


SPO Maine State Planning Office

## Residential Energy Conservation Code of Maine

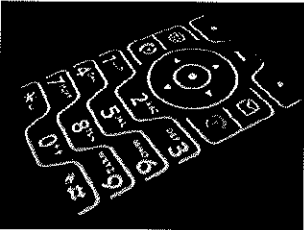
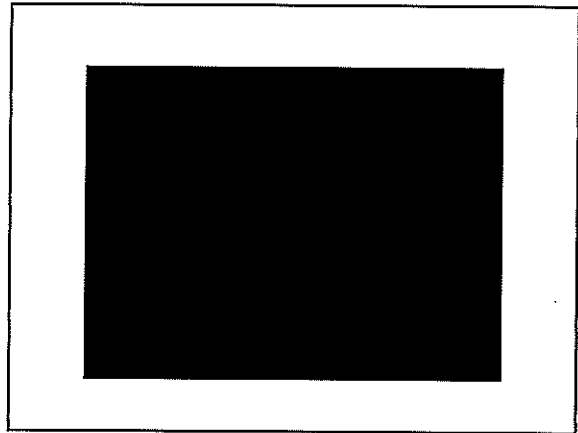


Michael Lessard

## Agenda

- o Title 16 Department of Public Safety
- o 635 (new) Bureau of Building Codes and Standards
- o Course time 6 hours
- o Overview of the Residential Energy Code
- o Certification Process
- o Timeline
- o Enforcement
- o Resources for Information
- o U.S. DOE Residential Requirements of the 2009 IECC
- o Navigating the Code
- o Revisions to the IECC
- o The "New School" of Building Science

Oh yeah... Those pesky cell phones!

## The New Standard

Title 16 Department of Public Safety  
635 (new) Bureau of Building Codes and Standards -  
Maine Uniform Building and Energy Code

Chapter 6 Energy Conservation Code of Maine

## Residential Energy Code

Establishes Residential Energy code component of the  
Maine Uniform Building and Energy Code (MUBEC)

The provisions of this chapter are based on a nationally recognized model building code published by the International Code Council, Inc., and is made part of the MUBEC through incorporation by reference.

This chapter also contains requirements for the enforcement of the Energy Conservation code by local building officials in municipalities with a population of more than 4,000 residents.

## Purpose and Scope

- o All building construction in Maine, with some exceptions, is governed by the MUBEC, which is adopted by the Technical Building Codes and Standards Board pursuant to 10 M.R.S. Chapter 1103.

The primary objective of the Board is to establish a uniform building code throughout the State of Maine.

## Purpose and Scope

- o Chapter 6 sets forth the regulation of the design and construction of buildings for the effective use of energy and is applicable to both residential and commercial buildings.

## Authority

- o The authority for this Chapter is 10 M.R.S. 9722, which provides that the Maine Technical Building Codes and Standards Board shall promulgate rules which adopt, amend, and maintain the Maine Uniform Building and Energy Code.

## Adopted Codes and Standards

The Residential Energy Conservation Code of Maine has adopted the following:


- o International Energy Conservation Code – 2009 and
- o International Energy Conservation Code – 2006 (reference residential basement wall insulation only)

To download rules that detail the amendments to the code, go to [www.maine.gov/dps/bbcs](http://www.maine.gov/dps/bbcs)

## Incorporation by Reference

The following Chapters of the 2009 International Energy Conservation Code, published by the International Code Council, Inc., are hereby adopted and incorporated by reference and are an enforceable part of the MUBEC:


- Chapter 1 Administration
- Chapter 2 Definitions
- Chapter 3 General Requirements
- Chapter 4 Residential Energy Efficiency (Also IECC 2006 for basement wall insulation)
- Chapter 5 Commercial Energy Efficiency
- Chapter 6 Referenced Standards



## Excluded from Adoption

At this time, none of the content contained in the 2009 International Energy Conservation Code has been excluded from adoption.

X



# Certification Standards

## Certification Standards

For Building Officials and Third Party Inspectors

The training and certification committee of the Technical Building Codes and Standards Board shall determine the standards for certifying building officials and third-party inspectors.

Standards shall enumerate the knowledge and training required to ensure that building officials and third-party inspectors have the basic understanding needed to apply the MUBEC and the ongoing education needed to stay current with code changes and amendments.

## Certification Standards

There are six new standards in which building officials may be certified.

- o International Residential Code (IRC)
- o International Building Code (IBC)
- o Residential Energy Code (IECC)
- o Commercial Energy Code (IECC)
- o Residential Ventilation Code
- o Commercial Ventilation Code

o Radon – Registration now required

## Advisory Rulings and Technical Support

The interpretation and enforcement of this Code are the responsibility of the local municipality.

However, the Bureau is available to provide advisory rulings and technical support for the administration of this Code, amendments, conflict resolutions, and interpretations. This support includes but is not limited to:

## Advisory Rulings and Technical Support

### Written Request

Upon written request of any interested person or entity, the Bureau may provide a nonbinding advisory interpretation with respect to the applicability of any statute, rule or code administered by the Bureau, on that person or entity, or the property of that person or entity, or actual state of facts.

The written request shall be made on the official Bureau form and shall include the following information:

### Written Request Shall include:

- o Specific identification of the subject code or codes with a description of the questioned application or perceived conflict.
- o Relevant construction documents to fully illustrate the issue upon which an advisory interpretation is sought.
- o The Bureau may request additional documentation or information required to issue an advisory interpretation or to provide technical support. All requested information shall be provided within 30 days of request, or the request for advisory interpretation or support may be deemed abandoned.

### Advisory Rulings and Technical Support

The technical support shall also include:

- Written, non binding advisory interpretation

### Other Considerations

- o Procedure for code amendment
- o Procedures for identifying and resolving conflicts between this Code and the Fire Safety Codes and standards.
- o Experimental buildings
- o Native lumber

### MUBEC does not apply to


- o Log homes or manufactured homes defined in Chapter 951.
- o Post and beam or timber frame construction.
- o Warehouses or silos used to store crops.
- o Seasonally restricted cottages.

### Timeline

### Timeline

On December 1, 2010, this code shall be applicable statewide.

The MUBEC must be enforced in a municipality with a population of 4,000 residents or more that had previously adopted any building code on or before August 1, 2008.



### Timeline

No later than July 1, 2012, this Code must be enforced in a municipality with a population of 4,000 residents or more that had not adopted any building code on or before August 1, 2008.

## Timeline

The provisions of the MUBEC do not apply to municipalities with a population of less than 4,000 residents, except to the extent that the municipality has adopted that code.

## MUBEC Components

Maine Uniform Building Code -- That portion of the MUBEC that does not contain energy code requirements as determined by the board pursuant to section 9722, subsection 6, paragraph L.

Maine Uniform Energy Code -- That portion of the MUBEC that contains only energy code requirements as determined by the board pursuant to section 9722, subsection 6, paragraph L.

## Municipalities Under 4,000

Effective September 2011, all towns under 4,000 in population have the following options:


1. Chose to adopt and enforce the MUBEC.
2. Choose to adopt and enforce MUBC only.
3. Choose to adopt and enforce MUEC only.
4. Choose to have no code.

## Timeline

Effective December 1, 2010, except as provided in 10 M.R.S. 9724(4) and 9725, any ordinance regarding any building code of any political subdivision of the State that is inconsistent with the MUBEC is void, with the following exception:

This provision does not apply to any adopted fire & life safety code, fire safety ordinance or any land use ordinance, including Land Use Regulatory Commission rules.

## Enforcement



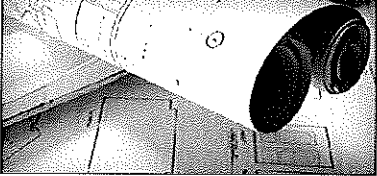
## Enforcement

Pursuant to 25 M.R.S. 2373, in municipalities with a population over 4,000, enforcement of the provisions of the MUBEC shall be the responsibility of the municipality and shall be accomplished by one or more of the following means:

**Enforcement**

Building Officials

Inspections performed by building officials certified pursuant to 30-A M.R.S. 4451.



**Enforcement**

Inspections by Virtue of Inter-local Agreements

Inspections performed by virtue of inter-local agreements with other municipalities, that share the use of building officials, certified in building standards pursuant to 30-A M.R.S. 4451.

**Enforcement**

Contractual Agreements

Inspections performed by virtue of contractual agreements with one or more municipalities, or county or regional authorities, that share the use of building officials certified in building standards pursuant to 10 M.R.S. 9723.

**Enforcement**

Third Party Inspection by Report

Inspections performed and verified by reports from a TPI, certified pursuant to 10 M.R.S. 9723.

**Enforcement**

If the municipality does not elect one or more of the four options listed above, then the applicant shall elect to have an inspection performed by a TPI at their own cost.

**Suggested Inspections**

104.1 General

Construction or work for which a permit is required shall be subject to inspection by the code official.

See Commentary

## Suggested Inspections

Some suggested inspection areas... **Envelope**

Foundation

- o Perimeter slab insulation
- o Below grade wall insulation

## IECC 2006 Provisions

402.2.6 Basement Walls.

Walls associated with conditioned basements shall be insulated from the top of the basement wall down to 10 feet below grade or to the basement floor, whichever is less.

Wall associated with unconditioned basements shall meet this requirement unless the floor overhead is insulated IAW sections 402.1.1 and 402.2.5.

*Residential Only*

## IECC 2006 Provisions

402.1.1 Insulation and fenestration criteria.  
The building thermal envelope shall meet the requirements of Table 402.1.1 based on the climate zone specified in Chapter 3.

CLIMATE ZONE	MINIMUM ROOF R-VALUE	MINIMUM CEILING R-VALUE	MINIMUM FLOOR R-VALUE	MINIMUM EXTERIOR WALL R-VALUE	MINIMUM WINDOW U-FACTOR	MINIMUM SKYLIGHT U-FACTOR	MINIMUM DOOR U-FACTOR	MINIMUM GLAZED ENTRY U-FACTOR
1	10	5	5	13	0.30	0.30	0.30	0.30
2	15	10	10	13	0.30	0.30	0.30	0.30
3	20	15	15	13	0.30	0.30	0.30	0.30
4	25	20	20	13	0.30	0.30	0.30	0.30
5	30	25	25	13	0.30	0.30	0.30	0.30
6	35	30	30	13	0.30	0.30	0.30	0.30
7	40	35	35	13	0.30	0.30	0.30	0.30
8	45	40	40	13	0.30	0.30	0.30	0.30
9	50	45	45	13	0.30	0.30	0.30	0.30
10	55	50	50	13	0.30	0.30	0.30	0.30

*Residential Only*

## Suggested Inspections

Some suggested inspection areas...

Framing

- o Foundation discrepancies corrected
- o Fenestration requirements
- o Air leakage of windows, skylights, doors, etc
- o Envelope air leakage
- o Skylight U-factors
- o Door U-factors

## Suggested Inspections

Insulation

- o Framing discrepancies corrected
- o Vapor retarders
- o Roof R-values
- o Type IC light fixtures
- o Interior wall R-values (adjacent to unconditioned space)
- o Floor R-values
- o R-values -- below grade walls
- o Protection of below grade insulation
- o Thermal barriers of above/below grade combo walls
- o R-values of exterior walls
- o Inform contractor of missing items or corrections needed
- o Final Inspection

## Suggested Inspections

Other inspection areas with similar suggested lists include...

**Mechanical**  
**Service water heating**  
**Electrical power and lighting**

### Required Inspections

104.5 Inspection Agencies

The building official is authorized to accept reports of approved agencies, provided such agencies satisfy the requirements as to qualifications and reliability.

### Required Inspections

104.6 Inspection Requests

It shall be the duty of the permit holder or their agent to notify the building official that such work is ready for inspection.

