Design Options for Locating Ducts within Conditioned Space

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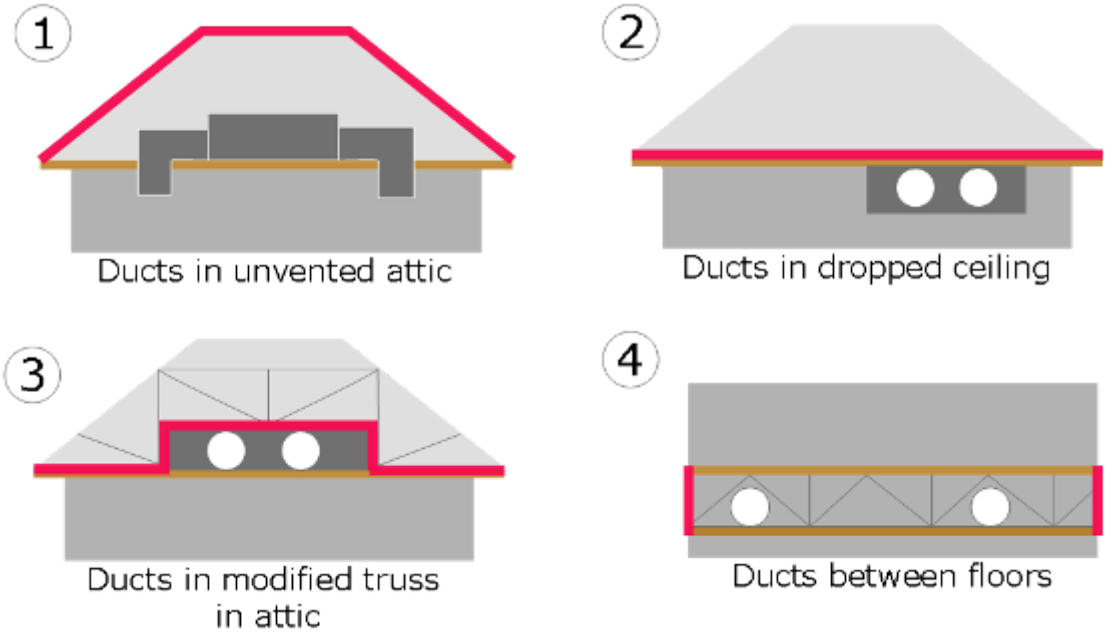
Why Ducts in Cond. Space?

- **Significant Thermal Losses:**
  - Thermal losses triple for ducts in unconditioned vs. conditioned space
  - Total thermal losses can range from 10-45%
  - Extensive unconditioned space penetrations
- **Significant Performance Impacts:**
  - IAQ
  - Comfort
  - Durability

Available Options

- Multiple Interior duct options exist
- Selecting the “best” option depends on multiple factors…



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Option: Ducts in Unvented Attic

- By moving the thermal boundary from the ceiling plane up to the roof plane, additional interior volume is created allowing the placement of HVAC equipment and ducts within the conditioned space

Option: Ducts in Unvented Attic

- This method of protecting the HVAC is well suited for retrofits when relocating existing equipment is impractical
- Storage is not code-allowed in these spaces without the use of thermal and ignition barriers (more in a moment)

Insulation for Condensation Control

Minimum R-value of Impermeable Insulation

Climate Zone	Minimum Impermeable Insulation R-Value*	2012 IECC Ceiling R-Values
2B and 3B Tile Roof	None Required	30
1, 2A, 2B, 3A, 3B, 3C	R-5	38
4C	R-10	38
4A, 4B	R-15	49
5	R-20	49
6	R-25	49
7	R-30	49
8	R-35	49

*contributes but doesn't supersede 2012 IECC insulation requirements

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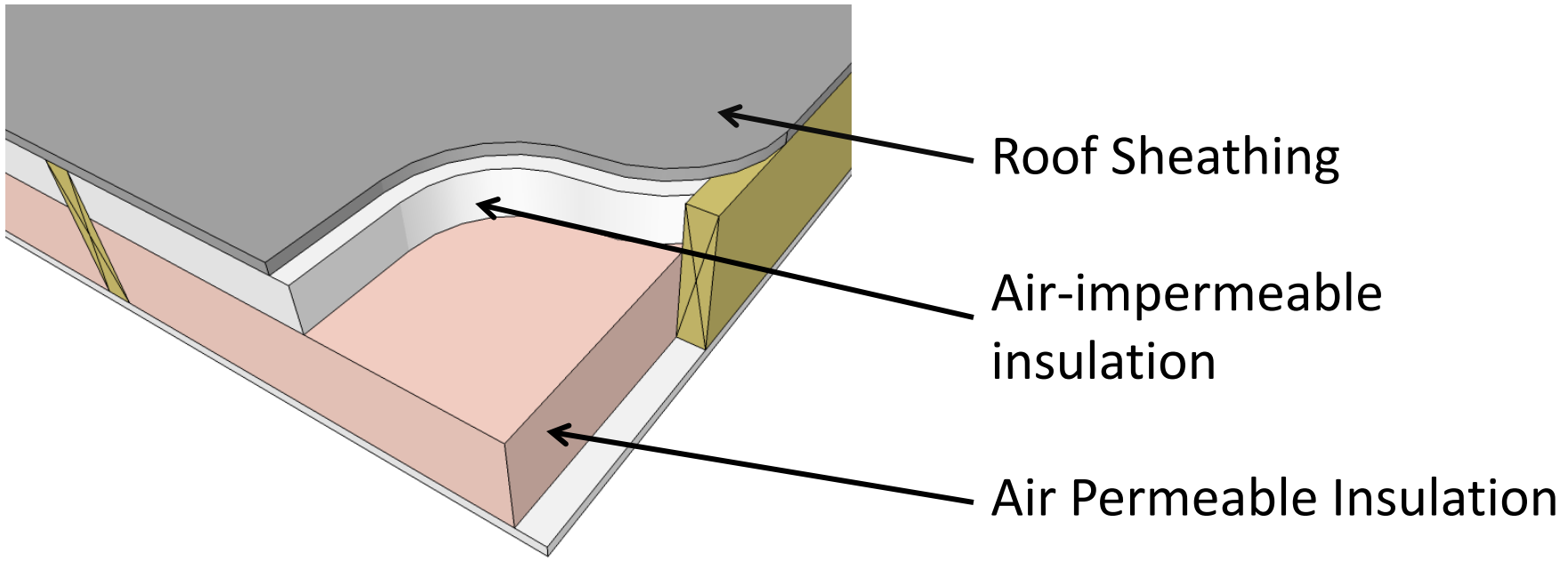
Insulating/Air Sealing Options

AIR-IMPERMEABLE and AIR-PERMEABLE insulation.



