



# MF Mechanical Systems

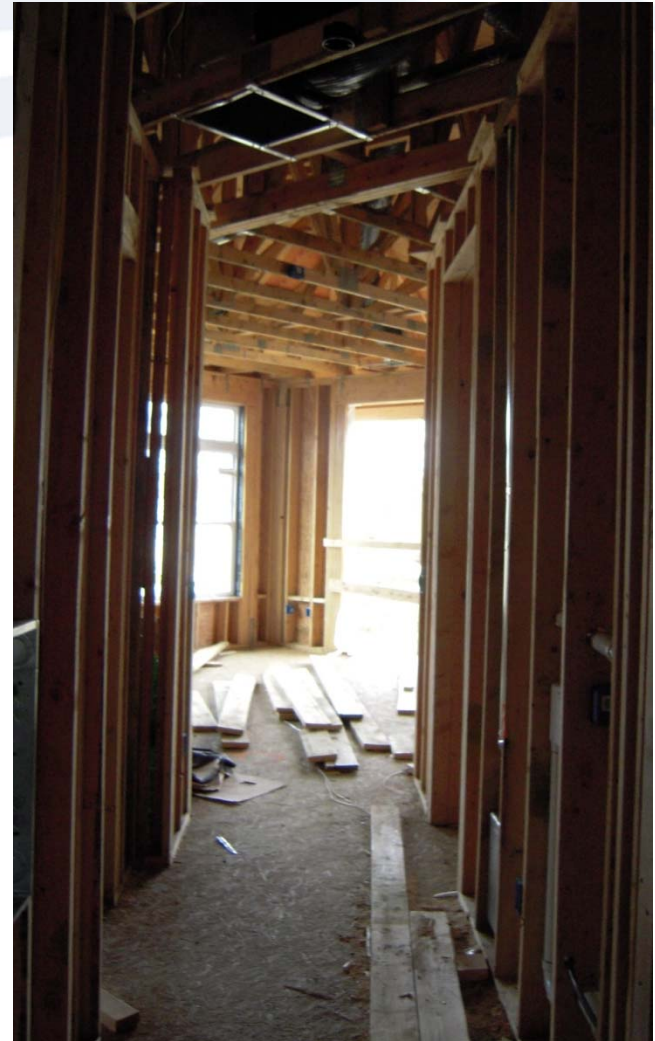
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March 2, 2016



# Overview

- ▶ RESNET MF Guideline Highlights
- ▶ Factors impacting HVAC Decisions
  - Building Construction
  - Space Configuration
  - Program/Rating Requirements
  - Fuel Considerations
  - Associated Space
- ▶ HVAC System Options
- ▶ Ventilation Options
- ▶ Testing Considerations
- ▶ Examples
- ▶ Questions







# RESNET Multi-Family Rating Guidelines

## What's different?

- **New Definitions from the MF Guidelines**
- **Changes to the modeling approach**
  - Central vs. Individual Systems
    - Heating, Cooling, Ventilation, Domestic Hot Water
  - Unique Building Components
    - Elevated slabs
    - Heated Garages and plenums at top and bottom
  - Tested criteria
    - Air leakage
    - Duct Leakage



- **Central mechanical system:**
  - A mechanical system (heating, cooling, ventilation, hot water) serving two or more *dwelling units* and/or *residential-associated common spaces*. This may include a combination of "central" and "individual" systems, such as a "central" boiler where *dwelling units* have "individual" fan coils for distribution.



- **Compartmentalization:**
  - Air-sealing of a space relative adjacent spaces, outdoors and adiabatic.



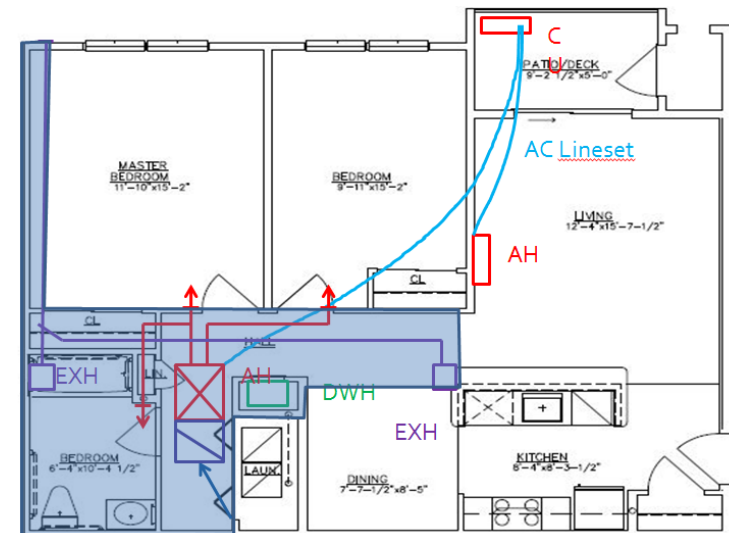




# Definitions

- **Ducted mechanical systems:**

- Systems that supply air to an occupiable space through supply ductwork exceeding 10 ft. in length and through a thermal conditioning component, except for evaporative coolers.
- Does not include balanced ventilation systems not connected to the space heating or cooling systems.
- When measuring supply duct length, 10 ft. is measured from the source to the supply register(s), including all supply trunks and branches. The 10 ft. is a total system allowance, and not the allowance for each supply run.



- **Dwelling unit Enclosure Area:**

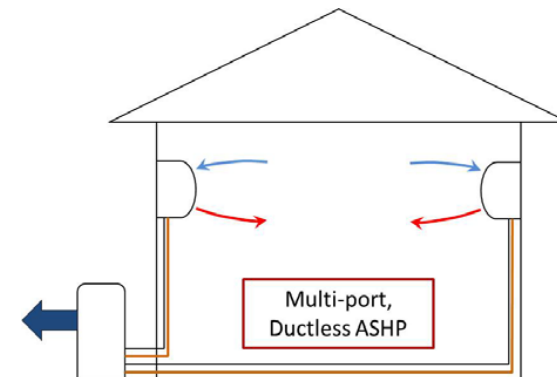
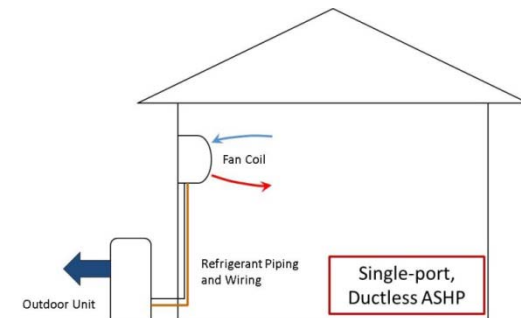
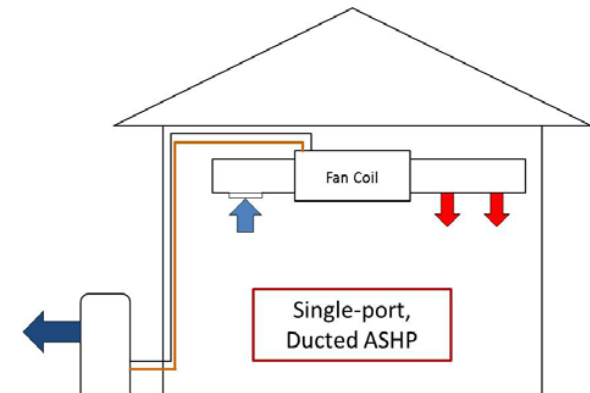
- The sum of all the boundary surfaces that define the *dwelling unit*, including top, bottom, and all sides. This does not include interior partition walls within the *dwelling unit*. *Wall height should be measured from the finished floor of the dwelling unit to the underside of the floor above (rather than stopping at the finished ceiling).*



# Definitions

## Variable Refrigerant Flow (VRF) Multi-Split Heat Pumps:

- These air-source heat pump systems are listed under “commercial” in the AHRI Directory and are used in commercial buildings and some *multifamily residential buildings*.
- They are considered *central mechanical systems*, as they serve more than one *dwelling unit*. The large outdoor units (5 tons or greater) are generally located on the roof of the buildings.
- The distribution within the *dwelling unit* is generally a ducted or non-ducted fan coil.





