TRI-COUNTY
REGIONAL ENERGY NETWORK
SAN LUIS OBISPO • SANTA BARBARA • VENTURA

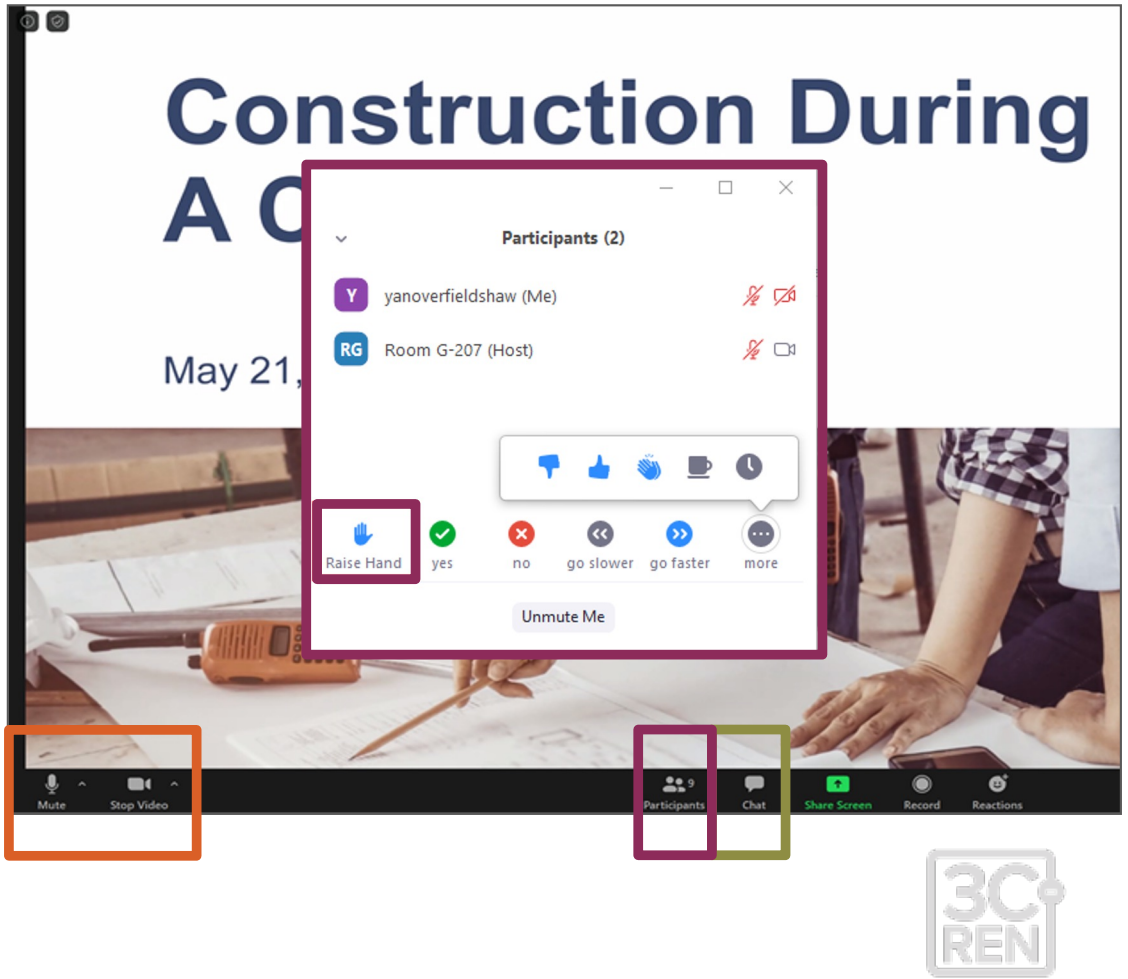
Crafting High Performance Enclosures: Roofs, Walls, and Floors

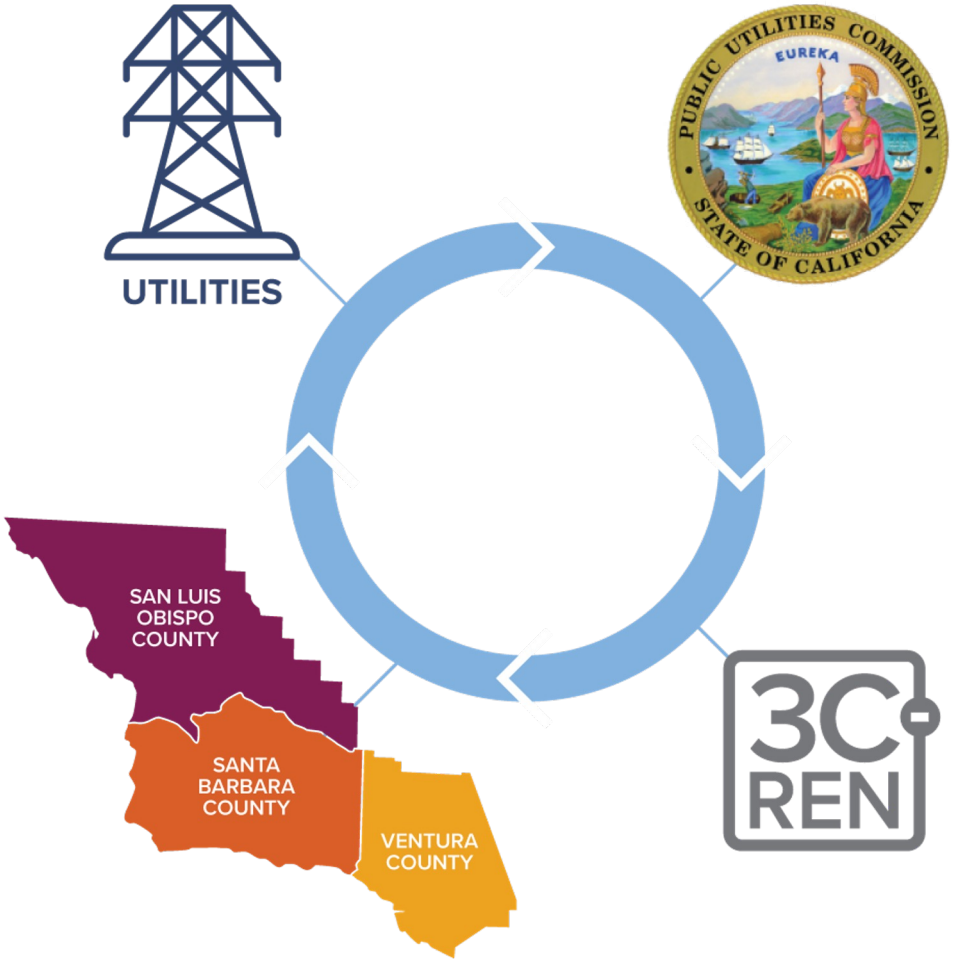
Judy Rachel – Home Performance Professional

March 4, 2025

Zoom Orientation

- Add an **introduction** in the chat. Be sure **full name** is displayed.
- Did you call in? Please **share** first and last name with us.
- Please **mute** upon joining
- Use the "**Chat**" to share questions or comments
- Under "**Participant**" select "**Raise Hand**" to share a question or comment verbally
- Session may be **recorded** and posted to 3C-REN's on-demand page
- Slides/recording are **shared** after most events





Tri-County Regional Energy Network

3C-REN is a collaboration between the tri-counties

Our programs reduce energy use for a more sustainable, equitable and economically vibrant Central Coast

Our free services are funded via the CPUC, bringing ratepayer dollars back to the region

Our Services

Incentives

HOME ENERGY SAVINGS

3c-ren.org/for-residents
3c-ren.org/multifamily

COMMERCIAL ENERGY SAVINGS

3c-ren.org/commercial

Contractors can enroll at
3c-ren.org/contractors

Training

BUILDING PERFORMANCE TRAINING

3c-ren.org/events
3c-ren.org/building

ENERGY CODE CONNECT

3c-ren.org/code

View past trainings at
3c-ren.org/on-demand

Technical Assistance

AGRICULTURE ENERGY SOLUTIONS

3c-ren.org/agriculture

ENERGY ASSURANCE SERVICES

3c-ren.org/assurance

3C-REN Achievements

4,000+

Individuals Attended Training

1,374

Energy-Saving Projects Completed

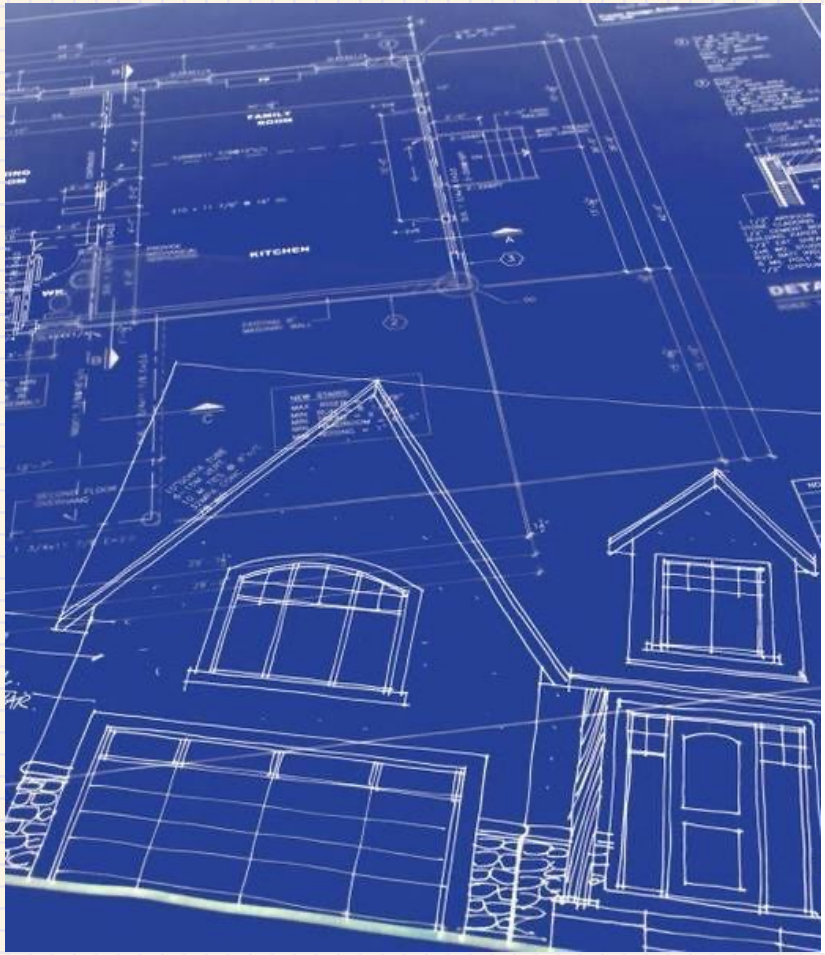
334

Title 24/CalGreen Questions Answered

$155M

Secured for investment in the tri-county region through 2028

Data from 2019-2023 for three programs

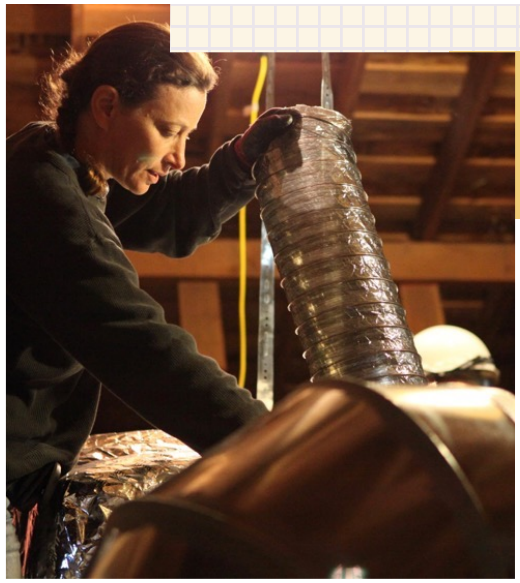


(Thermal)

Enclosure Best Practices: Ceilings, Walls, & Floors

JUDY RACHEL

INFO@JUDYRACHEL.COM



About Judy . . .

