IREM/DMAA

Education Program

Seal Your Building and Reduce Mold, Ice Damming, And Utility Cost

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ZERODRAFT

OF SOUTHEAST MICHIGAN

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Design and Constructive Objectives

Improve:

- Health
- Safety
- Durability
- Comfort
- Energy Efficiency

IREM/DMAA
Education Program

- Energy
  - Cost
  - Usage
  - Infiltration
  - Air Leak Percentages
- Mold Science
- Attic Mold Contamination
- Attic Ventilation
- Air Infiltration Sites
- What's In A Building?
- Physical Processes
  - Heat Flow
  - Air Flow
  - Moisture Flow
- Process and Subsystems Interact
- Effects of Building Materials
- Fixing Problems
- Air Sealant (Air Barrier) Foam Uses
- Productivity and Energy Conservation
- Pressurization Requirements
- Productivity Vs. Energy Cost Comparison
- Energy Cost Avoidance
  - Residential
  - Commercial
- Design Construction Strategy
- Conclusion
- Bibliography

Energy Usage (Residential)

Item	% of Use
Heating	50%
Air Conditioning	10%
Water Heating	15%
Refrigerator	5% (each)
Appliances	10%-15%
Lighting	5%-10%
Total	100%

Source: DTE Energy

Natural Gas Prices

12/01	$2.95 per MCF	01/04	$5.36 per MCF
01/02	$3.62 per MCF	07/04	$6.62 per MCF
01/03	$4.14 per MCF	04/05	$7.99 per MCF
02/03	$4.57 per MCF	08/05	$8.54 per MCF
07/03	$4.95 per MCF	10/05	$10.09 per MCF
08/03	$5.75 per MCF	11/05	$11.38 per MCF

Reasons for Gas Price Increases

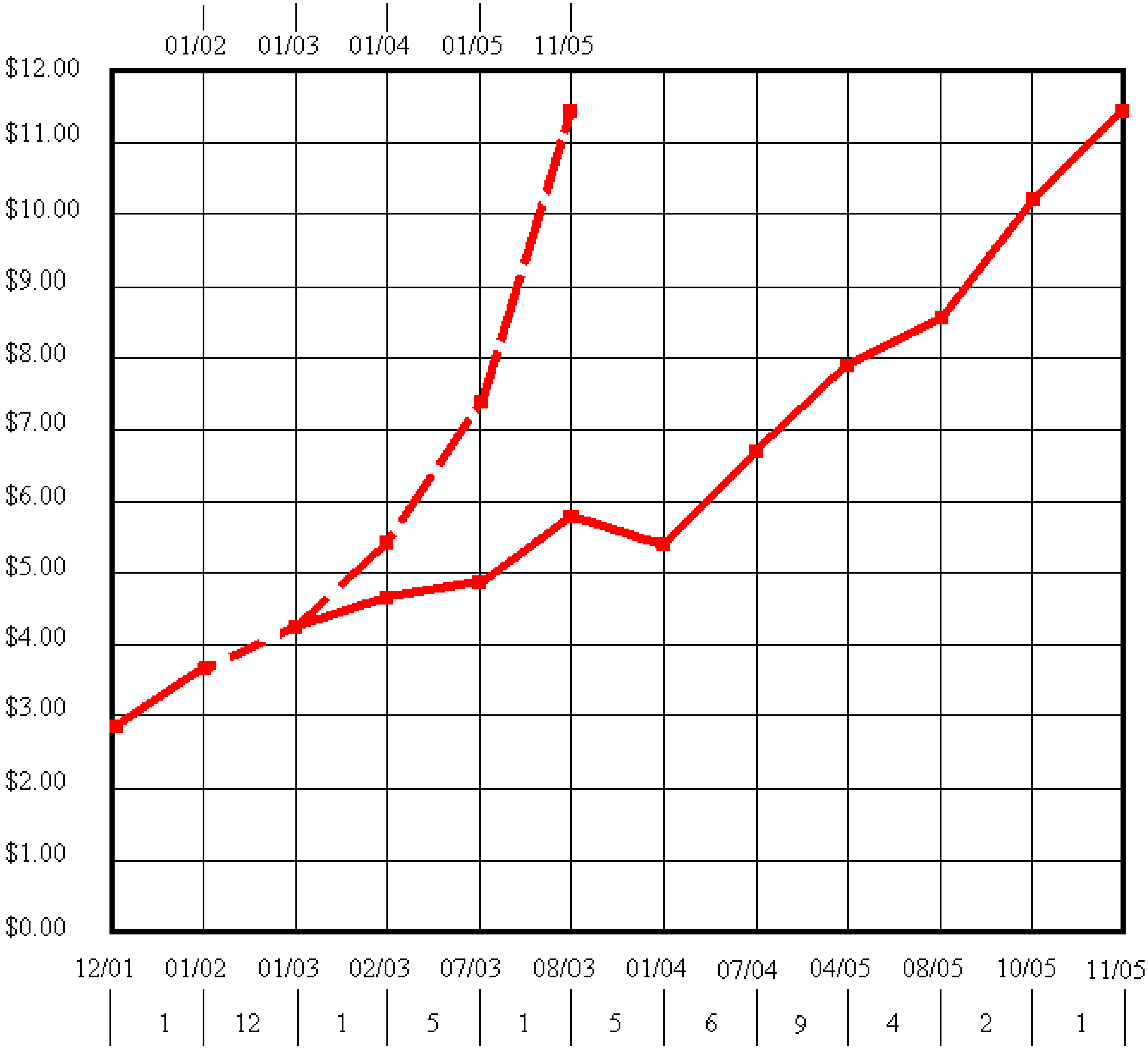
- Demand has outpaced supply due to construction of electric peaker plants
- No net additional supply from "lower 48" due to mature wells
- Imports from Canada projected to decline- US gets 50% of Canadian Gas
- Alaska gas pipeline is a decade away. LNG is 10 years away.
- Government restrictions on land and drilling

Midwest Implications

- Dependent on natural gas for space heating
- Large base of industrial use for natural gas
- 92% of natural gas is imported from other states and countries
- Each $1.00 per Mcf increase drains $4 billions a year from the midwest region
- A 2% drop in Gas demand can result in a 15% to 20% reduction in prices
- Hubbard said in the 1950's that oil would peak in 1970 and was right

Source: DTE Energy

1 yr. increments



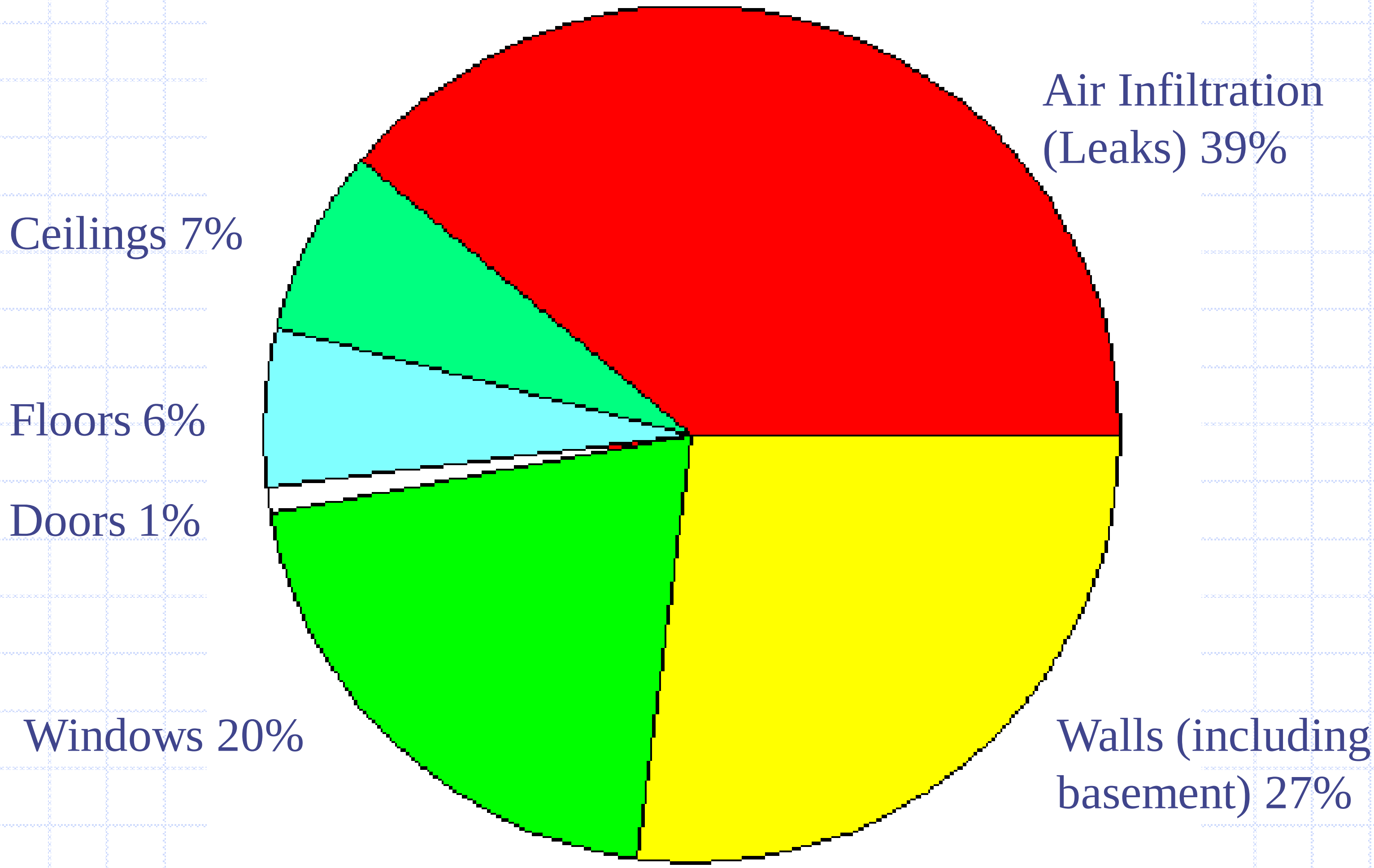
Natural Gas Prices - $ per MCF*

* 1000 cubic feet = MCF

Date & No. of Months

Source: DTE Energy

Where is heat loss?



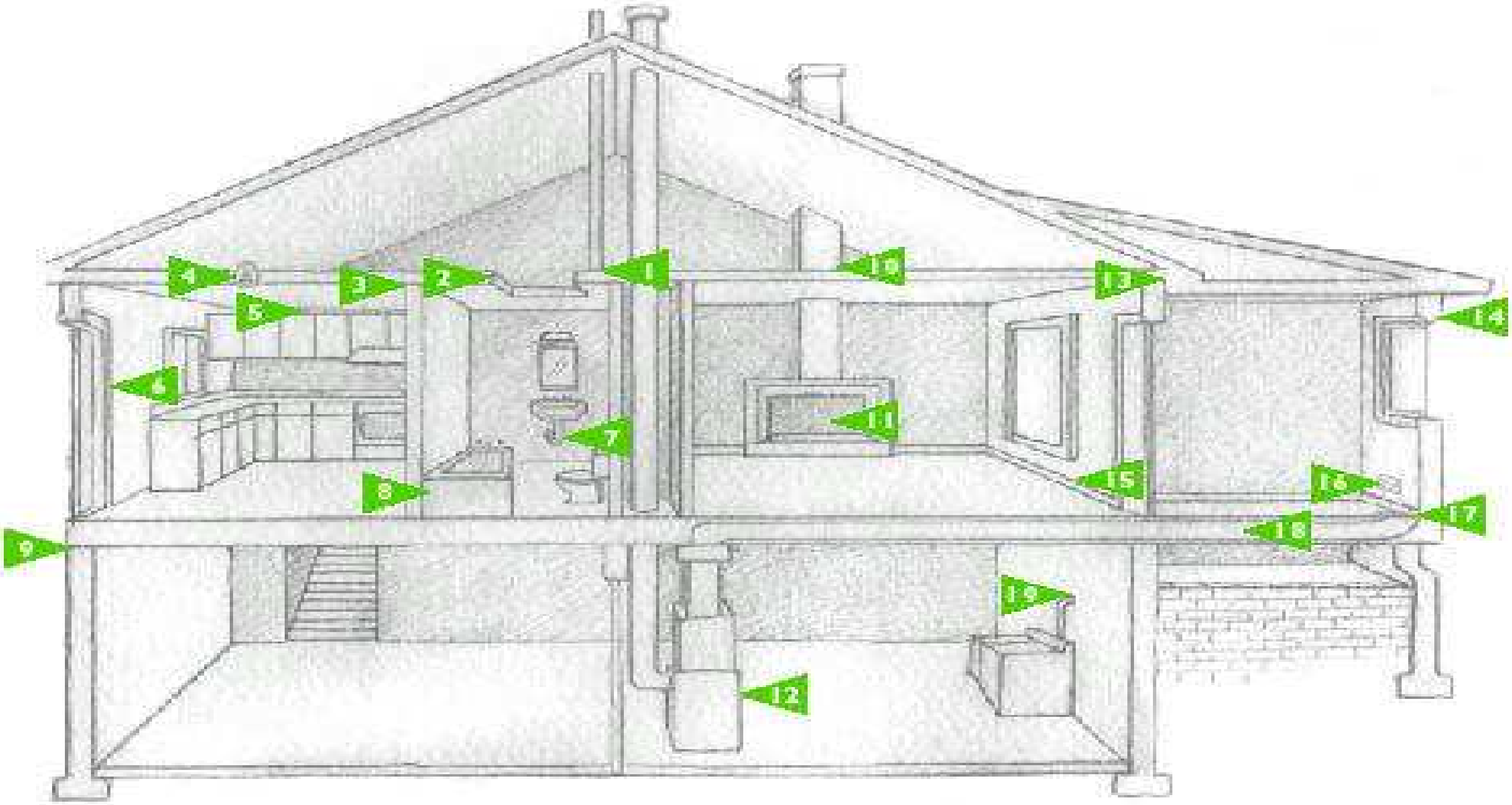
Source: DTE Energy

Air Filtration Rates

• Air Infiltration rate for Michigan	0.80 air changes per hour
• National air infiltration rate (model energy code)	0.50 air changes per hour
• Ideal air infiltration per Dept. of Energy and EPA	0.35 air changes per hour
• Air Infiltration rate causing health problem	Under 0.20 air changes per hour