Option: Ducts in Unvented Attic

Advantages and Limitations

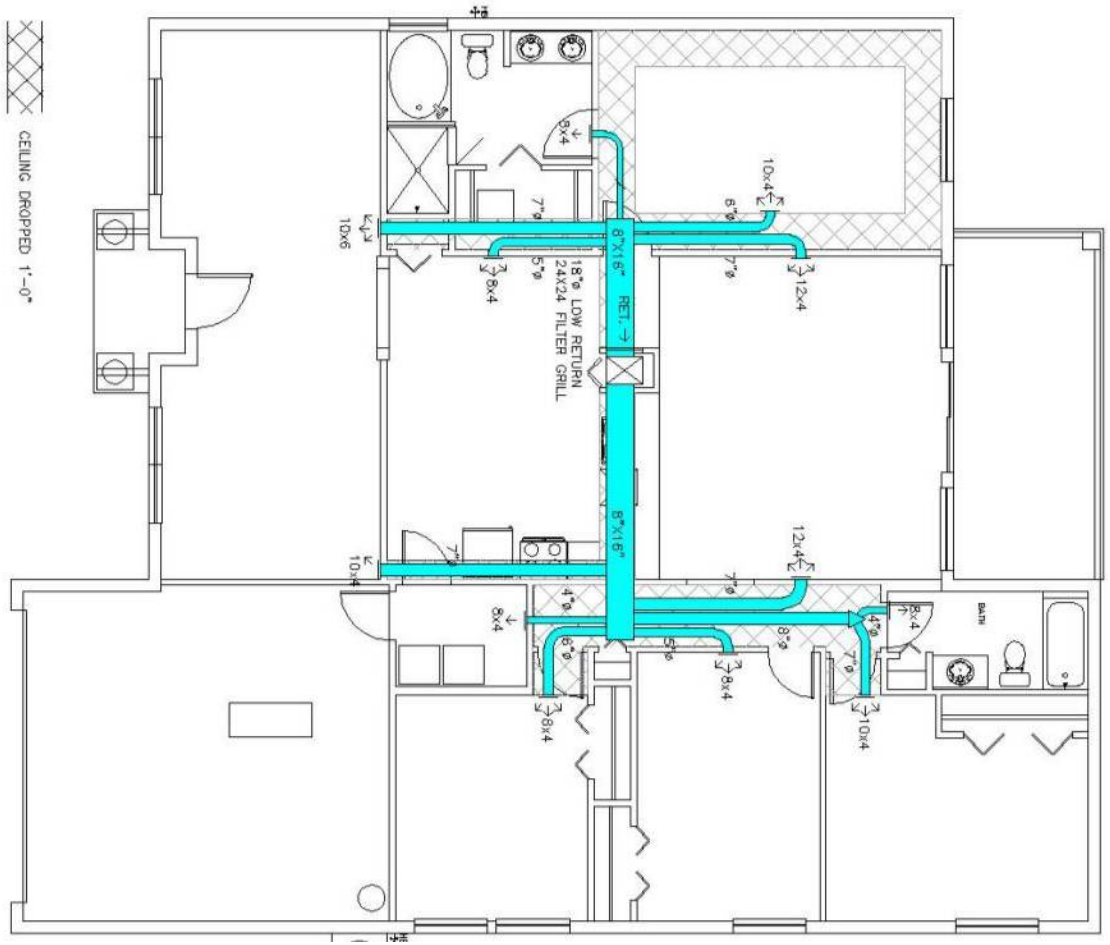
- Provides option for AHU placement as well as ducts
- Not as plan-dependent as other options
- Viable for retrofits
- Often the highest cost option
- Code limitations/requirements on roof deck insulation
- Increases heating/cooling loads by increasing surface area of thermal boundary

IRC Sections R806.4 Unvented Attic Assemblies, and R316 FOAM PLASTIC control these assemblies

Option: Ducts in Dropped Soffit

- Ducts are placed in soffits and dropped ceilings below the primary ceiling plane level
- Architectural integration and aesthetics are critical considerations

Dropped Soffit Configuration



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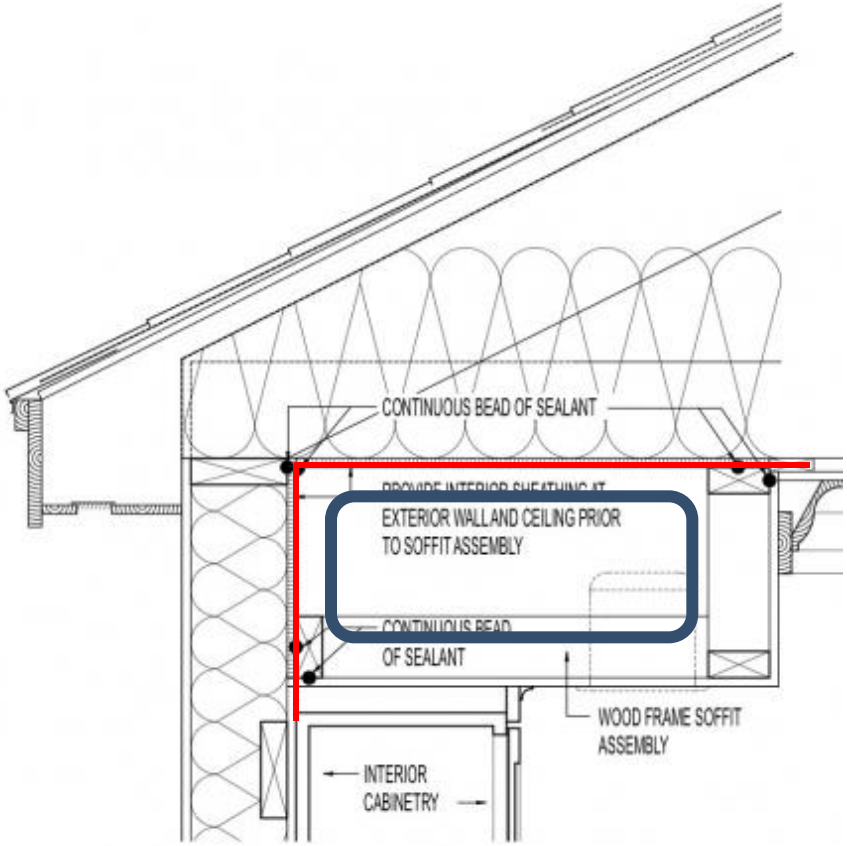
Soffit Construction Details