1. **Home Performance Technical Consultant**
2. **Contractor Field Mentor**
3. **Perform load calculations and HVAC system design**
4. **Field Research/Building Performance Testing**
5. **Diagnostic testing of existing HVAC systems**
6. **Trainer for Home/High Performance Homes, ACCA load calculations, Healthy Homes, use of diagnostic test equipment, combustion safety, etc.**

Agenda

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

Q&A

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 and Doors**
- **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, $Q=0.0000000017 * A * T^4$)

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
- Lack of training
- No testing

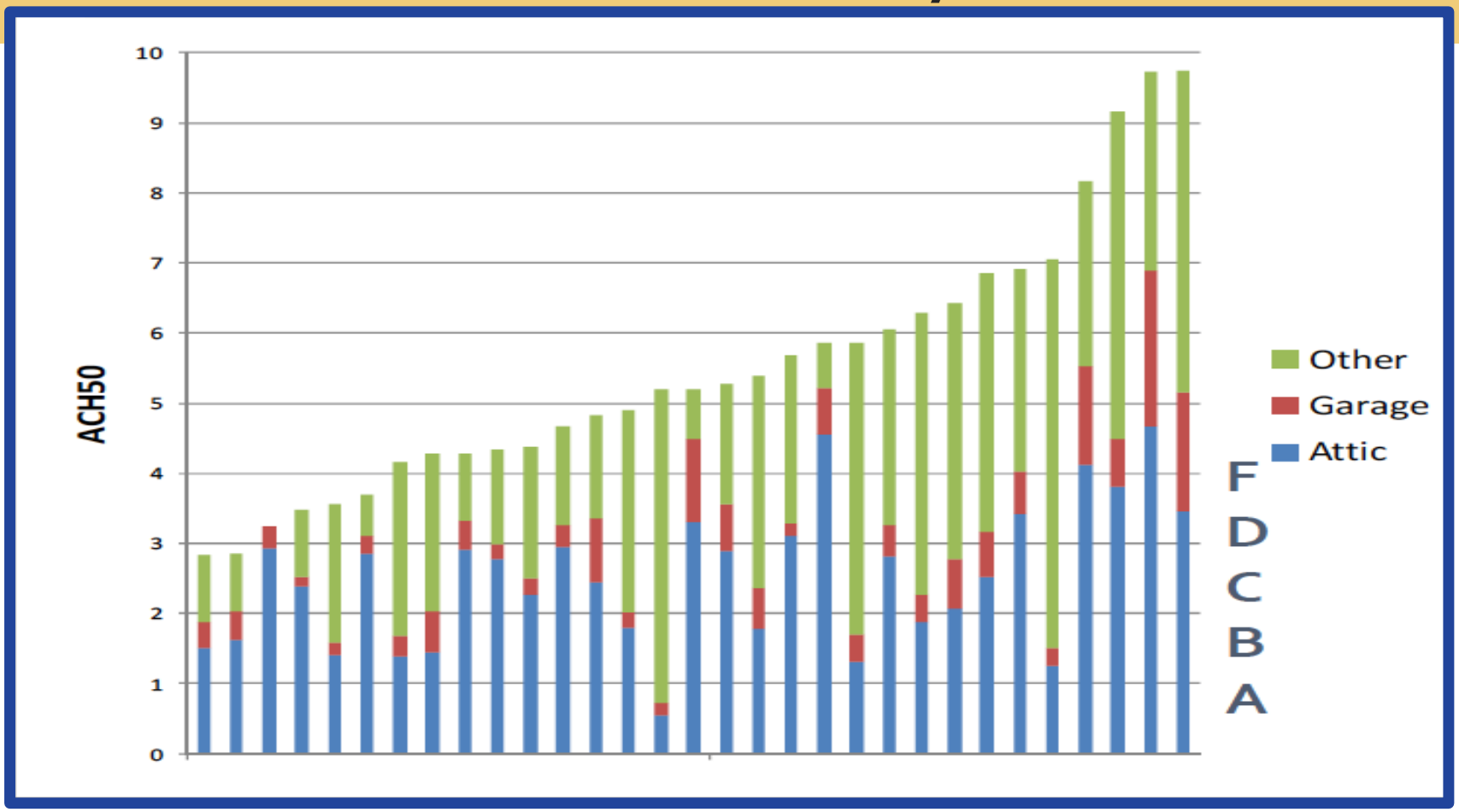
Testing the Building Enclosure

Blower Door

A diagnostic tool designed to measure the airtightness of buildings

- Quantifies enclosure air leakage
- Locates air leaks
- Measures the effectiveness of air sealing efforts
- Used to calculate air changes per hour (ACH_{50})

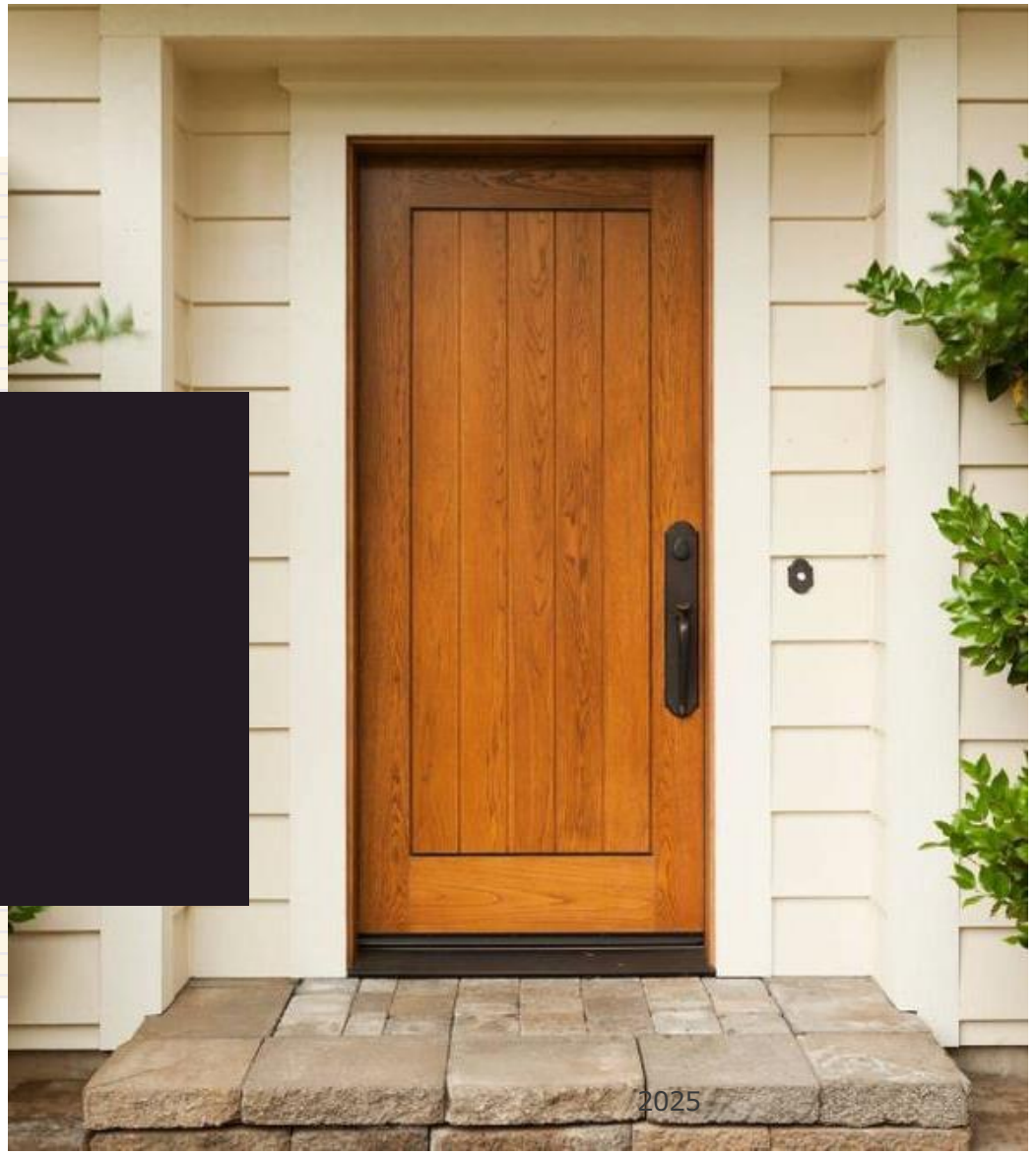
Blower Door Test Results in 40 Newly Constructed Homes



Enclosure Best Practices

2. Air Sealing

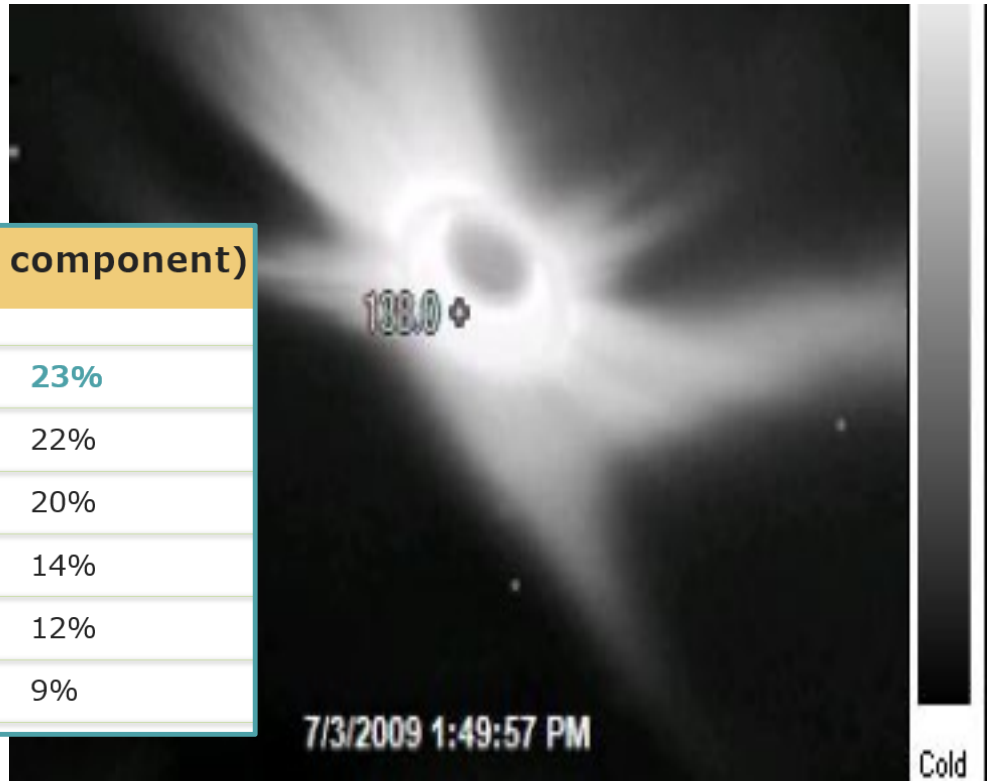
CEILINGS, WALLS, FLOORS

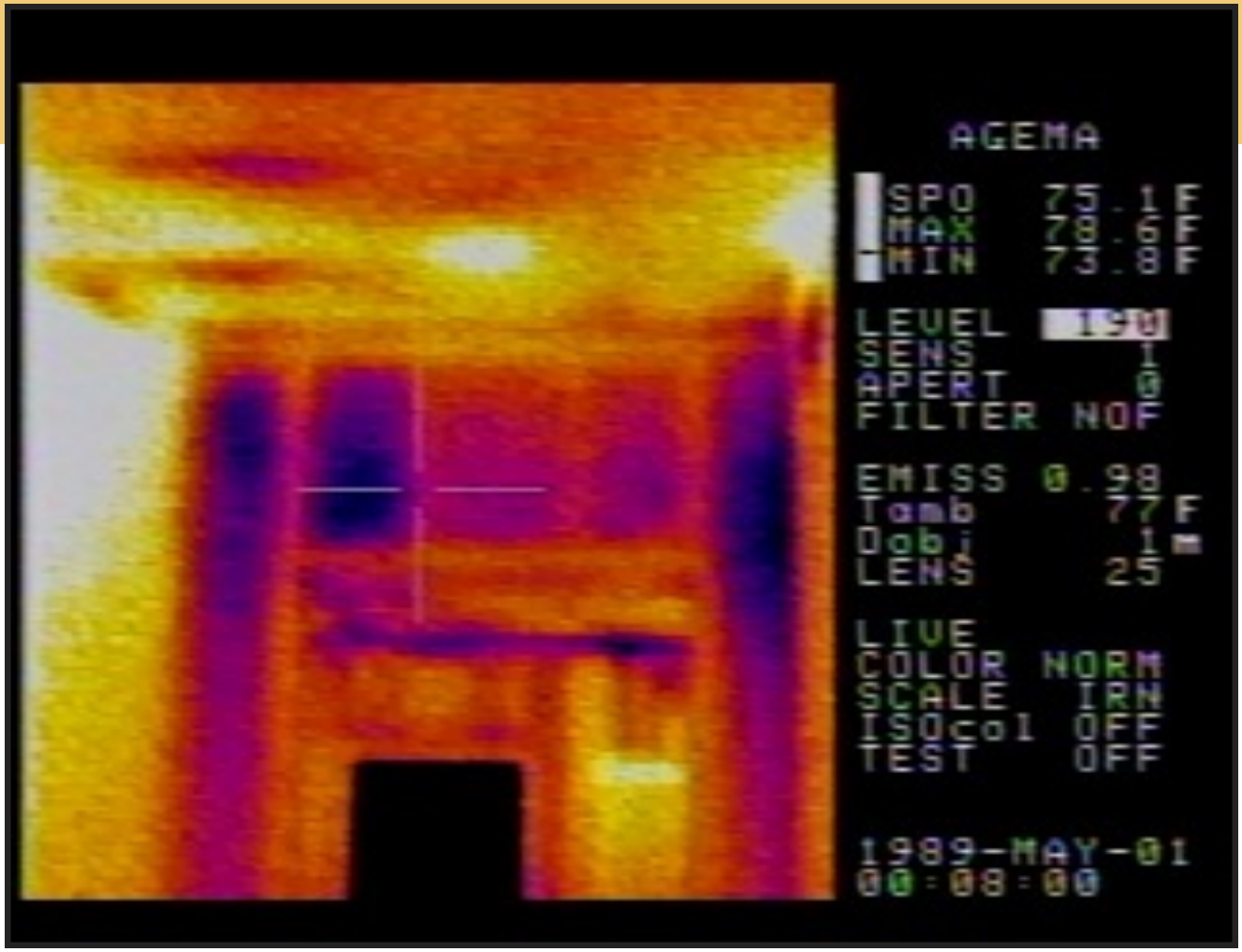


Air Sealing

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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MIN 73.8F
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APERT 0
FILTER NOF
EMISS 0.98
Tamb 77F
Dobj 1m
LENS 25
LIVE
COLOR NORM
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ISOcol OFF
TEST OFF
1989-MAY-01
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DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
51.8
176
Pa
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


FOGSTORM

Tape to the Top Plate

1.0 ACH 50

176 CFM 50

BEFORE INSULATION AND DRYWALL

Glue the Wall Drywall

0.6 ACH 50

81 CFM 50

Build Tight

‘Build tight and ventilate right’ is our mantra.

