We will be starting soon!

Thanks for joining us

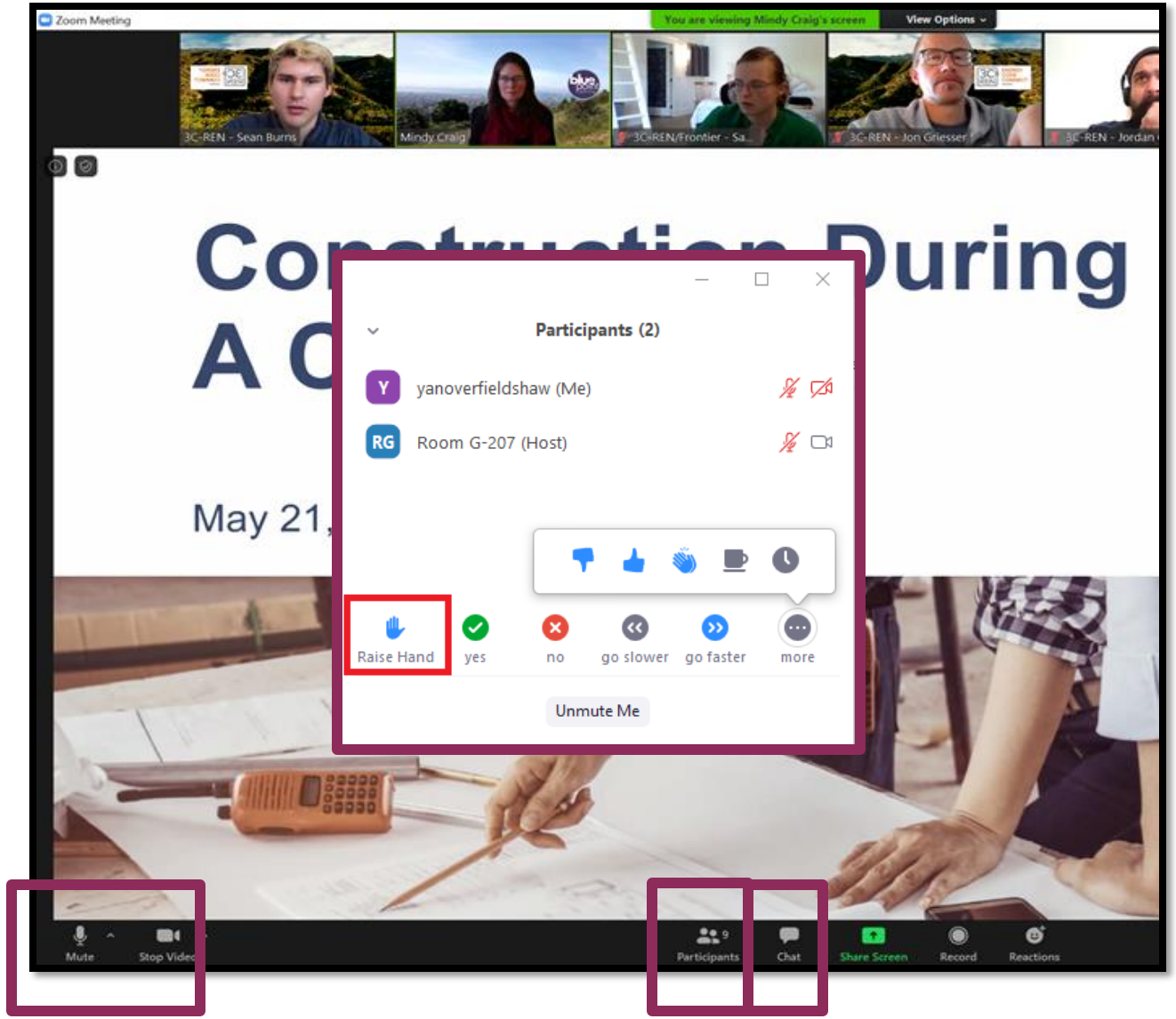
Enclosure Best Practices: Roofs, Walls, and Floors

Rick Chitwood

June 12, 2022

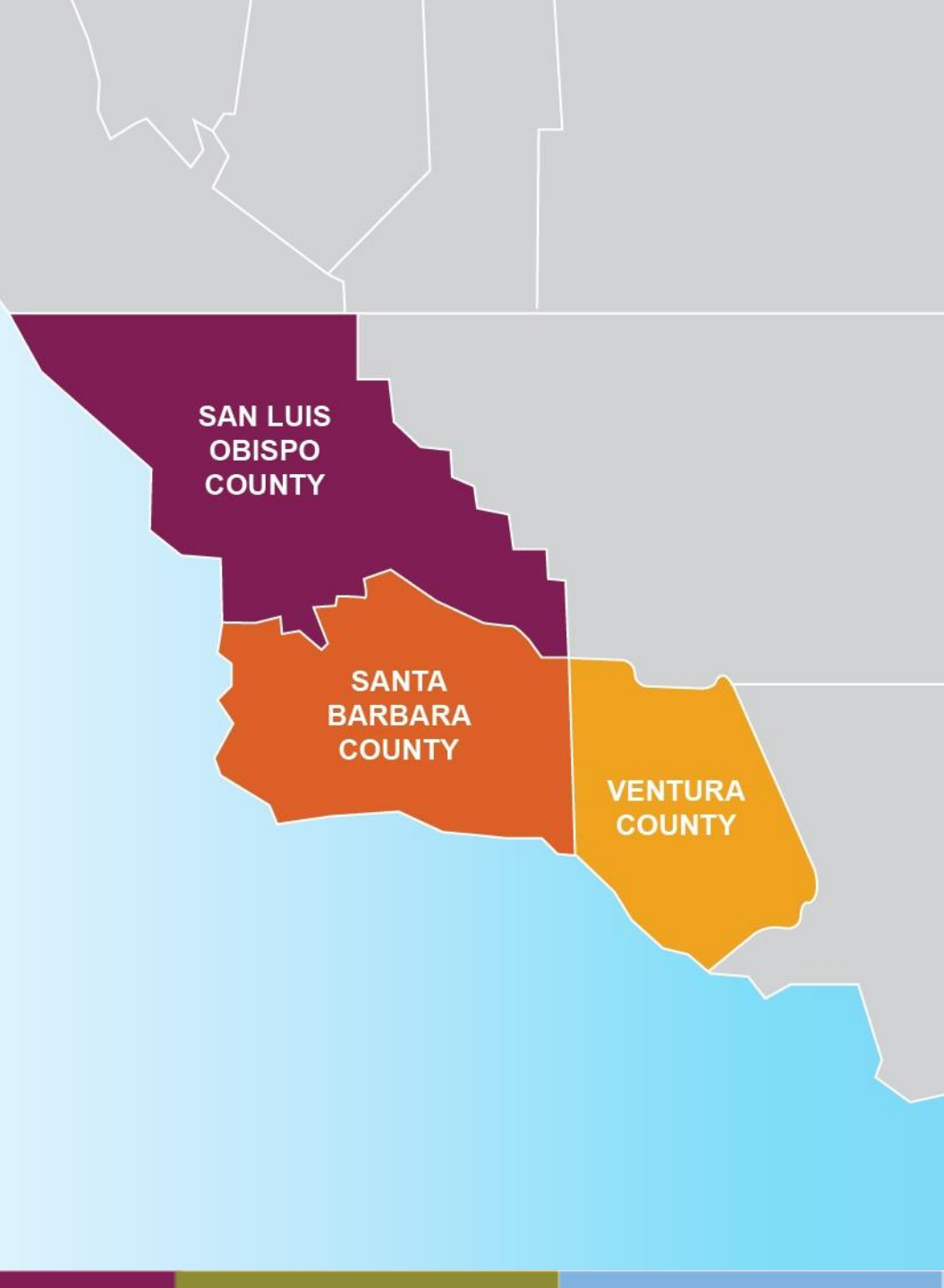
Zoom Orientation

- Please be sure your full name is displayed
- Please mute upon joining
- Use "Chat“ box to share questions or comments
- Under "Participant" select "Raise Hand" to share a question or comment verbally
- The session may be recorded and posted to 3C-REN's on-demand page. Feel free to ask questions via the chat and keep video off if you want to remain anonymous in the recording.



3C-REN: Tri-County Regional Energy Network

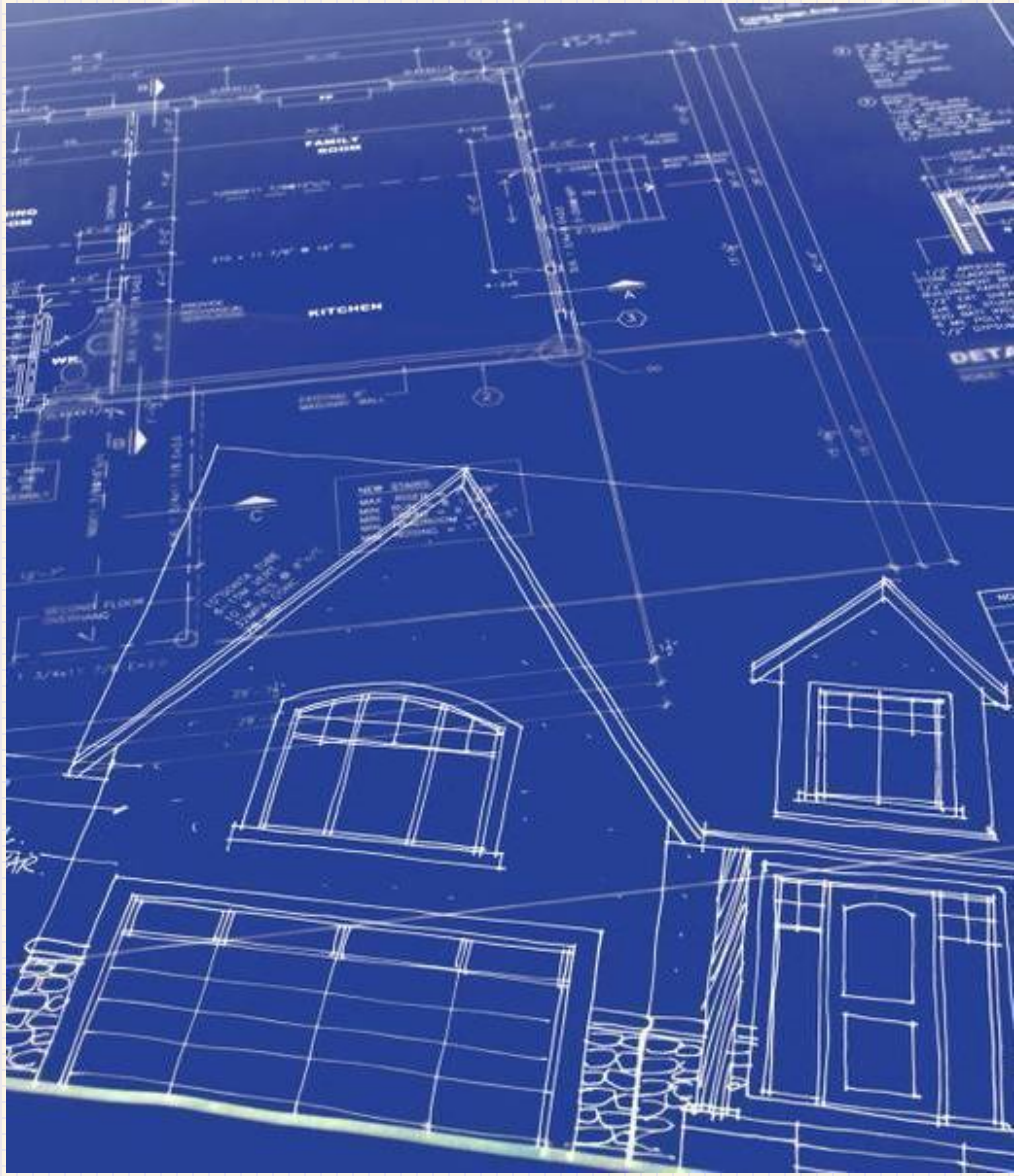
- Three counties working together to improve energy efficiency in the region
- Services for –
  - **Building Professionals:** industry events, training, and energy code compliance support
  - **Households:** free and discounted home upgrades
- Funded by ratepayer dollars that 3C-REN returns to the region



3C-REN
Staff Online

High Performance Fundamentals Series

- A series of 6 classes (intro, building science, **enclosures**, heat pumps, water heating, electrification)
- Focused on building practices to exceed code and optimize performance
- Outcomes are improved tenant health and comfort and minimized environmental impact
- This series is designed to provide a solid foundation in the building science knowledge needed for high performance work

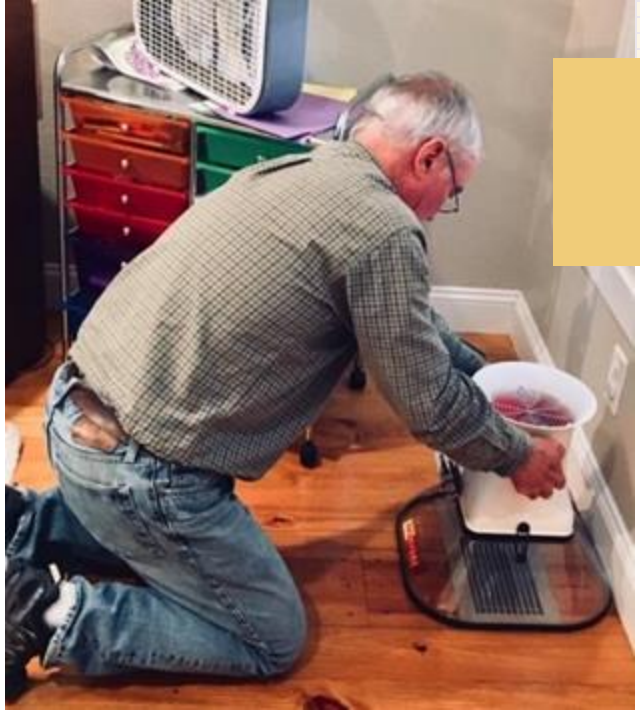


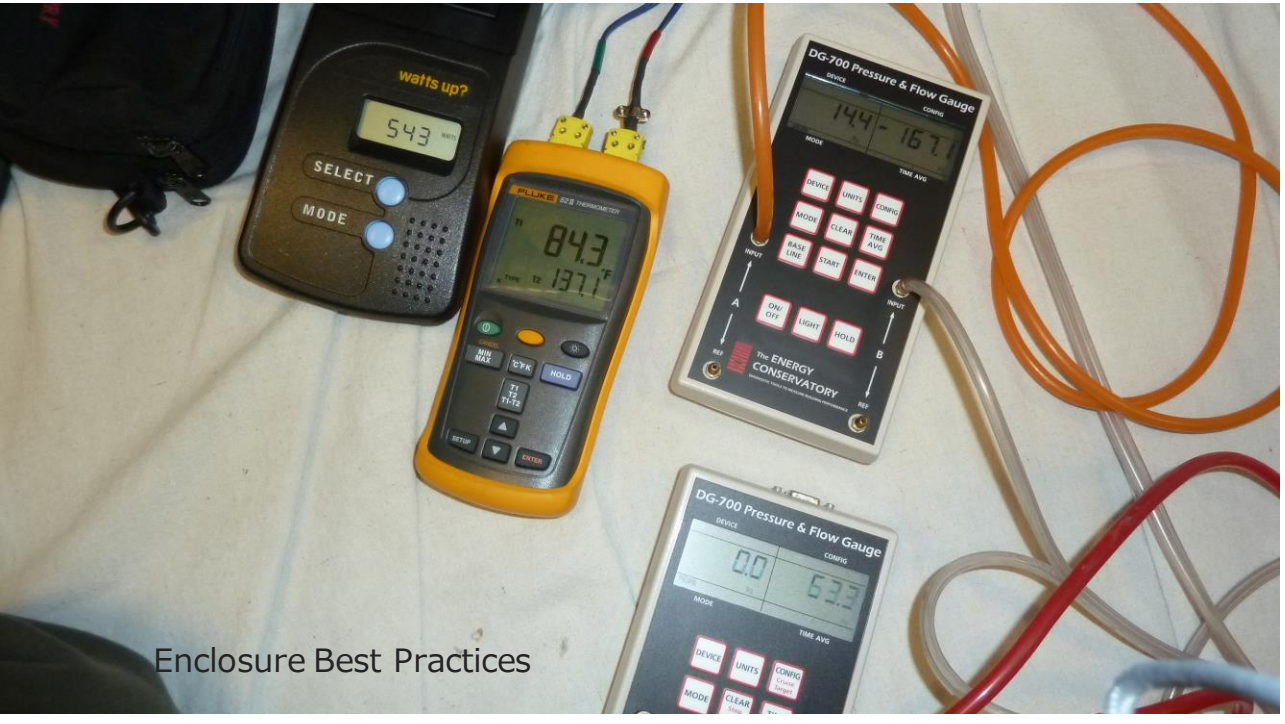
(Thermal)

Enclosure Best Practices: Ceilings, Walls, & Floors

RICK CHITWOOD

RICK@CHITWOODENERGY.COM





Rick's Background...

1. Broad experience but master of nothing
2. BSME, 1983
3. HVAC designer, installer, and commissioner – and – building insulation specifier, installer, and enclosure commissioner (wrote QII in 2003)
4. Field Research/Building Performance Testing
5. Co-author of; *Measured Home Performance* and *Real-World Zero Net Energy Homes For California*
6. BPI Hall-of-Fame inductee

Agenda

1. **Enclosure Basics**
2. **Ceilings**
3. **Walls** (and Attic Knee Walls)
4. **Windows**
5. **Floors** (and Slab Edges)
6. **Air Sealing**
7. **Two Case Studies**
8. **Recap**
9. **Most Important Enclosure Goals**

Q&A (15 minutes)

1. Enclosure Basics

SCIENCE AND TERMINOLOGY MATTER

Terminology

Enclosure, Envelope, and Shell are all terms used for what separates us from Mother Nature.