- **Individual ventilation systems (serving only one dwelling unit)**
  - *When the ventilation system serves only one dwelling unit, it shall be modeled similar to a detached single family building, including the measured flow rate, ventilation type, and the rated electrical consumption of the fan(s).*
- **Common ventilation systems (serving more than one dwelling unit)**
  - *Air flow, fan power, heating and cooling load (when conditioned) are allocated to the individual spaces that are served by the systems.*





# Individual Ventilation

- The source of the fresh air, not the exhaust air, is determining factor
- For individual exhaust only systems:
  - If passive air vents (from outside) are present – Model as Individual
  - If no passive air inlets are present within the dwelling units and central fresh air supply system is sized to include dwelling units – Model as Central
  - If no passive air inlets are present within the dwelling units and central fresh air supply system is not sized to include dwelling units - no mechanical ventilation system is modeled.



# Central Ventilation

- Balanced central ventilation
  - Outdoor supply air is delivered directly to the dwelling units and exhaust air is taken from the dwelling units, using a central ventilation system
  - with or without heat or energy recovery
  - May also serve residential-associated common spaces
  - "Balanced" may not always be "equal"
- Central supply-only ventilation
  - Serve multiple dwelling units with single system
  - Supply outdoor air directly to the dwelling units
- Conditioned ventilation (balanced or supply only)
  - The dwelling unit's energy model shall include additional HVAC equipment to represent the central mechanical system that actively conditions (heats and/or cools) the ventilation supply air.





# Modeling

- Indirect central ventilation
  - Central ventilation system supplies outdoor air to common spaces, such as corridors, with the intent of indirectly serving as the primary outdoor air supply for dwelling units.
  - Mechanical exhaust from dwelling units (central and/or individual fans)
- Central exhaust only
  - Mechanical exhaust from dwelling units with central fans
  - Passive air inlets within the dwelling units, and supply ventilation serving residential associated common spaces is not sized to include outdoor air for the dwelling units.



# Individual Mechanical Systems

- HVAC and DHW systems
- Serves individual dwelling unit
- May be located in common space
- Typically will have residential efficiency ratings (such as AFUE, SEER, EF)
- Modeled in the HERS Rating in accordance with the RESNET Standards for the relevant equipment type.





# Central Heating Systems

- Central heating plants in multifamily residential buildings are typically boilers with heated water distribution.
- Distribution inside the dwelling unit may be hydronic/radiant, fan coils, or terminal water loop heat pumps (WLHP).
- Each system has a different methodology for modeling. Refer to the Section; *Central mechanical systems - heating plants and distribution* of the MF Guidelines for details







# Central Cooling Systems

- Central cooling plants in multifamily residential buildings are typically chillers and cooling towers with cold water distribution
- Distribution inside the dwelling unit may be hydronic/radiant, fan coils, or terminal water loop heat pumps (WLHP)
- Each system type has a different methodology for modeling. Refer to the Section: *Central mechanical systems - cooling plants and distribution* of the MF Guidelines for details



# Modeling MF Duct Leakage

- All ducted mechanical systems in dwelling units must be tested for duct leakage to outside the unit.

## Exception:

Testing of duct leakage to outside the *dwelling unit may be skipped, and zero duct leakage to the outside modeled*, if all three of the following conditions are true.

1. The *dwelling unit unguarded blower door test (compartmentalization test) demonstrates* leakage no greater than 0.30 CFM50/ft<sup>2</sup> of enclosure area.
2. If a passive outdoor air ventilation duct is connected to the return side of the space conditioning duct system, an automatically-controlled mechanical damper must close off the outdoor air when there is no call for ventilation (even for continuous ventilation strategies).
3. The entire duct system, including the manufacturer's air handler enclosure, is within the dwelling unit's tested pressure boundary during the dwelling unit blower door test.



# Modeling MF Duct Leakage

## Examples

- A duct system in a vented attic does not qualify, but one located entirely in the interstitial space between conditioned units may qualify.
- Systems may qualify when the air handler is in a mechanical closet located on a balcony or accessed via the corridor, if that mechanical closet is within the tested pressure boundary during the *dwelling unit blower door test* (ie. *pressure in the closet must be within 10% of the living space during the test*).

Note: If the duct leakage results are to be used for assessing compliance with a *dwelling unit duct* leakage limit (e.g., defined by code or by an energy efficiency program), application of this exception may not be appropriate unless approved by the local code official or program administrator.





# Testing Overview

## What's Different

- Multifamily specific air leakage testing
  - Conflicts with current Chapter 8 standards
  - Alternate methodologies
- Mechanical system testing
  - System supply/return air flow testing
  - Supply/Return duct static pressure (individual ducted systems)
  - DHW Testing
  - Ventilation Testing
  - Duct Testing
  - Combustion Appliance Testing
- On-Site Inspection for Minimum Rated Features





# MF Testing Considerations

- Chapter 8 of the RESNET Standards were modified, where needed, to apply specifically to dwelling units in multifamily residential buildings.
- There was a need for tests that would not assume that all measured leakage was from the "outside"
- Guidance was needed to explicitly address systems in residential-associated common spaces
- Guidance was needed for tests not currently addressed by the Standard, such as low-flow plumbing fixtures and non-ducted returns.



# Conflicts with Chapter 8

The following were proposed, which conflict with the current protocols in Chapter 8 of the Standards.

- **802.2.8 Fans:**

- Current: Continuously operating ventilation systems shall be turned off and the air openings sealed, preferably at the exterior terminations.
- Proposed: Continuously operating ventilation systems (whether central or individual) shall be turned off and the air openings left unsealed.

# Conflicts with Chapter 8

- **802.2.11 Un-dampered or fixed-damper intentional openings between conditioned space and the exterior or unconditioned spaces:**
  - Current: Exception: Un-dampered supply-air or exhaust-air openings of continuously operating mechanical ventilation systems shall be sealed (preferably seal at the exterior of enclosure) and ventilation fans shall be turned off as specified above.
  - Proposed: Delete Exception





- **802.2.14 Operable window trickle-vents and through-the-wall vents:**
  - Current: Shall be closed.
  - Proposed: Shall be opened fully.
    - The justifications for leaving these opened or unsealed are as follows:
    - If central ventilation is ducted directly to the individual dwelling units (continuous or intermittent), the system is turned off, but the ventilation openings are not sealed. The reasons for this are:
      1. There is no consistent way to distinguish between holes that deliver ventilation air versus those that are intended as ventilation openings but actually leak, uncontrollably in both directions.
      2. Not all ventilation openings will be accessible for sealing.