It shall be the duty of the person requesting any inspections required by this code to provide access to and means for inspection of such work.

### Required Inspections

104.7 Reinspection and testing

Discusses that deficiencies noted by inspection must be corrected and reinspected.

### Required Inspections

104.8 Approval

After the prescribed tests and inspections indicate that the work complies in all respects with the code, a notice of approval shall be issued by the code official.

### Required Inspections

Remember... the aforementioned *suggested inspections* are those listed by the ICC, and published in the IECC and Commentary.

Those are only suggestions!

You have a handout from the U.S. DOE that may be used by building officials as a model to develop your own inspection checklist.

### Resources for Information



## Resources for Information

International Code Council

The International Residential Code (IRC), 2009 edition,  
500 New Jersey Avenue, NW, 6th Floor  
Washington, DC 20001  
1-888-ICC-SAFE (422-7233)

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

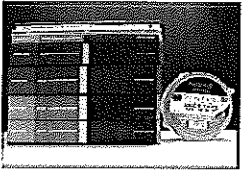
## U.S. Department of Energy

Residential Requirements of the 2009 IECC

## Navigating the Code

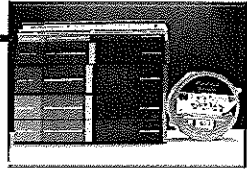
## Navigating the Code

The ICG codes and ASHRAE standards contain a substantial amount of information and updates for the new building code program.



## Navigating the Code

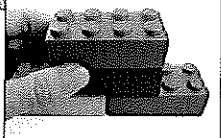
International Energy Conservation Code



Clearly, we won't be able to teach you all of the IECC today, however.

## Navigating the Code

We can break it down into manageable parts, and show you how to find the information that you need.



**Quickly!**  
Quickly!

## Chapters

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The book is broken down into Chapters to discuss major categories of information

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Please note that all Chapters of the IECC are included in the MUBEC

## General Comments

*Part I—Administrative*

**Chapter 1:  
Scope and Administration**

*General Comments*

Each chapter starts with some general comments about the material that will be covered.

This information can be helpful to when interpreting code or trying to explain details to others.

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## General Comments

*Part I—Administrative*

The comments also provide a briefing on each section in the chapter.

This gives you a speedy snapshot of what is covered in each section.

**Chapter 1:  
Scope and Administration**

*General Comments*

## General Comments

*Part I—Administrative*

**Chapter 1:  
Scope and Administration**

*General Comments*

Finally, a purpose statement is provided to give specific meaning and importance of the chapter

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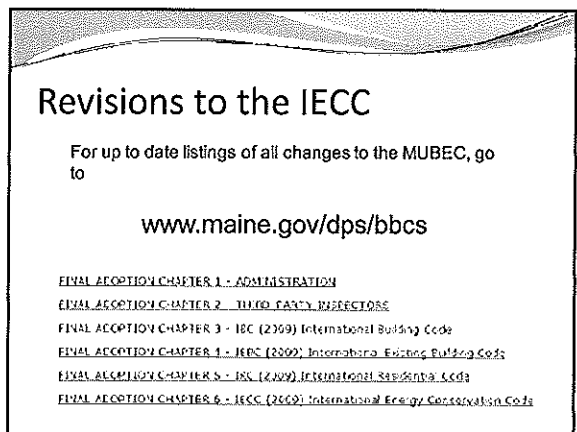
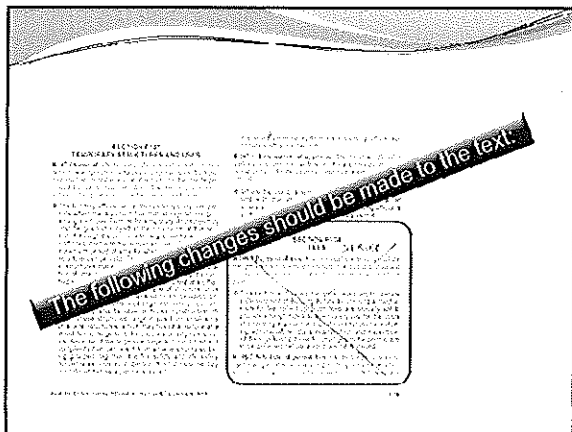
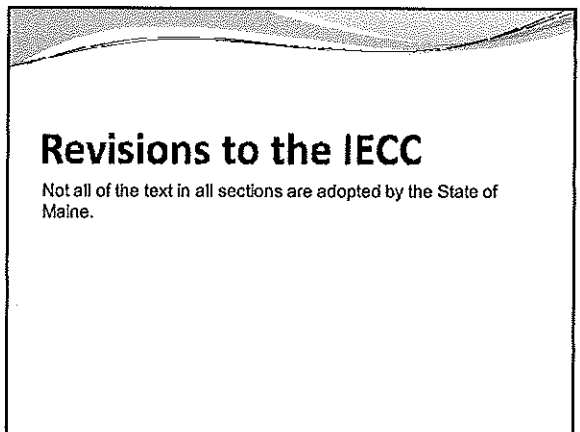
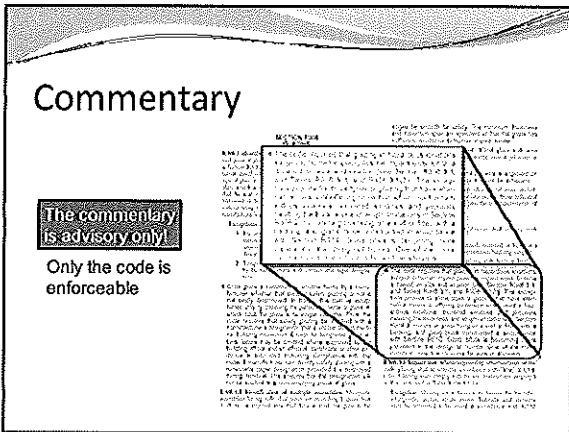
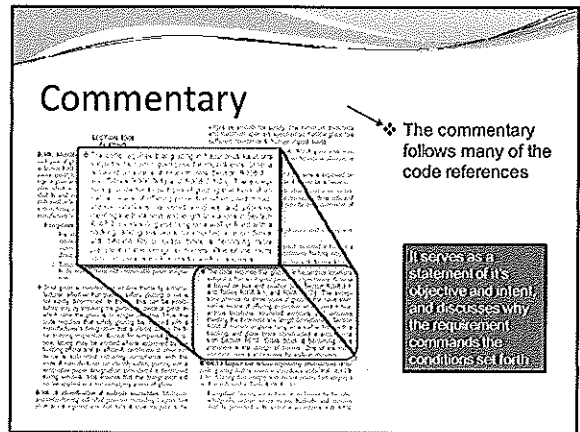
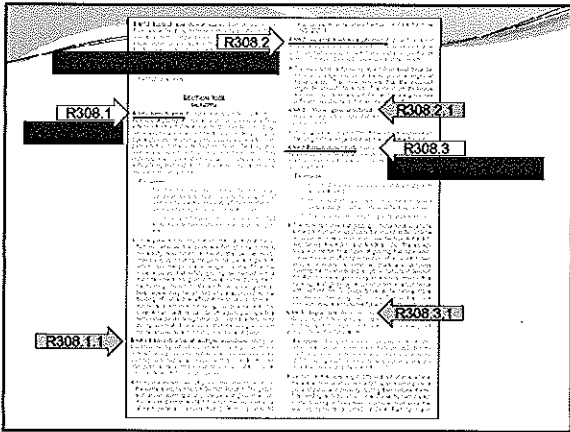
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Sections are further broken down into sub-sections according to more specific topics



### Revisions to the IECC

The following additions, insertions, deletions, and other changes are hereby made to the 2009 International Energy Conservation Code:

Generally all sections  
Delete "International Mechanical Code"  
Insert "applicable state codes and statutes"

- o Except for the specific Sections below where references to International Mechanical Code are specifically deleted and/or altered.

### Revisions to the IECC

The following additions, insertions, deletions, and other changes are hereby made to the 2009 International Energy Conservation Code:

Section 101.1  
Delete [NAME OF JURISDICTION]; and  
Insert "State of Maine" in its place.

### Revisions to the IECC

Sections 103, 104, and 108, and any amendments thereto shall only be applicable:

A. In a municipality with a population of 4,000 or more residents, beginning:

- (1) No later than December 1, 2010, if the municipality had previously adopted any building code on or before August 1, 2008; or
- (2) No later than July 1, 2012, if the municipality had not adopted any building code on or before August 1, 2008.

B. In a municipality with a population of less than 4,000 residents, if the municipality voluntarily elects to enforce the MUBEC.

### Revisions to the IECC

Section 101.4.7  
Insert "No provisions of the MUBEC shall be construed to prohibit the adoption or enforcement of an ordinance of any political subdivision that sets forth provisions for local enforcement of building codes.

Such ordinances may include items such as permits, fees, boards of appeals and violations."

### Revisions to the IECC

Section 107  
Delete Section R107 "Fees" in its entirety, without substitution.

### Revisions to the IECC

Section 109  
Delete Section 109 "Board of Appeals" in its entirety, without substitution.

### Revisions to the IECC

Section 402.4.2.1  
Delete "33.5 psf (50 Pa)" at the end of the first sentence and insert "50 Pa (1 psf)" in it's place.

### Revisions to the IECC

Section 403.9.1  
Insert "or LPG" after "natural gas".

### Revisions to the IECC

Section 503.2.5  
Delete "Chapter 4 of the International Mechanical Code" and insert "ASHRAE 62.1 – 2007" in it's place for both occurrences.

### Revisions to the IECC

Section 503.2.6.1  
Delete "(as established in Table 403.3 of the International Mechanical Code)", without substitution.

### Revisions to the IECC

Section 503.2.6  
Delete Exception 1 "Where energy recovery systems are prohibited by the International Mechanical Code," with no substitution.

### Revisions to the IECC

Section 503.2.7.1  
Delete "the International Mechanical Code" and insert "NFPA 90A" in it's place.

### Revisions to the IECC

Section 503.2.9.1  
Delete "in accordance with the requirements of Chapter 6 of the International Mechanical Code" without substitution.

### Revisions to the IECC

Section 503.3.1 Exception 2  
Delete Exception 2 "in order to meet the minimum ventilation requirements of Chapter 4 of the International Mechanical Code" without substitution.

### Revisions to the IECC

Section 503.4.5, Item 3  
Delete "Chapter 4 of the International Mechanical Code" and insert "ASHRAE 90.1-2007" in it's place.

### Revisions to the IECC

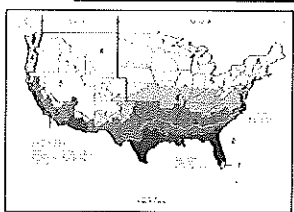
Chapter 6, First Paragraph  
Delete "107" from the end of the last sentence and insert "106" in it's place.