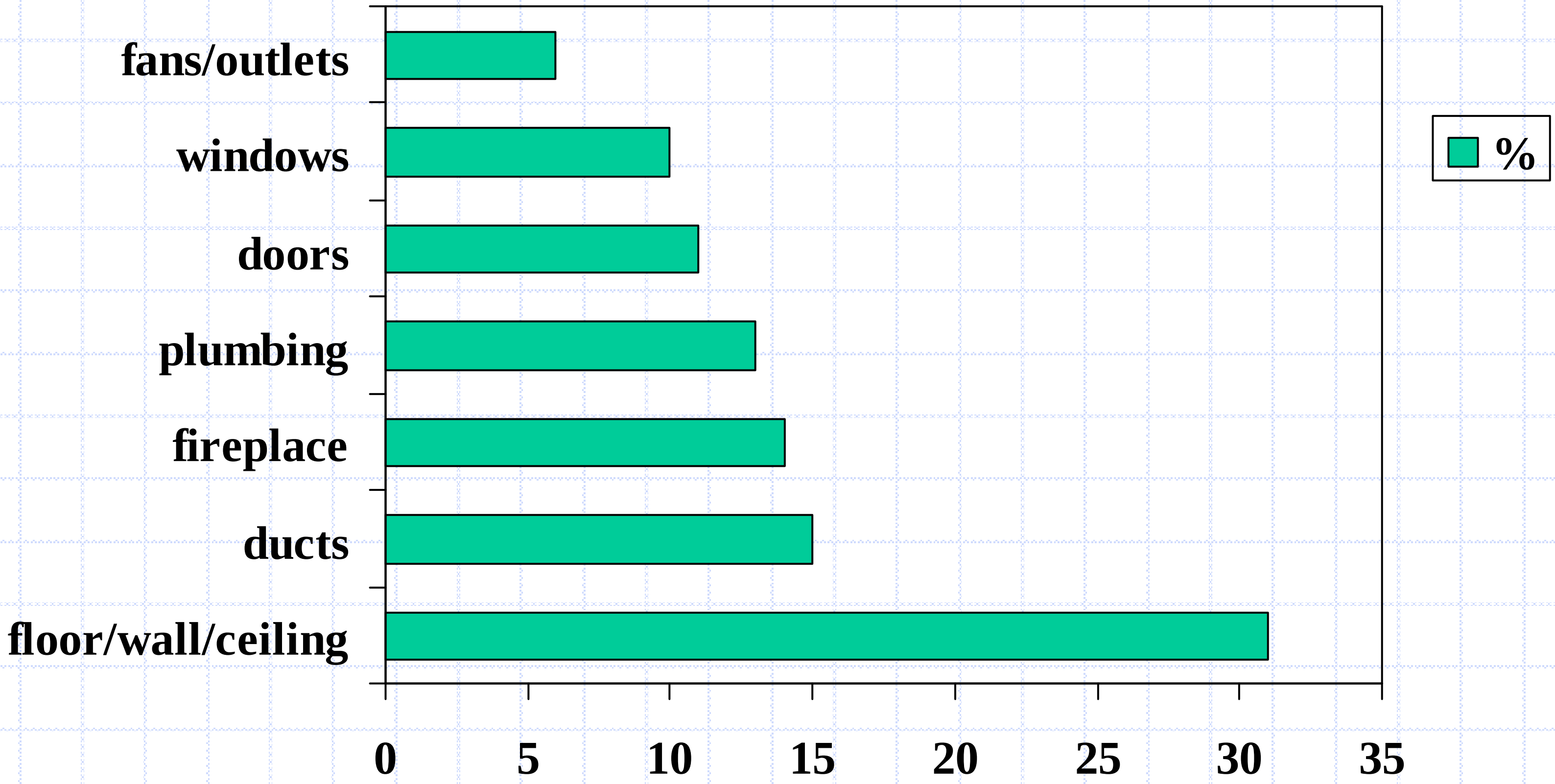
Source: DTE Energy

Sources of Air Leaks



Source: DTE Energy

Air Leak Percentages



Source: DTE Energy

Mold Science

Mold, or fungi, are neither plants nor animals.

Molds are organisms that contain a nucleus and undergo mitotic cell division. They belong to the kingdom of fungi. Molds are similar to the plant kingdom in that they have the ability to undergo photosynthesis. They differ from plants in that they lack chlorophyll. Unlike the animal kingdom, molds have no organs for food uptake.

A group of organisms that require an external food source, water, and suitable conditions for survival and proliferation.

Genus (i.e. *Stachybotrys*), species (*atra*)

Molds can be unicellular or multicellular. The cells are called hyphae, which are usually shaped like filaments. Reproduction can be sexual or asexual. Most molds reproduce asexually. Technically, fungal propagules from sexual reproduction are termed spores, and those from asexual organisms labeled conidia. However, the two terms are typically interchangeable.

There are in excess of 20,000 different genera and 1.5 million species.

Mold spores are generally 2-20 microns in size (a human hair is approximately 100 microns). Spores are highly adaptive for survival. When food sources run out, a fungus responds by switching to reproductive mode, resulting in spores. A one-inch diameter colony can produce 400,000,000 million spores. The small size provides for maximum dispersal, while the hardy cell wall protects them from destruction.

Are all molds toxic? Most molds are not toxic. To sensitive individuals, they may only be simple allergens.

Attics can be designed and constructed to be either vented or unvented in any thermal zone.

In cold climates (Michigan), the primary purpose of attic ventilation is to maintain a cold roof temperature to avoid ice dams created by melting snow, and to vent moisture that moves from the conditioned space into the attic.

The amount of roof cavity ventilation is specified by Michigan Codes by the ratio of vent area to insulated ceiling area of 1:150 or 1:300 if a vapor retarder is installed.

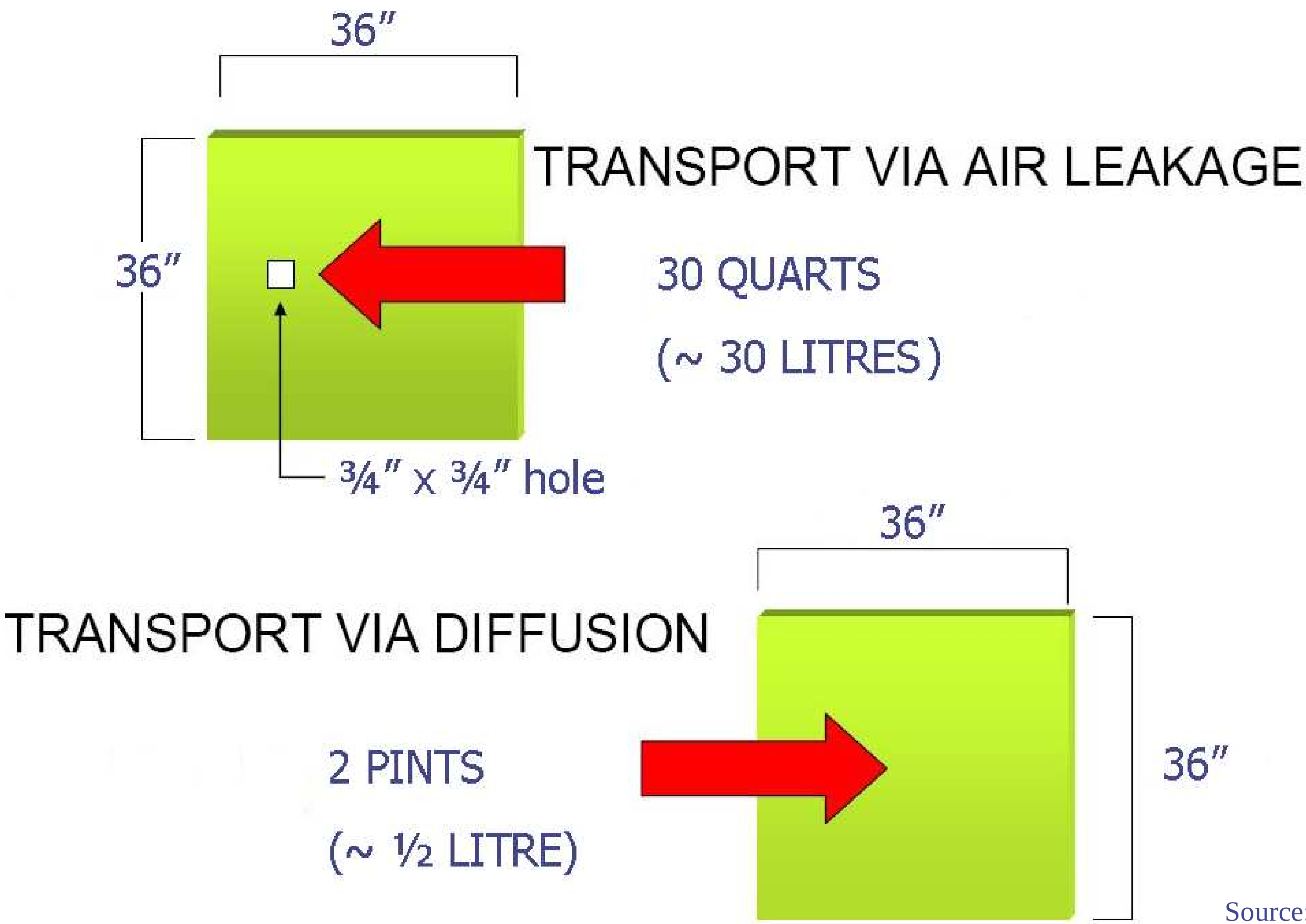
Moisture Migration

Moisture enters the attic (assuming no roof leaks) from the conditioned space in two ways:

1) Air filtration
2) Vapor Diffusion

In our climate the main strategy that should be used for roofs to be free from moisture problems and ice dams along with control of heat gain or heat loss is the elimination of air movement, particularly exfiltrating air. This can be accomplished by the installation of an air barrier system or by the control of air pressure differences across the roof system.

Water Transport

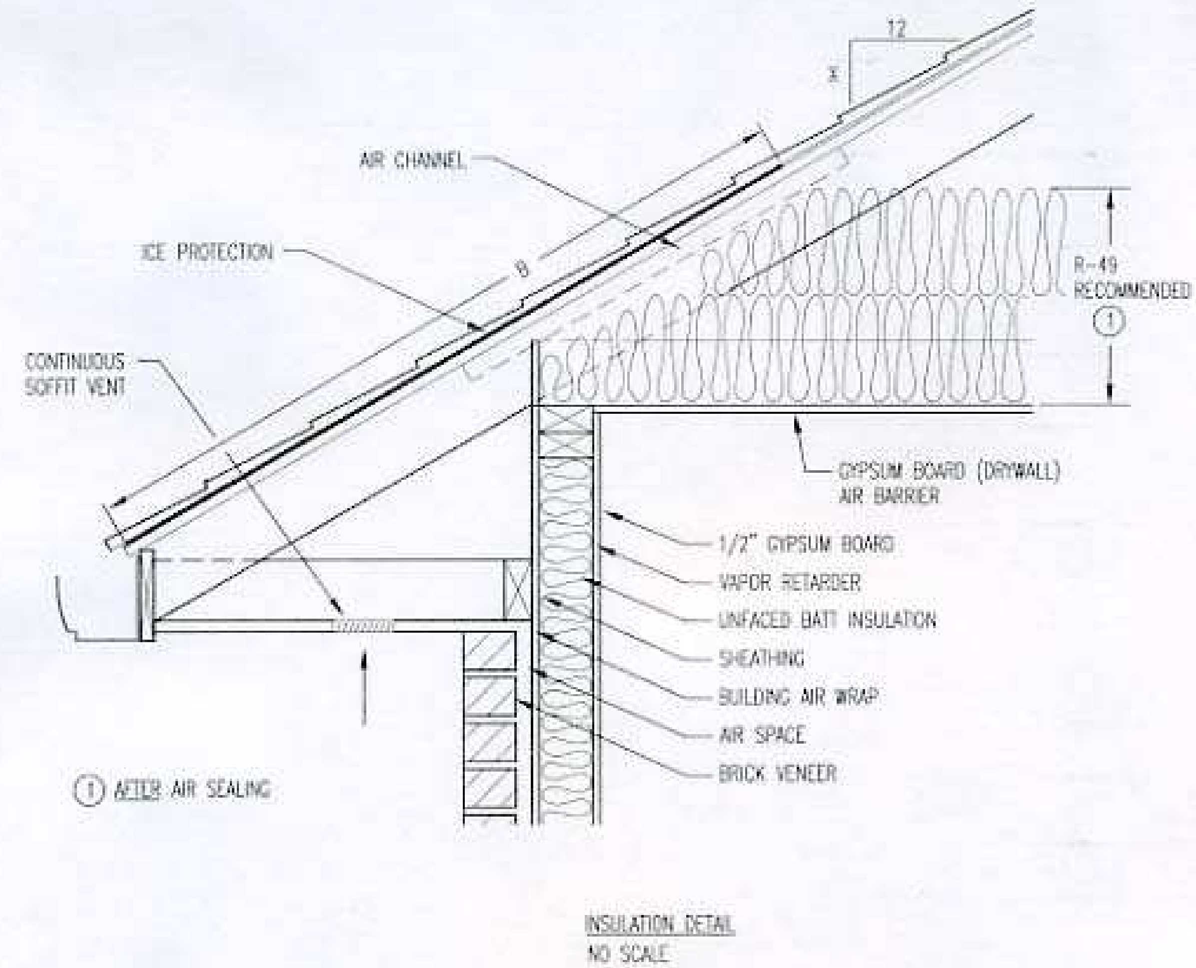


Source: ABAA

Vented Roof Design

Vented roof should not communicate with the conditioned space – they are coupled to the exterior. Therefore, an air barrier at the ceiling line should be present to isolate the attic space from the conditioned space. No services such as distribution ducts, air handling units, plumbing, etc. should be located external to the air barrier.

Gypsum board is an excellent air barrier.



12
X
AIR CHANNEL
ICE PROTECTION
8
CONTINUOUS
SOFFIT VENT
R-49
RECOMMENDED
1
GYPSUM BOARD (DRYWALL)
AIR BARRIER
1/2" GYPSUM BOARD
VAPOR RETARDER
UNFACED BATT INSULATION
SHEATHING
BUILDING AIR WRAP
AIR SPACE
BRICK VENEER
1 AFTER AIR SEALING
INSULATION DETAIL
NO SCALE

The Problem

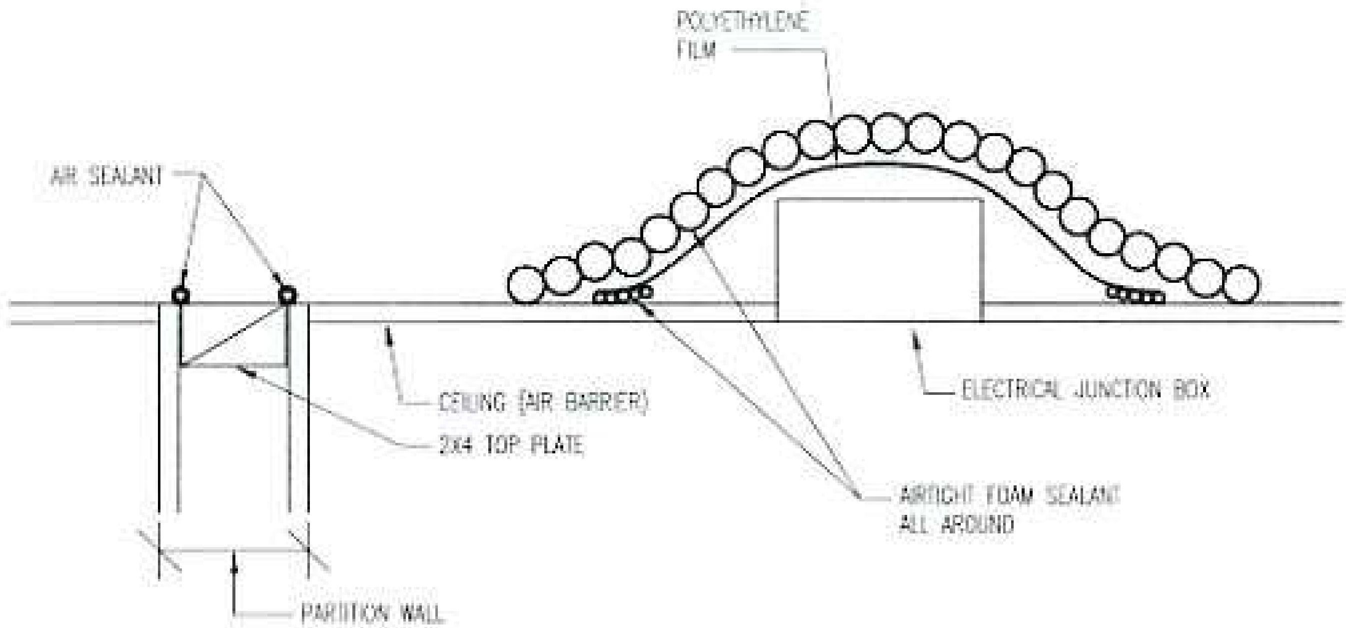
Penetrating the gypsum air barrier allows warm, moist air to exfiltrate into the attic. ((Attic insulation is not an air barrier)).