# HVAC System Testing

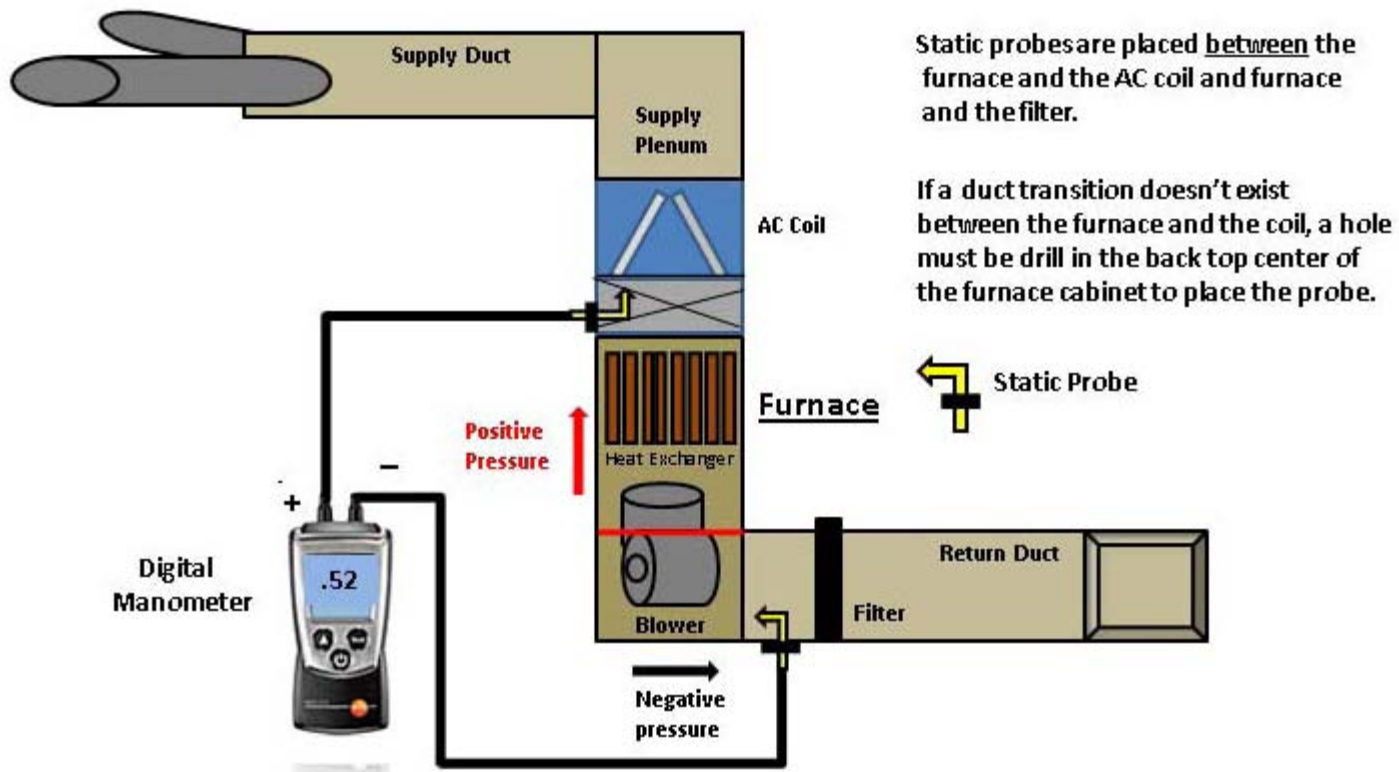


Figure 1: Location of ideal test hole locations (Courtesy of Jim Bergman, Tru Tech Tools)



# Duct Leakage Testing

- **Procedures for Multifamily Dwelling unit/Building Duct Testing**
  - **Duct testing, total leakage and Duct testing, leakage to outside**
    - When performing a duct leakage test (both Total Duct Leakage and Leakage To Outside) follow the procedures as described in Section 803 of the RESNET Standards and replacing "building" with "dwelling unit."
    - When following Section 803.3 of the RESNET Standards (Protocol for Preparing the Building and the Duct System for a Duct Leakage Test); original guidance is below and additional guidance is underlined and provided below:
    - 803.3.4 Any intentional openings into the duct system such as combustion air or ventilation ducts shall be left in their normal non-ventilation operating position. Motorized dampers should be closed. If openings are part of a continuous ventilation system, openings shall not be sealed.



# Duct Leakage Testing

- **Duct leakage testing protocol for non-ducted returns**



- Multifamily buildings with individual ducted mechanical systems in each dwelling unit commonly deliver return air to the air handler via a non-ducted return system. Usually this is accomplished by raising the air handler off the floor on a platform or stand, and leaving the return side of the fan compartment open to the air handler closet. An opening in the closet is then created so that air from the conditioned space can be drawn into the air handler by:
  - A grille in the mechanical closet wall that meets the manufacturer's specifications for minimum return grille size;
  - A louvered door on the mechanical closet;
  - Leaving the ceiling of the closet open and using a dropped ceiling plenum and ceiling grilles as the return pathway back to the air handler.



# Duct Leakage Testing

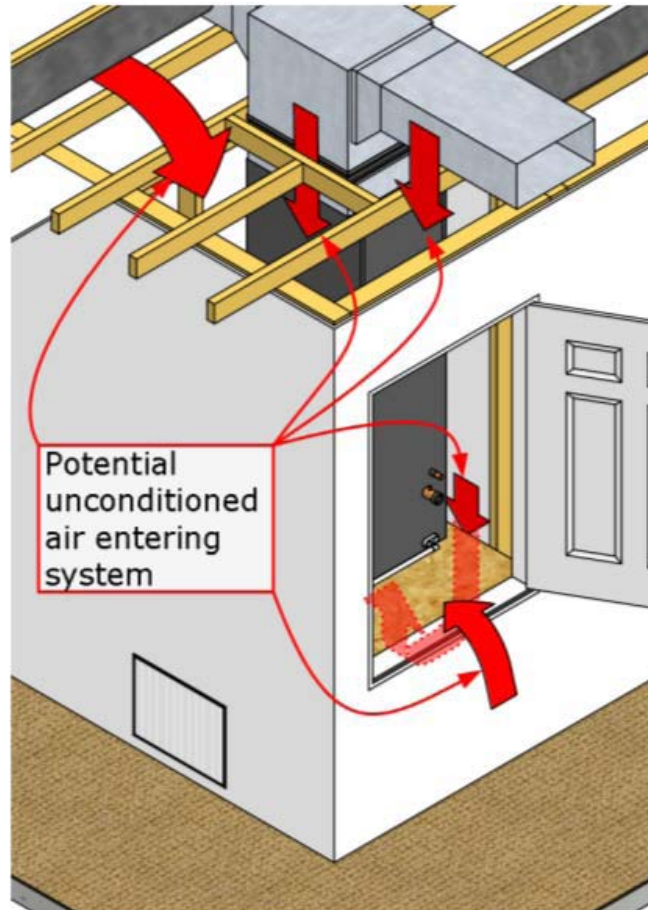


Image from DOE Measure Guideline: Air Sealing Mechanical Closets in Slab-On-Grade Homes



# Duct Leakage Testing

- Installation of the Duct Leakage Testing System with Non-ducted Returns
  - The mechanical closet and any peripheral cavities being used as return paths back to the air handler must be included in the duct leakage testing requirement unless the system qualifies under the exception by meeting all three of the criteria listed below:
    - a. A larger opening than manufacturer's minimum return grille free area sizing is installed;
    - b. The pressure difference between the mechanical area and the conditioned space  $\leq 3$  Pa with the air handler running at high speed;
    - c. There is an induced pressure difference between the mechanical area and the conditioned space of less than 10% of the induced pressure difference with respect to outside.



# Duct Leakage Testing

- If all three criteria are met, the duct blaster fan may be hooked directly to the return side of the air handler during the duct leakage test excluding the rest of the mechanical area from the duct leakage results.
- Otherwise, the duct blaster must be attached to the grille leading into the mechanical closet or furr-down plenum, essentially including any leakage in the closet or furr-down in the duct leakage results.
- Any building cavity plenums – ceiling, wall, floor – being used to direct air from the conditioned space to these mechanical areas must be left open to the mechanical area. Transfer grilles in the conditioned space leading to these ancillary plenums shall be sealed off. The duct blaster fan must be connected to a transfer grille in the ceiling plenum. This would result in the mechanical closet and ceiling plenum being included as part of the duct testing requirements.



# Duct Leakage Testing

- Balanced ventilation systems not connected to the space heating or cooling systems, or ducted systems with 10 ft. or less of supply duct length are **not** required to be tested for any duct leakage, unless any portion of the system is located in unconditioned space.
- They can be modeled as “ductless” systems in the HERS Rating software.
- When measuring supply duct length, 10 ft. is measured from the source to the register(s), including all supply trunk and branches.
- The 10 ft. is a total system allowance, and not the allowance for each supply run.

