

2026 CERTIFIED ENERGY EXPERT NATIONAL MEETING

BURIED DUCTS BREAKOUT SESSION

CEE | KEY TAKE-A-WAYS

- ✓ Why a Buried Ducts solution now
- ✓ Efficacy / How does it work – across ALL climate zones
- ✓ Impact to the different trades
- ✓ OC learnings from national builder trials. What processes are need to make buried ducts a standard practice?
- ✓ Installation and Marketing Tools



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CEE | MACRO ENVIRONMENT - CODE

- Meeting IECC 2024 is not easy
  - Builders likely to have to choose 1 of these options to meet 2024 IECC
    1) Upgraded Windows ≤U-0.24 (skinny triple or vacuum insulated)
    2) Ducts in Conditioned Space (DCS)
    3) HRV/ERV (Ventilation)
    4) Continuous Exterior Insulation
    5) Ultra Efficiency Water Heater/Heat Pump (92+% eff)



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CEE | MACRO ENVIRONMENT - BUILDER

- National Builders are interested in Buried Ducts to meet IECC 2024
  - David Weekley & K.Hovnanian trials in Florida w/NAHB/DOE/HIRL/OC/JM
  - Pulte trials in Austin, TX
  - KB Home, DR Horton, Lennar, MI Homes, NVR, etc all watching these trials

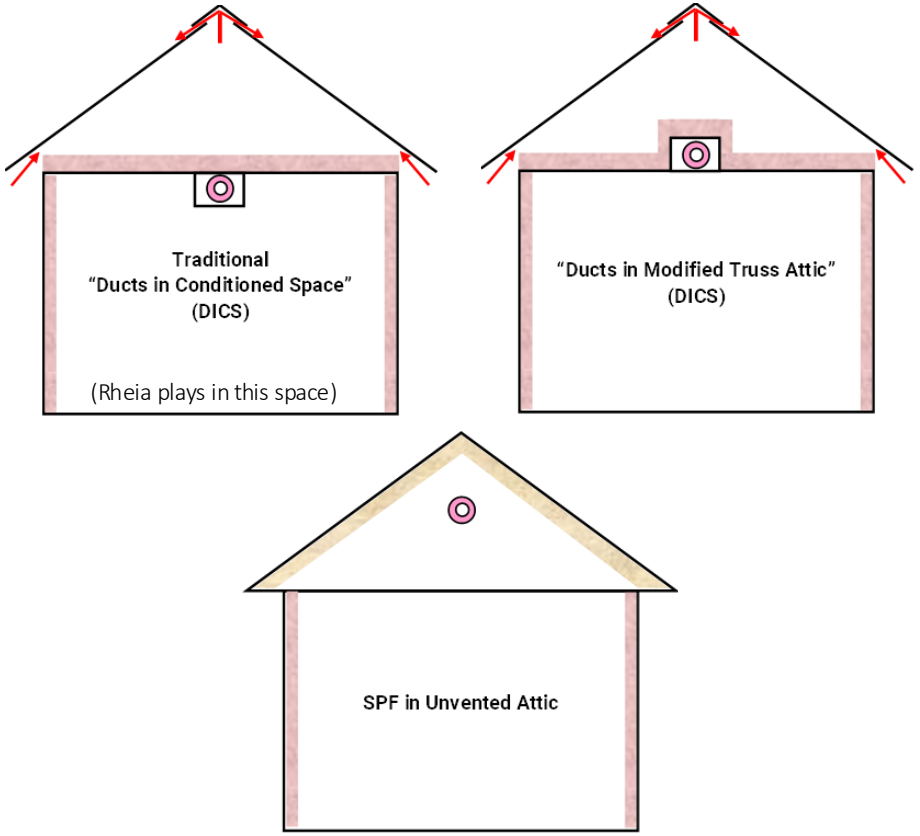
  - National Builder key questions
    1. Can this new buried ducts solution be scaled with trades? Yes
    2. What is the cost impact? Minimal / Possibly a Savings
    3. Can I use this to trade off instead of other energy efficiency options? Yes



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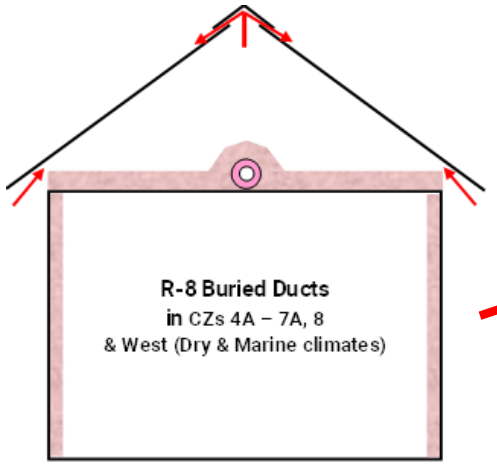
CEE | DUCTS IN CONDITIONED SPACE

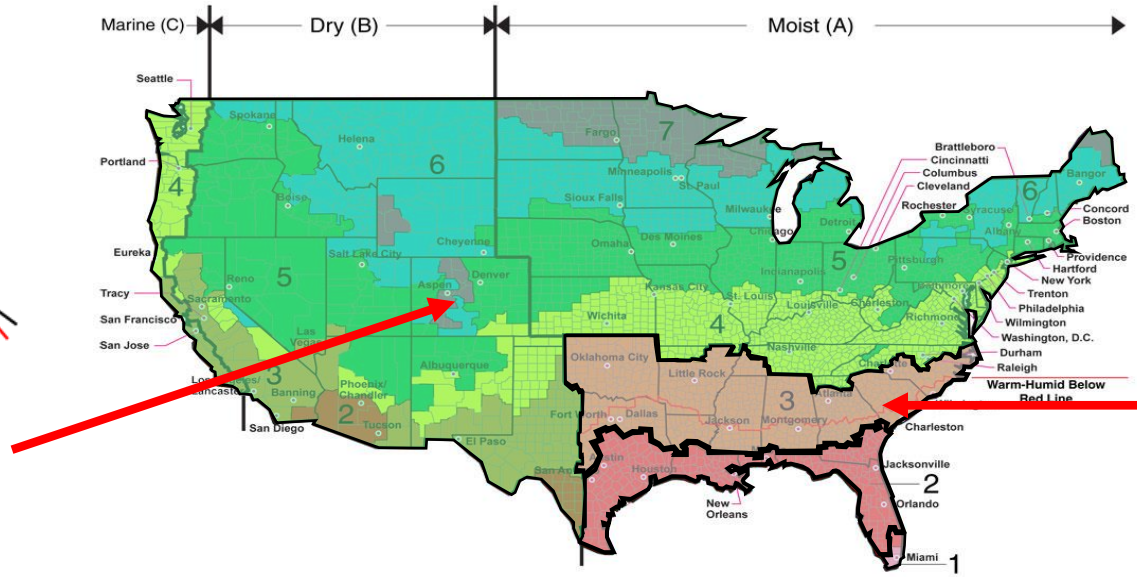


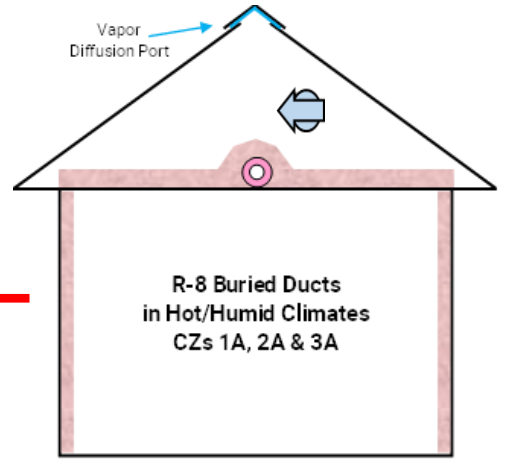
- These are the most recognized approaches for achieving ducts in conditioned space credit *(base code compliance)*
- The bottom detail is the most common building practice for slab markets, but still only accounts for a small percentage of homes built

CEE | BURIED DUCTS GEOGRAPHICAL APPLICATION

1. Un-vent the attic to reduce air-carried, bulk moisture entry to the attic
2. Vapor Diffusion at Roof Ridge
3. Small Amount of Supply Air







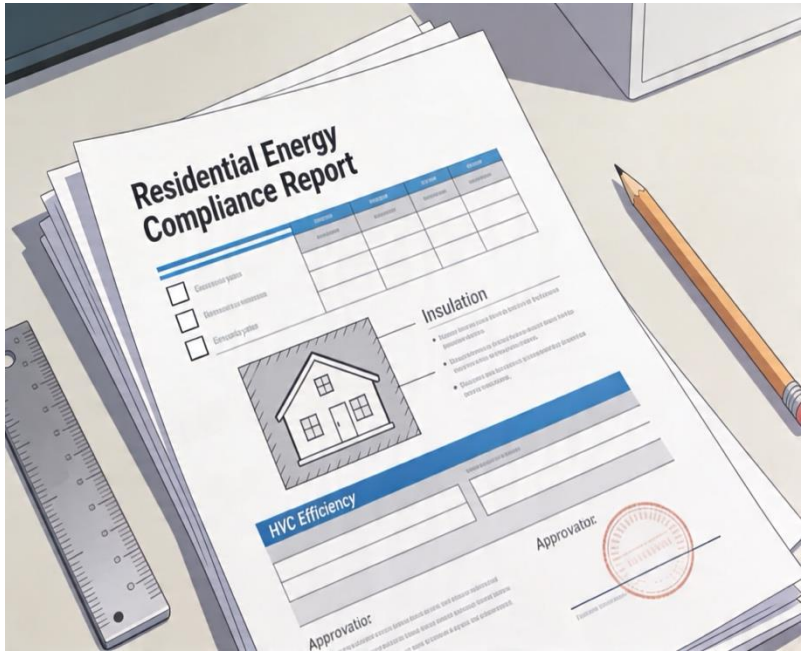
= Supply Air (not in 2024 IRC with insulation at attic floor, but is an OC best practice and cheap durability insurance)

CEE | VALUE TO BUILDER

- ✓ Most cost-effective approach to meet Ducts in Conditioned Space
  - 2 – 4 HERS points to assist in meeting IECC 2021/2024 codes
  - Can potentially trade-off from higher cost MEP efficiency measures (Cost per efficiency measure)
- ✓ Can address call backs
  - Attic moisture call backs in CZs 1A, 2A & 3A → due to reduced attic moisture and active drying
  - Comfort call backs → due to the delivery of design temperature air to all rooms
- ✓ Sellable value to the home buyer/occupant
  - Physical Comfort (Thermal, Humidity)
  - Financial Comfort (Monthly Savings Today & Future)
  - Psychological Comfort (Knowing that the home is the best way to live for my family and the environment)

HVAC TRADE WILL TYPICALLY BE A HEADWIND AS WE ARE MAKING THE HOUSE MORE EFFICIENT & NEEDING SMALLER SIZED EQUIPMENT.