The following are examples of air exfiltration sites:

- Attic access hatch
- Heating and air conditioning ducts - connections and insulation - boot penetrations
- Chimneys
- Fireplace flues
- Plumbing stacks
- Wire penetrations
- Top plates (all walls)
- Dropped ceilings (over showers)
- Exhaust fans - ducted to roof, insulated, sealed joints, and perimeter sealed
- Recessed light fixtures
- Knee walls
- Duct and pipe penetrations
- Shafts (behind showers)
- Party walls
- Skylights
- Junction boxes for ceiling fans or surface mounted lights
- Retractable projection equipment
- Laundry chute
- Where additions meet older sections of the house
- Split level discontinuities
- Above pocket doors
- Whole house fans (removal recommended)
- Supply air registers
- Central vacuum
- Verify that the effective net free area of the attic ventilation meets or exceeds code and adequately vents the space.

The Solution

Air seal all penetrations of the gypsum board air barrier in compliance with Zerodraft technology and methodology developed and perfected in Canada for more than 25 years.

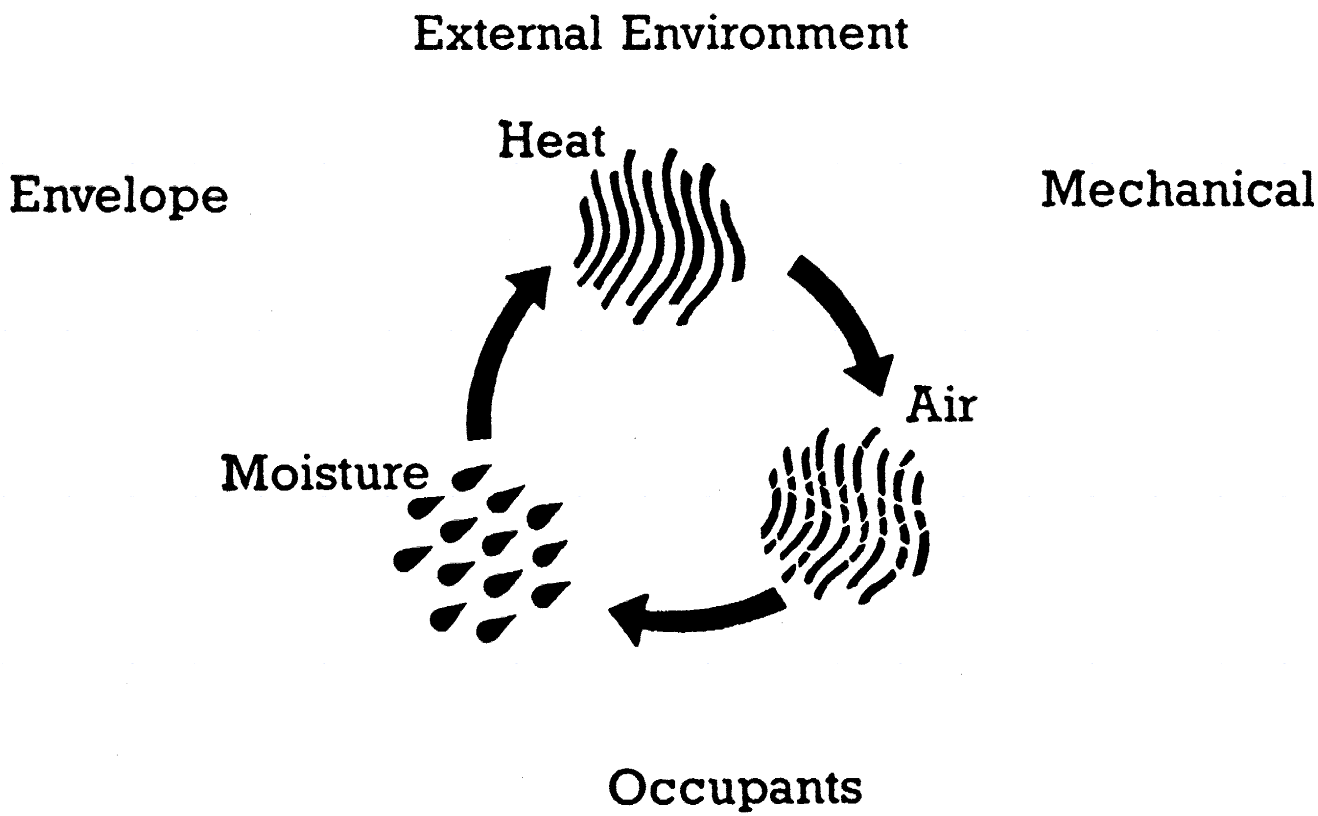

POLYETHYLENE
FILM
AIR SEALANT
CEILING (AIR BARRIER)
2X4 TOP PLATE
ELECTRICAL JUNCTION BOX
AIRTIGHT FOAM SEALANT
ALL AROUND
PARTITION WALL

AGENDA: “Everything’s connected”

- What’s in a building?
- Physical processes: heat, air and moisture
- Processes and sub-systems interact
- Effects of building materials
- Air quality, ventilation
- Fixing problems

What's in a building?

- Everything's connected



What's in a building?

- Walls, ceilings, windows, doors
- Below grade walls
- All exterior surfaces of the building
- Defines/encloses the indoor space

What's in a building?

- All equipment and appliances used for:
  - Space heating and cooling
  - Indoor humidification and dehumidification
  - Air exhaust and intake
  - Domestic water heating

What's in a building?

- Systems that add/remove heat, moisture and air from indoor space

- Examples:
  - Heating and cooling equipment
  - Humidifiers and dehumidifiers
  - Fresh air supply
  - Extractor fans

What's in a building?

- People, plants, animals
- Release heat and moisture
- Control mechanical system operation
- Open/close windows and doors
- Change in occupants = change in building operation

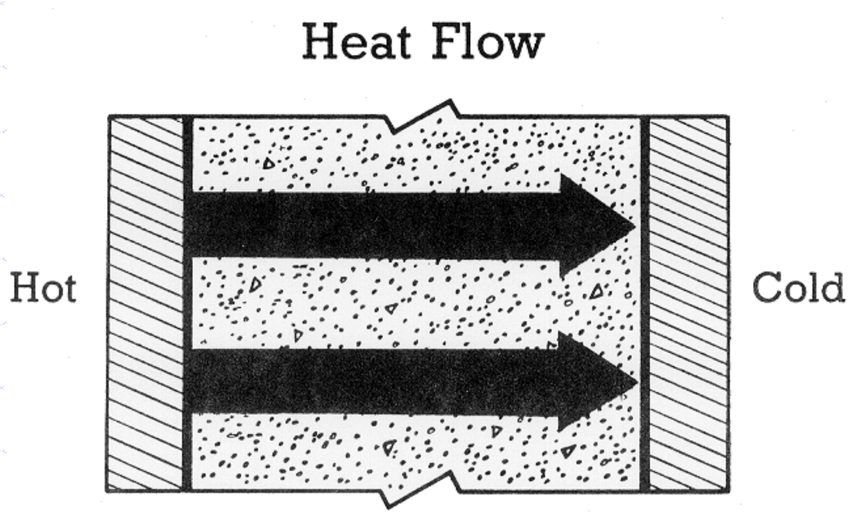
Physical processes
Heat flow • Air flow • Moisture flow

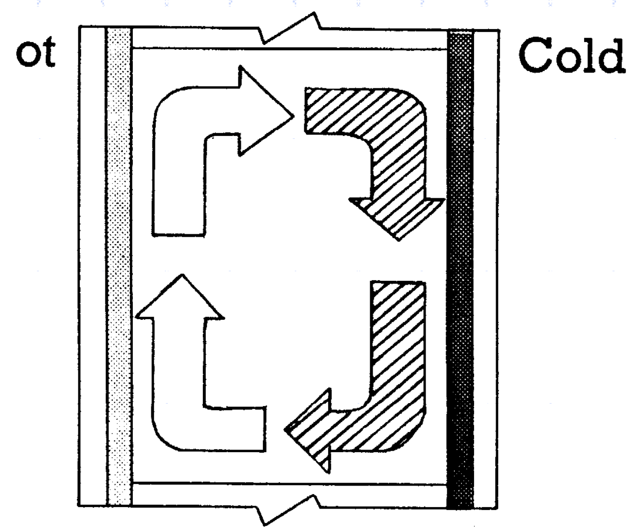
- Heat flow, conduction, convection and radiation
- Air flow, stack effect, wind effect
- Flue and ventilation effect, composite effect
- Moisture flow, movement of water as liquid
- Gravity, capillary action
- Movement of water as vapor
- Vapor diffusion and movement

Physical processes

Heat flow • Air flow • Moisture flow

- Always moving
- From higher to lower temperature space
- Heat transfer always hot to cold
- …unless balance is achieved



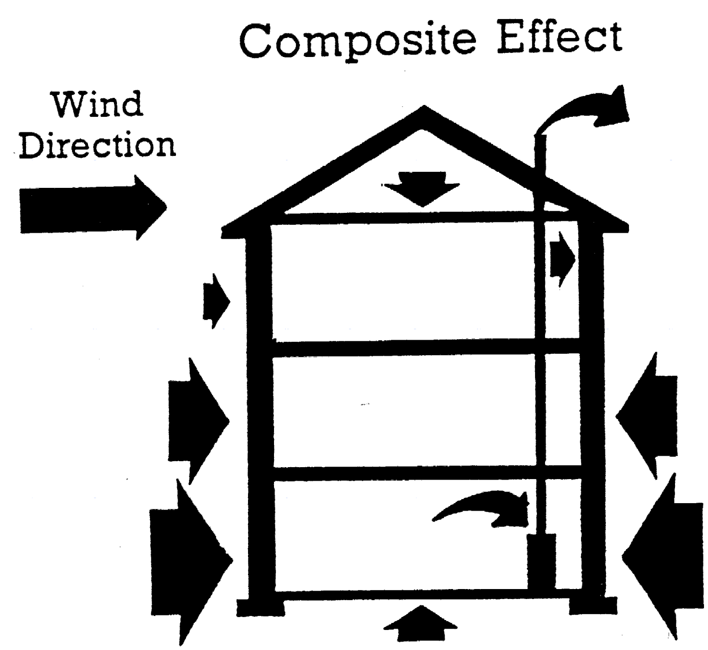


Physical processes
Heat flow • Air flow • Moisture flow

- From high pressure to low pressure area
- Leakage occurs where they differ
- Pressure differences are caused by:
  - stack effect
  - wind action
  - mechanical system effect

Physical processes
Heat flow • Air flow • Moisture flow

- Composite effect
- Stack effect + wind effect + mechanical effect
- = air infiltration
  and exfiltration



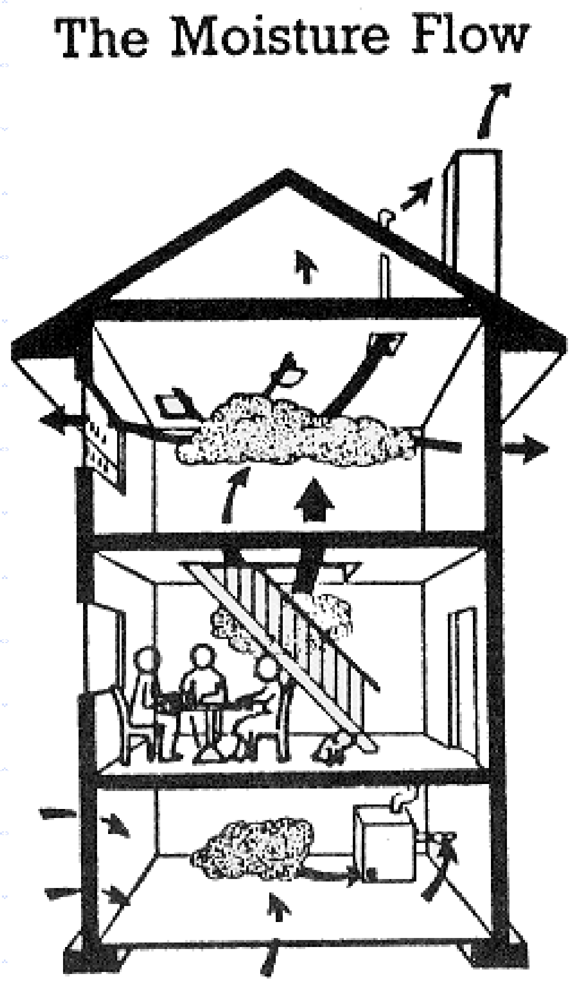
Physical processes
Heat flow • Air flow • Moisture flow

- 90% of all problems in buildings are caused by water

As a solid

As a liquid

As a gas



Physical processes
Heat flow • Air flow • Moisture flow

- 90% of all problems in buildings are caused by water

As a solid:

- Ice inside wall or cavities, cracks, crevices

Processes and sub-systems interact

Building envelope • Mechanical system • Occupants

Heat loss reduced by:

- Air leakage control measures
- Increasing thermal resistance of walls, attic, foundation, windows, etc.

