January 14th, 2020 – Andrew Poerschke, IBACOS

Ductwork in Attics, One of the Last Holdouts of Inefficient Home Design

www.phrc.psu.edu

PennState College of Engineering | PENNSYLVANIA HOUSING RESEARCH CENTER

NARI CEU Approved

ICC PREFERRED EDUCATION PROVIDER

PHRC

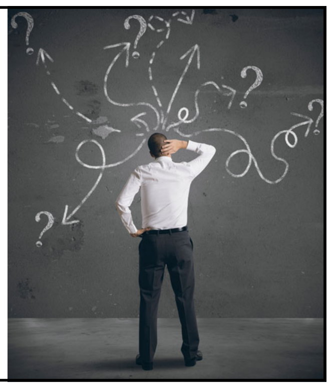
Overview

- HVAC Design Process
- Review Code Changes
- Discuss Duct Strategies and Risks
- Examples
- Conclusions

Why are we here?

Mechanical design process (dysfunction)

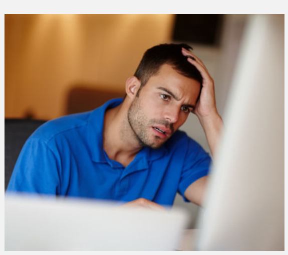
- Architect designs house
- House is engineered and optimized for framing cost
- HVAC designer is given house and framing plan and tasked with fitting ductwork in the least invasive way possible
- HVAC designer knows keeping ductwork compact and within insulation envelope is best, but keeps running into problems
  - Chase is too big
  - Staircase in the way
  - Structural beam in the way
- Ducts are large and a challenge to integrate



Result:

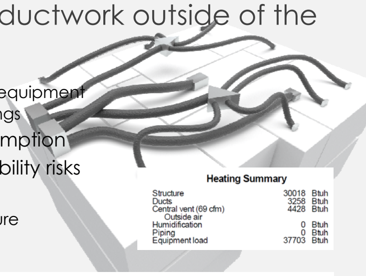
- HVAC designer ends up putting ductwork outside of the house, in the attic, crawlspace, garage or basement.
- Excessively long runs are needed to go around obstructions, requires bigger ducts
- Convoluted plans that are difficult to follow

- Comfort is compromised
- Increased energy use



The problem with ductwork outside of the envelope

- 10-40% increase in load
  - Larger / more expensive equipment
  - Bigger ductwork and fittings
- Increased Energy Consumption
- Condensation and durability risks
- Comfort risks
  - Milder delivery temperature
  - Slug of cold / hot air



Heating Summary

Structure	30018	Btuh
Ducts	3258	Btuh
Central vent (69 cfm)	4428	Btuh
Outside air		
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	37703	Btuh

Heating Summary

Structure	22454	Btuh
Ducts	7558	Btuh
Central vent (121 cfm)	4098	Btuh
Outside air		
Humidification	0	Btuh
Piping	0	Btuh
Equipment load	34110	Btuh

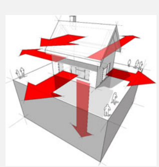
Sensible Cooling Equipment Load Sizing

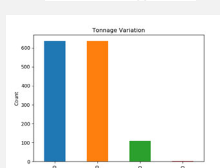
Structure	20775	Btuh
Ducts	8953	Btuh
Central vent (121 cfm)	3330	Btuh
Outside air		
Blower	0	Btuh
Use manufacturer's data	n	

Something needs to change

ACCA Manual J

- Calculate building total thermal load and zone requirements
- Should be specific to orientation
  - Plans with inadequate exposure diversity may see ½ ton + change in load
  - Master bedroom design changes from 75 – 90 CFM (20%)
- Should be specific to exact options package.
  - Ex: Sliding glass door adds 100 CFM
- Internal gains should reflect design and intended occupancy

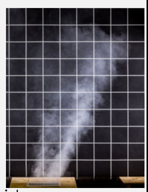




ACCA Manual S

- Equipment selection
  - Multi-step process accounts for various environmental factors
    - Outdoor drybulb
    - Indoor wetbulb
    - Airflow
  - Reference manufacturer data
  - Furnace capacity should be no more than 40% greater than load
  - Air conditioner capacity should be no more than 15% greater than load
- Fan speed selection
  - Fan speed should be specified for correct SHR
  - Fan speed must be set by mechanical contractor

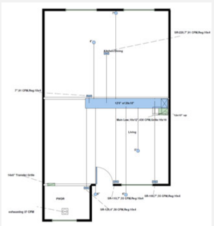
ACCA Manual D / T



- Sizing supply and return duct runs
  - Fundamentally oversized, not predictive or balanced
- Sized for max of cooling and heating load
  - Different for cooling / heating dominate climates
  - Systems don't automatically adjust seasonally
- Designing return air pathways
  - Maintain < 3Pa between rooms and hallways
  - Specify large enough or thick enough filters, furnace side may not be big enough
- Specify register sizes
  - Should be selected for velocity, throw and noise
  - Usually few sizes selected to save $

What's missing?