- **Ceilings**
- **Walls**
- **Windows**
- **Floors**

Our Building Enclosures Must Control:

WATER

WATER VAPOR

AIR FLOW

HEAT FLOW

INDUSTRY HAS ADDRESSED (MORE OR LESS) SUCCESSFULLY

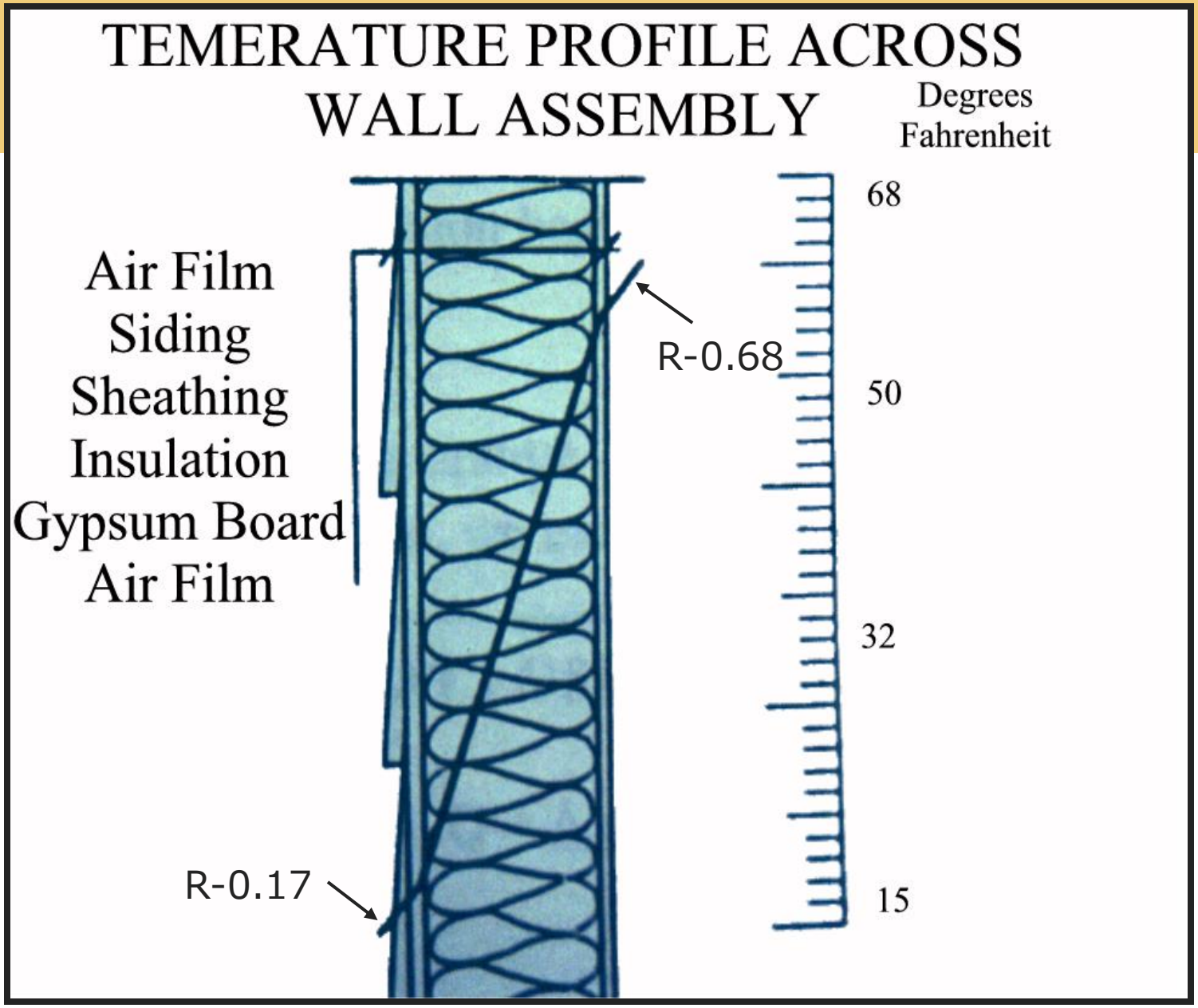
INDUSTRY HAS ***NOT*** ADDRESSED SUCCESSFULLY

Three Types of Heat Transfer

Conduction – heat transfer through solid materials and assemblies

Convection – heat transfer due to moving fluids (air)

Radiation – heat transfer between objects (requires a large temperature difference, $Q=0.0000000017 * A * T^4$)


TEMERATURE PROFILE ACROSS WALL ASSEMBLY
Degrees Fahrenheit
Air Film
Siding
Sheathing
Insulation
Gypsum Board
Air Film
R-0.68
R-0.17
68
50
32
15

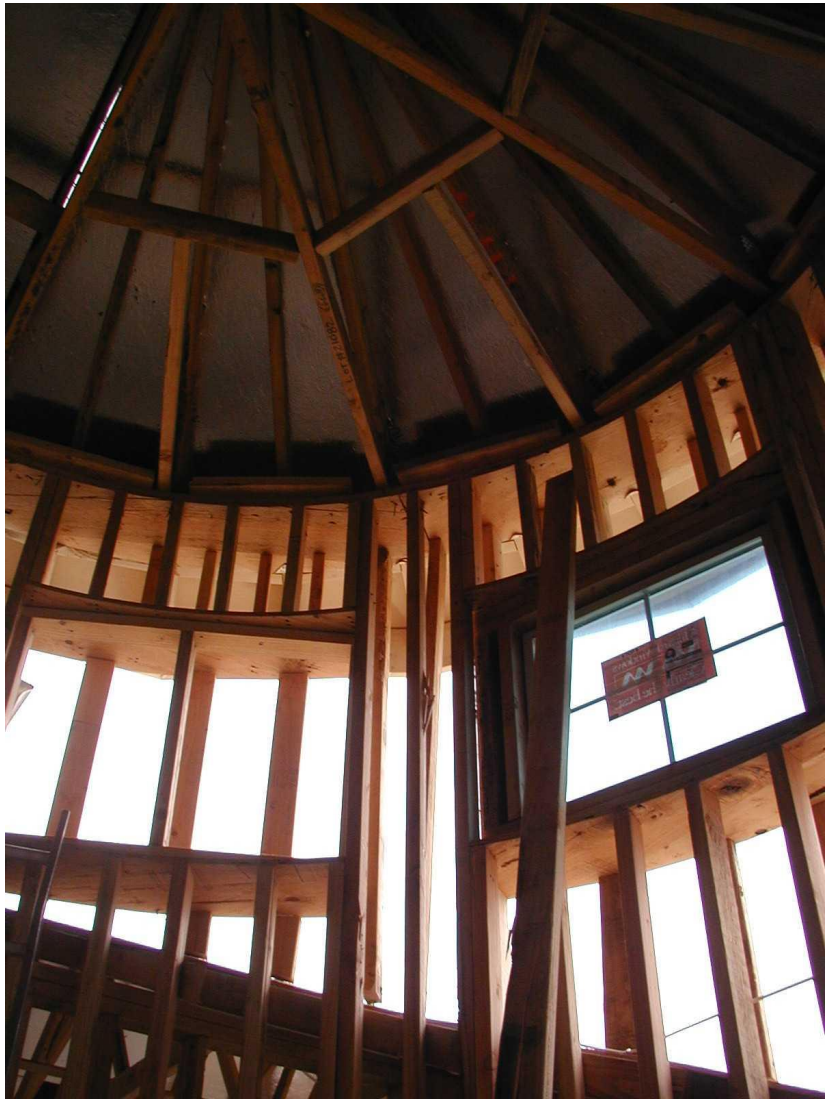
Enclosure Heat Loss (by component)

Air Infiltration	23%
Windows	22%
Slab Edge	20%
Walls	14%
Ducts	12%
Ceiling	9%

(Based on CEC CBECC computer model)

Barriers to Enclosure Performance

- Architectural complexity
- Price pressure
- No testing
- Lack of training



Tackling the Barriers

- **Architectural complexity**
  - Design awareness
- **Price pressure**
  - Tough nut to crack ... but education can help!
- **No testing**
  - Challenging ... but can be fixed by practitioners with knowledge and persistence!
- **Lack of training**
  - Why we're here!

Universal Enclosure Performance Factors

1. Continuous air barriers
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

Build Tight

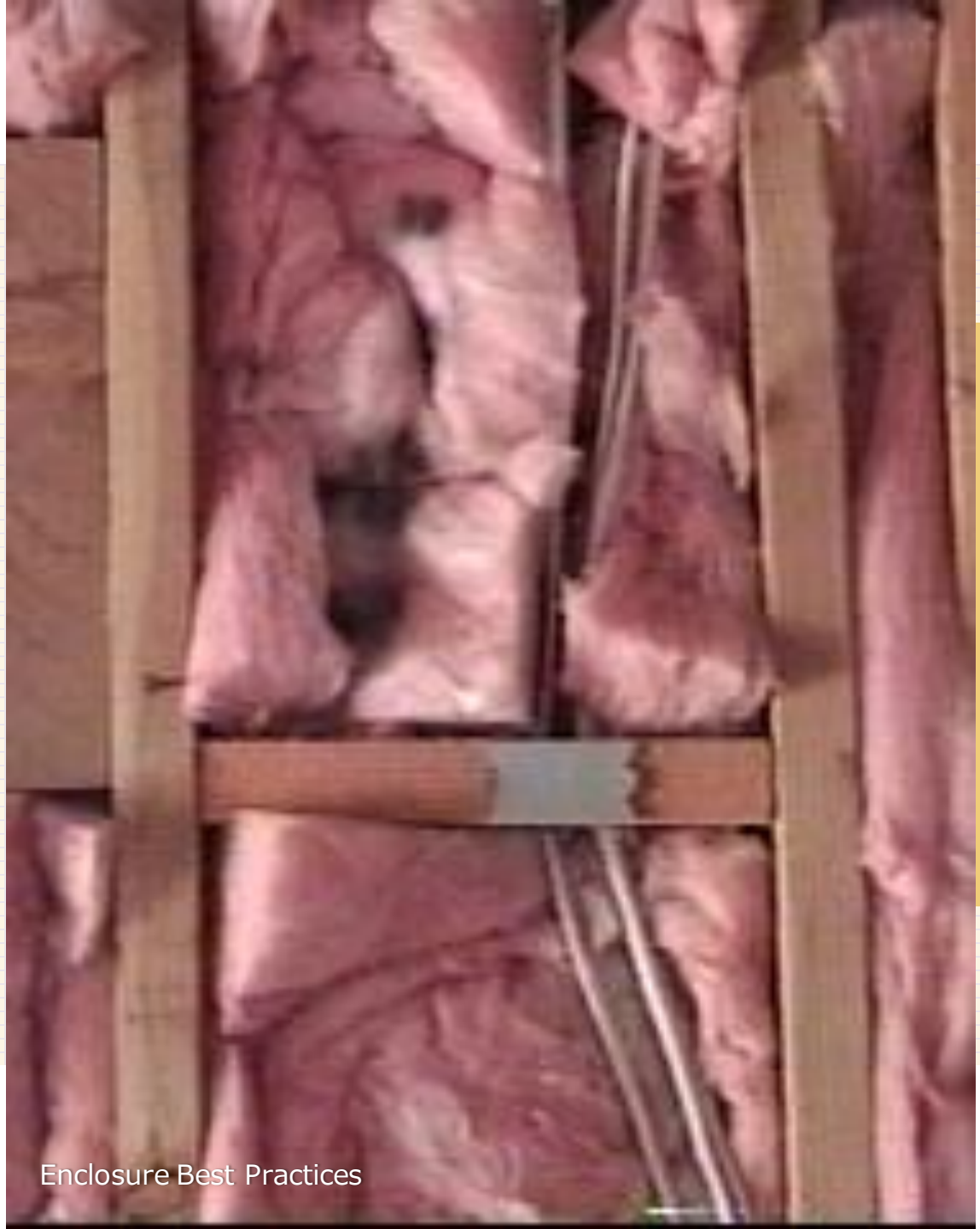
‘Build tight and ventilate right’ is our mantra.

Why?

Wind Pressures Vary

Stack Effect Varies

Mechanical Effect Varies



Installation Quality is More Important Than R-value

2. Ceilings

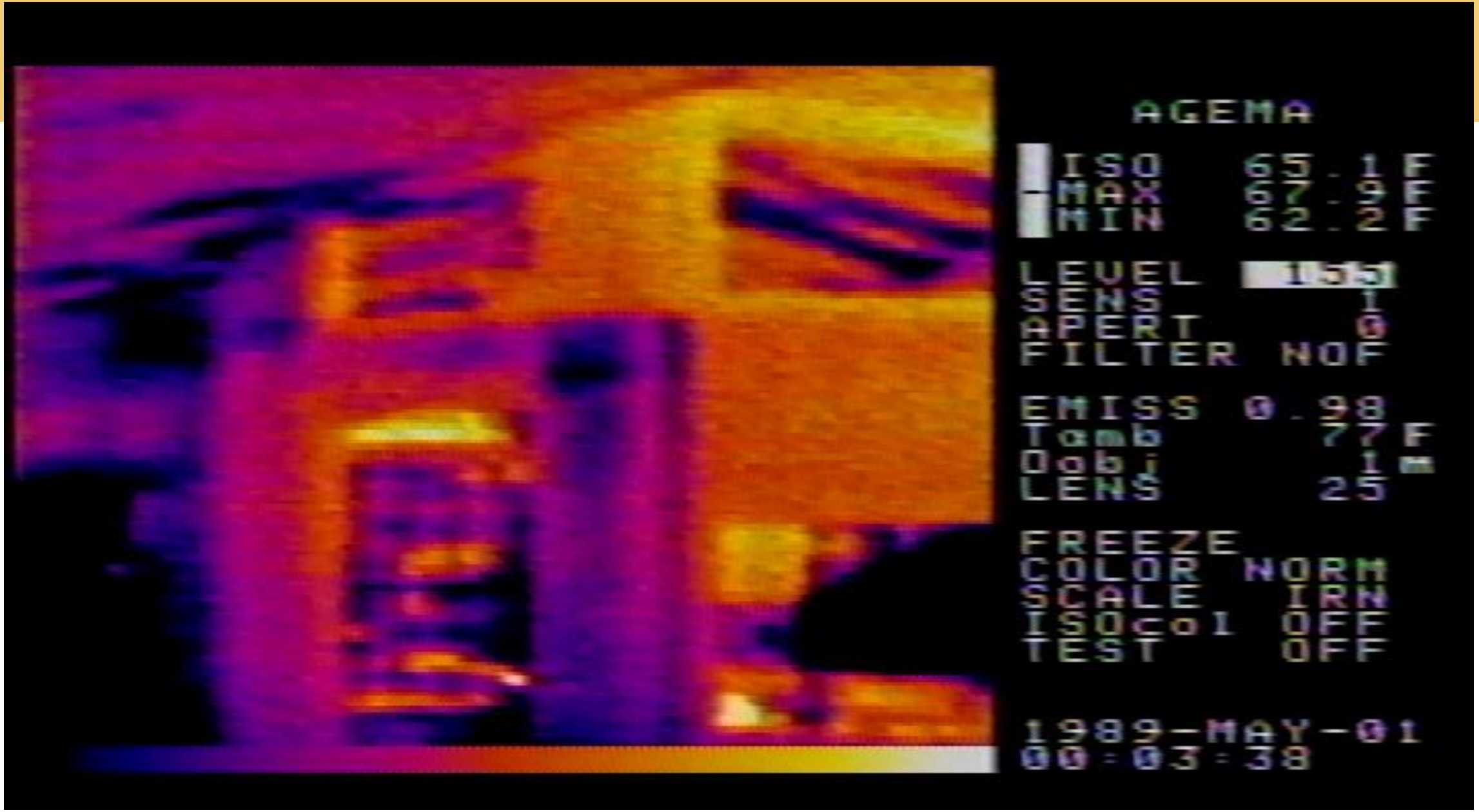
Performance Factors for Ceilings

CEILING SPECIFICS

1. **Continuous and airtight ceiling air barrier** (usually the drywall)

