IR Cameras and Building Insulation Performance

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Infrared Training Center

FLIR Systems, Inc

Outline

Infrared Inspection of Building Envelopes - 2009
Presenter: Jay Bowen, FLIR Systems, Inc.
St. Charles Room A
With increasing energy costs, thermal imaging cameras have quickly become prevalent for commercial and residential building inspection. Building structures commonly exhibit quality and performance problems caused during construction and maintenance that can impact energy performance and, in some cases, render them dangerous. Regardless of the building type involved, infrared imaging has been shown to provide remarkable, nondestructive information about construction details and building performance.
This session will discuss the numerous applications for thermal imaging technology currently being used to inspect building envelopes. These include validation of structural details, verification of energy performance (conduction and air leakage), location of moisture intrusion, and the identification of structural and system degradation of roofs and facades. Examples will be given for each application and the basic conditions required will be discussed.

Cameras

Some cameras were simply easier to use???

Camera

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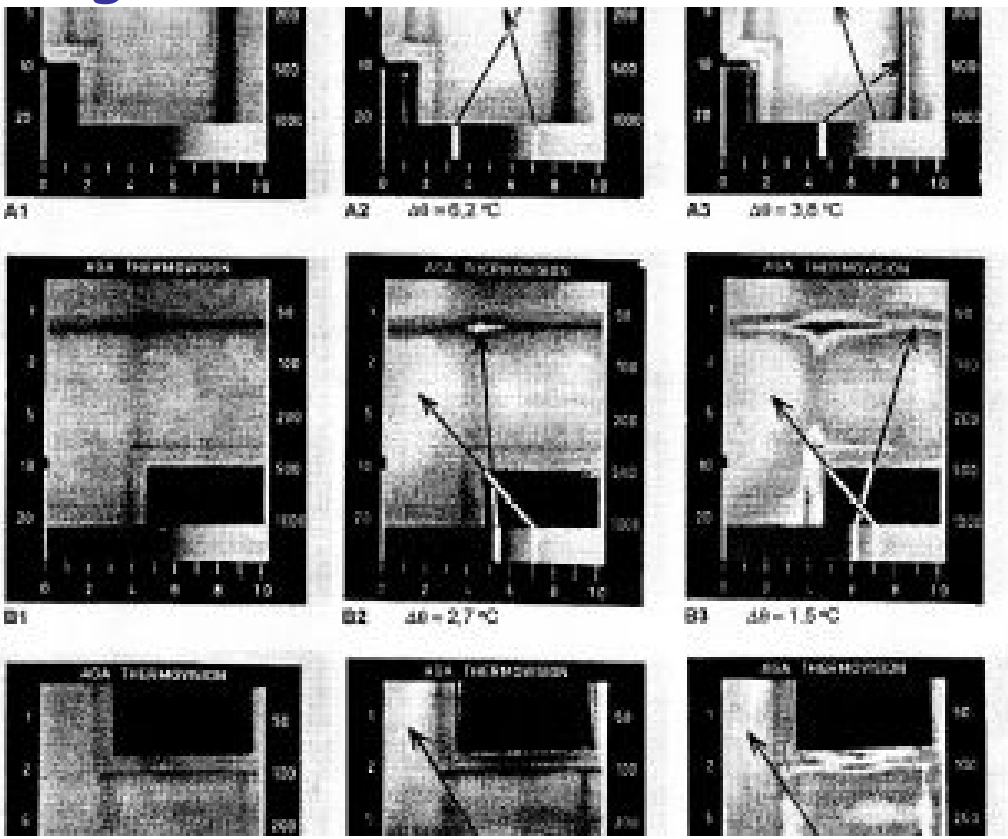
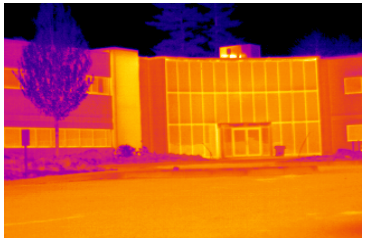
Sample Images from AGA 680 Circa 1972

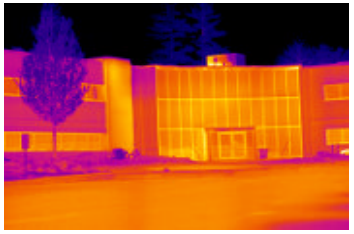


Camera Detectors

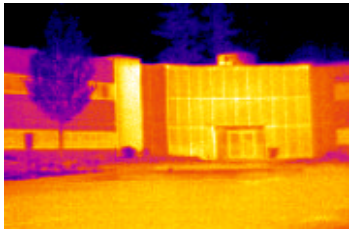
640x480
1 IR Image



320x240
4 IR Images
(1/2 the distance to get same resolution)

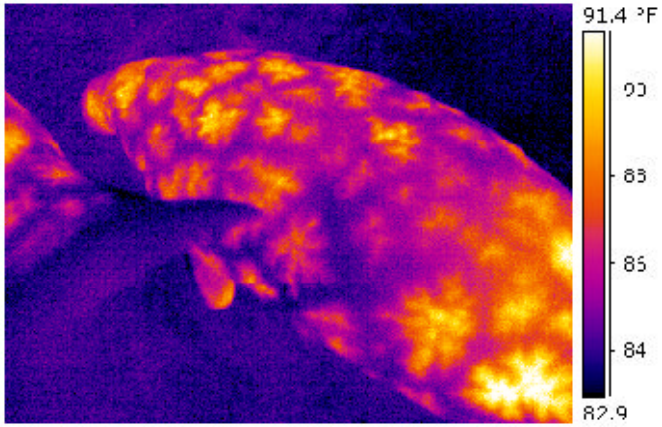


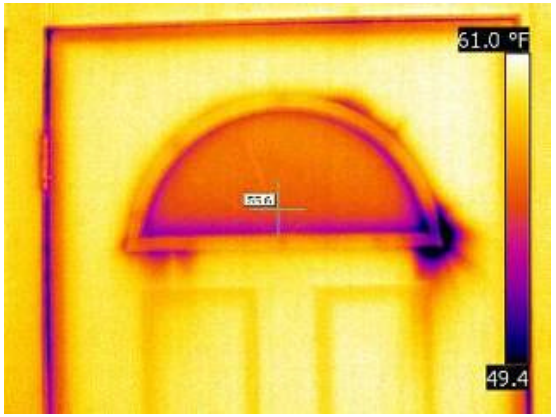
160x120
16 IR images
(1/4 the distance to get same resolution)



Sometimes you can't make it simple

- IR images are easy to get, often difficult to interpret
- The obvious isn't always obvious
- Don't try to make IR easy with simple (but wrong) shortcuts
- Good training can get & keep you on track





IR is Magic

- Just point the IR camera at a target
- Move the measure tool where needed
- Get an accurate temperature
- It's that easy

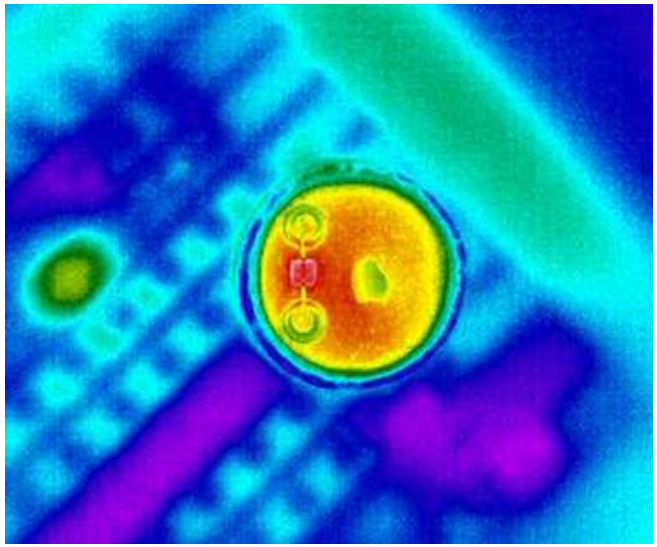
Or is it?

Thermographic Cameras

- Must be within a correct distance
- Must be focused thermally and optically
- Must enter measured object emissivity
- Must enter reflected temperature
- Must be in the correct range

Target Resolution or Spot Size

Small targets



Large targets

Thermal Tuning and Focus

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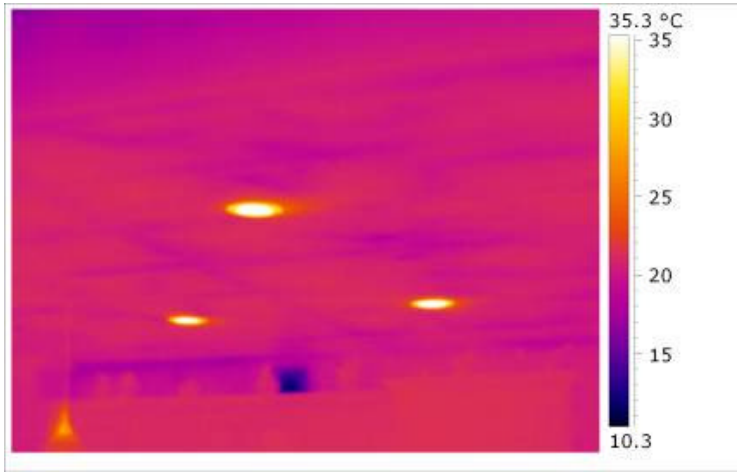
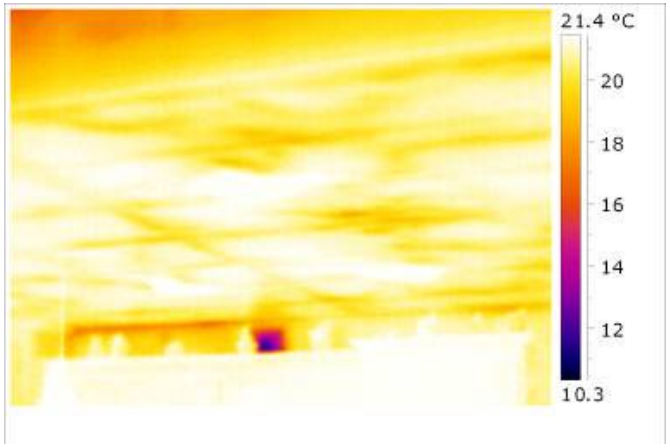
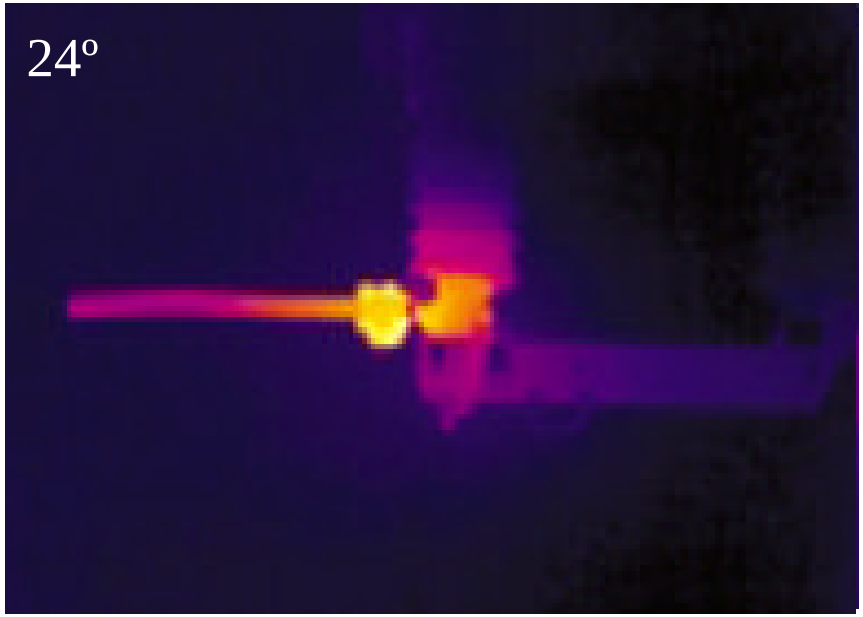
Proper Tuning