CEE | VALUE TO BUILDER – BE A MINI-CONSULTANT



- ✓ **Performance Path Code Compliance Modeling (R405)**
  - Builders can contract with HERS Raters to model the entire home's construction and energy profile
  - Including Buried Ducts boosts their *compliance percentage*
- ✓ **Energy Rating Index Compliance Modeling (R405)**
  - Builders can contract with HERS Raters to model the entire home's construction and energy profile
  - Including Buried Ducts helps *lower their HERS Index scores*
- ✓ REScheck UA Trade-Off Path (R402.1.5)
  - ANYONE can utilize this free web software to do a simplified energy model based on the building envelope and select other features
  - Including the Prescriptive version of Buried Ducts (with air handler inside conditioned space) contributes to the home's effective thermal performance

Conclusions:

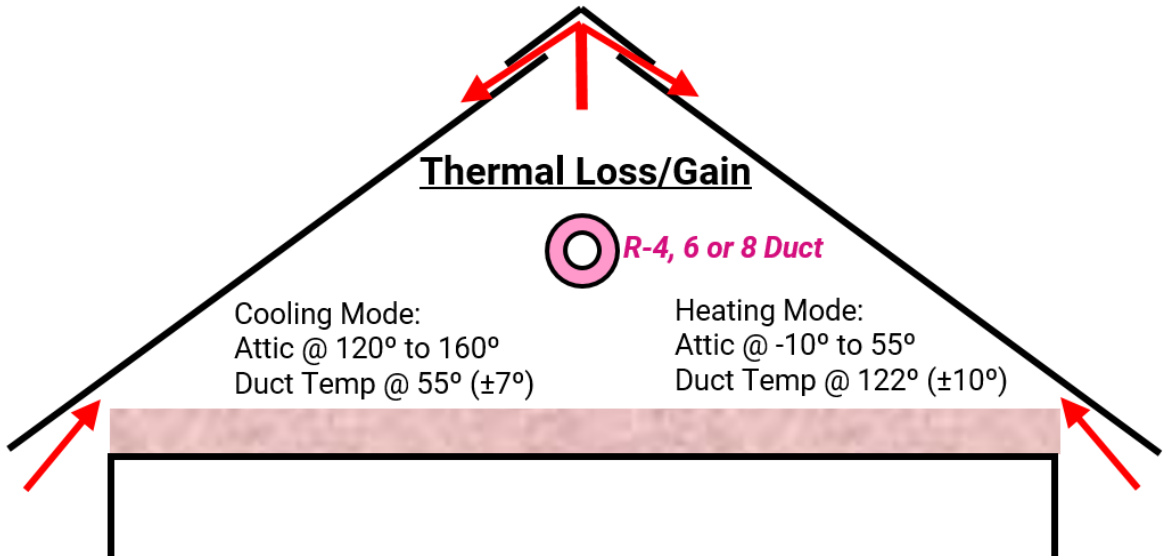
- ❖ Direct relationships with HERS Raters in your area can keep your interests represented in these processes
- ❖ At minimum, having someone on staff equipped to do REScheck calcs will give you leverage with non-Rater builders

CEE | $$ VALUE TO CONTRACTOR

	Hot/Humid Unvented	Cool/Dry & Hot/Dry Vented
Insulator – 15 mins of added install time (rulers / coverage)	~$250 / attic (truss) ~$400 / attic (stick / TX)	~$250 / attic (truss)
Insulator – 25% more material used per home (40% TX)		
Insulator? – Air sealing of registers to ceiling gypsum (not required)	~$50	~$50
Insulator? – Air Sealing of truss blocking	~$75-$100	N/A
	~$375 - $400 ~525 - $550 (TX)	**~$300**
HVAC Co – 0.5, 1.0 or 1.5 tonnage reduction in sizing (Manual J)	~($450) / ($900) / ($1350)	~($450) / ($900) / ($1350)
HVAC Co – No negative speed impact / supply house stocks required accessories	$0	$0
HVAC Co – Adds one 3” supply duct in attic	~$50	~$50
	~($400) / ($850) / ($1300)	~($400) / ($850) / ($1300)
Roofing Co – Installs vapor diffusion fabric (ridge or off-ridge)	~$80-$100	N/A
Framer – Truss Blocking to seal the attic	Variable	N/A
Siding Co – Unvented Soffits to seal the attic	Variable	N/A

HOT/HUMID EFFICACY TRIAL OUTCOMES

CEE | Energy Concern & Condensation Concern with Ducts in Vented Attics?



1) Condensation on Ducts in CZs 1A – 3A

2) Thermal Exchange (Loss/Gain) in Ducts
   - Temperatures gain/loss can be 10-15 degrees across a typical long duct run (30+ ft)

3) Duct Leakage @ 3-12% total system leakage is typical (New) / 25-40% leakage (retrofit pre-2000)
   - Reduces the designed volume of air to the register which impacts the ability to heat/cool

Impact → Up to 20% of total BTUs (SF-New) are used to offset performance of Ducts

- Forces the system to run longer to heat/cool
- Changes occupant behavior to adjust thermostat
- Comfort Call Backs increase

CEE | TESTING & OUTCOMES PHASE 1

- Timing – Spring/Summer 2021

- Experimental Procedure –
  R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in a Vented Attic

- Outcomes –
  - R-8 buried ducts under the white metal "cool attic" experienced somewhat higher duct outer jacket moisture potential.
  - Some periods where the top of duct measurement achieved 100% RH
  - Top of Duct Measurement is the most important location to measure RH/Moisture
    → ASHRAE Safety Target of 80% RH at top of duct (daily average)
  - CZ 2A has 2 to 2.5 months in the summer where the daily RH and dew point stays high throughout the day. The vented attic RH is consistent with outside RH. The primary concerns comes into play at nighttime. The solar heating load is removed and reduces the ability to dry the ducts if/when condensation does occur. Occupants in this climate will continue to run systems throughout the night with lower temp set points in the evening forcing the system to operate, but with less drying potential in the attic due to the elimination of solar heat gain.

- Next Steps –
  - Pivot to next option as this is too risky to support in CZs 1A-2A.

CEE | TESTING & OUTCOMES PHASE 2

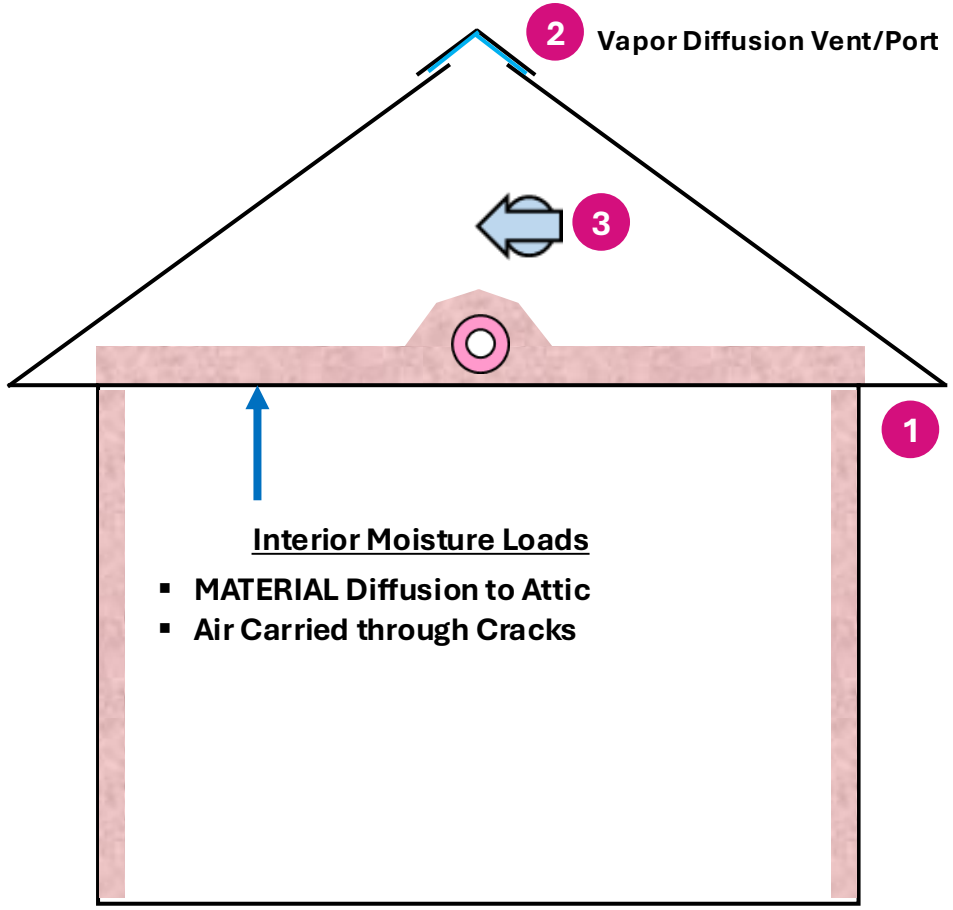
- Timing – Late Summer 2021 to Summer 2022
- Experimental Procedure –
  - R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in an unvented attic
  - Install vapor diffusion port at ridge vent (20+ vapor permeance) to allow attic and occupant created moisture to escape (meeting IRC R806.5.2, air barrier, roof WRB but vapor open)
  - Evaluated methods to un-vent the attic
    1) Un-vent via soffits → OSB/Fiber Cement type & aluminum (with and without caulk)
    2) Blocking between trusses → top plate & roof sheathing (with and without can foam/caulk)
- Outcomes –
  - The un-venting of the attic immediately showed positive impact to lower the top of duct RH by 12-15%.
  - Vapor Diffusion Port showed its ability to "assist" in drying the interior occupant created moisture load
  - Performed well with setpoint at 75F and under black asphalt roof.
  - Duct condensation risk still seen in a stressed situation where the occupant changed setpoint to 65-68F and under the white reflective roof. White reflective roofs cool the attic and provide less drying potential.
- Next Steps – Pivot to next option as this is still risky to fully support.