- Framing plan integration
- Who should own the design?
  - HVAC contractor?
  - Builder?
  - Central design firm?
- Feedback loop with Architect



≠

Code Changes

- Prior to 2018 IECC the code did not specifically address buried ductwork
  - Inconsistent treatment in different jurisdictions
  - No specific requirements for condensation control
  - No credit for energy savings
- Code adopting buried duct language as a concession to the challenges of bringing conventional ductwork into conditioned space.
- PA has Section R403.3.6 & R403.3.7 of 2018 IECC

R403.3.6:

- "Where supply and return air ducts are partially or completely buried in ceiling insulation, such ducts shall comply with all of the following:"
  - Supply and return R-8 min
  - R-19 minimum sum of ceiling insulation around duct
  - R-13 minimum duct insulation CZ1A,2A,3A
  - EXCEPTION: Sections of the supply duct that are less than 3 feet from the supply outlet shall not be required to comply with these requirements
  - Given min 3.5" insulation above, and max 5.5" below, effective R-value of R-25 can be claimed

2018 – IECC, International Code Council

R403.3.7 :

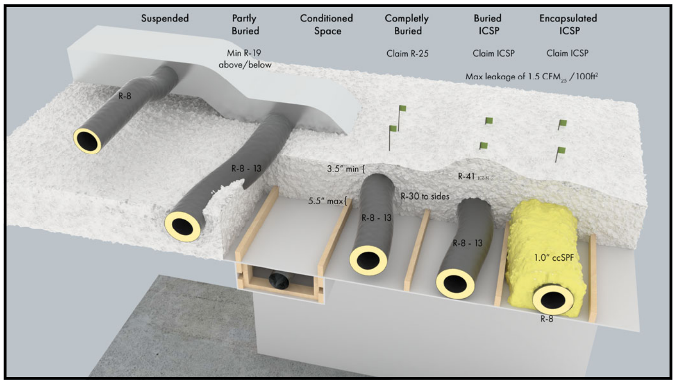
- "For ducts to be considered inside a conditioned space…"
- "The duct system shall be located completely with the continuous air barrier and within the building thermal envelop."
- Ducts shall be buried according to R403.3.6 and:
  - AHU must be with the "continuous air barrier"
  - Duct leakage less than 1.5 CFM_{25} per 100 ft^2
  - Ceiling insulation = R ceiling – R duct (R-49 – R-8 = R-41)

2018 – IECC, International Code Council

Duct Strategies

Strategy	Performance	Cost	Risk	Ease
Attic exposed	*	$	*	***
Attic unvented	**	$$$	*	***
Attic partly buried	**	$$	**	**
Attic deeply buried	***	$$	***	*
Conditioned space	***	$$	*	*
Ductless	***	$$	*	**

Buried Ducts

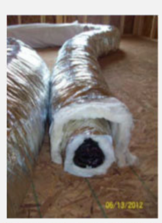


Examples

HIRL Study - Compact ducts buried

- Buried duct strategy with no encapsulation
- Hot / humid climate
- Found no condensation on R-8 ducts in Maryland / New Jersey / South Carolina
- Complex phenomena of moisture transport through attic insulation
- Worked well under controlled environment

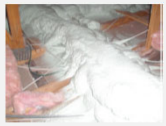
Compact Buried Ducts in a Hot-Humid Climate House – HIRL 2016



Images from HIRL

CARB Study - Buried and encapsulated

- Several studies have shown this is an effective option for reducing risk of condensation
- Effective with 1.5" ccSPF over R-4.2 and 1.0" ccSPF over R-6
- May require adjusting construction schedules and multiple trips for the insulation contractor.



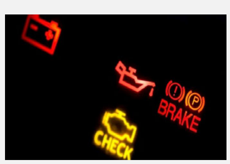
Images from CARB
"Reducing Thermal Losses and Gains With Buried and Encapsulated Ducts in Hot-Humid Climates" CARB - 2013

Benefits

- Can claim higher R value for ductwork
  - R-25
  - Ducts in conditioned space
- Shorter, more compact runs
  - Savings on duct material
  - More efficient delivery of air
- Straighter runs when not hung
  - Lower static pressure
- Possible duct installation speed improvements

Risks

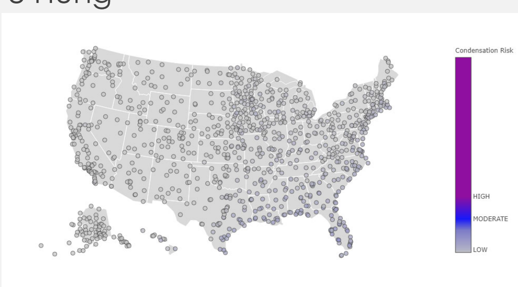
- Complexity of code
  - Many acceptable scenarios
  - Difficulty in inspection
- Condensation
  - Must make sure ducts are not touching
- Installation Complexity
  - Must be done perfectly, relying on materials to perform
- Quality Control
  - Difficult to verify insulation amount and quality underneath plenums and ducts.
  - Once buried, cannot confirm correct installation.