Inadequate Tuning

Lens Change for Distance

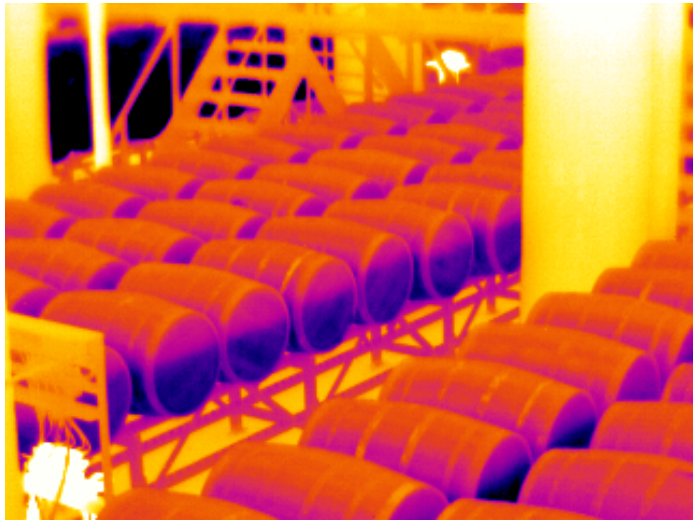


Some cameras are able to change lenses to assist resolution.

Thermal Emissivity

- Efficiency of objects to radiate heat
- For opaque objects: Emissivity (ε) plus reflectivity (ρ) equals one
- High ε means low ρ and vice versa

Target Surfaces



Wood Barrels –
High Emissivity &
Low Reflectivity

Shiny Metal –
High Reflectivity
& Low Emissivity

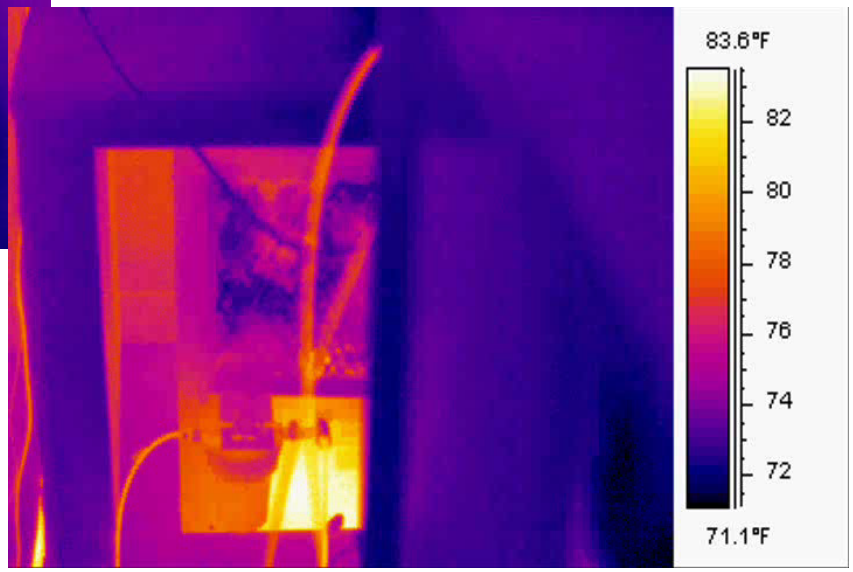
IR Camera Workings

- Capture en flected energy
  - Subtract cted energy,
- Use object normalize to a
- Find tempe alibration table
  - M alette

Target Interpretation

Still or static

Moving or dynamic



Focus

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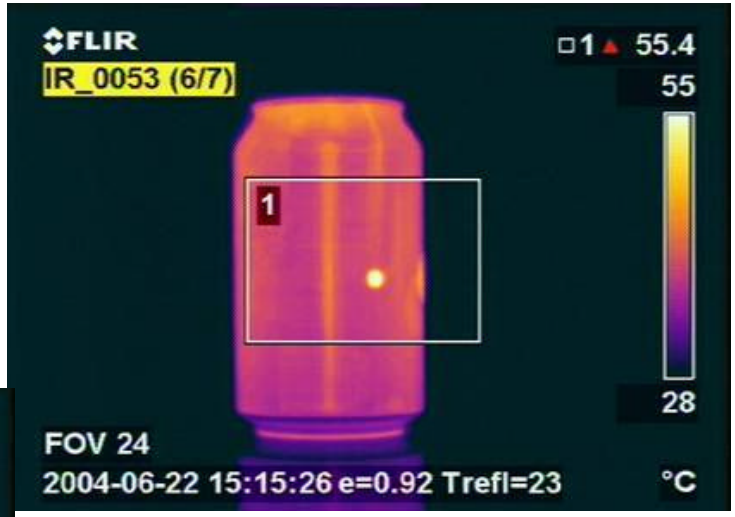
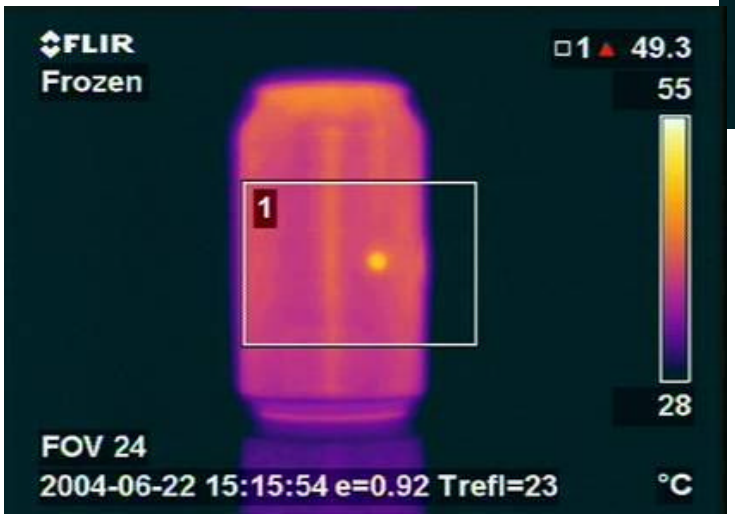
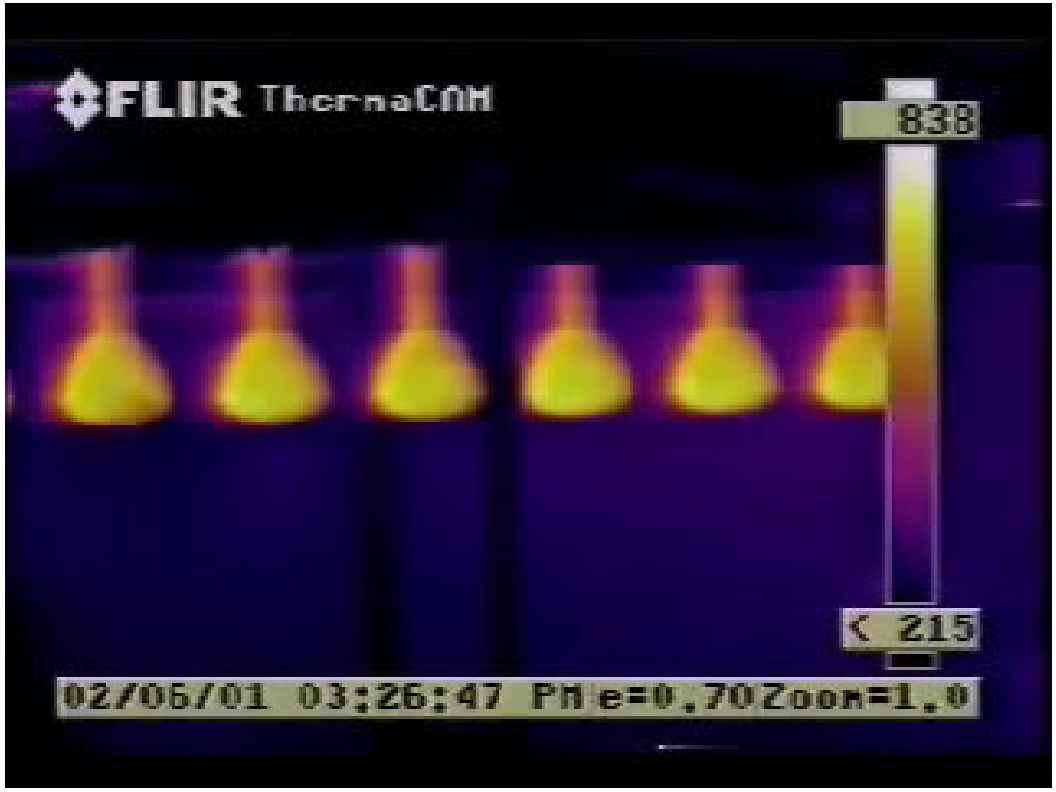
Focused = Accurate





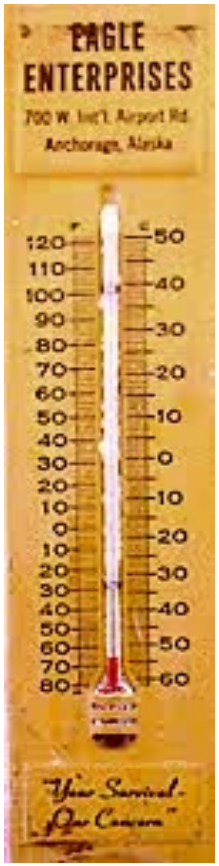
Unfocused = Inaccurate

Scan Rate



Better

Environmental Accuracy



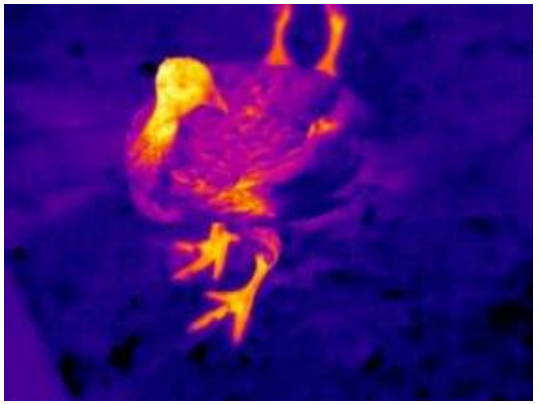
From this

To this

Camera should remain accurate through it's entire operating range

Review

- Today's cameras are easy to operate
- Understanding IR is as important as understanding your equipment
- You need proper training to be a thermographer
- Experiment!
- Practice!