UNIVERSAL

2. Insulation in contact with the air barrier
3. No gaps, voids, or compression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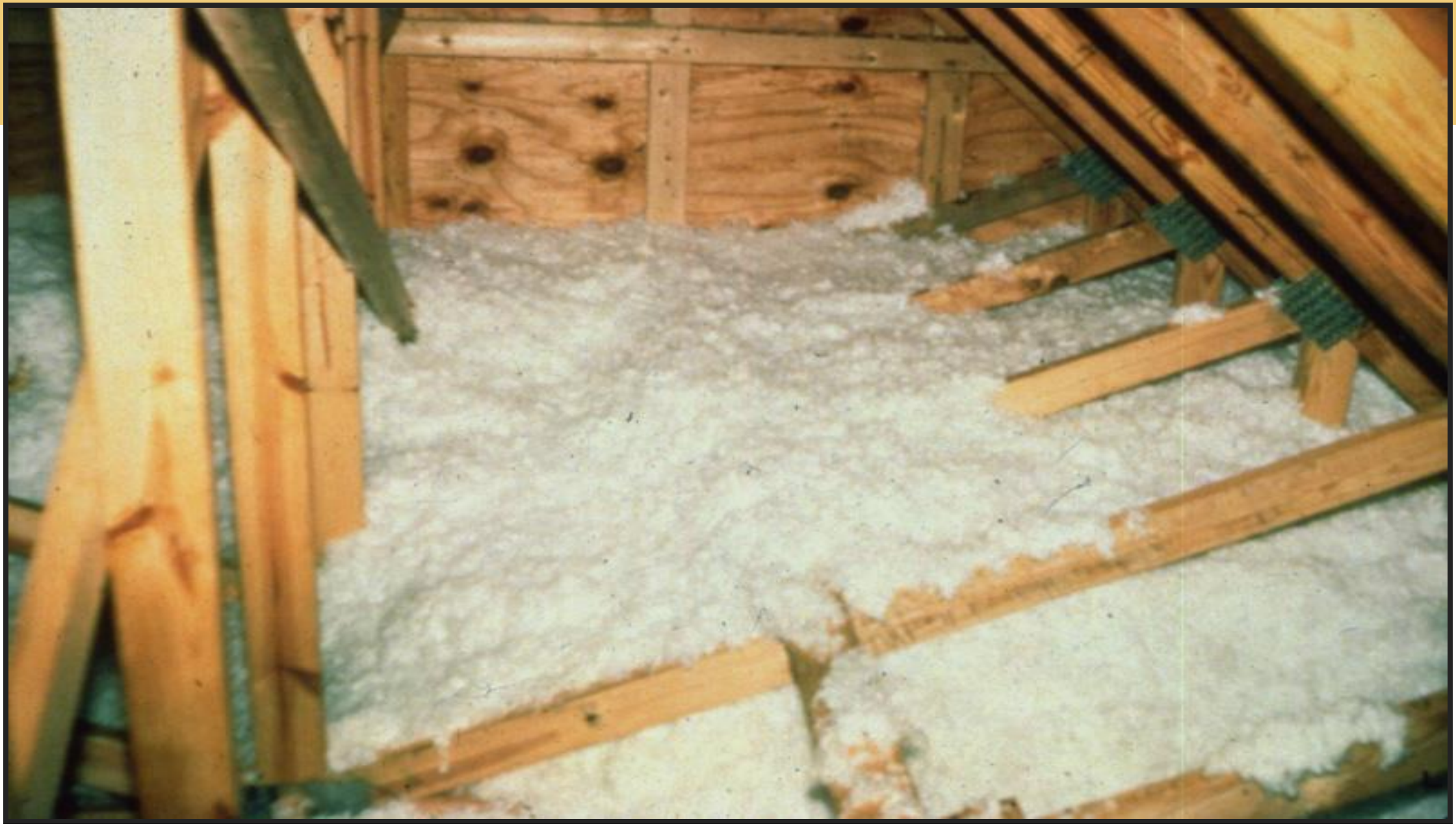
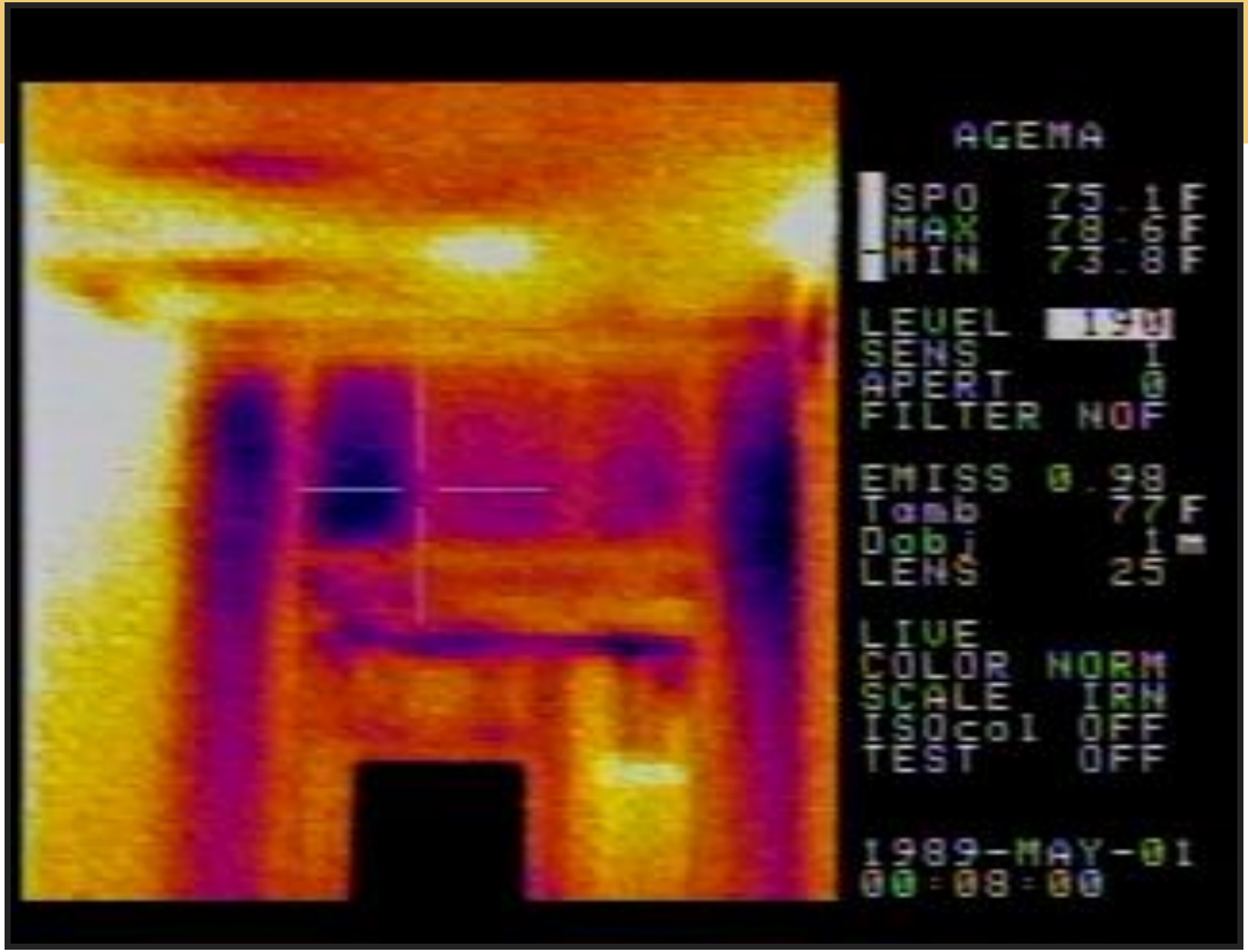


Interstitial Cavities open to the Attic (AKA Missing Fire Blocking)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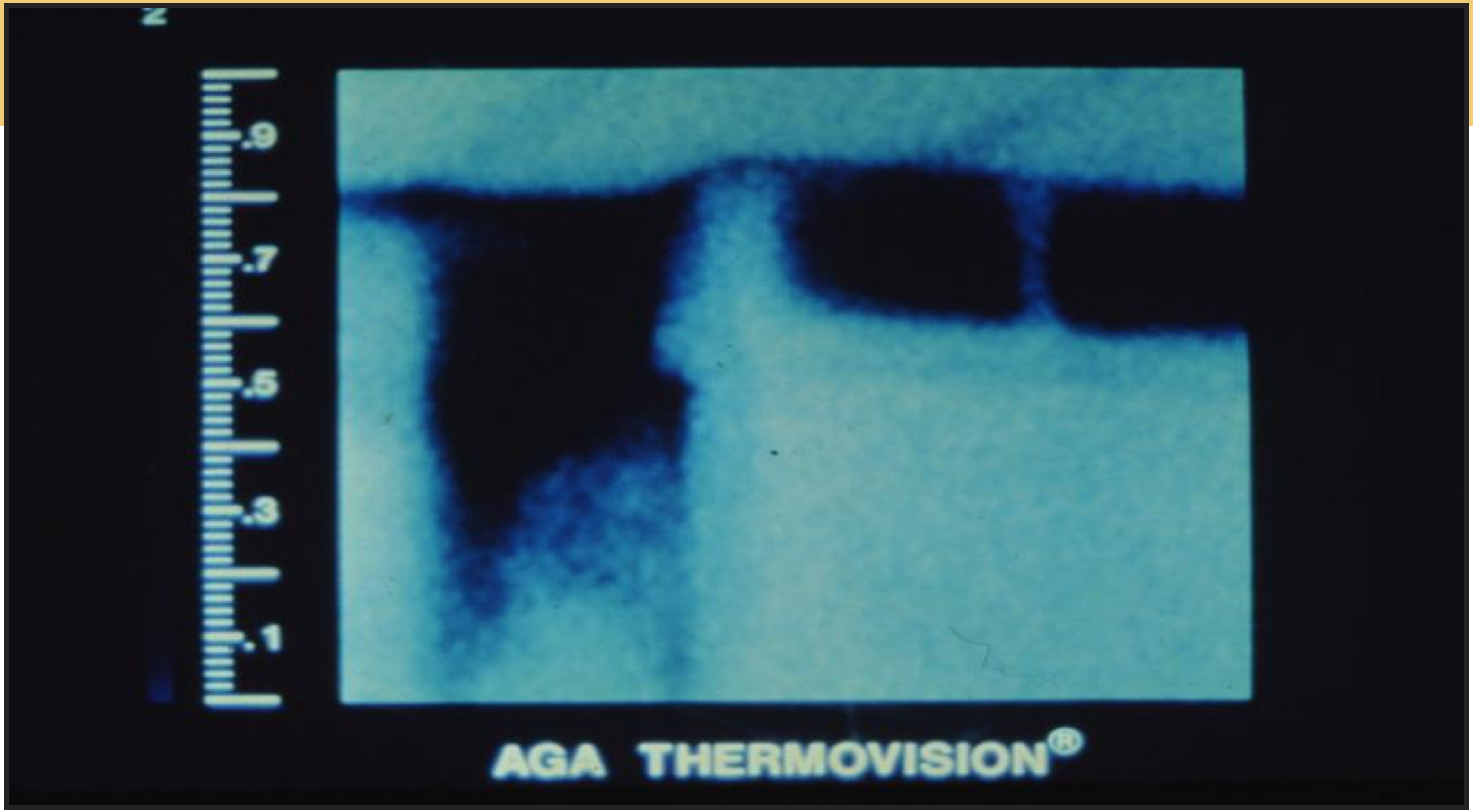
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Review Performance Factors for Ceilings

1. Continuous and airtight ceiling air barrier (usually the drywall)
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

3. Walls

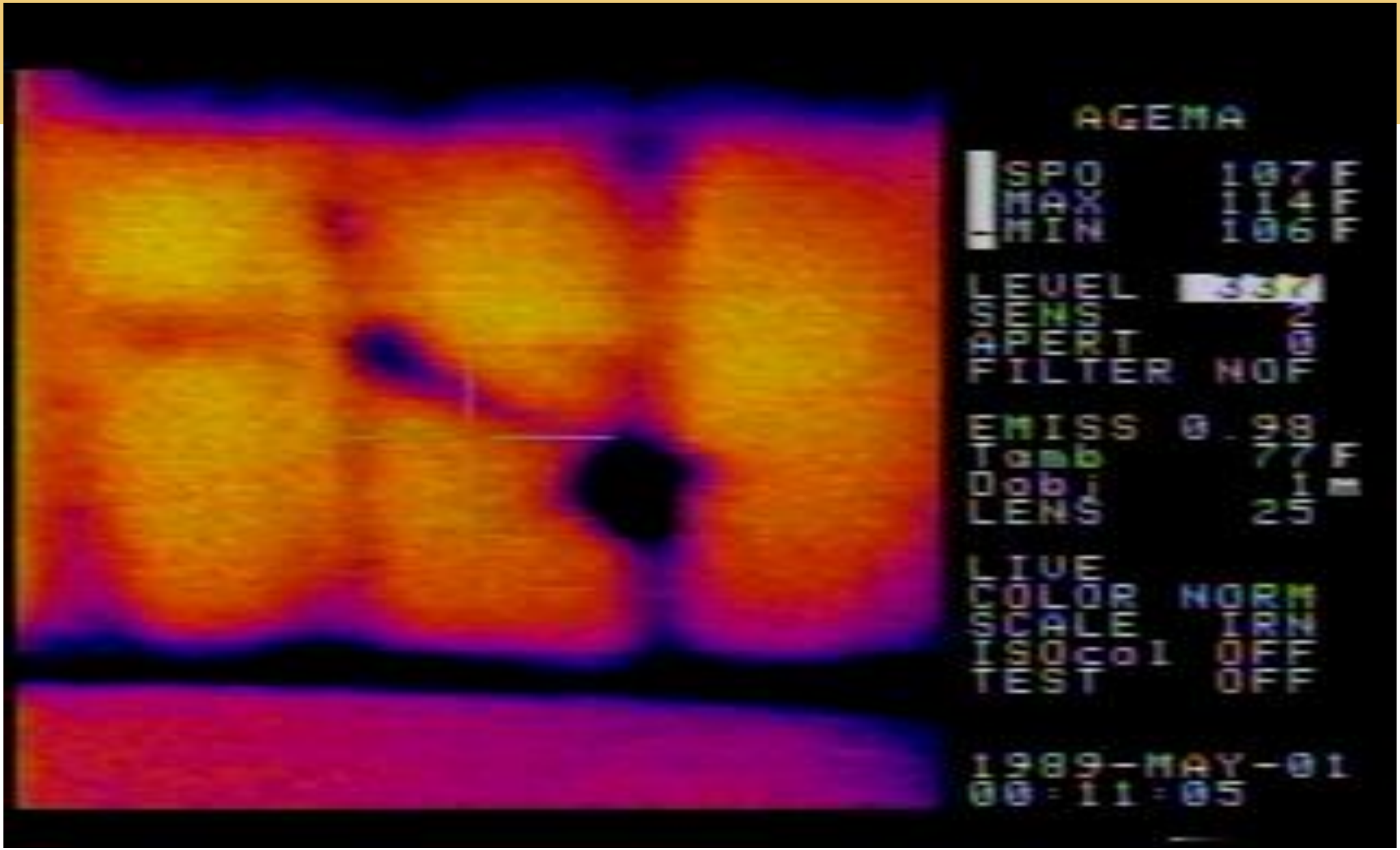
Performance Factors for **Walls**

WALL SPECIFICS

1. **Substantially airtight wall cavity**
2. **Insulation in contact with the air barriers** (in contact with all 6 sides of the cavity)
3. **Framing factor**