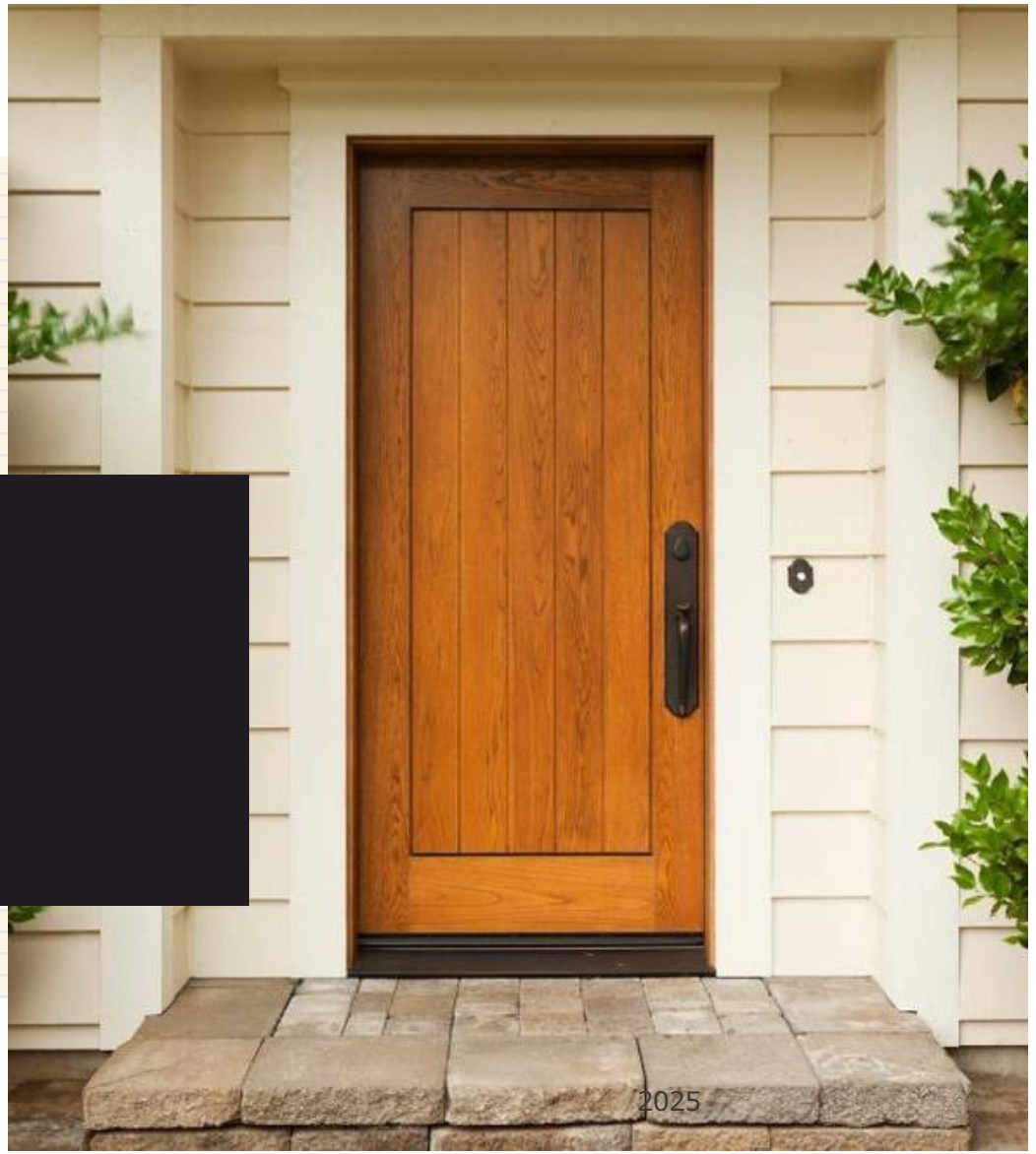
Why?

Wind Pressures Vary

Stack Effect Varies

Mechanical Effect Varies

Universal Enclosure Performance Factors



Universal Enclosure Performance Factors

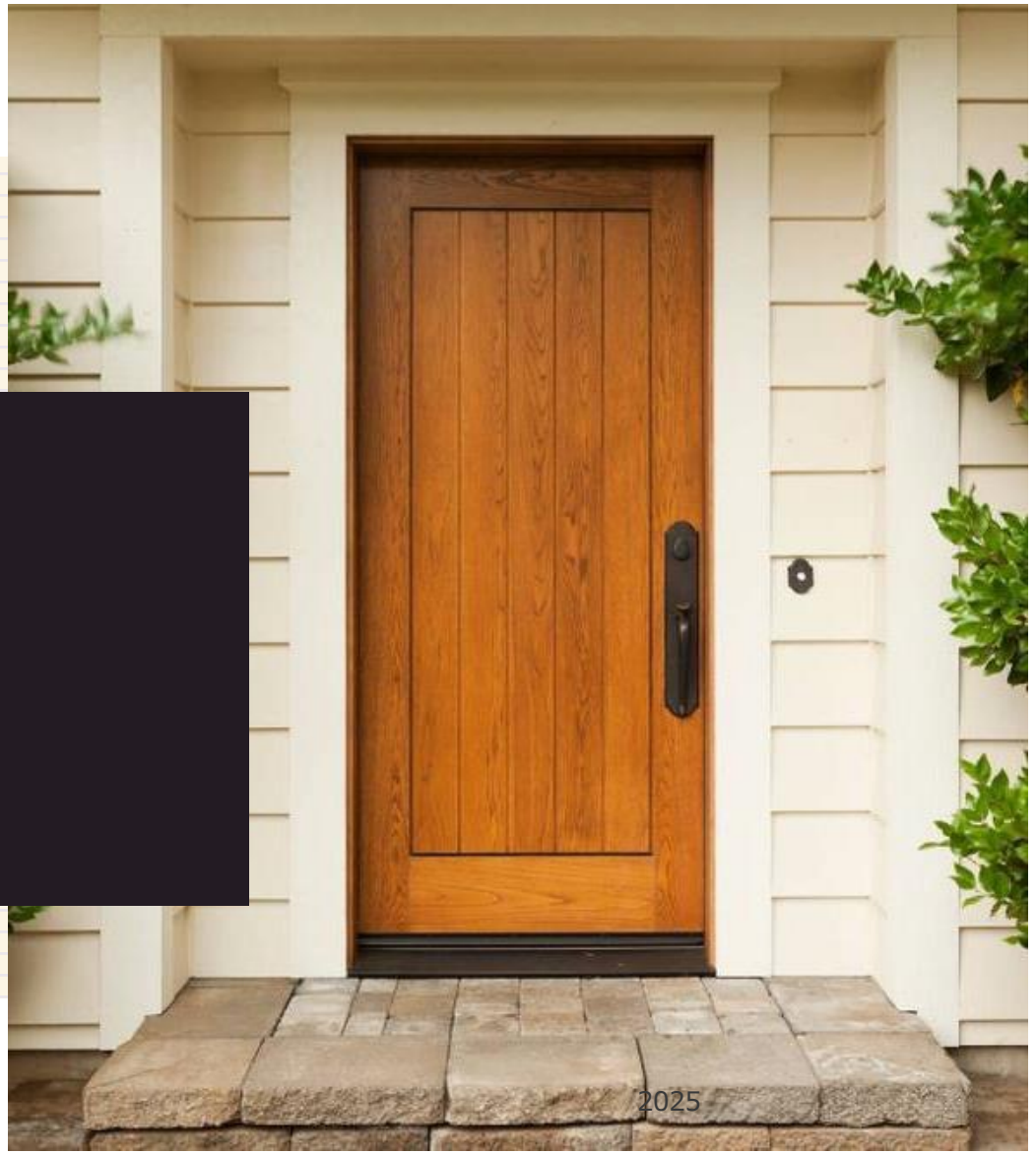
1. Continuous, airtight air barriers
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