Need Ideas?

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Typical Existing Homes

Use Of IR Camera For…

- **Building Shell Analysis:**
  - Identifying framing and insulation integrity of the building envelope
  - Air leakage out of and movement through the building shell
- **QA/QC of Corrective Measures**
  - installation of insulation and infiltration reduction measures
  - Repair of same

Viewing Thermal Images Of Buildings

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- Image is only the surface temperatures of object in picture (but beware!)
- It is the effect of the materials beneath the surface on the surface temperature that make you think you are seeing through materials.
- You may think you see an image of something beneath the surface but you are viewing the last surface only.
- It is our ability to interpret the images and the information that is of value!

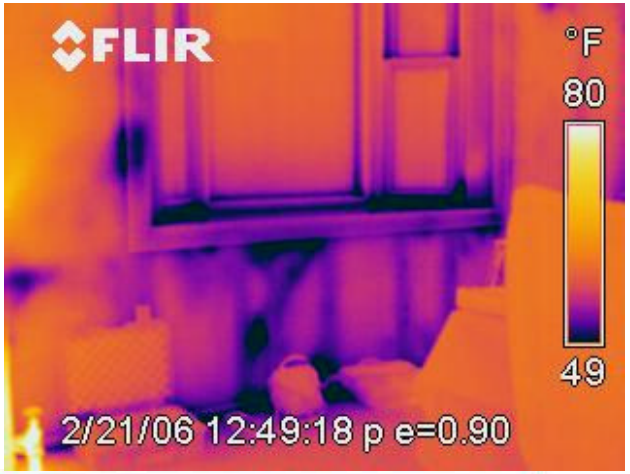
Use Caution When Evaluating Exterior Wall Images

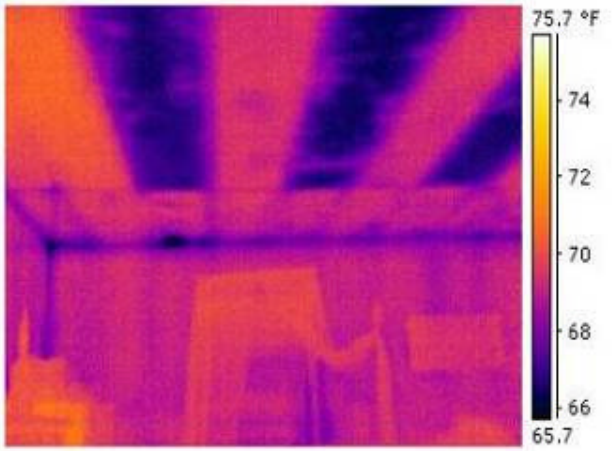
- Insulating sheathing materials can skew interpretation by moderating the surface temperature of the interior wall. This is particularly true with a brick façade.
  - Examples of Insulating Sheathing:
    - Urethane Panels
    - Celetex
    - Extruded Polystyrene
- BOTTOM LINE: You may still need to do selective sampling to physically determine what is in the wall cavity!!!

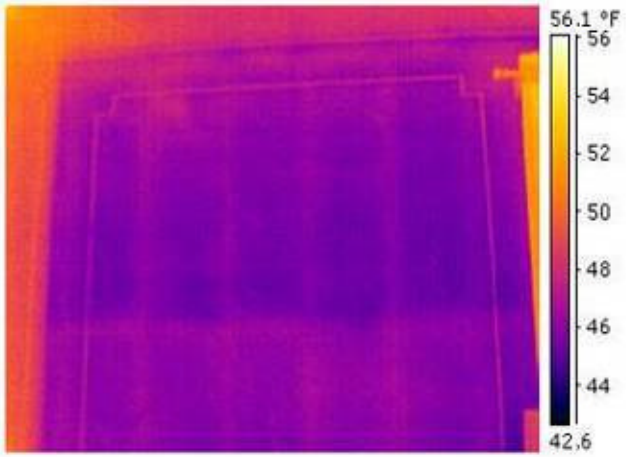
Analyzing Shell Framing And Insulation

- Look For Inconsistencies In The Thermal Boundary
  - In a well insulated wall, the framing may not be as obvious. However, you will notice a dark line where 2 or more surfaces meet (wall – ceiling, wall-wall, and at corners).
  - This is common point of thermal boundary issues.

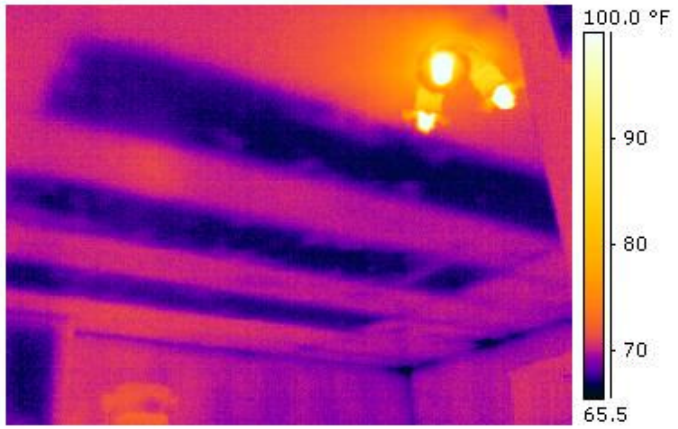
Walls And Ceilings

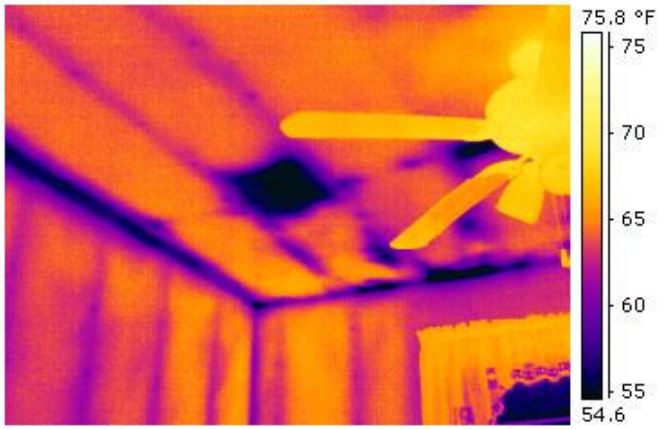




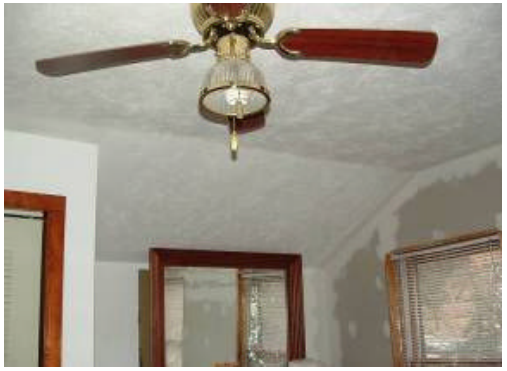


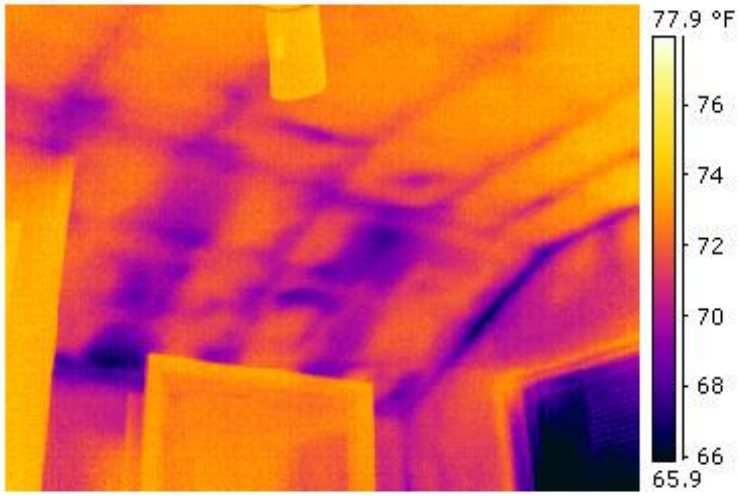
Missing Insulation Is Evident With The IR Camera

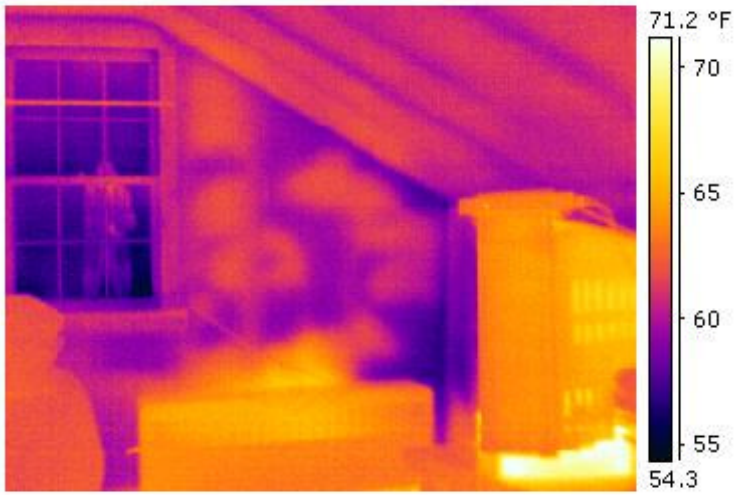




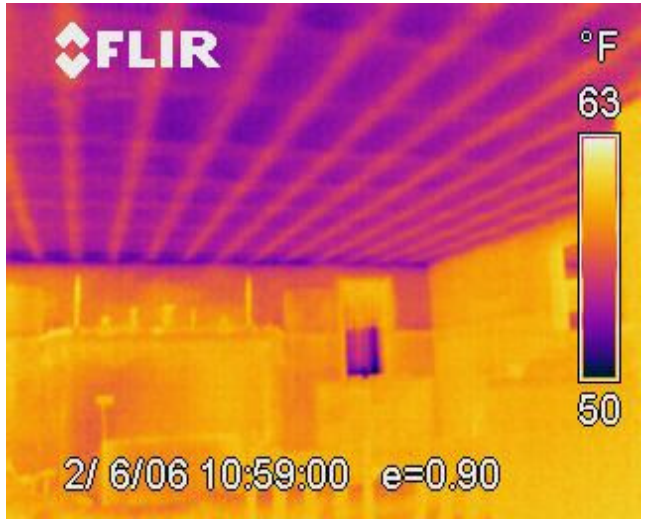
Poorly Installed Fiberglass Batt and Blown Insulation