Influences:

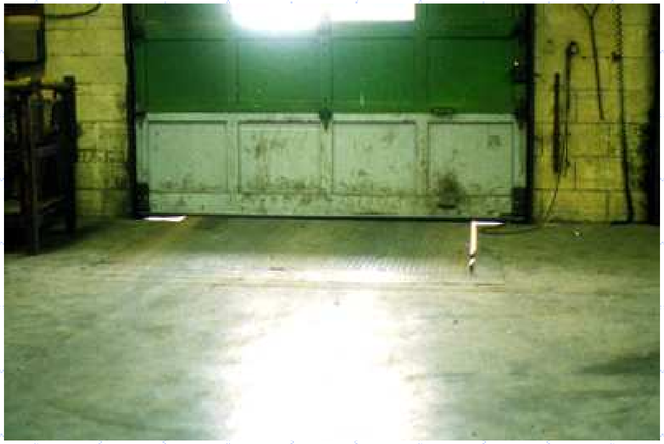
- Operation and size of heating system
- Fuel efficiency and energy consumption
- Stack effect
- Moisture levels and flow

Processes and sub-systems interact

Building envelope • Mechanical system • Occupants

Causes of poor heating:

- Poor balancing in distribution system
- High heat loss/leakage from ducts
- Lack of insulation
- Cold air leakage

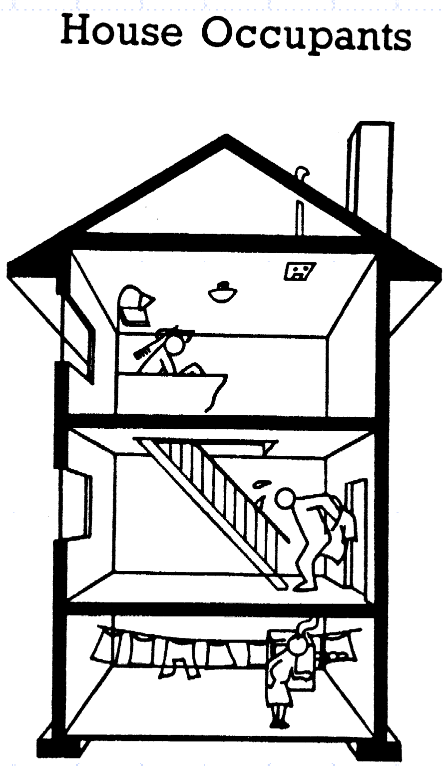


Processes and sub-systems interact

Building envelope • Mechanical system • Occupants

Effects on heat, air and moisture flow:

- Number of people, lifestyle, plants, animals
- Preferred indoor temperature
- Moisture from bathing, cooking, laundry
- How they operate mechanical systems



Processes and sub-systems interact

Building envelope • Mechanical system • Occupants

Summary

- Interaction involves:
- 3 sub systems:
    - Building envelope
    - Mechanical
    - Occupants
- Physical processes:
    - Heat flow
    - Air flow
    - Moisture flow
- External environment

Change in one or more will affect the other(s)

Effects of building materials

Heat flow • Air flow • Moisture flow

Insulation

Types of insulating materials:

- Wood shavings, wool, eel grass, seaweed, newspapers
- Fiberglass batts, polystyrene beads
- Cellulose, blown glass fibers, mineral wool
- Extruded or expanded polystyrene
- Urethane foam
- Polyisocyanurates

Effects of building materials

Heat flow • Air flow • Moisture flow

Fibrous v. closed-cell foam insulation

Fibrous:

- Fibers form discontinuous shell around pocket
- Changes path of conduction
- Changes amount of solid materials
- Lower R-value

Closed-cell foams

- Plastic shell surrounding bubble of air/gas
- Eliminates convection currents
- Heat transfer by conduction
- Foaming agents reduce heat conduction
- Higher R-value

Effects of building materials

Heat flow • Air flow • Moisture flow

Air barrier:

Material designed to stop the passage of air.

Effects of building materials

Heat flow • Air flow • Moisture flow

Moisture barrier:

Material designed to restrict or retard passage of vapor or moisture.

Effects of building materials

Heat flow • Air flow • Moisture flow

Vapor barrier:

Material designed to restrict or retard passage of water vapor.

Air quality & ventilation

Air • Moisture flow • Ventilation

Indoor air quality (IAQ)

- A key factor in comfort
- Increasing in importance
- Affects health of occupants

Air quality & ventilation

Air • Moisture flow • Ventilation

Air quality is determined by:

- Rate at which pollutants are generated, released or brought in
- Rate at which pollutants are removed from indoor air

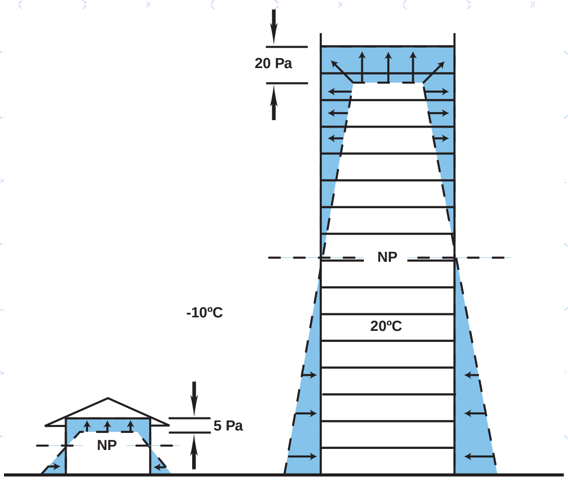
Air quality & ventilation

Air • Moisture flow • Ventilation

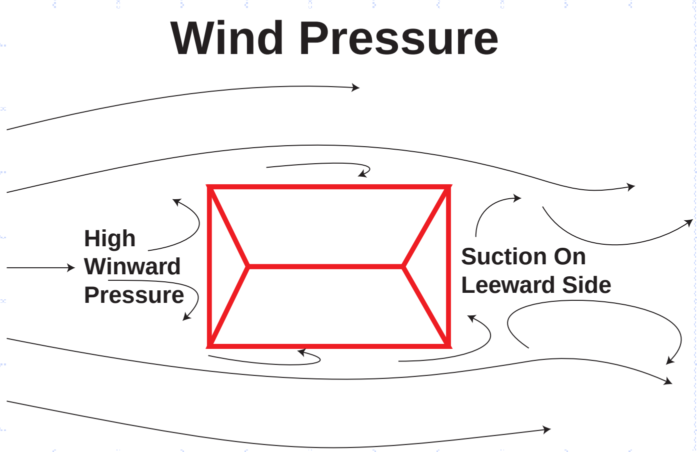
Remember the forces:

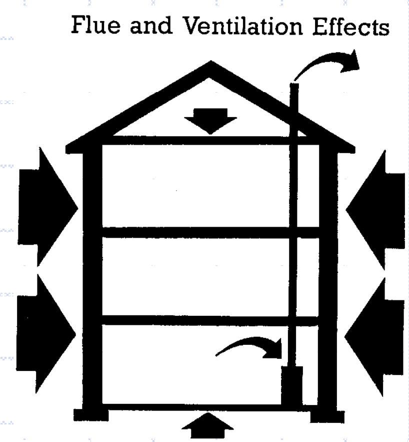
- Stack effect
- Wind effect
- Flue effect

Build tight, ventilate right



STACK EFFECT





Fixing Problems

- Create conditions that allow the building to work as a system
- A continuous air barrier system is an essential condition
- Urethanes have properties to create continuity
- Urethanes have delivered results
- What measures need to be taken…

Fixing Problems

- Assess overall building leakage
- Identify exit/entry points
- Identify air pathways inside building
- Prepare plan to create air barrier continuity

Fixing Problems
Building envelope assessment

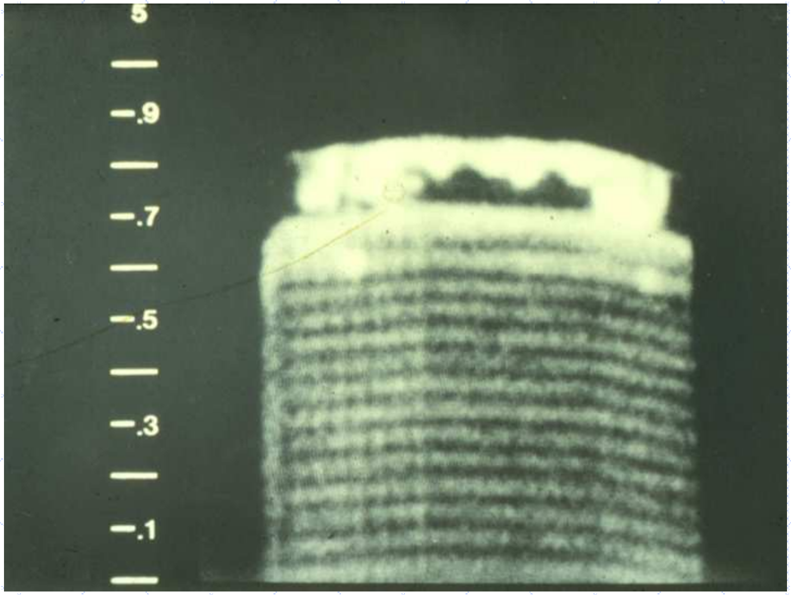
- Depressurization testing

Fixing Problems
Building envelope assessment

- Depressurization testing
- Locating air leakage

Fixing Problems
Building envelope assessment

- Depressurization testing
- Locating air leakage
- Infrared thermography



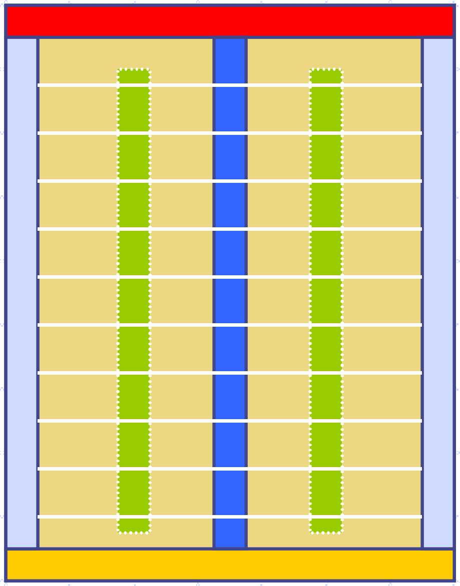
Fixing Problems
Building envelope assessment

- Depressurization testing
- Locating air leakage
- Infrared thermography
- Energy savings analysis – EC 128/ALCAP

Fixing Problems
Building envelope

Seal pathways in this order:

- Seal top
- Seal bottom
- Seal vertical shafts
- Seal outside walls and openings
- Compartmentalize



Fixing Problems
Building envelope

Seal top of building

- Roof/wall intersections
- Mechanical penthouse doors and walls
- HVAC equipment
- Other roof penetrations

Fixing Problems
Building envelope

Seal top of building

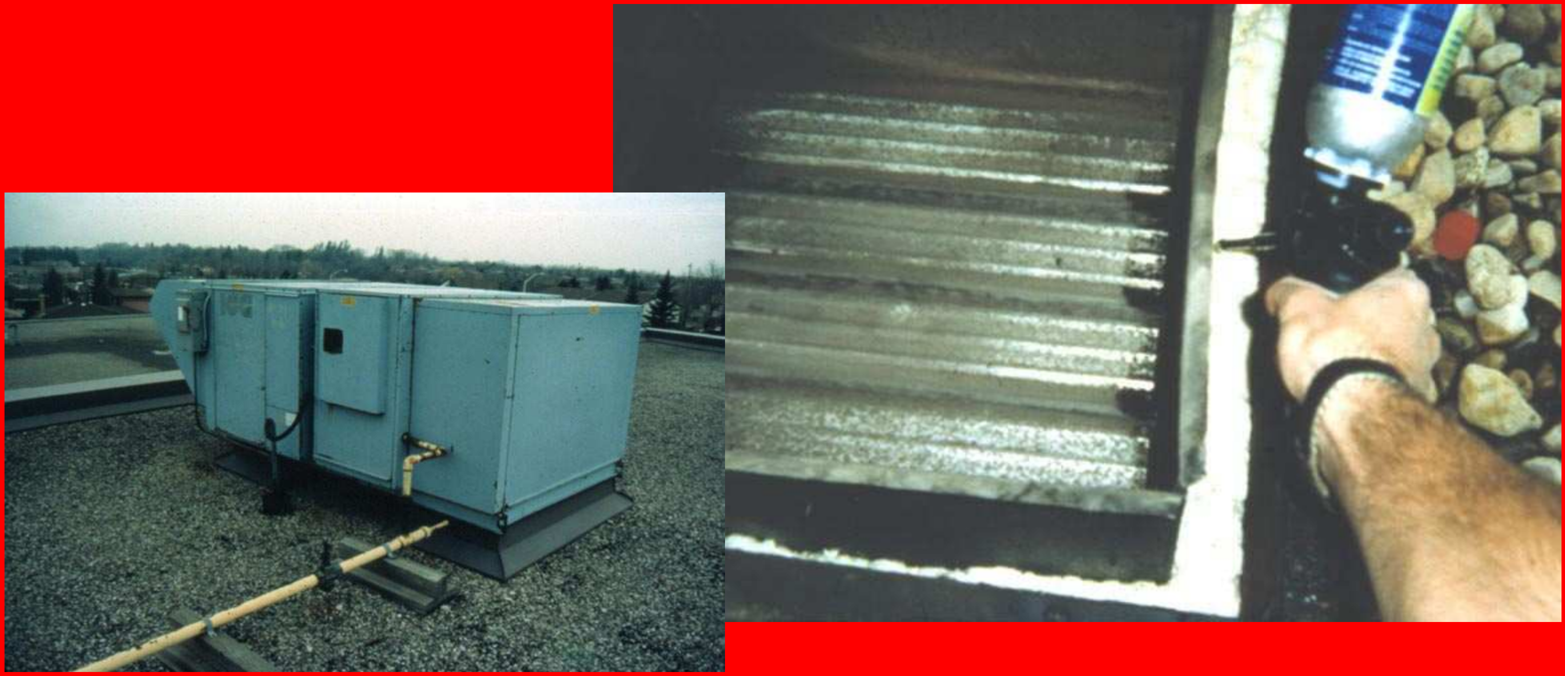


Fixing Problems
Building envelope

- Seal top of building

Fixing Problems
Building envelope

Seal top of building



Fixing Problems
Building envelope

Seal bottom of building

- Underground parking access doors
- Exhaust and air intake vents
- Soffits and ground floor access doors
- Pipe, duct, cable and other service penetrations into core of building
- Sprinkler hangar penetrations, inspection hatches and other holes
- Seal core wall to floor slab

Fixing Problems
Building envelope

Seal bottom of building

Fixing Problems
Building envelope

Seal bottom of building

Fixing Problems
Building envelope

Seal vertical shafts

- Stairwell fire doors
- Fire hose cabinets
- Plumbing, electrical, cable and other penetrations within service rooms
- Elevator rooms- cable holes, door controller cable holes, bus bar openings

Fixing Problems
Building envelope

Seal vertical shafts

- Garbage chute perimeter and access hatches
- Hallway pressurization grille perimeters
- Smoke shaft access doors
- Elevator shaft smoke control grilles
- Service shafts

