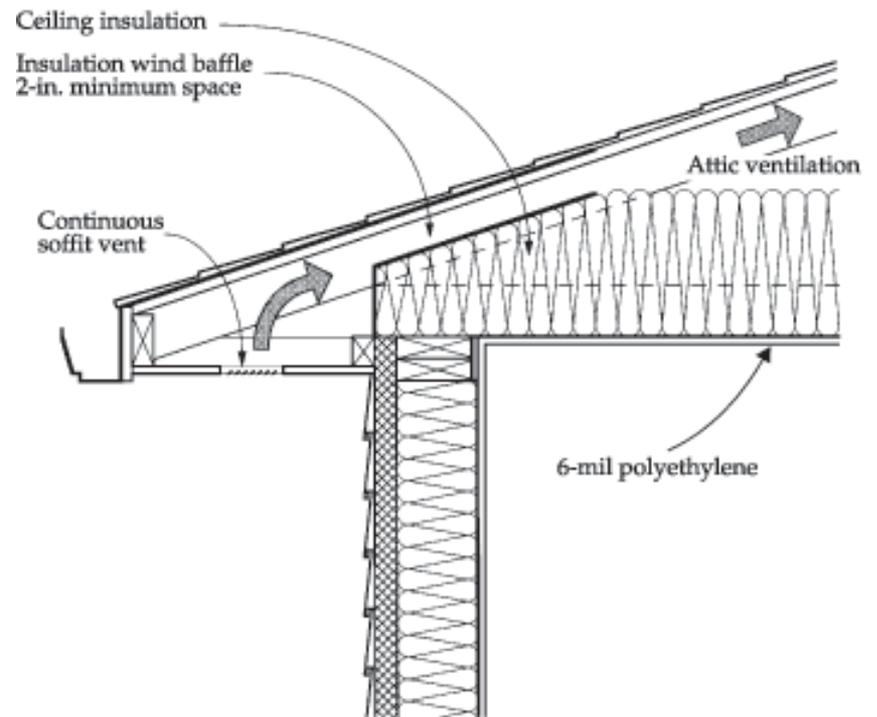
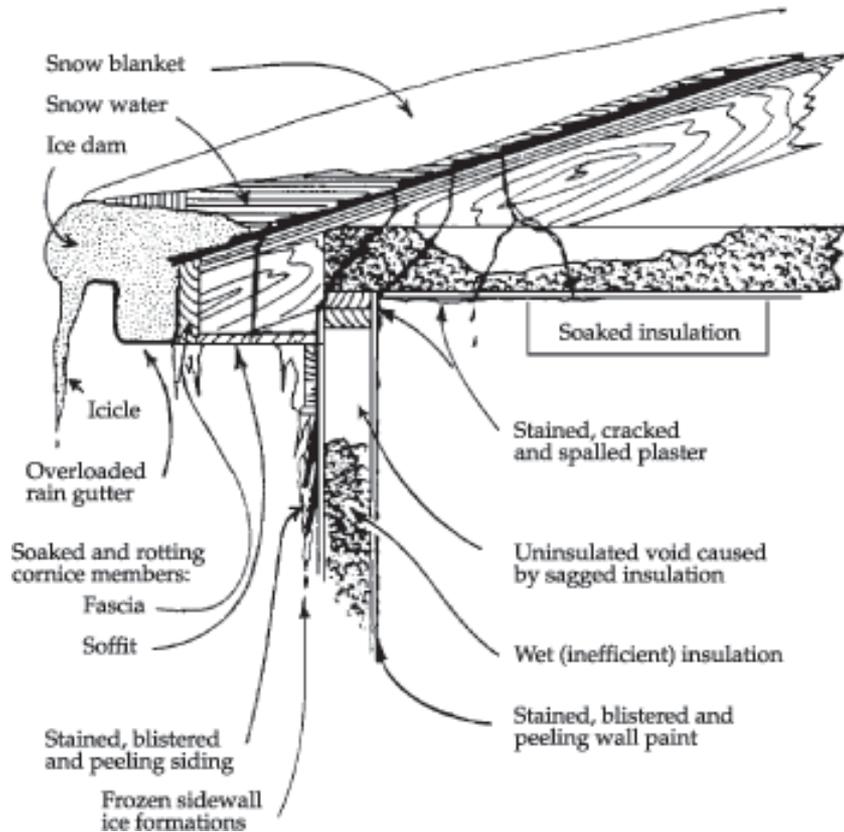