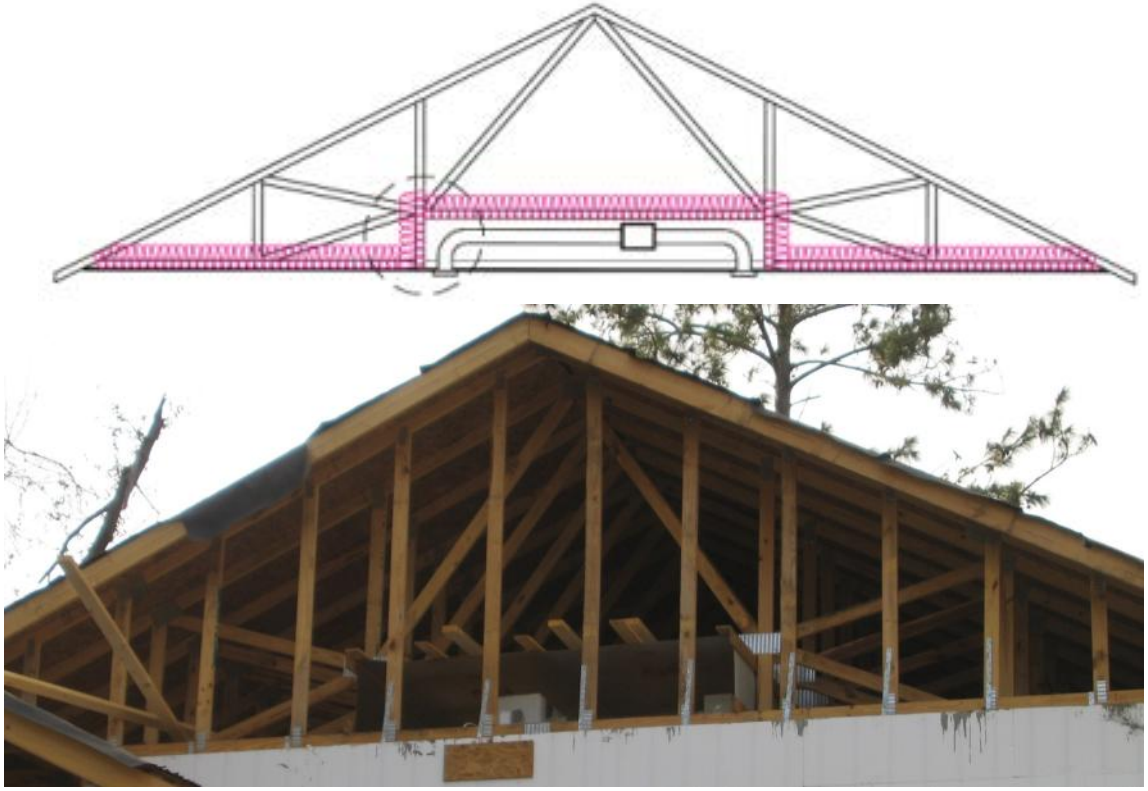


Option: Ducts in Dropped Soffit

Advantages and Limitations

- Low-cost in simple plans
- Easy to understand and implement
- Minimal code restrictions
- Heavily plan dependent
- Advanced planning and design integration is essential
- May be limited by throw distance – duct design critical
- Additional air barrier step and unique air-sealing
- No provision for AHU