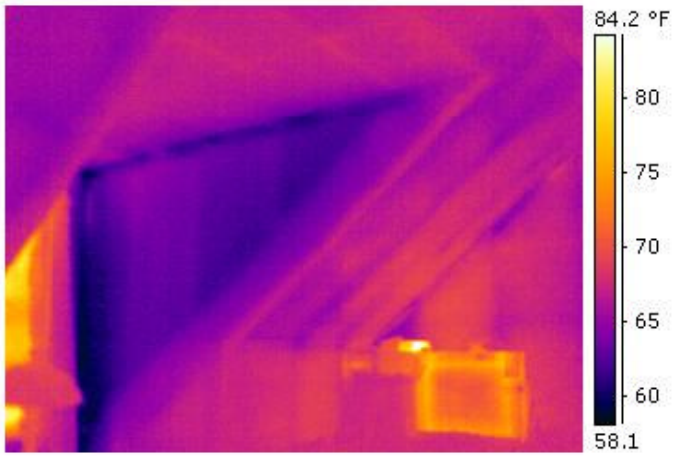


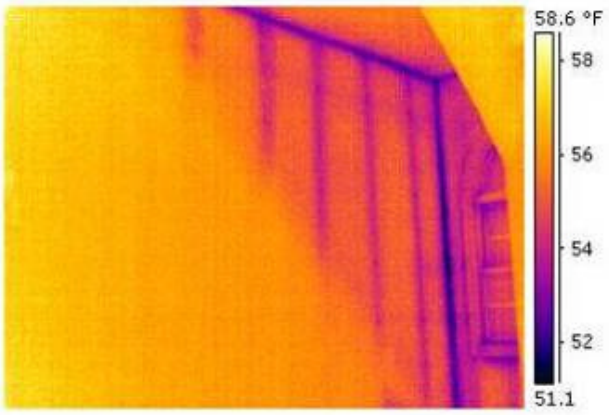
No Insulation In Attic

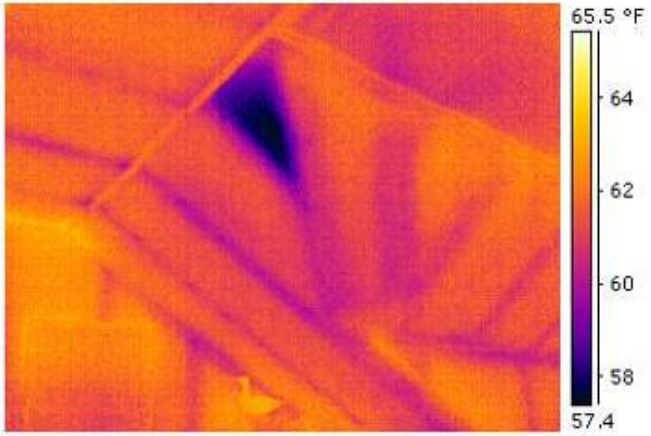


Dormers!

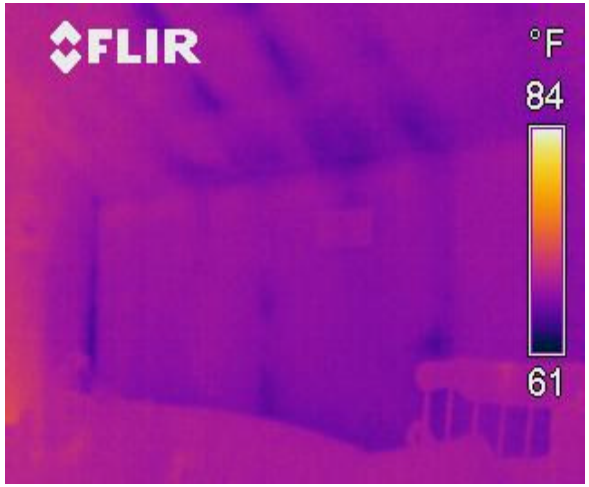

FLIR
°F
62
48
12/ 5/05 9:31:28 e=0.90

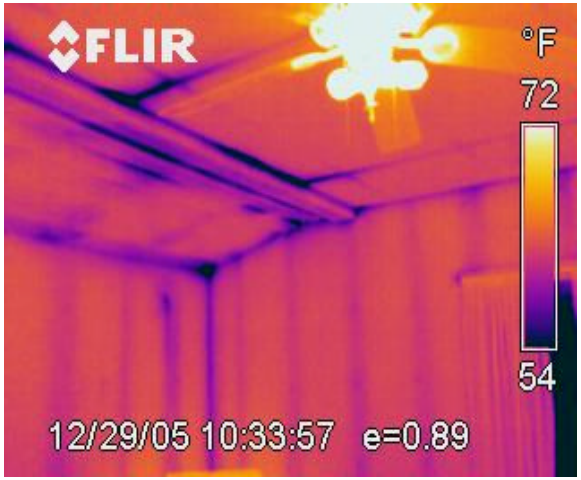

84.2 °F
80
75
70
65
60
58.1

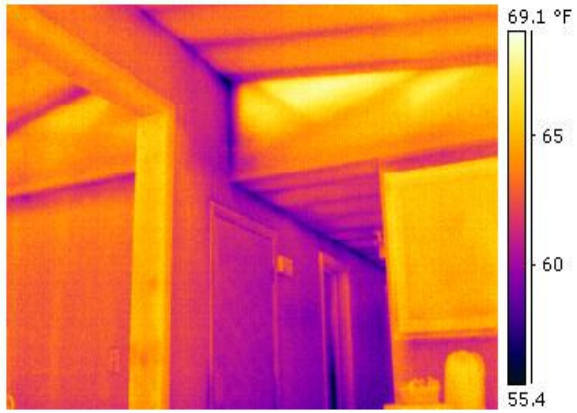

58.6 °F
58
56
54
52
51.1

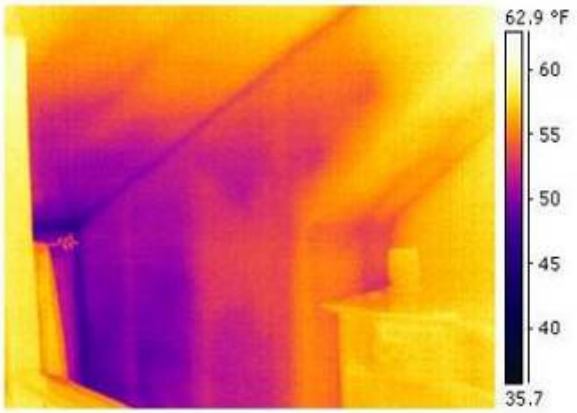

65.5 °F
64
62
60
58
57.4

Knee Walls

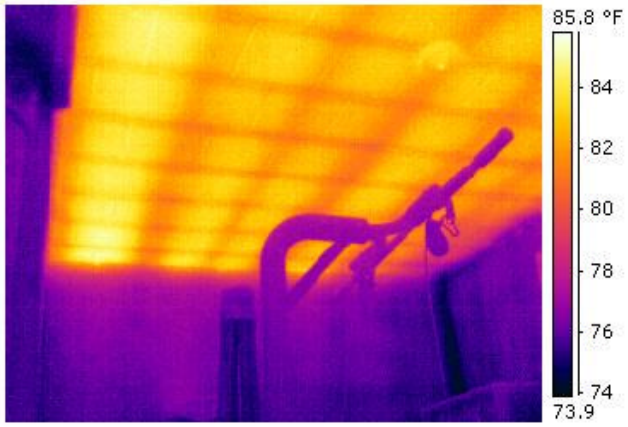

FLIR
°F
84
61

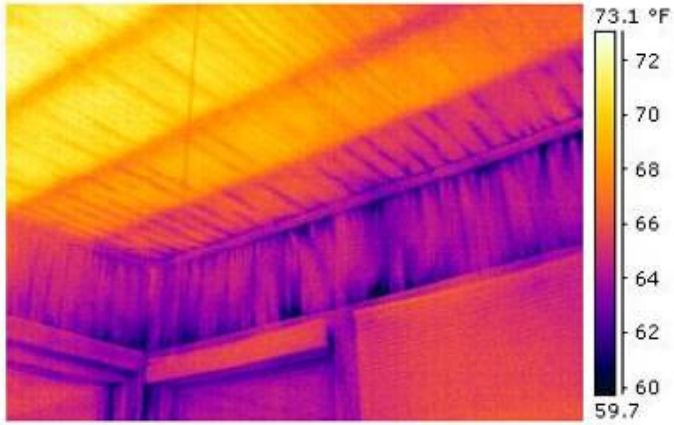

FLIR
°F
72
54
12/29/05 10:33:57 e=0.89


69.1 °F
65
60
55.4

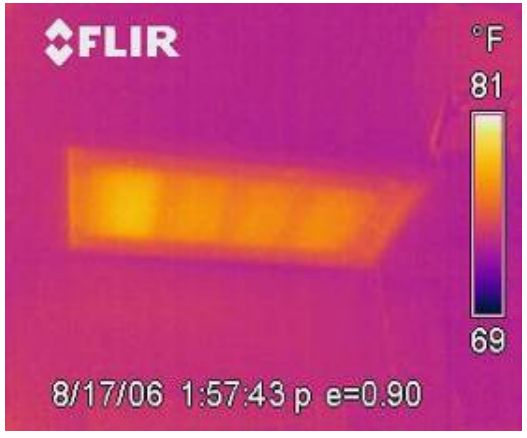

62.9 °F
60
55
50
45
40
35.7

Flat Roof Images



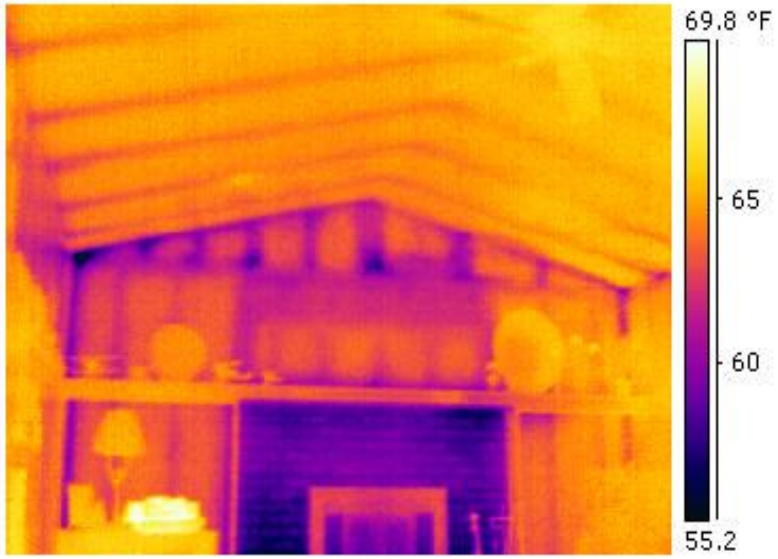


Attic Hatches



- The top image is a pull-down stairway.
- The bottom image is also a pull-down staircase.
- Why are these images different?