CORRECT

Installation Quality is More Important Than R-value

INCORRECT

3. Ceilings



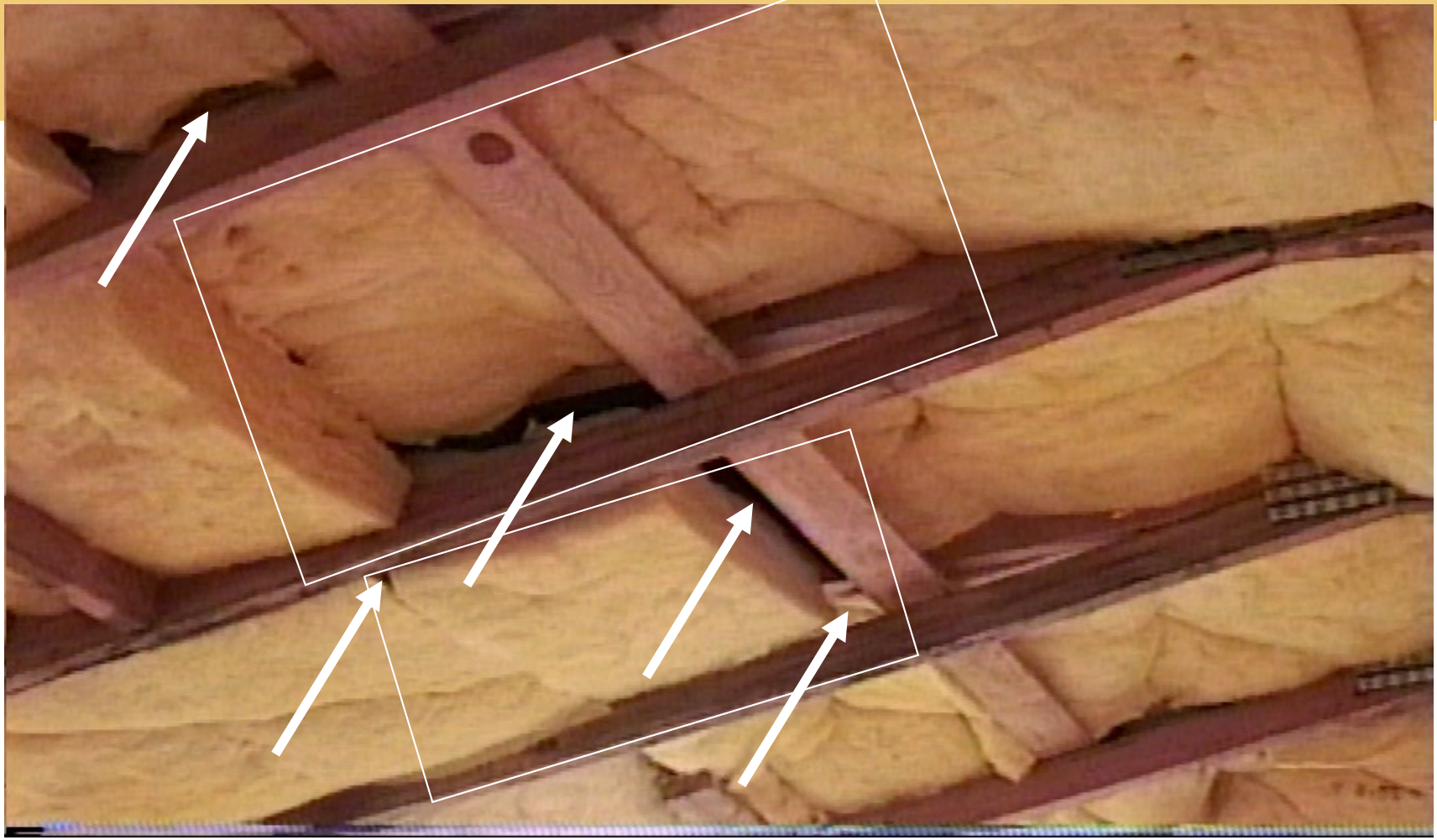
Performance Factors for Ceilings

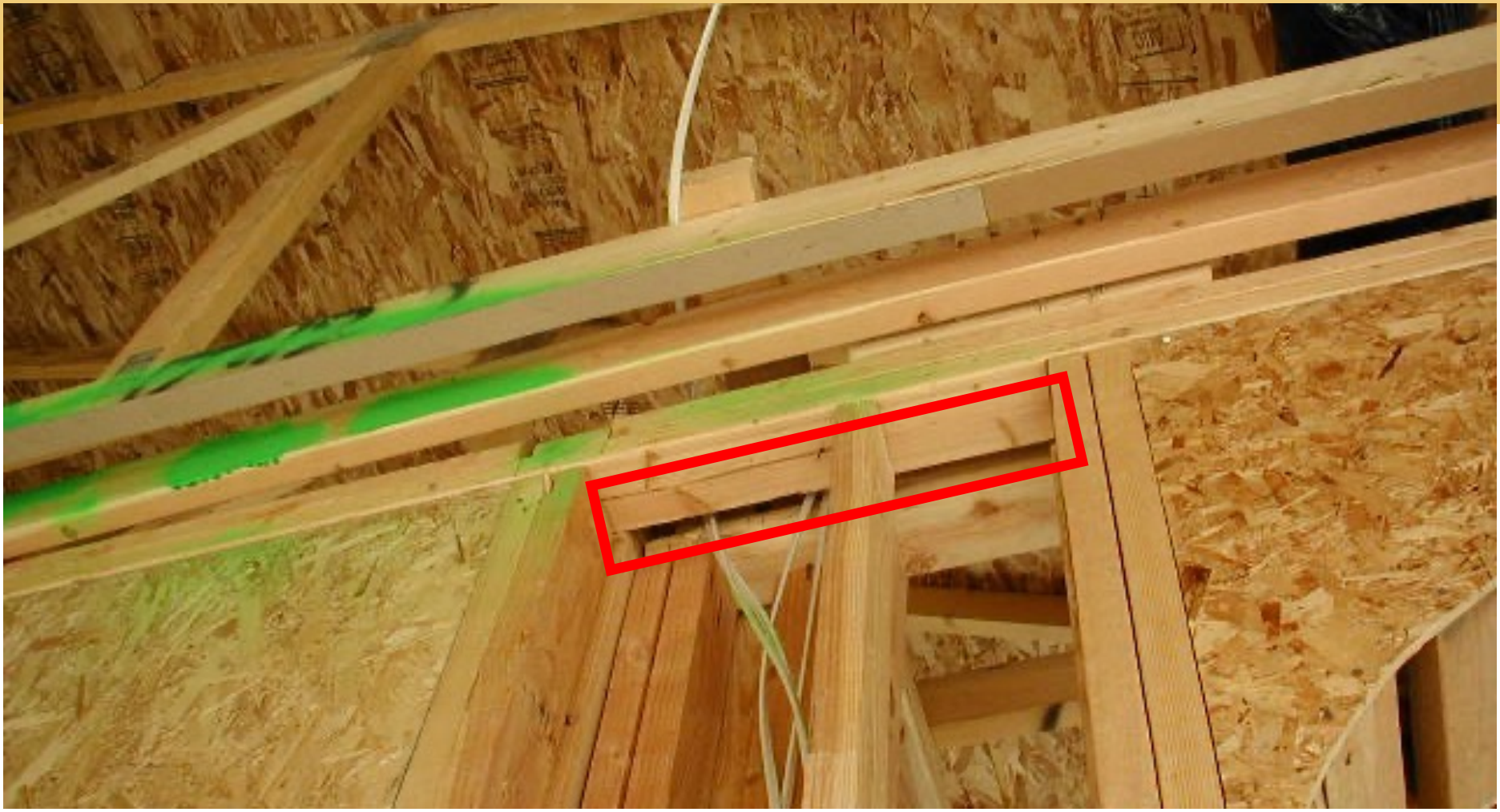
CEILING SPECIFICS

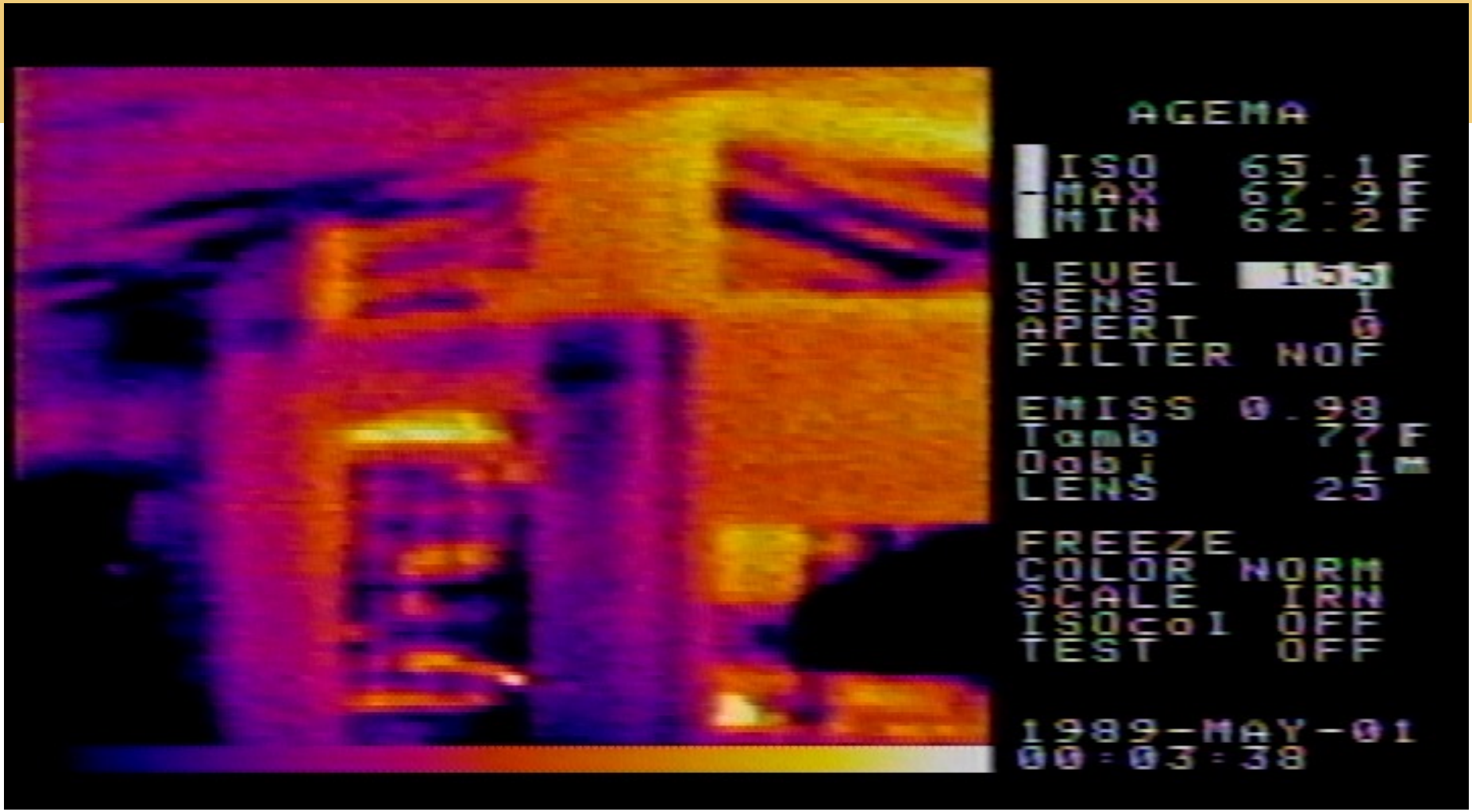
1. **Continuous and airtight ceiling air barrier** (usually the drywall)

UNIVERSAL

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



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MIN 62.2F
LEVEL 155
SENS 1
APERT 0
FILTER NOF
EMISS 0.98
Tamb 77F
Dobj 1m
LENS 25
FREEZE
COLOR NORM
SCALE IRN
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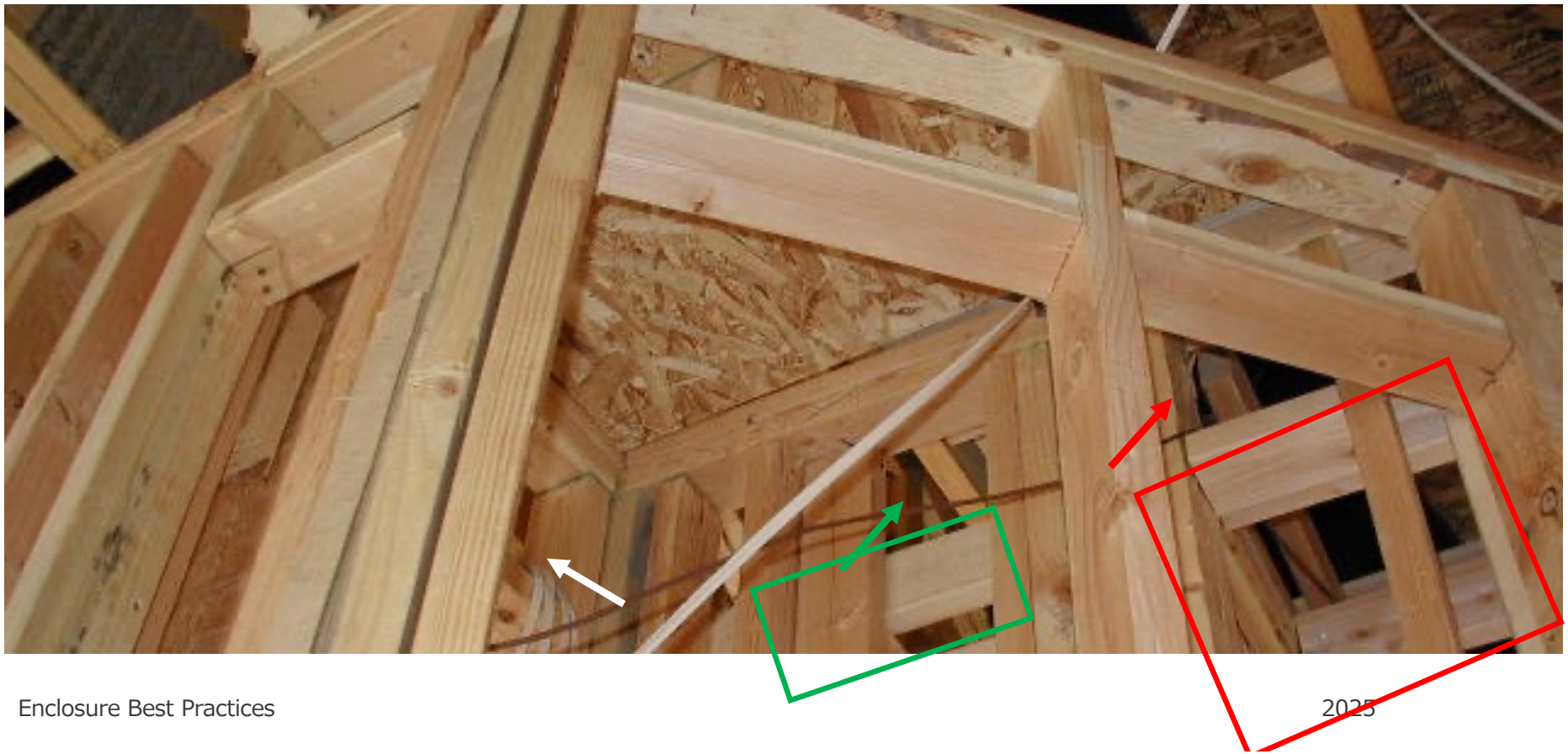
Interstitial Cavities open to the Attic (AKA Missing Fire Blocking)

