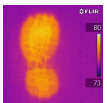
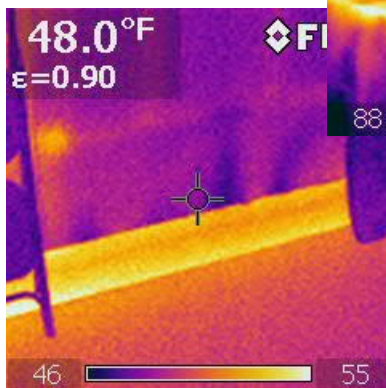
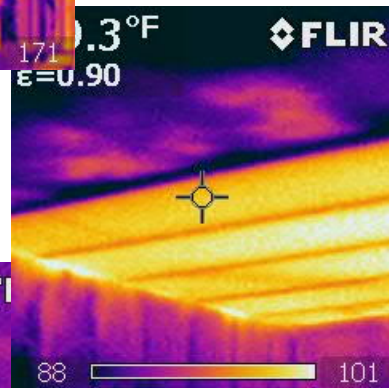
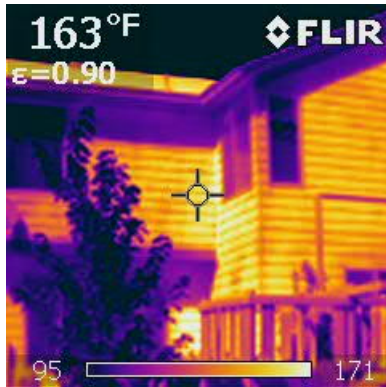


# Seeing Your Details in a Different Light

## Quality Control & Lessons Learned Through Infrared (IR) Imaging

Presented by Shawn LeMons

- ❖ Inspected 3+ million SF of buildings
- ❖ Certified ICC, BPI, RESNET, LEED, PHIUS, and Thermographer
- ❖ 10 years experience in Thermography
- ❖ 20+ years experience in home improvement with small and large companies.
- ❖ Committed to doing better with the resources we have.



Builder QC Through IR

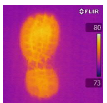
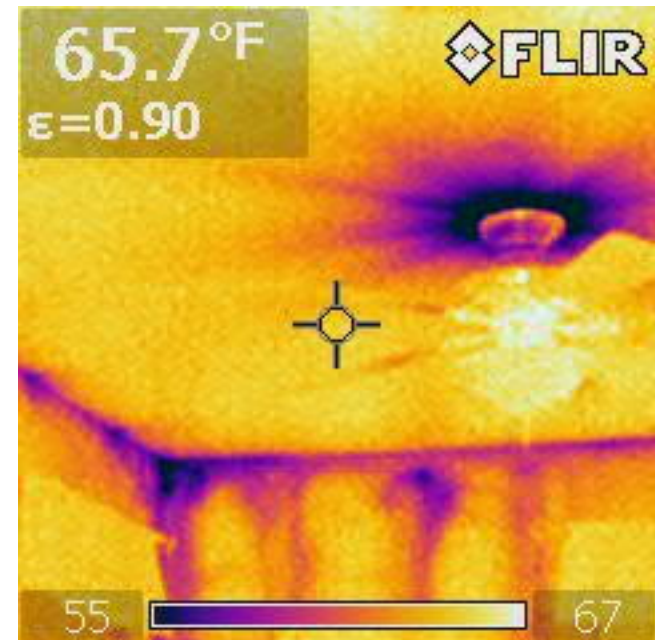
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# Builder QC Through IR

This training will cover...

- 1) Heat & IR Basics
- 2) False Indicators
- 3) Heat Transfer in Buildings
- 4) Persistent Thermal Bypasses
- 5) Additional Observations

Q&A – ask questions throughout, we learn better in conversation.



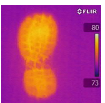
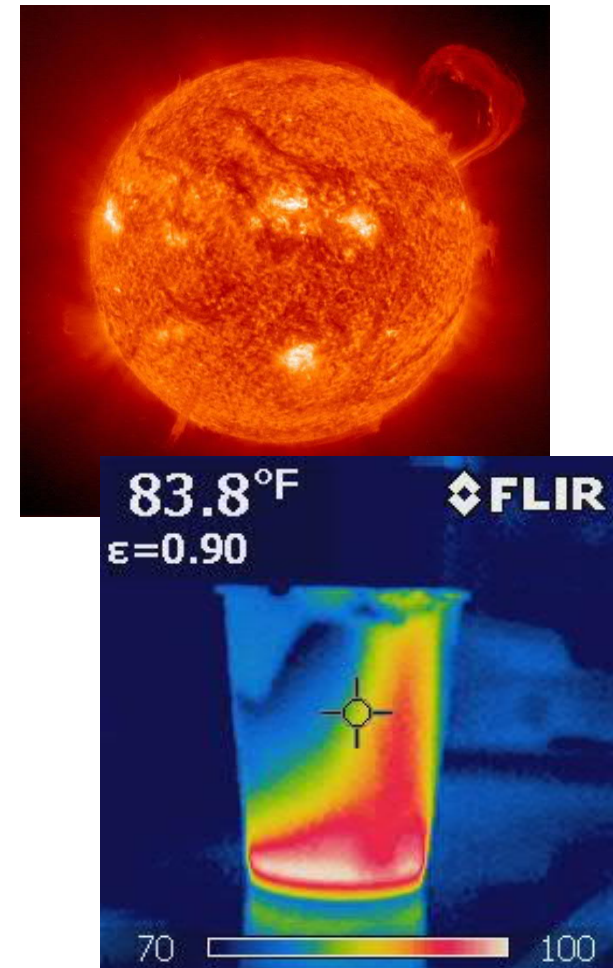
Builder QC Through IR

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## Section 1: Heat & IR Basics

# Thermodynamics and Heat

- ❖ 1<sup>st</sup> Law - Energy is neither created or destroyed...  
it simply changes form and flows.
- ❖ 2<sup>nd</sup> Law – (Entropy) Heat flows from high temperature to low temperature.
- ❖ Heat flows through Conduction, Convection, and Radiation.
- ❖ Temperature is a measure of heat from molecular activity.
- ❖ Infrared Thermography records temperature in the infrared spectrum.



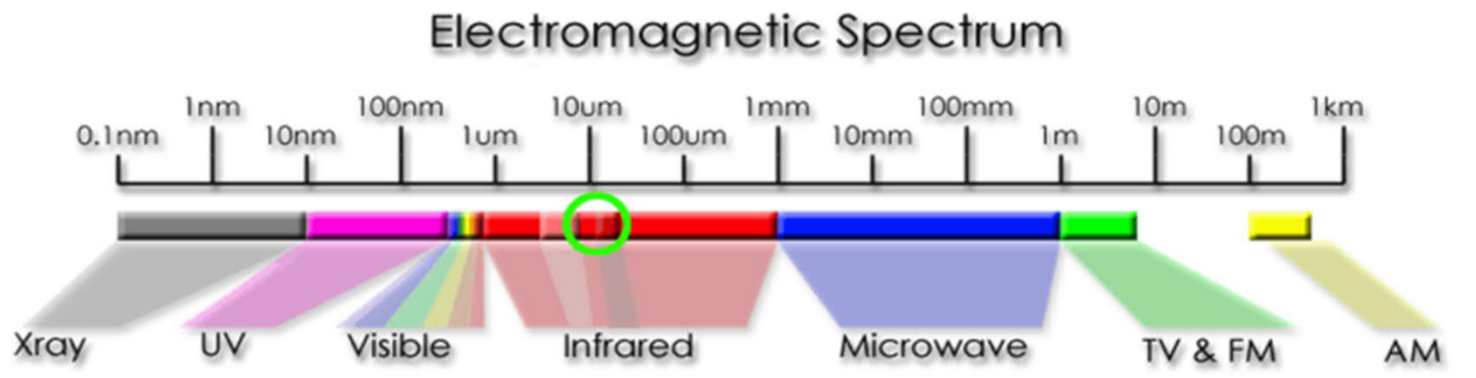
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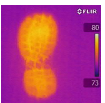
## Section 1: Heat & IR Basics

# Electromagnetic Spectrum

- ❖ Molecules emit radiation at various wavelengths based on temperature. These wavelengths make up the ...



- ❖ Visible light is one part of the spectrum, Infrared is another.
- ❖ IR cameras allow us to “see” in a spectrum of light which corresponds to common temperatures of our built environment.



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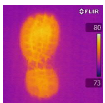
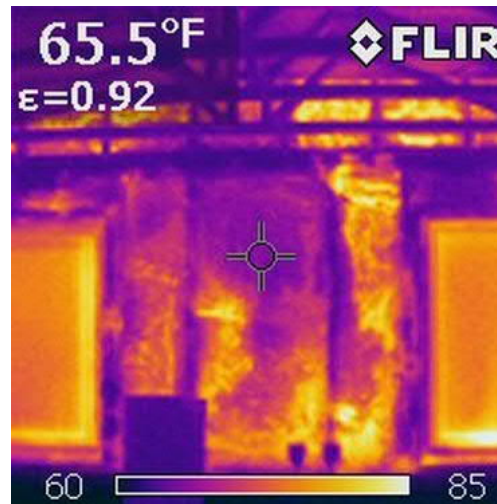
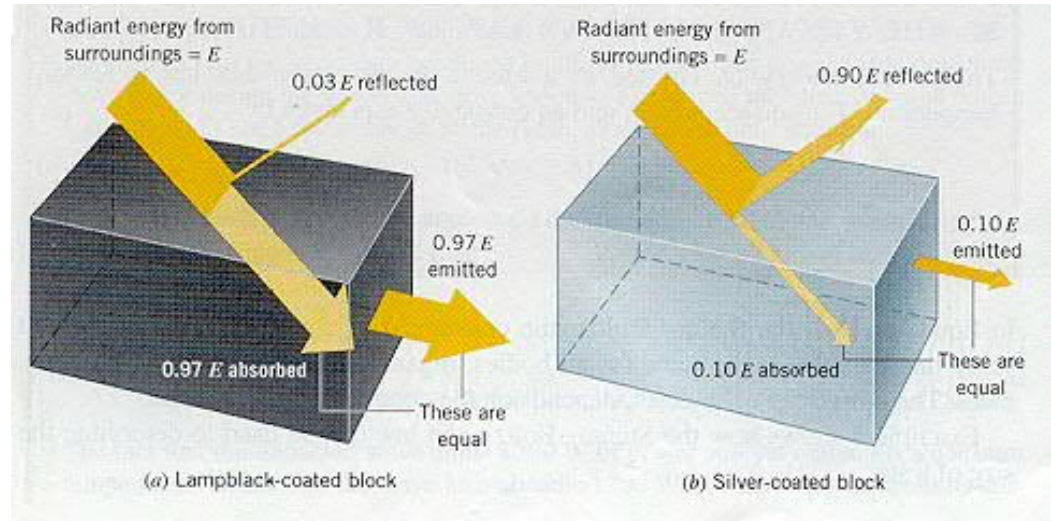