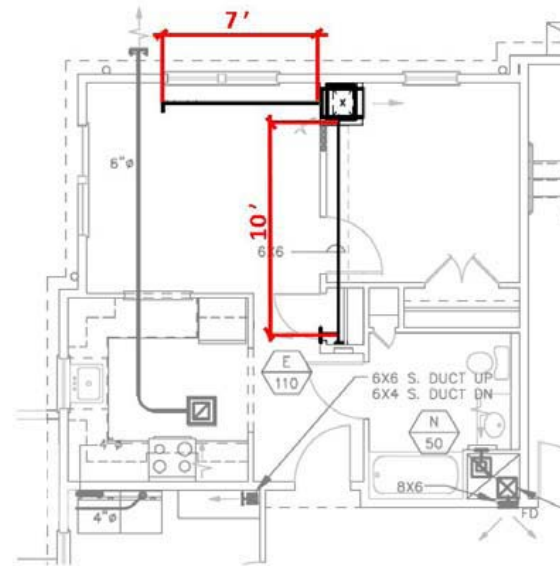
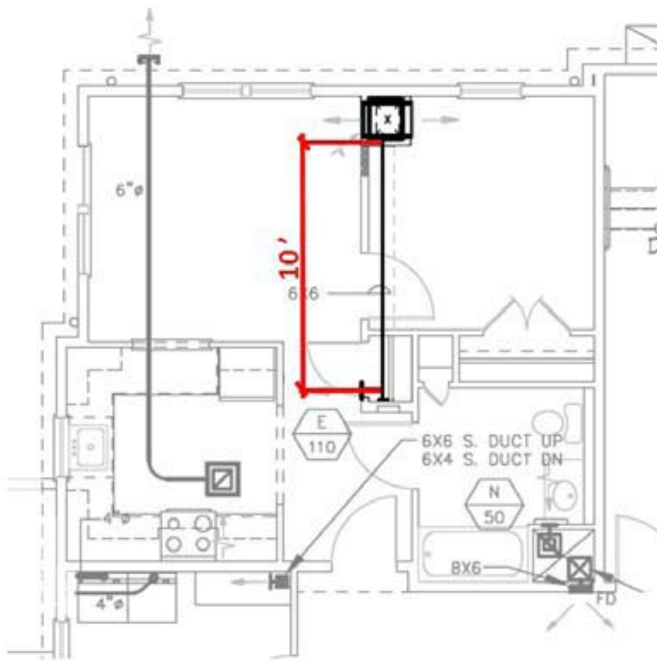




# Duct Leakage Testing

## *Duct Leakage Testing to Outside and Duct Leakage Total Exception*

The image on the left qualifies for the exception. The image on the right does not qualify for the exception.





# Duct Leakage Testing

- **Duct Leakage Testing to Outside Exception**

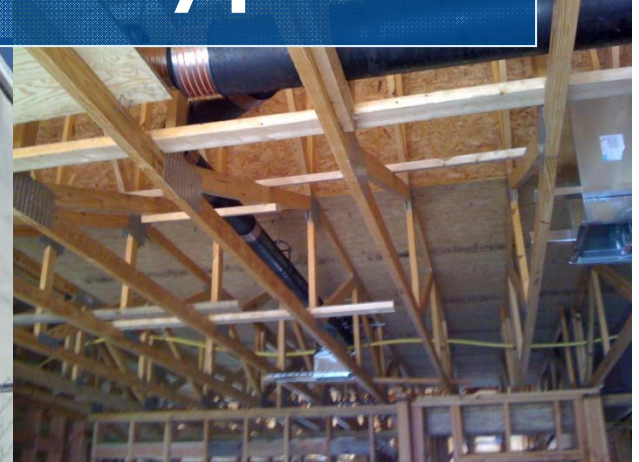
- All ducted mechanical systems in dwelling units must be tested for duct leakage to outside the unit, or use the RESNET Default leakage.

Exception: Testing of duct leakage to outside the dwelling unit may be skipped, and zero duct leakage to the outside modeled, if all three of the following conditions are true.

1. The dwelling unit unguarded blower door test (compartmentalization test) demonstrates leakage no greater than 0.30 CFM50/ft<sup>2</sup> of enclosure area.
2. If a passive outdoor air ventilation duct is connected to the return side of the space conditioning duct system, an automatically-controlled mechanical damper must close off the outdoor air when there is no call for ventilation. This damper must be installed even for continuous ventilation strategies, such that if the power goes off, the damper closes.
3. The entire duct system, including the manufacturer's air handler enclosure, is within the dwelling unit's tested pressure boundary during the dwelling unit blower door test.

# Building Construction Type

- ▶ Frame, wood or steel
- ▶ Concrete/steel
- ▶ Masonry shell
- ▶ Rated walls
- ▶ Rated floor/ceiling
- ▶ Roof/Ceiling
- ▶ Foundation type





# Site Conditions

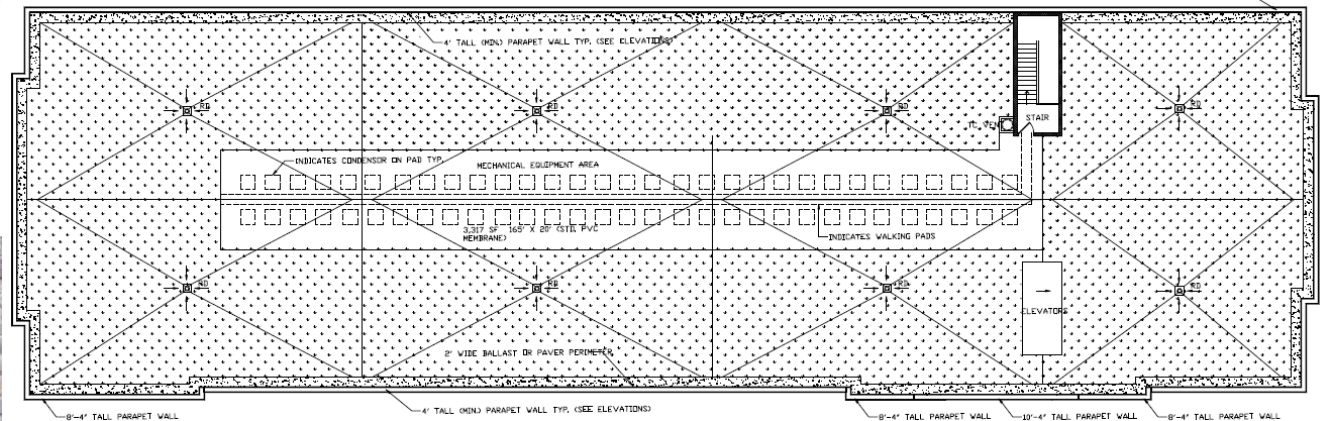
- ▶ How much space do you have?
- ▶ How much do you need?
- ▶ Utilities / Meters





# Site Conditions

- ▶ Site Approval Conditions
- ▶ Special Requirements
  - Geothermal, Solar, Green Roof
- ▶ Roof Type



# Space Configuration

- ▶ Low/Mid/High Rise
- ▶ Flats (do they stack?), multi-story, lofts
- ▶ Individual Entry, Stair Tower or Central Hall Entry
- ▶ Mechanical equipment location
  - Interior closets (hall access or unit access)
  - Central closet in unit
  - Exterior/balcony closet
  - Central Plant
  - Recessed units (ceiling plenum)
  - Thru the wall
  - Pad mounted exterior units (roof or ground)
- ▶ Where are the fire separation boundaries?