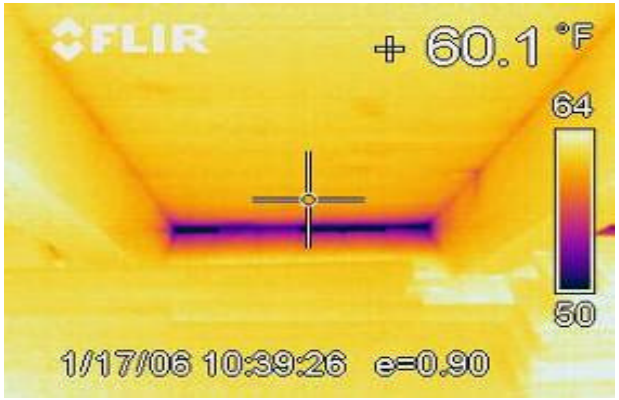
Fireplaces And Intersections With Exterior Walls

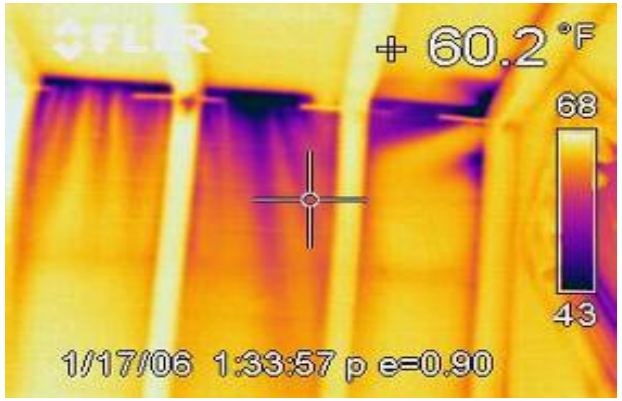


Air Infiltration = Heat Exfiltration

- Common sources of air infiltration
  - Around Doors
  - Balloon Framing
  - Rim Joists at the top of Foundation Walls
  - Exterior Wall Outlets and Switches
  - Bath and Kitchen Exhausts
  - Vertical Intersection of Walls and Horizontal Intersection of Walls and Ceilings
  - Plumbing and Electrical Chases

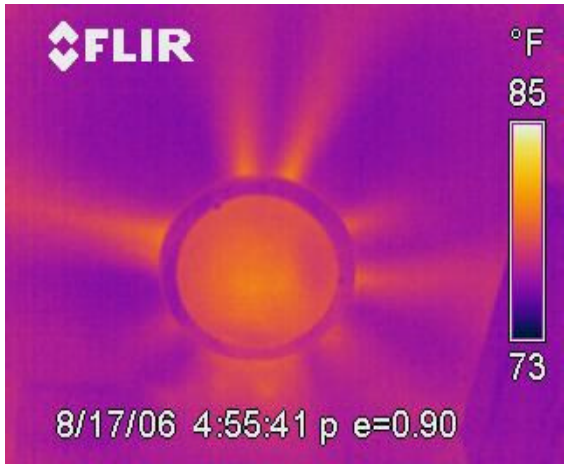
Air Infiltration: With And Without a Blower Door

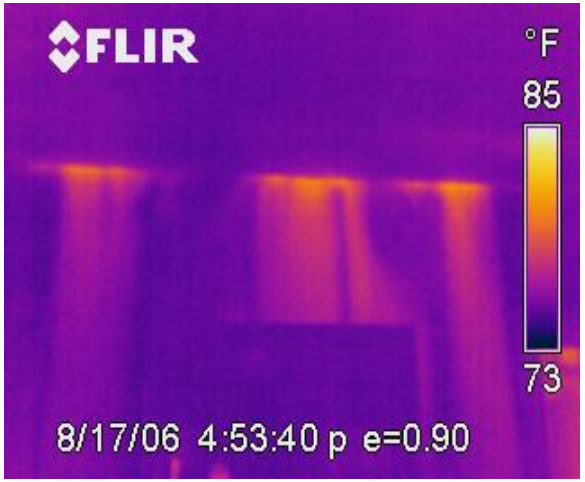


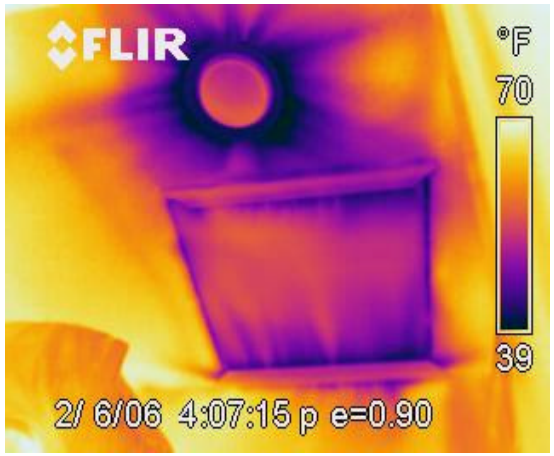


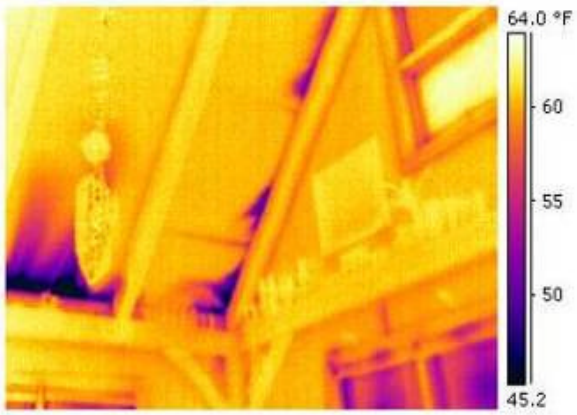
- Infrared image doesn't show air leakage at top of cathedral ceiling. Why?
- Because air leaking out shows no temperature difference from inside
- With Blower door, air leakage becomes obvious because air leakage is reversed

Blower Enhanced Images

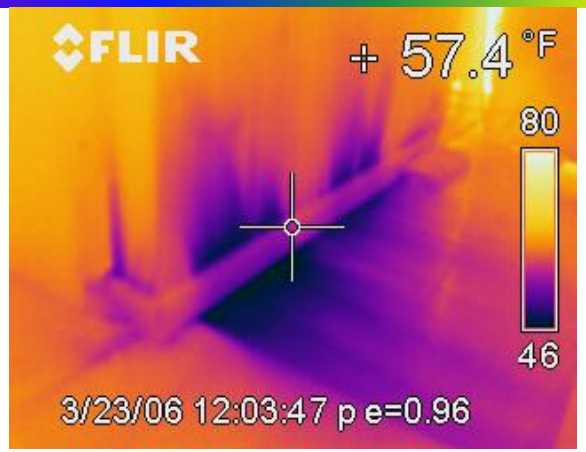


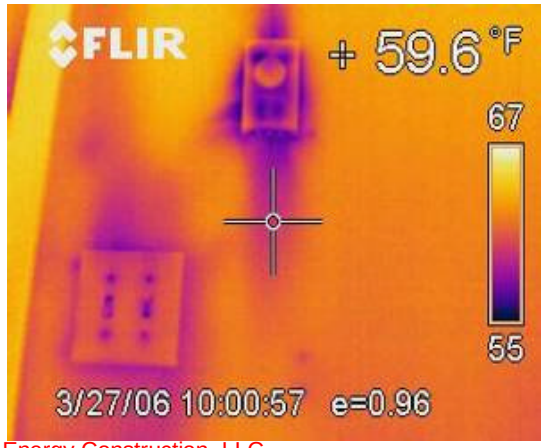






Blower Enhanced Images





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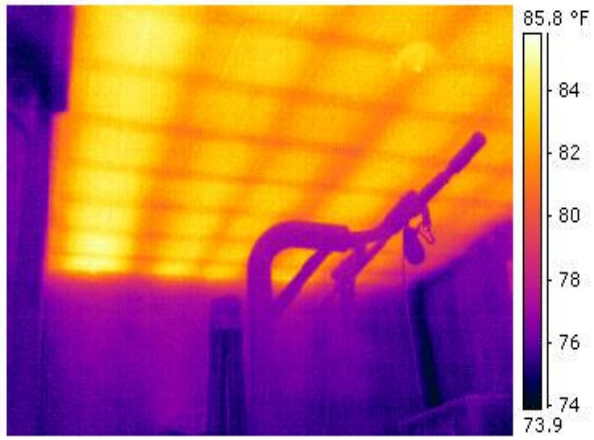
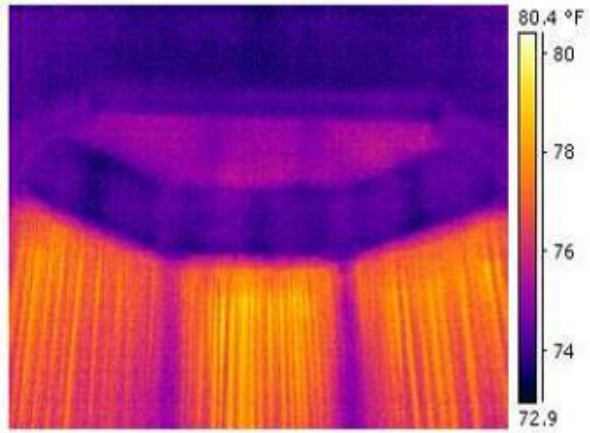
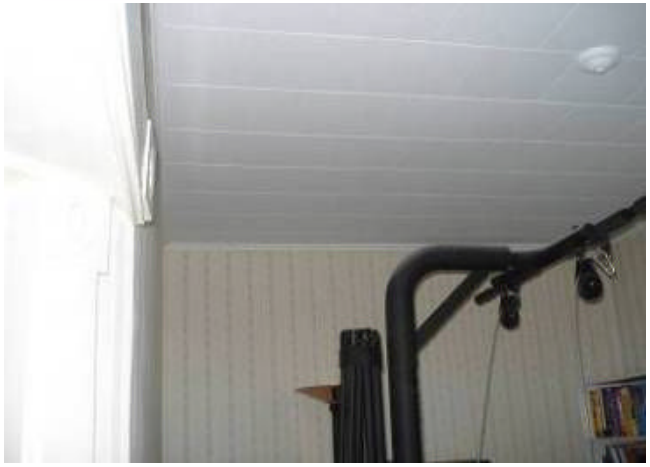
Its Not Always Winter!!!