## Section 1: Heat & IR Basics

# Reflected, Emitted, Transmitted Energy

- ❖ Reflected energy...  
bounces off an object and changes the apparent temperature.
- ❖ Emissivity ...  
absorbed and emitted energy are equal.
- ❖ Transmitted energy...  
passes through a few IR transparent materials.

$$R + E + T = 100\%$$



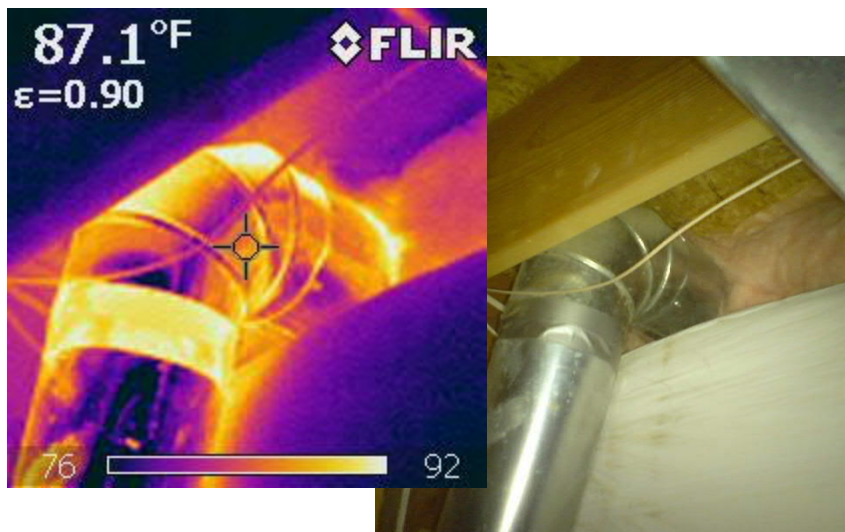
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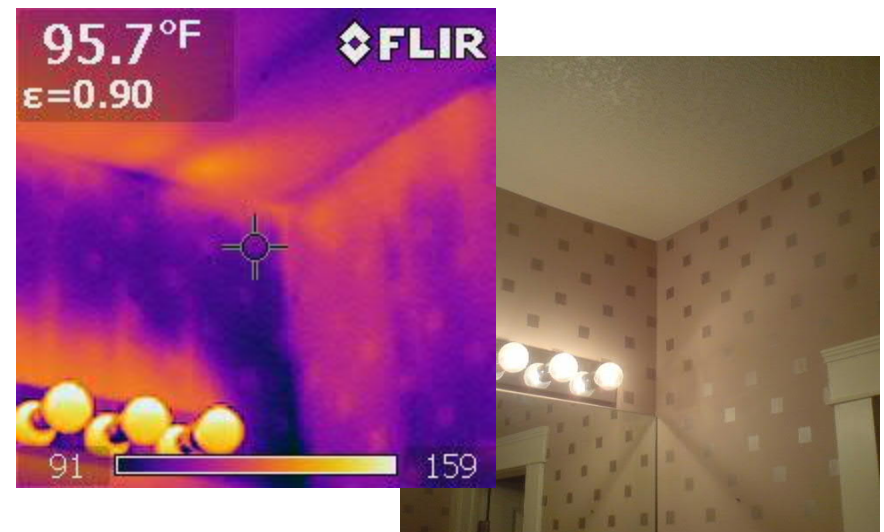
## Section 2: False Indicators

# Emissivity and Other Clues

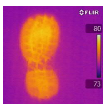
- ❖ The camera only show apparent temperature.
- ❖ Low-E surfaces reflect surroundings.  $E=0.05 = 5\%$  of object temp.
- ❖ Radiant heat and convection confuse the image.
- ❖ Use your head and senses first, then use the camera to document.



- ❖ Warm duct or warm air leakage?



- ❖ Missing insulation? Bulbs heating wall, ceiling? Top plate air leakage?



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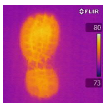
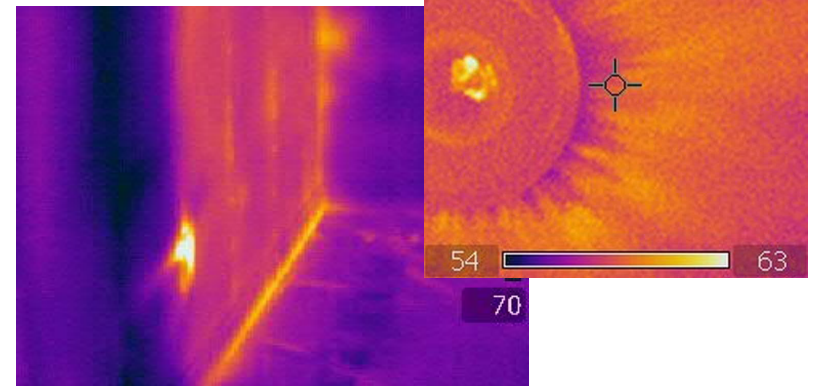
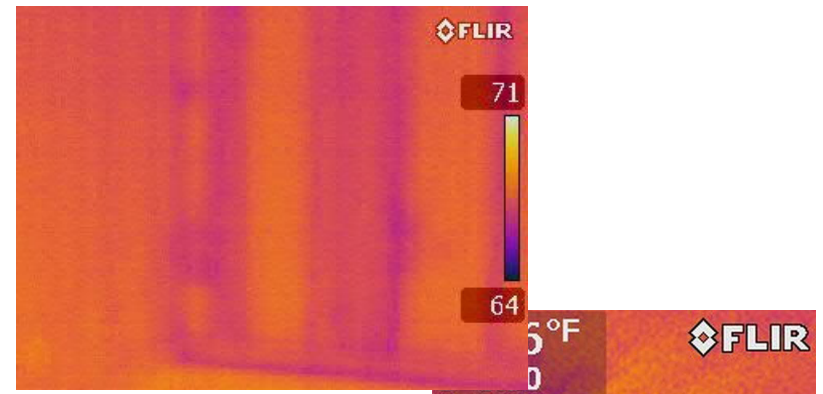
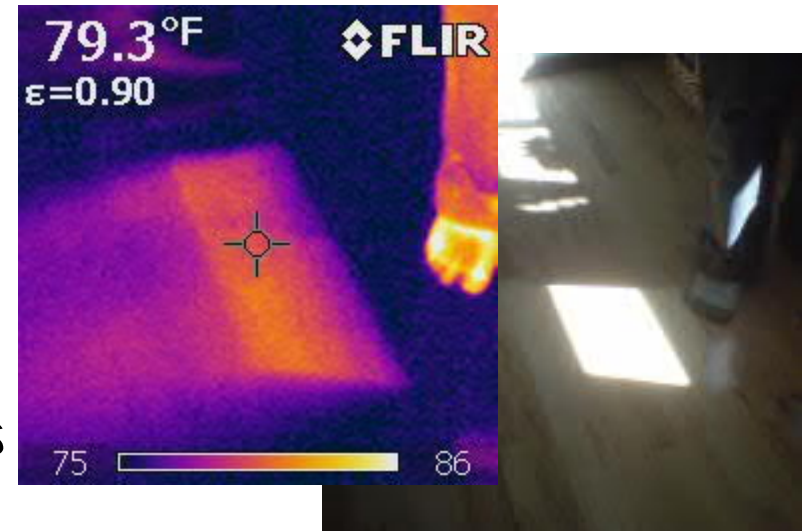


## Section 2: False Indicators

# Effects of Sunlight & Time



- ❖ Irregular patterns may appear to be insulation problems when they're not.
- ❖ Interior surfaces showing thermal delay or mass.
- ❖ Where WAS the heat / cold?
- ❖ Exterior transitions or surfaces can be very useful in spring and fall.



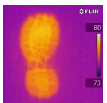
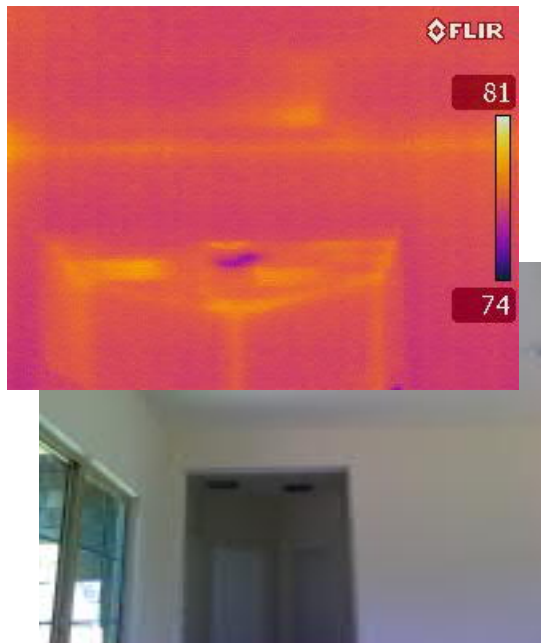
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## Section 2: False Indicators

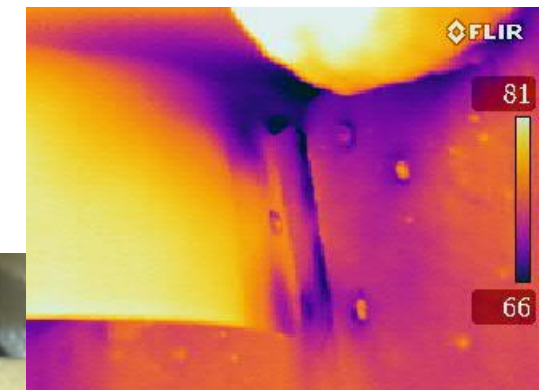
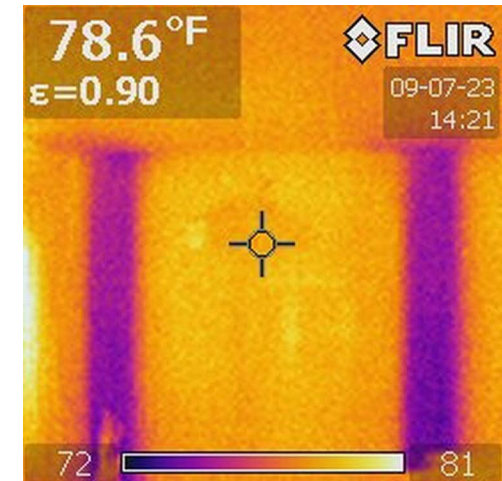
# Same Temp Inside & Out?