UNIVERSAL

4. **No gaps, voids, or compression**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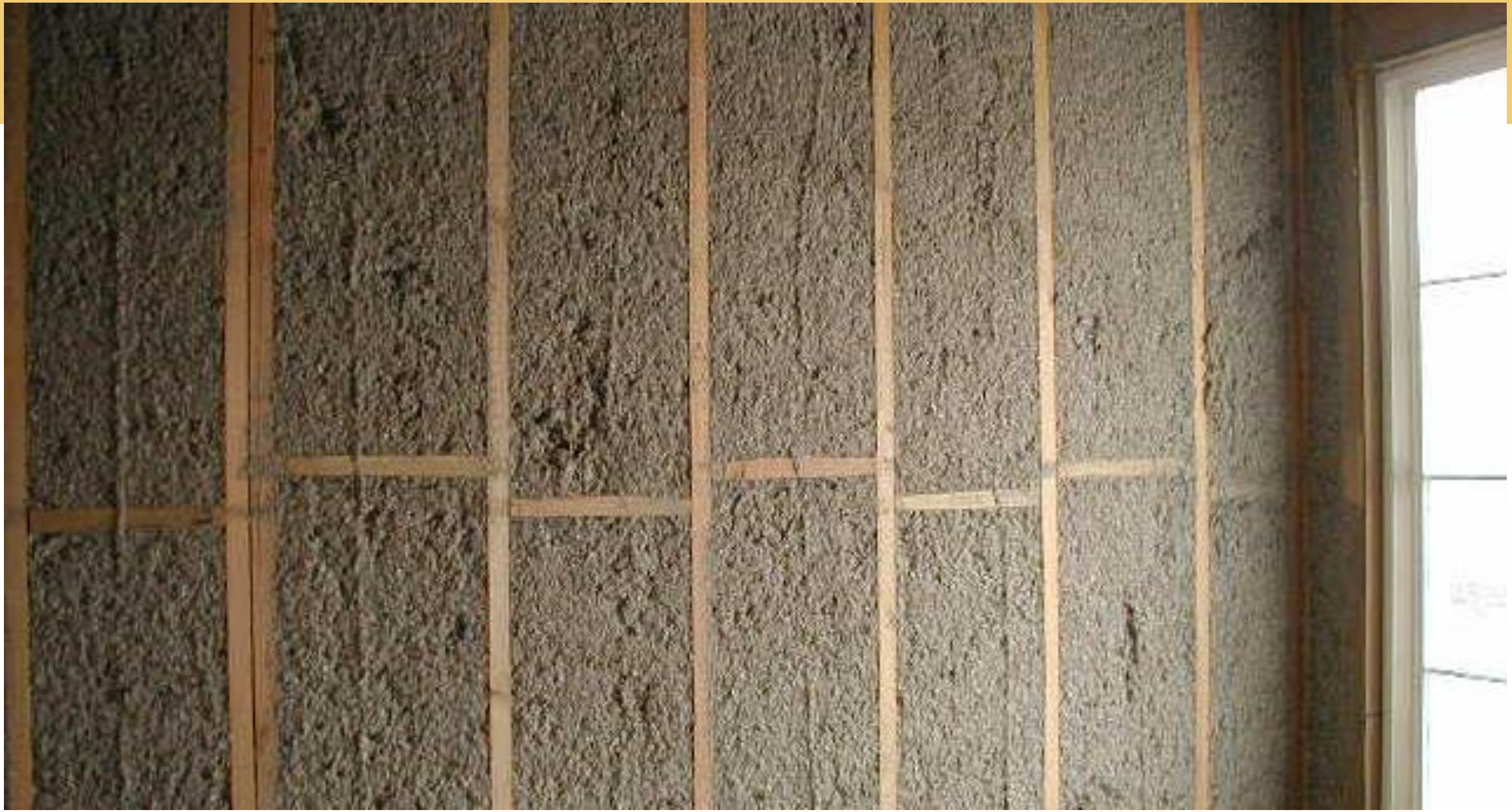
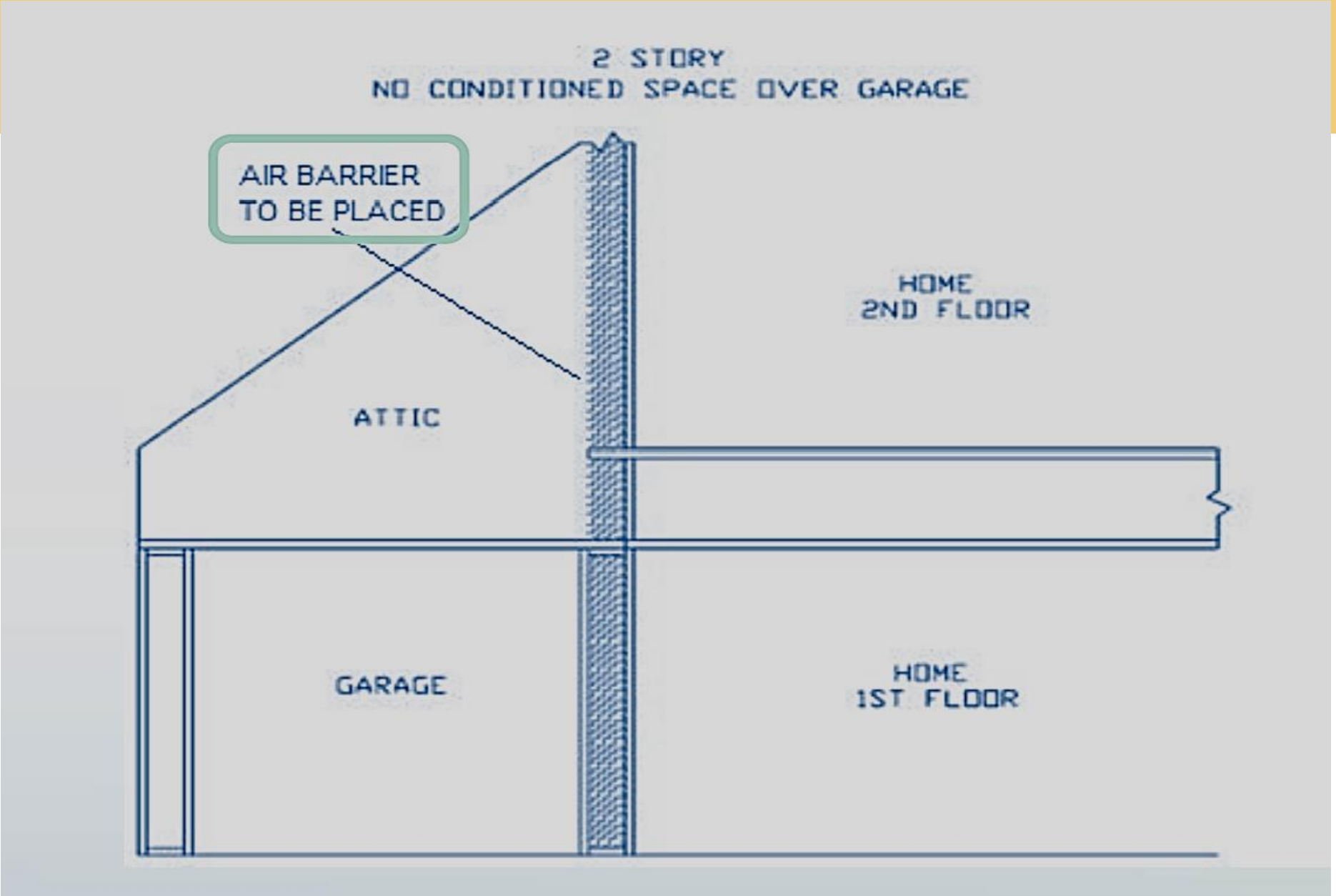
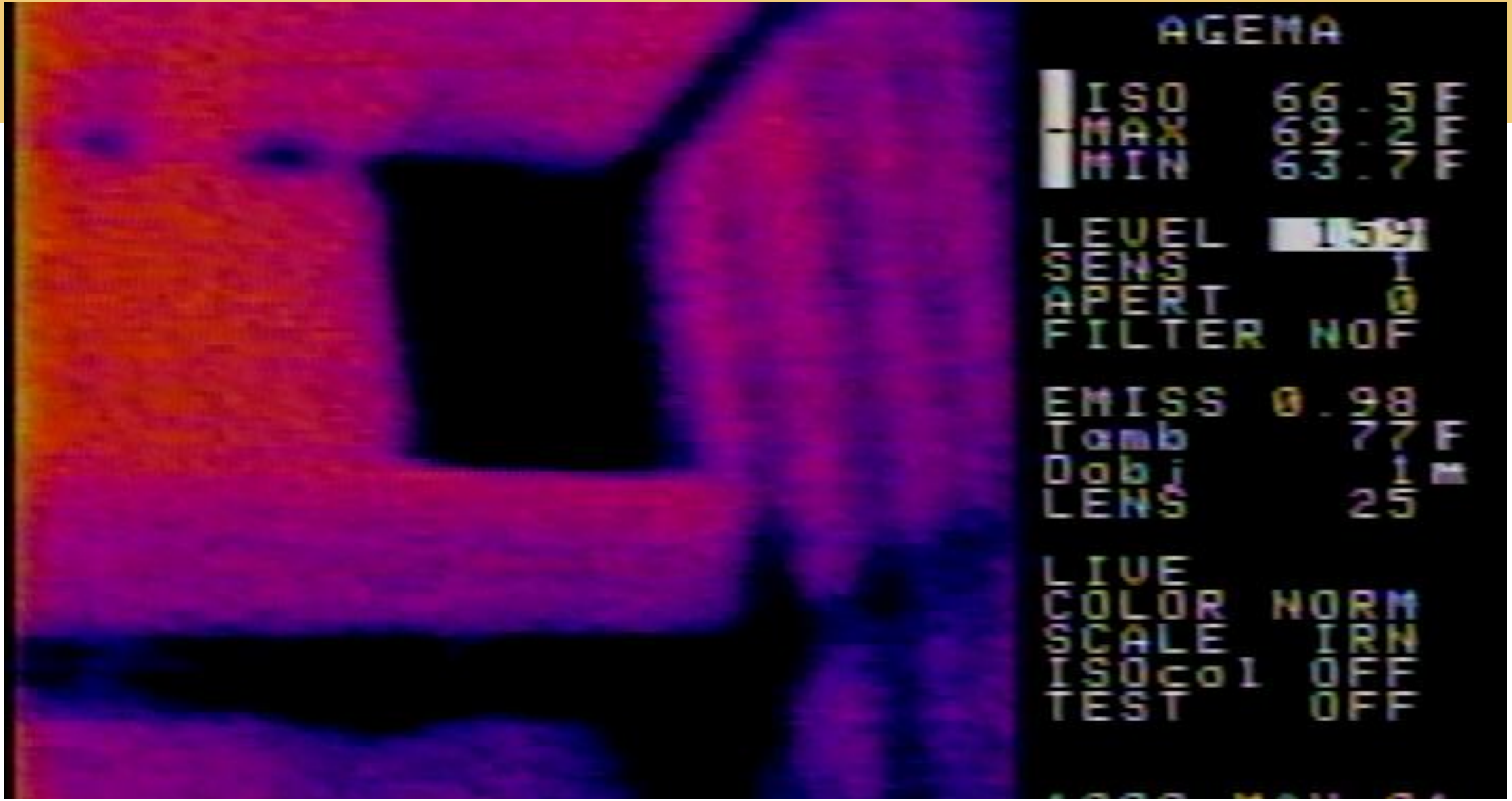


Special Case: Attic Kneewalls

OUR MOST DIFFICULT WALL


2 STORY
NO CONDITIONED SPACE OVER GARAGE
AIR BARRIER
TO BE PLACED
HOME
2ND FLOOR
ATTIC
GARAGE
HOME
1ST FLOOR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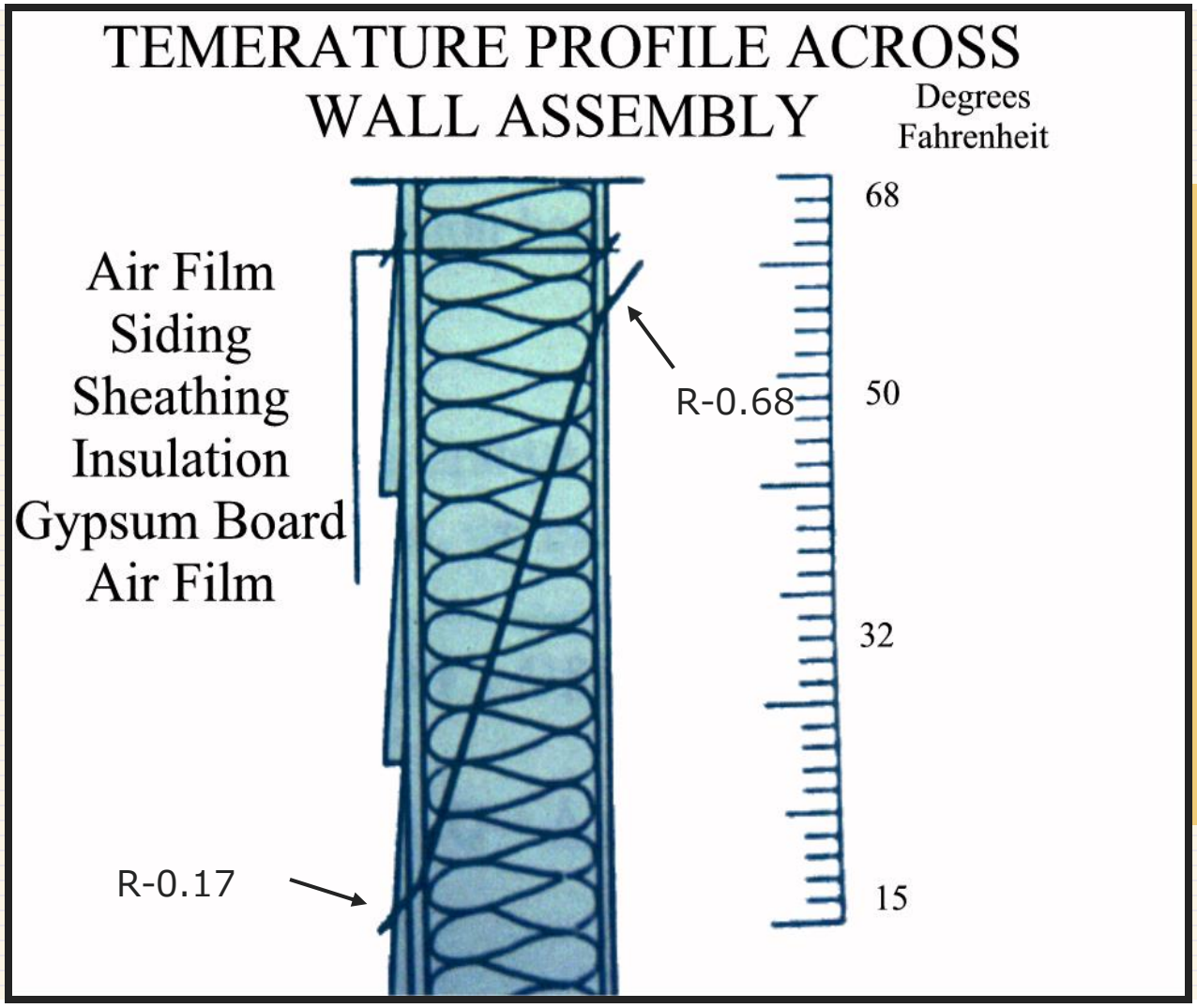
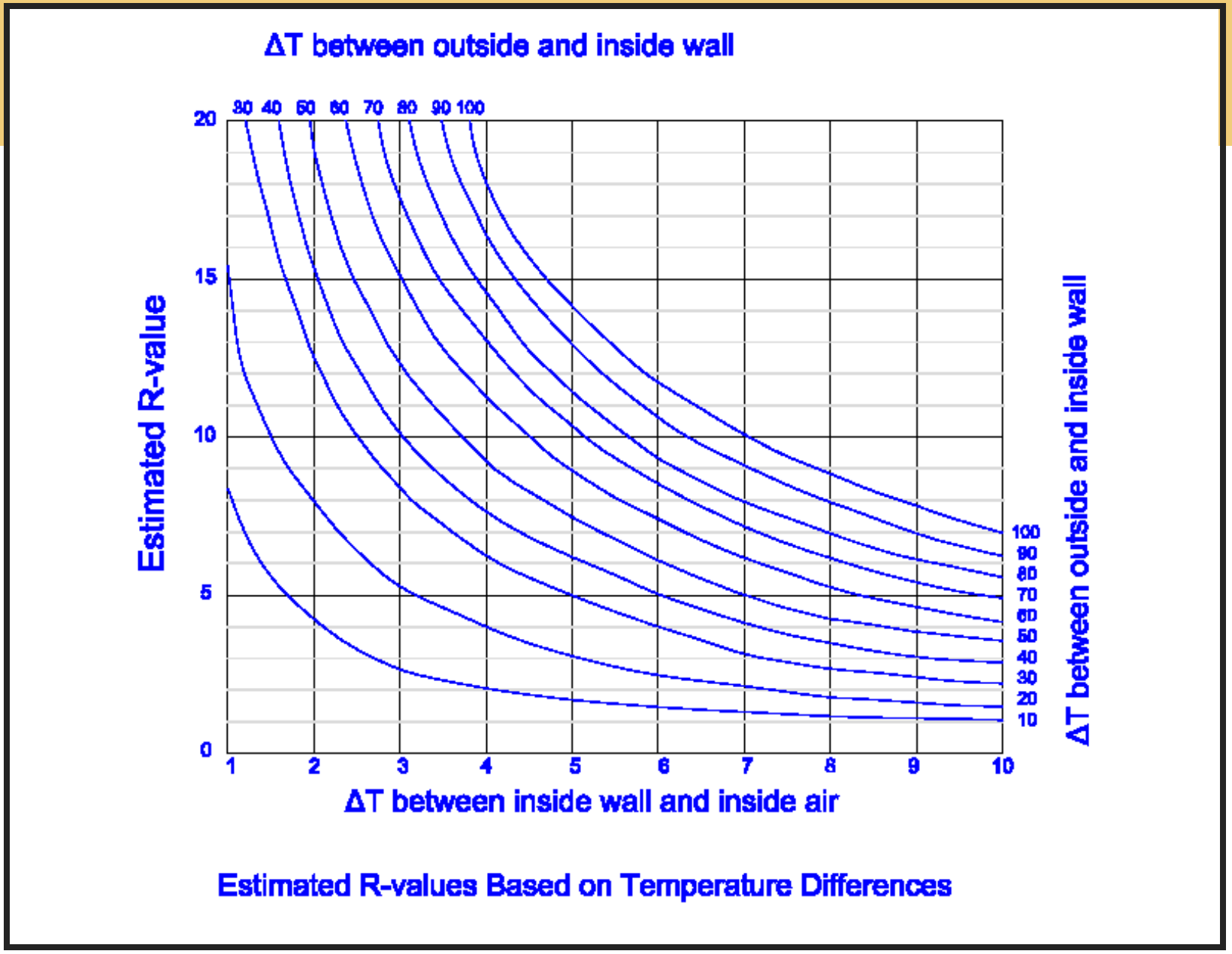


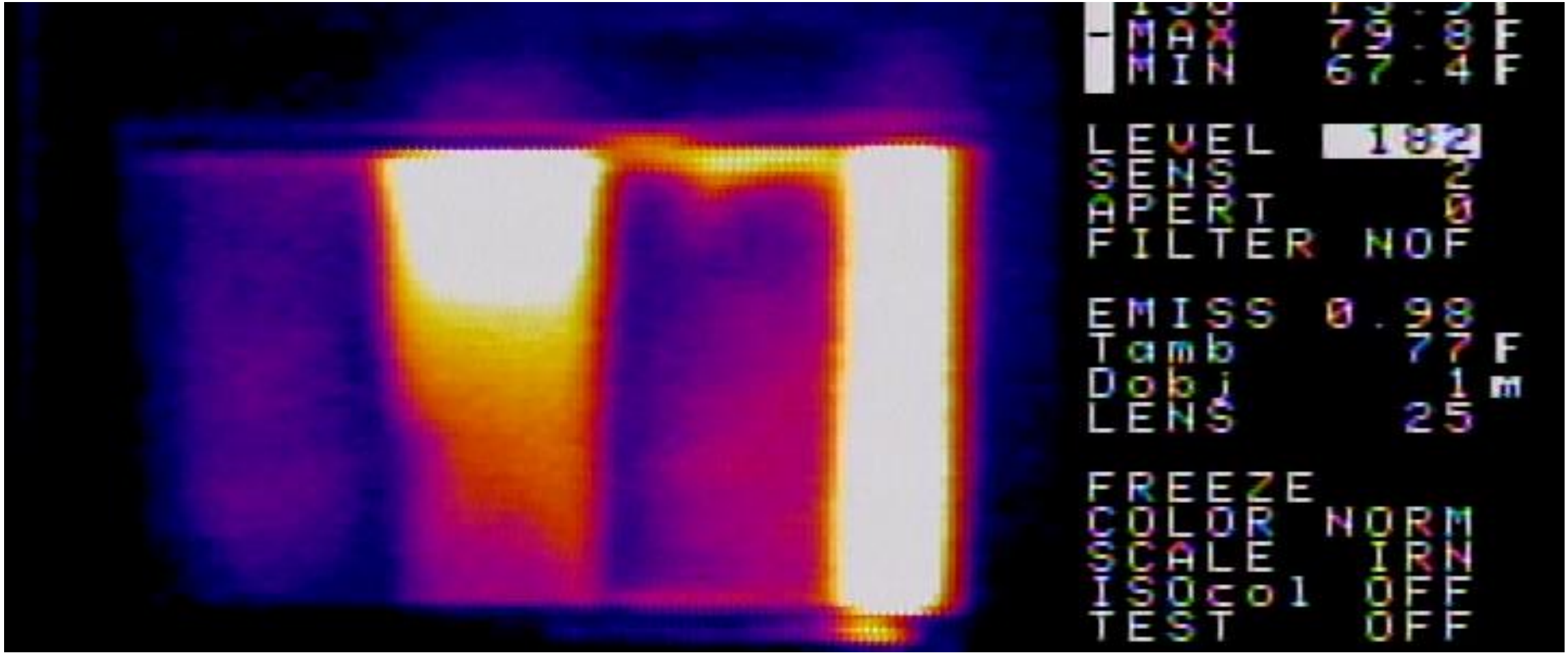
Estimating Assembly Performance:

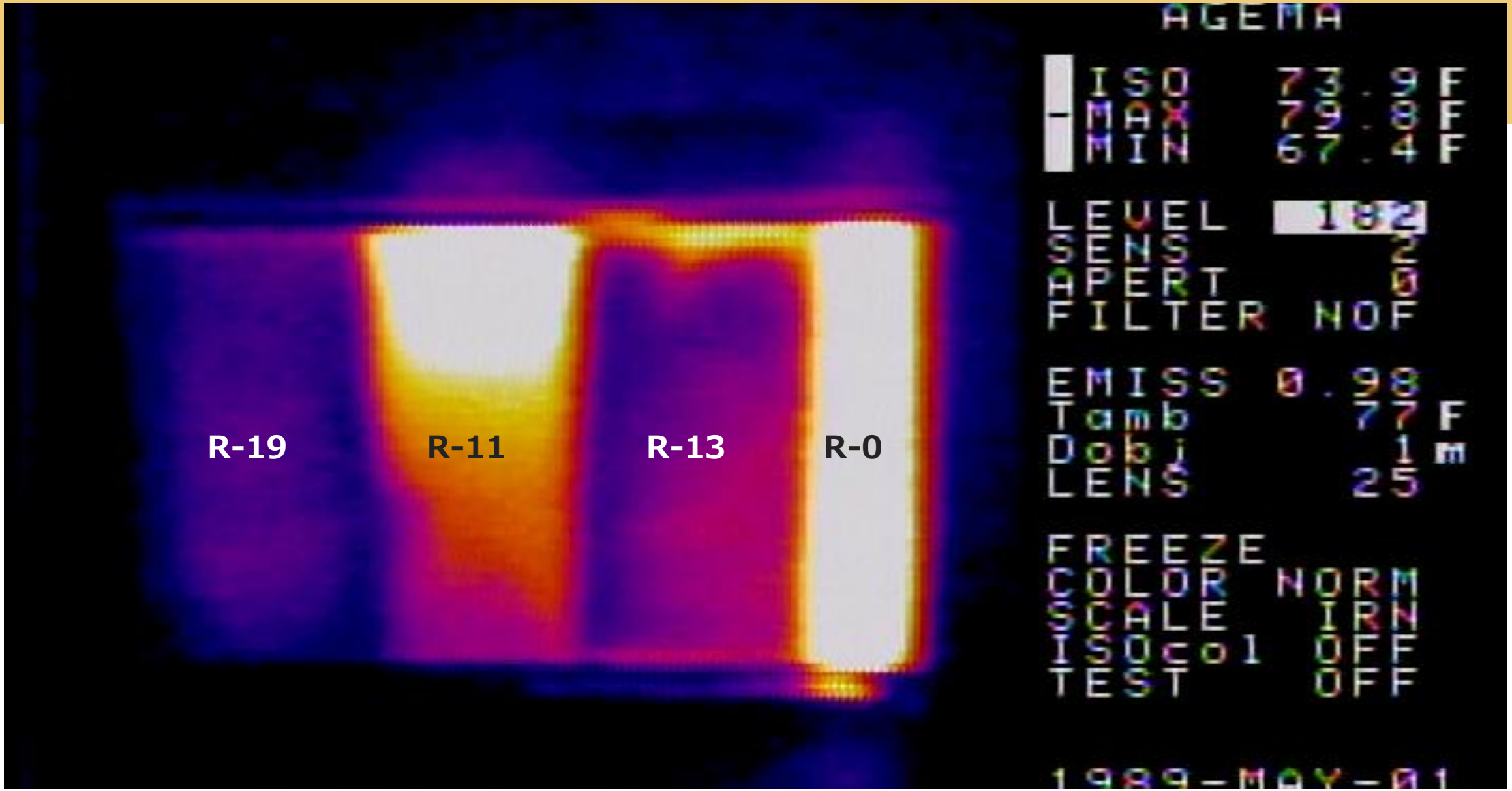
1. Assume the profile line is straight
2. Measure ΔT across the air film
3. Measure the outside temperature



Estimated R-values Based on Temperature Differences

Kneewall Demo – 4 Different R-values; 0, 11, 13, and 19

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COLOR NORM
SCALE IRN
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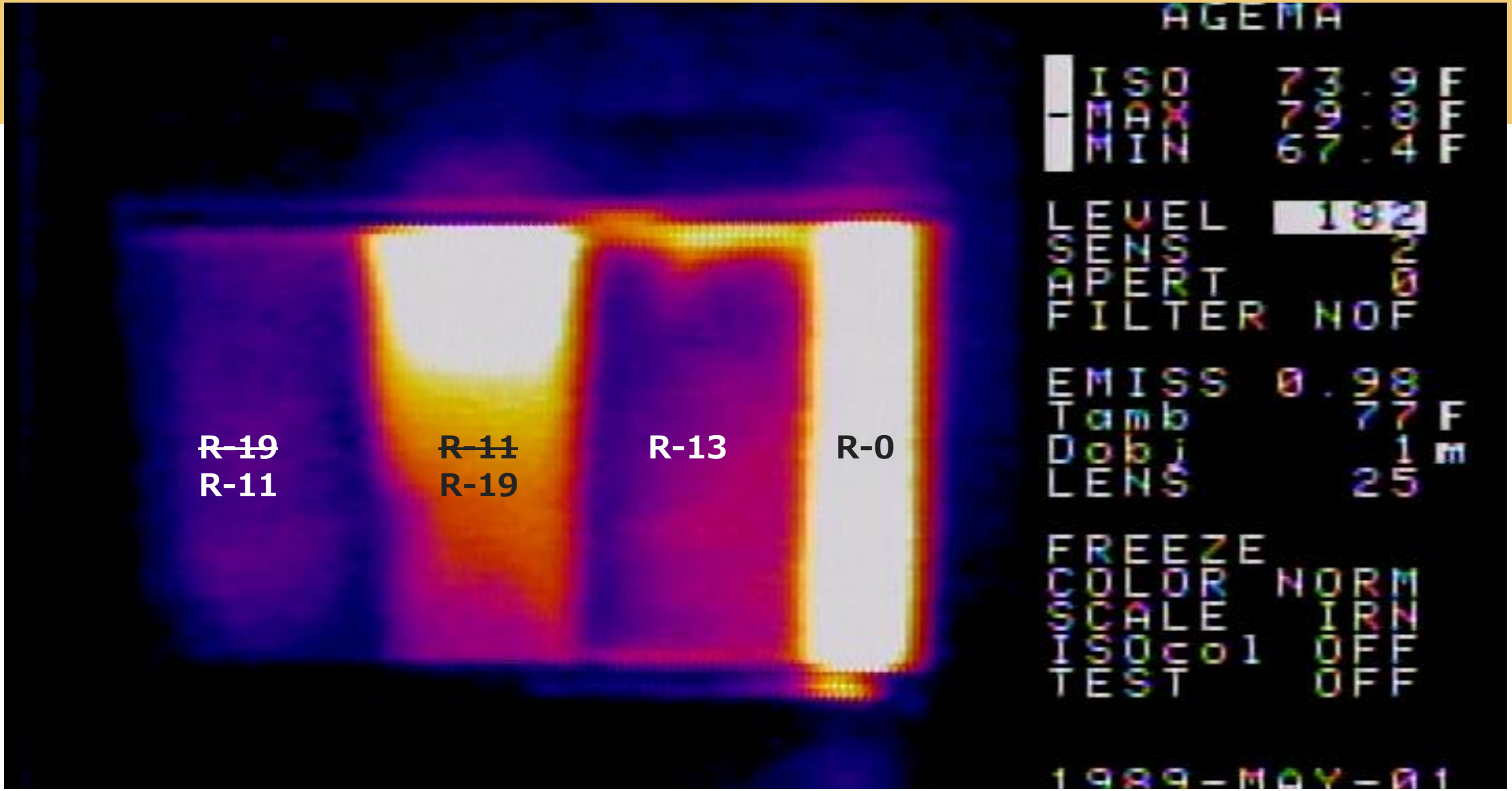
R-19
R-11
R-13
R-0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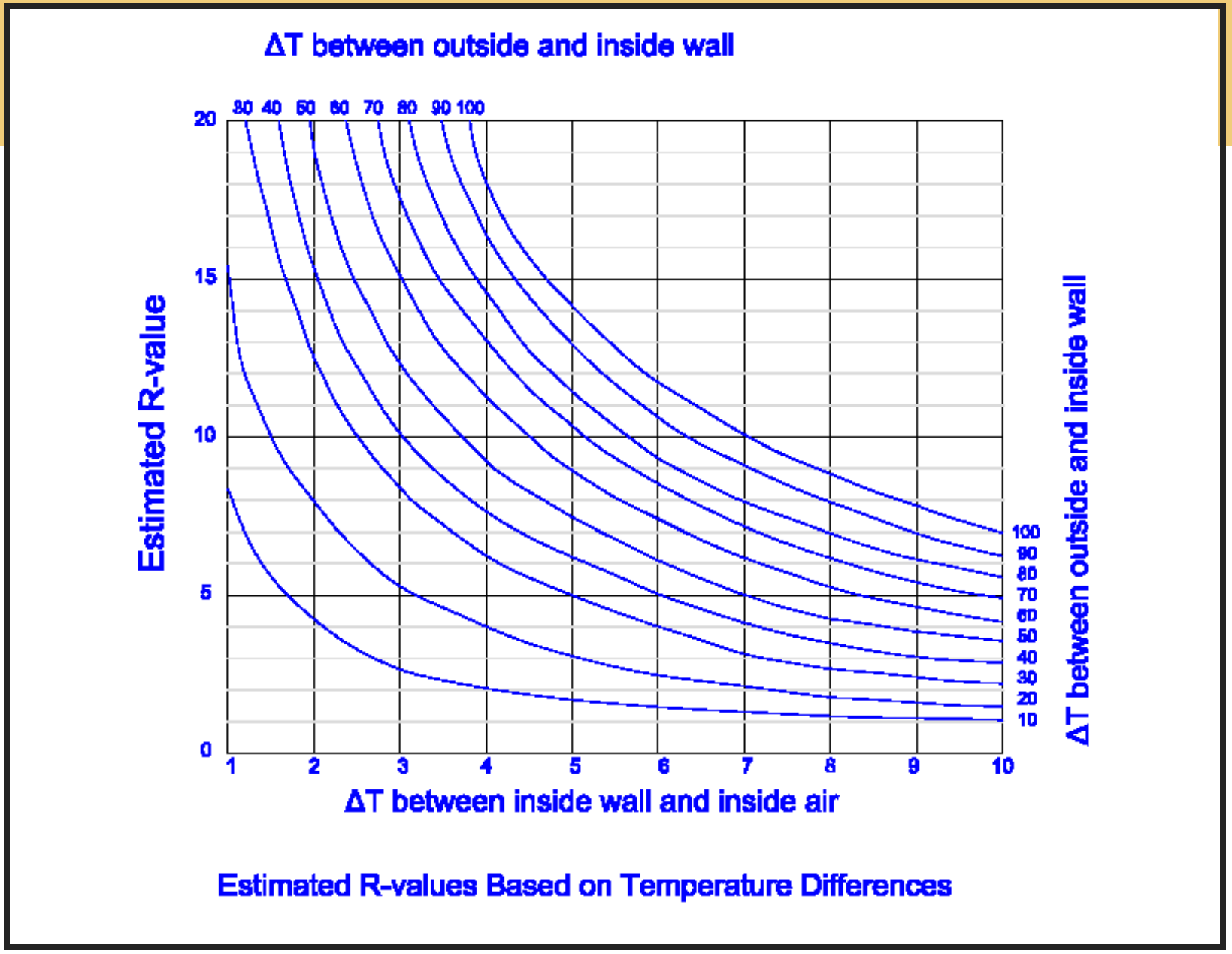
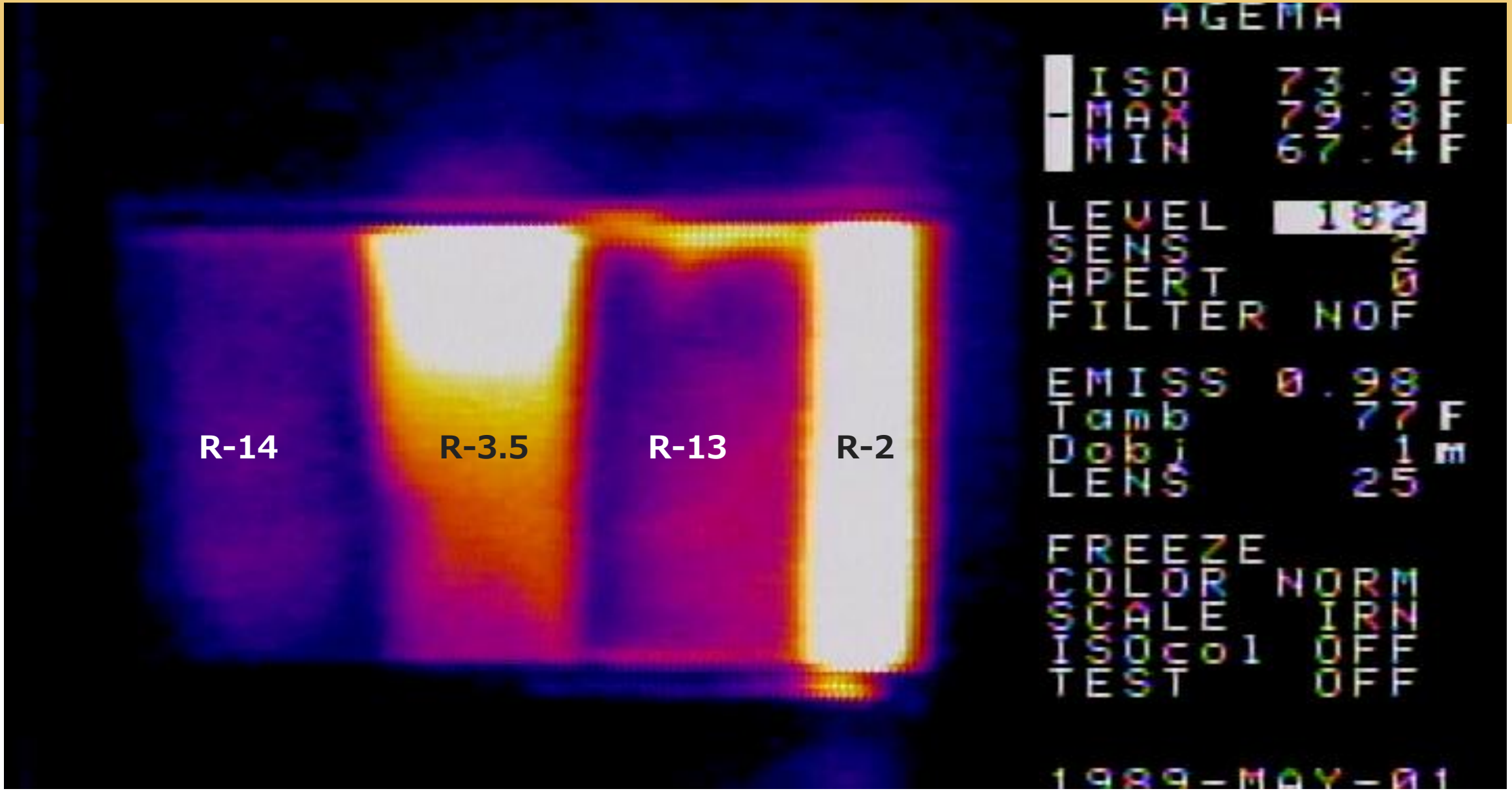
R-11
~~R-11~~
R-19
R-13
R-0



Estimated R-values Based on Temperature Differences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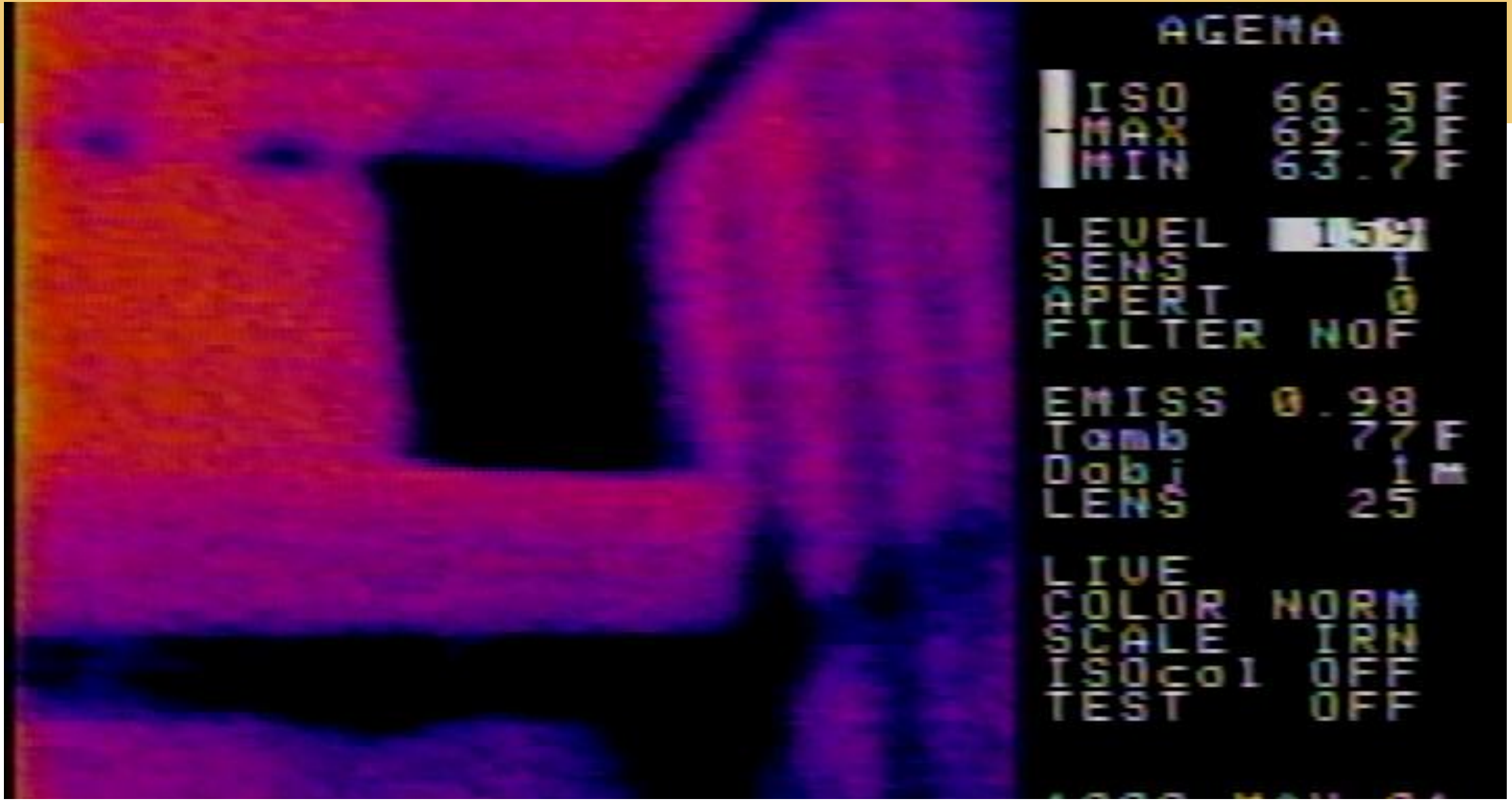
R-2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TEST OFF