- When outside temperature rise above indoor temperatures infrared images completely change.
- Exterior temperature differences will no longer be darker.
- Awareness of this is critical in making correct interpretations

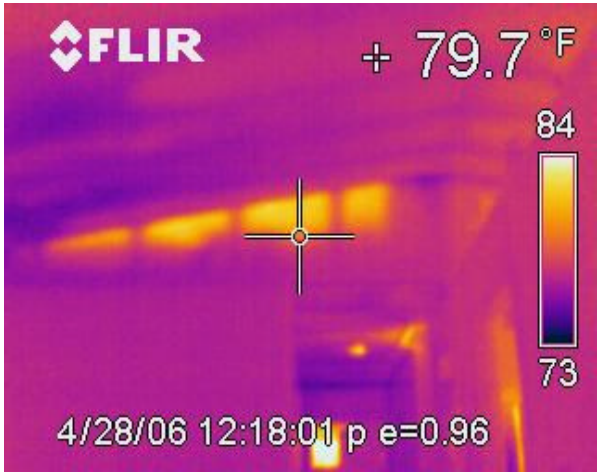
Summer Changes Everything

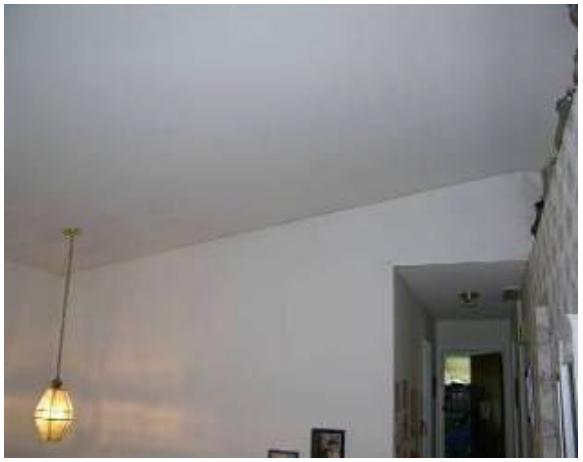






Wall And Ceiling Interface





Watch for "Solar Loading"

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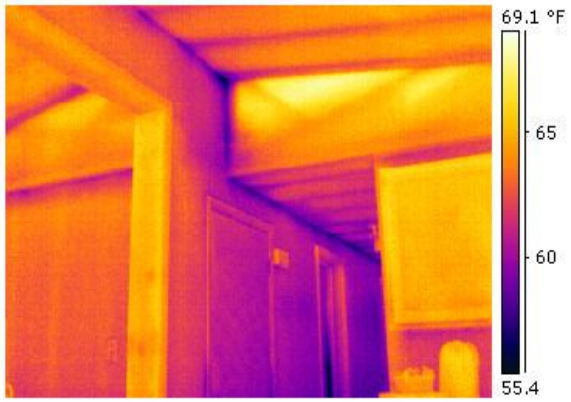
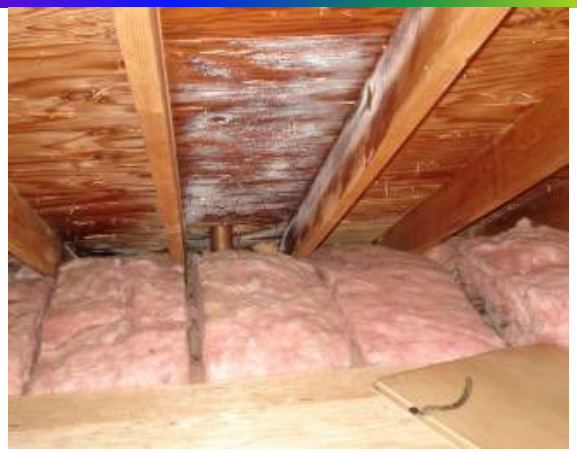
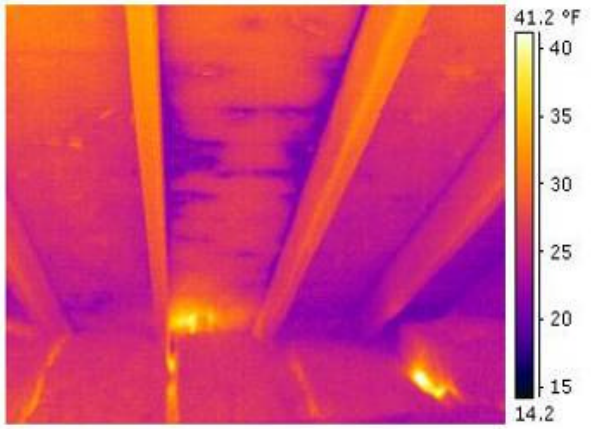
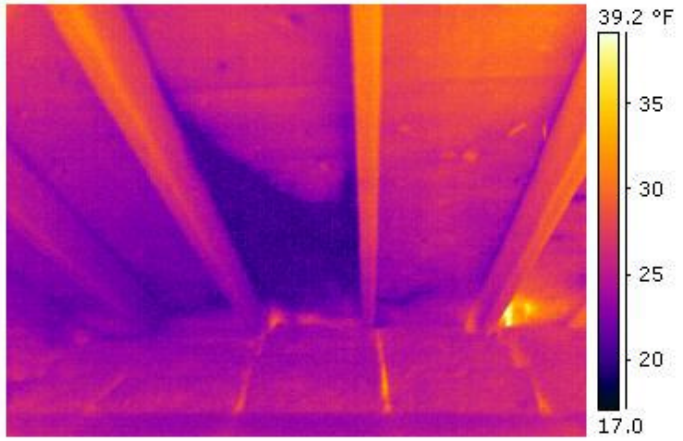


Heat And Moisture Escaping Into Attic

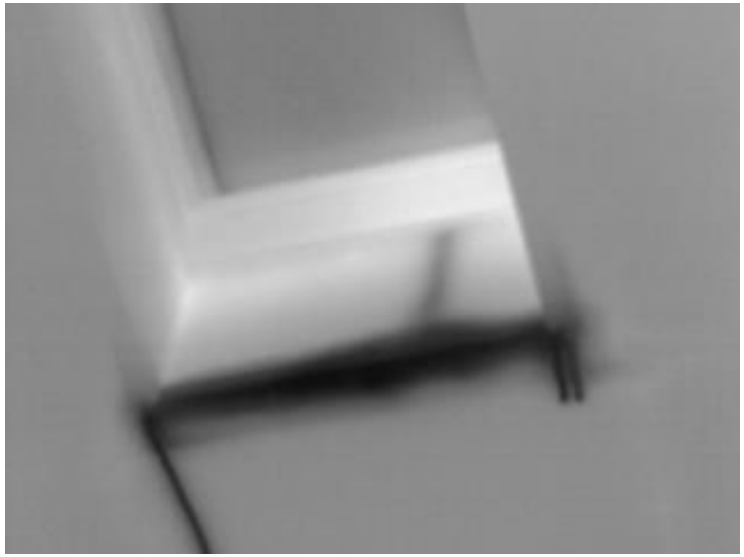
Moisture In An Attic





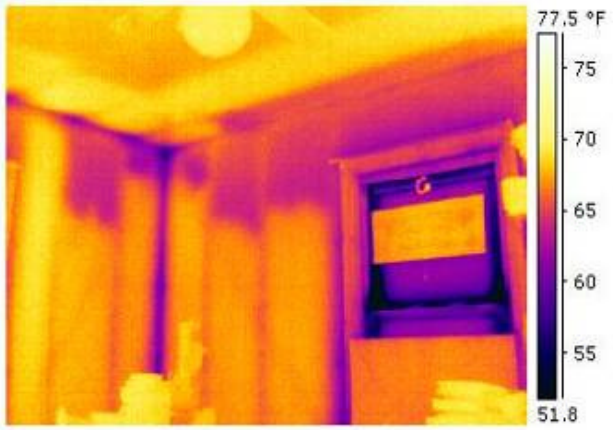


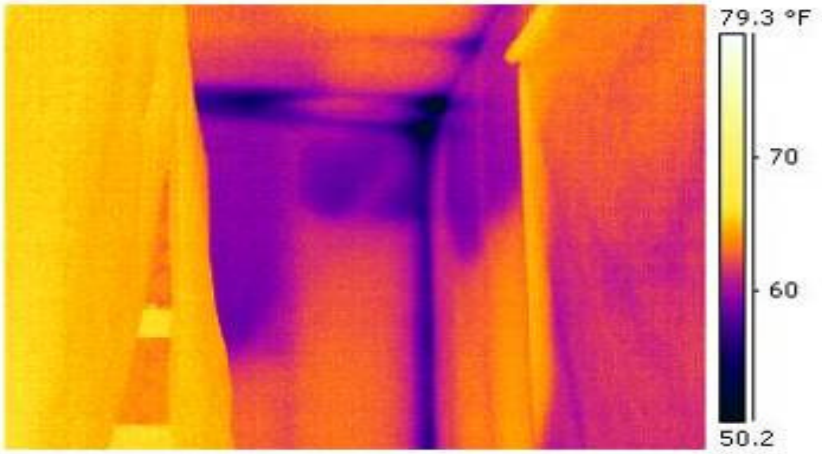
Moisture Within Building Materials



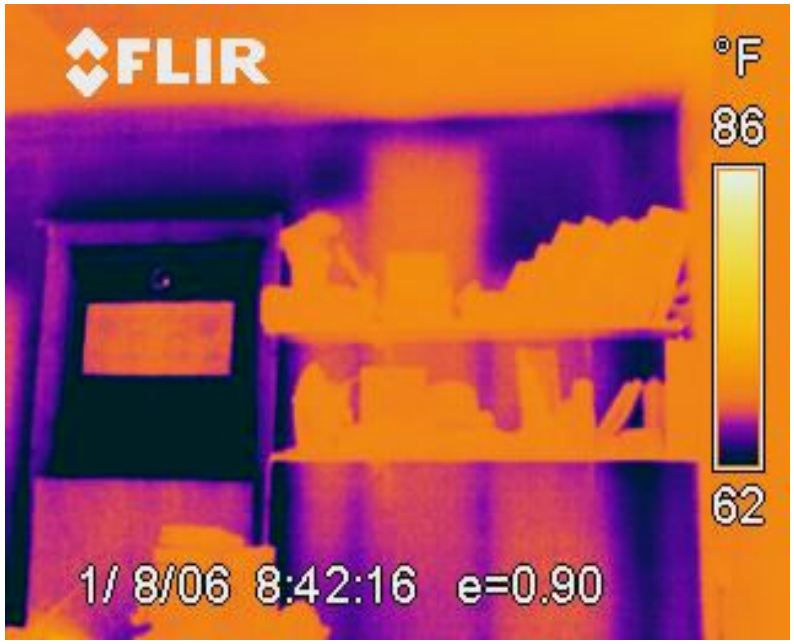
The key to remember is that moisture can be mistaken for cold air infiltration. Therefore, you have to validate those "dark" areas for the presence of moisture!!!