- ❖ Useful images require a difference in temperature.
- ❖ 7°F or more, but lower delta T can yield acceptable results.
- ❖ Adjusting house temp has pros and cons.
- ❖ This is a temperature camera, not an air flow camera.
- ❖ If less than 7°F, you have to know where to look
- ❖ Don't make assumptions. Use your #1 tool... your head!



Builder QC Through IR

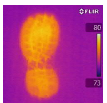
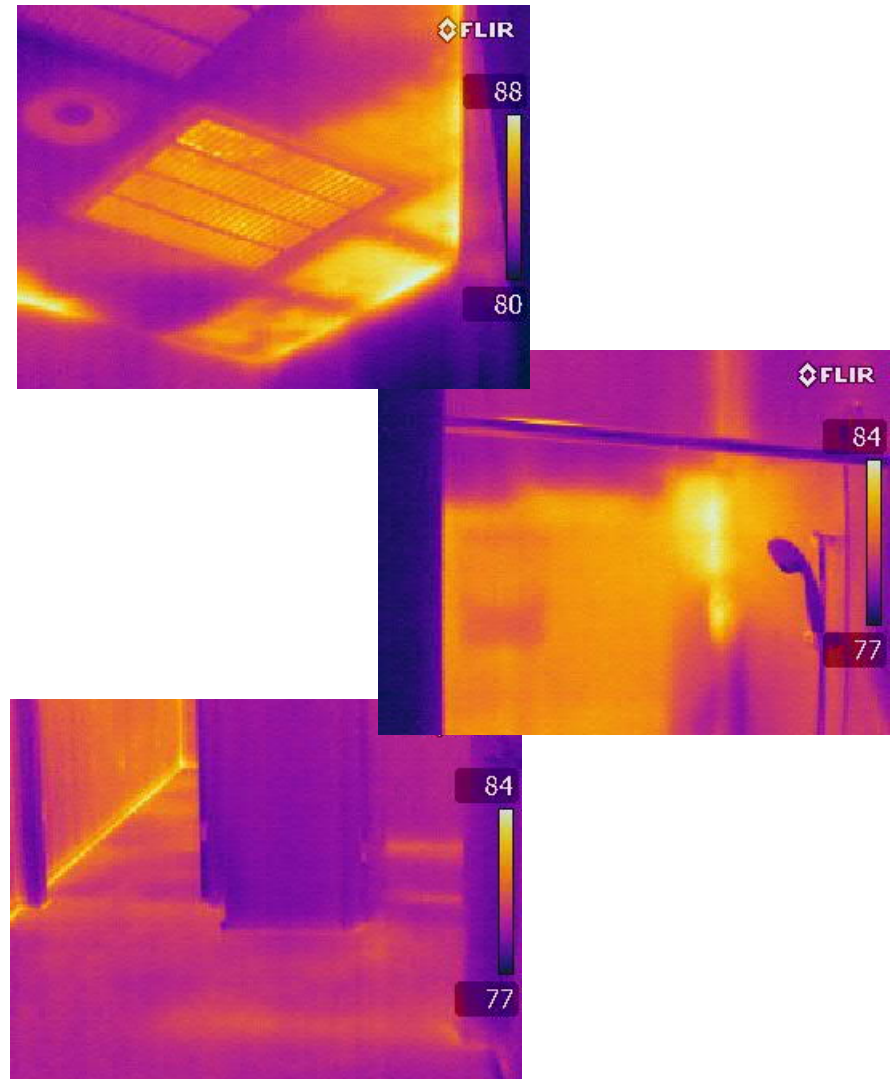
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# Close the Gap on Weighted Averaging

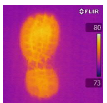
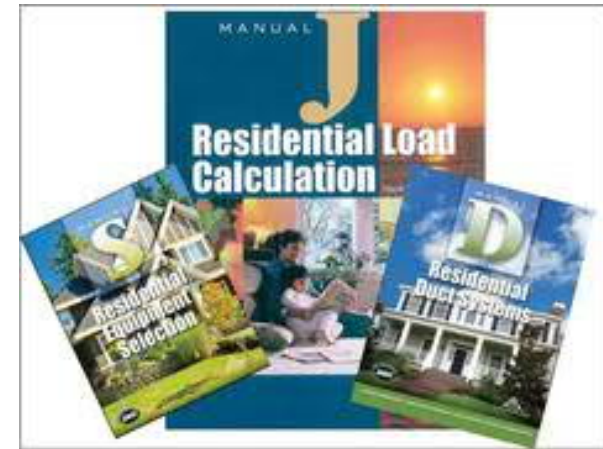
- ❖ Insulation gaps and low points create exponential heat transfer.
  - ❖ R-38 with 1% R-1 gap = R-28, a 37% increase in heat transfer.
  - ❖ R-38 with 2% R-1 gap = R-22, a 74% increase in heat transfer.
  - ❖ R-38 with 10% R-10 = R-30, a 28% increase in heat transfer.
  - ❖ R-13 with 33% R-9 = R-11, a 15% increase in heat transfer.
- ❖ Heat transfer = BTU load



## Section 3: Heat Transfer in Buildings

# HVAC Load Calculations

- ❖ BTU heating and cooling loads typically determined by ACCA Manual J, S, D calculations.
- ❖ Maintain comfort at “design conditions” 99% of the year, based on TMY3 data.
  - ❖ 75°F summer, 70°F winter
  - ❖ 50% relative humidity
- ❖ Systems sized at or below 140% of heating load and 115% of cooling load.
- ❖ Code officials are increasing enforcement of Load Calcs.



Builder QC Through IR

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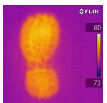
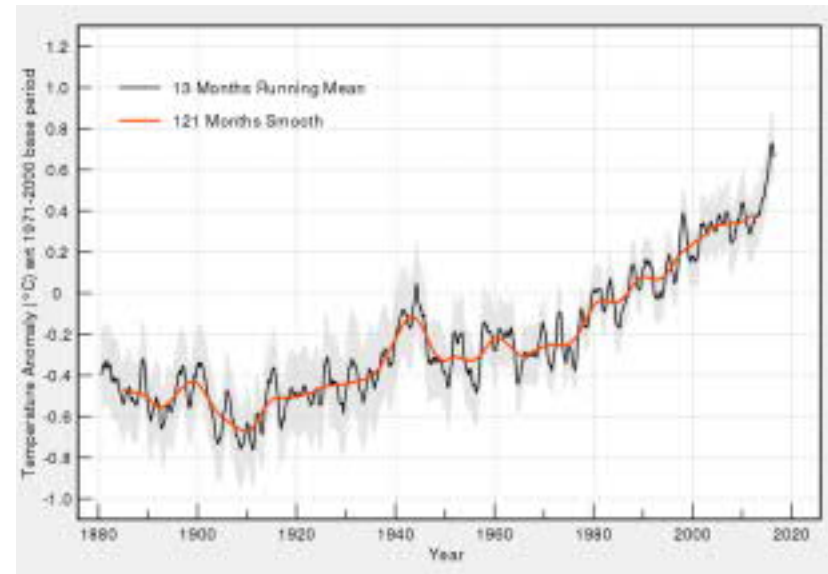
## Section 3: Heat Transfer in Buildings

# TMY3 Data?

- ❖ TMY3 = Typical Meteorological Year data set spanning 1976 - 2005.  
(NREL Technical Report TP-581-43156, Revised May 2008)
- ❖ The good news - we have plenty of room for error on the heating loads.
- ❖ The bad news - 8 out of the 10 hottest years on record have occurred after the TMY3 data set.
- ❖ 115% limit on cooling load just lost 5% of margin.
- ❖ Don't forget Heat Island Effect and humidity increases due to warmer air.

Top 10 warmest years (NOAA)  
(1880–2017)

Rank ↕	Year ↕	Anomaly °C ↕	Anomaly °F ↕
1	2016	0.94	1.69
2	2015	0.90	1.62
3	2017	0.84	1.51
4	2014	0.74	1.33
5	2010	0.70	1.26
6	2013	0.66	1.19
7	2005	0.65	1.17
8	2009	0.64	1.15
9	1998	0.63	1.13
10	2012	0.62	1.12



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❖ [https://en.wikipedia.org/wiki/Instrumental\\_temperature\\_record](https://en.wikipedia.org/wiki/Instrumental_temperature_record)



## Section 3: Heat Transfer in Buildings

# TMY3 Data?

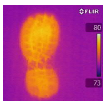
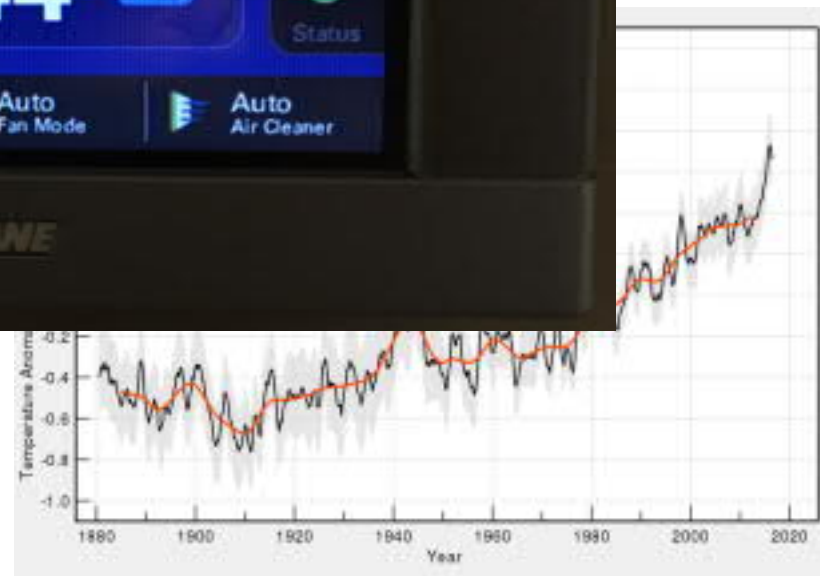
- ❖ TYM3 = Typical Meteorological Year data set spanning 1976 - 2005.