### Tables and Figures

TABLE 503.2.10.1  
Minimum Ventilation Requirements


TABLE 503.2.10.2  
Minimum Ventilation Requirements

There are many tables and figures, conveniently numbered by the sub-sections that they apply to



Climate Zone	Minimum Ventilation Rate (cfm/sq ft)
1	0.06
2	0.07
3	0.08
4	0.09
5	0.10
6	0.11
7	0.12
8	0.13
9	0.14
10	0.15
11	0.16
12	0.17
13	0.18
14	0.19
15	0.20
16	0.21
17	0.22
18	0.23
19	0.24
20	0.25
21	0.26
22	0.27
23	0.28
24	0.29
25	0.30
26	0.31
27	0.32
28	0.33
29	0.34
30	0.35
31	0.36
32	0.37
33	0.38
34	0.39
35	0.40
36	0.41
37	0.42
38	0.43
39	0.44
40	0.45
41	0.46
42	0.47
43	0.48
44	0.49
45	0.50
46	0.51
47	0.52
48	0.53
49	0.54
50	0.55
51	0.56
52	0.57
53	0.58
54	0.59
55	0.60
56	0.61
57	0.62
58	0.63
59	0.64
60	0.65
61	0.66
62	0.67
63	0.68
64	0.69
65	0.70
66	0.71
67	0.72
68	0.73
69	0.74
70	0.75
71	0.76
72	0.77
73	0.78
74	0.79
75	0.80
76	0.81
77	0.82
78	0.83
79	0.84
80	0.85
81	0.86
82	0.87
83	0.88
84	0.89
85	0.90
86	0.91
87	0.92
88	0.93
89	0.94
90	0.95
91	0.96
92	0.97
93	0.98
94	0.99
95	1.00
96	1.01
97	1.02
98	1.03
99	1.04
100	1.05

Some tables contain numerous notes and conditions which must be considered to arrive at an accurate determination of the data



### Using Tables and Figures

Let's take a look at Table 402.1.1

- o What is the required R value for a heated slab in Zone 2?

### Using Tables and Figures

Let's take a look at Table 402.1.1

- o What is the required slab edge R value and insulation depth for a heated slab in Zone 6?

### Using Tables and Figures

Let's take a look at Table 402.1.1

- o What is the required ceiling (attic) R value in Zone 6?

### Using Tables and Figures


Let's take a look at Figure 402.2.1(1)

Please note the (1) indicates this is the first table in a series in Sub-section 402.2.1.

How would the applicant comply with the requirement for R-49 insulation in the portion of the attic near the eaves, where it is not possible to achieve the full thickness of the insulation?

### Using Tables and Figures

Let's take a look at Table 402.2.1(2)



Please note the (2) indicates this is the second table in a series in Sub-section 402.2.1.

Notice the advantage of the raised heel truss system from an energy perspective.

Consider the increased R value near the eave, where R value is typically very low.

### Using Tables and Figures

Let's take a look at Table 402.4.2

What is the requirement for air barrier and insulation inspection component criteria for ceilings/attics?

### Let's flip over to Chapter 3

The first part of Chapter 3 defines climate zones for the United States.

These serve to establish exterior design conditions and provide general requirements for

- o Interior design conditions
- o Materials
- o Systems
- o Equipment

### Let's flip over to Chapter 3

The climate zones are referred to throughout the codes to help you to determine

- o Required wall and roof insulation R-values
- o Window and door thermal transmittance requirements (U-factors)
- o Provisions that affect mechanical systems

### Let's flip over to Chapter 3

If you are using a code book that is older than 2006, you will notice many changes in the climate zone map.

A thorough discussion of the zones development can be found at

[www.energycodes.gov/implementation/pdfs/climate\\_paper\\_review\\_draft\\_rev.pdf](http://www.energycodes.gov/implementation/pdfs/climate_paper_review_draft_rev.pdf)

Climate Classification for Building Energy Codes and Standards

### Let's take a look at Figure 301.1

CLIMATE ZONE MAP

Notice that all of Maine except for Aroostook County is in Climate Zone 6A

#### Energy Compliance Certificate

Geographic Area	State
Address	City
Project Name	Project No.
Contractor Name	Contractor License No.
Inspector Name	Inspector License No.
Inspector Title	Inspector Signature
Inspector Date	Inspector Seal

401.3 requires a certificate of compliance be posted on or in the electrical distribution panel.

#### Energy Compliance Certificate

Geographic Area	State
Address	City
Project Name	Project No.
Contractor Name	Contractor License No.
Inspector Name	Inspector License No.
Inspector Title	Inspector Signature
Inspector Date	Inspector Seal

Your handout illustrates the minimum listing requirements for the certificate.



## Additional Training Materials

Additional training materials and... your homework assignment are available at

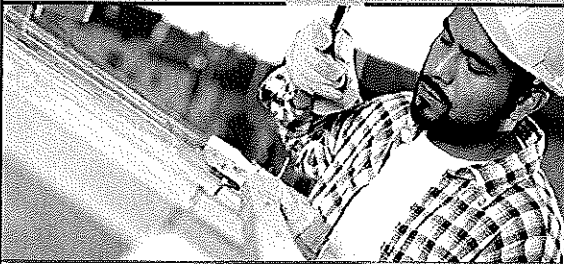
[www.energycodes.gov](http://www.energycodes.gov)

- o Recertification credit can be obtained for REScheck Basics Webcast

## Homework??? Yikes!

[www.energycodes.gov/becu/documents/2009iecc\\_residential\\_BECU.ppt](http://www.energycodes.gov/becu/documents/2009iecc_residential_BECU.ppt)

**BUILDING ENERGY CODES UNIVERSITY** **ENERGY** Energy Efficiency & Renewable Energy




Residential Requirements of the 2009 International Energy Conservation Code  
August 2010  
PHD-08-003

## The “New School” of Building Science

Now... before we talk about Energy Code...

Let's talk about some “new school” energy fundamentals!

This will also help you to understand where all of this energy code came from.



### Goals of the Energy Industry

- Create safe indoor environment
- Increase occupant comfort
- Save money and energy
- Extend dwelling life
- Conserve natural resources!

**But my Dad did it this way!**

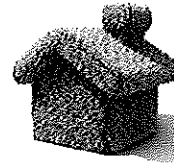
Construction training has always been essentially a guild system where people learn on the job from someone who learned the same way.



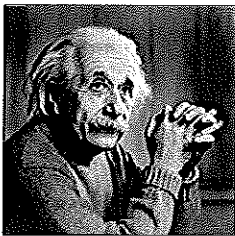
Essential skills are transferred primarily by observation, trial & error, and traditional "best practices".



Energy professionals are being trained in a new skill set, beginning with a new way to look at buildings.



Albert Einstein had a great and well fitting analogy...



Albert Einstein

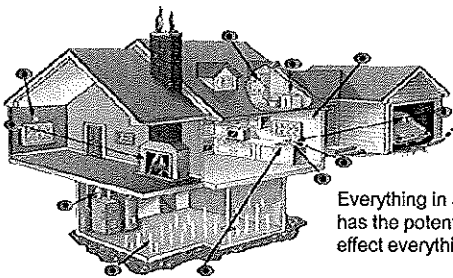
"The problems we face cannot be solved with the same thinking that created them."

**Why those old methods do not work anymore**

Houses are:

- Smaller
- Tighter
- Have more exhaust appliances
- Have weaker natural draft combustion appliances
- Have less drying potential

**We have to look at the entire building as a system**



Everything in a house has the potential to effect everything else!

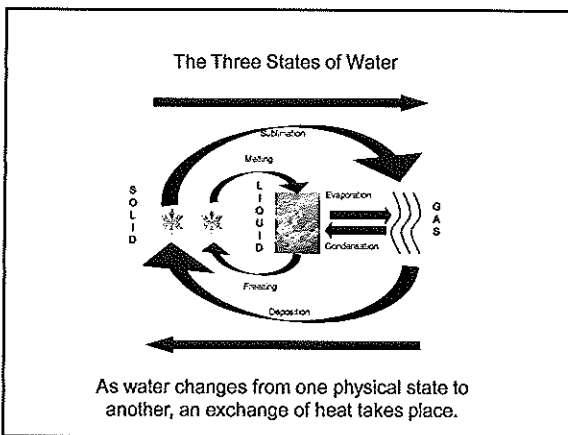
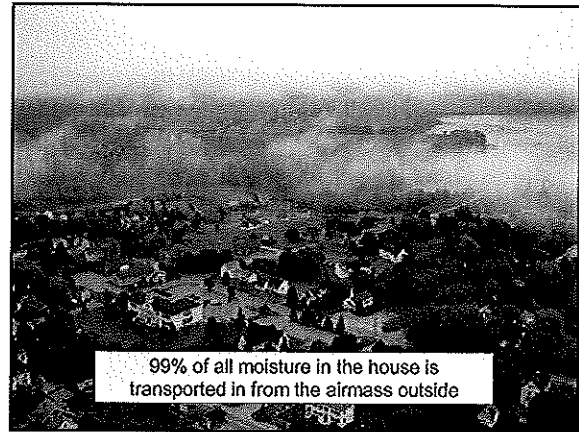


Including the people



### Moisture

- Moisture can be a pollutant when weatherizing
- Wet basements & crawlspaces are particularly troublesome
- 99% of moisture is transported into the house from outside
- When moisture is found its way in, so do other contaminants and toxins



### Fans and Exhausting Appliances

- Bathroom fans
- Range hoods
- Dryer vents
- Air conditioners
- Air handlers

Contents

- Ducting
- Heat Loss
- Minimum Ventilation Req.
- Managing Ventilation

### Fans and Exhausting Appliances

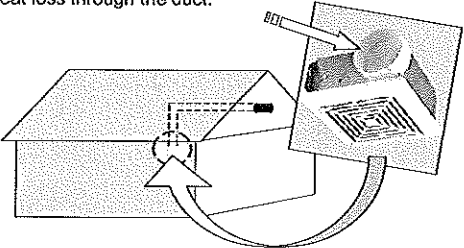
All fans must be ducted to the building exterior, preferably through the gable end.

### Fans and Exhausting Appliances

All duct joints must be sealed with appropriate sealant.

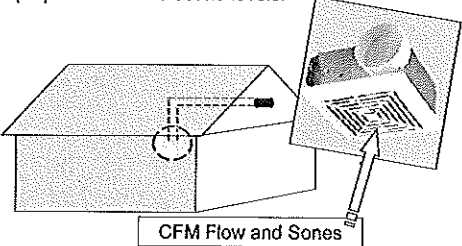
### Fans and Exhausting Appliances

All ducted appliances should have a flap to prevent heat loss through the duct.



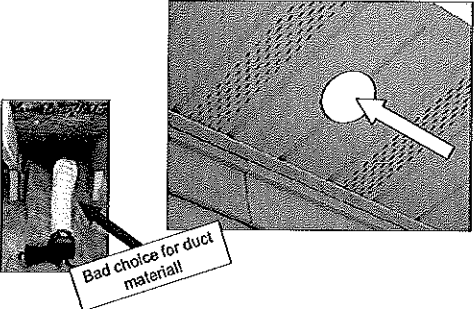
### Fans and Exhausting Appliances

Your energy auditor will recommend correctly sizing for proper airflow and sound levels.



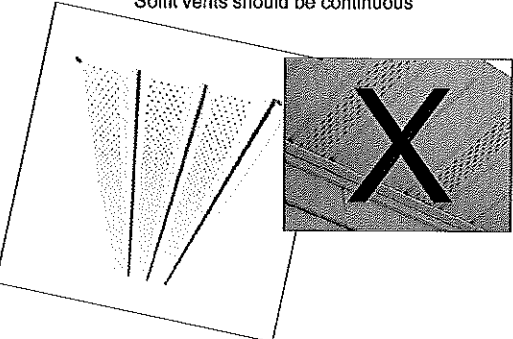
CFM Flow and Sones

If you can't vent through the gable end, you can go through the eave soffit

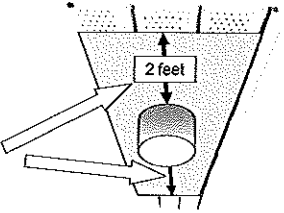


Bad choice for duct material!