Review Performance Factors for Walls

1. Substantially airtight wall cavity
2. Insulation in contact with the air barriers (in contact with all 6 sides of the cavity)
3. Framing factor
4. No gaps, voids, or compression

4. Windows

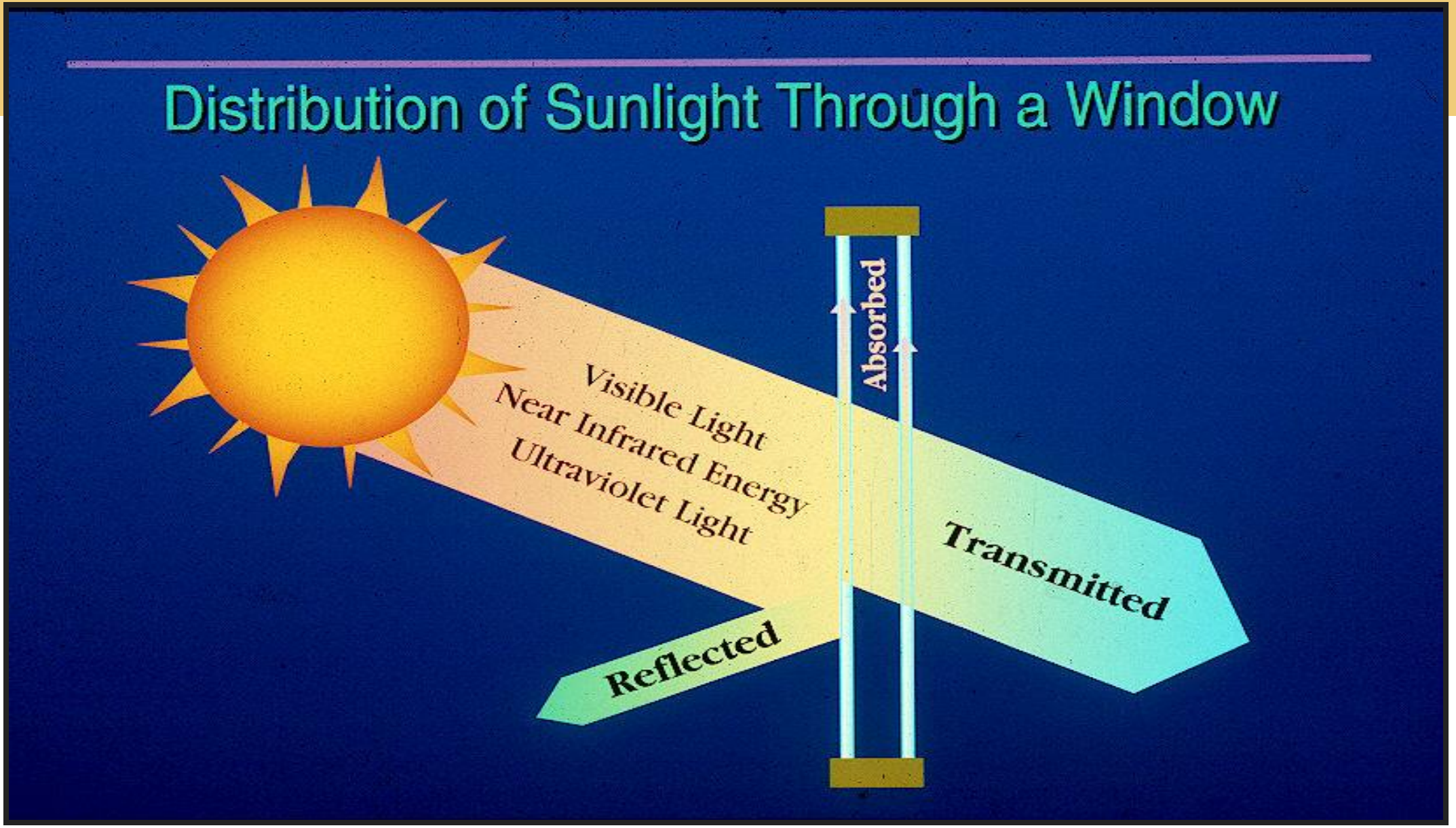
Enclosure Heat Loss (by component)

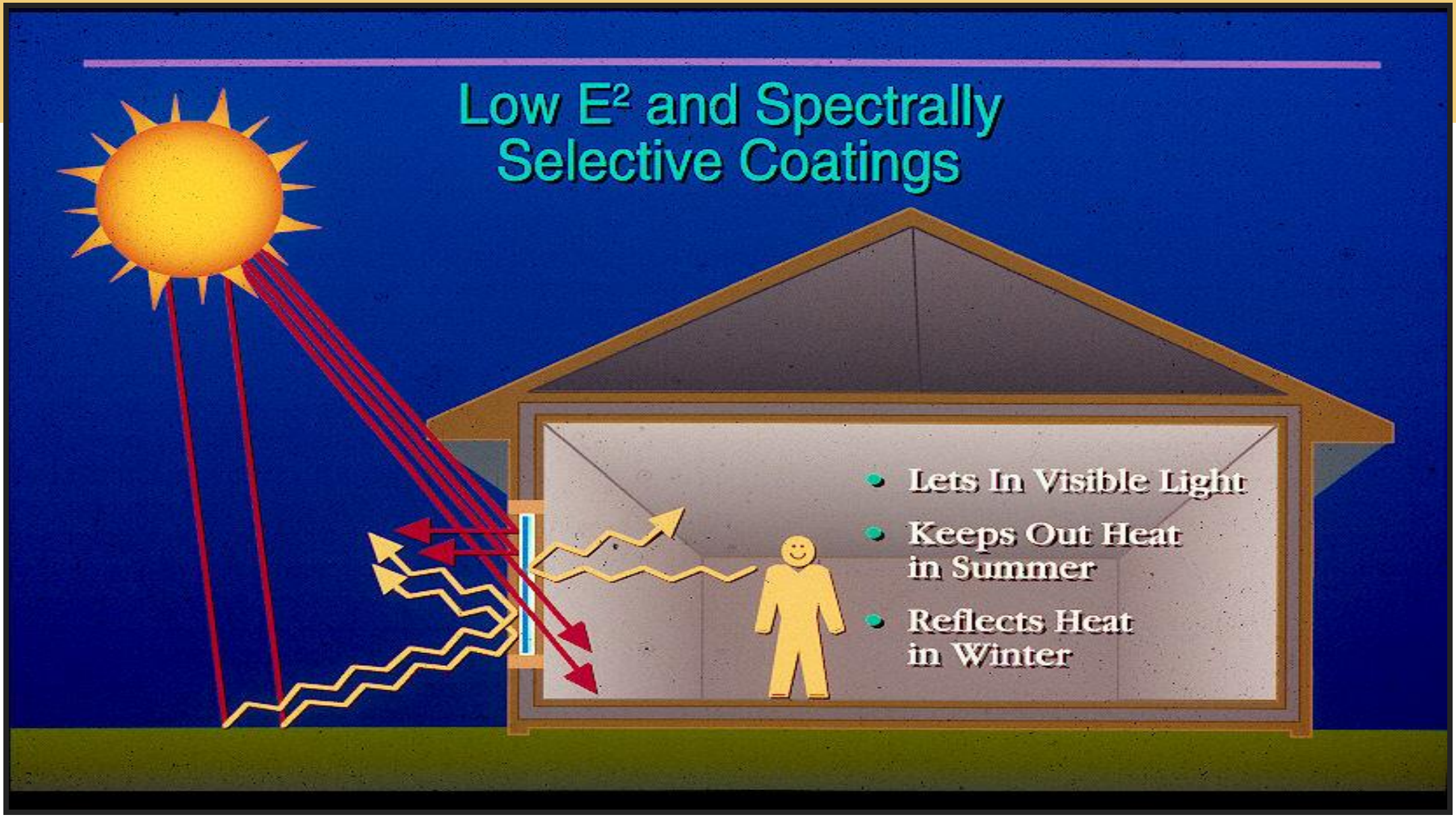
Air Infiltration	23%
Windows	**22%**
Slab Edge	20%
Walls	14%
Ducts	12%
Ceiling	9%

(Based on CEC CBECC computer model)

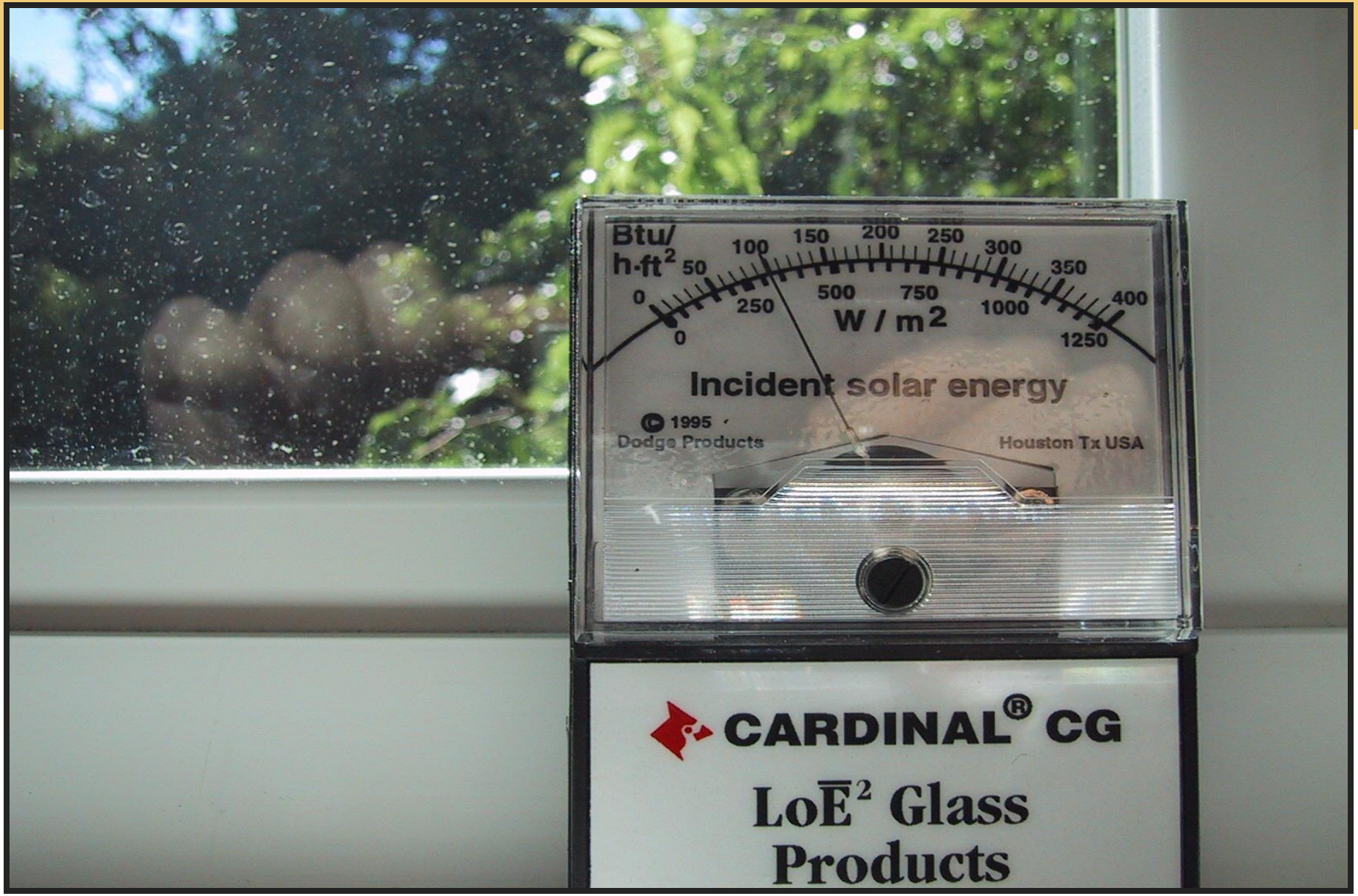
Performance Factors for Windows

1. Glass performance
2. Frame performance
3. Air leakage
4. Exterior shading


Distribution of Sunlight Through a Window
Visible Light
Near Infrared Energy
Ultraviolet Light
Absorbed
Transmitted
Reflected


Low E² and Spectrally Selective Coatings
Lets In Visible Light
Keeps Out Heat in Summer
Reflects Heat in Winter


Btu/
h·ft²
0
50
100
150
200
250
300
350
400
0
250
500
750
1000
1250
W / m2
Incident solar energy
© 1995
Dodge Products
Houston Tx USA
CARDINAL® CG
LoE² Glass
Products
The Clear Choice for Year-Round
Energy Savings and Comfort


Btu/
h·ft²
0
50
100
150
200
250
300
350
400
0
250
500
750
1000
1250
W / m2
Incident solar energy
© 1995
Dodge Products
Houston Tx USA
CARDINAL® CG
LoE² Glass
Products

GLASS + FRAME performance: U-Factor and SHGC

How Spectrally Selective Low-E Works

	Low-E Type	Glass VLT	"Typical" Window Properties		
			U-Factor	SHGC	VLT
Double Pane Insulating Glass	None (clear glass)	81%	0.55	0.60	0.60
	High Solar Gain	75%	0.33	0.52	0.56
	Medium Solar Gain	70%	0.32	0.32	0.53
	Low Solar Gain	66%	0.31	0.22	0.50

Air Leakage; best to worst

Fixed

Hinged

Slider

Exterior Shades

- Less expensive than window replacement
- Appropriate for California's sunny and mild climate
- Critical for large glass areas
- Exposure and sun angles matter

5. Floors

AND SLAB EDGES

Performance Factors for Floors (similar to ceilings)

FLOOR SPECIFICS

1. **Continuous and airtight floor air barrier** (usually the subfloor)

UNIVERSAL

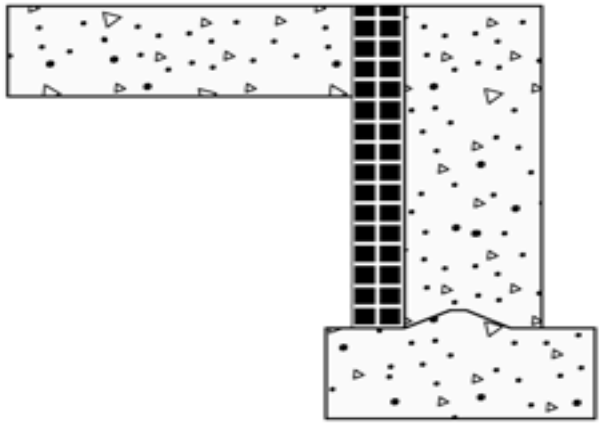
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

Enclosure Heat Loss (by component)

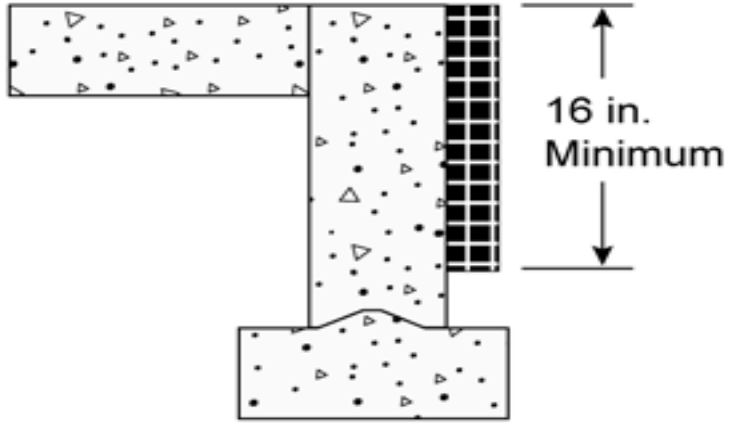
Air Infiltration	23%
Windows	22%
Slab Edge	**20%**
Walls	14%
Ducts	12%
Ceiling	9%

(Based on CEC CBECC computer model)