(NREL Tech  
2008)

- ❖ The go of room loads.
- ❖ The ba hottest occurred
- ❖ 115% I lost 5%
- ❖ Don't f and humidity increases due to warmer air.

Top 10 warmest years (NOAA)  
(1880–2017)

Rank	Year	Anomaly °C	Anomaly °F
1	2016	0.94	1.69
2	2015	0.88	1.58
3	2014	0.85	1.53
4	2013	0.82	1.48
5	2012	0.78	1.40
6	2011	0.75	1.35
7	2010	0.72	1.30
8	2009	0.68	1.22
9	2008	0.65	1.17
10	2007	0.62	1.12



Builder QC Through IR

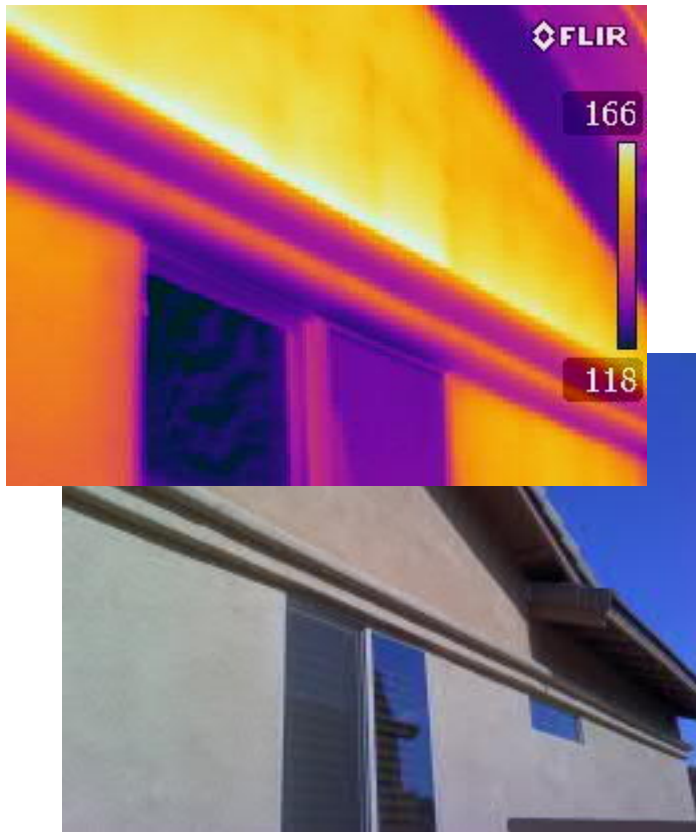
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❖ [https://en.wikipedia.org/wiki/Instrumental\\_temperature\\_record](https://en.wikipedia.org/wiki/Instrumental_temperature_record)

## Section 3: Heat Transfer in Buildings

# Surface Temperatures

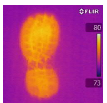
### ❖ Building Surfaces



### ❖ Ambient Spaces



These are not accounted for in Manual J load calcs.



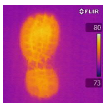
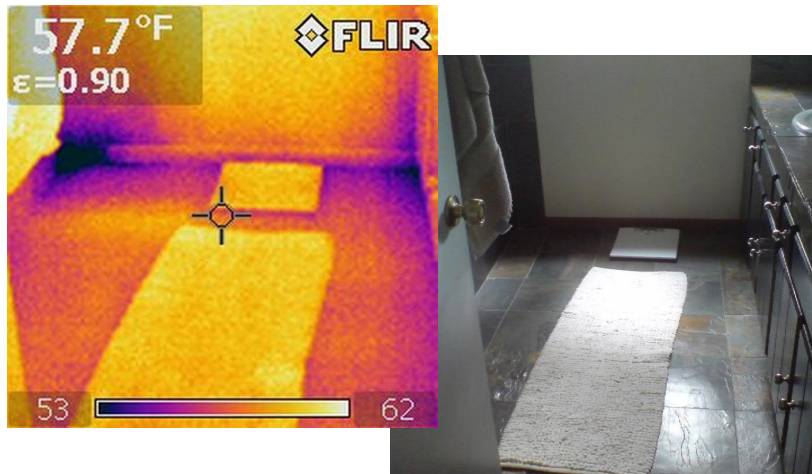
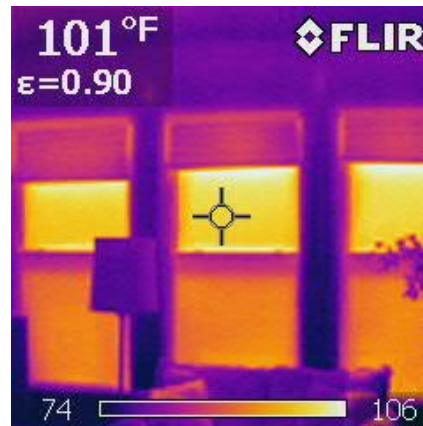
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## Section 3: Heat Transfer in Buildings

# Mean Radiant Temperature

- ❖ MRT = Weighted mean temperature of all radiant sources around a person.
  - ❖ Exterior surfaces – ceilings, walls, floors, windows, doors.
  - ❖ Interior surfaces – building, curtains, furniture, etc.



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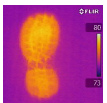
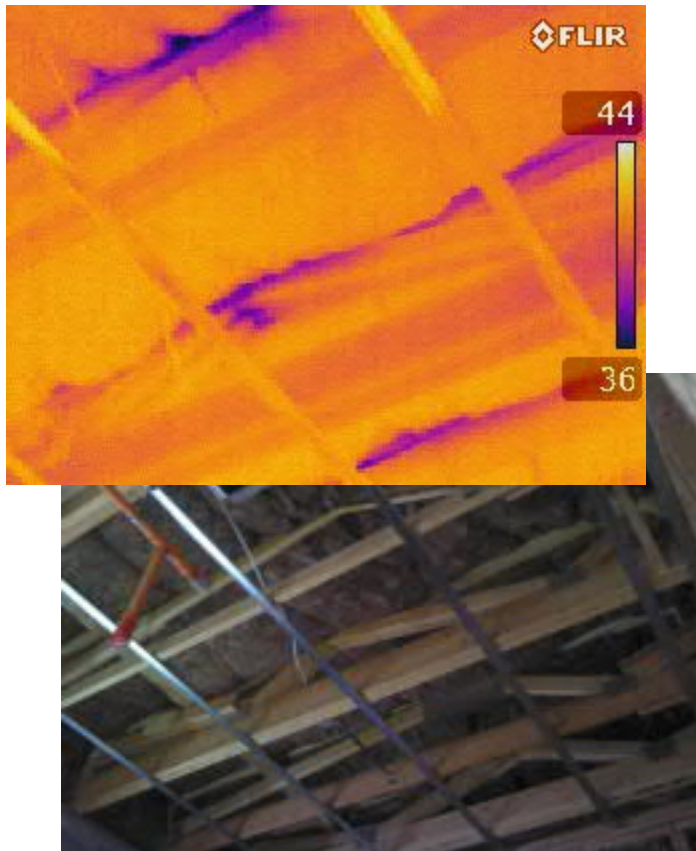
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## Section 4: Persistent Thermal Issues

# Fiberglass QC

- ❖ Verify and reinforce scope of work



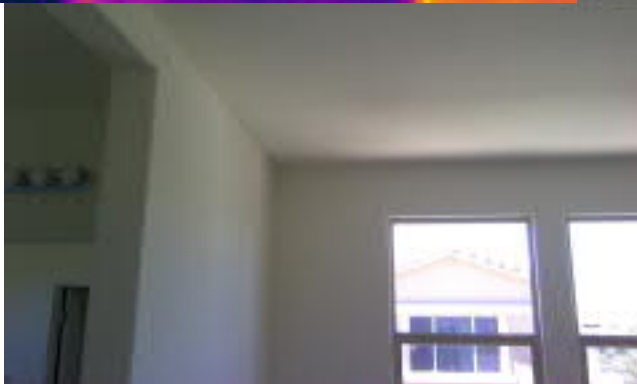
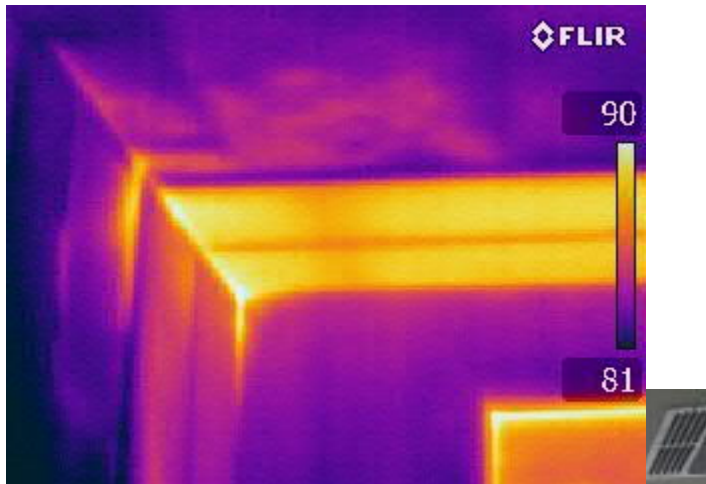
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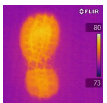
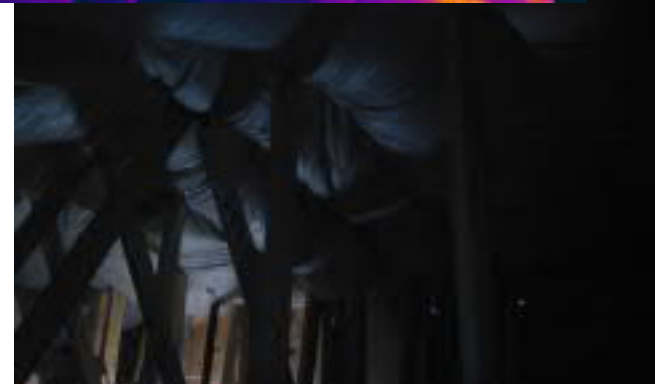
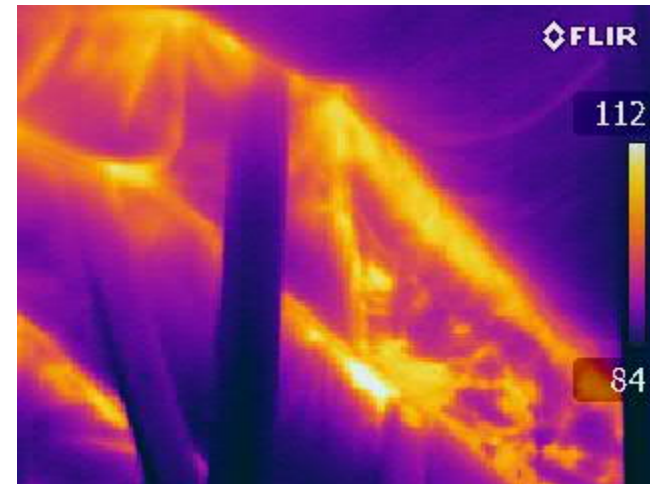
## Section 4: Persistent Thermal Issues