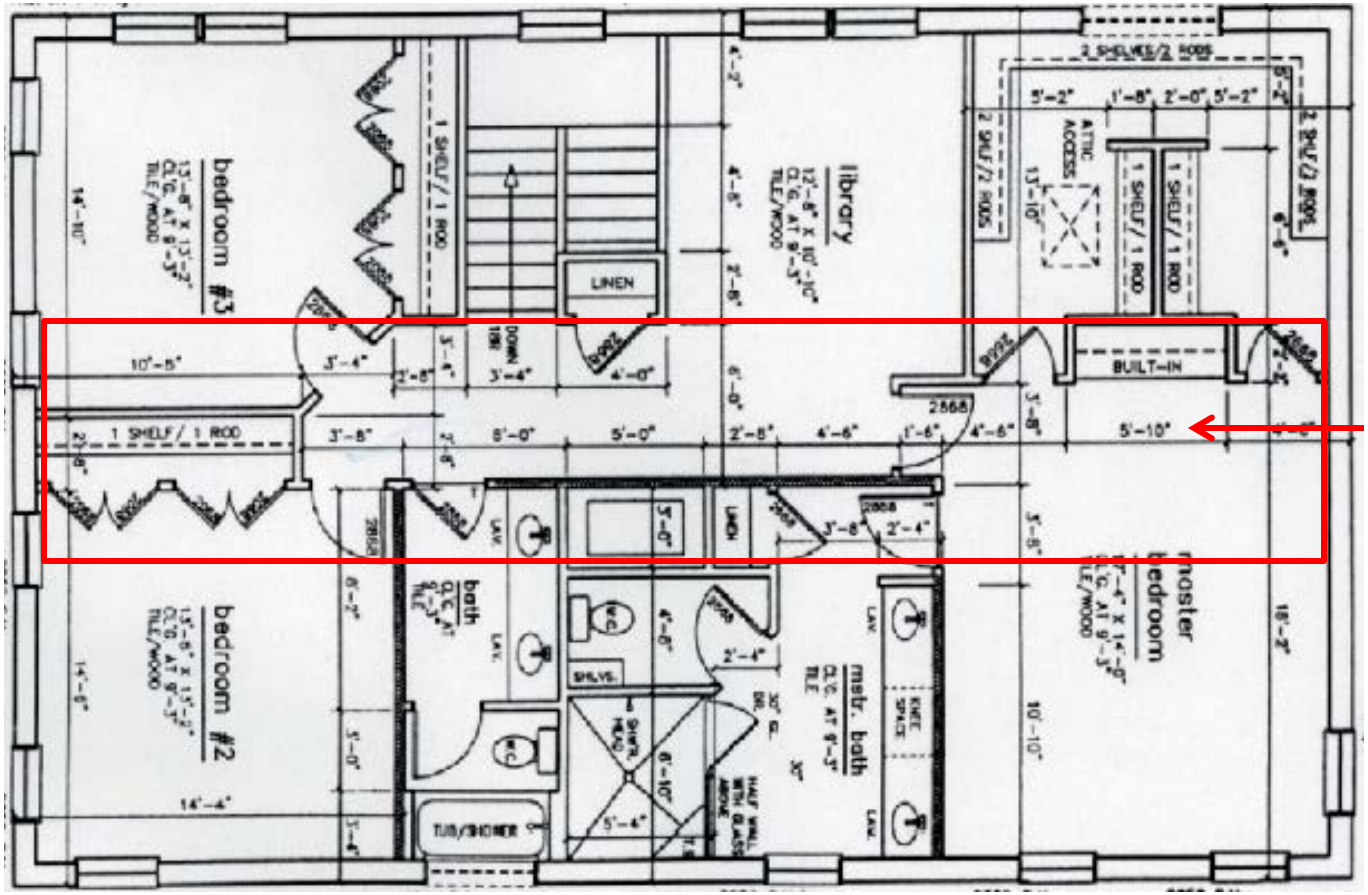
Option: Ducts in Modified Truss



- A space for ducts is created above the ceiling plane by using a modified roof truss configuration and moving the thermal boundary up into the attic.