**NDSU**  
Extension Service

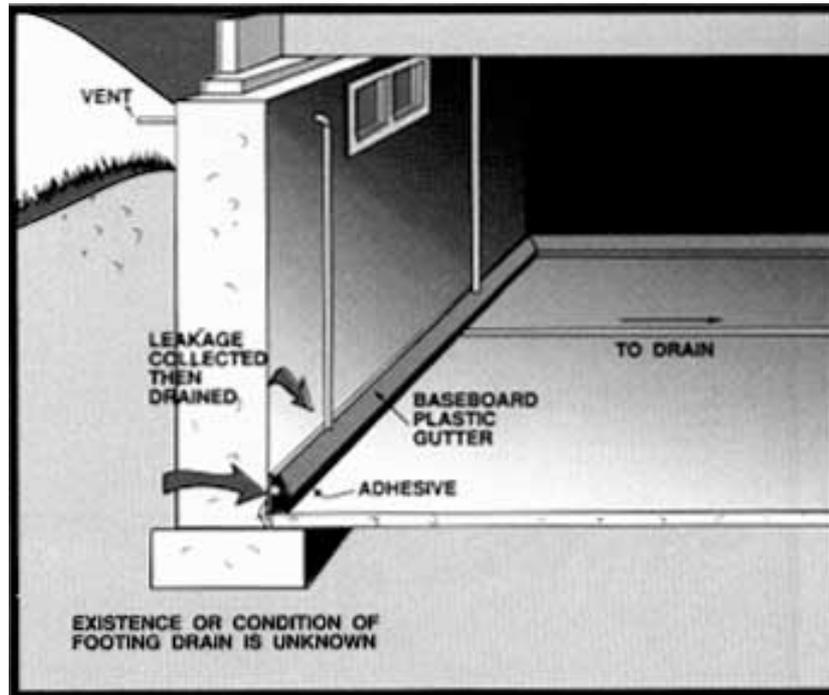


BUILDING A FRAMEWORK  
FOR HEALTHY HOUSING

# Ice Dams

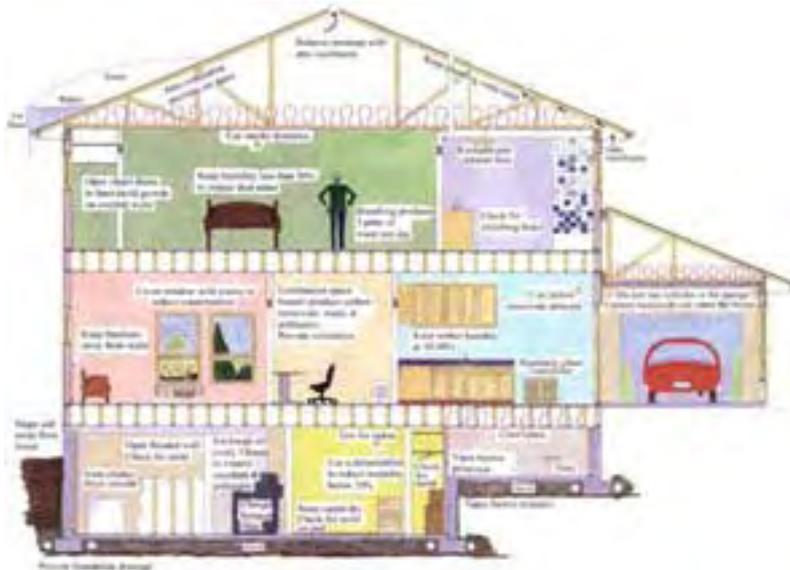


# Determine Moisture Source



**NDSU**  
Extension Service





Home Moisture

Indoor Air Quality

Mold

Coping With Disasters

General Housing

Keep Your Home Healthy

Care For People

Presentations

Contacts

# [www.HomeMoisture.org](http://www.HomeMoisture.org)