# Cellulose QC

❖ Missed over-framed attic and low levels in main attic



❖ Netted / pillowed at roof deck



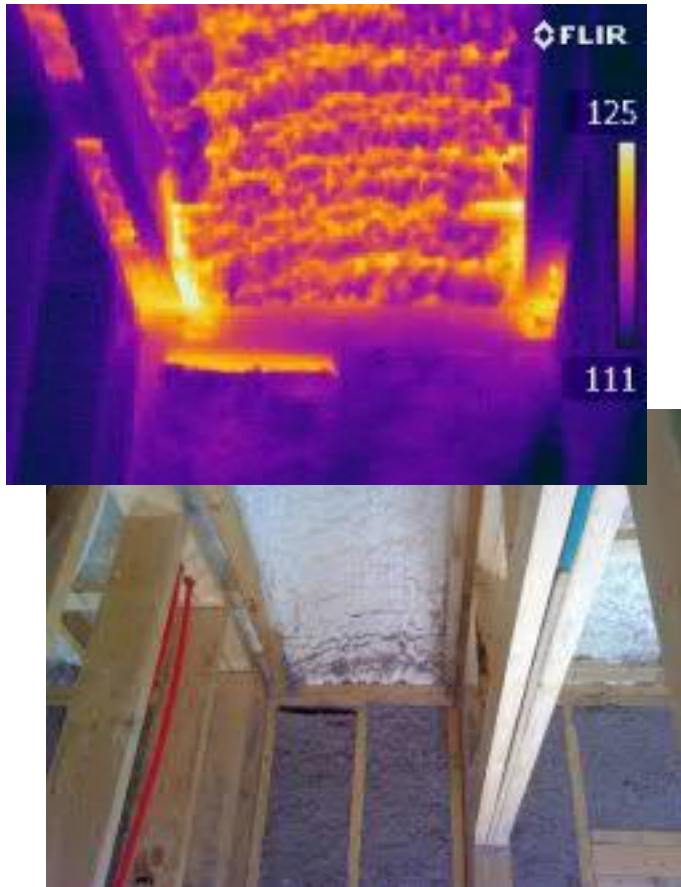
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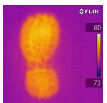
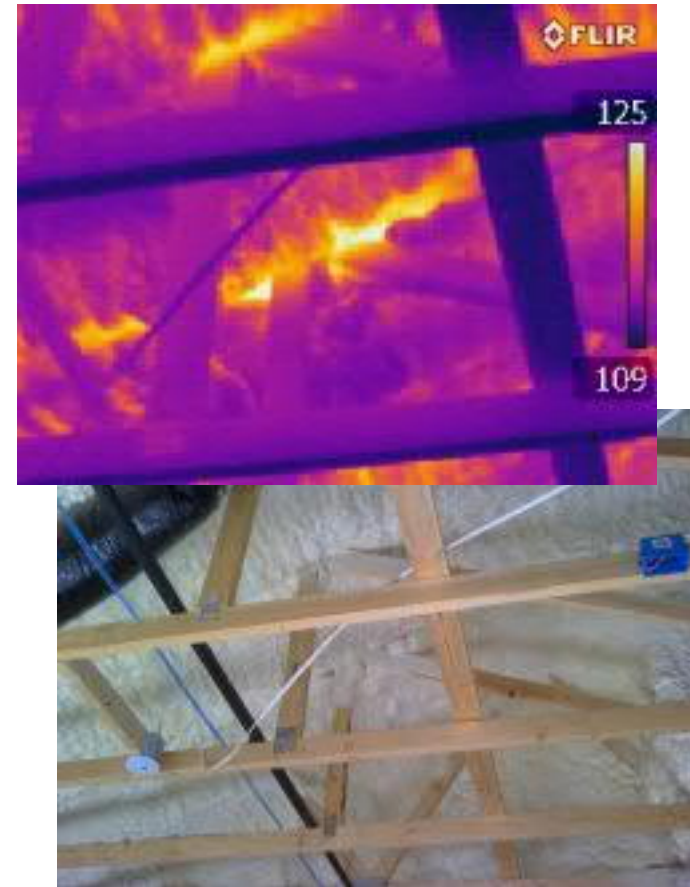
## Section 4: Persistent Thermal Issues

# Foam QC

### ❖ Gussets, gullies, & gaps



### ❖ Gussets and trusses



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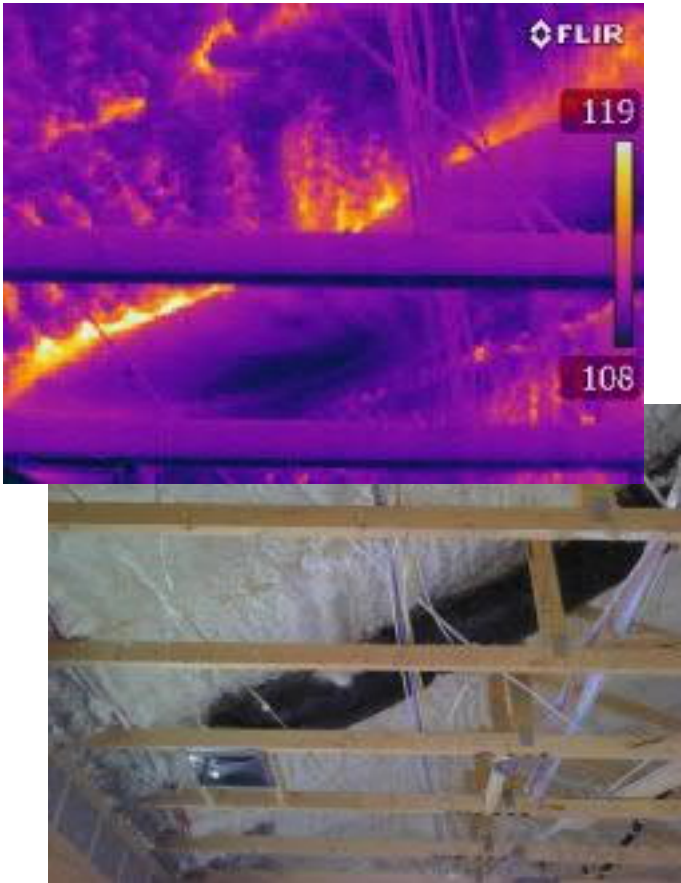
Low points hurt more than high points help



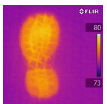
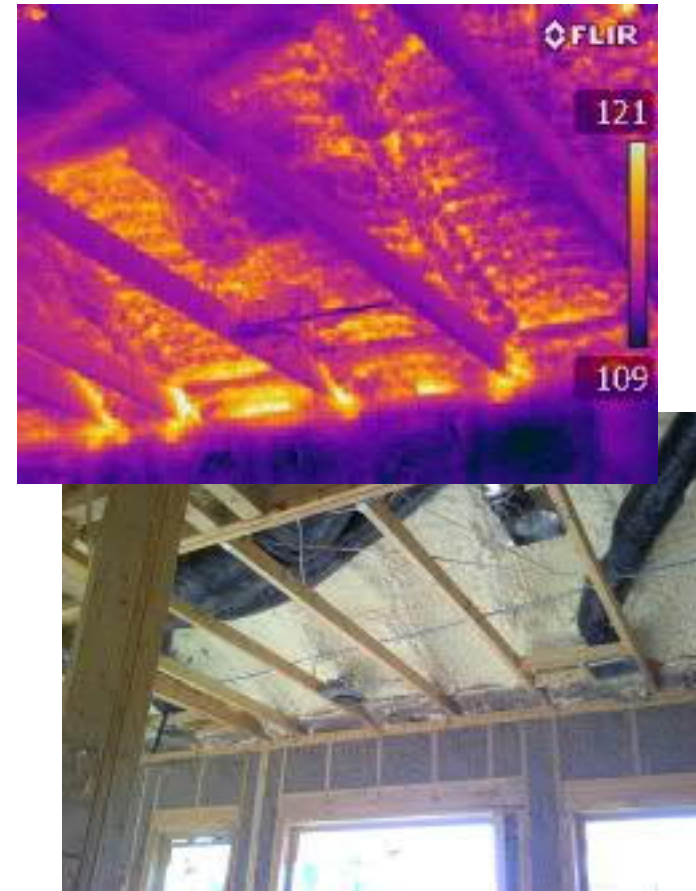
## Section 4: Persistent Thermal Issues

# Foam QC

❖ Ducts too close for comfort



❖ Nominal or inconsistent?