Improperly Blown & Differential Settling of Insulation

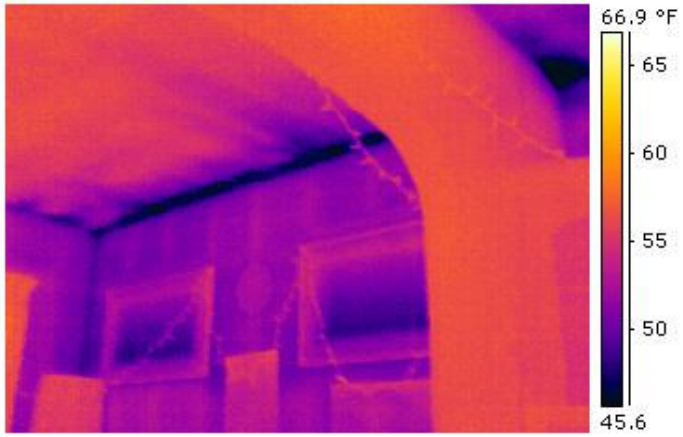


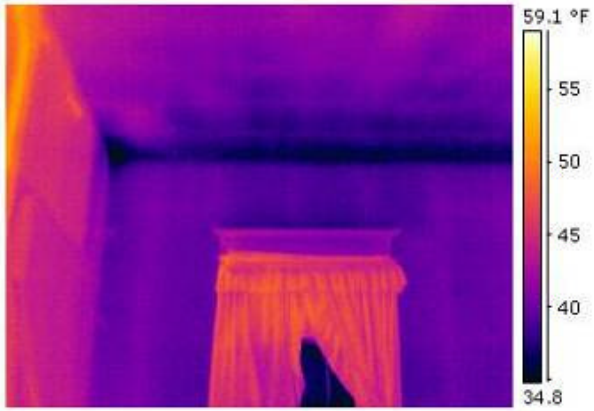


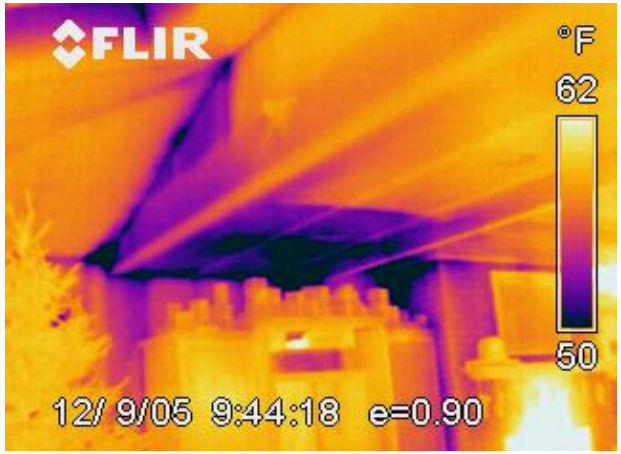
Improperly Blown Wall Cavities



Check for Continuity of Thermal Boundary And Eliminate Problems "Down the Road"







Standards

- C1153.5035-1 Location of Wet Insulation in Roofing Systems Using Infrared Imaging
- C1060.5903-1 Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
- E1186.6605-1 Air Leakage Site Detection in Building Envelopes and Air

Standards (Best)

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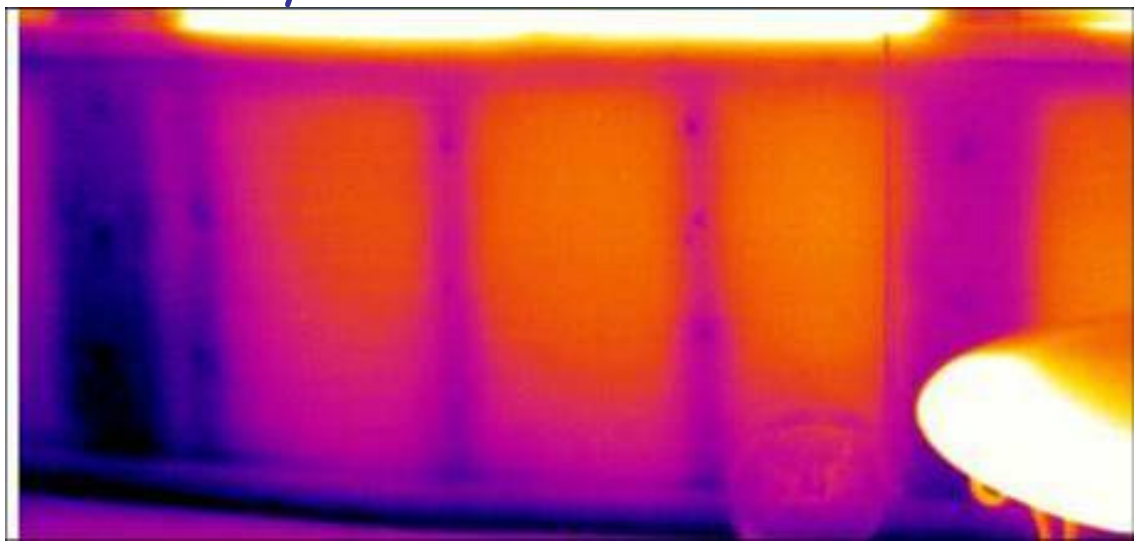
- Time of day considerations (non sunny)
- Minimum temp differential (18F)
- Minimum distance to size of target or MFOV
- Wind speed considerations (none)
- Angle of view (perpendicular)

Conductivity and R value

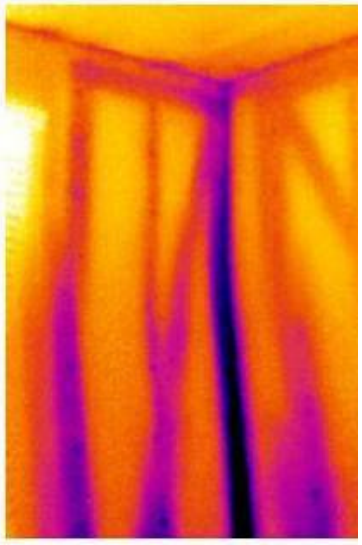
- Insulation material has k=.27 or R=13
- Wooden stud has k=0.97 or R=3.6
- Wooden studs conduct more energy than the insulation – appears cold on the inside when the heat flow is away from the viewer



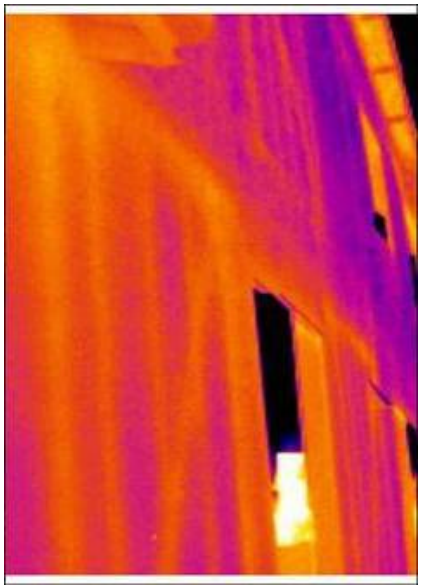
Conductivity and R value

- Insulation material has a low k=.27
- Metal stud has a high k=346.9
- Metal studs conducts allot more energy than the insulation – appears cold on the inside

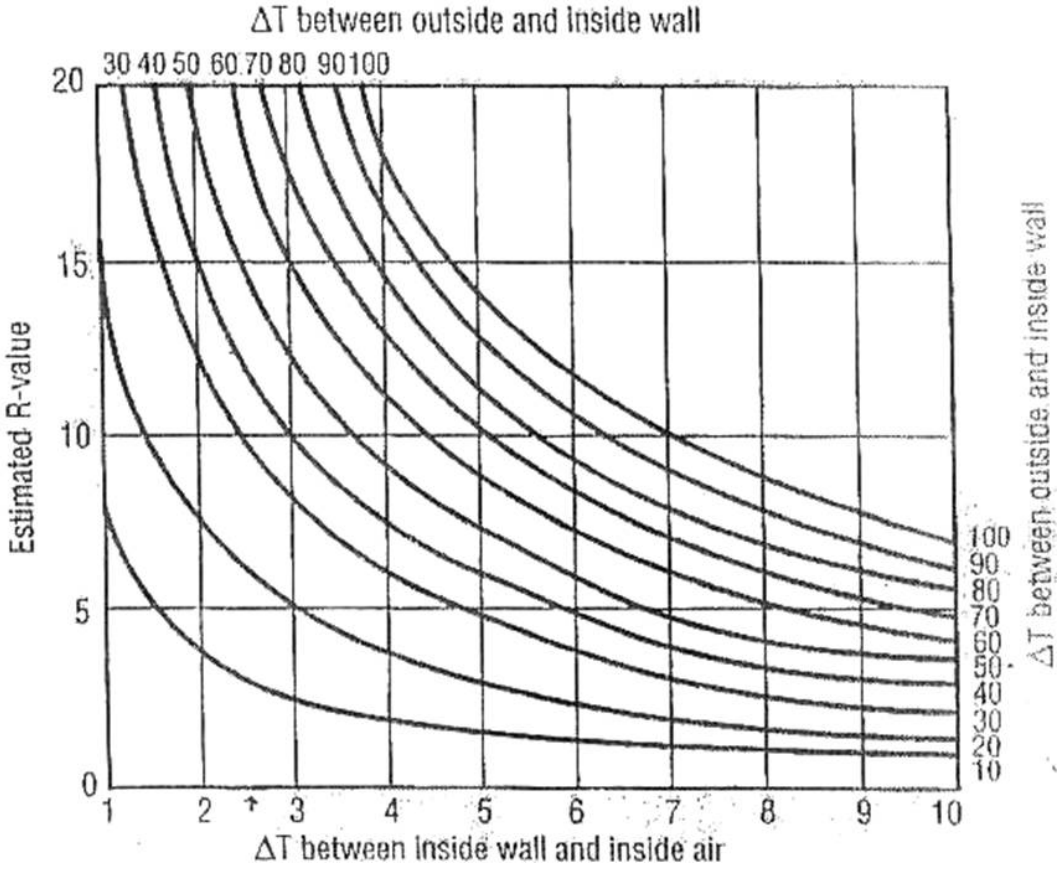
Cold on the inside?