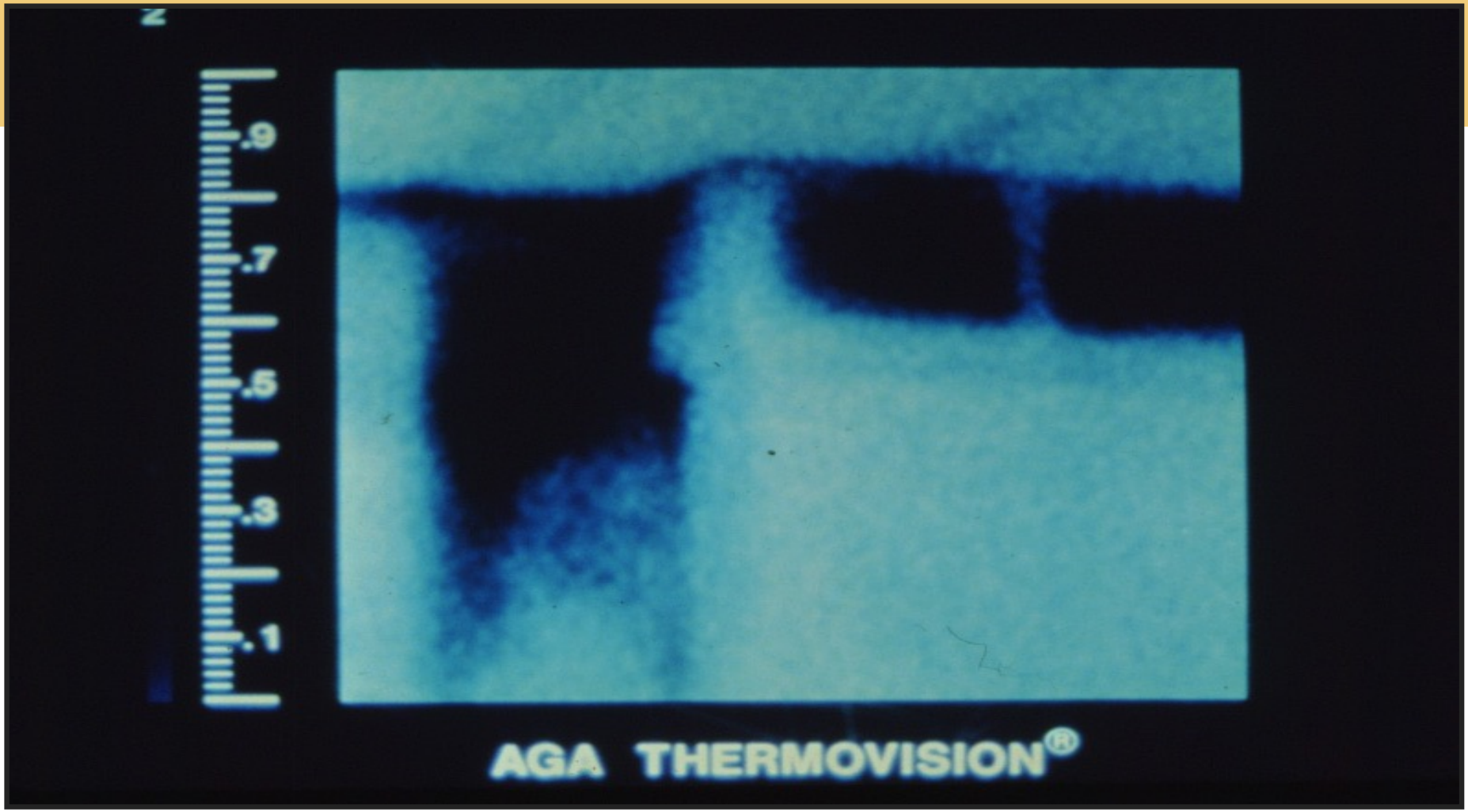


Truss framed attic

Stick framed attic


CORRECT
JET STREAM 733
23
22
21
20
19
18
17
16
15
14
R-60
R-49
R-44


Missing fire block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.7
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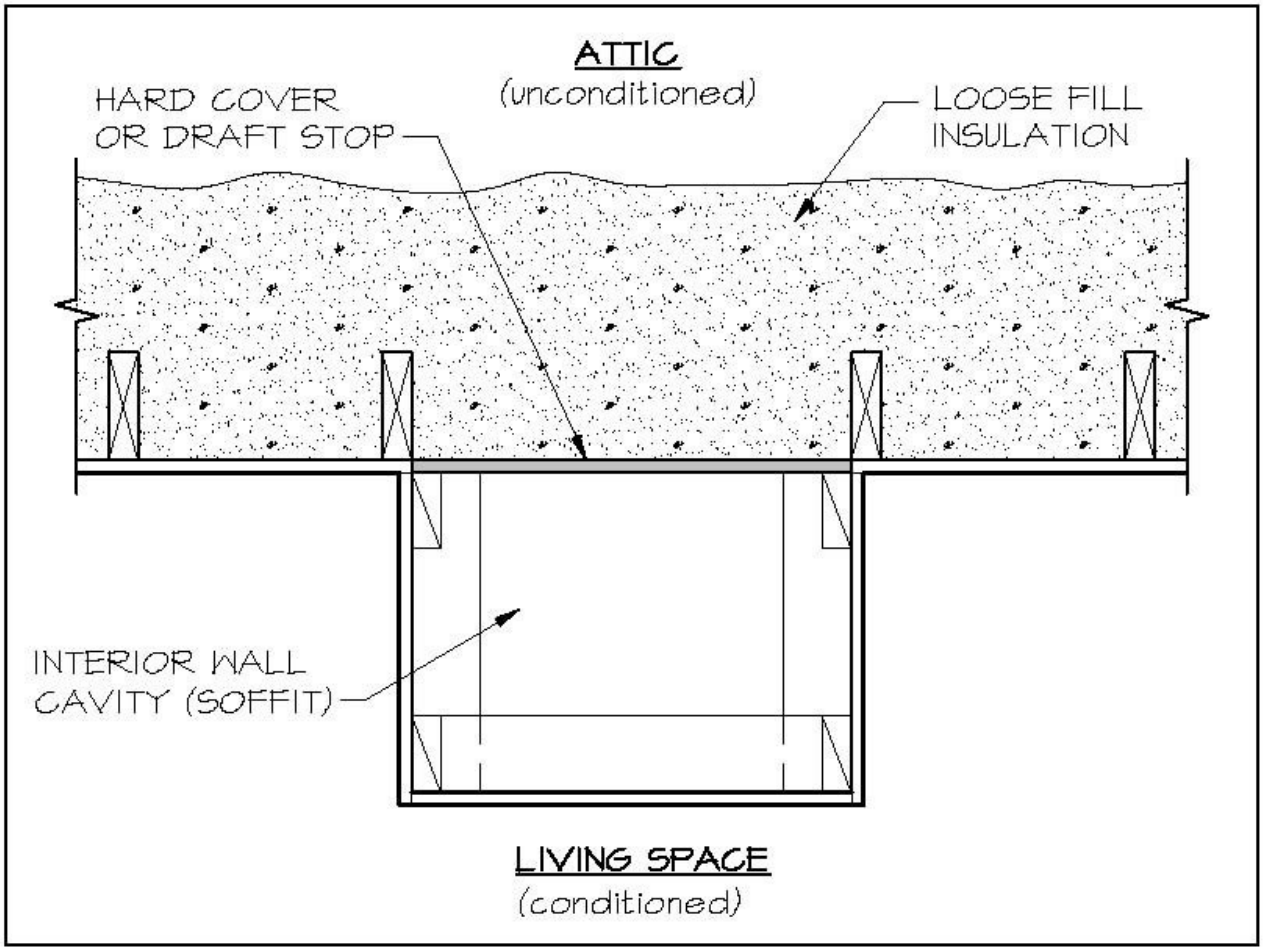
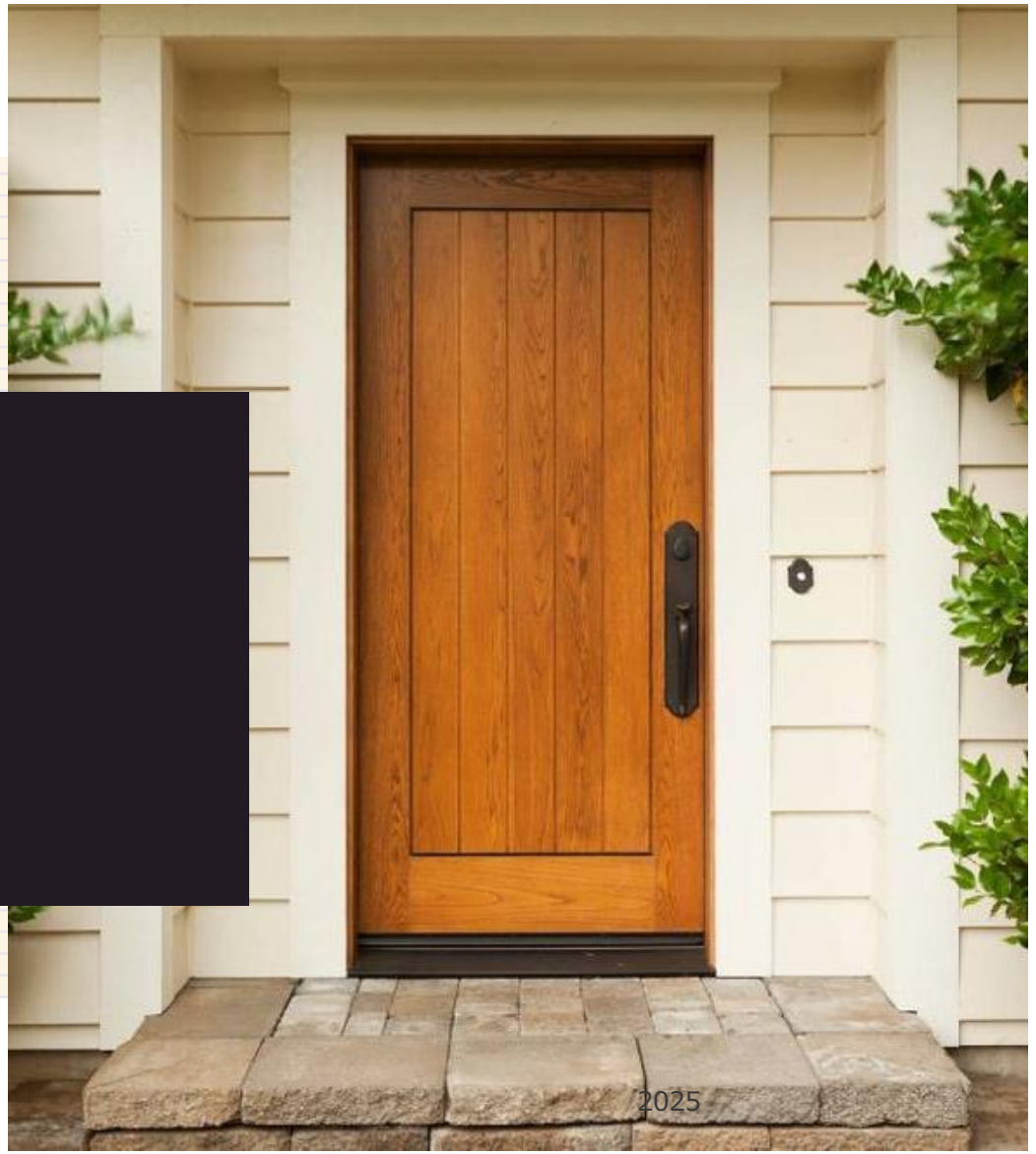
AGA THERMOVISION®


ATTIC
(unconditioned)
HARD COVER
OR DRAFT STOP
LOOSE FILL
INSULATION
INTERIOR WALL
CAVITY (SOFFIT)
LIVING SPACE
(conditioned)

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**

4. Walls



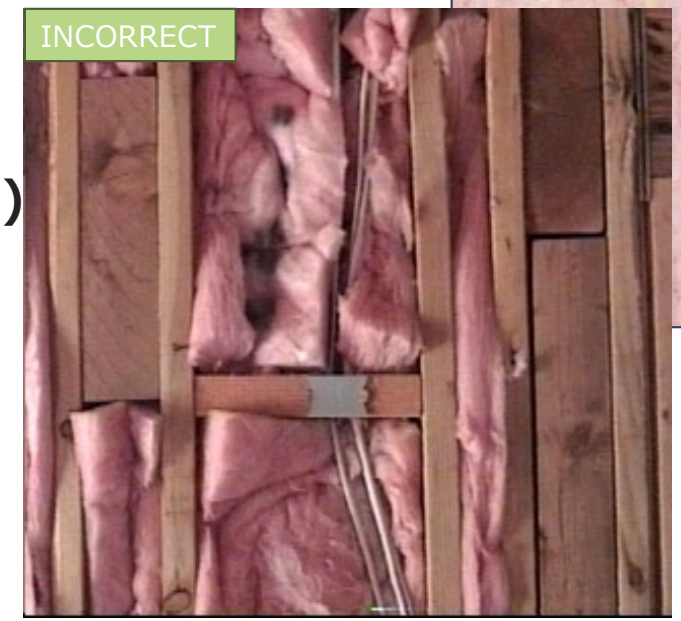
Performance Factors for **Walls**

WALL SPECIFICS

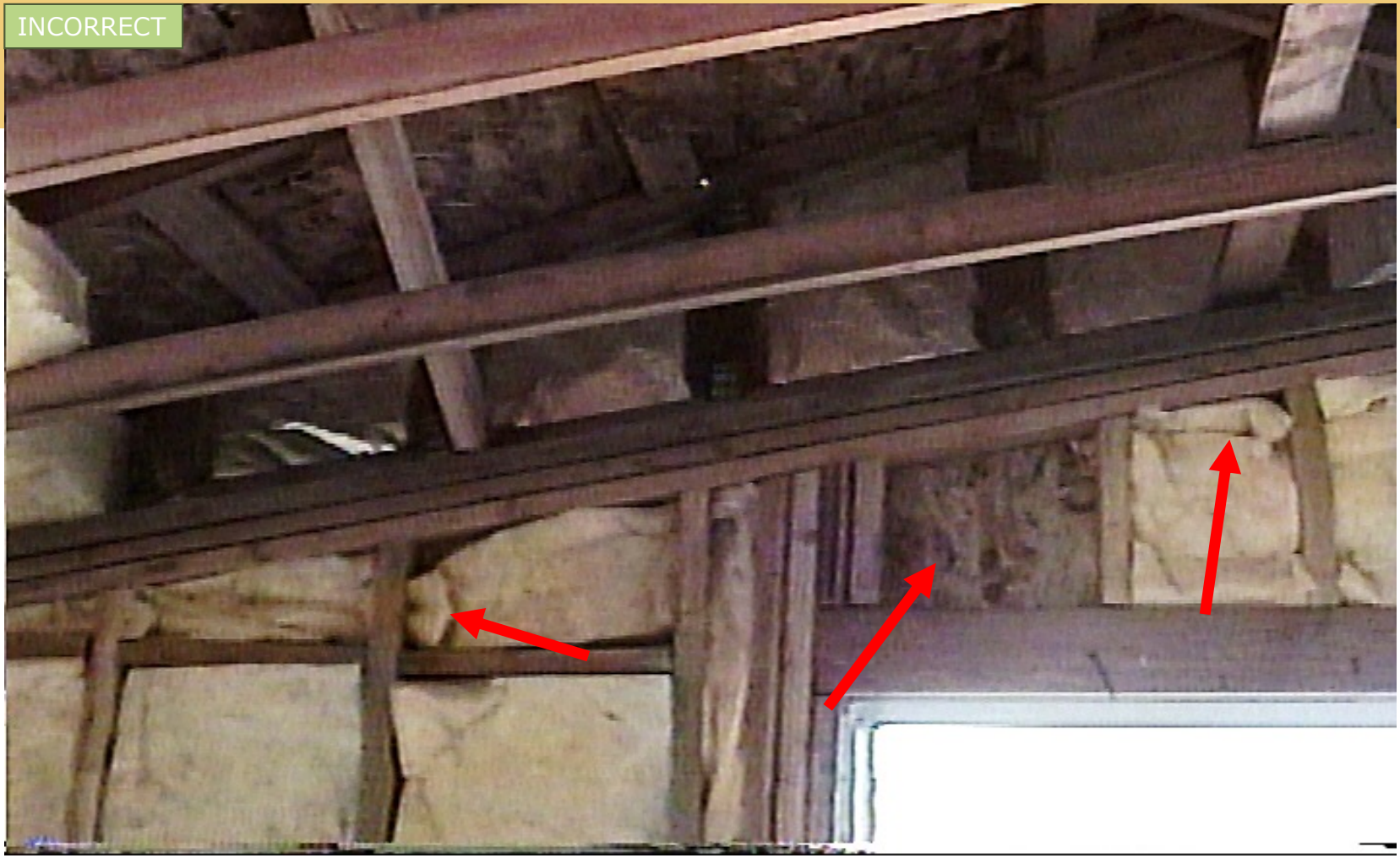
1. **Substantially airtight wall cavity**
2. **Insulation in contact with the air barriers (in contact with all 6 sides of the cavity)**
3. **Framing factor**