Builder QC Through IR

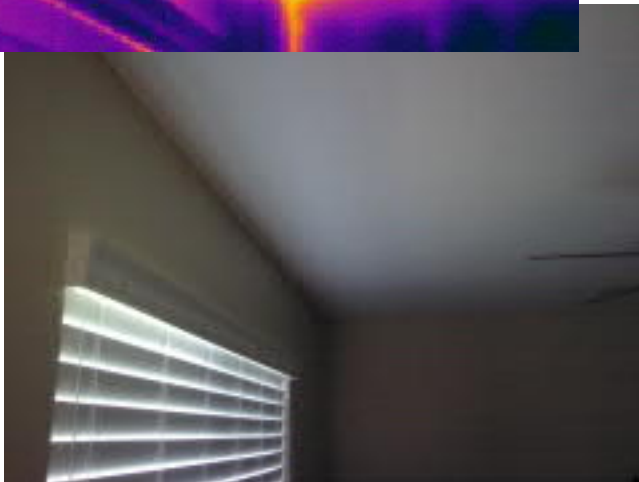
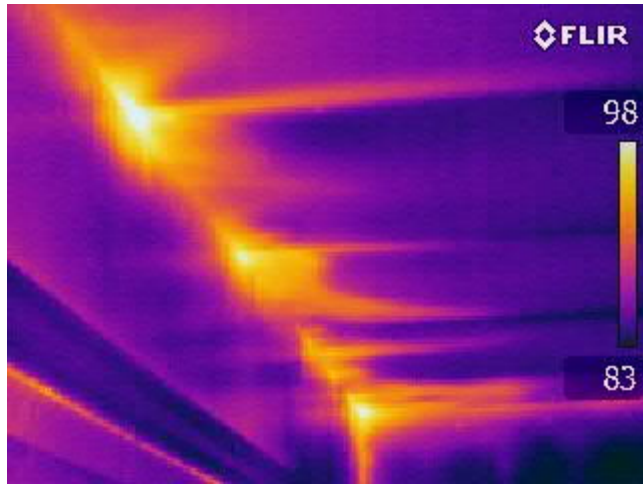
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Low points hurt more than high points help

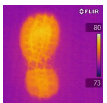
## Section 4: Persistent Thermal Issues

# Foam QC

- ❖ Top plate air leakage across drywall in sealed attic



- ❖ Bottom plate / rim joist air leakage behind drywall



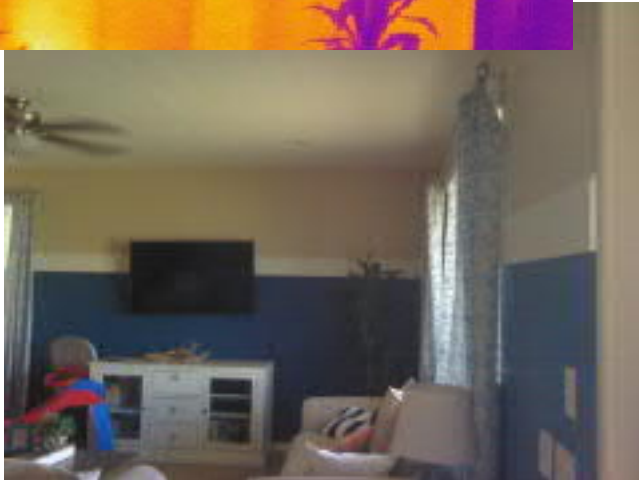
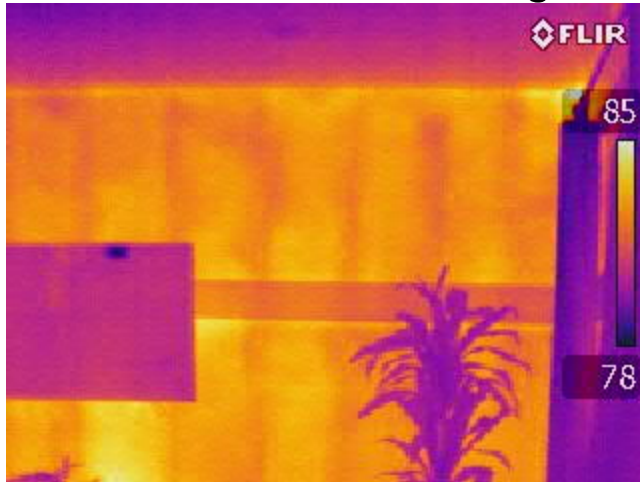
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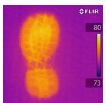
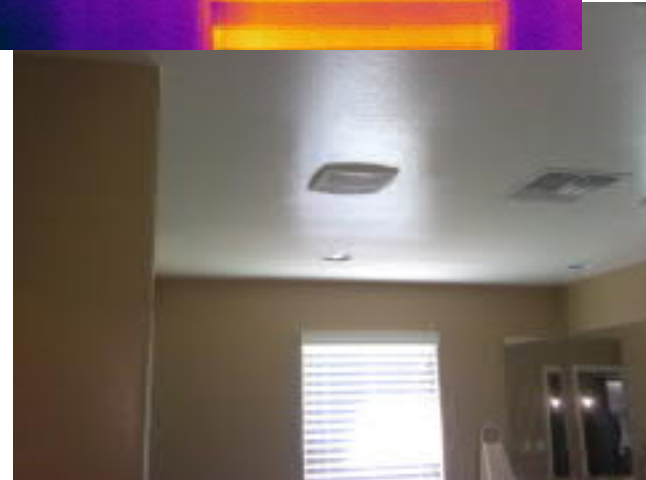
## Section 4: Persistent Thermal Issues

# Foam QC

- ❖ Partial foam filled wall, R-13 in 2x6 framing



- ❖ Over-framed sealed attic, different than main attic



Builder QC Through IR

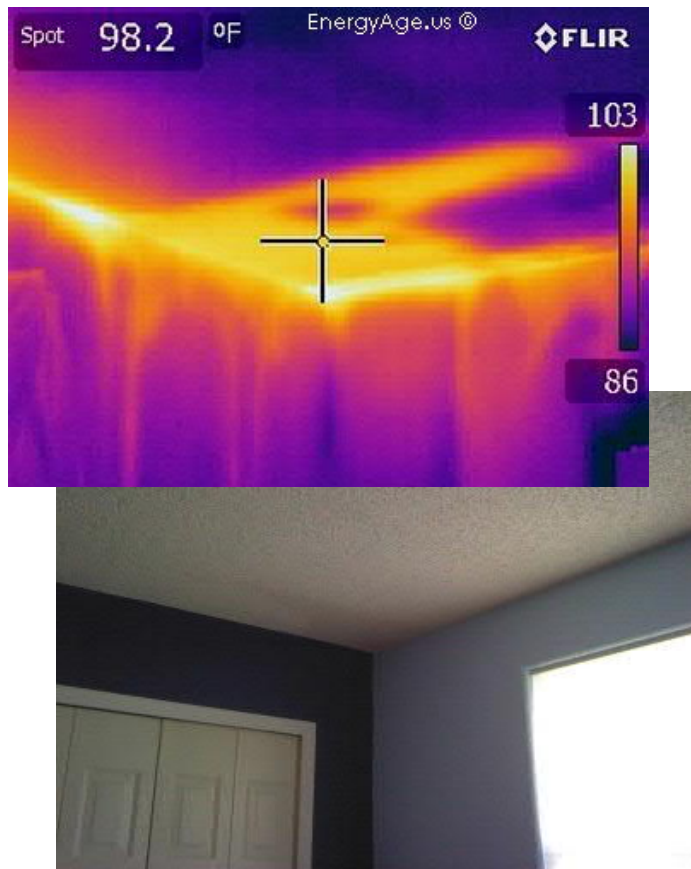
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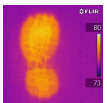
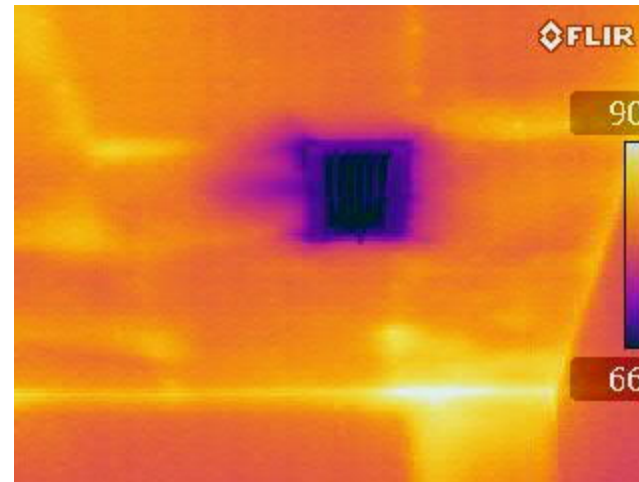
## Section 4: Persistent Thermal Issues

# Warranty QC

❖ Uncomfortable perimeter rooms?



❖ HVAC doesn't keep up at 400 sf / ton?



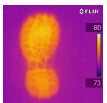
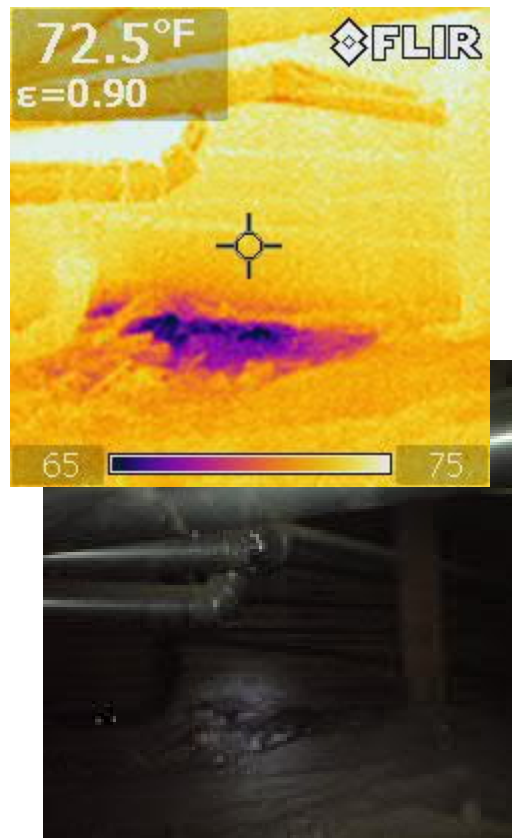
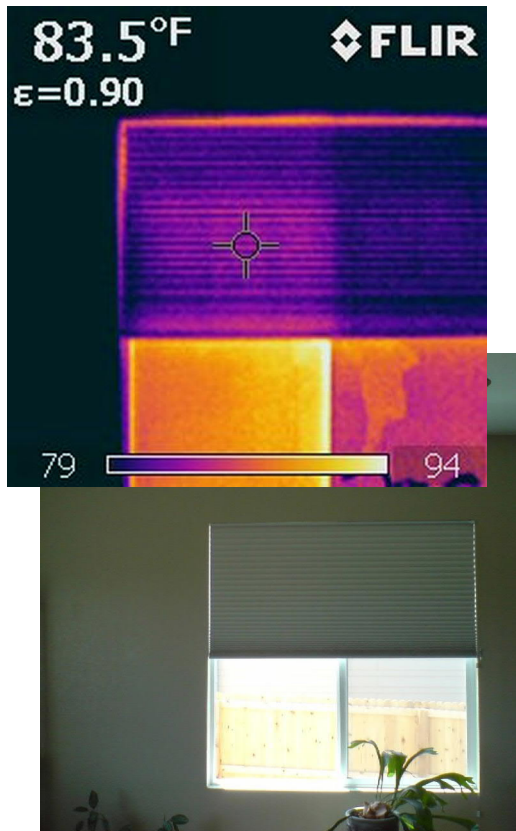
Builder QC Through IR