CEE | TESTING & OUTCOMES PHASE 3

- Timing – Late Summer 2022 to Summer 2023

- Experimental Procedure –
  R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in an unvented attic
  Install vapor diffusion port at ridge vent to allow attic and occupant created moisture to escape (meeting water, air & vapor barrier requirements… IRC R806.5.2)
  Added supply air to aid in drying the attic
    50cfm of supply air per 1,000 sf of attic floor
    very small energy penalty
- Outcomes –
  - Adding of the supply air adequately & immediately addressed the potential of duct condensation build while system was in operation even when stressing the system to 65F setpoints and under the white metal "cool roof".
  - Once supply air was added, top of duct RH stayed between 40% and 80% during runtime which is very safe.
  - Added air leakage to metal boots to determine potential of condensation. Dry air leak provided adequate drying and saw/measured no results of condensation at all on metal boots/registers.
  - Roof deck moisture @ or below 12% moisture content. <16% moisture content is considered safe.
  - No roof deck moisture uptick when the system was not calling for air. VDP showed it ability to dry to the interior load.
- Next Steps –
  - This solution was determined to be a safe solution for climate zones 1A – 3A.

CEE | Unvented Attic + VDP + Supply Air



1. **Un-vent the attic to reduce Air Carried, Bulk Moisture entry to the attic**
   - Provides the primary source to block moisture

2. **The Vapor Diffusion Vent/Port works in Hot Climates to remove moisture in unvented attic**
   - Provides the moisture safety valve while also creating an air & bulk water barrier

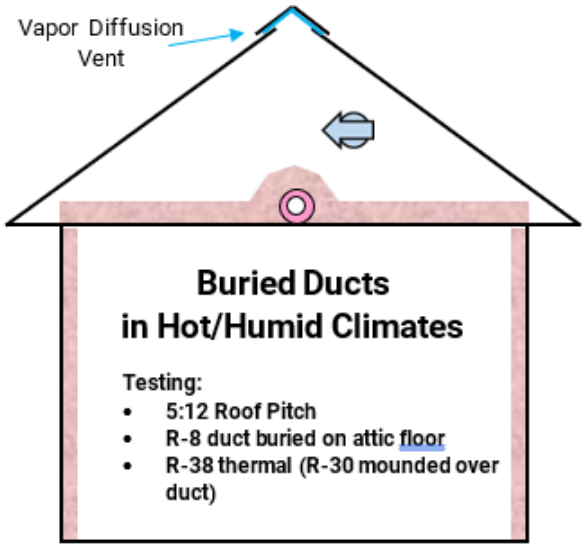
3. **Supply Air to the Attic → Add a small amount of supply air to dry the attic**
   - 50cfm per 1,000 sqft of attic floor (ex. 1,500 sq ft attic = 75cfm of supply air)
   - Highly impactful in keeping top of duct RH low → drying the attic & ducts
   - Very small energy penalty
   - Will provide drying to external or internal sourced moisture loads in the attic

CEE | EFFICACY SUMMARY

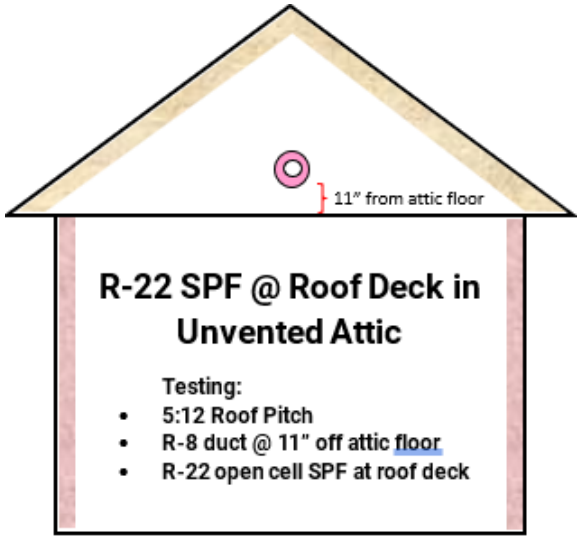
- ❑ Buried Ducts (New version with Unvented Attic) are considered safe to operate without the risk of damage from condensation in Hot/Humid climates
- ❑ Top of Duct RH consistently under safety standard (80%)
  - Stressed setpoints @ 68°F / High Internal RH loads / Summer external RH
  - top of duct RH (black asphalt roof @ 44-53%)
  - top of duct RH (white highly reflective roof @ 57-66%)
- ❑ Supply air at 1.8°F ΔT daily avg on 40' Duct Run (on trials)
  – *ORNL lab tests validated consistent results in labs*

June, July & August 2024 Results (CZ 2A, Cocoa, FL Test Lab):

70.1°F average top of duct



73.1°F average top of duct



INSTALLATION, TRADES & BUILDER CONSIDERATIONS

CEE | IMPACT ON TRADES

- ❑ HVAC
  - R-8 ducts minimum, ducts on/close to floor, returns always strung over supply ducts
  - Compact design using throw is better than running registers near exterior walls (ability to bury)
  - Use 90 degree register boxes
  - Run ducts off the side (not top) of the plenum
  - Supply air designed into attic near plenum or center of attic @ 50 cfm per 1,000 sq ft of attic floor
- ❑ Roofing
  - Ventilation at/off ridge meets 1:150 NFVA (standard code practice)
  - Review install instructions of how to install the vapor diffusion fabric & tape
- ❑ Framer/Sider
  - Confirm the application meets unventing requirements
- ❑ Insulation
  - Estimating of Loosefill → estimate material as typical and add 25% if truss or 40% if stick
  - Duct Rulers on ducts & Attic card highlighting buried ducts
  - Loosefill attic insulation is typical but certain cases may need batts (like top of duct board)

CEE | THE PATH TO BUILDER CONVERSIONS

- ❑ NAHB/LBA full alignment @ IBS (Feb 2026) – KHov & DWH both supporting
- ❑ Publish the FL Trial Results → Start Converting the Builders waiting for Results – Complete
- ❑ Codes actions in CA, GA & FL
  - CA – Buried Ducts allowed | need to overcome netting & radiant barrier reqs.
  - GA – Buried Ducts allowed | NAIMA leads prescriptive actions in 2026 (2024 IECC adoption)
  - FL – Buried Ducts allowed if jurisdiction allows IECC model language | Next code cycle for prescriptive language
  - TX – Buried Ducts allowed if jurisdiction allows IECC model language | Next code cycle for prescriptive language
- ❑ CEEs→ Trained & Supporting – 2026 Actions for Sales & Technical Sales

RESOURCES AND TOOLS

BURIED DUCTS RESOURCES (*FLASH DRIVE)

- Buried Ducts Install Guides*
  - Requirements and Pre-Job Planning
  - HVAC Ducts & Accessories
  - Unvented Attic
  - Vapor Diffusion Port
  - Attic Insulation & Air Sealing
- Buried Ducts Overview Sell Sheet*
- Buried Ducts Project Plan*
- FSEC Research Report*
- Buried Ducts Rulers
- OCU – General Training Video



CEE | PROJECT PLAN

BURIED DUCTS PROJECT PLAN — **Project Name | Lot ## | Elevation | Address** — **Revised: 1/1/2025**

PRE-CONSTRUCTION

Topic/Objective	Critical Tasks/Sub Goals	Dates	% Completion	Owner	Notes
Base Case Analysis	Walk base case homes and confirm typical building practices		0%		What must be adjusted when going with buried ducts application?
Construction Docs	Obtain Plans/CDs for Trial Houses		0%		
	Obtain Energy Files for typical build practices (Energy Rater Files)		0%		
Address Code Language with City/Jurisdiction	Jurisdictional Code Reference, R403.3.5 Ductwork Buried within Ceiling Insulation		0%		prescriptive code language
	Jurisdictional Code Reference, R403.3.4 Duct Systems Located in Conditioned Space		0%		prescriptive code language / additional conversation with rater to discuss performance path
	Jurisdictional Code Reference, R806.5 Unvented Attic and Unvented Enclosed Rafter Details		0%		language for ridge/off-ridge roof vapor diffusion venting
	Conversation with juridiction lead inspector		0%		communicate with the insector as the solution is new
HVAC Design	Conversation with HVAC contractor to discuss revisions to HVAC design when burying ducts in the attic ((1) System sizing, (2) Supply Air, (3) Duct location/layout and (4) 90 degree register boxes)		0%		
	execute Manual J/S/D for HVAC system		0%	HVAC Designer	make necessary adjustments in sizing software to address enhanced thermal resistance over the supply and return ducts.
	Alignment on HVAC design changes and system final selection (system, duct size & layout)		0%		
	HVAC system ordered		0%		
Vapor Diffusion Port @ Ridge/Off-Ridge	Conversation with Roofer/Framer → design/plan to get to 1:150 target net free vent area via ridge and/or off-ridge ventilation per IRC R806.5		0%		
	☐ selection → Ridge only ventilation to meet NFVA requirement				
	☐ selection → Ridge + Off-ridge ventilation to meet NFVA requirement				
	☐ selection → Off-ridge only ventilation to meet NFVA requirement				
	Vapor Diffusion Fabric & Tape selection. Fabric is required to be 20+ vapor permenance + approved as WRB in this application + Air Barrier		0%		
	WUI Zone Restrictions? **Yes or No**		0%		
	If yes, confirm the fabric and ridge/off-ridge exhasut vents are selected correctly for WUI zone requirements.				
Unventing @ Soffits	Confirm practice to unvent at soffits/eaves (no intake ventilation)		0%		
	☐ selection → **Top Plate Truss Blocking (22.5" Block) + Air Sealing around blocks + Unvented Soffit**				
	☐ selection → **Top Plate Truss Blocking (22.5" Block) + Air Sealing around blocks**				
	☐ selection → **Stucco soffit** with no intake vents				
	☐ selection → **Unvented Hard Stock soffit (OSB/FC type) - joints caulked**				note to caulk joints where butt joints and transitions do not land on nailer
	☐ selection → **Unvented Aluminum/Vinyl soffit – caulk embedded in F/J channel**				Unvented Aluminum/Vinyl soffit with no caulk is Not Allowed | Water Vapor is not controlled
	Update insulator's scope of work to add the air sealing around truss blocks (if truss blocking)		0%		to be executed as part of the air sealing package

CEE | CONSTRUCTION PROCESS CHECKLIST CONT.