UNIVERSAL

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



INCORRECT

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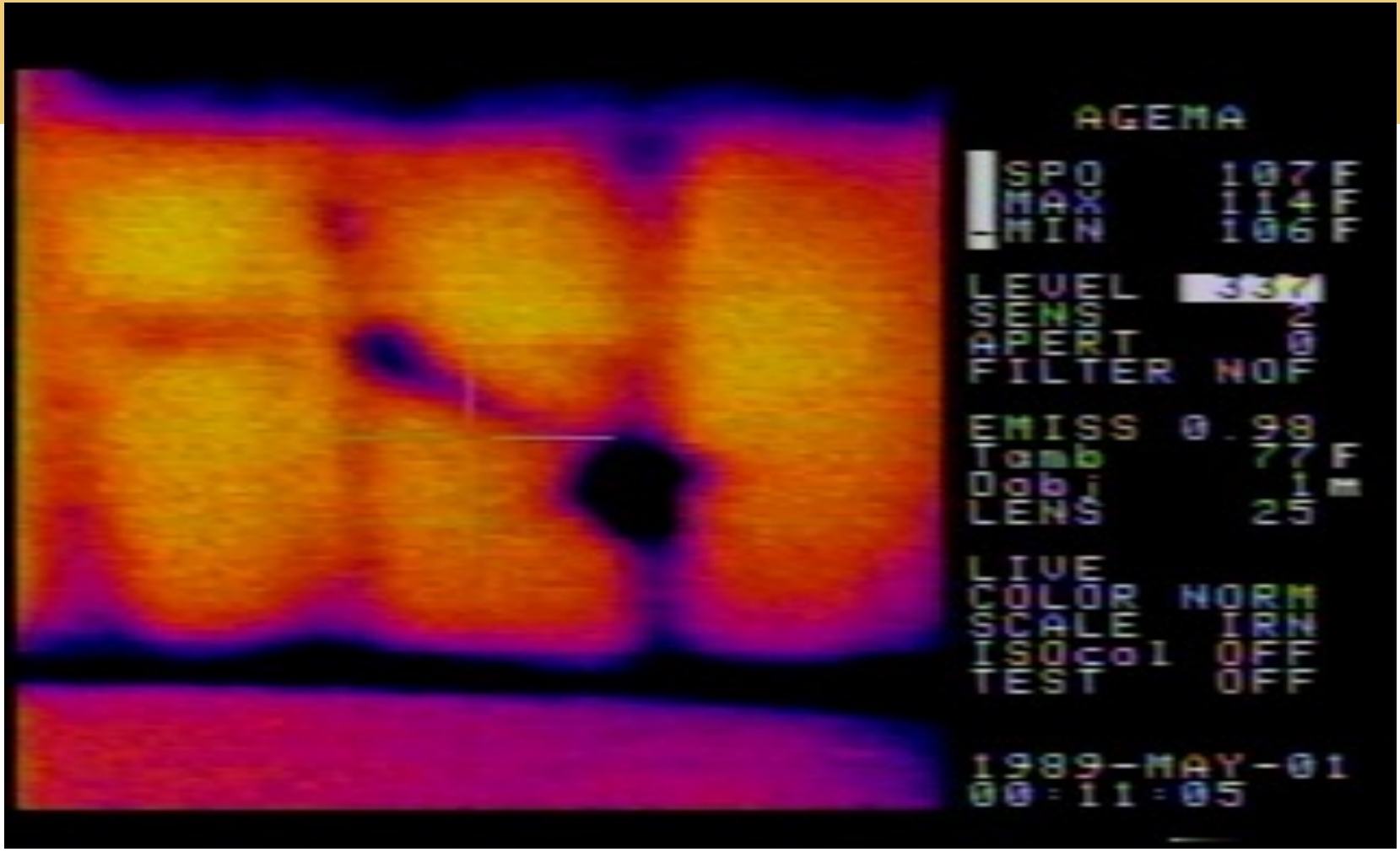
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MAX 114 F
MIN 106 F
LEVEL 337
SENS 2
APERT 0
FILTER NOF
EMISS 0.98
Tamb 77 F
Dobj 1 m
LENS 25
LIVE
COLOR NORM
SCALE IRN
ISOcol OFF
TEST OFF
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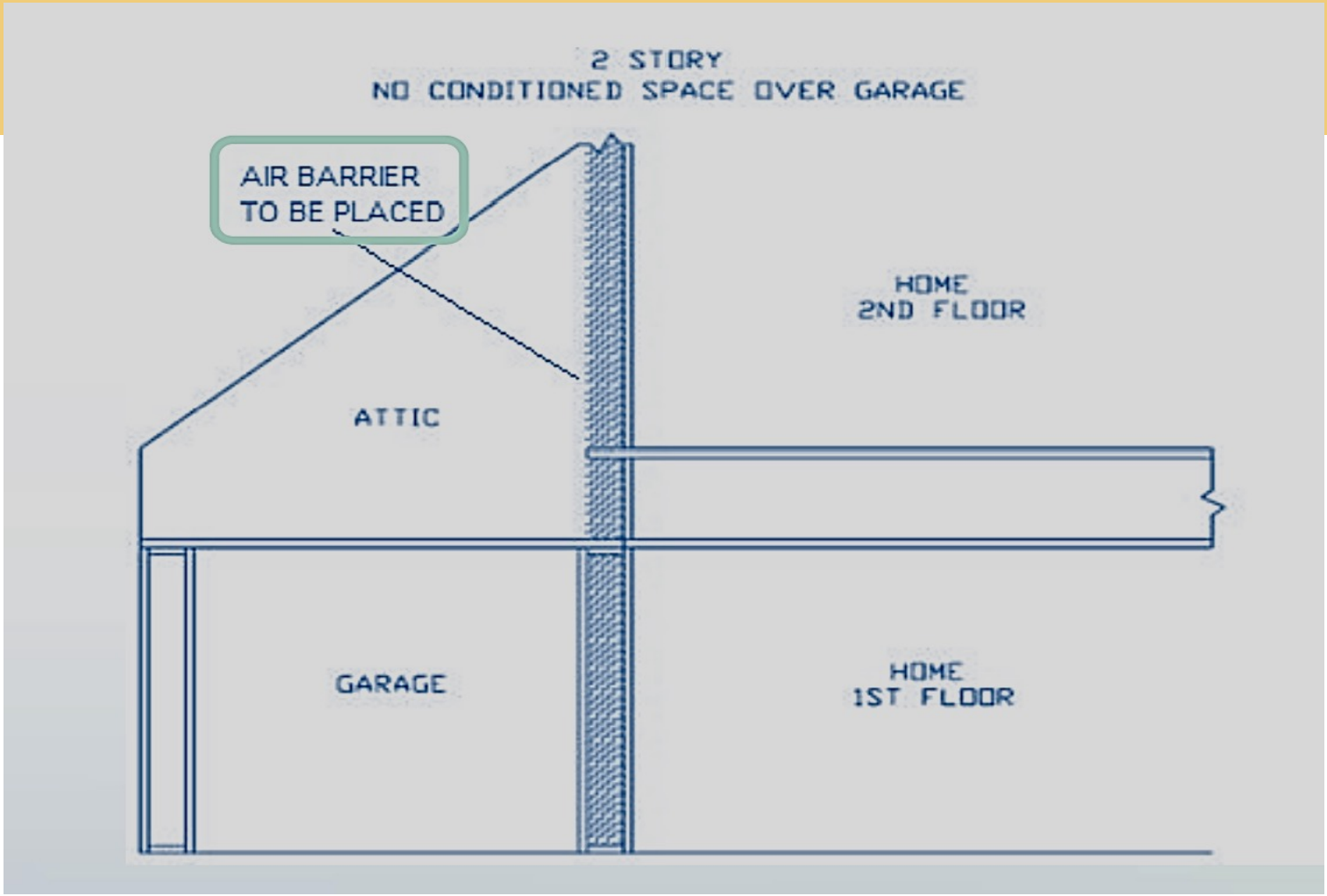
BEST PRACTICE