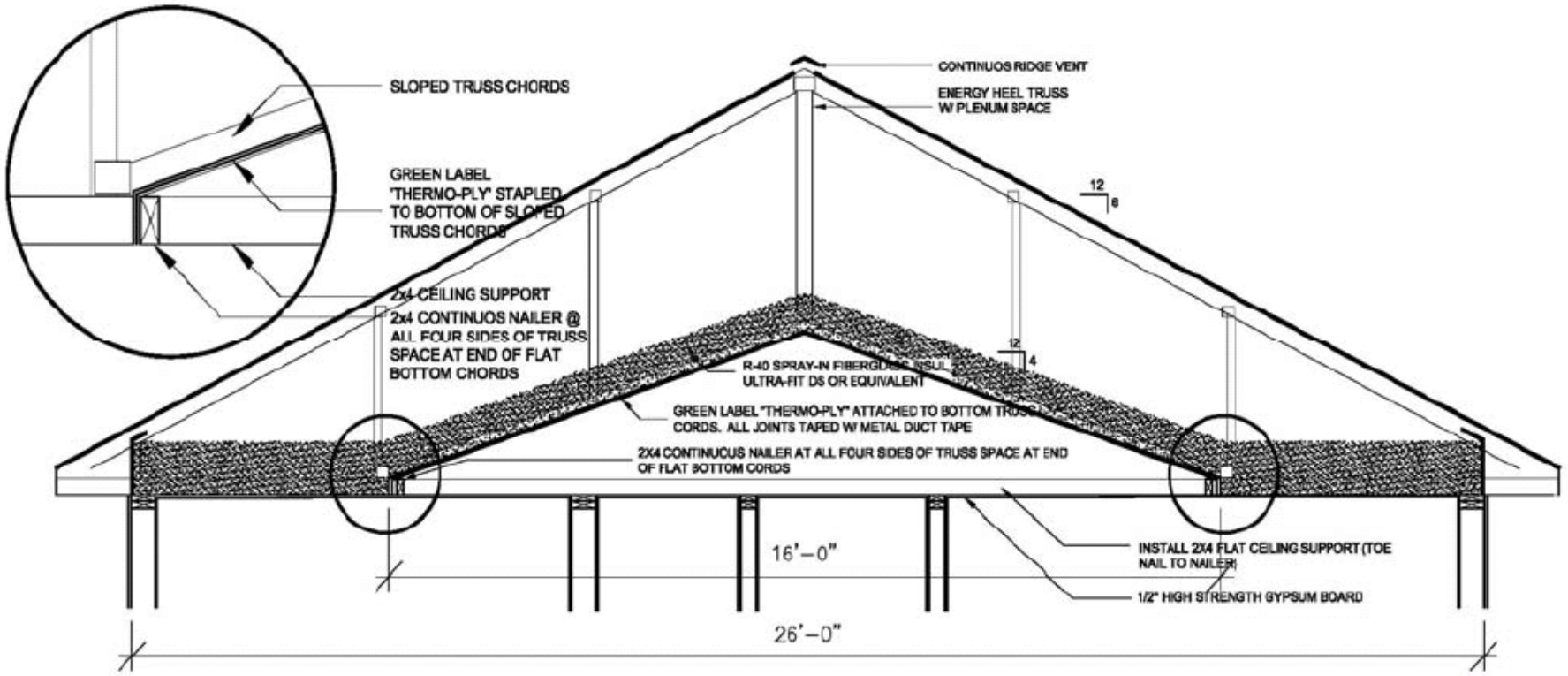
Option: Ducts in Modified Truss

Option: Ducts in Modified Truss



Plenum space area

Modified Scissor Truss Method



Plenum Truss Detail

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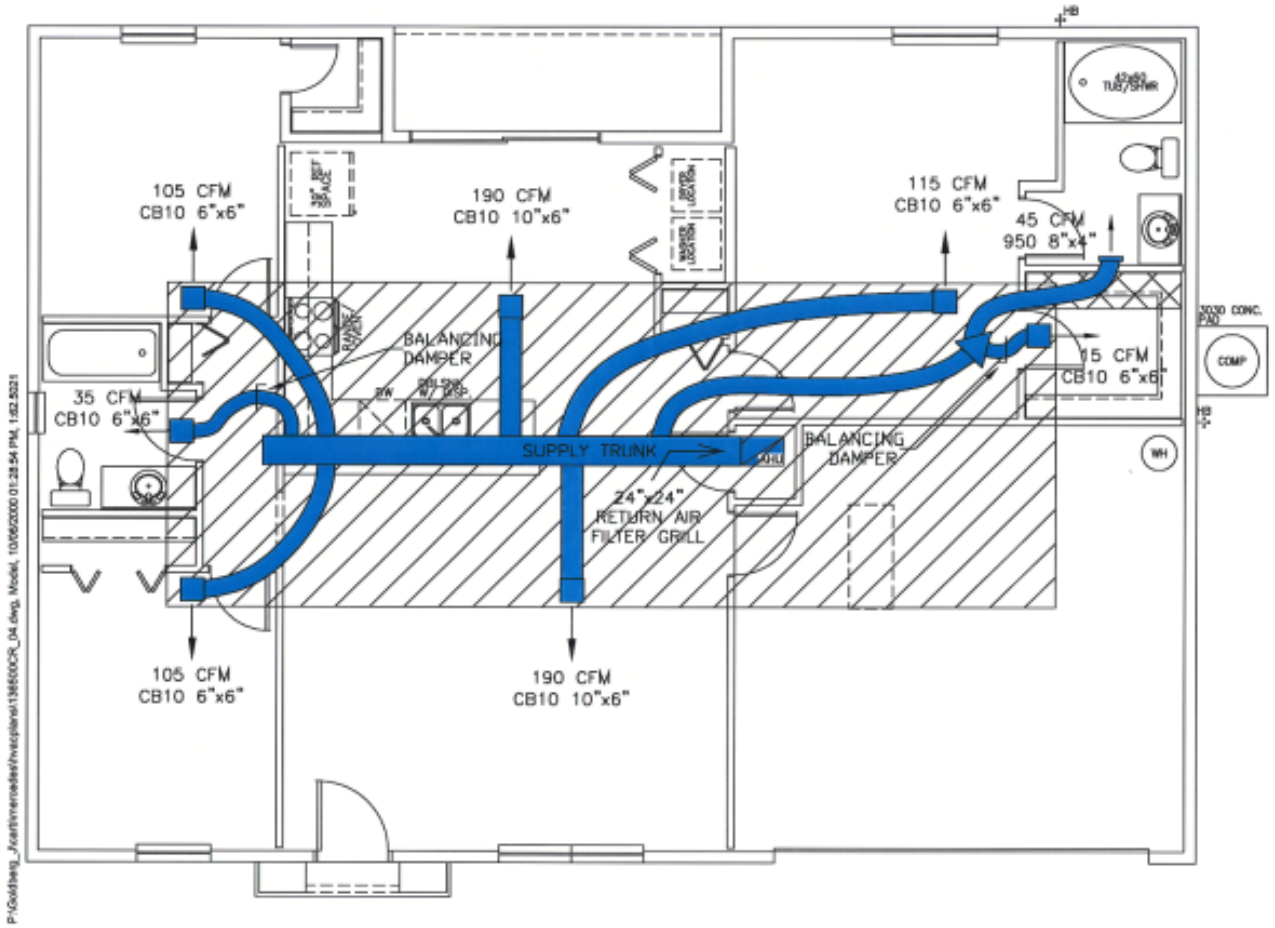
Option: Ducts in Modified