Fixing Problems
Building envelope

Seal vertical shafts

Fixing Problems
Building envelope

Seal vertical shafts

Fixing Problems
Building envelope

Seal vertical shafts

Fixing Problems
Building envelope

Seal outside walls and openings

Fixing Problems
Building envelope

Seal outside walls
and openings

Fixing Problems
Building envelope

Compartmentalize

- Vented mechanical rooms
- Garbage compactor room
- Emergency generator room
- High voltage rooms
- Shipping docks
- Elevator rooms
- Workshops

Fixing Problems
Building envelope

Compartmentalize

Fixing Problems
Building envelope

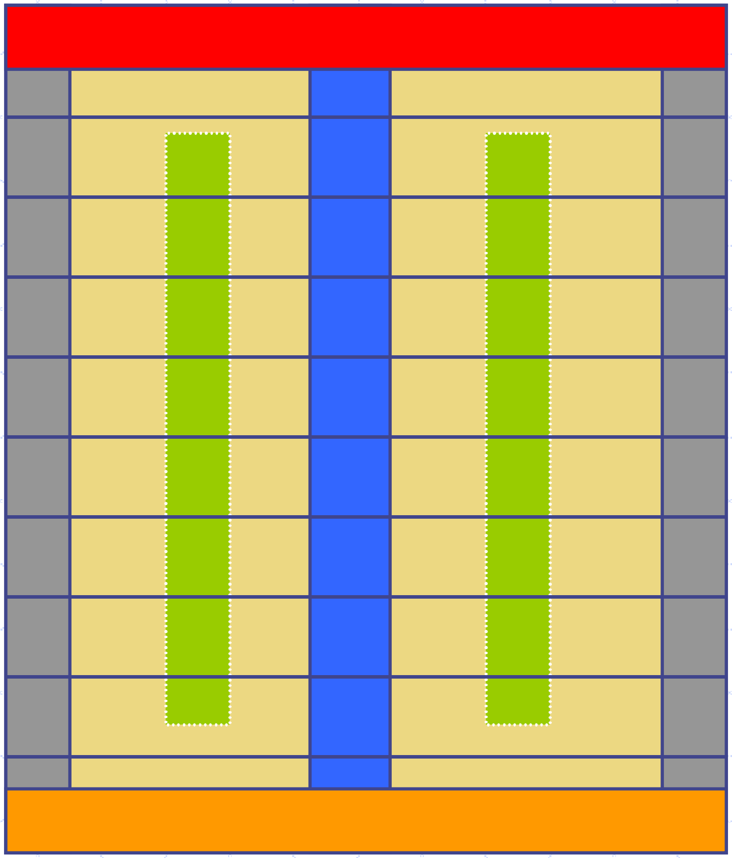
Compartmentalize

Fixing Problems
Building envelope

RECAP:

Seal the air leakage pathways in this order

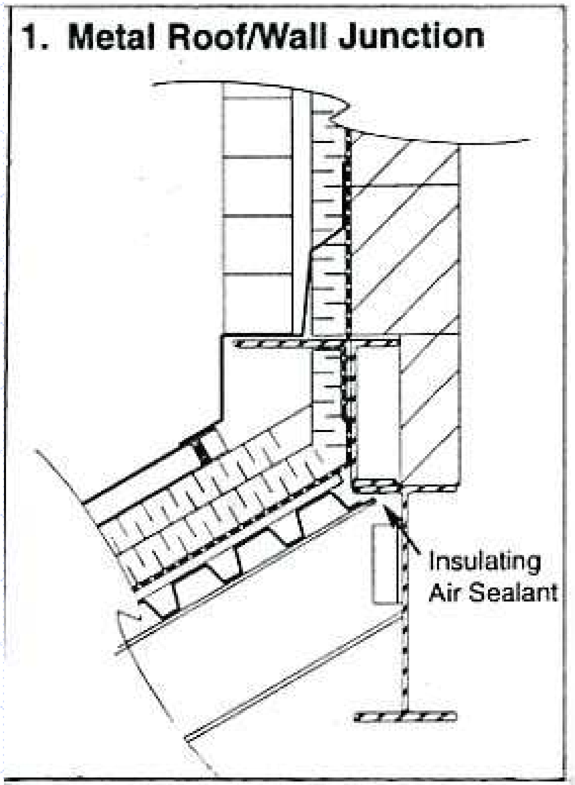
i.	TOP
ii.	BOTTOM
iii.	VERTICAL SHAFTS
iv.	OUTSIDE WALLS
v.	COMPARTMENTALIZE

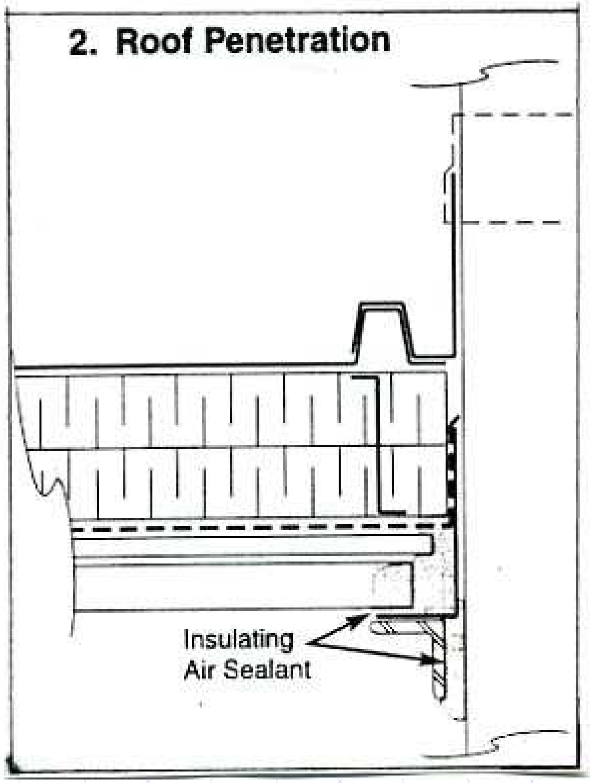


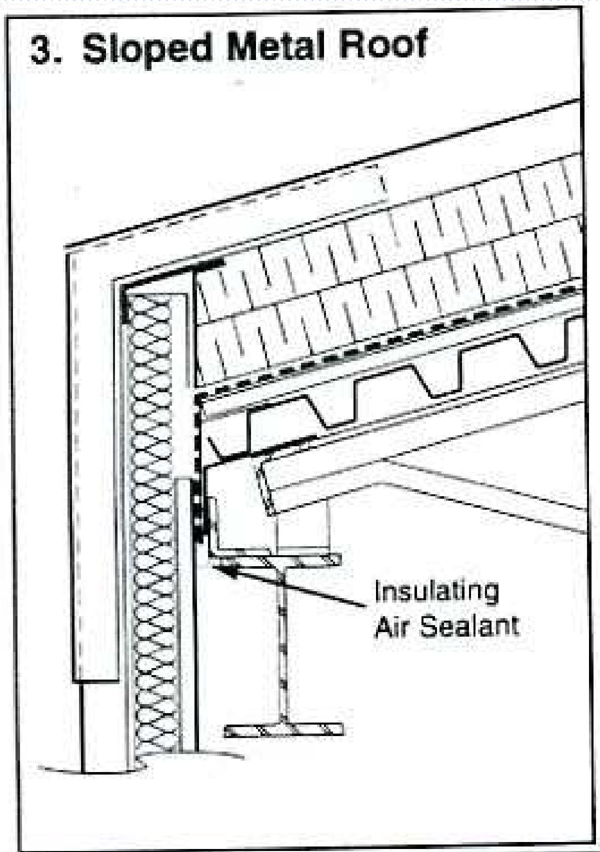
Examples of Materials Used

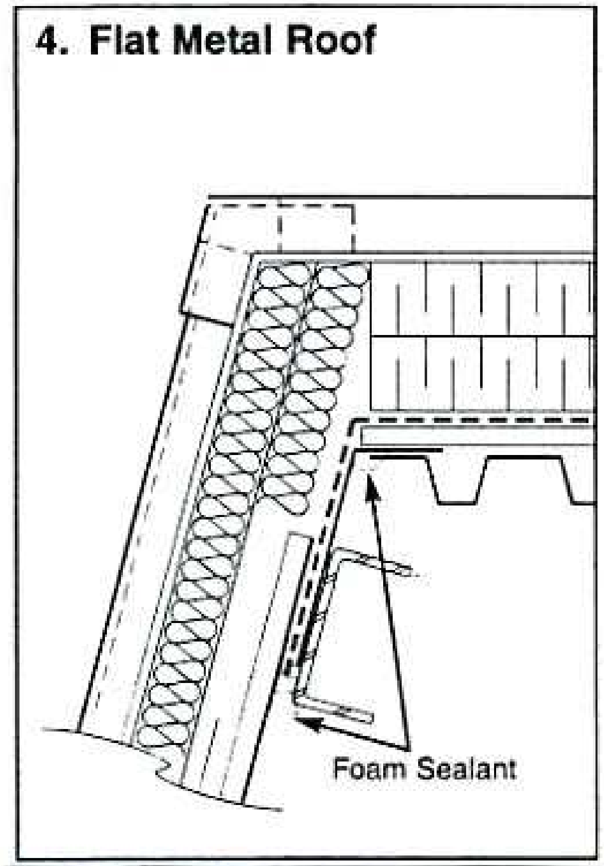
- 2-component polyurethane foam insulating air seal kits
- 1-component polyurethane foam sealant
- Door and window weather-stripping and seals
- Air seal/ fire stop systems

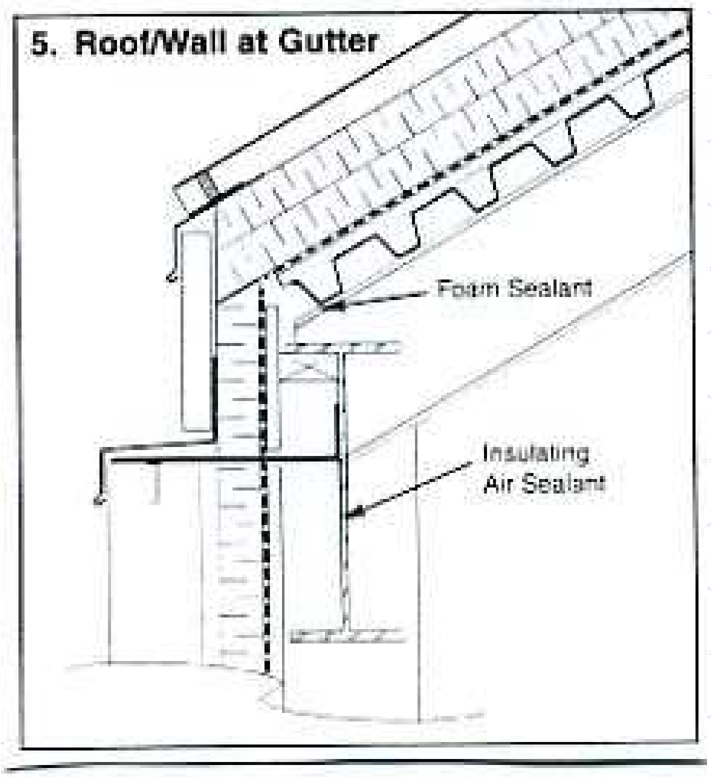
Examples of locations for Foam Sealant and Insulating Air Sealant