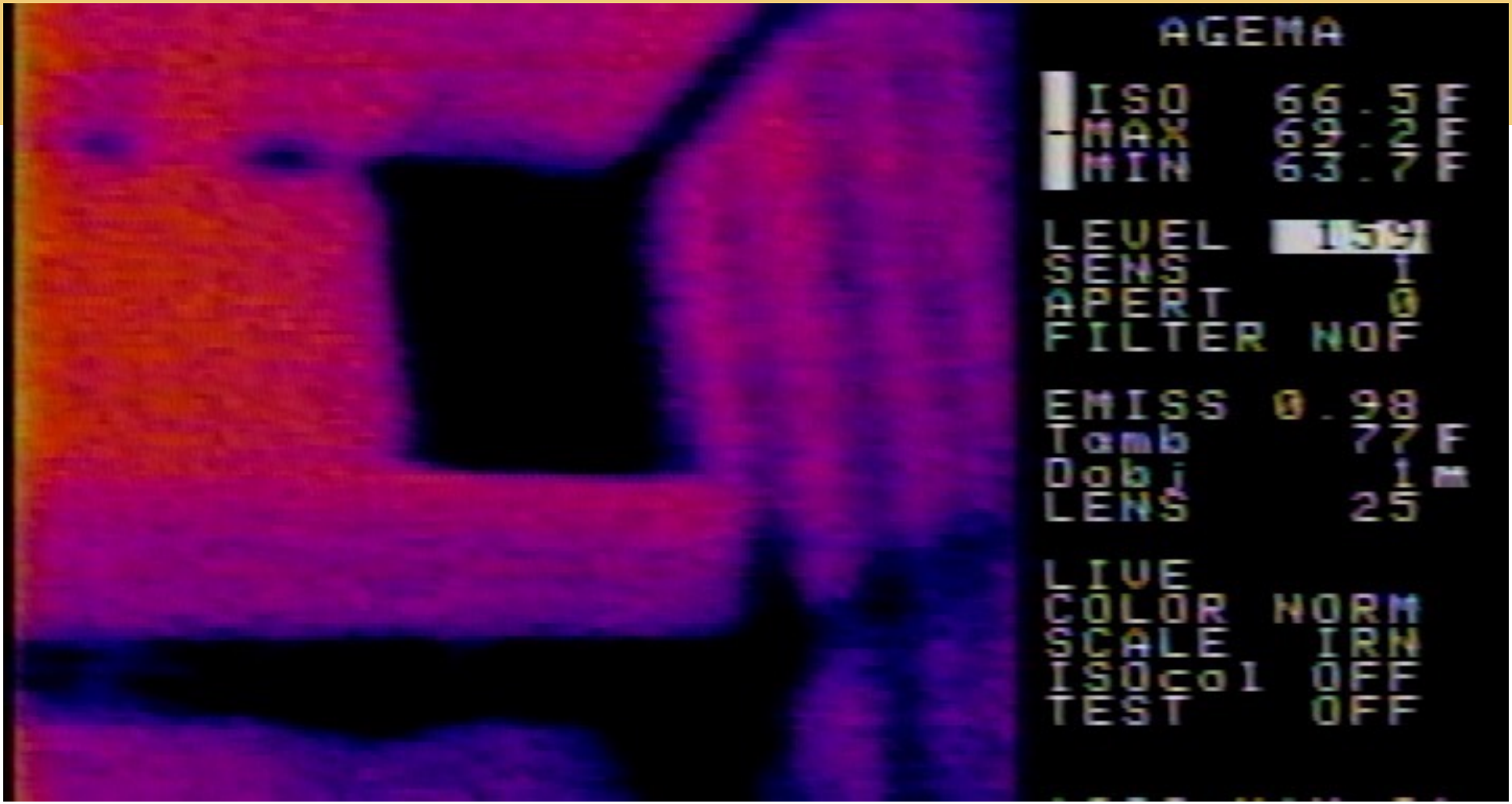
BEST PRACTICE

BEST PRACTICE

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


AGEMA
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MIN 63.7F
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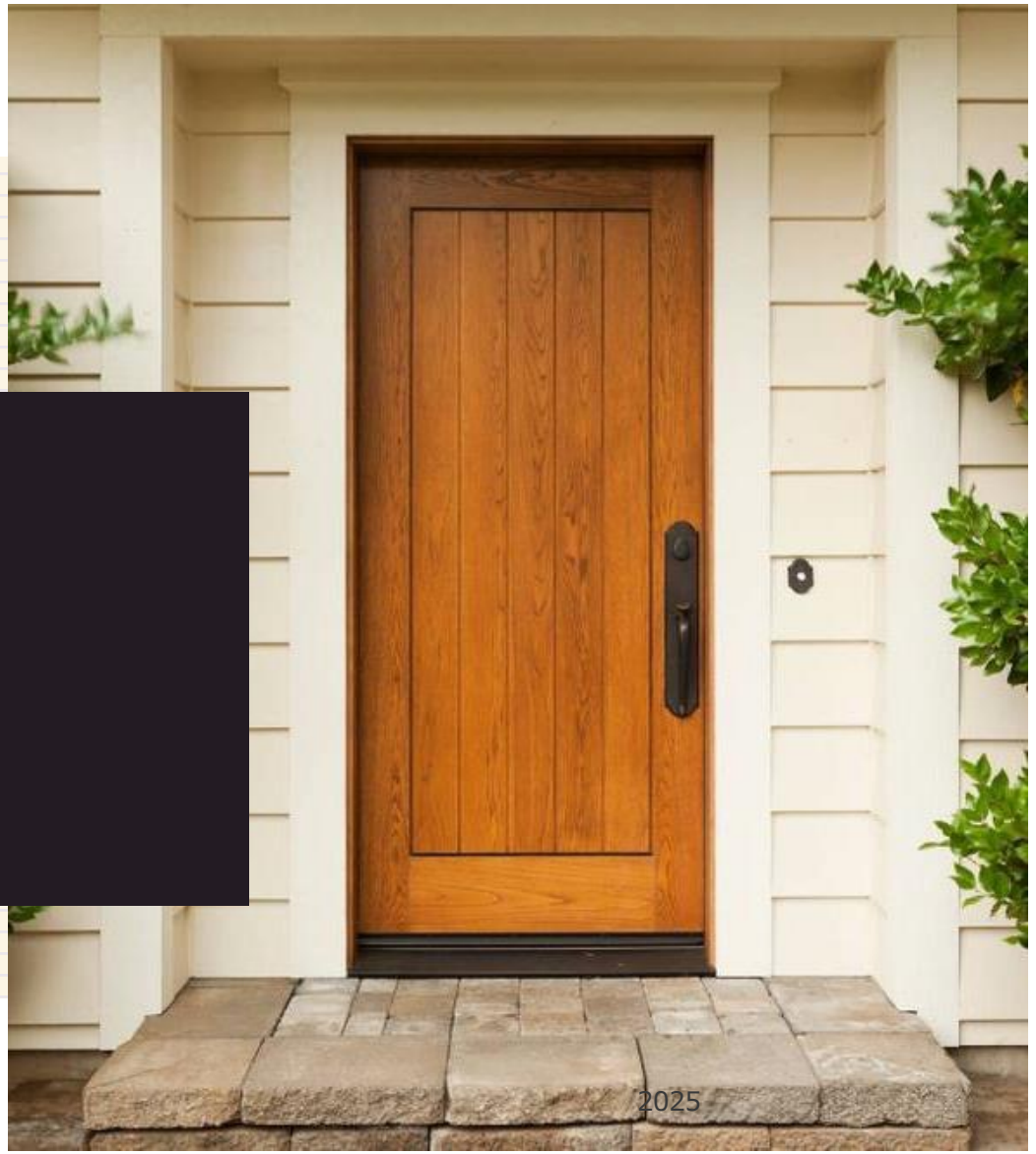
SENS 1
APERT 0
FILTER NOF
EMISS 0.98
Tamb 77F
Dobj 1m
LENS 25
LIVE
COLOR NORM
SCALE IRN
ISOcol OFF
TEST OFF

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

5. Windows



Enclosure Heat Loss (by component)

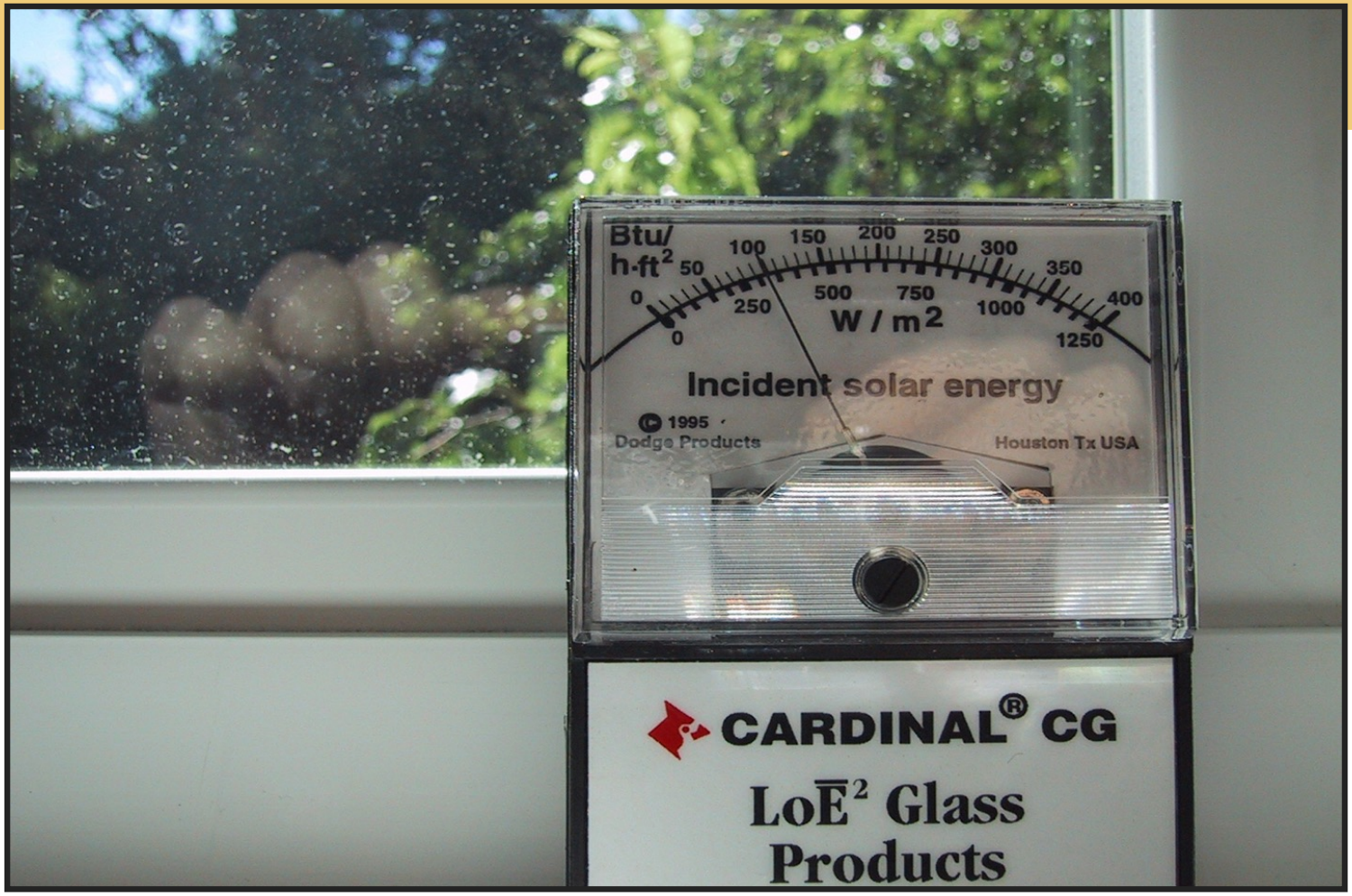
Air Infiltration	23%
Windows	**22%**
Slab Edge	20%
Walls	14%
Ducts	12%
Ceiling	9%

(Based on CEC CBECC computer model)

Performance Factors for **Windows**

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


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

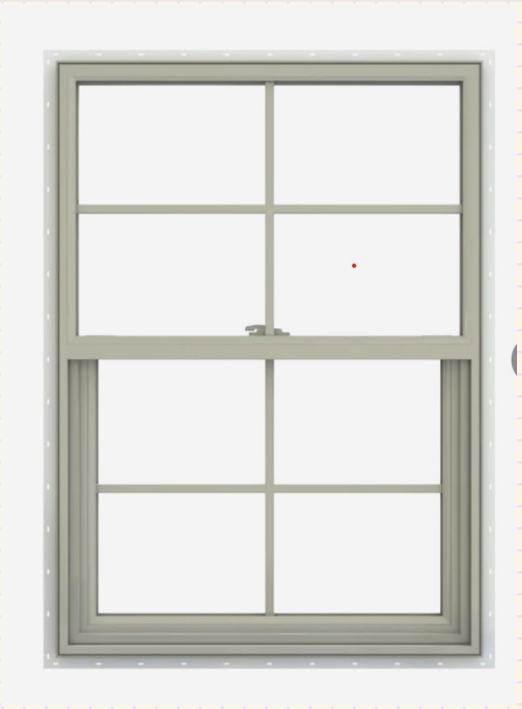

Btu/
h·ft²
0
50
100
150
200
250
300
350
400
0
250
500
750
1000
1250
W / m2
Incident solar energy
1995
Dodge Products
Houston Tx USA
CARDINAL® CG
LoE² Glass
Products

Air Leakage; best to worst

Fixed

Hinged

Single hung



Exterior Shades

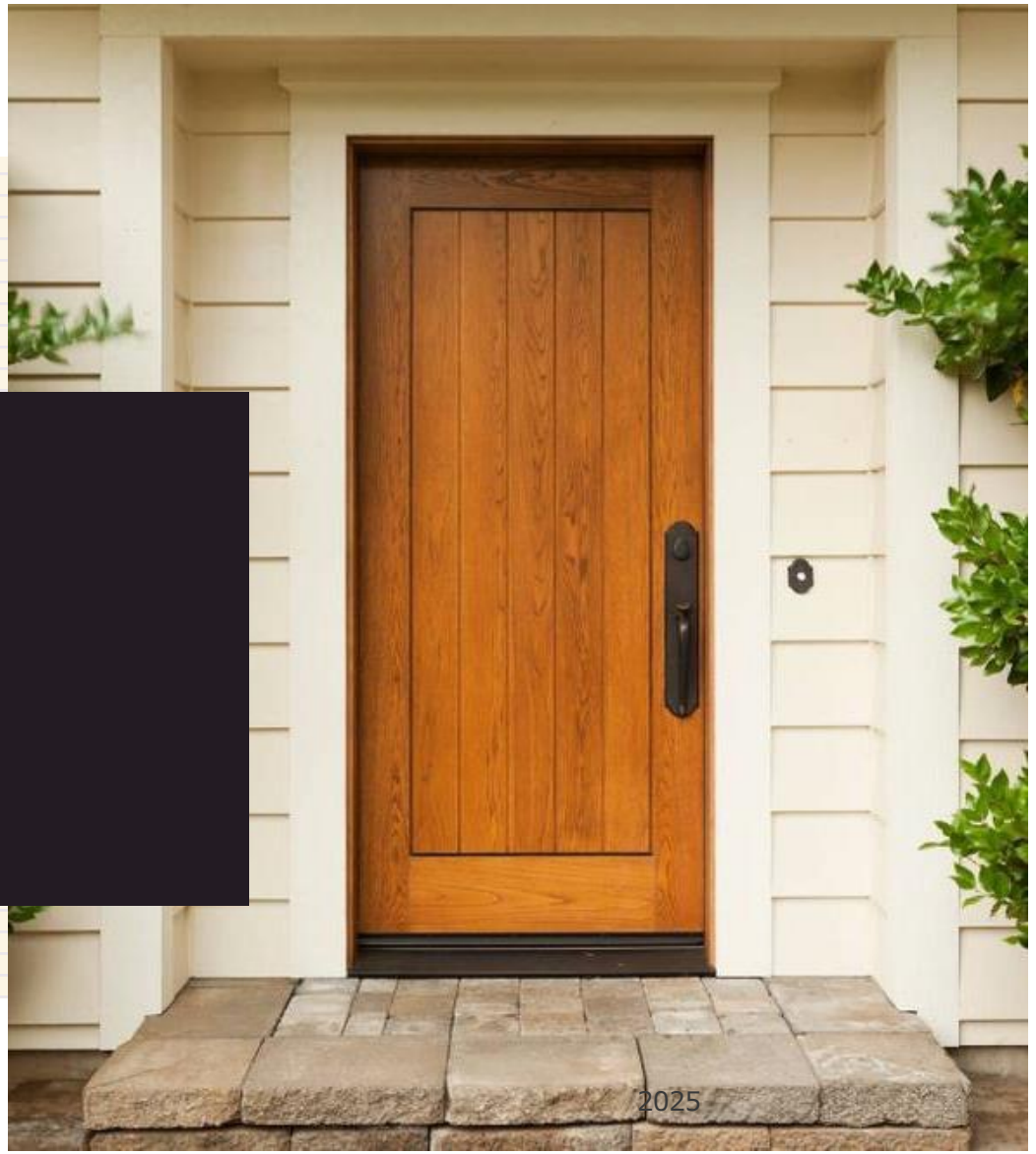
- Less expensive than window replacement
- Appropriate for California’s sunny and mild climate
- Critical for large glass areas
- Exposure and sun angles matter