	Pre-Con Meeting	**Pre-Construction Meeting to Discuss variations with buried ducts application:**		0%	All	
		HVAC - R-8 ducts minimum, ducts on/close to floor, returns always strung over supply ducts		0%		
		HVAC - compact design using throw is better than running registers near exterior walls (ability to bury)				
		HVAC - use 90 degree register boxes and run ducts off the side (not top) of the plenum				
		HVAC - supply air designed into attic near plenum or center of attic - 50 cfm per 1,000 sq ft of attic floor				
		Roofing - ventilation at/off ridge meets 1:150 NFVA		0%		
		Roofing - review install instructions of how to install the vapor diffusion fabric & tape				
		Soffit/Eaves Unvented - confirm the application meets unventing requirements		0%		
		Insulation - Estimating of Loosefill → **estimate material as typical and add 25% if truss or 40% if stick**		0%		
		Insulation - Duct Rulers on ducts & Attic card highlighting buried ducts				
		Insulation - Loosefill attic insulation is typical but certain cases may needs batts (like top of duct board)				
PRODUCTION		**Installations - provide onsite support**				
	Ridge/Off-Ridge Vents	Install - onsite for installation of ridge vents + vapor diffusion fabric		0%		
	Unventing Soffit	Install - onsite for installation of soffits		0%		
	Ducts & Registers	Install - onsite for installation of ducts and register boxes		0%		
	Attic Air Sealing	Install - Insulator to also air seal around truss blocks during air sealing install		0%		
	Leakage Testing	leakage tests (envelope ACH + gaurded attic LTO test)		0%		
	Attic Insulation	Install - onsite for installation of ducts and registers		0%		
				0%		
				0%		
				0%		
				0%		
				0%		
				0%		

APPENDIX

Builder/Designer Process

CEE | TRADE & BUILDER TOOLS WORKSTREAM

- ❑ Tools for the Trades to Execute
  - Summary Install Guide (Requirements) – Active
  - Detailed Design & Install Guide by Trade (Insulator, HVAC, Roofer, Framer/Sider) – April 2026
  - Buried Ducts Rulers - Active
  - Buried Ducts Attic Cards – April 2026
  - Training Modules – videos, animations, etc (CEEs, OC University, ON3 AI) – TBD
- ❑ Tools for the Builder
  - Construction Process Checklist (Design | Pre-Con | Installation | Post Install QC) – Active
  - Quality Control Checklist – April 2026
  - Scope of Work Language for each Trade – April 2026

BUSINESS CONFIDENTIAL

Design / Planning

- **Manual J** (tonnage will reduce)
  - properly sized system
  - Single stage will work / Two-Stage is a best practice

- **Manual S & D** (duct size will be reduced)
  - Properly sized ducts as per software outputs
  - Layout – compact design + register throw is best
  - Layout – supply ducts first / returns strapped up over supply ducts if intersecting

- **Vapor Diffusion Port Selection**
  - Ridge / Off-Ridge / Combination of both (all acceptable) → 1/150 NFVA (architect)
  - 20+ vapor permeance fabric

- **Select how to Un-vent the Attic**

BUSINESS CONFIDENTIAL

Design / Planning (Rater / Codes Official)

Codes Officials –

- **2024 IECC | R403.3.3 Ducts Buried within Ceiling Insulation**
- **2024 IECC | R403.3.3(1) Effective R-Value of Buried Ducts**
- **2024 IECC | R403.3.2 Ducts Located in Conditioned Space**
- **2024 IRC | R806.5.2 Air Permeable Insulation installed in Unvented Attics (Vapor Diffusion Port)**

Raters –

1) **Ducts @ R-25 → R403.3.3(1) Effective R-Value of Ducts Buried**
   - Completely buried
2) **Ducts in Conditioned Space → R403.3.2 Ducts Located in Conditioned Space**
   - Deeply buried
   - AHU located in conditioned space
   - 1.5% LTO = 4% total leakage (expect this to go away soon)
3) **Variable Compliance in HERS/ERI**
   - Deeply buried meeting thermal code (R-38 = R-8 duct + R-30 burying the duct)
   - ~~AHU located in conditioned space~~
   - % of ducts buried

CEE | BUILDER COSTS SCENARIOS

Vented Attic Buried Duct vs. Unvented Attic Buried Ducts Financials				
Who?	**Description**	**based on Tonnage Reduction**		
		0.5 tons	**1.0 tons**	**1.5 tons**
HVAC	**HVAC System Tonnage Reduction**	$ (450)	$ (900)	$ (1,350)
HVAC	addition of supply air duct	$ 50	$ 50	$ 50
Insulation	25% Material to Bury (5-6 bags of loosefill on 1,100 sf attic)	$ 250	$ 250	$ 250
Insulation	Additional Labor for Insulation (duct rulers & install time)	$ 50	$ 50	$ 50
Actions to Unvent Attic (CZs 1A - 3A)				
Insulation	Additional Air Sealing of Attic	$ 75	$ 75	$ 75
Roofer	Diffusion Port Fabric @ Roof Ridge (Material + Labor)	$ 150	$ 150	$ 150
Framer/Cornice	Sealing of Attic - Unveted Soffit	$ -	$ -	$ -
Framer/Cornice	Sealing of Attic - Truss Blocking	$ 400	$ 400	$ 400
Total Impact to Builder (Additional Cost)		**$ 525**	**$ 75**	**$ (375)**

DOES NOT INCLUDE HIGH EFFICIENCY FAU IN ATTIC (DEPENDS ON BASE SPEC IF GAS APPLIANCE)

IF 80% gas FAU and unvented…

Upgrade to 95% AFUE FAU in Attic Space (4T)	
Region	Average Added HVAC Cost
Hot-dry Southwest	$2,000
Hot-Humid South	$2,750
Mixed-humid Mid-Atlantic/Midwest	$2,500
Cold/Very Cold North	$3,500

DATA VIA PERPLEXITY PRO AI SEARCH

✓ **Either way, buried ducts is the most cost-effective approach to meet Ducts in Conditioned Space credits**

Deeper Dive Code & Efficacy Details

CEE | 2024 IECC LANGUAGE

Codes / I-Codes / 2024 International Energy Conservation Code (IECC)

Chapter [RE] 4 Residential Energy Efficiency

R403.3.5: Ductwork buried within ceiling insulation. INSIGHTS

Where supply and return *ductwork* is partially or completely buried in ceiling insulation, such *ductwork* shall comply with the following:

1. The supply and return *ductwork* shall be insulated with not less than R-8 insulation.
2. At all points along the *ductwork*, the sum of the ceiling insulation *R-value* against and above the top of the *ductwork*, and against and below the bottom of the *ductwork*, shall be not less than R-19, excluding the *R-value* of the duct insulation.
3. In Climate Zones 0A, 1A, 2A and 3A, the supply *ductwork* shall be completely buried within ceiling insulation, insulated to an *R-value* of not less than R-13 and in compliance with the vapor retarder requirements of Section 604.11 of the *International Mechanical Code* or Section M1601.4.6 of the *International Residential Code*, as applicable.

   Exception: Sections of the supply *ductwork* that are less than 3 feet (914 mm) from the supply outlet.

4. In Climate Zones 0A, 1A, 2A and 3A where installed in an unvented attic with vapor diffusion ports, the supply *ductwork* shall be completely buried within the insulation in the ceiling assembly at the floor of the attic, insulated to an *R*-value of not less than R-8 and in compliance with the vapor retarder requirements of Section 604.11 of the *International Mechanical Code* or Section M1601.4.6 of the *International Residential Code*, as applicable.

   Exception: Sections of the supply *ductwork* that are less than 3 feet (914 mm) from the supply outlet.

   4.1. Air permeable insulation installed in unvented attics shall comply with Section R806.5 of the *International Residential Code*.

INSIGHTS (1)

https://codes.iccsafe.org/content/IECC2024V1.2/chapter-re-4-residential-energy-efficiency#IECC2024V1.2_RE_Ch04_SecR403.3.5

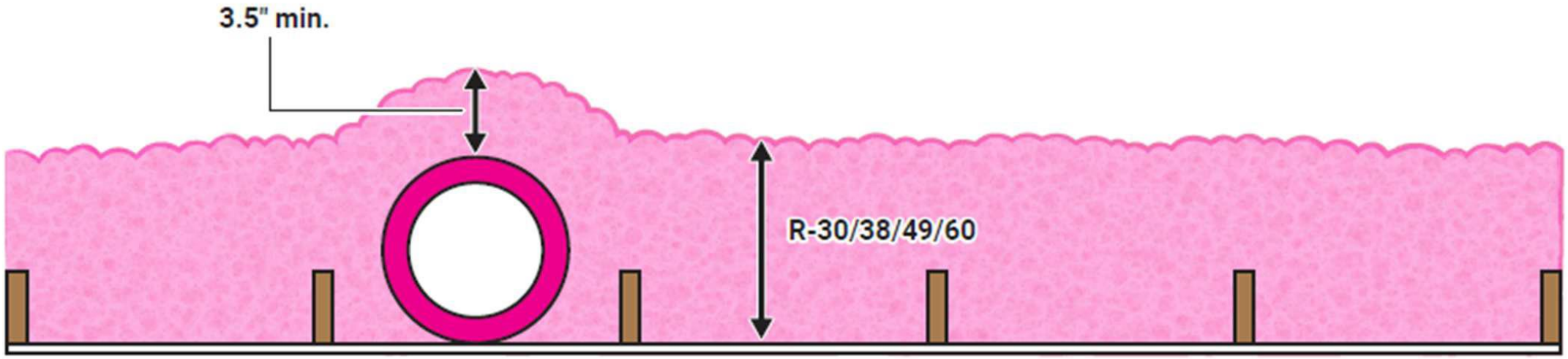
DEEPLY BURIED DUCTS – ICSP

- Deeply buried ducts where the total ductwork leakage is at 1.5% or lower and the air handler is located in conditioned space.
- Can claim "Ducts in Conditioned Space" in performance path softwares, Energy Star and Zero Energy Ready Home programs and for 45L tax credit programs.