# Program/Funding Requirements

- ▶ Market Rate vs Affordable
  - Affordable Projects may have mandatory above-code energy requirements
- ▶ Residential vs Commercial Programs
  - ENERGY STAR for Homes – v3
  - ENERGY STAR Multi-Family High Rise
  - LEED for Homes
  - LEED for Homes Multifamily Midrise
  - Other HERS Based Programs
  - Other Program Specific Requirements

# Program/Funding Requirements

- ▶ Performance requirements
  - Duct leakage requirements
  - Equipment Efficiency
  - HVAC commissioning
- ▶ Metering
  - Program requirements, laws and owner preferences drive many projects to individual systems
- ▶ Ventilation/exhaust requirements
  - Supply/Exhaust/Balanced
  - Fresh air source
  - Point Source Control vs Continuous
- ▶ Owner Requirements

# HVAC System Types

## ► Distribution

- Ducted Forced Air
  - Dropped soffit
  - Exposed
  - In-structure
- Ductless Forced Air
  - Thru the wall
  - Wall mounted
  - Ceiling Mounted
  - Recessed Cassette



# HVAC System Types

## ▶ Natural Gas

- Direct Fired
  - Furnace
  - Gas Fired PTAC
- Indirect Fired (in combo with DHW)
  - Air handler w/hot water coil
  - Convectors

## ▶ Electric

- Heat pump
  - Ground Source
  - Air Source
  - Water Loop
  - Mini-Split
  - VRF
- Resistance heat

# Ventilation

- ▶ Code/Program Requirements
  - Which code
    - 2009/2012/2012
    - IRC or IBC
- ▶ Exhaust/Supply/Balanced
- ▶ Heat Recovery/Energy Recovery
- ▶ Stand Alone or Integrated
- ▶ Individual unit or Central system
- ▶ Distributed?

# Interior Closet – Unit Access



- ▶ Student Housing on Infill Site
  - Modular Construction – Interior hallways
  - Electric Water Heater
  - Heat Pumps w/short duct runs in dropped soffit (no fire dampers)
  - Roof Mounted Condensing Units





# Interior & Exterior Closets



## Market Rate

- Stick Frame
- Hot Water Coil in Air Handler for heating (interior closet)
- Ductwork dropped in soffits
- Thru-the wall condensing units (exterior closet)
- Tankless Gas Water Heating (exterior closet)

# Interior Closet – Unit Access



- ▶ Affordable Housing Project
  - Stick Framed w/stair tower entry
  - Electric Water Heaters
  - Gas Furnaces w/ductwork in trusses w/fire dampers
  - Roof Mounted Condensing Units

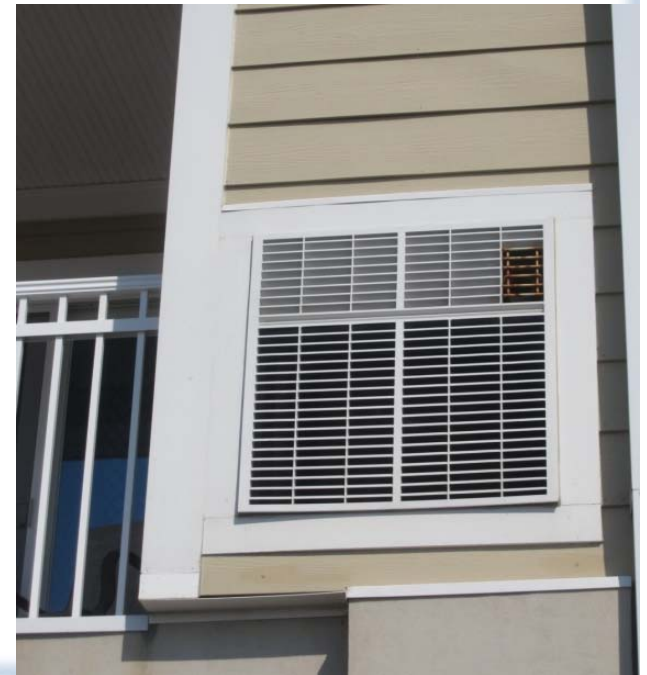




# Exterior Closet



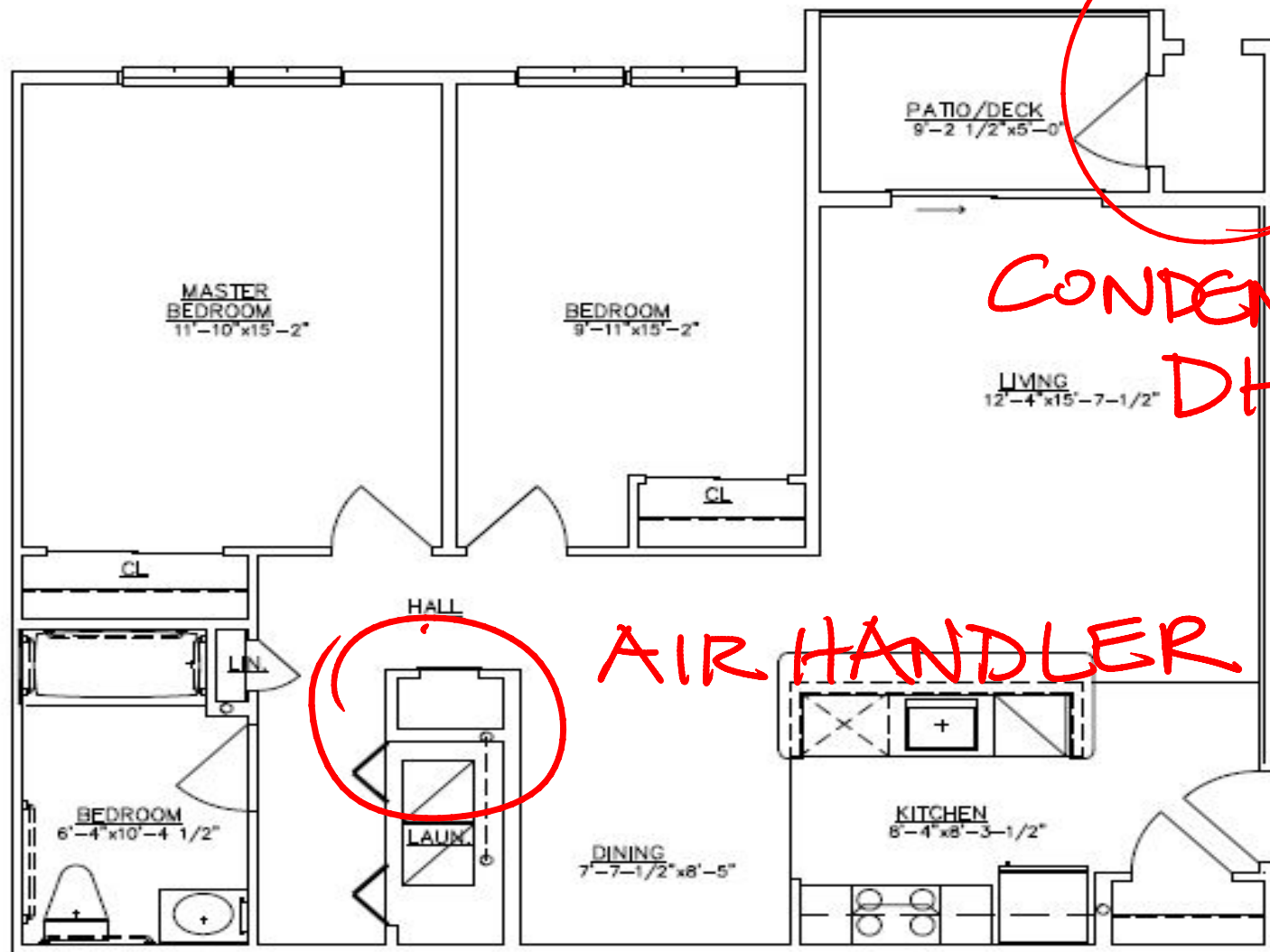
- ▶ Market Rate
  - Concrete & Metal Framing w/exterior balcony access
  - Gas Water Heating
  - Thru-the-Wall Gas heating & cooling w/duct in dropped soffits