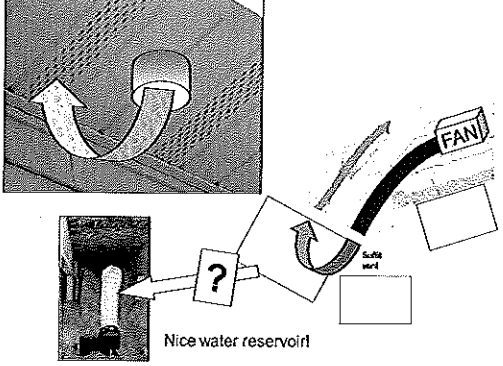
Soffit vents should be continuous



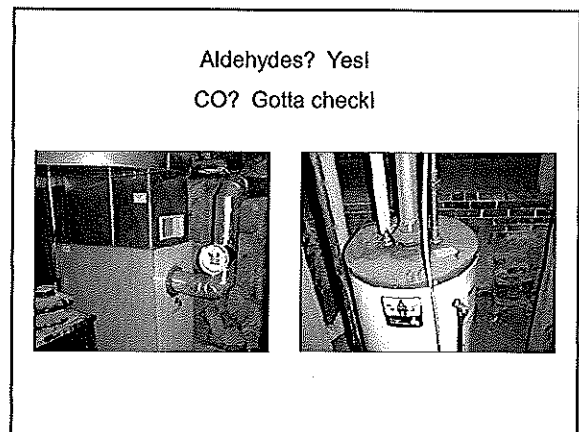
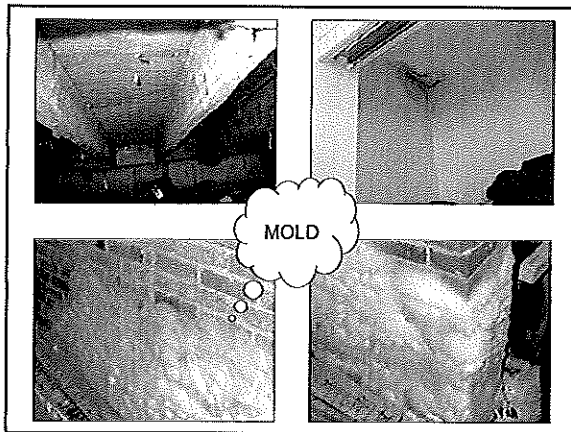
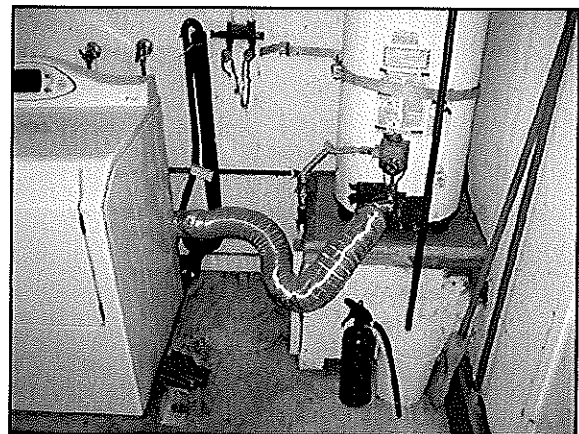
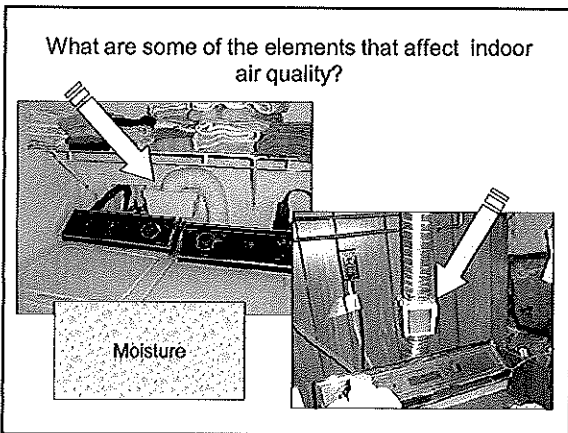
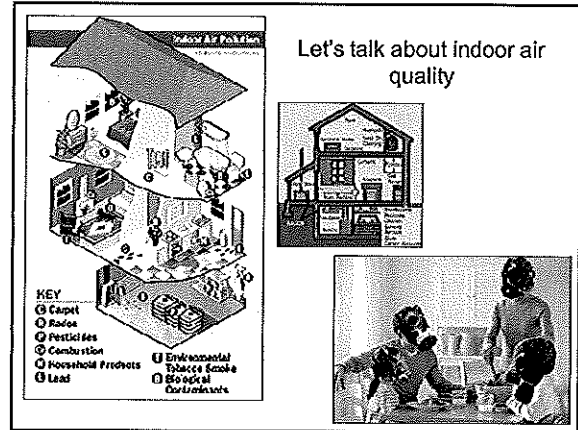
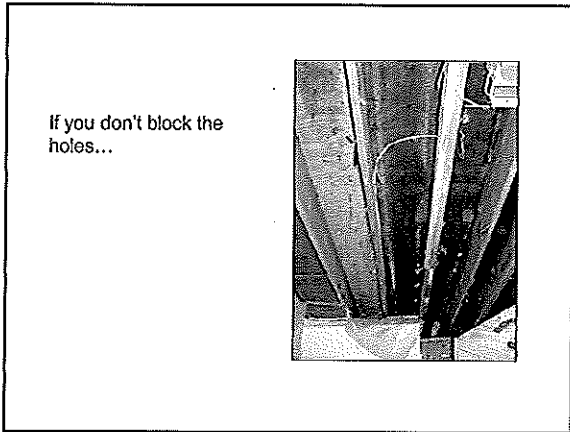
If you are going to vent through the soffits, you must block the vent holes 2 feet either side of the vent stack.




2 feet



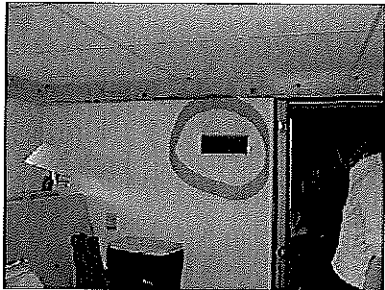
Nice water reservoir!



### Depressurization and Back Drafting

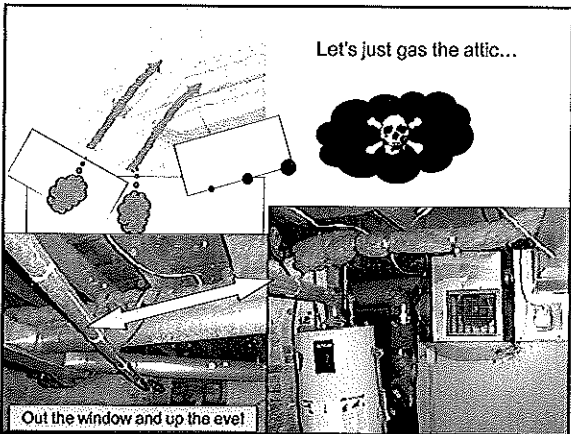


carbonmonoxidekills



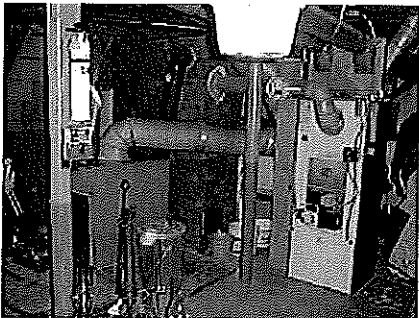
Furnace back drafting combined with return duct leaks

Let's just gas the attic...




Out the window and up the eave!

Anything wrong here?



### Weatherizing Single Family Homes


- Air seal
- Insulate attic
- Insulate walls
- Insulate basements
- Typical savings 20%



### Weatherizing your Home



Involves understanding and attacking

- Air transported Heat Loss
- Conductive Heat Loss



Lets look at

### Air Transported Heat Loss

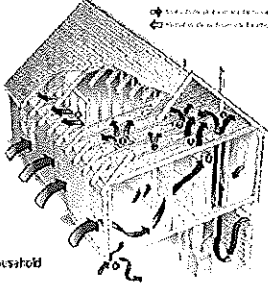



### The Three(?) Air Leak Drivers

1. Stack Effect
2. Wind
3. Mechanical Ventilation

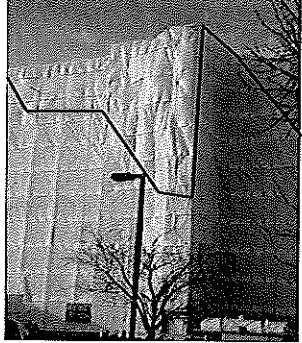
4. *And sometimes Duct Leaks*

#### Effects of Air Leaks



Common Household Air Leaks

- Attic doors
- Attic hatches
- Windows
- Roof leaks
- Open to the outside
- Basement light
- Pressure of Duct
- Cracks in the wall or floor
- Open to the outside
- Basement floor
- Basement walls



Sometimes, stack effect is quite obvious

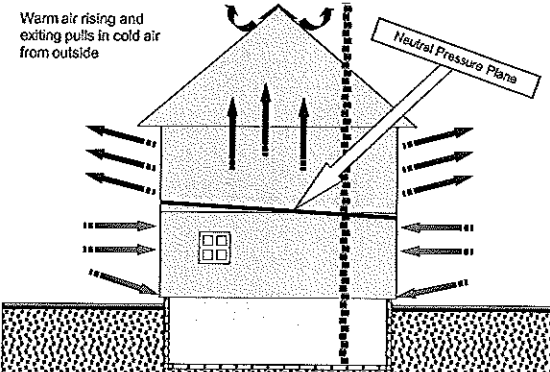
### We must also understand that...