Option: Ducts in Modified Truss

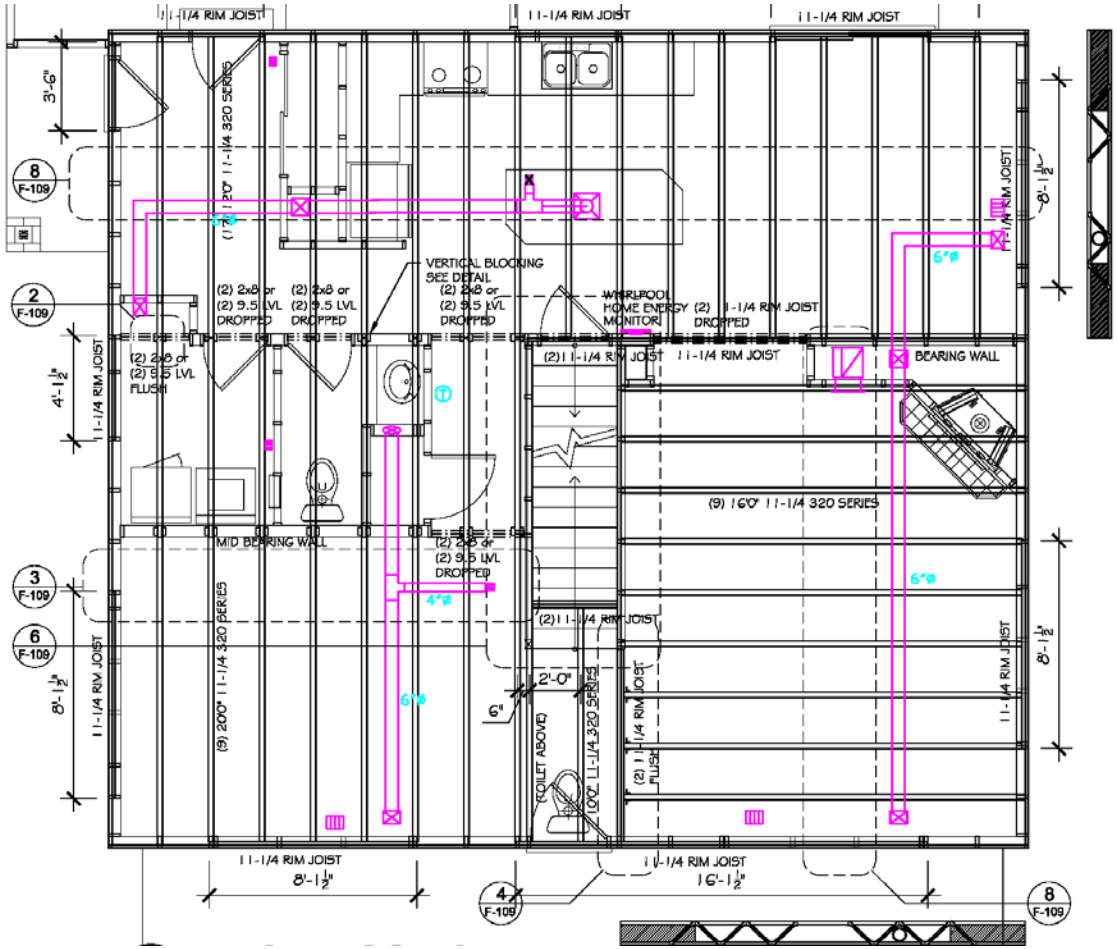
Advantages and Limitations

- Low-cost in simple plans
- Not as plan dependent as dropped soffit solution
- Minimal code restrictions
- Works best in linear plans
- Additional air-barrier and unique air-sealing
- Requires custom, non-standard roof trusses
- No provision for AHU

Option: Floor Truss-Integrated

- HVAC ducts and supply registers are placed within the vertical space created by the floor trusses

Option: Floor Truss Integrated Ducts



- A high degree of planning and coordination between the floor structure and the HVAC design is required
- 12” member depth or greater
- Need to coordinate duct sizes with permissible opening size, location

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Option: Floor Truss Integrated Ducts

- Ceiling registers blowing down and floor registers blowing up can be used. High wall registers are better than floor registers for cooling and can also be accommodated.

Option: Floor Truss Integrated Ducts

Advantages and Limitations

- Low-cost in simple plans
- Easy to execute w/ no changes to enclosure
- Uses existing conditioned space volume
- Flexible register locations
- Minimal code restrictions
- Works best in two-story plans
- Requires structural, HVAC, and architectural coordination
- Requires deep trusses
- No provision for AHU

Option: Ducts in Sealed Crawlspace

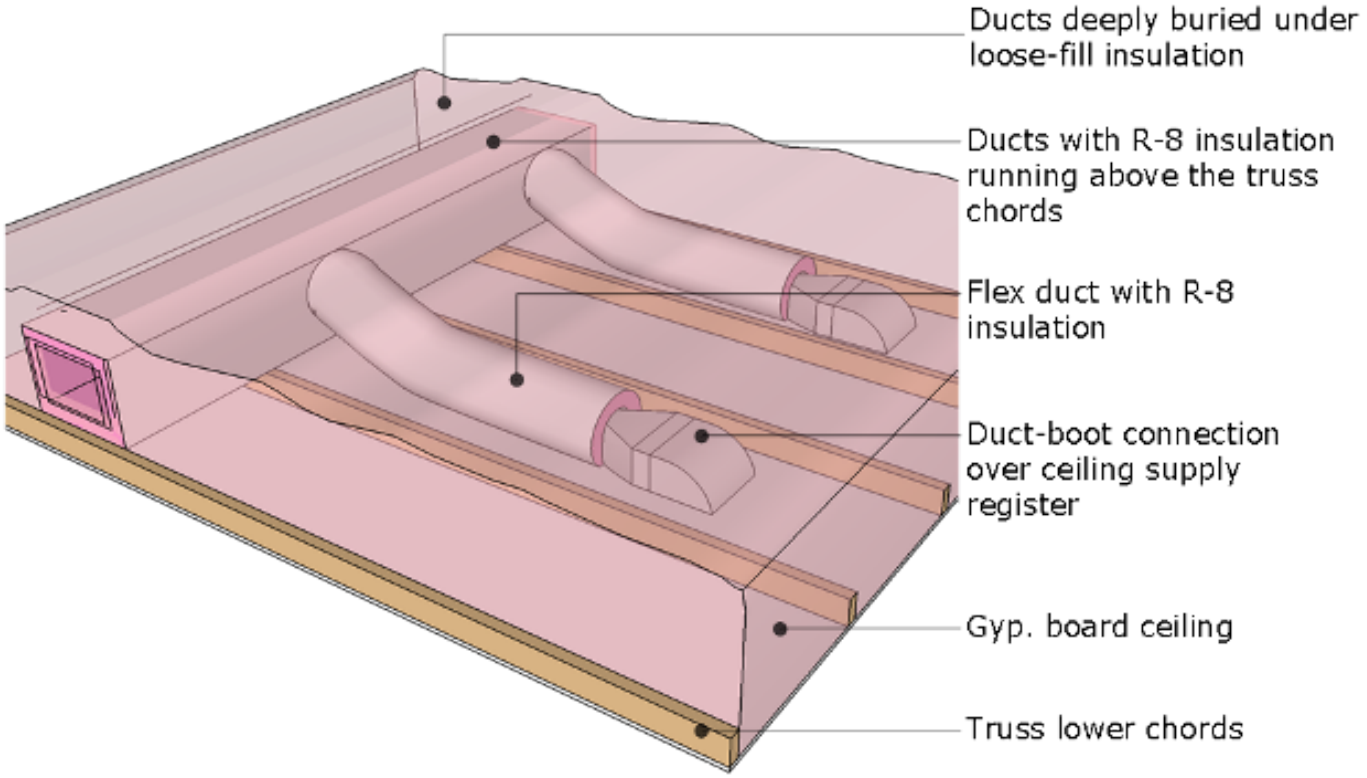
- Bring the crawlspace (or basement) inside conditioned space and use the volume to place HVAC equipment and ducts

Option: Ducts in Sealed Crawlspace

Advantages and Limitations

- Improves enclosure performance
- Accommodates AHU and other equipment
- Flexible register locations
- HVAC/ducts accessible for service
- Code thermal insulation requirements
- Code mechanical ventilation requirements