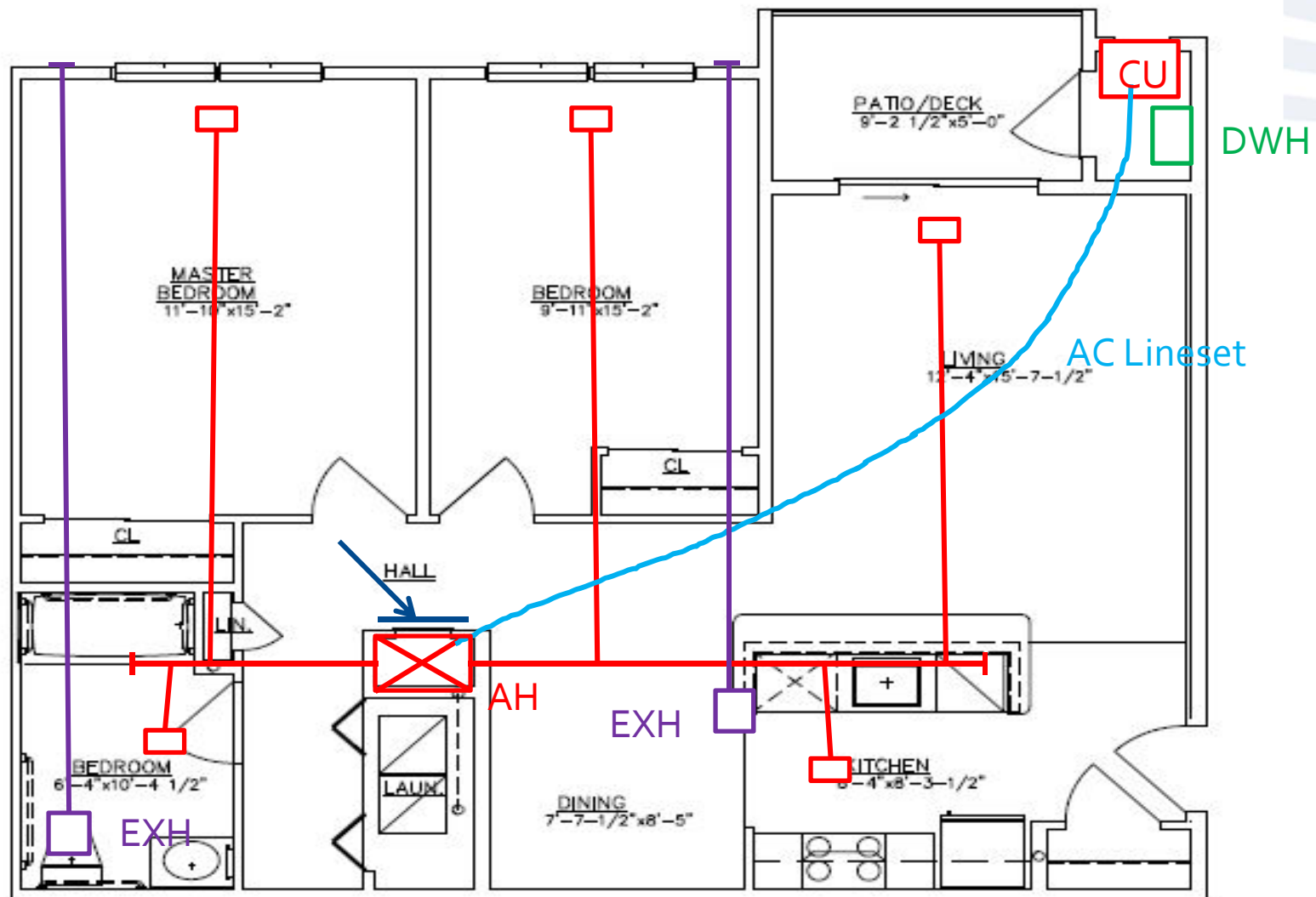


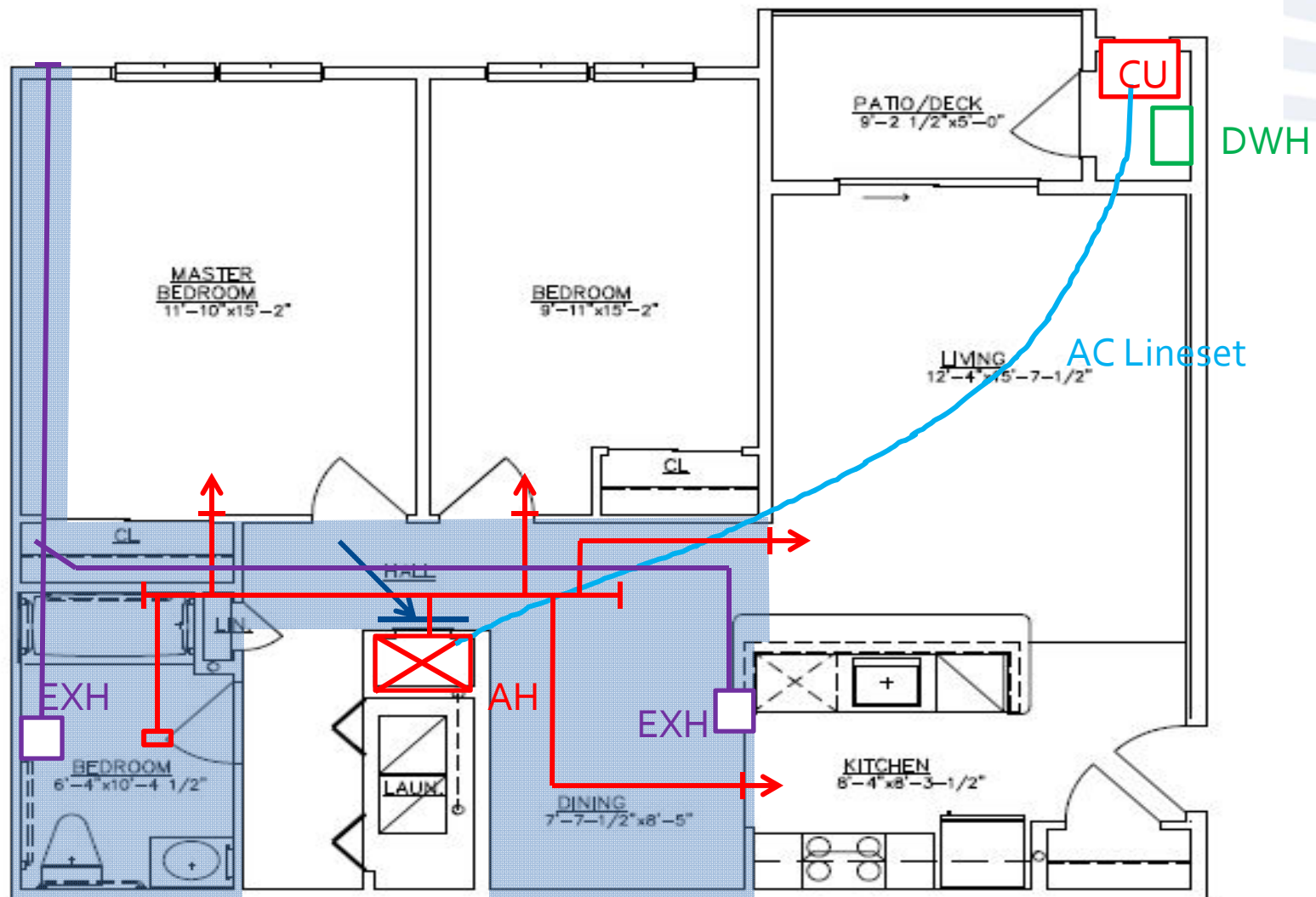
# Example #1

- ▶ Multi Family Unit – Perimeter Closet
- ▶ Building Type:
  - Slab on Grade with Pitched Roof;
  - Wood Frame with Floor-Ceiling Trusses,
  - No space at grade for mechanical equipment
  - Common Entries with stair towers, no elevator
  - Low Rise (3 stories), Affordable, Rental
- ▶ LEED for Homes, ENERGY STAR Homes, HMFA Funding
- ▶ Fuels:
  - Individually metered Gas & Electric