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## Section 4: Persistent Thermal Issues

# Remodel QC

- ❖ Windows solar gain
- ❖ Drain-waste leak
- ❖ Adding fixtures



Builder QC Through IR

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## Section 4: Persistent Thermal Issues

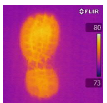
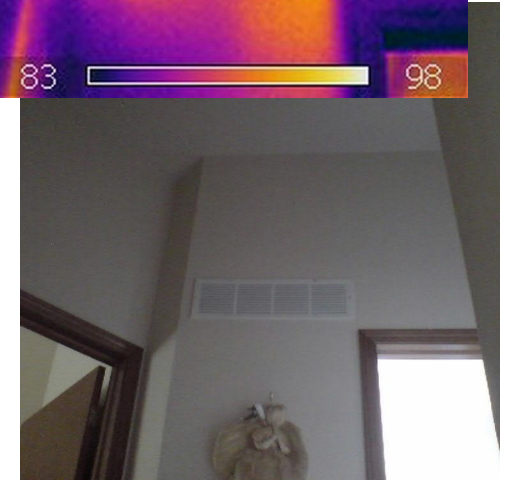
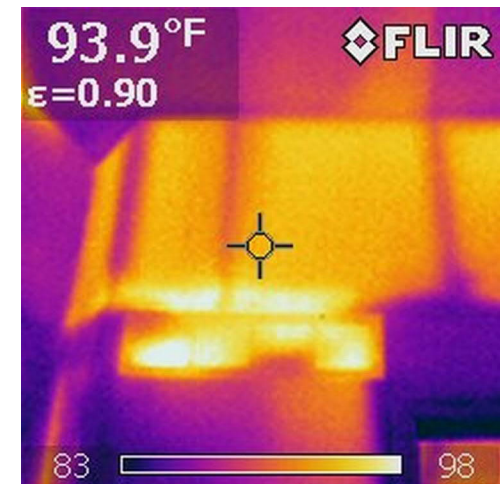
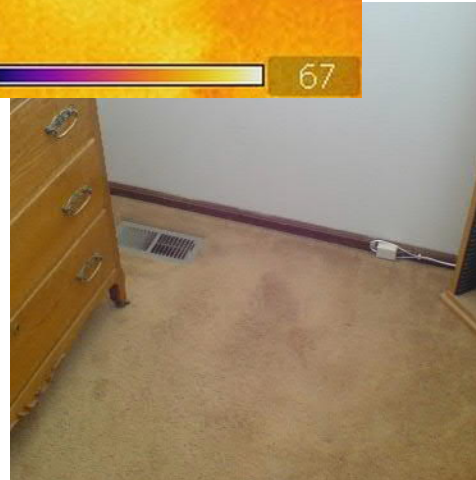
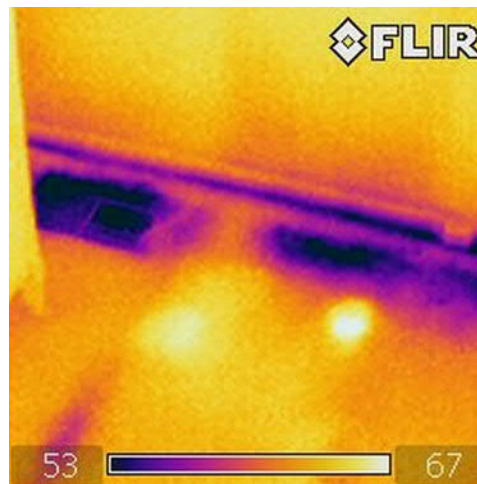
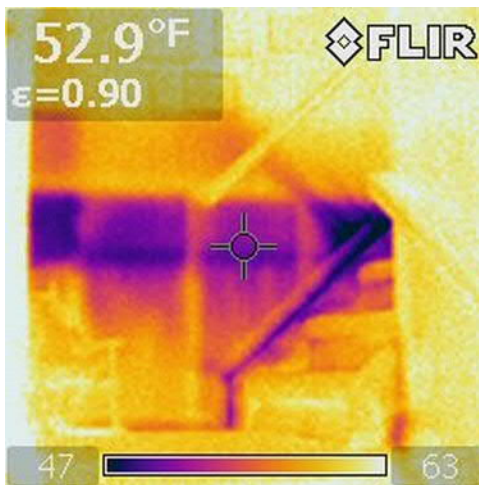
# Remodel QC

Potential scope of work to add on?

❖ Floor cavity

❖ Sub-floor, duct

❖ Attic walls, duct



Builder QC Through IR

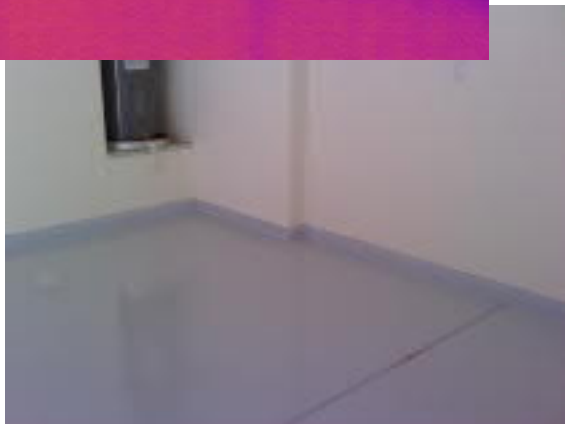
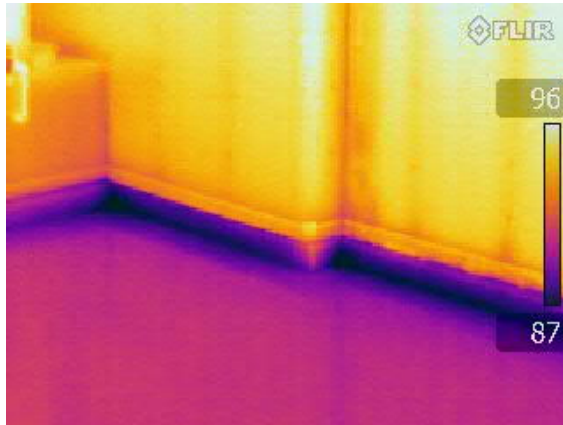
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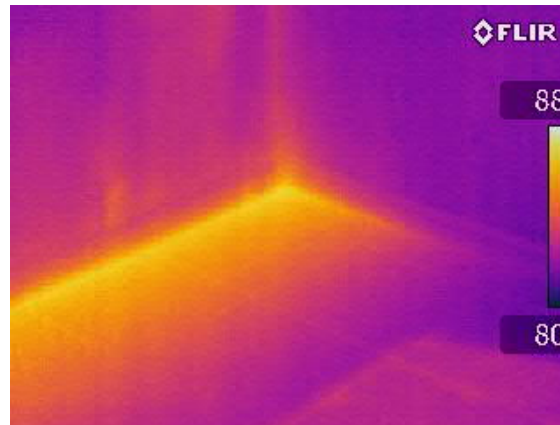
## Section 4: Persistent Thermal Issues

# Foundation & Slab QC

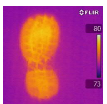
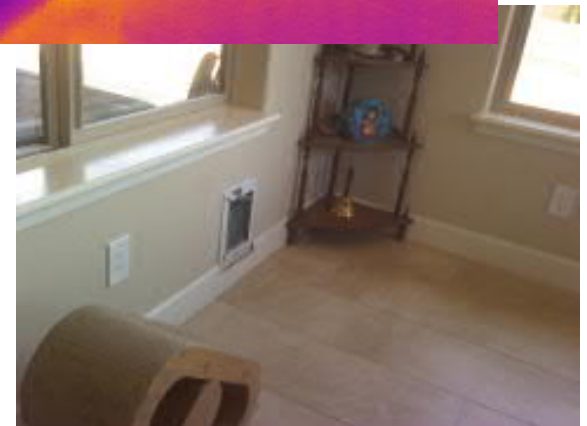
❖ Garage slab



❖ Tile in sun



❖ Tile in shade



Builder QC Through IR

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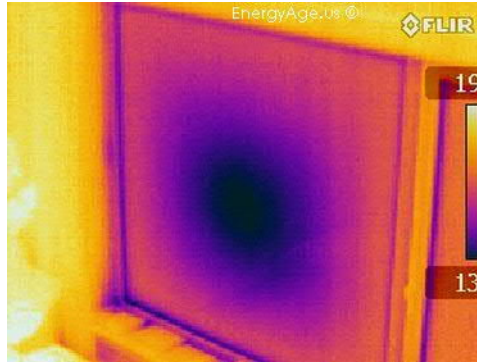
## Section 5: Additional Observations

# Ghosts? Portals Into Another Dimension?

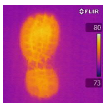
Or design and quality control opportunities?



- ❖ Polished copper heat reflector behind wood stove.