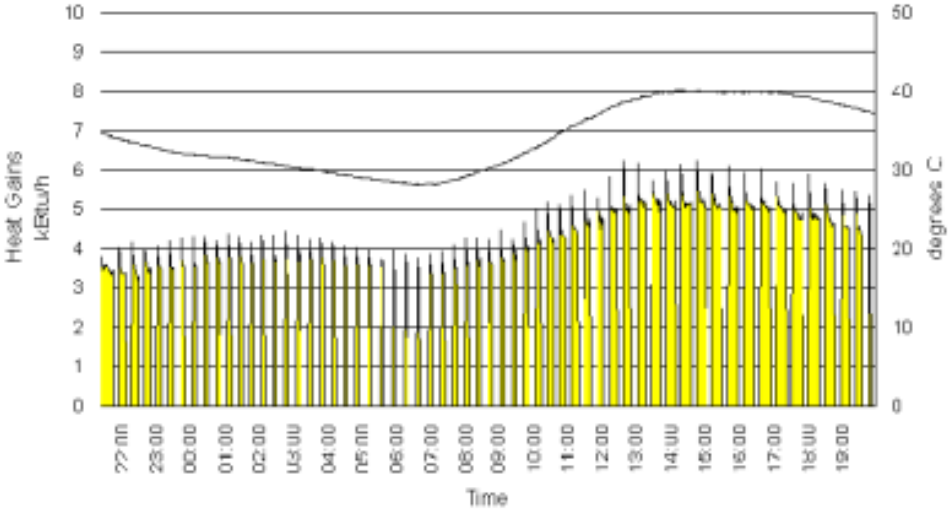
Option: Buried Ducts



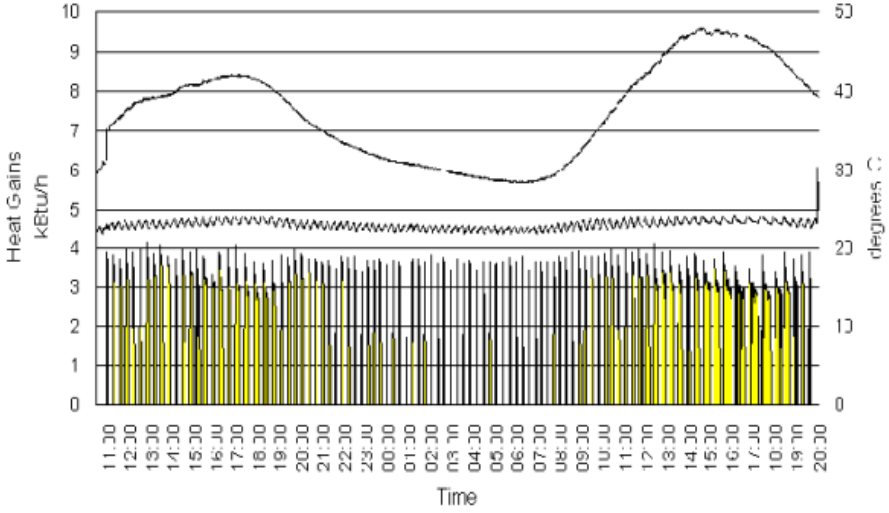
- Low cost, high-performance duct strategy
- Very high R-values

Proof of Concept Testing

Control House 1
Duct Conduction Heat Gains and Attic Temperature



Prototype House
Duct Conduction Heat Gains, Attic and Thermostat Temperatures



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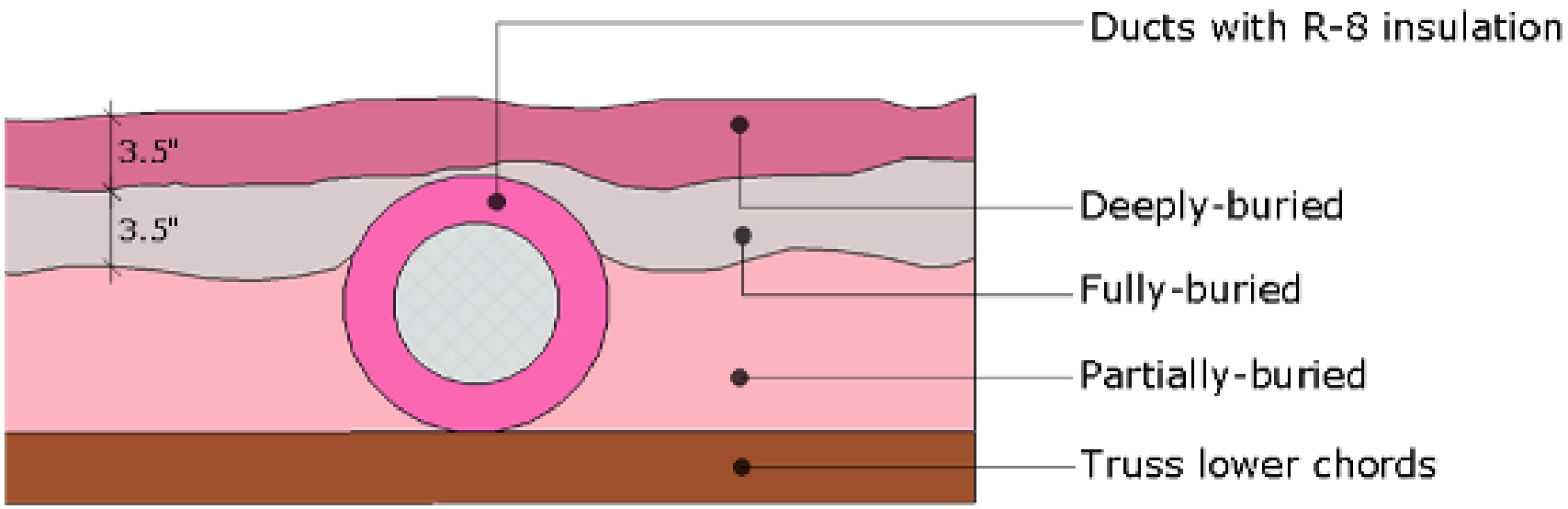
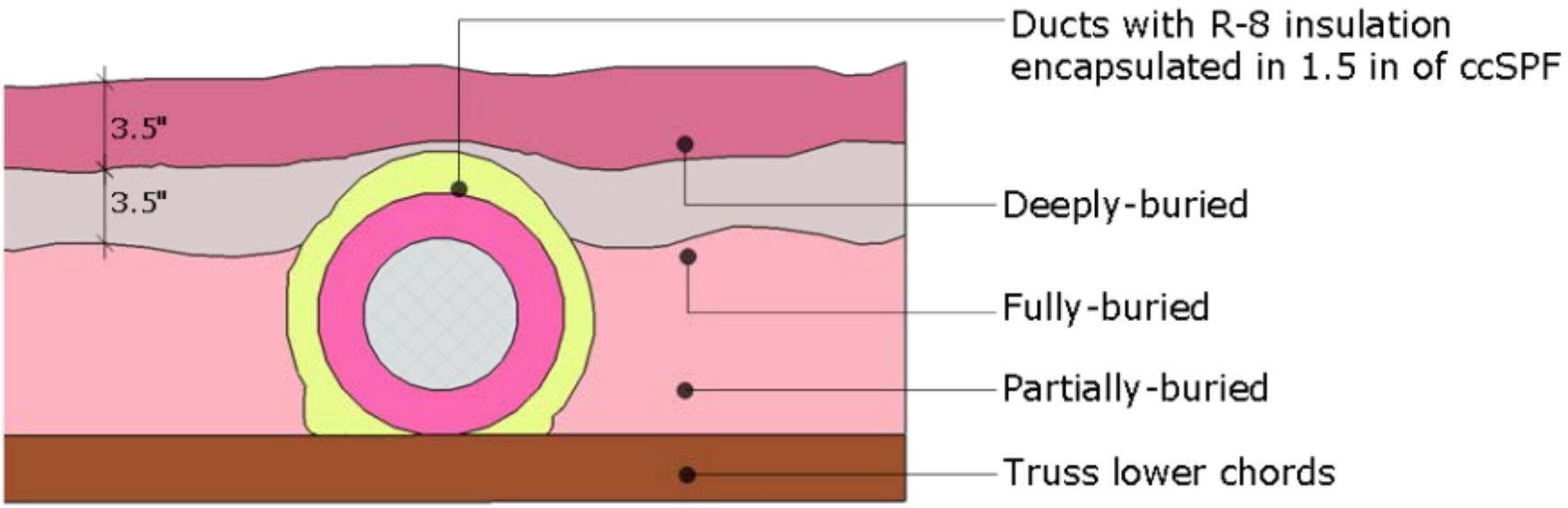
Buried Duct Classification