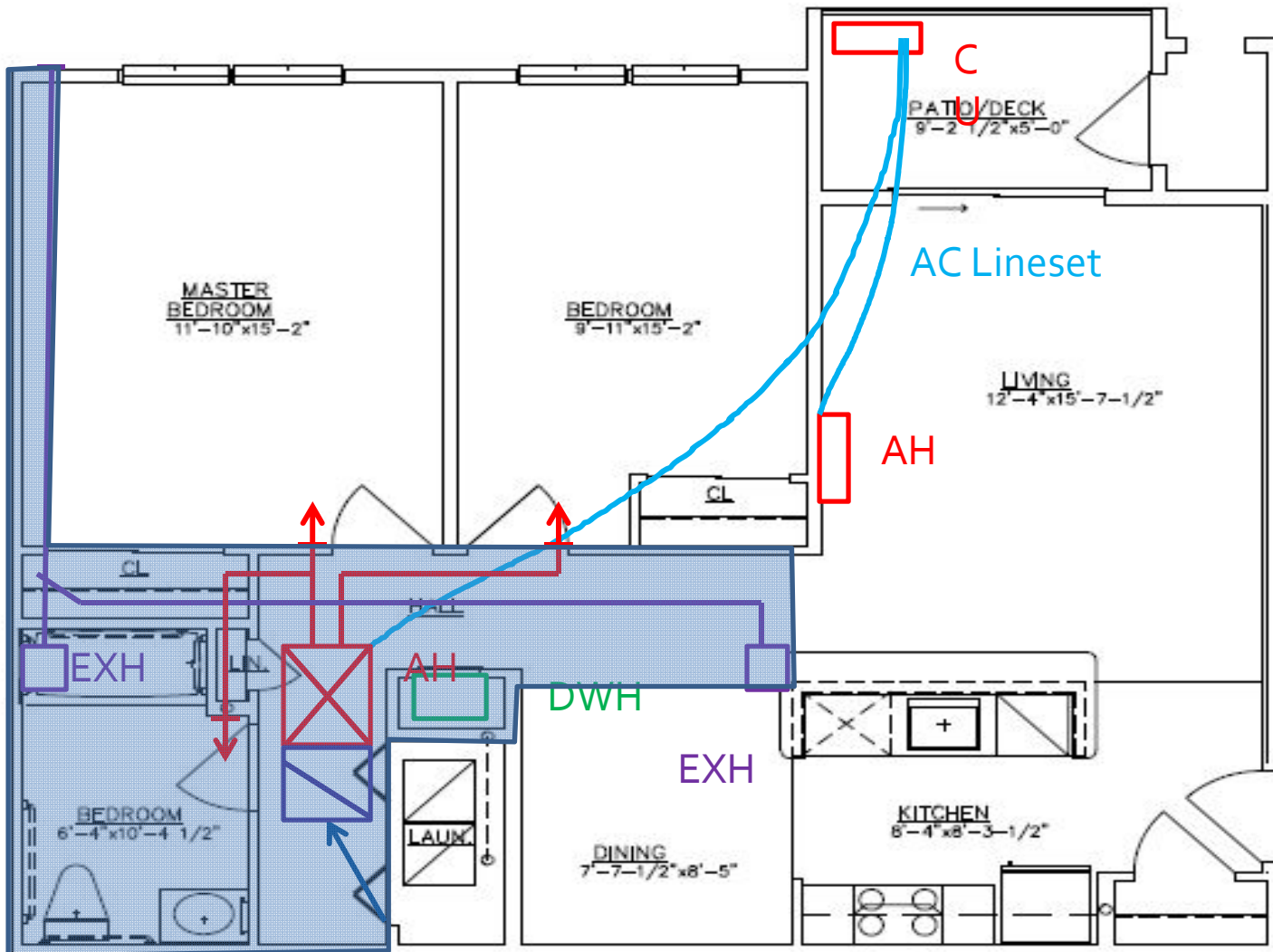






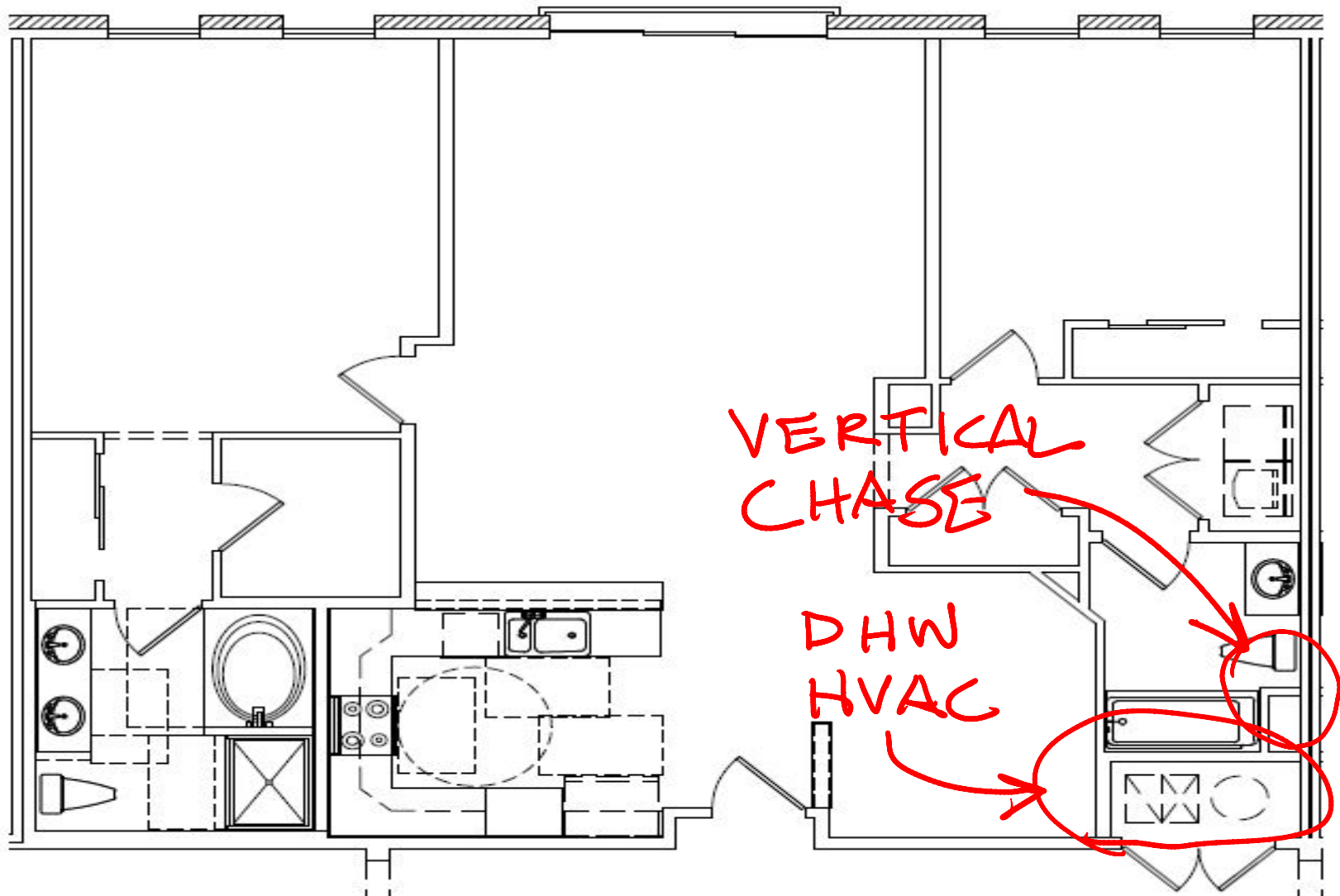




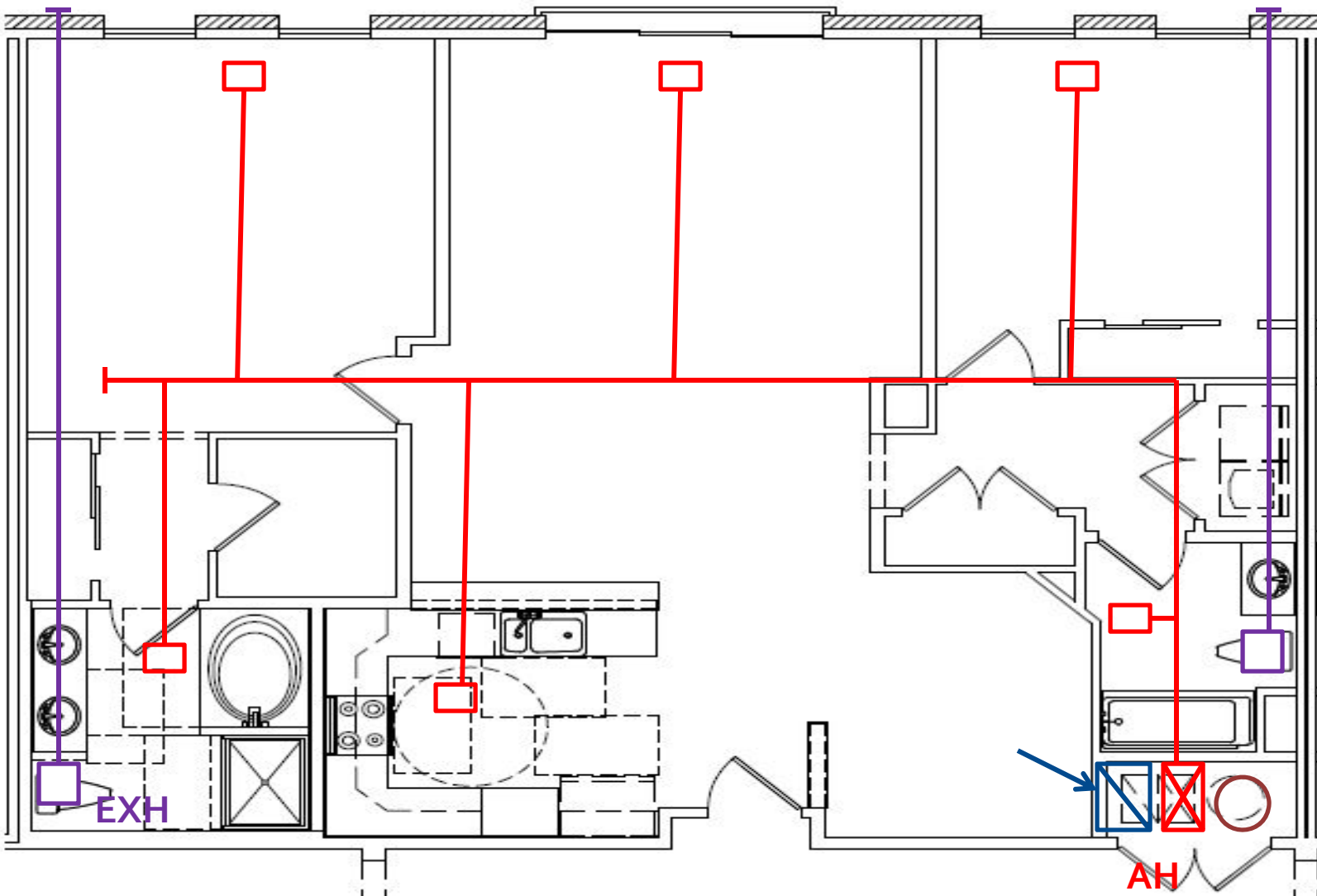


# Example #2

- ▶ Multi Family Unit – Hall Closet
- ▶ Building Type:
  - Wood frame above parking garage and transfer slab;
  - Hybrid Mansard Roof with hidden flat section in center;
  - Wood Frame with Floor-Ceiling Trusses;
  - No space at grade for mechanical equipment;