- ❖ Large double-pane window produced at a higher altitude. Inside (left) and outside (right)



Builder QC Through IR

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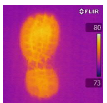
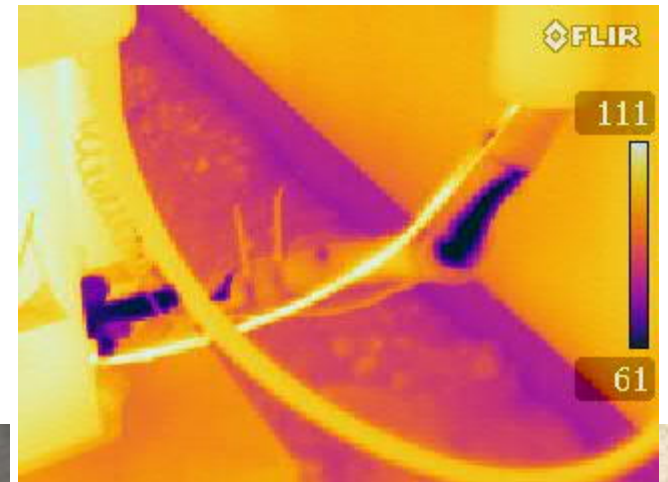
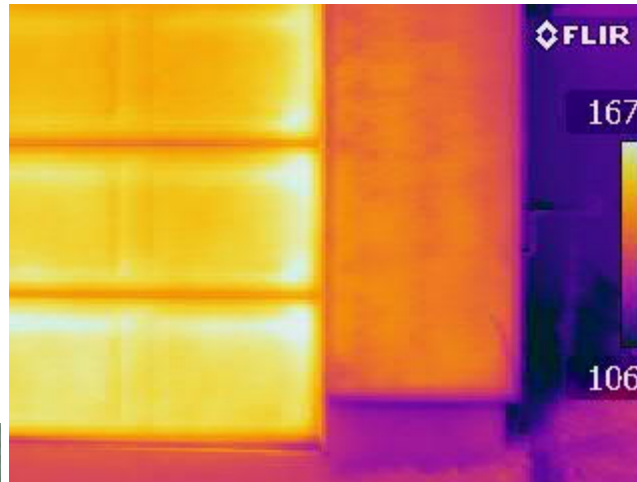
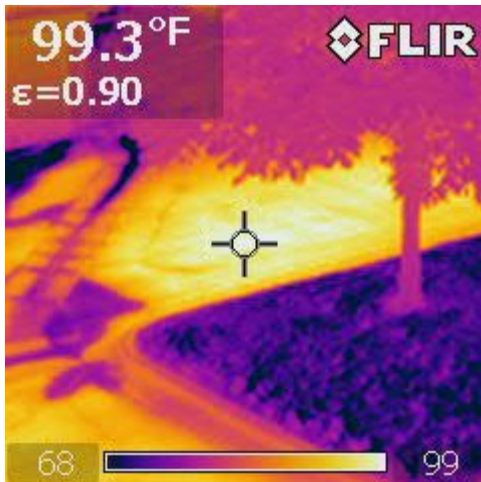
## Section 5: Additional Observations

# Exterior Impact

❖ Green = Cool

❖ Hot room over garage

❖ Line-set insulation sun damage



Builder QC Through IR

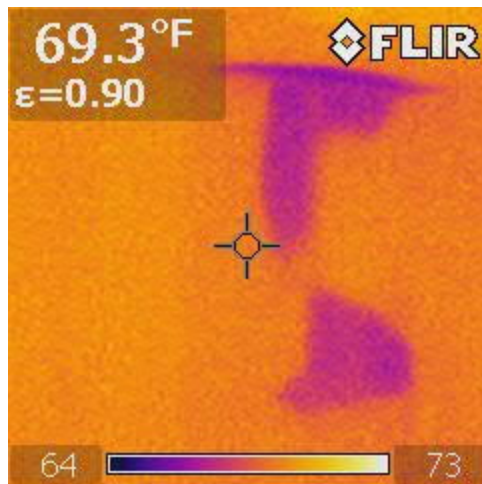
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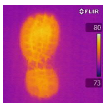
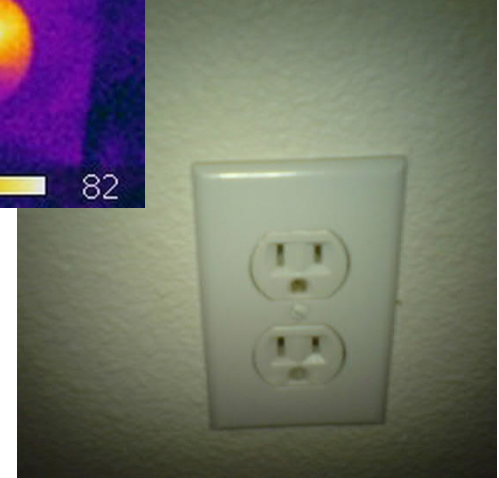
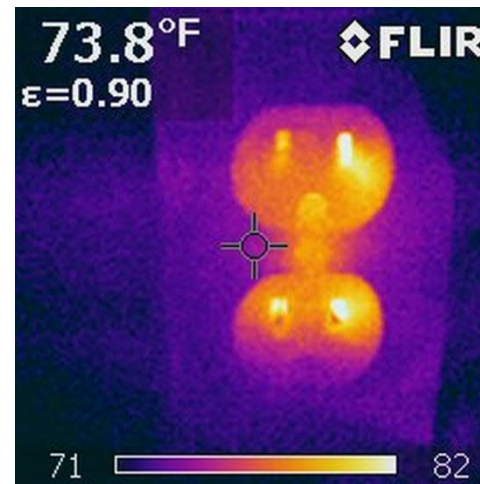
## Section 5: Additional Observations

# Health and Safety

❖ This is not insulation...



❖ This is not air flow...



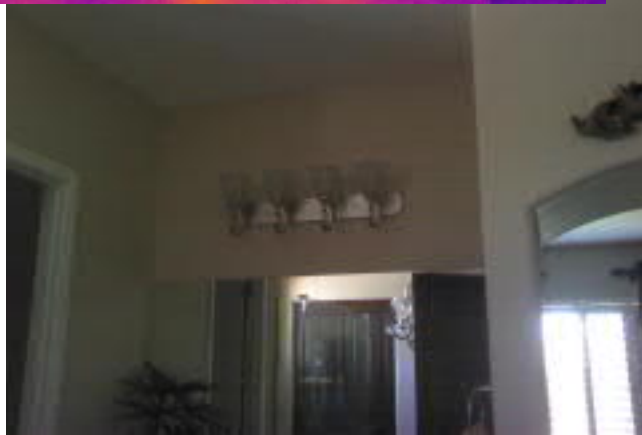
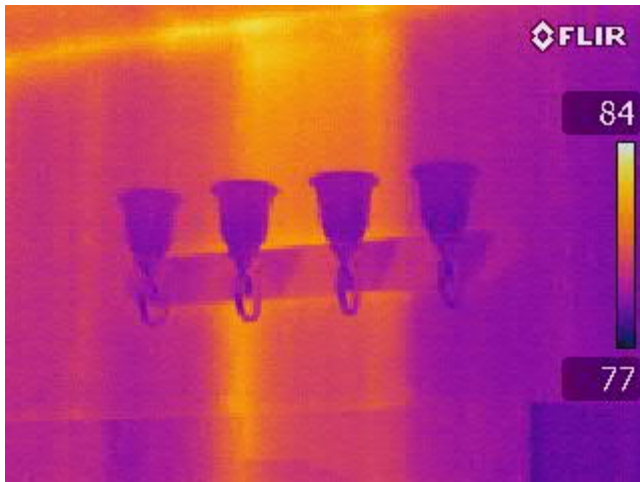
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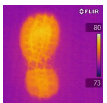
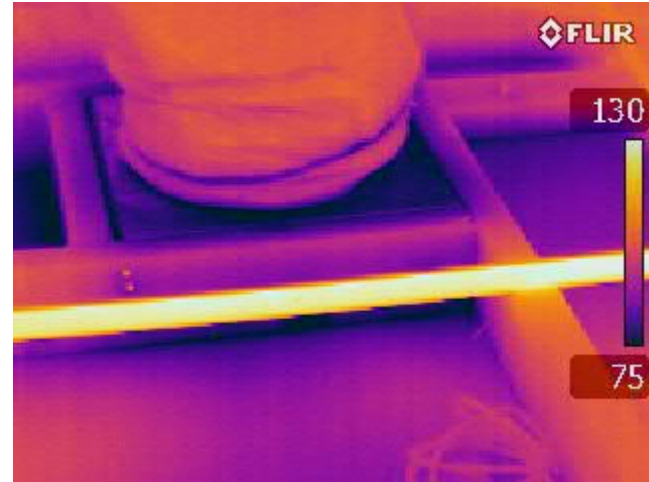
## Section 5: Additional Observations

# DHW Systems QC

- ❖ Hot water circulation at interior wall



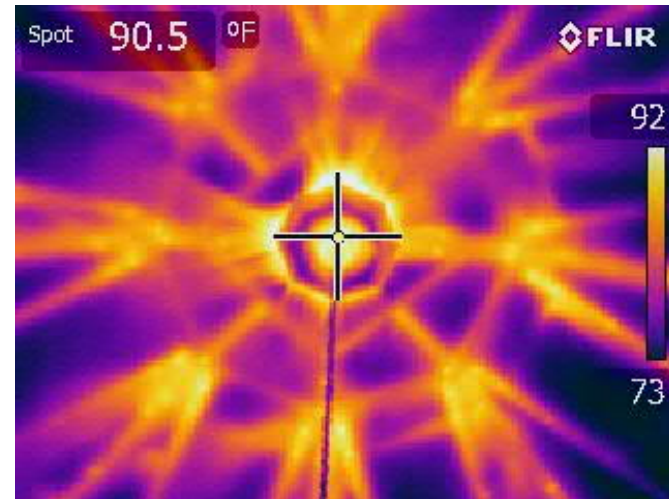
- ❖ Uninsulated hot water lines with circ pump



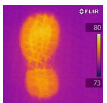
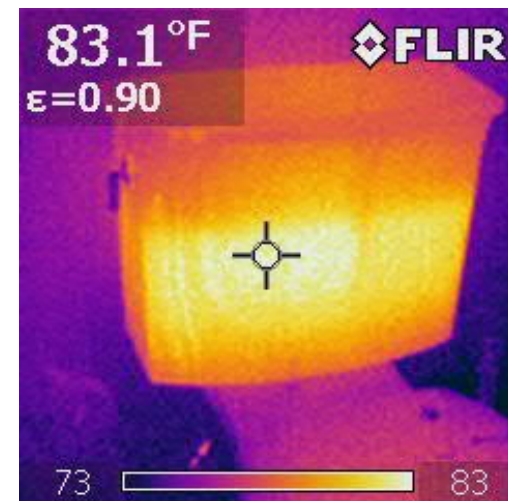
Builder QC Through IR

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# Stay Curious and Think!



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