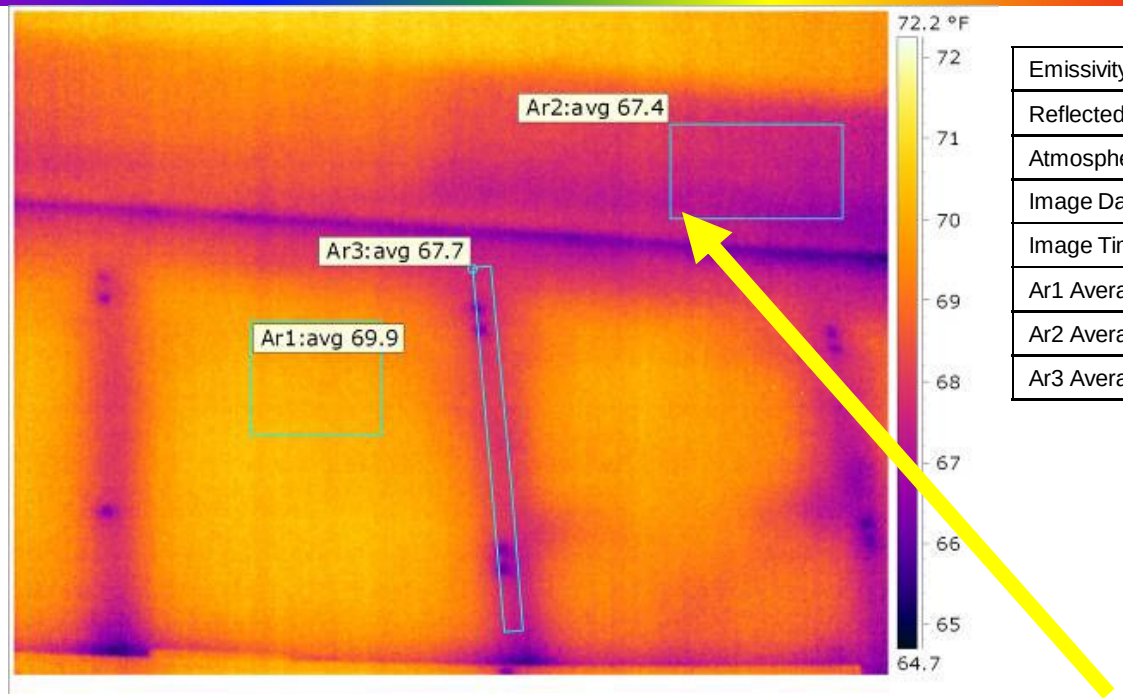
Hot on the outside?



R value estimates using Temp Diff



Temp Diff Example



Emissivity	0.93
Reflected Apparent Temperature	72.3 °F
Atmospheric Temperature	70.0 °F
Image Date	1/19/2008
Image Time	9:10:07 AM
Ar1 Average Temperature	69.9 °F
Ar2 Average Temperature	67.4 °F
Ar3 Average Temperature	67.7 °F

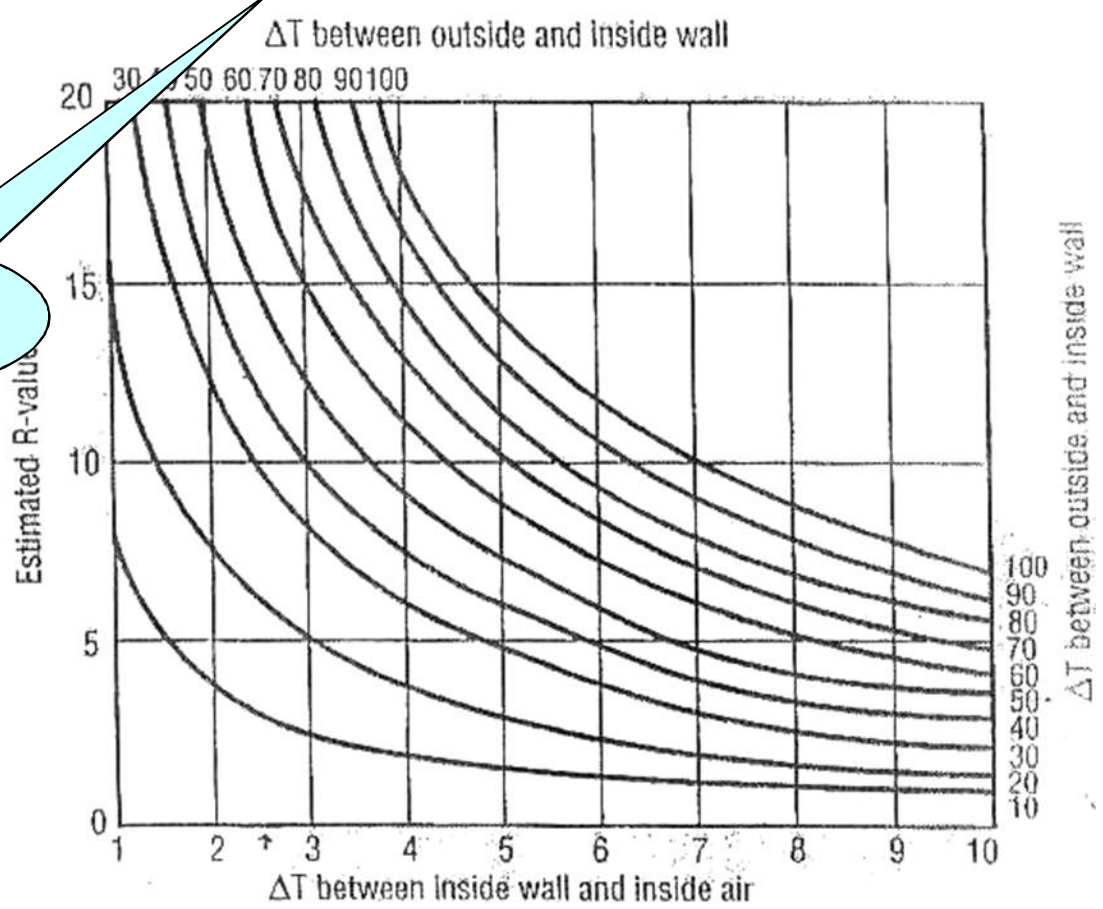
Outside air = -5 °F

Temp diff O – I=-5 – 70 = 75

IW-IA = 67.4-70-= 2.6

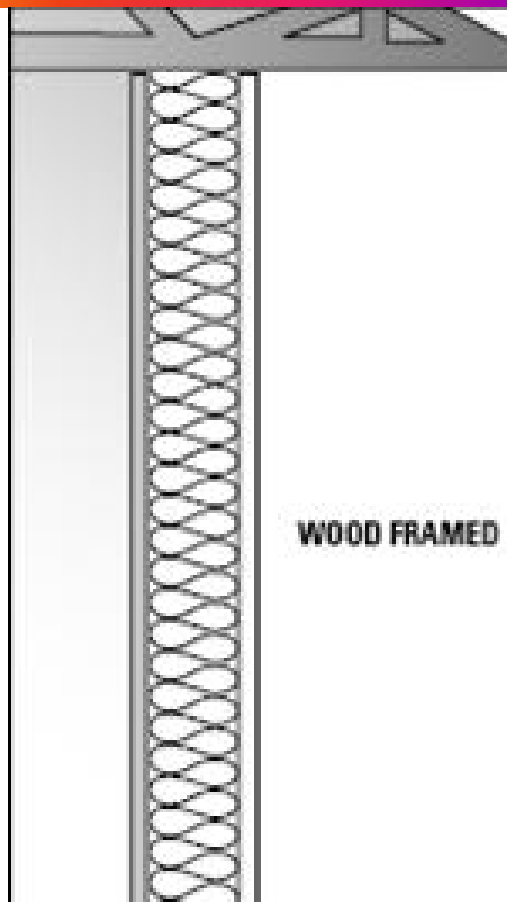
R value estimates using Temp Diff

2.6 & 75



R value Estimates

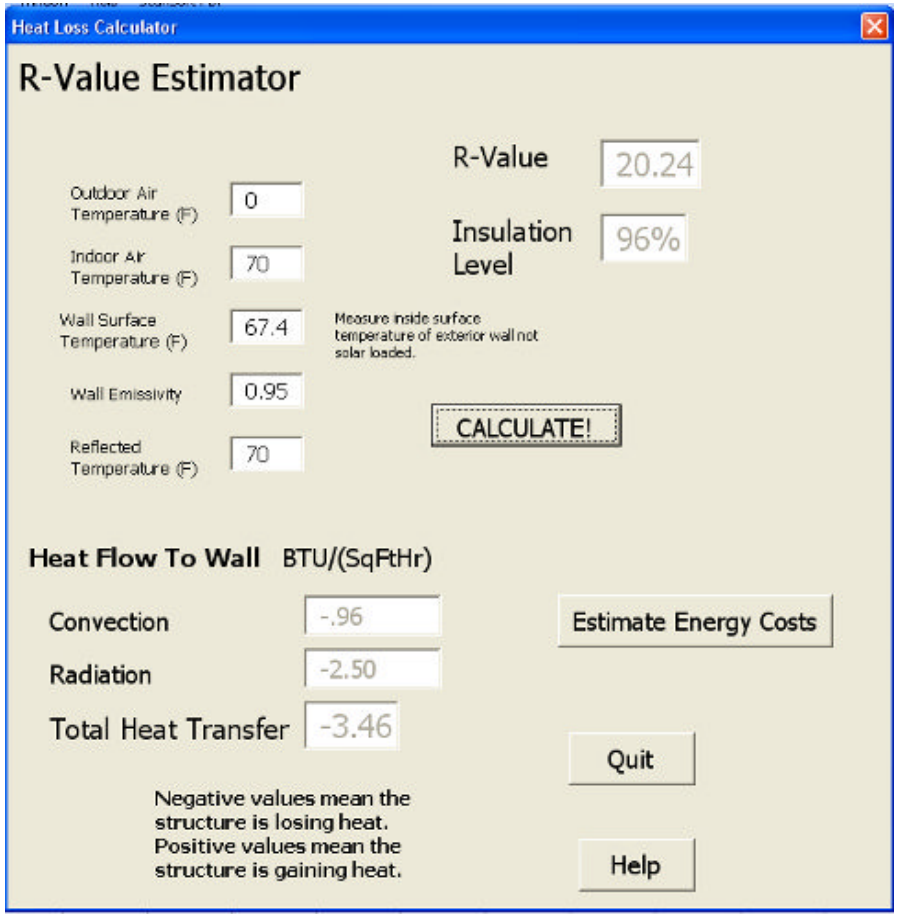
	Wall	Stud
Interior air boundary	.68	.68
Wallboard	.45	.45
Insulated Sheathing	7.1	7.1
Wood siding	.59	.59
Exterior air boundary	.17	.17
Insulation 3.5"	13	3.6
Total =	21.99	12.59



R Value Summary

- Very Difficult to do
- Prone to error
- Image could have infiltration or a thermal bridge involved.

An R Value Calculator



Developed by Dr. Bob Madding of Infrared Training Center

Thank You Very Much!