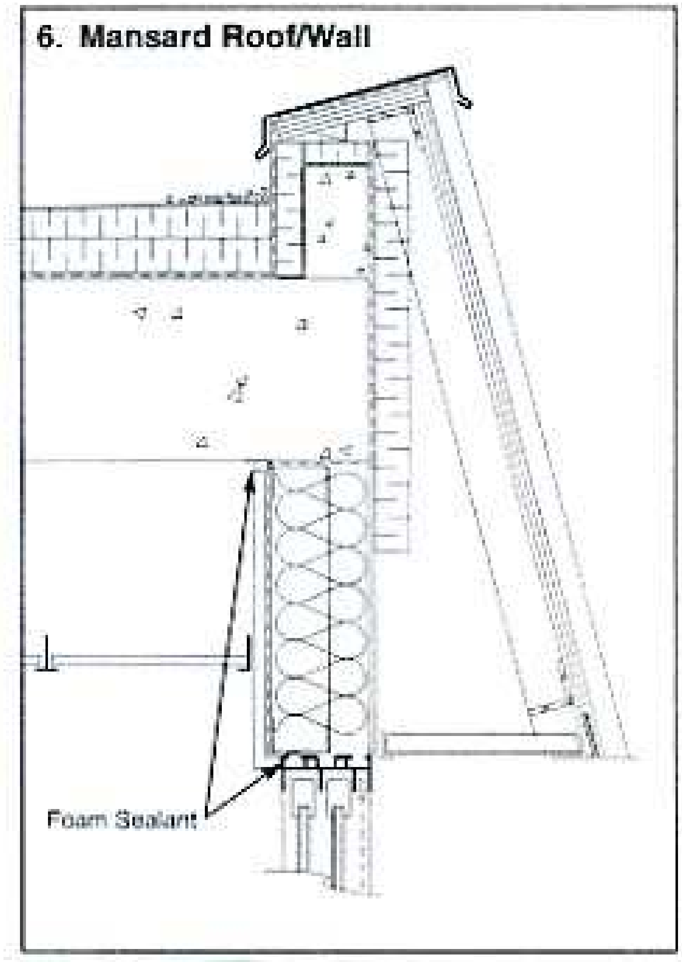




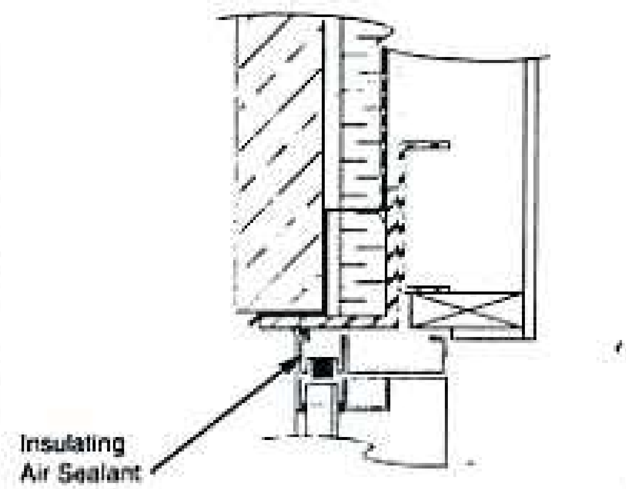

3. Sloped Metal Roof
Insulating
Air Sealant


4. Flat Metal Roof
Foam Sealant

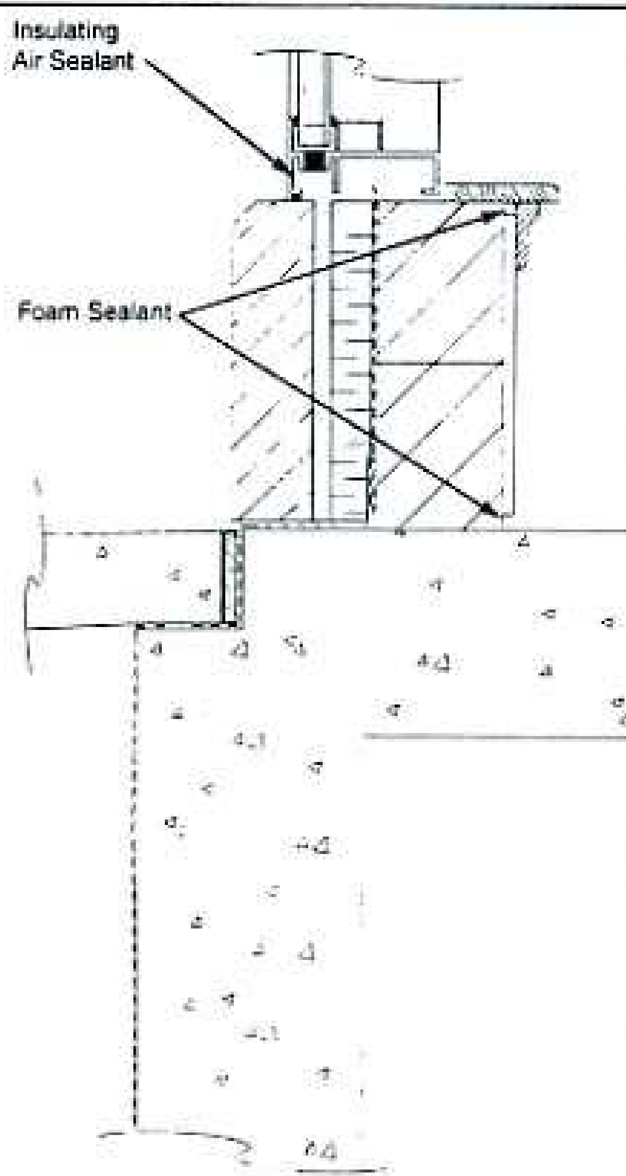

5. Roof/Wall at Gutter
Foam Sealant
Insulating
Air Sealant


6. Mansard Roof/Wall
Foam Sealant

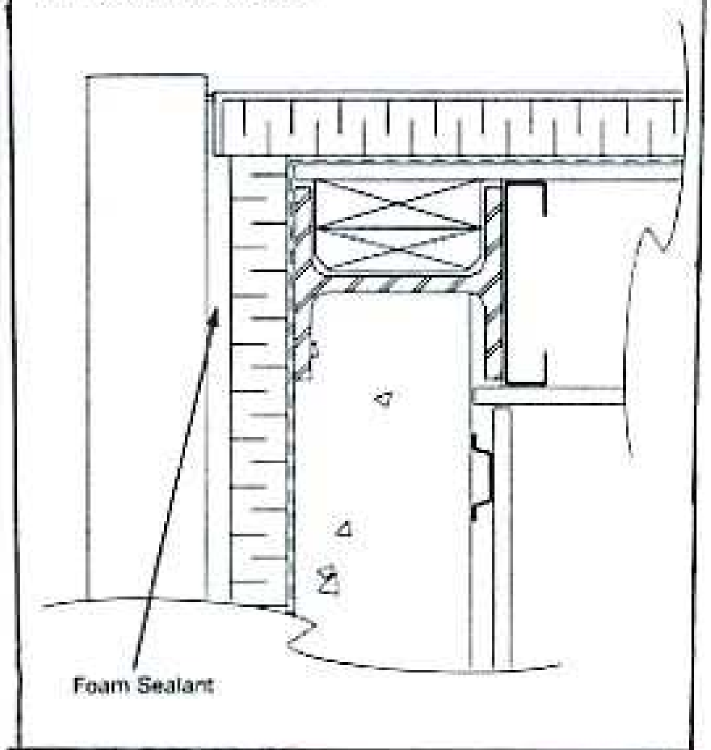
7. Window Head



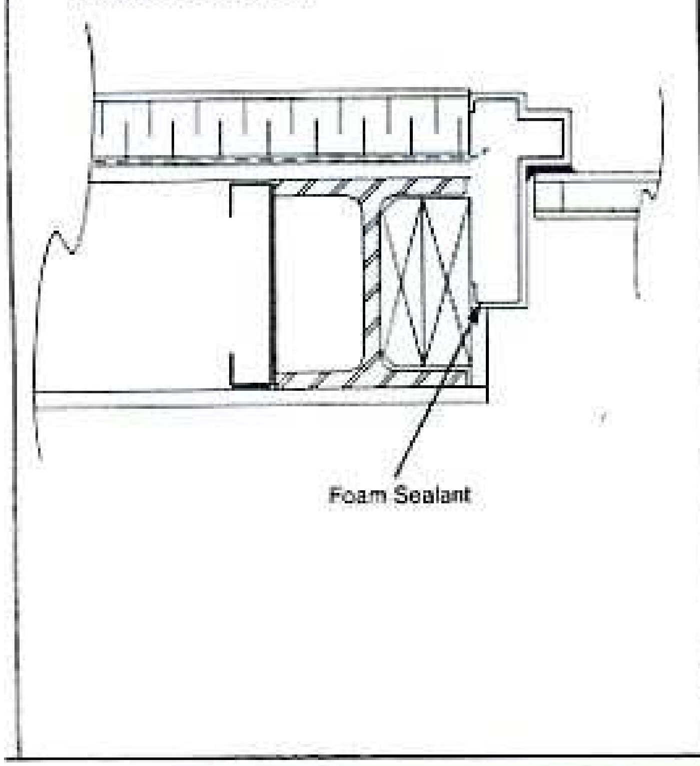
8. Window Sill



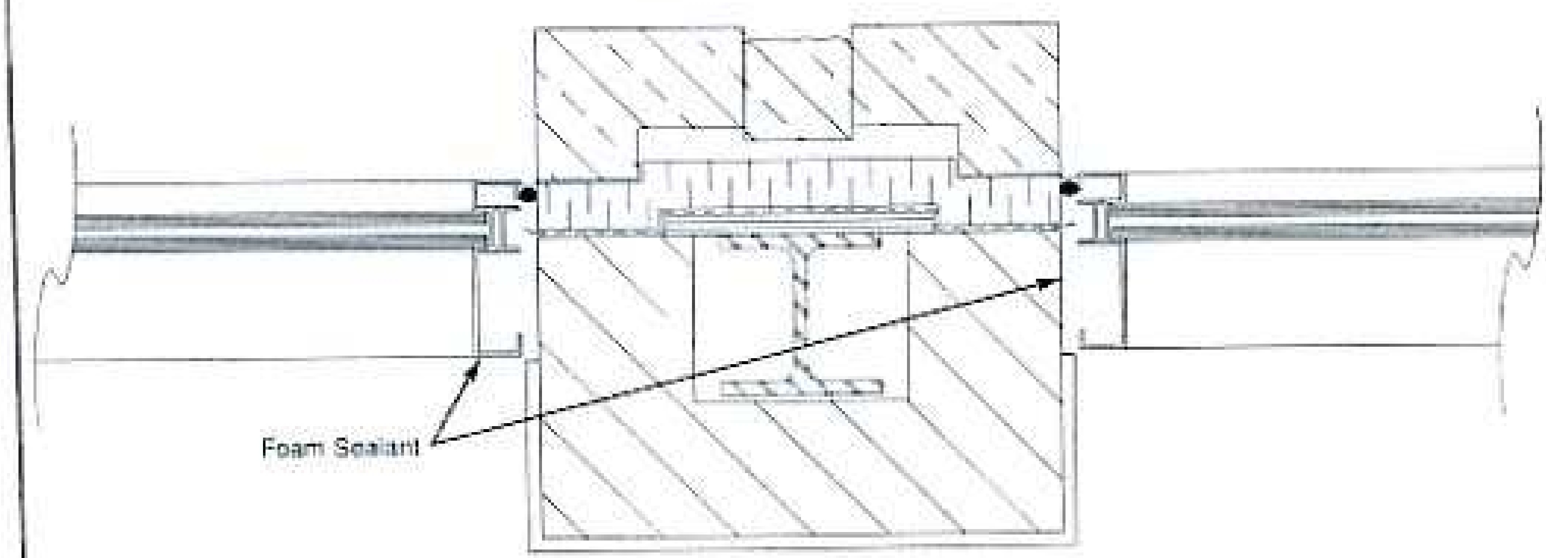
9. External Corner

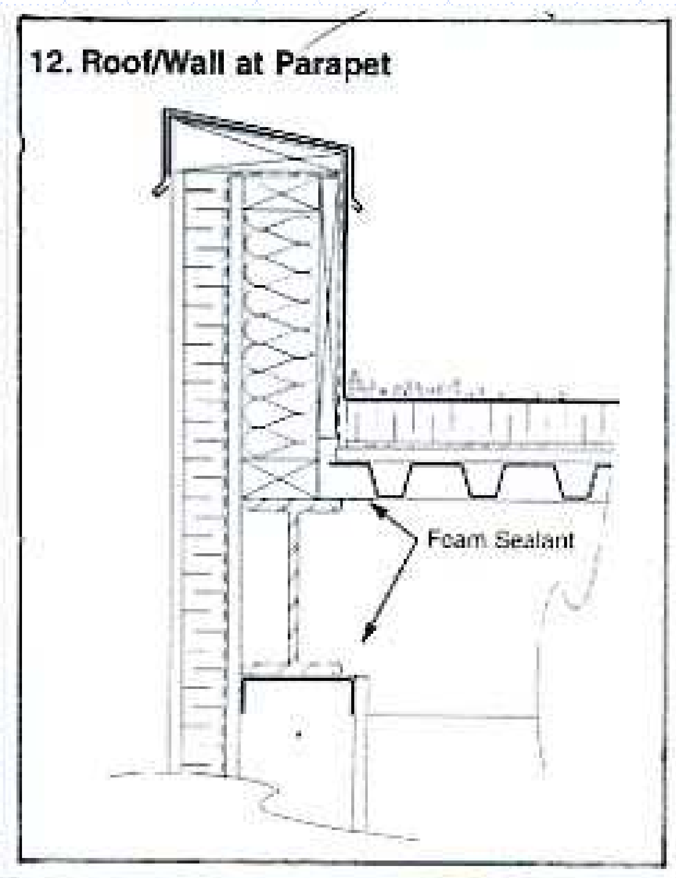


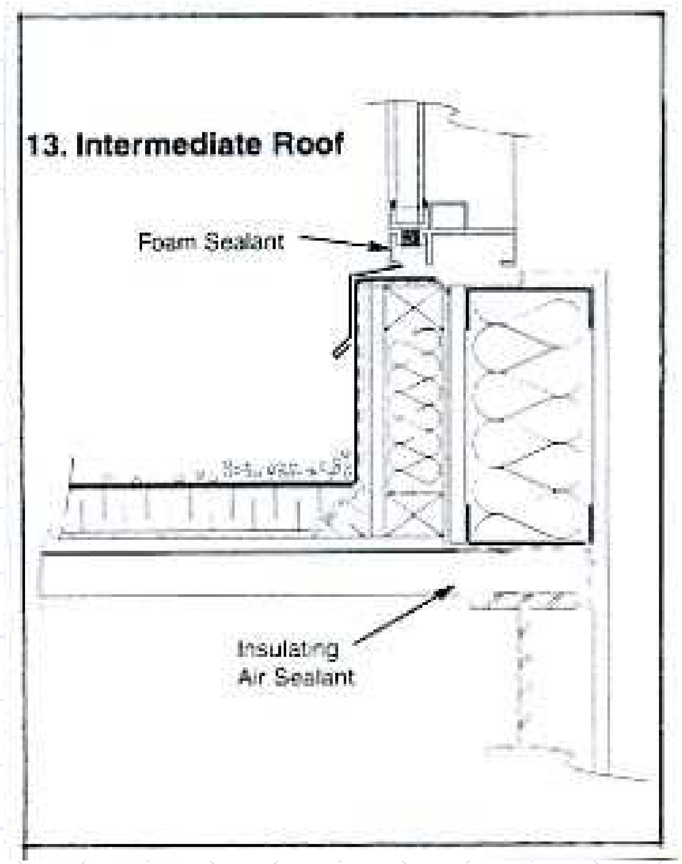
10. Window Jamb



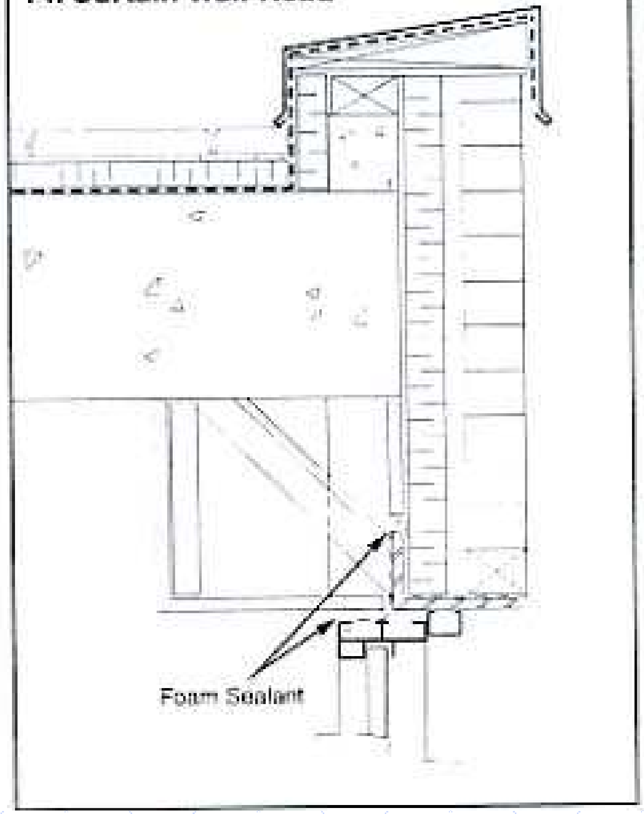
11. Column



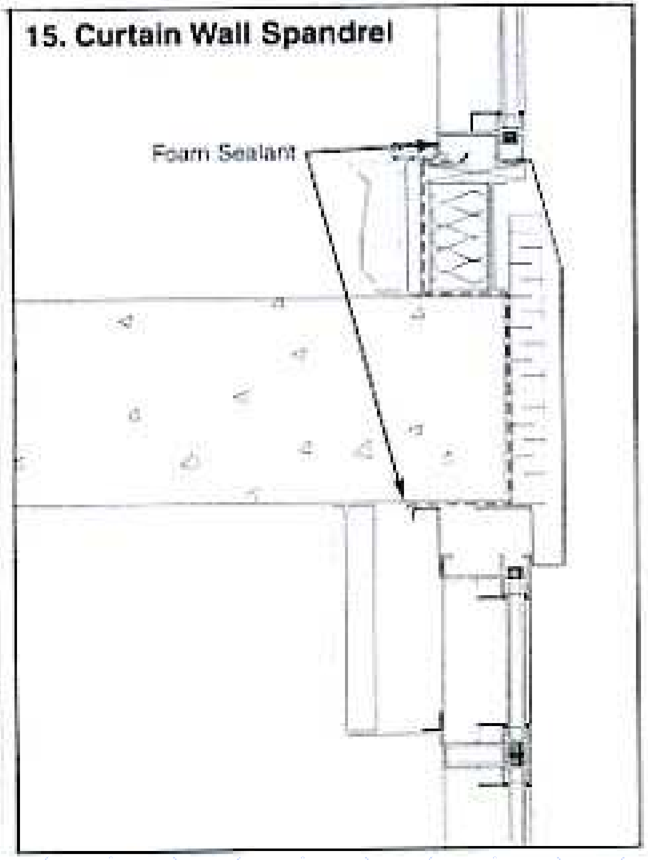

12. Roof/Wall at Parapet
Foam Sealant


13. Intermediate Roof
Foam Sealant
Insulating
Air Sealant

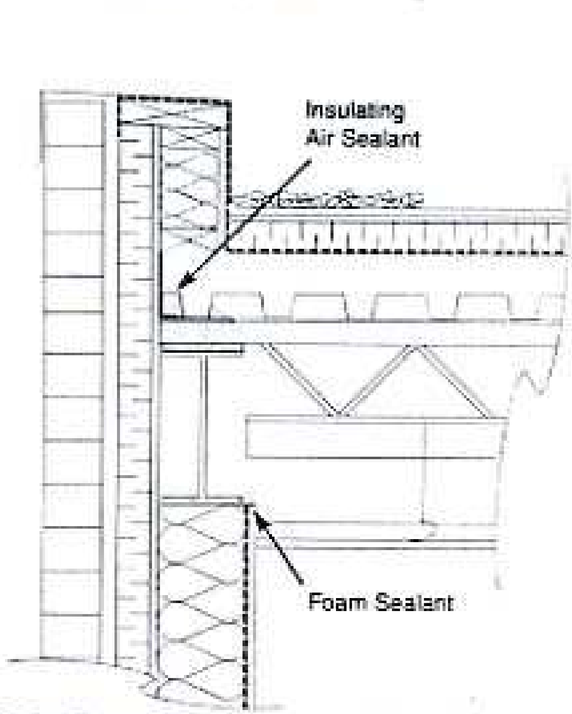
14. Curtain Wall Head



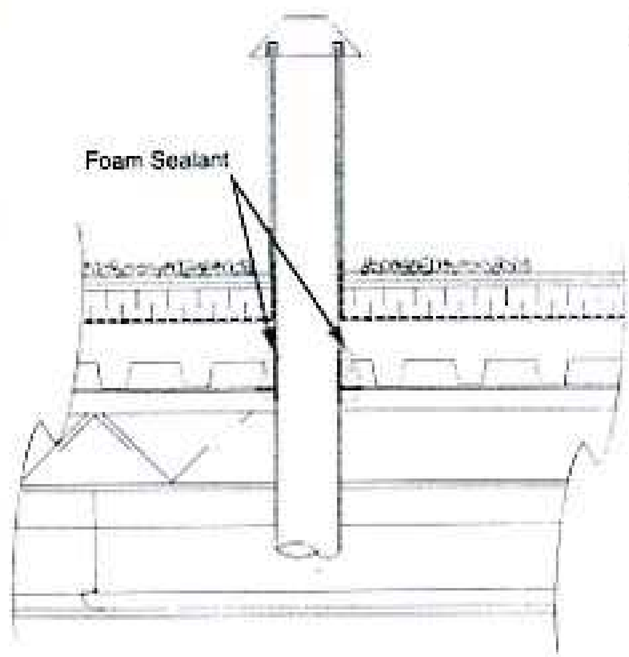
15. Curtain Wall Spandrel

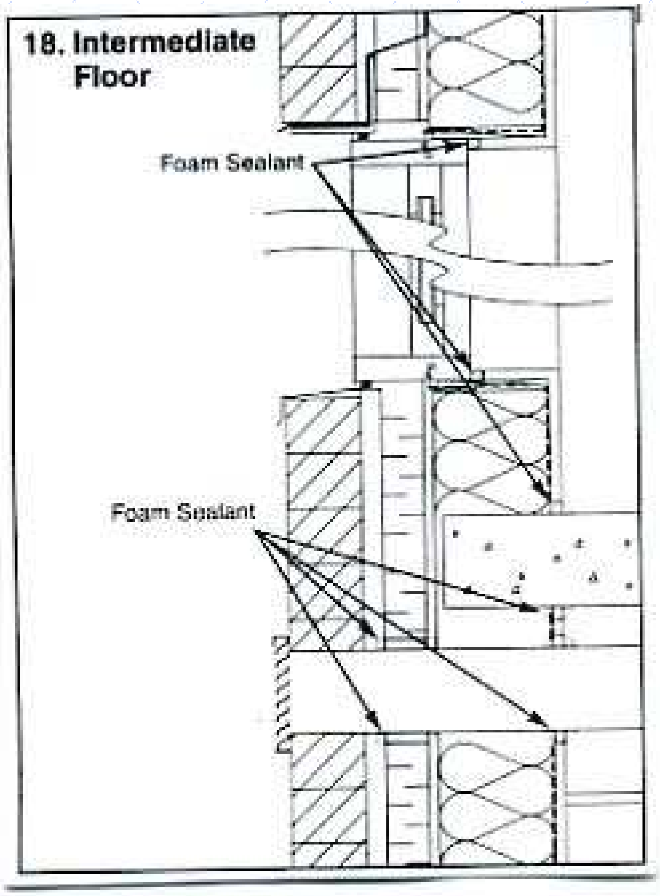


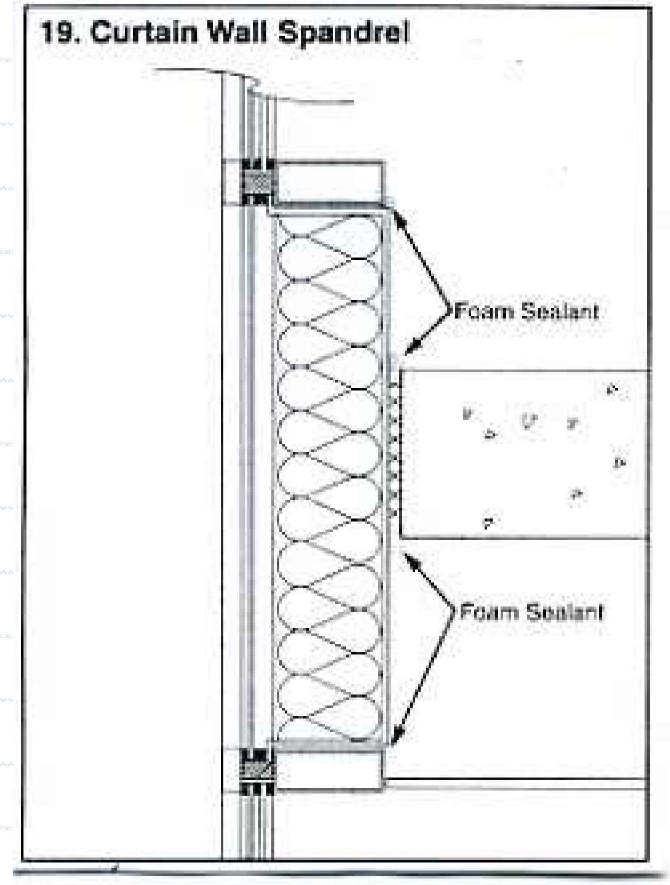
16. Roof at Masonry Wall

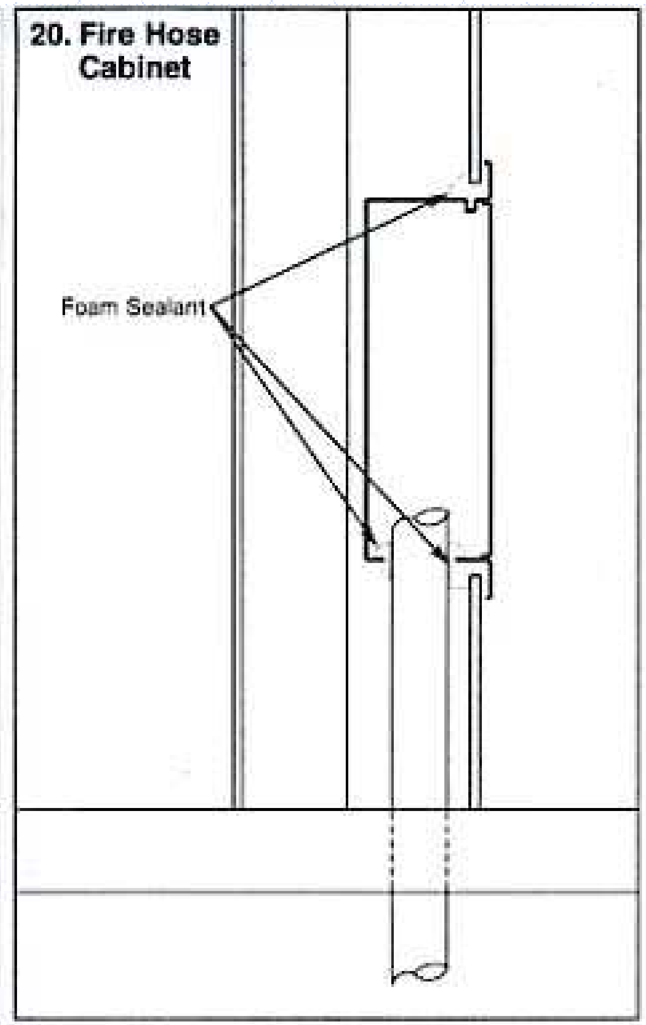


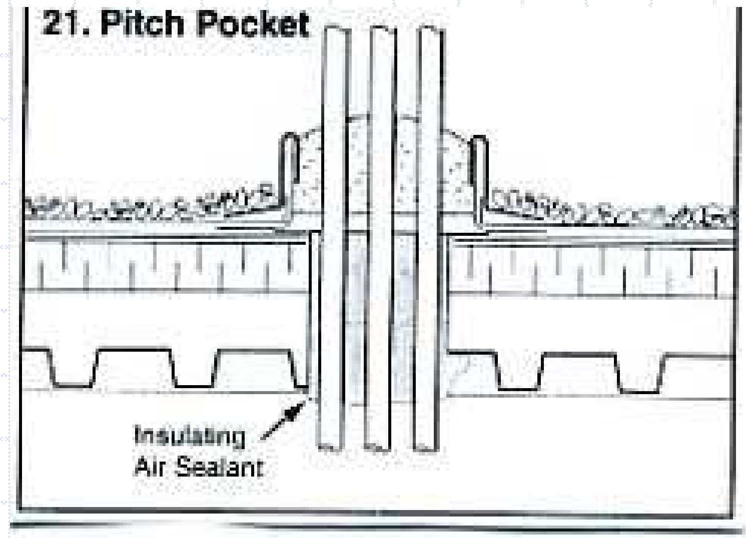
17. Roof Vent Penetration



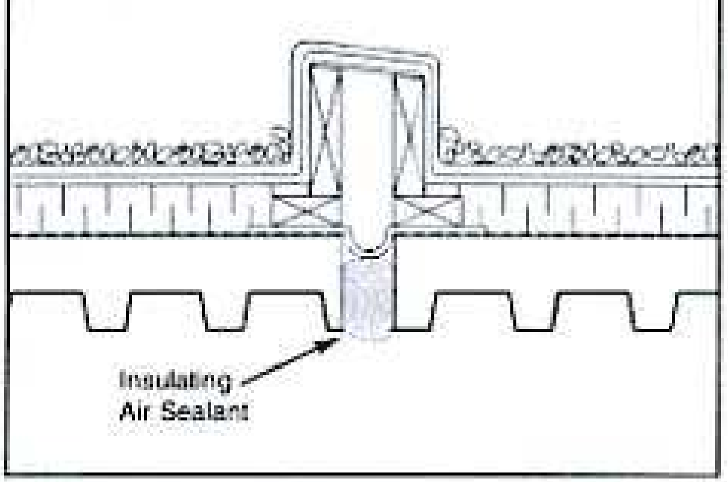

18. Intermediate Floor
Foam Sealant
Foam Sealant


19. Curtain Wall Spandrel
Foam Sealant
Foam Sealant

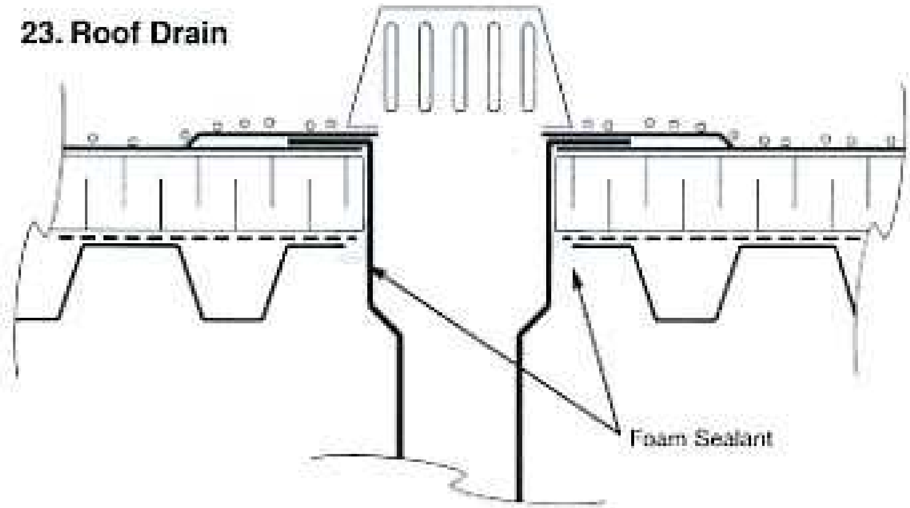

20. Fire Hose Cabinet
Foam Sealant


21. Pitch Pocket
Insulating Air Sealant

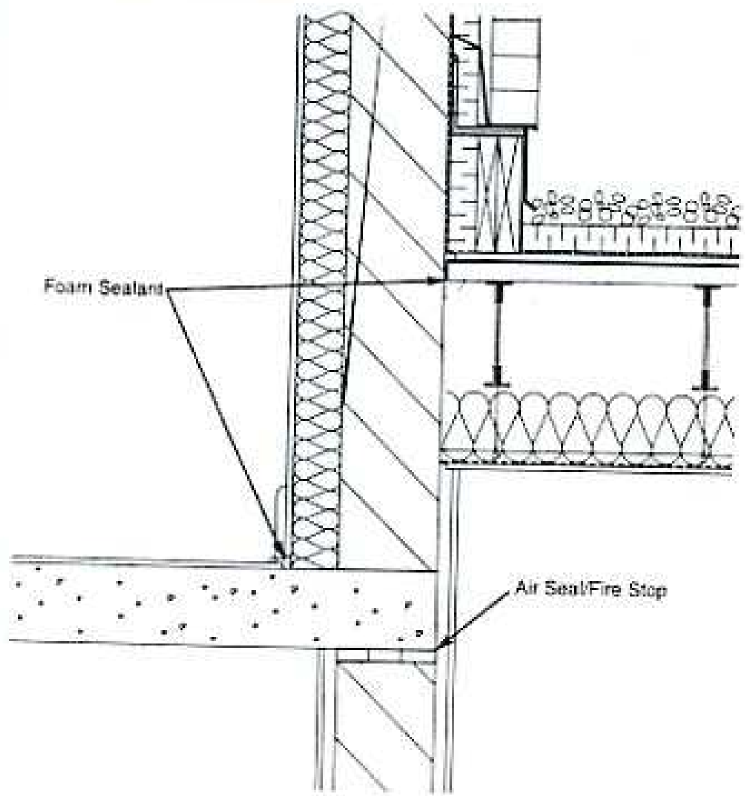
22. Expansion Joint

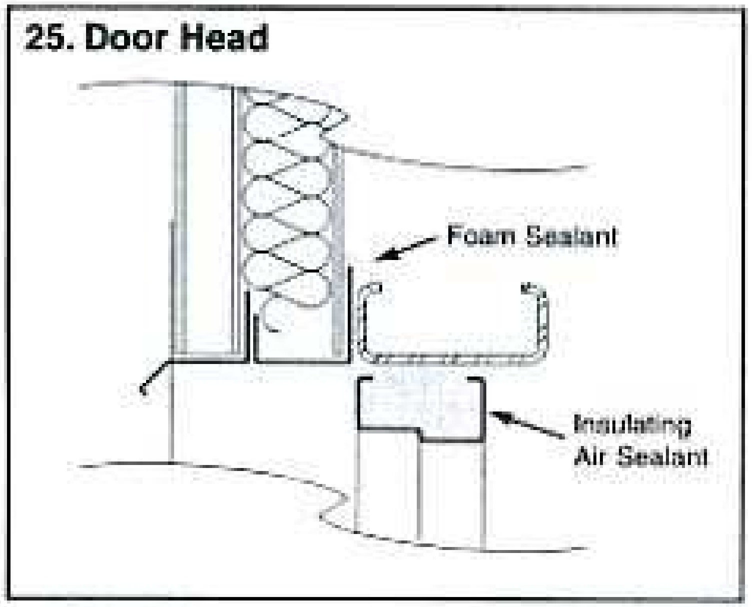


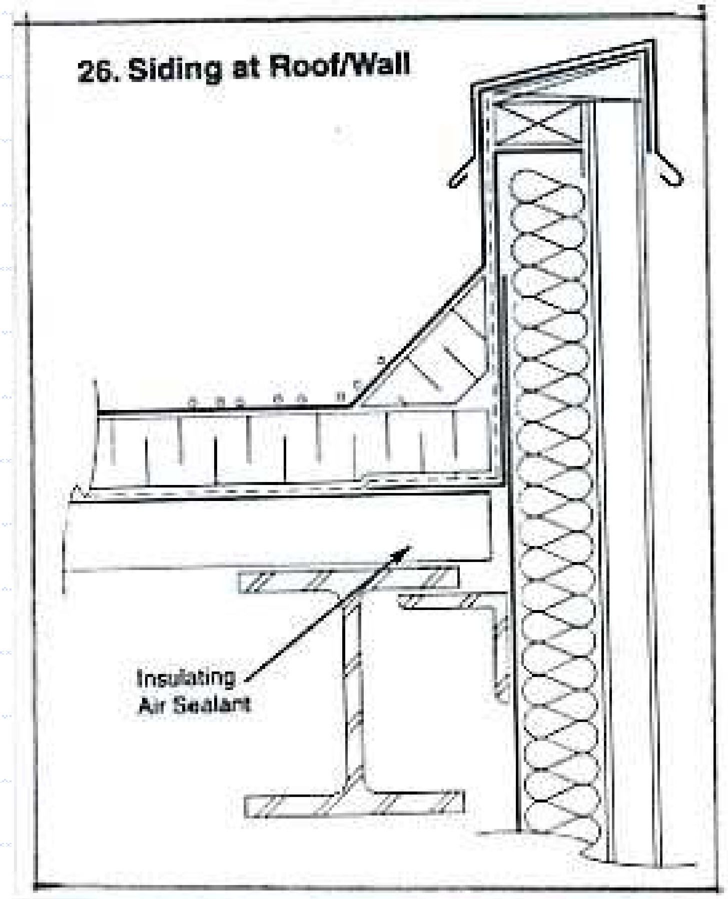
23. Roof Drain



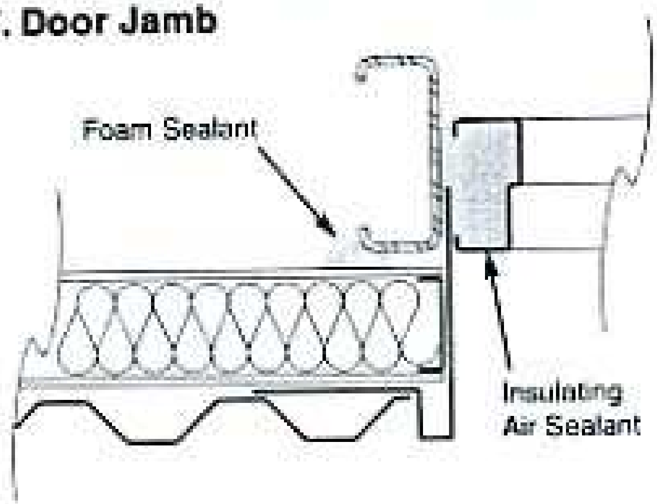
24. Low Roof/Wall Junction

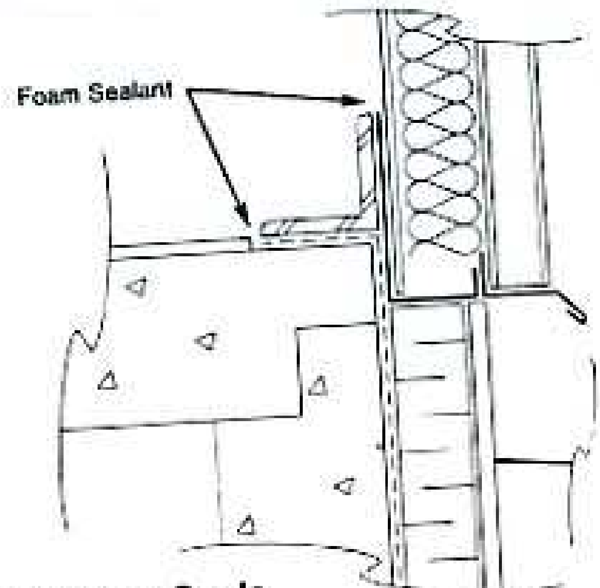



25. Door Head
Foam Sealant
Insulating
Air Sealant


26. Siding at Roof/Wall
Insulating
Air Sealant

27. Door Jamb





28. Siding at Grade

Productivity and Energy Conservation Mutually Exclusive Objectives

Instead of concentrating in the energy cost alone, we should be looking at the greater positive impacts that are expected (by orders of magnitude larger). We have design methods and technologies that can minimize or eliminate any financially negative impacts.

Ventilation Rate Minimums and Pressurization Requirements

We must be wary of methods that allow the drastic reduction of outdoor air intake rates. Intake rates should not be reduced below the point required to maintain adequate and consistent space pressurization. More precise controls are needed to effectively maintain smaller minimum rates. Precision control would all but eliminate the very large risks created by negatively pressurizing the space. It would also allow effective and dynamic control of both pressurization and outdoor air intake, regardless of the rate selected.