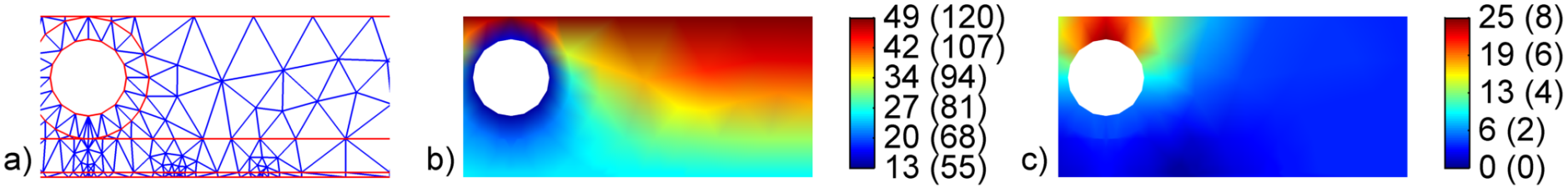
Buried Duct Schematic (Dry Climate Only)

Buried Duct Classification



Buried & Encapsulated Duct Schematic (All Climates)

Finite Element Method



Newton Method Mesh Temperature Distribution Heat Flux Magnitude

Table 1. Effective R-values of R_{SI}-1.4 (R_{US}-8.0) Ducts by Insulation Strategy, m^2-K/W (hr-ft^2-°F/Btu)

Duct Diameter, mm (in)	Insulated Round	Encapsulated with 38 mm (1.5 in) of ccSPF	Buried (Not Encapsulated)			Buried & Encapsulated with 38 mm (1.5 in) of ccSPF		
			Partially	Fully	Deeply	Partially	Fully	Deeply
100 (4)	1.05 (6.0)	1.74 (9.9)	1.5 (8.8)	2.1 (12.0)	3.2 (17.9)	2.5 (14.4)	3.1 (17.5)	4.0 (22.7)
150 (6)	1.18 (6.7)	2.04 (11.6)	1.9 (10.9)	2.6 (14.9)	4.0 (22.6)	3.2 (18.1)	3.9 (22.0)	5.1 (28.7)
200 (8)	1.26 (7.2)	2.24 (12.7)	2.2 (12.6)	3.0 (17.3)	4.6 (26.4)	3.7 (21.1)	4.5 (25.6)	5.9 (33.6)
250 (10)	1.32 (7.5)	2.40 (13.6)	2.5 (14.2)	3.4 (19.3)	5.2 (29.6)	4.2 (23.7)	5.1 (28.7)	6.7 (37.8)
300 (12)	1.36 (7.7)	2.51 (14.3)	2.7 (15.5)	3.7 (21.1)	5.7 (32.5)	4.6 (26.0)	5.5 (31.5)	7.3 (41.4)
350 (14)	1.39 (7.9)	2.61 (14.8)	2.9 (16.7)	4.0 (22.7)	6.2 (35.0)	4.9 (28.0)	6.0 (33.9)	7.9 (44.7)
400 (16)	1.42 (8.0)	2.68 (15.2)	3.1 (17.8)	4.3 (24.2)	6.6 (37.4)	5.3 (29.9)	6.4 (36.1)	8.4 (47.7)

Install Low-Profile, Compact Duct

- Before ceiling drywall

- After ceiling drywall

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Apply 1.5” minimum ccSPF

- Apply min. 1.5” ccSPF prior to or after ceiling gypsum board

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Install Loose-fill insulation

- Insulation must be ASTM classified as “mineral-fiber”, and must cover the ccSPF by a minimum of 1.5” (cellulose doesn’t qualify)
- Some foams are exempt from this requirement (more in a moment)

Option: Buried / Encapsulated D

Advantages and Limitations

- Low-cost in simple plans
- Easy to execute w/ no changes to enclosure
- Minimal plan coordination
- Flexible register location
- 2009 IRC compliant Sections R316.5.3, M1601.3

- Requires HVAC design coordination
- No provision for AHU

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