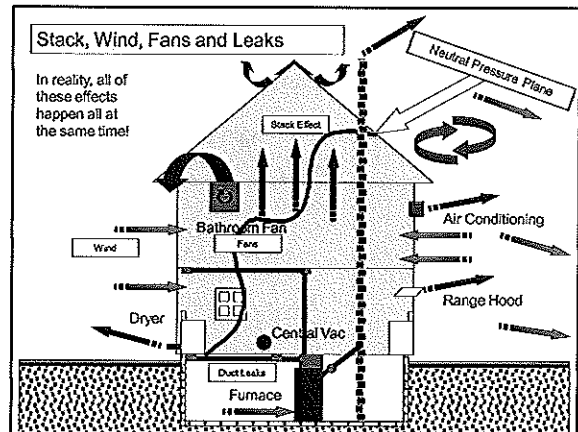
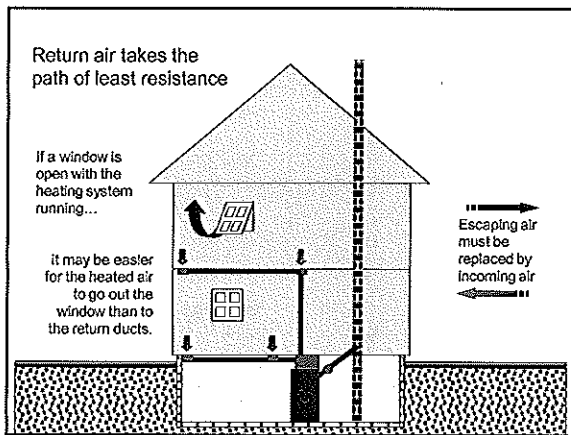
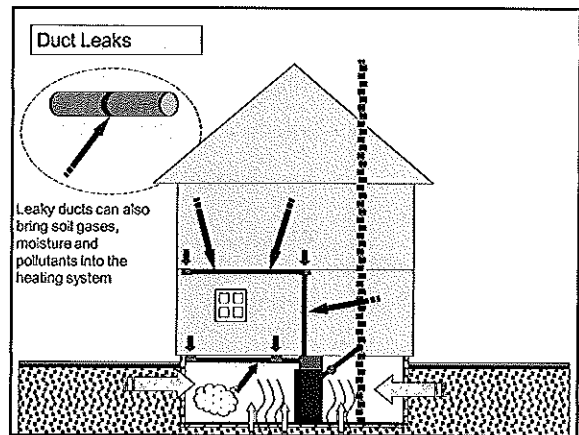
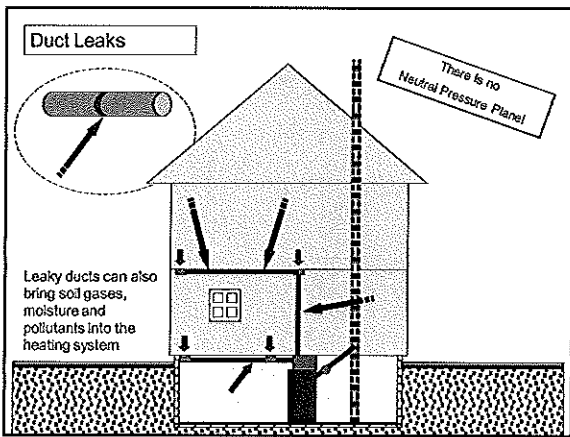
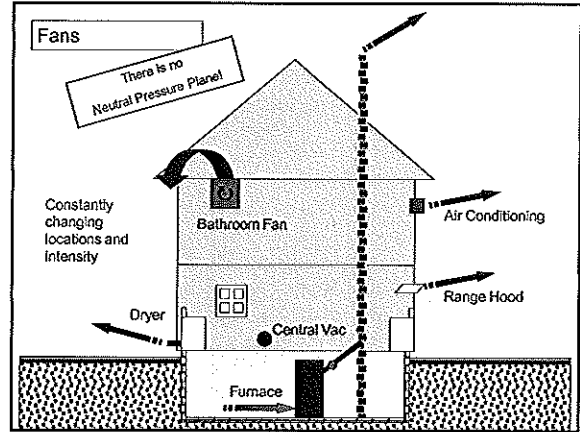
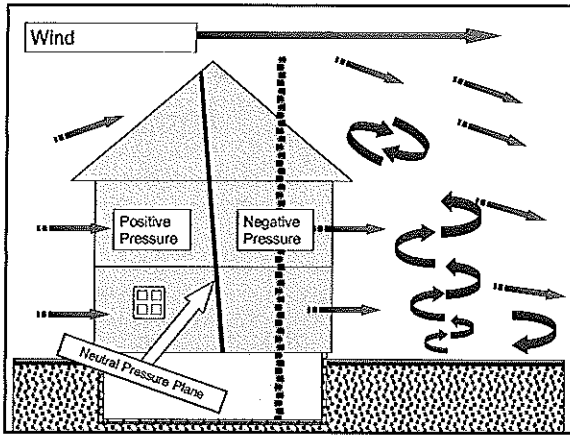
Stack Effect  
Wind  
Mechanical Ventilation and  
Duct leaks

⇒ Are all in a constant state of change  
⇒ All happen simultaneously

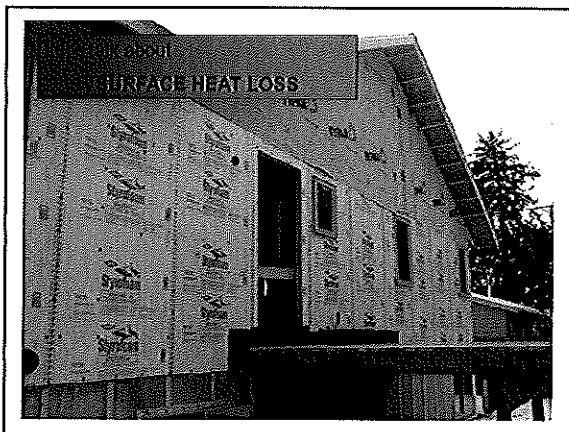
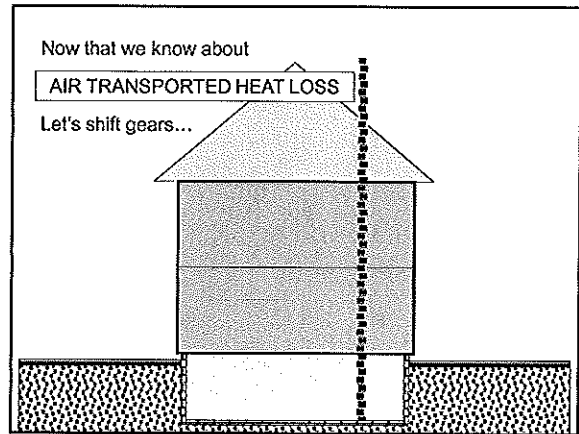
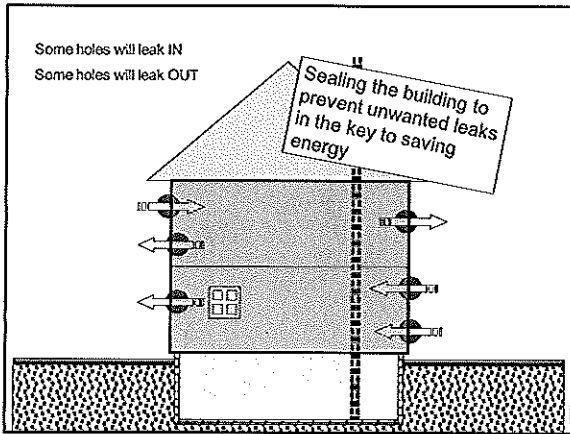
### Stack Effect

Warm air rising and exiting pulls in cold air from outside









Heat moves by three methods

- Conduction
- Convection
- Radiation

### CONDUCTION

The movement of heat through a solid.  
Conduction requires physical contact

The pans are in contact with the burners. Heat is conducted from the burners to the bottom of the pans via solid surface contact.

If you touch the pot, conductive heat will burn your hand.

### CONVECTION

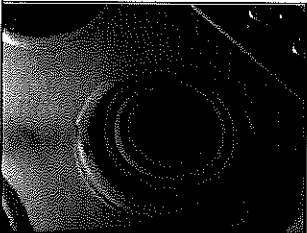
The movement of heat through a fluid.  
Air is a fluid (Bernoulli's Principle)

Heat rises as cooler fluid moves in to fill the void. The circulation of the water in the pot is a convective flow.

### RADIATION

The movement of heat in the form of rays sent through space.

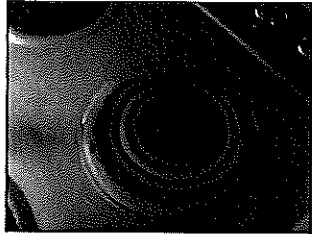
Radiation does not need physical contact or a medium!



Heat is radiating from this burner, warming any adjacent matter.

Everything radiates or absorbs heat all the time.

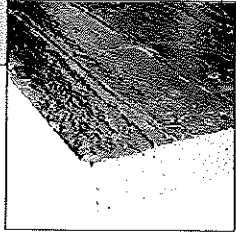
All three mechanisms can happen concurrently



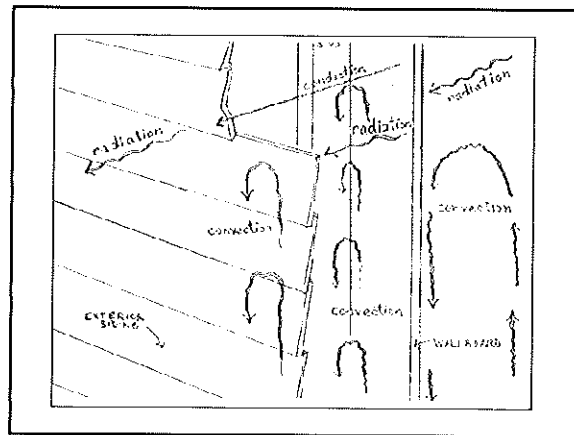
Radiation is warming the air adjacent to the burner  
The warmed air is rising due to Convection.  
If the ceiling is shiny, some heat may be radiated back into the room.

The brackets supporting the burner are being heated by conduction, in turn heating the metal stovetop.

Insulation reduces conductive and convective movement by trapping small pockets of air.



Reflective insulation slows radiation?



### Keeping heat in requires

Reducing conduction, convection & radiation  
and  
Stopping air movement

All of these must occur in the same plane

### Why in the same plane?

- Heat has the potential to escape by any of the three mechanisms at any given time. Stopping one without dealing with the others is pointless.
- Dealing with surface heat loss without considering air transported heat loss is also pointless.
- Insulation does not effect air sealing nor can it perform as designed without air sealing.
- Beyond that, it is necessary that insulation & air sealing occur at the same plane and be in contact with each other.

### So what is the building envelope?

Pressure Boundary (structure)  
 Thermal Boundary (insulation)  
 Vapor Barrier (moisture shield)

The three together make up the building envelope

### The building envelope

All barriers & boundaries have to be in contact with each other

### Why in contact?

**Air transported heat loss**  
 By convection (stack effect), room air freely moves through the ceiling & insulation, warming the area between the ceilings to the same temperature as the room below.

The heat is then lost to the attic via conduction through the un-insulated ceiling.

**Air tight plaster ceiling**  
**Non air tight suspended ceiling**

This configuration slows heat transfer, but, given enough time, the same amount of heat is lost as would be without the insulation!

### Let's reverse the situation

**Conductive Heat Loss**  
 Room heat conducts/radiates through the air tight ceiling, warming the space between the ceilings to the same temperature as the room below.

By convection (stack effect), air above the drywall ceiling freely moves through the broken plaster & insulation, warming the attic to the same temperature as the area between the ceilings.

**Broken/faded plaster ceiling**  
**Air tight dry wall ceiling**

This configuration also slows heat transfer, but again, over time, the same amount of heat is lost as would be without the insulation!

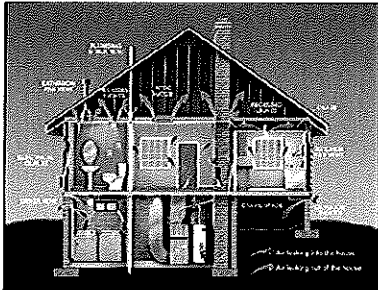
## #1 The First Rule of Boundaries

All barriers & boundaries have to be in contact with each other!

- Ideally, the pressure boundary, the thermal boundary and the vapor boundary (or retarder) should be one & the same.
- If that isn't possible (it often isn't) they must be in physical contact with each other.
- The three together make up the building envelope.

### Some things that need to be done in most houses

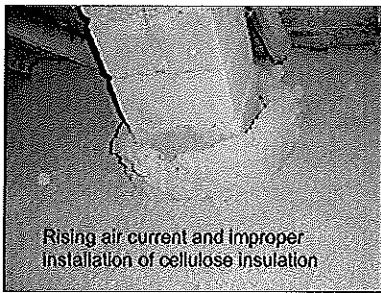
All of those features penetrate the building envelope and contribute to Air Transported Heat Loss



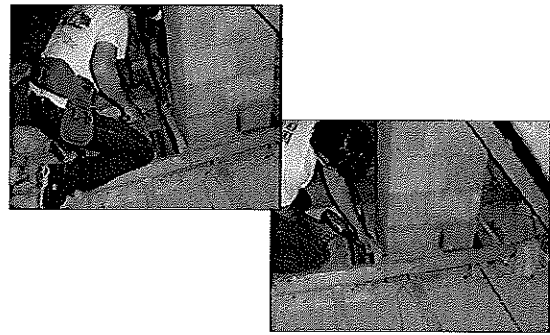
Chimney chase



This is what stack effect looks like!