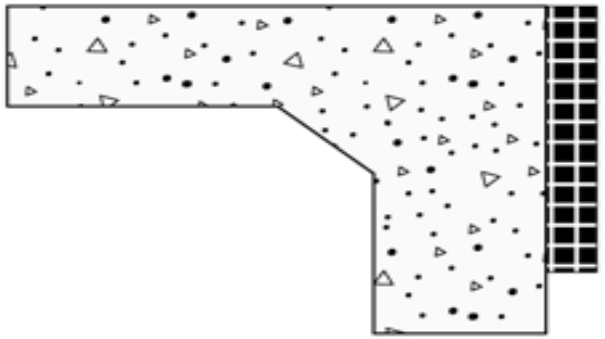
Inside Insulation



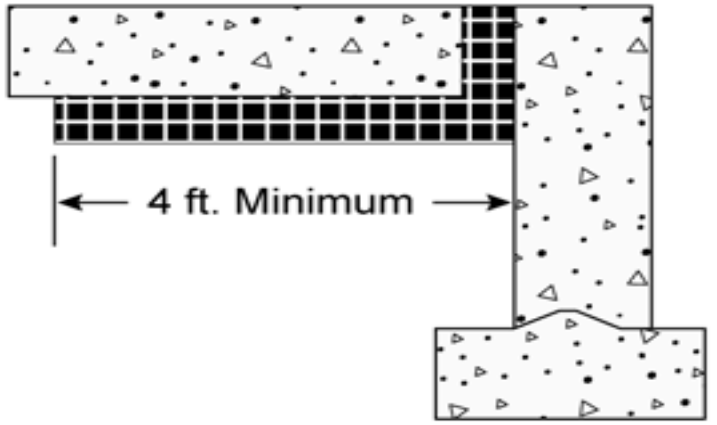
Outside Insulation



Monolithic Slab Insulation



Beneath Slab Insulation



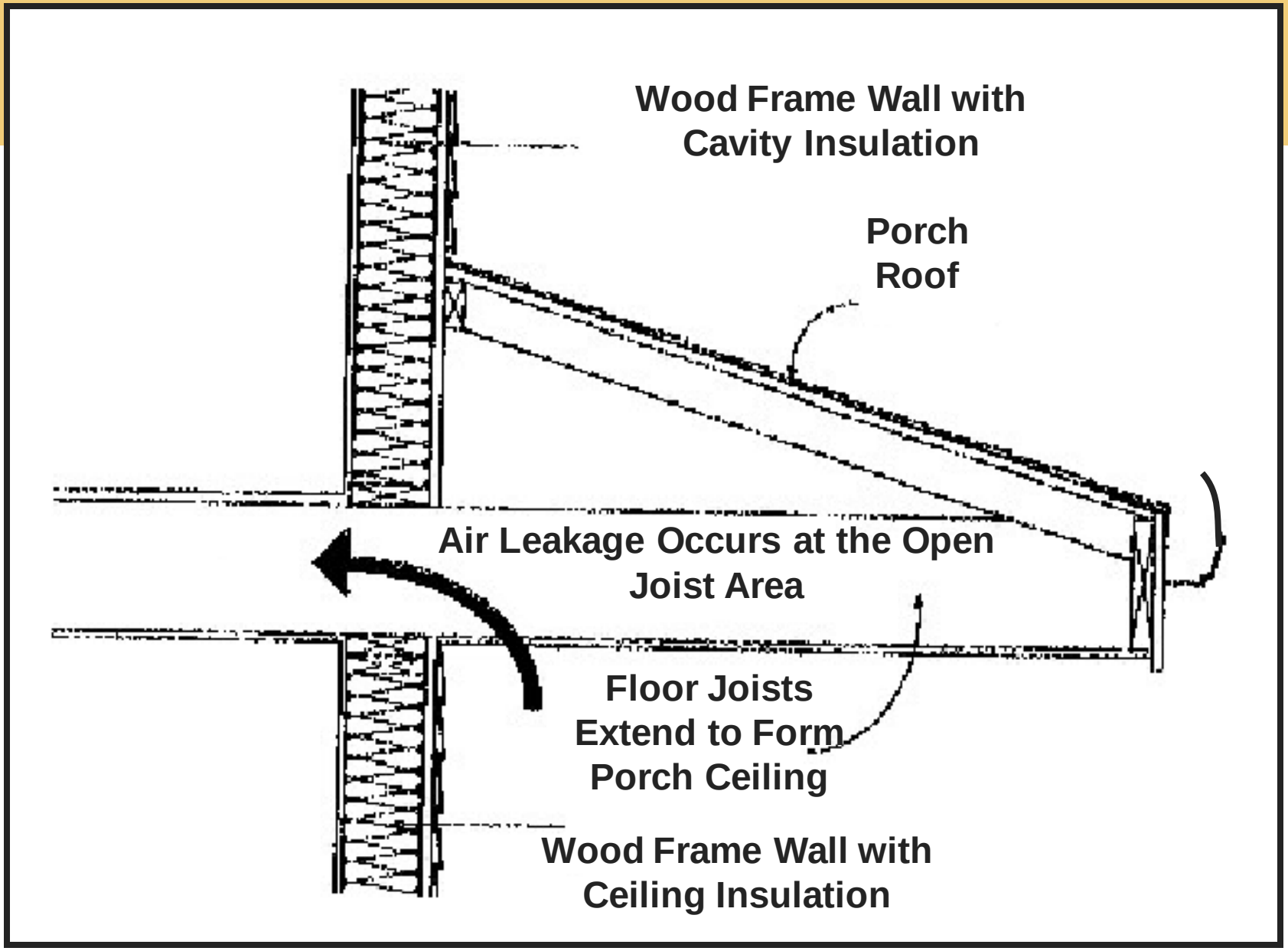
Note: Not to scale.


OWENS CORNING
250
A2310062


JM


CELLULAR CORE


APA


Wood Frame Wall with
Cavity Insulation
Porch
Roof
Air Leakage Occurs at the Open
Joist Area
Floor Joists
Extend to Form
Porch Ceiling
Wood Frame Wall with
Ceiling Insulation

Review Performance Factors for Floors

1. Continuous and airtight floor air barrier (usually the subfloor)
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

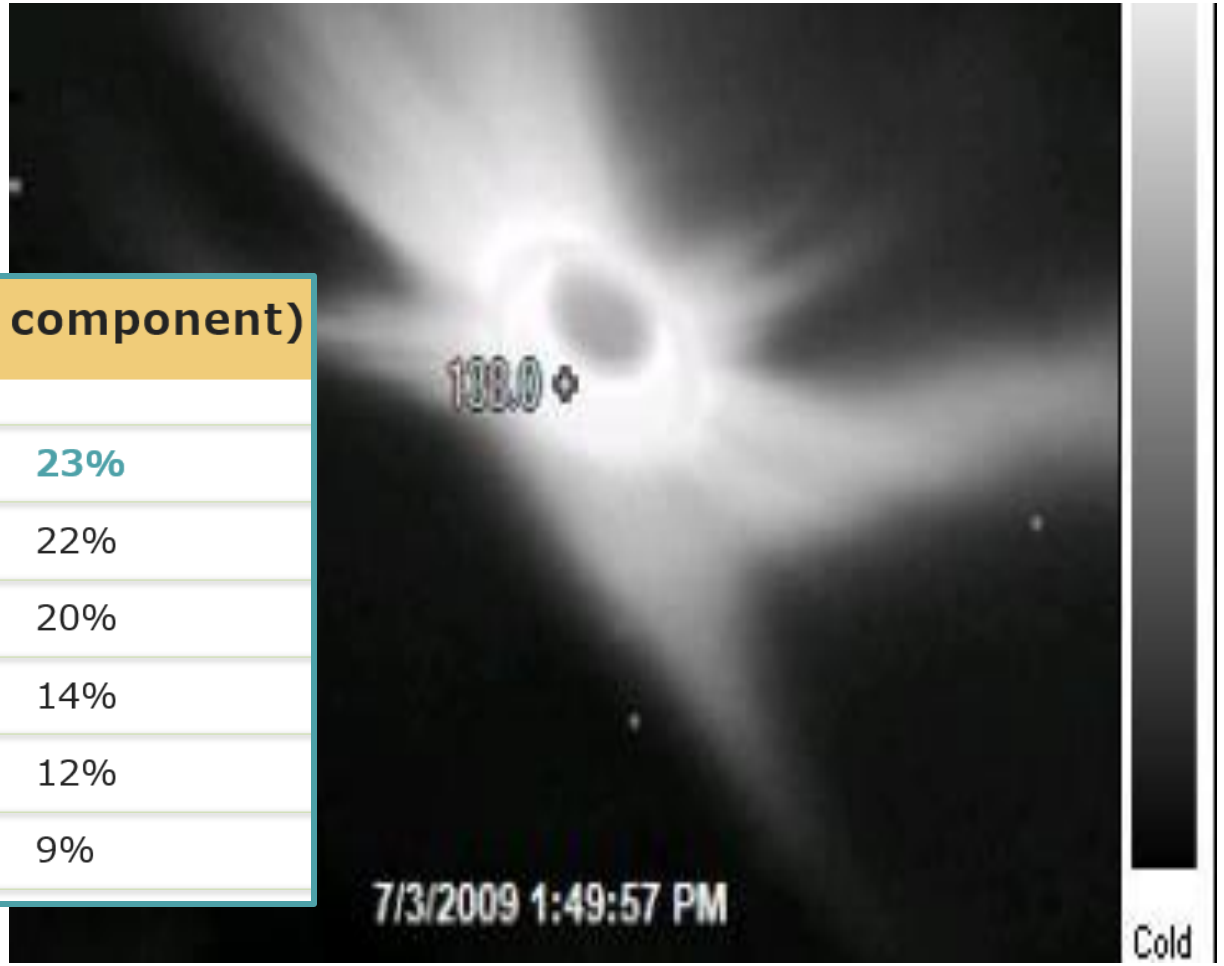
6. Air Sealing

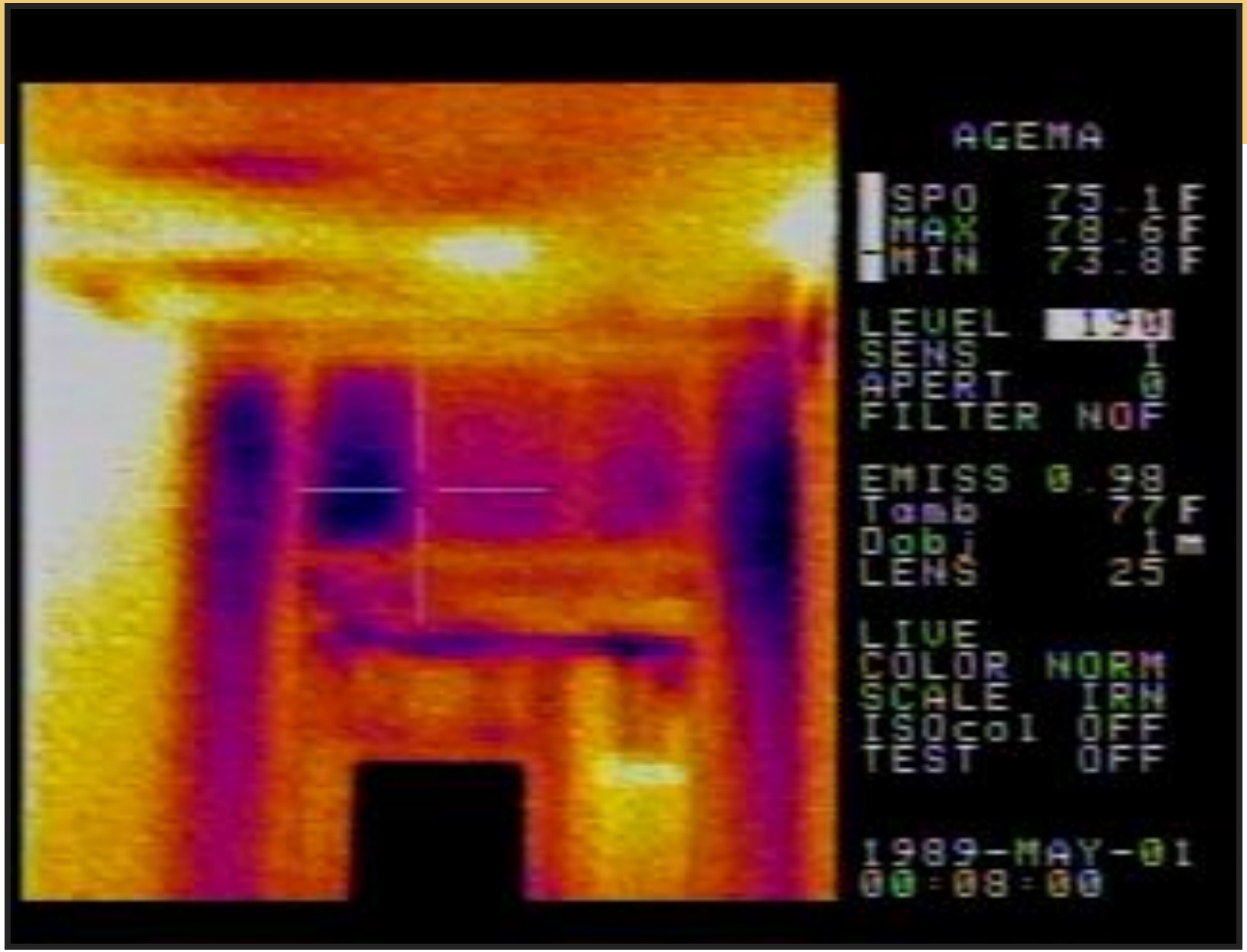
CEILINGS, WALLS, FLOORS

Air Sealing

1. Air Leakage is a Big Deal
2. Measure It
3. Reduce It

Enclosure Heat Loss (by component)	
Air Infiltration	**23%**
Windows	22%
Slab Edge	20%
Walls	14%
Ducts	12%
Ceiling	9%

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BD 3
B2
- 49.9
CRUISE
ADJ
Pa
263
CFM@50
PR/ FL @50
MODE
TIME AVG
DEVICE
UNITS
CONFIG
Cruise
Target
MODE
CLEAR
Stop
Fan
TIME
AVG
BASE
LINE
START
Start
Fan
ENTER
Begin
Cruise
INPUT
INPUT
ON/
LIGHT
HOLD
B
OFF
CRF
Factor
1.6
1.8
2.2
2.9


DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
51.8
Pa
176
CFM@50
MODE
TIME AVG
DEVICE
UNITS
CONFIG
Cruise
Target
MODE
CLEAR
Stop
Fan
TIME
AVG
BASE
LINE
START
Start
Fan
ENTER
Begin
Cruise
ON/
OFF
LIGHT
HOLD
INPUT
REF
ON
OFF

Tape to the Top Plate

1.0 ACH 50

176 CFM 50

9 CFM Natural

BEFORE INSULATION AND DRYWALL


FOGSTORM

Glue the Wall Drywall

0.6 ACH 50

81 CFM 50

4 CFM Natural

7. Two Case Studies

2005 HOME WITH SOME AIR SEALING

2019 HIGH PERFORMANCE

Case Study – 2005 Showcase Homes

Showcase Home – Performance Monitored by DOE

- High-end custom home (Realtor's Showcase of Homes)
- Conventional architecture
- Conventional framing
- Conventional insulation (R-21 batts in walls, R-38 loose fill in attic)
- Minimal air sealing (only missing fire stops)
- Conventional HVAC system (ducts in the attic)

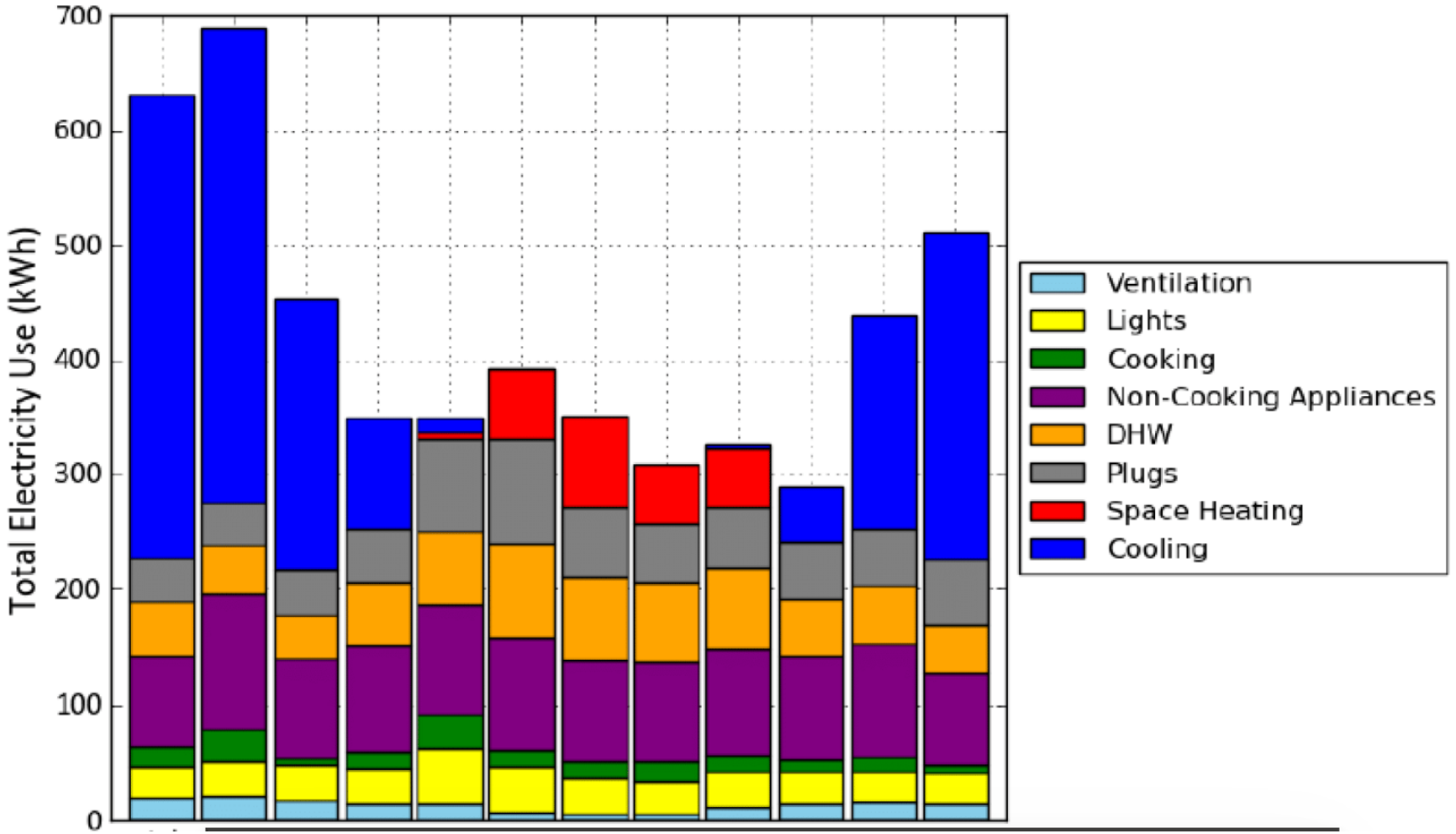
Showcase Home – Performance Monitored by DOE