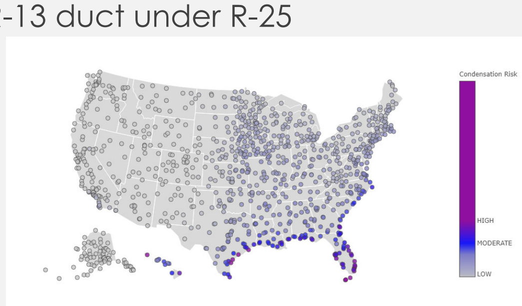
How much condensation is a problem

- Brief occurrences of condensation are likely to dry
- More research needed to fully characterize the phenomena
- Risk goes up significantly if ducts are crossing / touching
- Lower temperature at register / boot, increased condensation potential

R-8 Hung



R-13 duct under R-25



Conditioned Space

Conditioned Space

- Benefits
  - Less risk
  - Lower tonnage equipment
  - ERI Improvement
  - Different leakage testing requirements
- Challenges
  - Structural integration
  - Aesthetic impact
  - Large duct sizes
  - Routing returns
  - Rooms over garages

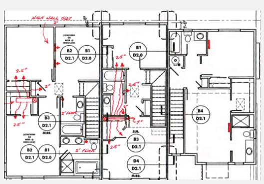
Conditioned Space

- Can work well but requires:
- Planning
- Putting structural changes on the table
  - Taller ceiling height (>8 ft) on first floor
  - Joist orientation
  - Joists bear on walls, not beams
  - Interior wall location and thickness
  - Central chases
  - Stair location
  - Open web trusses
  - Drop ceilings and soffits
- Mechanical closet

Conditioned Space Example

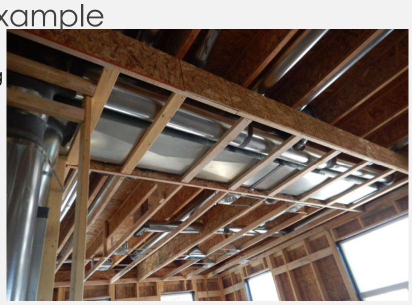

Multi-family

- Frequently ductwork already in conditioned space
- Limited space and access constraints
- Enabled by use of better planning and open web trusses.



Multi-family example

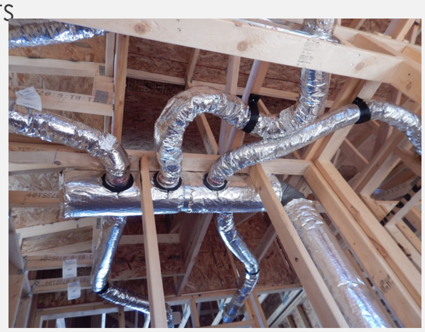
- Dropped ceiling over portion of living space
- Ceiling and floor registers
- Equipment in conditioned space
- Vertical chase to second floor



Alternatives

Ducted MSHP

Smaller Ducts



Concluding Thoughts

- Codes are moving toward more efficient requirements for ductwork
- Buried ductwork may be a temporary strategy to ease transition, research shows it can work, but still ongoing. Condensation and moisture is a complex phenomena.
- Buried ductwork must be done with care and rigor not always seen in the industry.

Concluding Thoughts

- Not a challenge technology alone can solve
- Ultimate goal is ductwork actually within conditioned space, but this will require true mechanical integration
- Collaboration is key

Resources / References

- Buried Duct Tech Spec https://www.homeinnovation.com/~/media/Files/Reports/TechSpec-Buried-Ducts-2017.pdf
- Compact Buried Ducts in a Hot-Humid Climate House: https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/compact-buried-ducts-hot-humid.pdf
- Reducing Thermal Losses and Gains With Buried and Encapsulated Ducts in Hot-Humid Climates: https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/encaps_ducts_hothumid.pdf
- Buried Ducts: Advantages, Challenges, and New Options in the 2018 IECC : https://www.energycodes.gov/sites/default/files/becu/Buried_Ducts_Webinar_Presentation_Slides.pdf

Ductwork in Attics, One of the Last Holdouts of Inefficient Home Design

www.phrc.psu.edu

PennState College of Engineering | PENNSYLVANIA HOUSING RESEARCH CENTER

NARI CEU Approved

ICC PREFERRED EDUCATION PROVIDER

PHRC