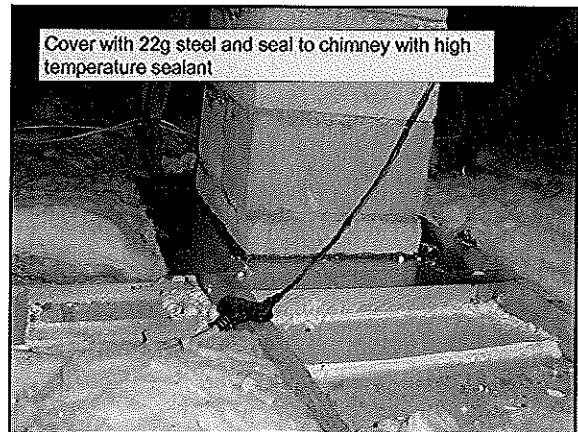
Framing in your chimney seal

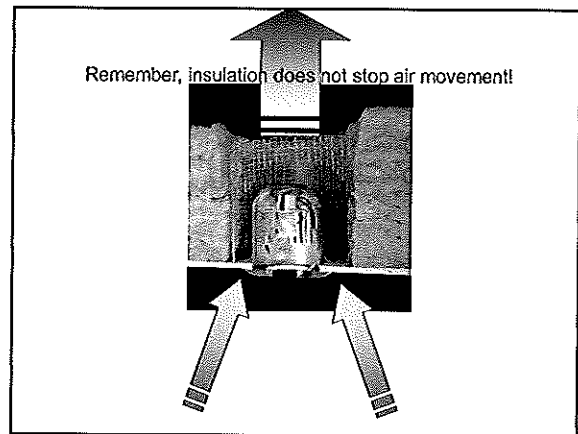
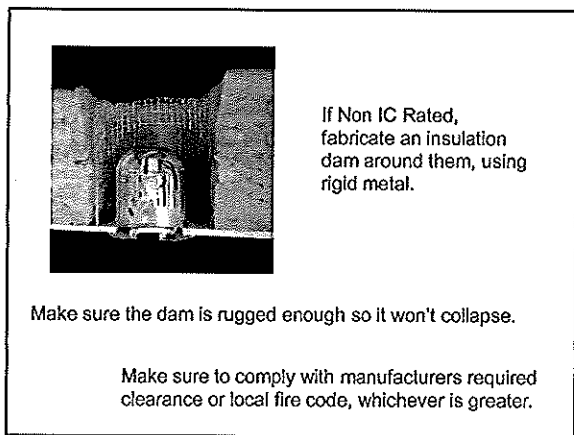
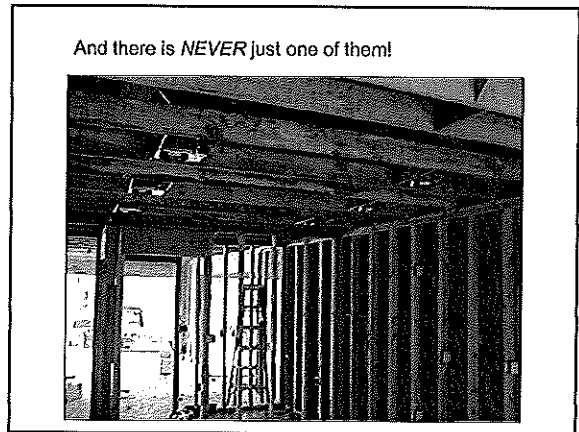
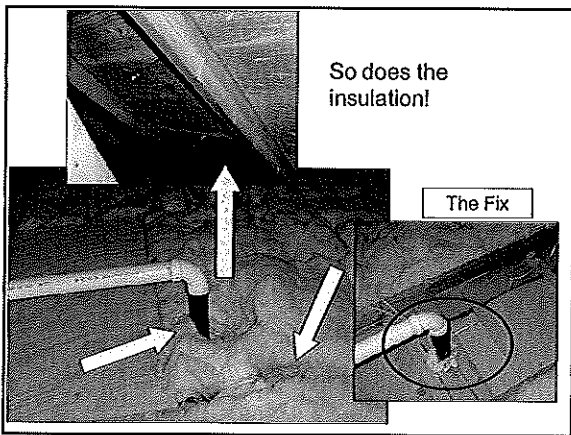
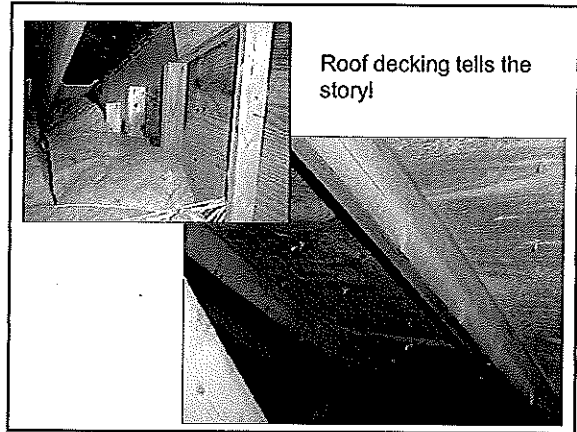
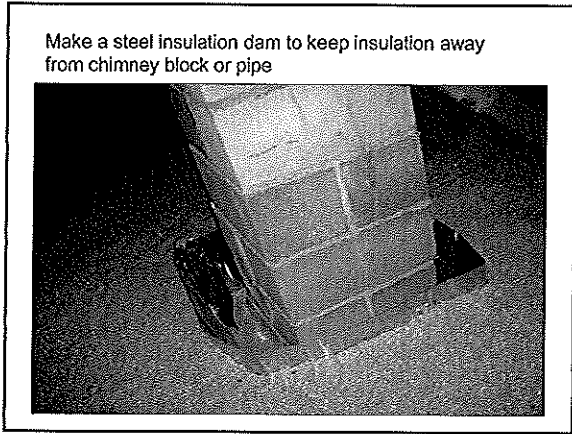


Lay a bead of high temp (2000° plus) sealant on the framing

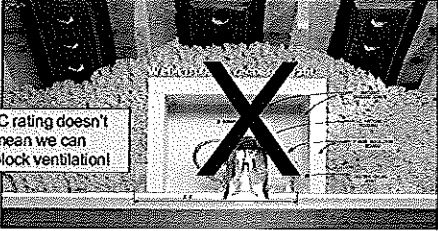


Cover with 22g steel and seal to chimney with high temperature sealant





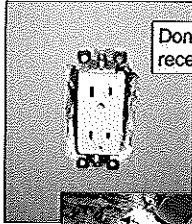
Some people have tried to enclose the fixtures...



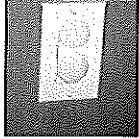
IC rating doesn't mean we can block ventilation!

This may violate fire codes or create fire hazards.

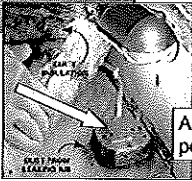
It will almost certainly cause the thermal protection to shut the fixture down.



Don't forget to seal the receptacles and switch boxes

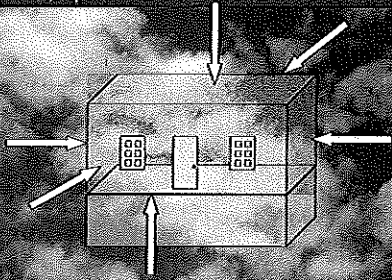


Plug unused receptacles



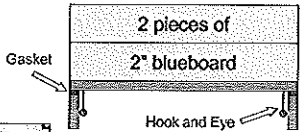
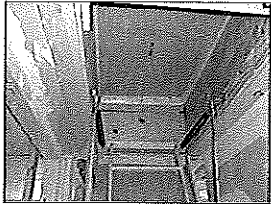
And seal holes and penetrations in junction boxes

The building envelope must be sealed on all sides, top and bottom!

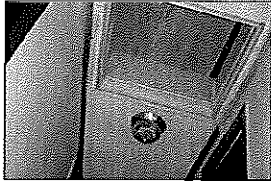


The top might include fold down stairs or hatches

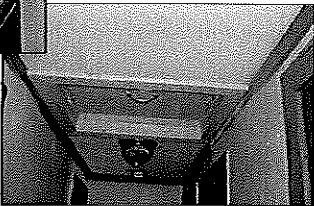
These need an upper "coffin" for the stairs to fold up into

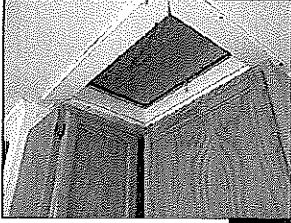
Must be air sealed, gasketed and hooked for a good seal



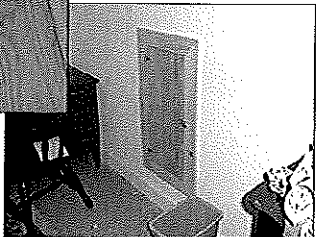
Under construction



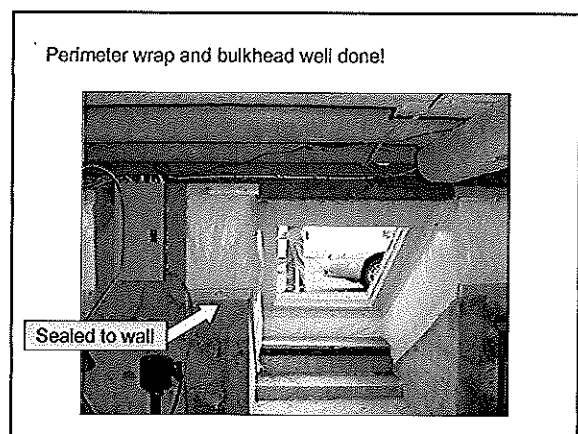
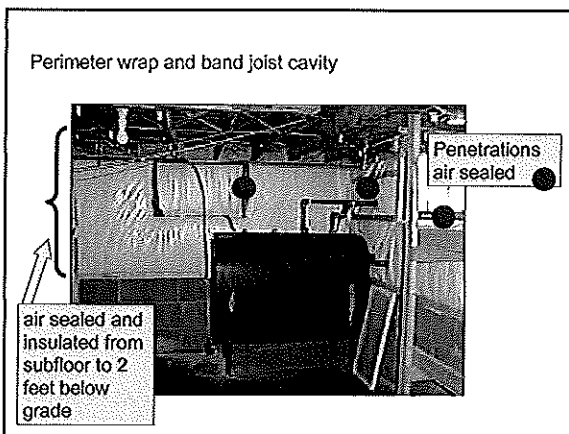
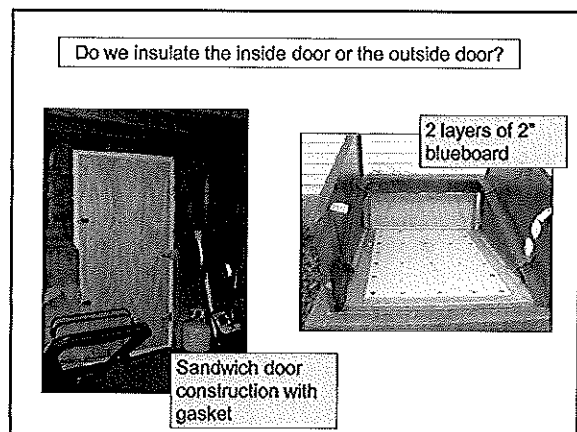
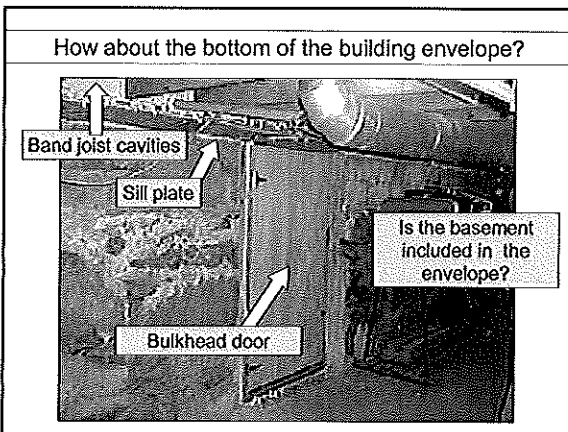
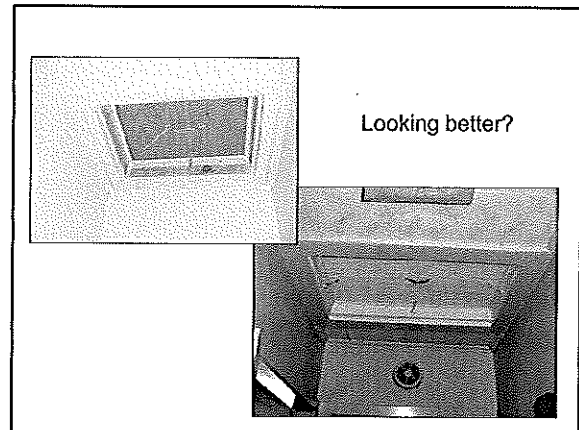
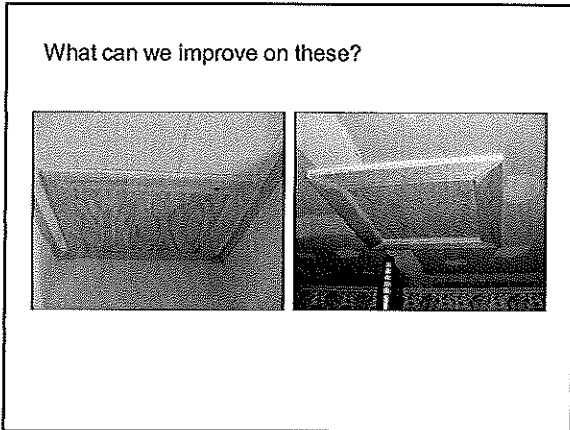
Well done