COMPLETELY BURIED DUCTS

Minimum of 3.5" of insulation over the duct for unique situations like jumper ducts and situations where the register runouts are close to the roof deck (not enough room to deeply bury the duct).

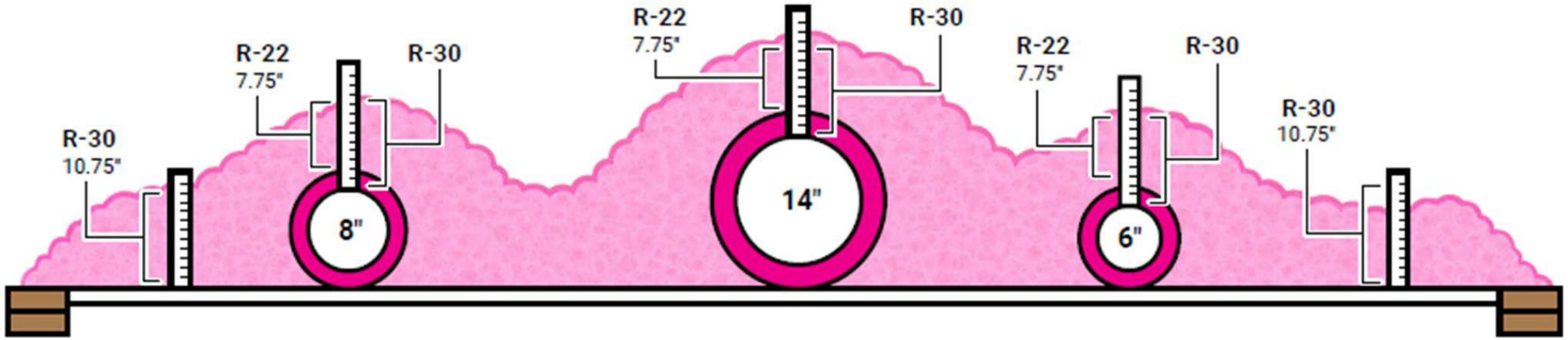
- Can only claim R-25 effective R-value over that % of total ductwork not located in conditioned space.



CEE | 2024 IECC LANGUAGE

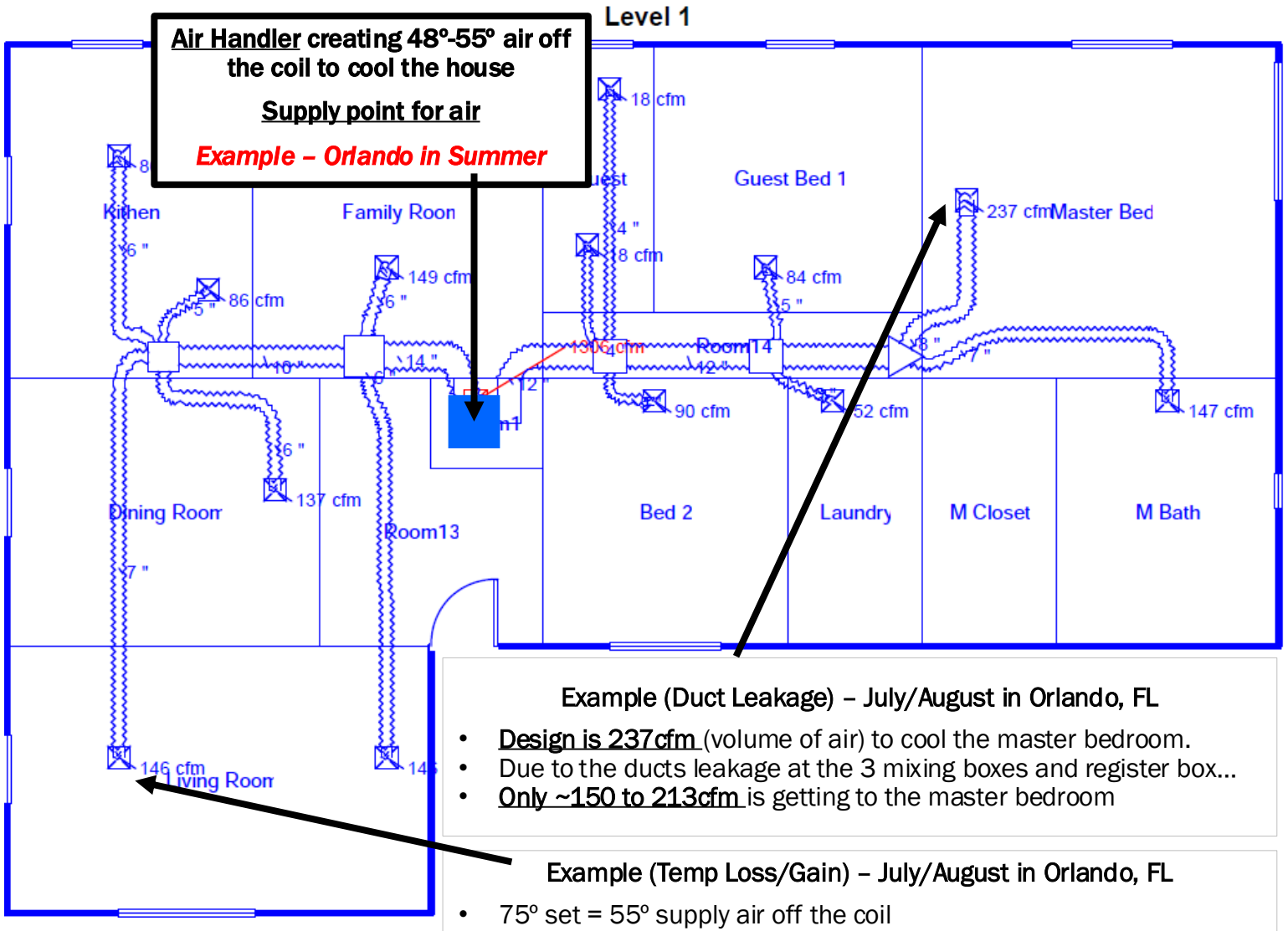
DEEPLY BURIED DUCTS (STANDARD APPLICATION)

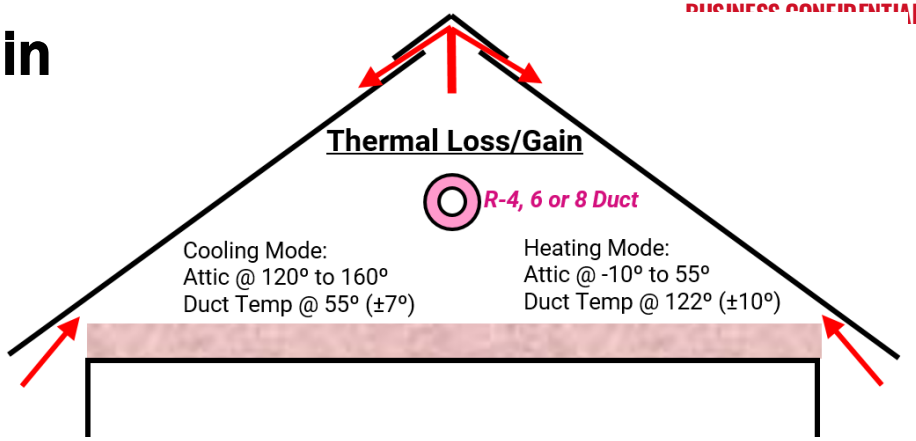
- Mounded Insulation over a minimum R-8 duct meeting the applicable attic thermal requirement (R30/38/49/60).
  - R-8 minimum duct + R-22 insulation mounded over duct equaling R-30 of duct insulation.
  - R-8 minimum duct + R-30 insulation mounded over duct equaling R-38 of duct insulation.
  - R-8 minimum duct + R-41 insulation mounded over duct equaling R-49 of duct insulation.
  - R-8 minimum duct + R-52 insulation mounded over duct equaling R-60 of duct insulation.
- In performance path software, the thermal duct value can be considered as insulated to the target attic thermal value.



BUSINESS CONFIDENTIAL

The Energy Concern & Condensation Concern with Ducts in Vented Attics?