  - Common Entries with stair towers and central elevator;
  - Mid-Rise (4 stories), Market Rate, Condo
- ▶ No Above Code Program
- ▶ Fuels:
  - Individually metered Gas & Electric





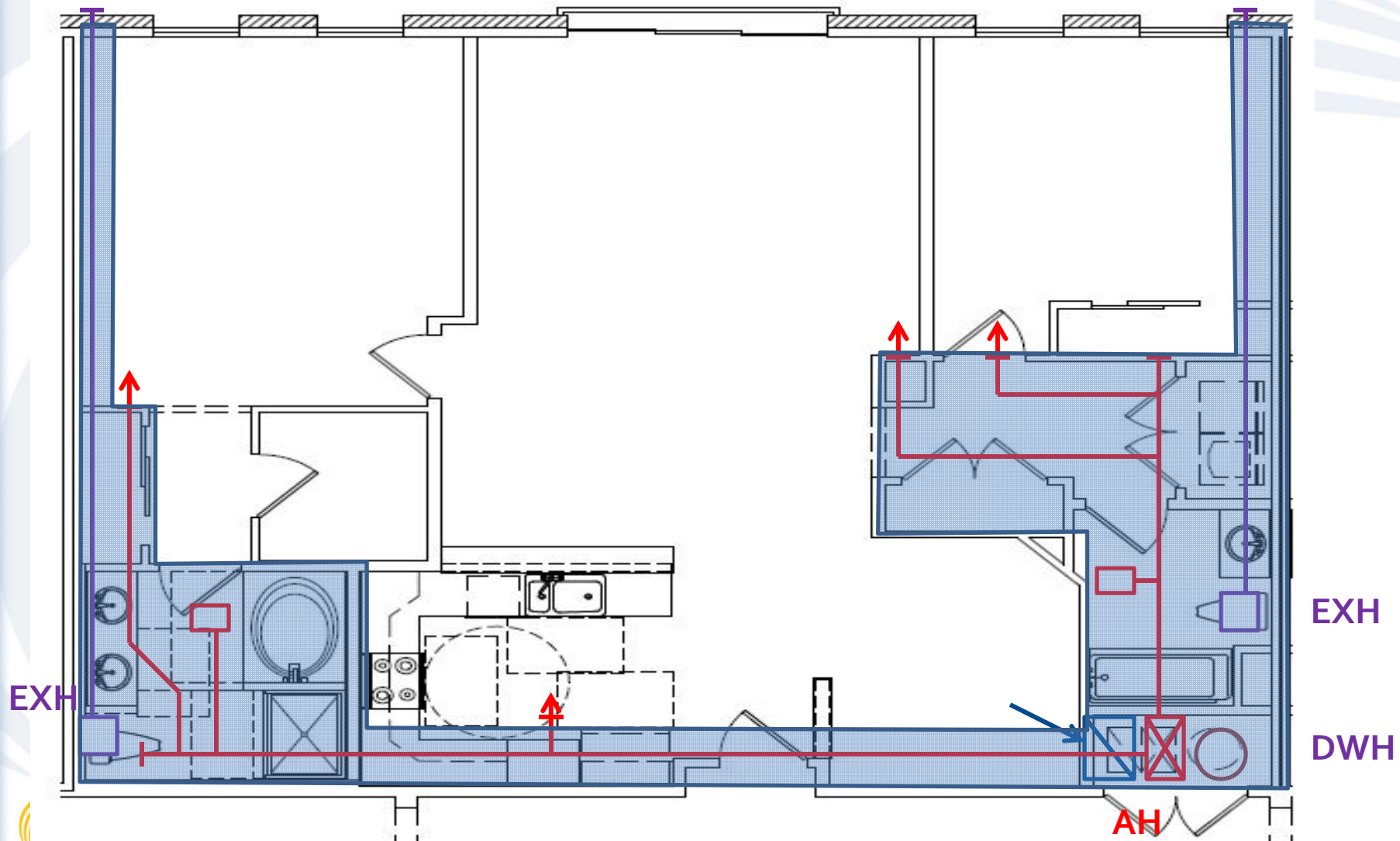


EXH

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AH





# Questions?



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