Performance Factors for **Windows**

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

6. Floors

AND SLAB EDGES



Performance Factors for **Floors** (similar to ceilings)

FLOOR SPECIFICS

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

UNIVERSAL

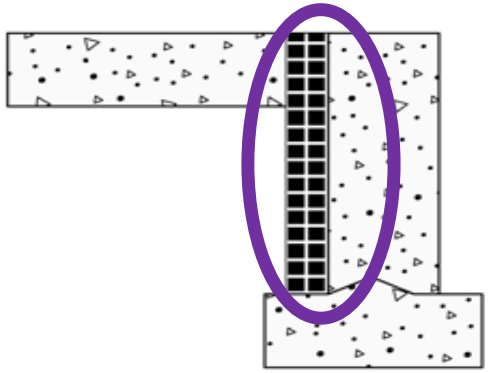
2. Insulation in contact with the air barrier
3. No gaps, voids, or compression

Enclosure Heat Loss (by component)

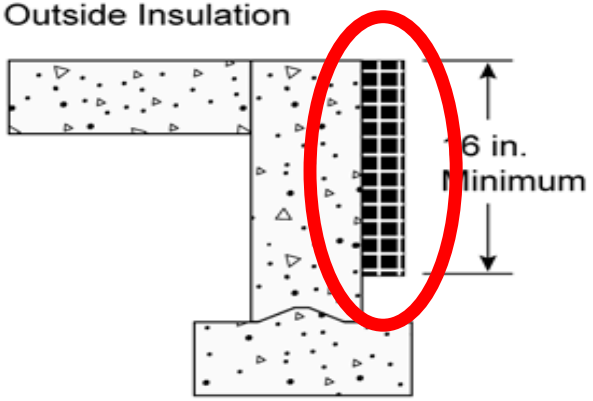
Air Infiltration	23%
Windows	22%
Slab Edge	**20%**
Walls	14%
Ducts	12%
Ceiling	9%

(Based on CEC CBECC computer model)

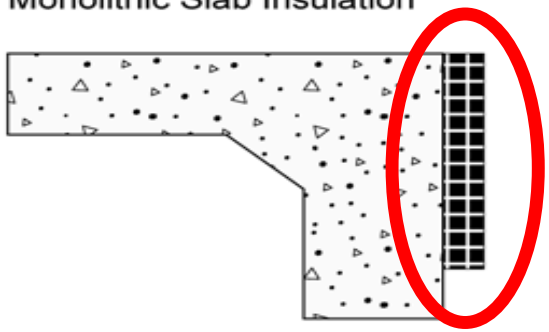
Inside Insulation



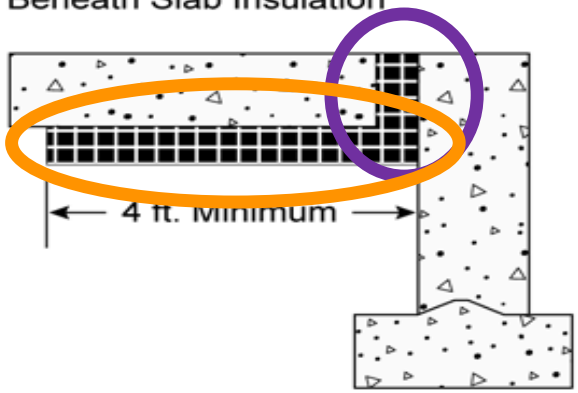
Outside Insulation



Monolithic Slab Insulation



Beneath Slab Insulation



Note: Not to scale.


JM

Cantilevers


CELLULAR CORE

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**

7. Two Case Studies

2005 HOME WITH SOME AIR SEALING

2019 HIGH PERFORMANCE

Case Study – 2005 Showcase Homes

Showcase Home – Performance Monitored by DOE

1. High-end custom home (Realtor's Showcase of Homes)
2. Conventional architecture
3. Conventional framing
4. Conventional insulation (R-21 batts in walls, R-38 loose fill in attic)
5. Minimal air sealing (only missing fire stops)
6. 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 Redding, CA Home

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**	

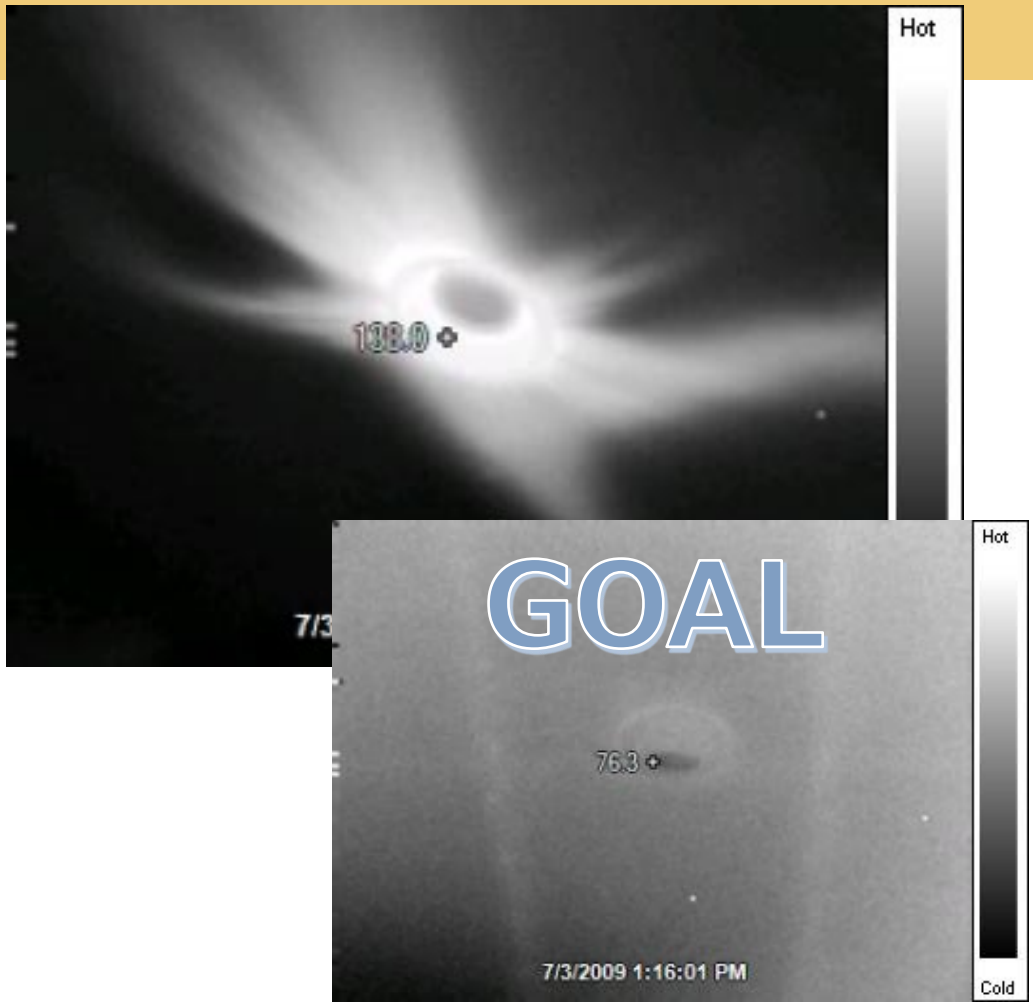
9. Most Important Enclosure Goals

AIR SEALING AND INSULATION PERFORMANCE

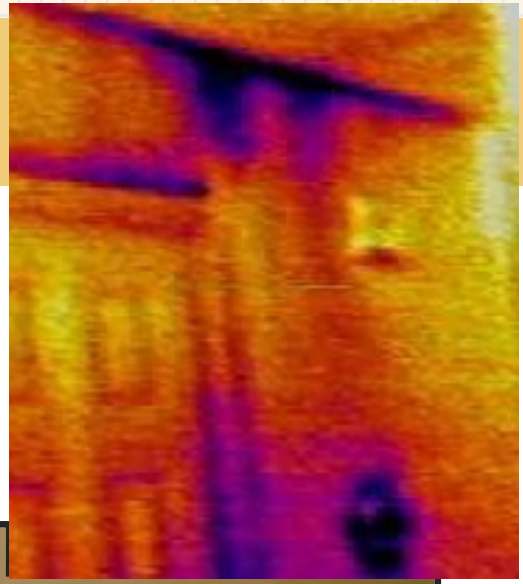
Air Sealing

1. Find the air leaks and fix them.
2. Provide consistent test results below

2.0 ACH50



Insulation Performance

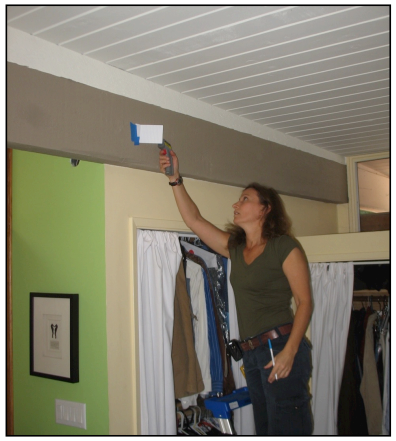


1. Find the insulation defects and fix them.
2. Provide consistent infrared scans that show zero defects

Final Note

There is no Silver Bullet,

There are a thousand Silver BBs.

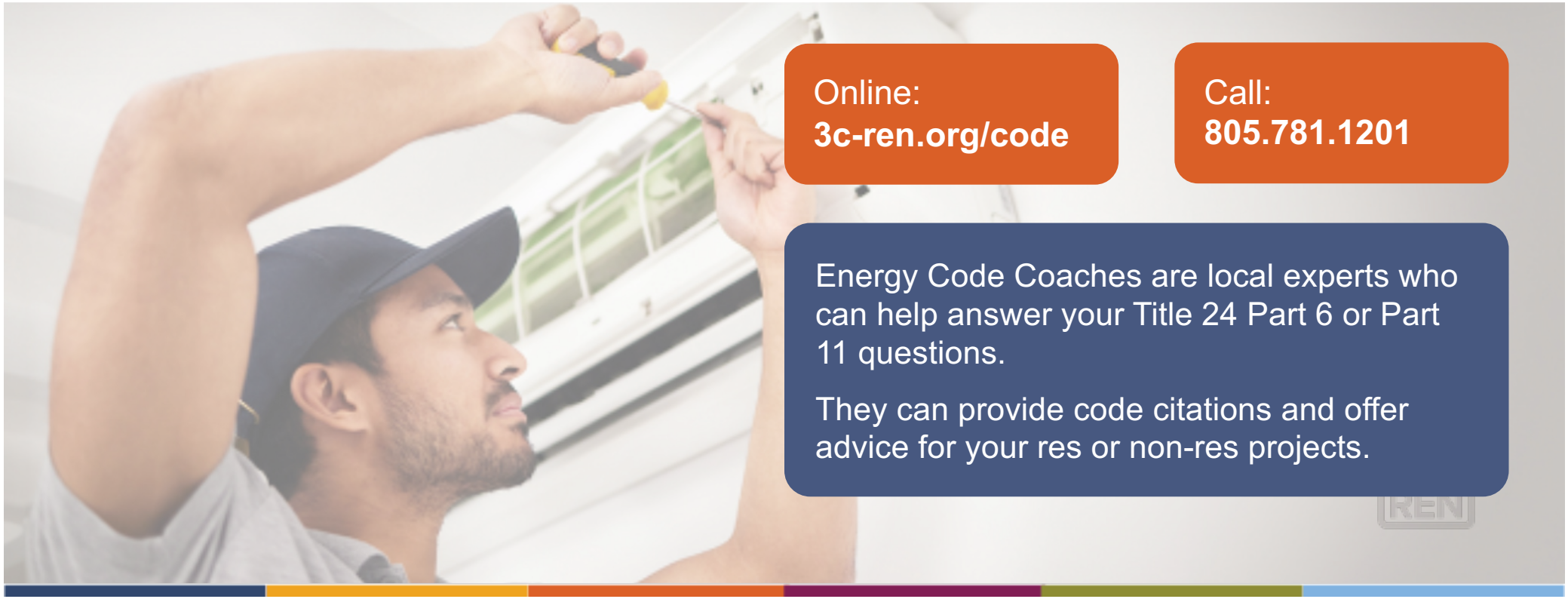
Thank you

JUDY RACHEL

INFO@JUDYRACHEL.COM

Questions about Title 24?

3C-REN offers a *free* Code Coach Service



Online:
3c-ren.org/code

Call:
805.781.1201

Energy Code Coaches are local experts who can help answer your Title 24 Part 6 or Part 11 questions.

They can provide code citations and offer advice for your res or non-res projects.

Closing

Continuing Education Units Available

Contact chloe.swick@ventura.org for AIA LUs

Coming to Your Inbox Soon!

Slides, Recording, & Survey – Please Take It and Help Us Out!

Upcoming Courses:

Recovery Ventilators: 2022 Energy Code Energy Savings and Compliance Credit (3/5)

Diagnosing Heating and Cooling Comfort Problems in Homes (3/18)

Batteries: Options and Implementation for a Building's Energy Storage System (3/20)

Certified Passive House Designer/Consultant Pacific Spring Cohort (4/9)

Introduction to the Passive House Standard (4/17)

Any phone numbers who joined? Please share your name!

Thank you!

More info: **3c-ren.org**

Questions: **info@3c-ren.org**

Email updates: **3c-ren.org/newsletter**

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