1) Condensation on Ducts in CZs 1A – 3A

2) Thermal Exchange (Loss/Gain) in Ducts
   - Temperatures gain/loss can be 10-15 degrees across a typical long duct run (30+ ft)

3) Duct Leakage @ 3-12% total system leakage is typical (New) / 25-40% leakage (retrofit pre-2000)
   - Reduces the designed volume of air to the register which impacts the ability to heat/cool

Example (Duct Leakage) – July/August in Orlando, FL

- Design is 237cfm (volume of air) to cool the master bedroom.
- Due to the ducts leakage at the 3 mixing boxes and register box…
- Only ~150 to 213cfm is getting to the master bedroom

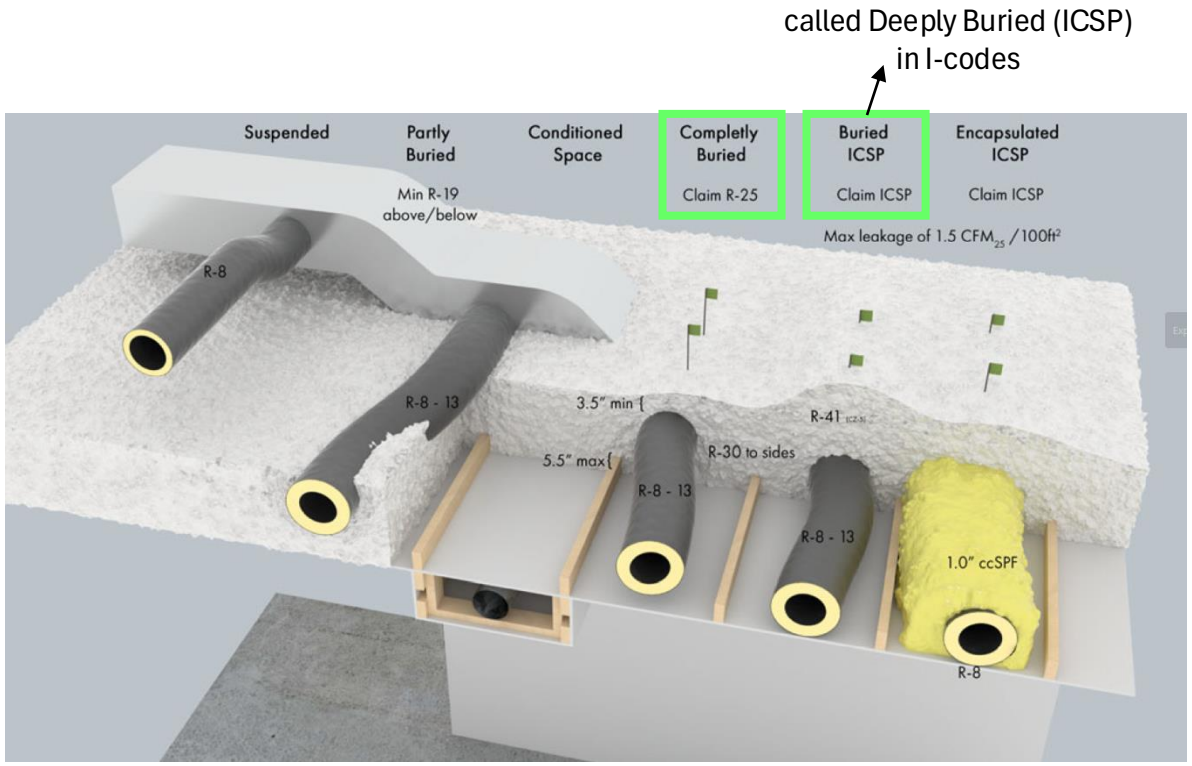
Example (Temp Loss/Gain) – July/August in Orlando, FL

- 75° set = 55° supply air off the coil
- Due to the duct running through a 140° attic at 5pm, the temperature by the time it reaches the Living Room is 69° (gaining 14° of temp from coil to register)

Impact → Up to 20% of total BTUs (SF-New) are used to offset performance of Ducts

- Forces the system to run longer to heat/cool
- Changes occupant behavior to adjust thermostat
- Comfort Call Backs increase

What Type of Buried Duct options are we discussing?

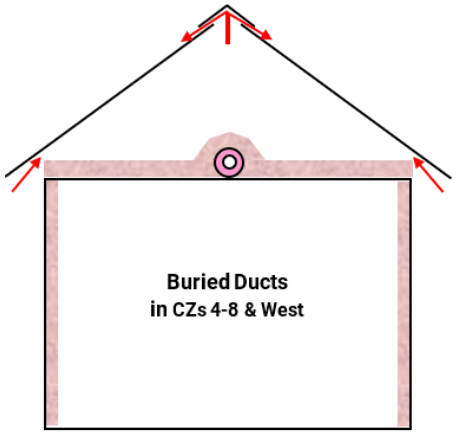


https://www.phrc.psu.edu/assets/docs/Webinars/Ductwork_in_Attics_Handouts.pdf

What Type of Buried Duct?

- **Partially Buried** – No, doesn't minimize thermal exchange in ducts located in attics to be considered "Ducts in Conditioned Space"
- **Completely Buried** – Yes, effective at reducing thermal exchange in ducts located in attics.
  - R-8 duct thermally broken by minimum 3.5" of insulation. Can claim R-25 for effective R value (R-8 duct + 3.5" loosefill (mounded))
  - Also for jumper ducts, registers near wall (no raised heel), etc.
  - R403.3.5 IECC
- **Deeply Buried (ICSP)** – Yes, minimizes thermal exchange in ducts located in attics to be considered "Ducts in Conditioned Space"
  - Duct thermally broken by attic thermal req., R-38 = R-8 duct + R-30 loosefill (mounded)
  - Duct on attic floor or perpendicular to attic truss (fill any air voids below)
  - R403.3.4.2 IECC
- **Encapsulated** – No

Testing Outcomes – PHASE 1



Initial Efficacy Test

- Vented Attic
- R-38 Attic
- R-8 Buried under R-30

- **Timing – Spring/Summer 2021**
- **Experimental Procedure –**
  - R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in a Vented Attic
- **Outcomes –**
  - R-8 buried ducts under the white metal "cool attic" experienced somewhat higher duct outer jacket moisture potential.
  - Some periods where the top of duct measurement achieved 100% RH
  - Top of Duct Measurement is the most important location to measure RH/Moisture
    → ASHRAE Safety Target of 80% RH at top of duct (daily average)
  - CZ 2A has 2 to 2.5 months in the summer where the daily RH and dew point stays high throughout the day. The vented attic RH is consistent with outside RH. The primary concerns comes into play at nighttime. The solar heating load is removed and reduces the ability to dry the ducts if/when condensation does occur. Occupants in this climate will continue to run systems throughout the night with lower temp set points in the evening forcing the system to operate, but with less drying potential in the attic due to the elimination of solar heat gain.
- **Next Steps –**
  - Pivot to next option as this is too risky to support in CZs 1A-2A.

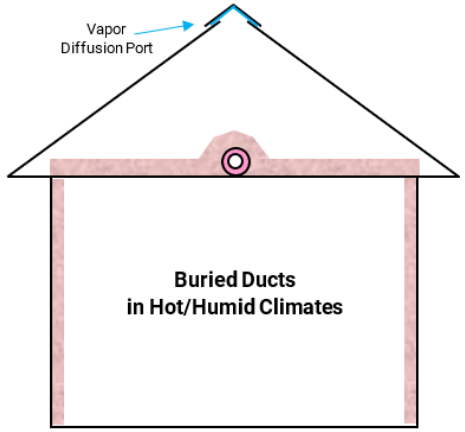
Orlando/MCO

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
°F High	71	75	79	83	88	91	92	92	89	85	78	74
°F Low	51	55	58	63	69	74	75	75	74	69	60	55
°F Dewpoint	51	53	55	60	65	71	73	74	72	67	59	55

Atlanta

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
°F High	53	58	65	73	80	86	89	88	83	73	63	55
°F Low	33	36	43	50	59	67	70	69	63	52	41	36
°F Dewpoint	32	35	41	49	59	66	69	67	61	50	40	35

Testing outcomes – Phase 2



Secondary Option

- *(change) Unvented Attic*
- *(add) Vapor Diffusion Port*
- R-38 Attic
- R-8 Buried under R-30

- **Timing – Late Summer 2021 to Summer 2022**
- **Experimental Procedure –**
  - R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in an **unvented attic**
  - Install **vapor diffusion port at ridge vent (20+ vapor permeance)** to allow attic and occupant created moisture to escape (meeting IRC R806.5.2, air barrier, roof WRB but vapor open)
  - Evaluated methods to un-vent the attic
    1) Un-vent via soffits → OSB/Fiber Cement type & aluminum (with and without caulk)
    2) Blocking between trusses → top plate & roof sheathing (with and without can foam/caulk)

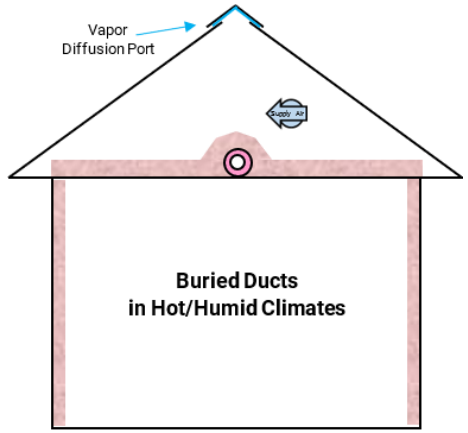
Vapor Diffusion Port @ Ridge (prior to ridge vent installation)





- **Outcomes –**
  - The un-venting of the attic immediately showed positive impact to lower the top of duct RH by 12-15%.
  - Vapor Diffusion Port showed its ability to "assist" in drying the interior occupant created moisture load
  - Performed well with setpoint at 75F and under black asphalt roof.
  - Duct condensation risk still seen in a stressed situation where the occupant changed setpoint to 65-68F and under the white reflective roof. White reflective roofs cool the attic and provide less drying potential.
- **Next Steps –** Pivot to next option as this is still risky to fully support.

Testing outcomes



Third Option

- *(change) Unvented Attic*
- *(add) Vapor Diffusion Port*
- *(add) Supply Air, 50cfm/1000sf of attic floor*
- R-38 Attic
- R-8 Buried under R-30





- **Timing – Late Summer 2022 to Summer 2023**
- **Experimental Procedure –**
  - R-8 ducts buried under R-30 loosefill insulation (meeting R-38 thermal requirement) in an **unvented attic**
  - Install **vapor diffusion port at ridge vent** to allow attic and occupant created moisture to escape (meeting water, air & vapor barrier requirements… IRC R806.5.2)
  - Added **supply air** to aid in drying the attic
    - *50cfm of supply air per 1,000 sf of attic floor*
    - very small energy penalty
- **Outcomes –**
  - Adding of the supply air adequately & immediately addressed the potential of duct condensation build while system was in operation even when stressing the system to 65F setpoints and under the white metal "cool roof".
  - Once supply air was added, top of duct RH stayed between 40% and 80% during runtime which is very safe.
  - Added air leakage to metal boots to determine potential of condensation. Dry air leak provided adequate drying and saw/measured no results of condensation at all on metal boots/registers.
  - Roof deck moisture @ or below 12% moisture content. <16% moisture content is considered safe.
  - No roof deck moisture uptick when the system was not calling for air. VDP showed it ability to dry to the interior load.
- **Next Steps –**
  - This solution was determined to be a safe solution for climate zones 1A – 3A.