Negative pressurization could pull untreated humid air through cracks and gaps in the building envelope into walls where it can cool and condense to liquid form. This increases the risk of unhealthful mold infestation by providing the ingredients for a wonderful growth medium. Negatively pressurizing a space would also increase operating costs for energy usage immediately and decrease the systems ability to control comfort. Consistent positive pressurization flow would provide a barrier to infiltration, effectively seal the envelope from infiltration and providing a proactive solution one of the causes of mold infestation in exterior building walls.

The potential negative health impacts from "toxic" mold have been hyped by the media to the point of consumer and insurance carrier panic. It is an area of IAQ that is fairly obvious. The impact of dilution ventilation, however, is not as apparent and therefore does not get the same visibility. It is only when linked to "sick building syndrome" and the damage awards for occupants that it generated that we tend to hear about it.

As we will see in subsequent examples, dilution ventilation rates have also demonstrated a profound impact on the measured productivity of building occupants. You will see significant authorities referencing that occupant salaries in offices often exceed one hundred times the building energy and maintenance costs. That equals nearly as much as the annual amortized cost of construction or rental.

Productivity vs. Energy Cost Comparisons

Several significant organizations have already concluded that building management policies that ignore the IAQ impact can have a negative financial effect that far outweighs the minor savings projected from those policies. For example, NIBS and the Naval Facilities Engineering Command as early as 1997 stated in their *Whole Building Design Guide*:

“Because worker salaries exceed building energy, maintenance and annualized construction costs by a large factor, the cost-effectiveness of improvements in indoor environments will be high even when the percentage improvements in health and productivity are small……. ***The resulting benefit-to-cost ratios were very high, approximately 50 to 1 …. for increased ventilation…"***

They go on to propose:

".… a 'productivity' increase of 1% will completely offset the building's entire energy bill. *This implies that it is crucial that interventions made in the name of energy efficiency do not negatively impact occupant satisfaction and productivity."*

Energy Cost Avoidance Residential

As noted earlier residential air infiltration rates for Michigan is currently 0.80 air changes per hour (80% of the building air changed every hour). The ideal air infiltration rate per DOE and EPA is 0.35 air changes per hour (35% of the building air changes every hour).

The 228% difference is 39% of our heating cost being leaks (air infiltration).

1600 SF x 8′ x (0.80/60) = 170 cfm

1600 SF x 8′ x (0.35/60) = 75 cfm

Difference   170 – 75 = 95 cfm

Potential Savings (:@ natural gas cost of 11.38 MCF)

(95 x (0.472) x 3778.56 x 37.9) =

$240.00/ year (heating only)

2400 SF house:

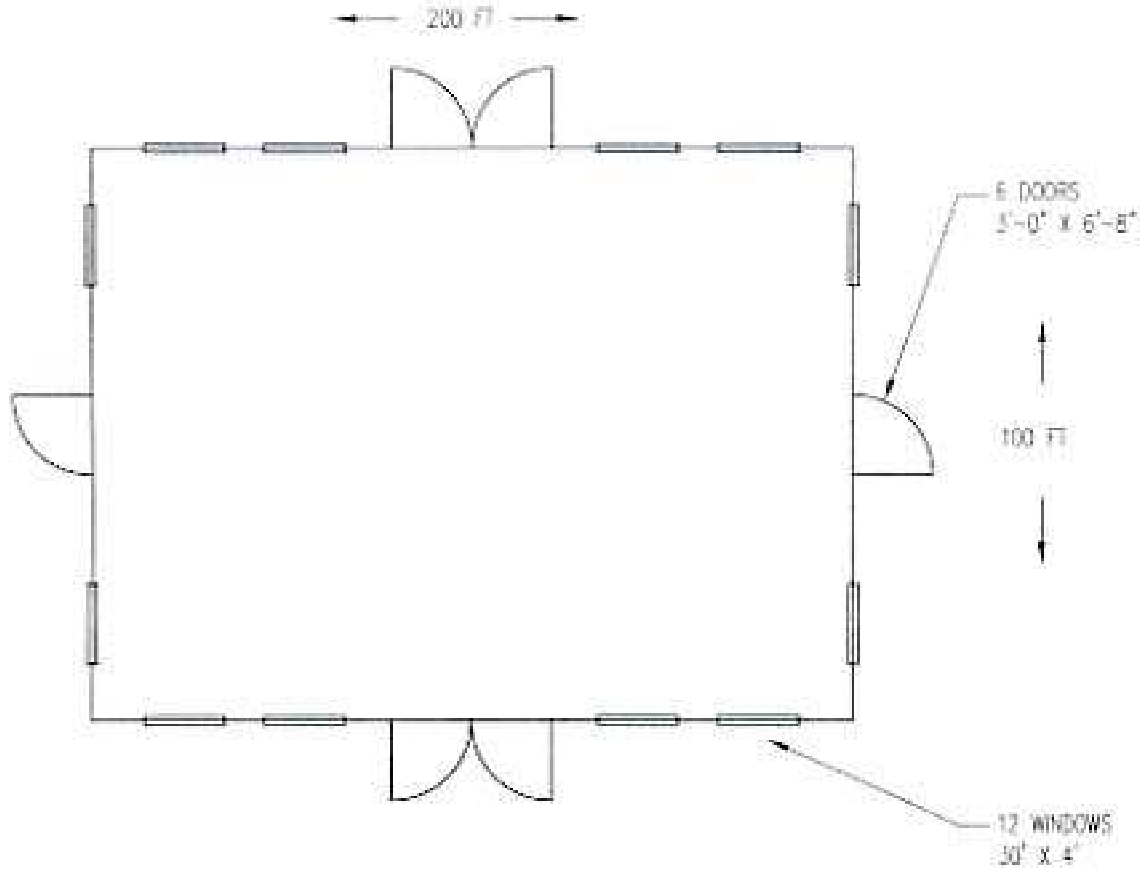
170 x 2400/1600 = 255;   75 x 2400/1600 = 112.5

Difference   255 – 112.5 = 142.5 cfm

Benefits: Improved comfort
Eliminates Ice Damming
Prevents Mold growth
Protects your investment
Controls smoke odor migration
Reduces Energy consumption

Potential Savings

$240.00/ yr x (142.5/95) = $360.00/yr (heating only)


200 FT
6 DOORS
3'-0" X 6'-8"
100 FT
12 WINDOWS
30' X 4'

Openings in Envelope: SF

600 Lf roof/wall intersection @ 1/8" opening =	6.25
6 doors @ 19.33 Lf and & 1/16" opening =	0.603
12 operable windows (weather-strip)	
2' x 4' @ 1/32" opening =	0.374
12 windows caulk @ 1/64" opening =	1.061
Total Crack Area =	8.29 SF

Q = 100 x 5.58 x 0.804 = 448.6 l/s (951 cfm)

Cost = 448.6 x 3778.56 x 37.9/ 26700 = $2406.3/yr

Design and Construction Objectives

Improve health, safety, durability, comfort and energy efficiency

Design and Construction Strategy

Consider urethanes to prevent and correct failure of the building as a system.

Conclusions

The energy doom-sayers should be silenced with common sense and the thoughtful pursuit of improvements in greater objectives: PRODUCTIVITY & HEALTH.

We have the research and supporting documentation to show that these objectives support “sustainability”. They do not need to add to the operating costs of a building. We have the methodology. We have the needed hardware and technology to implement the method. So, what’s stopping you now?

Bibliography

ABAA: Air Barrier Association of America

DTE Energy

NIST: National Institute of Standards and Technology

EPA: Environmental Protection Agency

Canam Building Envelope Specialist Inc.

EIA: Energy Information Administration