- Actual cooling costs reduced 81% (83% compressor, 68% fan, report page 10)
- Actual heating costs 49% reduction in gas usage, 65% fan energy reduction (report page 10)
- Cost of energy improvements were 0.4% of home cost, or $5,139.00 (see report page 11)

Case Study – 2019 Mike MacFarland Home


FUJITSU

PG&E 2019 Residential Title 24 Code Readiness Support



SF	Volume	Description	
2372	21348	SF floor area a 9' flat ceilings	
570	2458	Mech space 15' x 38' with 10" floor	
	188	Vaulted area of mech space	
	23994	Total volume conditioned space	
	400	CFM for ACH50@ 1.0	
	240	CFM for ACH50 @0.60	
	209	**Enter CFM50 from testing***	Final 6/25
	0.52	**Resulting ACH50**	

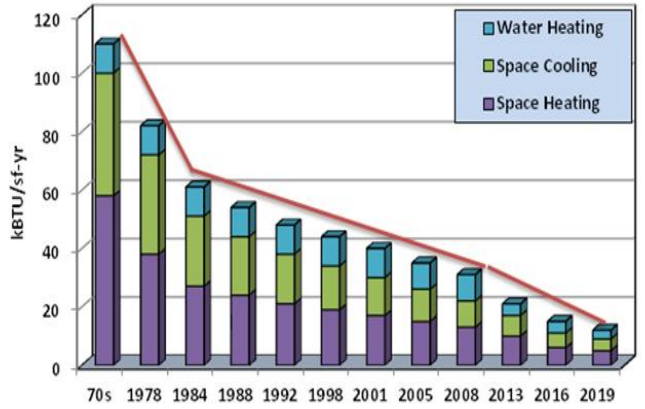
8. Recap

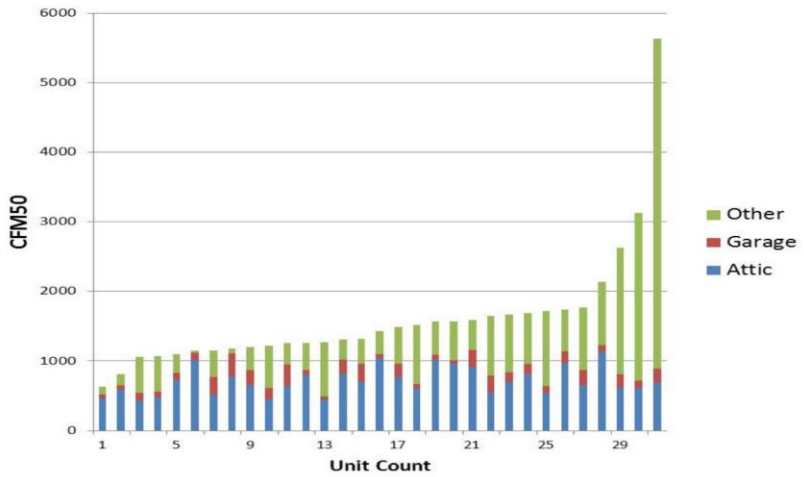
CHALLENGES & SOLUTIONS

Challenges

Research shows that the opportunity for improvement is HUGE:

1. **Code has advanced *BUT***
2. **Performance has not kept pace *AND***
3. **Modeling is seldom accurate – it doesn't reflect what happens in the field**





Challenges

Industry culture poses obstacles:

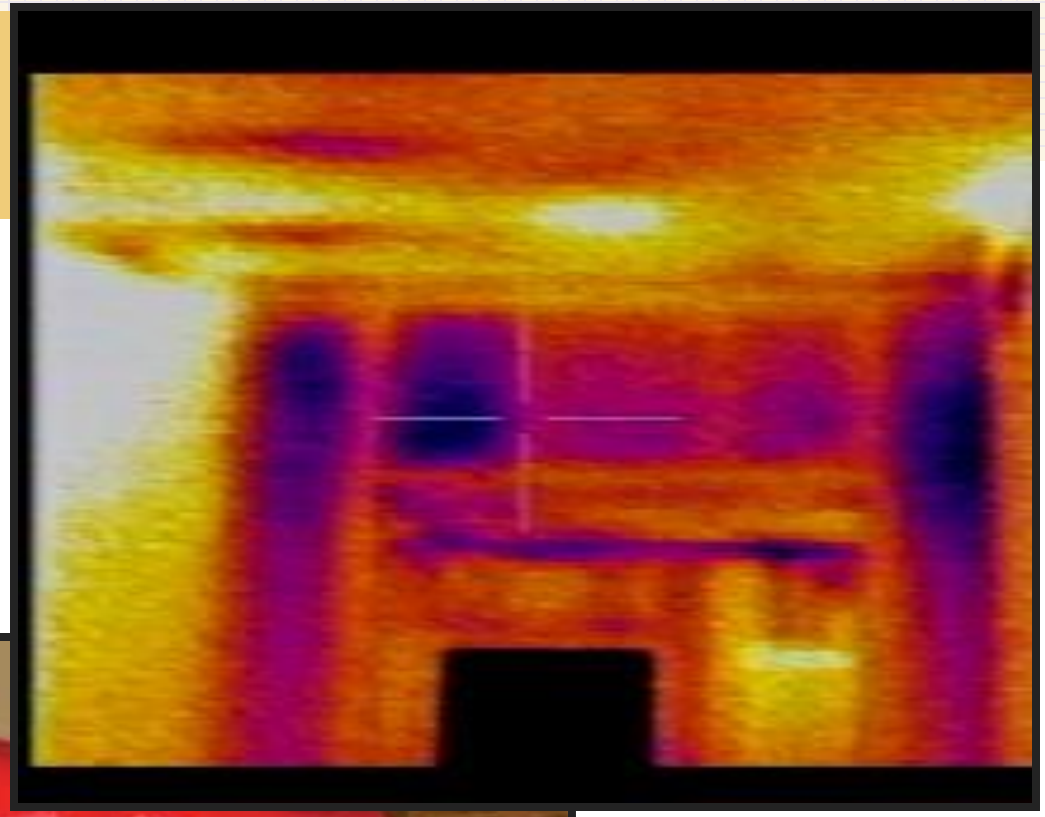
4. Lack of performance testing
5. Code minimum—not high performance—is the standard goal
6. Bid competition breeds optimism (& mediocrity)

9. Most Important Enclosure Goals

AIR SEALING AND INSULATION PERFORMANCE

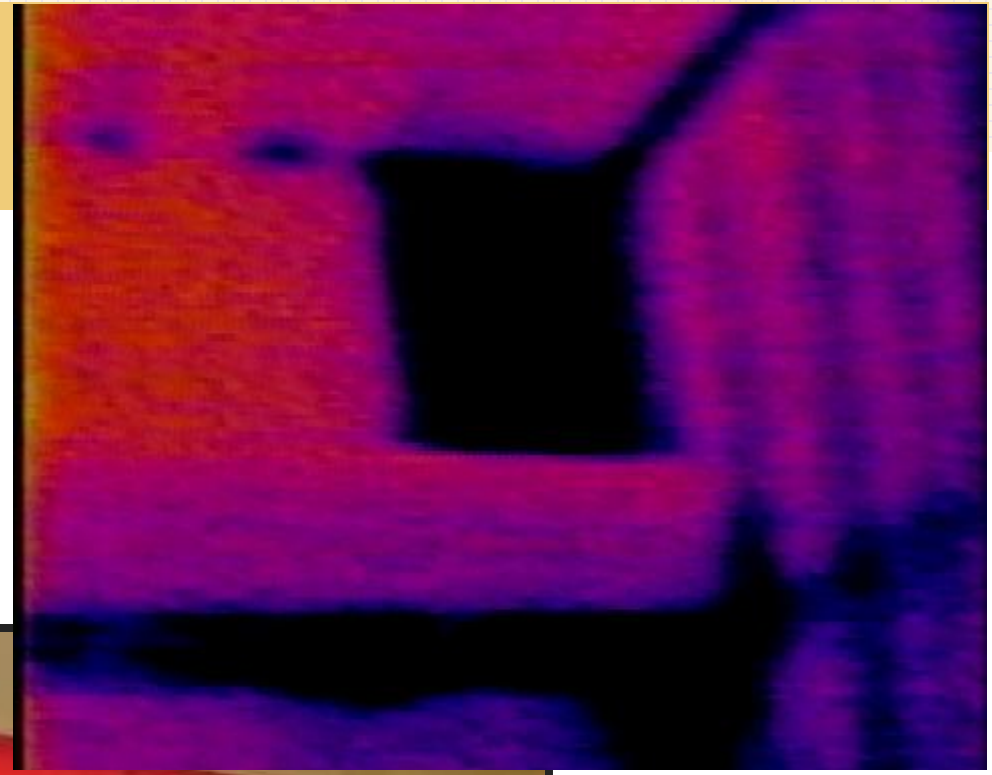
Air Sealing

1. Find the air leaks and fix them.
2. Provide consistent test results between 2.0 and 0.6 ACH50



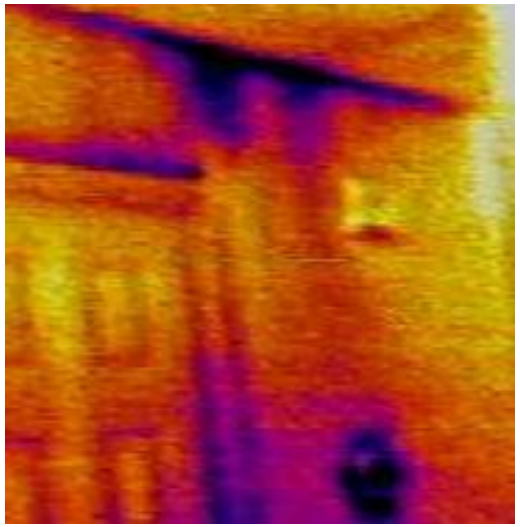
Insulation Performance

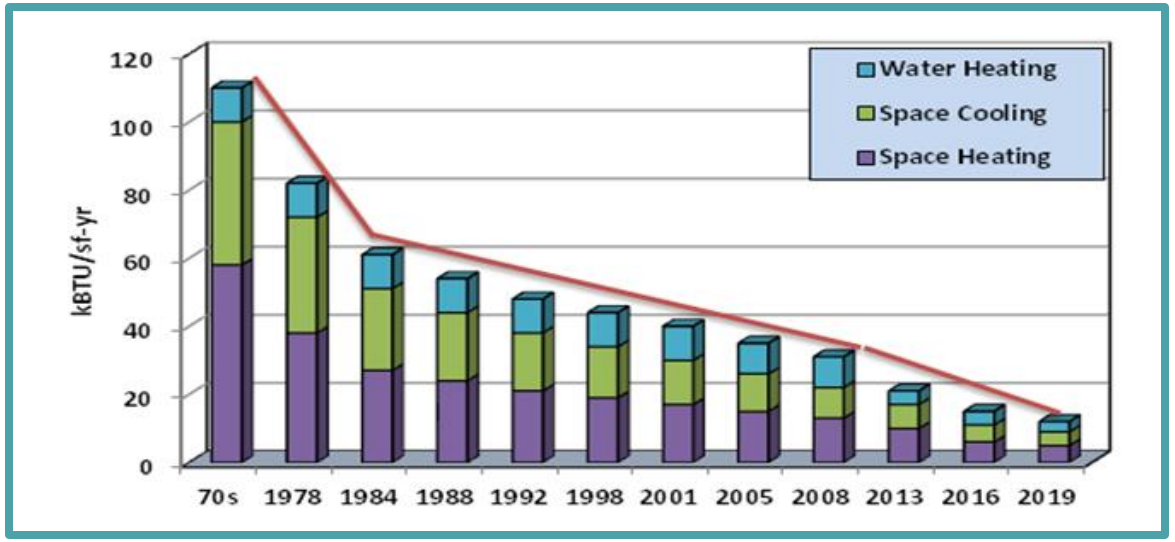
1. Find the insulation defects and fix them.
2. Provide consistent infrared scans that show zero defects



Final Notes

1. There is no Silver Bullet, there are a thousand Silver Beebees. There are other performance factors to get correct.
2. The next class in the HPF Series is Heat Pump Performance





Thank you

RICK CHITWOOD

RICK@CHITWOODENERGY.COM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- Serves all building professionals
- Three services –
  - **Energy Code Coach**
  - **Training and Support**
  - **Regional Forums**
- Makes the Energy Code easy to follow

Energy Code Coach:
3c-ren.org/codes
805.220.9991

Event Registration:
3c-ren.org/events

BUILDING PERFORMANCE TRAINING

- Serves current and prospective building professionals
- Expert instruction:
  - **Technical skills**
  - **Soft skills**
- Helps workers to thrive in an evolving industry

Event Registration:
3c-ren.org/events

3C REN HOME ENERGY SAVINGS

Multifamily (5+ units)

- No cost technical assistance
- Rebates up to $750/apartment plus additional rebates for specialty measures like heat pumps

Single Family (up to 4 units)

- Sign up to participate!
- Get paid for the metered energy savings of your customers

Enrollment:
3C-REN.org/contractor-participation

Closing

- Continuing Education Units Available
  - Contact itzel.torres@ventura.org for AIA LUs
- Coming to Your Inbox Soon!
  - Slides, Recording, & Survey – Please Take It and Help Us Out!
- Upcoming Courses:
  - Central Coast Reach Codes Policy Workshop (7/14)
  - Passive House Windows (7/19)
  - Incentive Opportunities and Resources in the Central Coast (7/20)
  - 2022 California Energy Code: Reaching Towards Higher Efficiency Standards (3C-REN Regional Forum) (7/21)
  - Whole House Assessment: The Home Energy Audit Explained (7/26)
  - Save Money & Go Green: How to Bring Clean Energy to Affordable Multifamily Housing (7/28)
  - Communicating the Value of High Performance (Ongoing Invitation)

Thank you!

For more info:
3c-ren.org

For questions:
info@3c-ren.org

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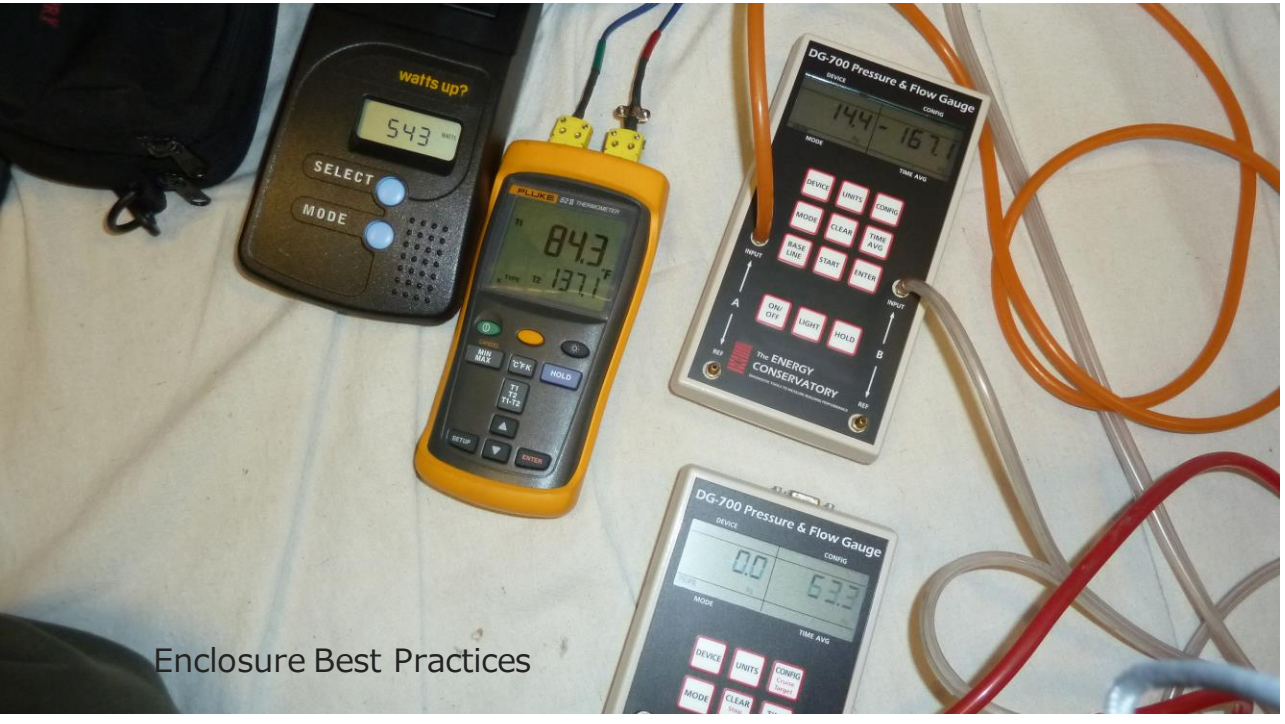
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Questions

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