PERFORMANCE OF BURIED DUCTS | IMPACT OF THERMAL EXCHANGE IN DUCTS

Example Climate Zone 2A – Boca Raton, FL (modeled results via MiTek Wrightsoft Manual J)

Ductwork Options	Duct R-value	Ductwork as a % of Total Building Energy Consumption		Annual			% Improvement	Avg Annual Dollars Lost in Cooling Mode (due to Inefficiency) *Avg @ $0.15/kWh electric*
		Heating	Cooling	Heating Loss (kBTU)	Cooling Loss (kBTU)	Total Loss (kBTU)		
Suspended Ducts (Existing Homes)	R-4.2	33.8%	35.6%	960	44,906	45,866		$1,974
Suspended Ducts (New Homes)	R-8	10.6%	13.6%	222	12,745	12,967	Baseline	$560
Completely Buried	R-25	4.8%	5.7%	95	4,935*	5,030	61%	$217
Deeply Buried ICSP	R-38	3.7%	4.2%	91	4,343*	4,433	66%	$191
SPF R-22 at Roof Deck	R-4.2	9.9%	8.3%	199	7,202	7,401	43%	$317

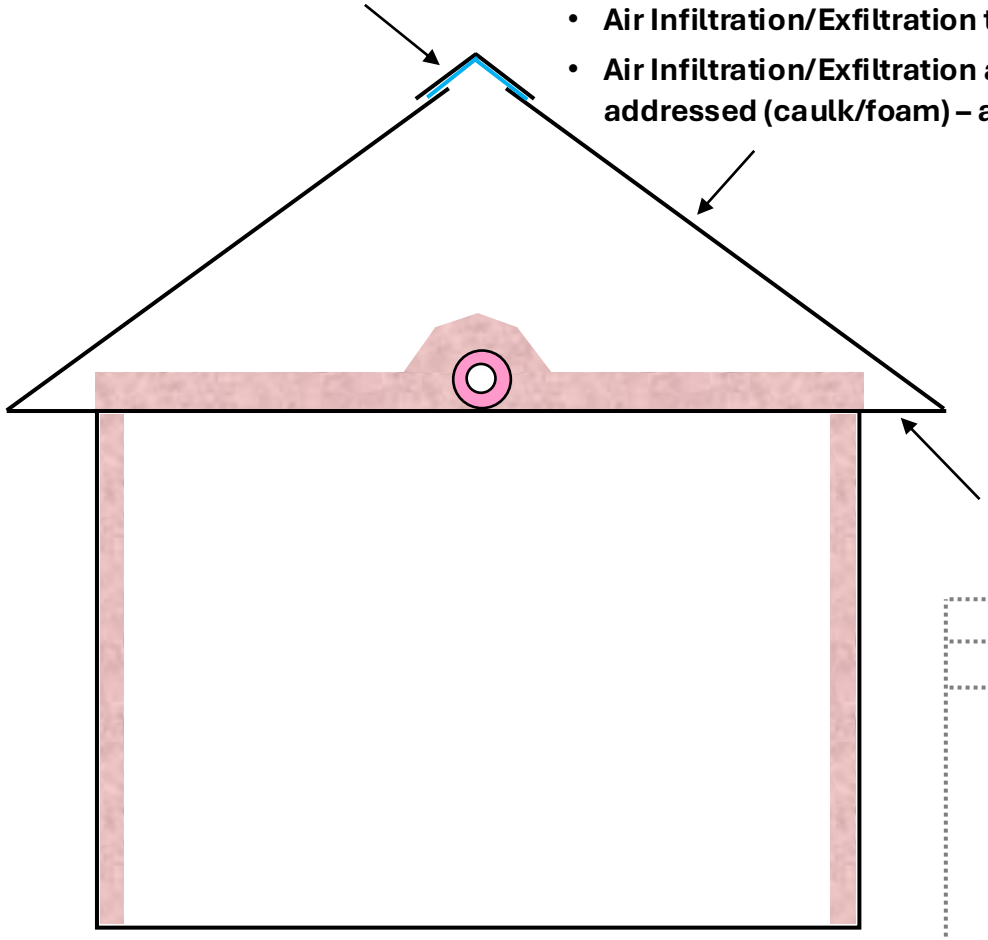
**includes 50cfm of supply air / 1,000sf of attic floor*

Example Climate Zone 6A – Minneapolis, MN (modeled results via MiTek Wrightsoft Manual J)

Ductwork Options	Duct R-value	Ductwork as a % of Total Building Energy Consumption		Annual			% Improvement	Avg Annual Dollars Lost in Heating Mode (due to Inefficiency) *Avg @ $19.18/mcf gas*
		Heating	Cooling	Heating Loss (kBTU)	Cooling Loss (kBTU)	Total Loss (kBTU)		
Suspended Ducts (Existing Homes)	R-4.2	21.1%	36.8%	93,053	7,459	100,512		$1,738
Suspended Ducts (New Homes)	R-8	7%	14.1%	26,053	2,098	28,111	Baseline	$486
Completely Buried	R-25	3.3%	6.1%	11,834	834	12,668	55%	$221
Deeply Buried ICSP	R-38	2.4%	4%	8,372	537	8,909	68%	$156
SPF R-22 at Roof Deck	R-4.2	3.3%	5.5%	10,685	702	11,387	59%	$200

(1) Actions to Un-vent the Attic

Vapor Diffusion Vent is an air barrier



- **Air Infiltration/Exfiltration through Roof Deck is very low**
- **Air Infiltration/Exfiltration around roof penetrations must be addressed (caulk/foam) – air sealing contractor**

Top Plate Truss Blocking + Air Sealing Illustration

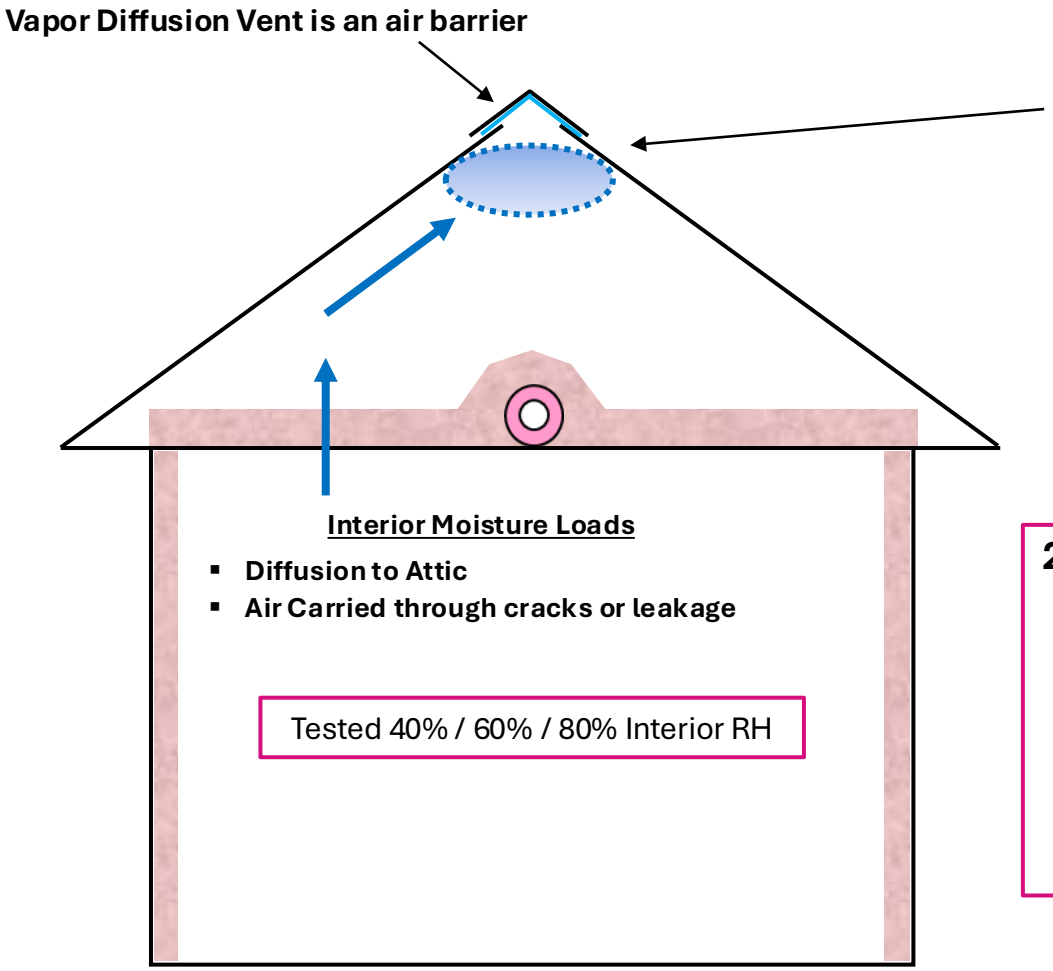


1. Unventing of the Attic reduces exterior air carried moisture to the attic (12-15% reduction to top of Duct RH)

- ✓ Top Plate Truss Blocking (22.5” Block) + Air Sealing + Soffit (Best)
- ✓ Top Plate Truss Blocking (22.5” Block) + Air Sealing + No Soffit
- ✓ Stucco soffit
- ✓ Hard Stock soffit (OSB/FC type) – caulked
- ✓ Hard Stock soffit (OSB/FC type) – not caulked
- ✓ Aluminum/Vinyl soffit – caulk embedded in F/J channel
- X Aluminum/Vinyl soffit – no caulk (Not Allowed | Water Vapor not Controlled)