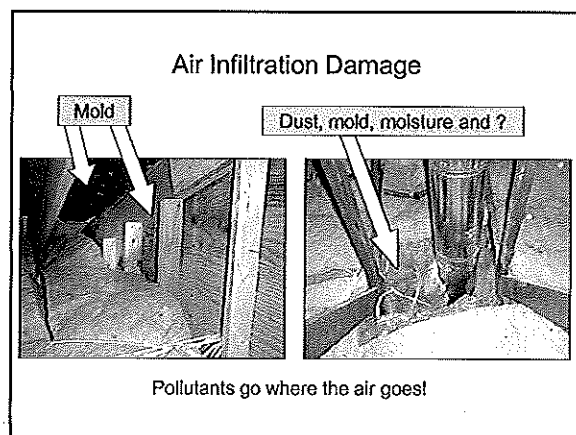
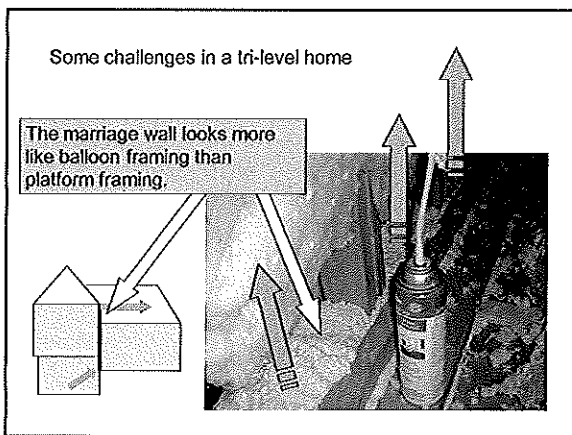
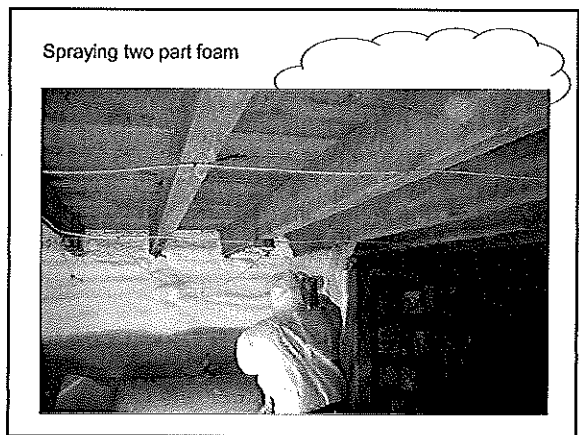
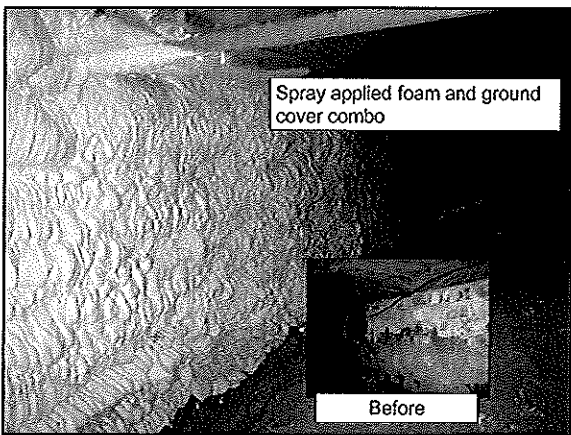
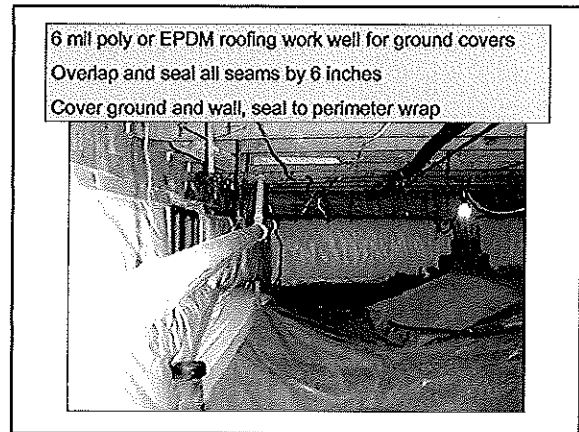
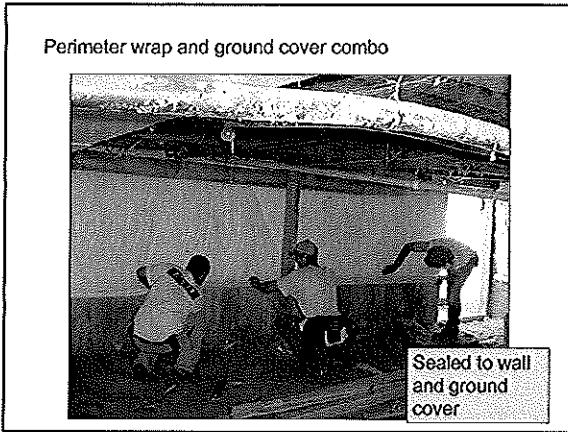


The retrofit

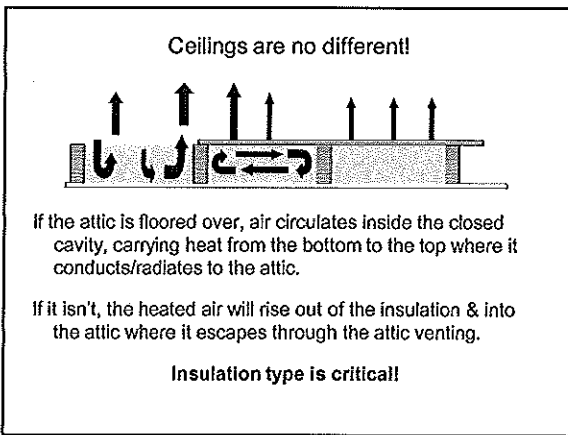
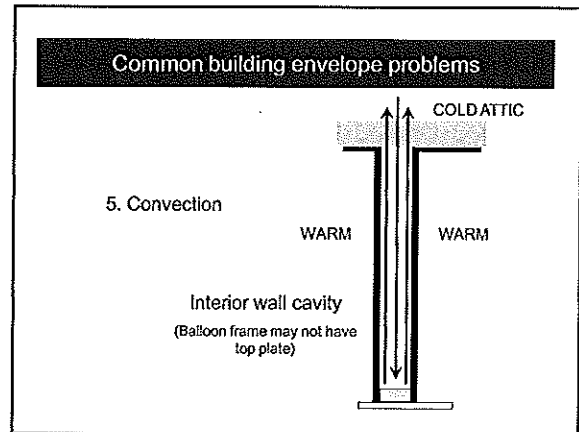
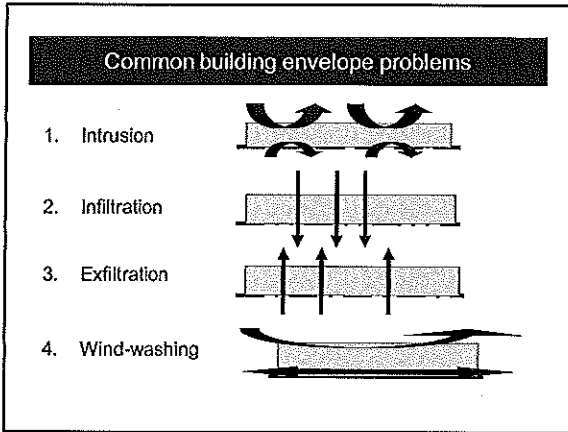


Knee wall hatch



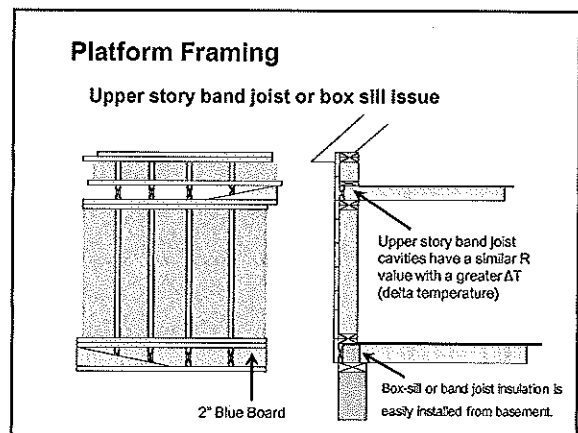
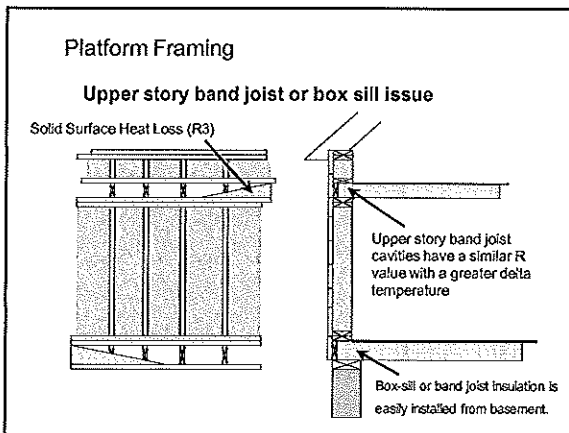