Consistent with spray foam attic air leakage (guarded testing)

(2) The Vapor Diffusion Vent/Port (+20 perms)



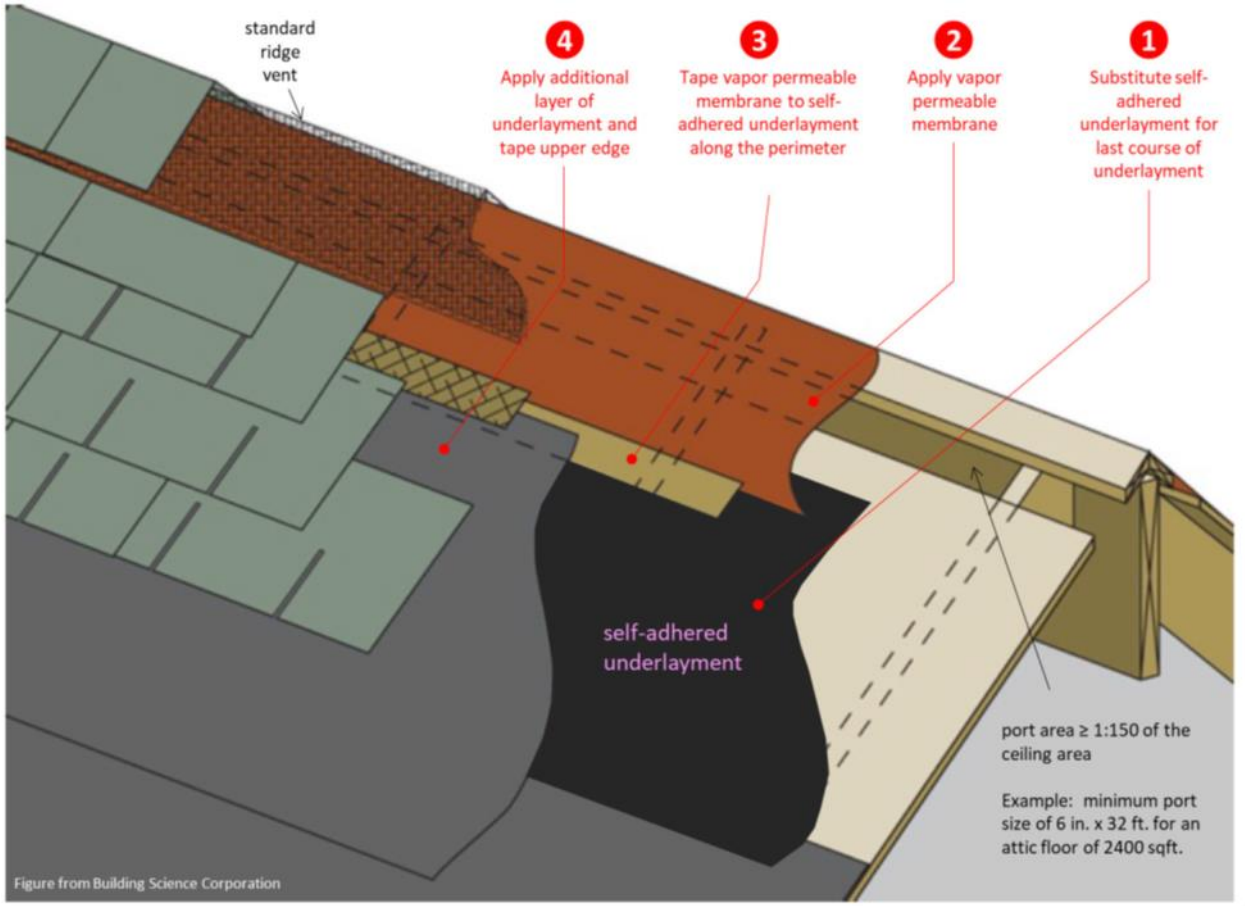
- Past work completed by ORNL confirms moisture movement to the ridge in unvented attics
- NREL testing & paper published Sep 2024 confirms ORNL work
  - Moisture Performance of Unvented Attics With Vapor Diffusion Ports and Buried Ducts in Hot, Humid Climates, is published: https://www.nrel.gov/docs/fy24osti/86619.pdf

2. The Vapor Diffusion Vent/Port works in Hot Climates to remove moisture in unvented attics

- ❑ Temperature Stratification & Hydric Buoyancy → drives moisture to the ridge
- ❑ Roof Deck sheathing moisture levels stay below 16% moisture content

Vapor Diffusion Port (Hot/Humid Climates, 0A – 3A)

The diffusion port material under ridge vents allows moisture out of the attic while eliminating the free movement of air.

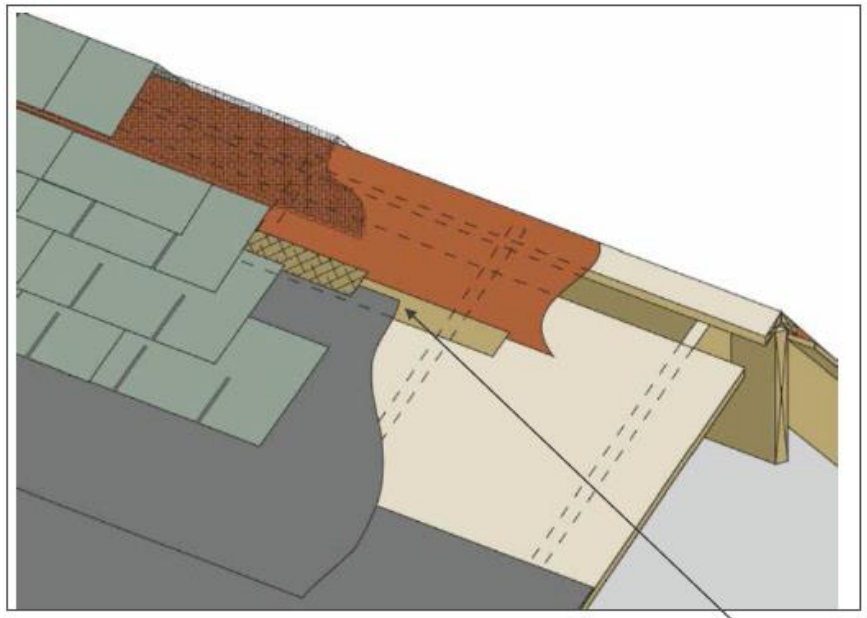




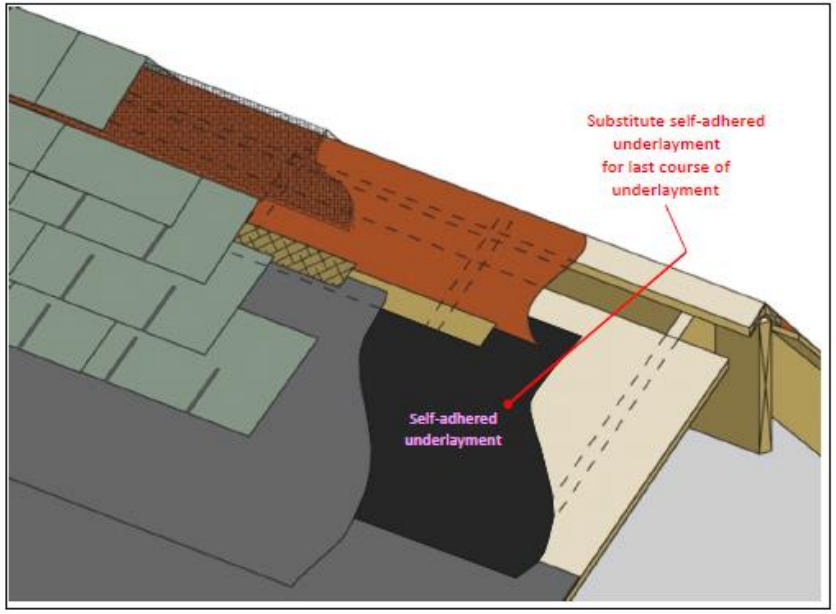


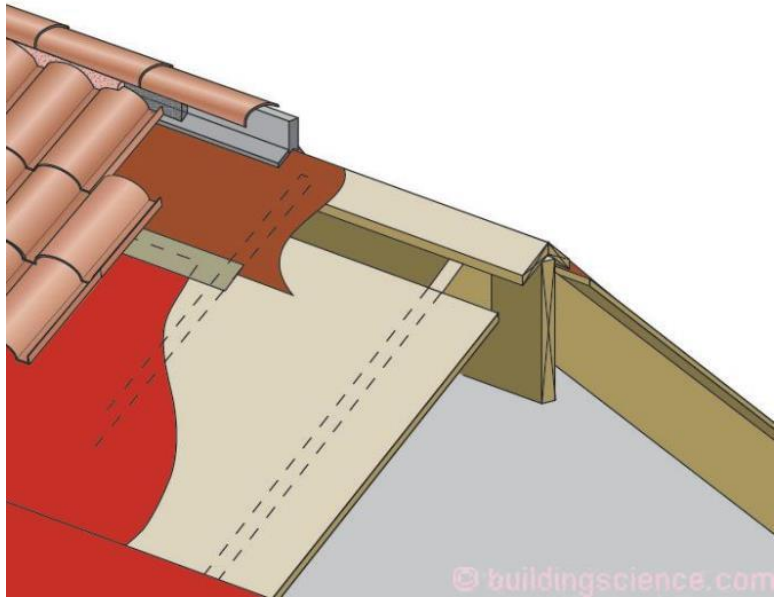


Recommendation by Building Science Corp.



Adaptation to address counter-flashing





Eliminates the counter-flashing that occurs here.

- Any shelf ridge vent works.
- The only change is covering the vent area cut through the sheathing with a water tight but vapor open covering. A high perm “housewrap” works – over 20 perms. Must also be considered an air barrier and water-resistant barrier.