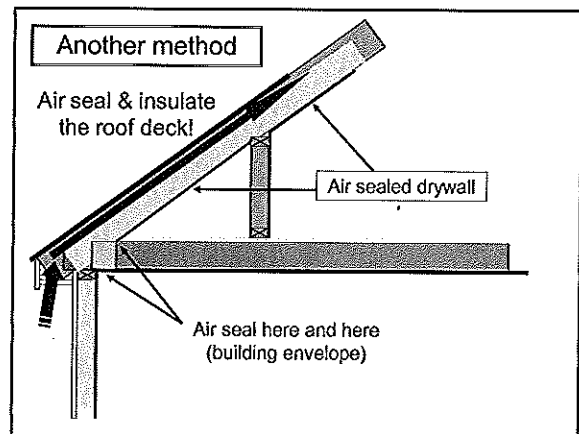
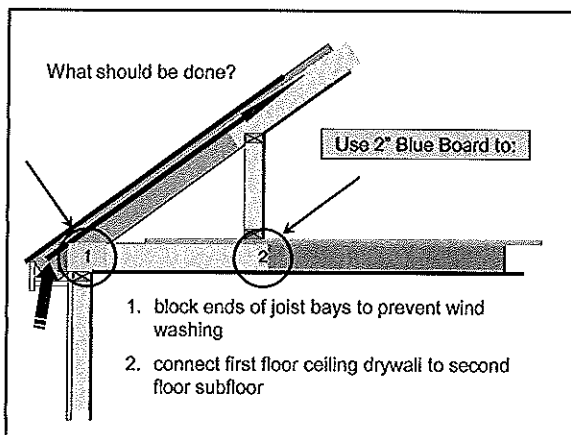
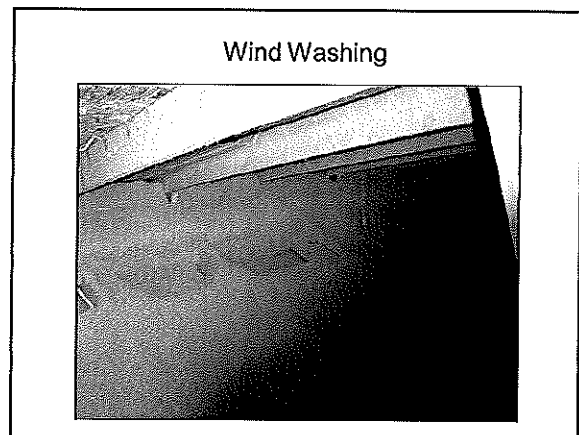
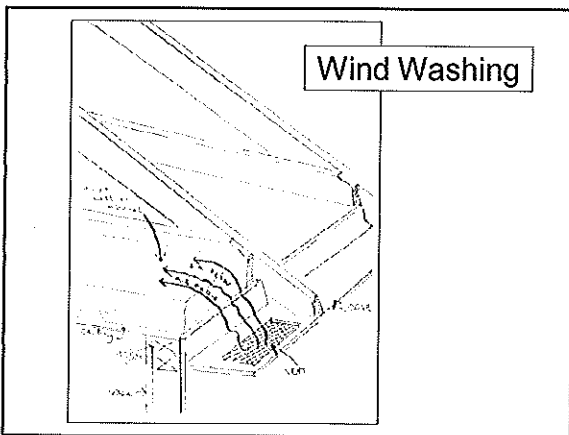
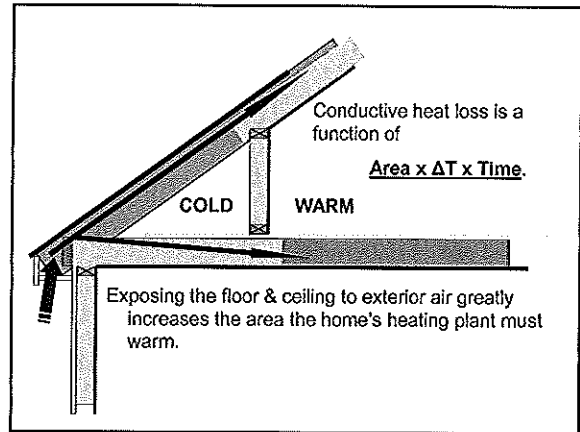
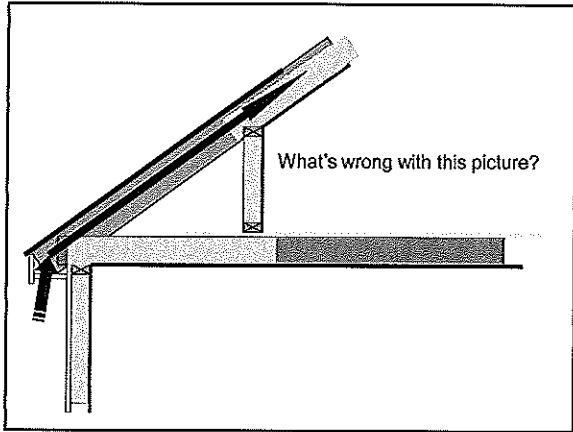


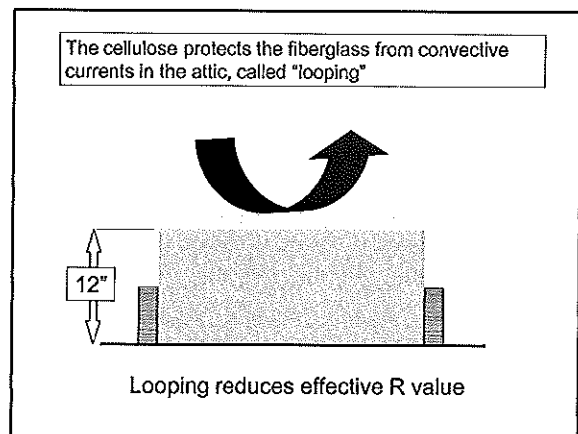
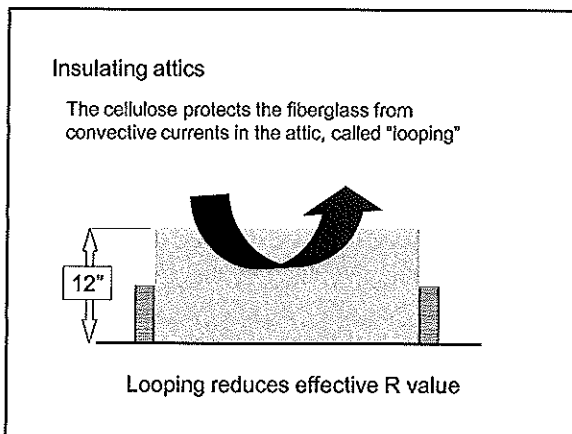
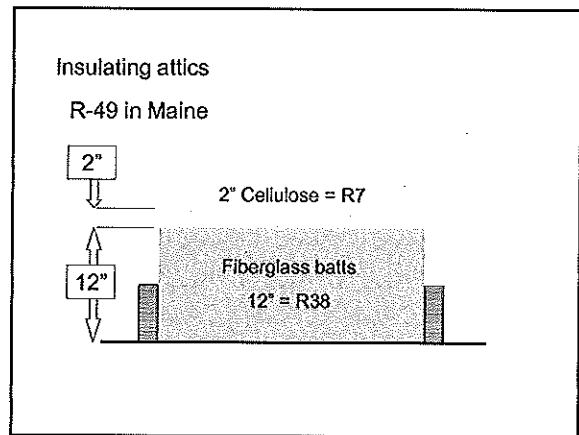
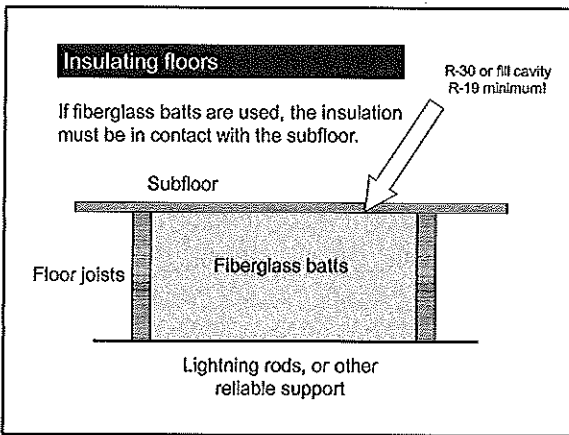
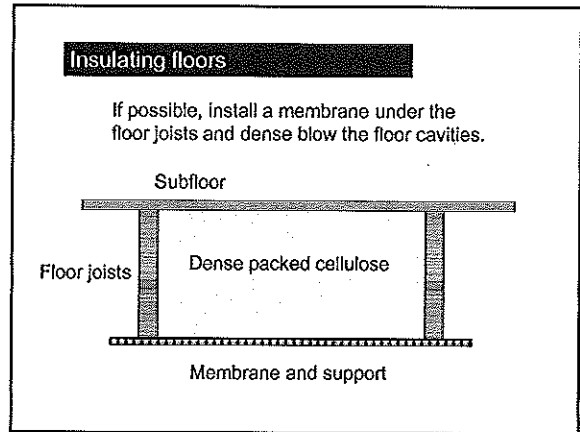
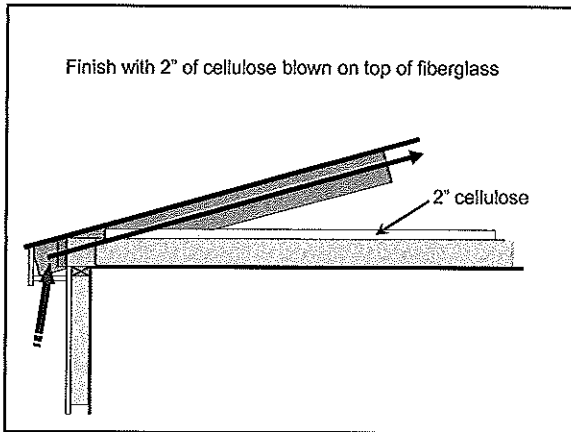


**Remember!**

- Air intrusion, infiltration, exfiltration, wind-washing and looping all go on continuously, depending upon the strength of the drivers & size of the holes.
- Reducing the drivers is impractical.
- Your task is to locate & plug the holes !

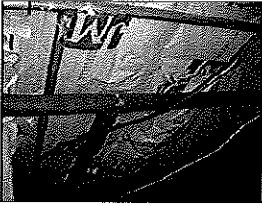
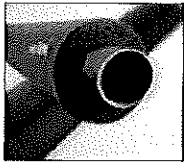






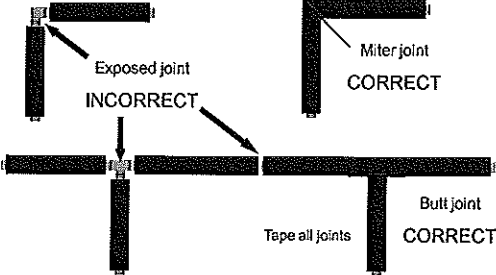
### Insulating pipes

Pipes loose a tremendous amount of heat


The larger the diameter, the more heat they loose per lineal foot

### All hot water pipes should be well insulated




### How can we tell how well we did with our weatherization efforts?

Weatherization Quality Control



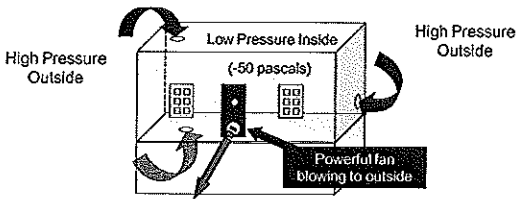
- Blower door
- Infrared imagery
- Digital camera
- Core sampling



### The blower door

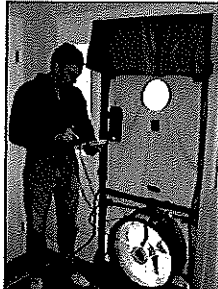

- Creates negative pressure throughout the building envelope. Generally test at -50 pascals
- Very accurate tool to measure total aggregate hole size in building envelope
- Use with smoke or infrared imaging camera to find leaks in building envelope
- Use two finger test to determine which rooms are leaky
- Find holes in attics and basements

### How the blower door works



Fan depressurizes the building envelope to minus 50 pascals with reference to outside

### The blower door test is done to airtightness of the envelope (402.4.2.1)

Or meet the visual inspection requirements of (402.4.2.2)

Inspectors can use the blower door and pressure diagnostics to determine if:

- Attics are connected to basements
- Chimney chases are connected to the house
- Plumbing or electrical chases leak to building envelope
- Some rooms leak more than others
- ...etc.

Pressure doesn't lie!