Connecticut ASHRAE Chapter

A2L Considerations for VRF Systems

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In this and all other ASHRAE meetings, we will act with honesty, fairness, courtesy, competence, inclusiveness and respect for others, which exemplify our core values of excellence, commitment, integrity, collaboration, volunteerism and diversity, and we shall avoid all real or perceived conflicts of interests.

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MITSUBISHI ELECTRIC TRANE HVAC US

A2L VRF Design & Application

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While we have made efforts to present information that is current as of the date of this presentation, we disclaim any assurances that such information is complete and correct, and you are urged to confirm all such information before relying on it.

Product information and applicable standards and codes are subject to change, and we disclaim any obligation to inform you of any subsequent changes.

Objectives

- A2L Product Timeline
- ASHRAE 15-2022 Refrigerant Charge Limits for Design
- ASHRAE 15-2022 Shafts & Shaft Ventilation
- VRF Design & Applications

A2L Product Timeline

A2L Product Timeline

Split Systems & Multi-Split Single Phase

Sell through and new installations until 12/31/25 approved by EPA

No import of R-410A product after 1/1/25 except for purposes of service of existing system

VRF & 3 Phase Multi-Split Systems

Sell through and new installations until 12/31/26

No import of R-410A product after 1/1/26 except to service/repair existing installations

Service after 2026 shall not include increase of system capacity (ODU)

ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7 – PAGE 10

New ASHRAE Standard 15-2022

- A2L HVAC designs need to ensure that a portion of the system's refrigerant charge that can be released into a space meets the EDVC amount.
- Key Terms:
  - **7.3.1 effective dispersal volume charge (EDVC):** the maximum refrigerant charge permitted for an effective dispersal volume
  - **7.3.4 releasable refrigerant charge (m_{rel}):** a portion of the system refrigerant charge that can be released into a space as a result of a single point of failure.

7.2* Volume Calculations

7.2.1 General. The *effective dispersal volume* identified in Section 7.3 into which *refrigerant* will disperse in the event of a release *shall* be calculated in accordance with this section. Volume calculations *shall* evaluate each space or *connected spaces* relevant to each refrigeration system. The smallest volume into which *refrigerant* disperses *shall* be used to determine the *refrigerant* quantity limit in the system.

7.6.1.1* Refrigeration Systems with Air Circulation. Where a *high-probability system* for human comfort using Group A2L *refrigerants* has either

a. *air circulation* initiated by a *refrigerant detector* in compliance with Section 7.6.2.4 or
b. continuous *air circulation*,

the *refrigerant* charge quantity *shall* be limited per Equation 7-8. Control of continuous *air circulation shall* be performed by the *listed* equipment and *shall* operate continuously other than short periods for maintenance and service:

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ} \quad (7\text{-}8)$$

where

$EDVC$ = *effective dispersal volume charge*, lb (kg)
V_{eff} = *effective dispersal volume*, ft^3 (m^3)
LFL = *lower flammability limit*, lb/ft^3 (kg/m^3)
CF = concentration factor, value of 0.5
F_{occ} = *occupancy* adjustment factor; (For all *occupancies* other than *institutional occupancies*, F_{occ} has a value of 1. For *institutional occupancies*, F_{occ} has a value of 0.5.)

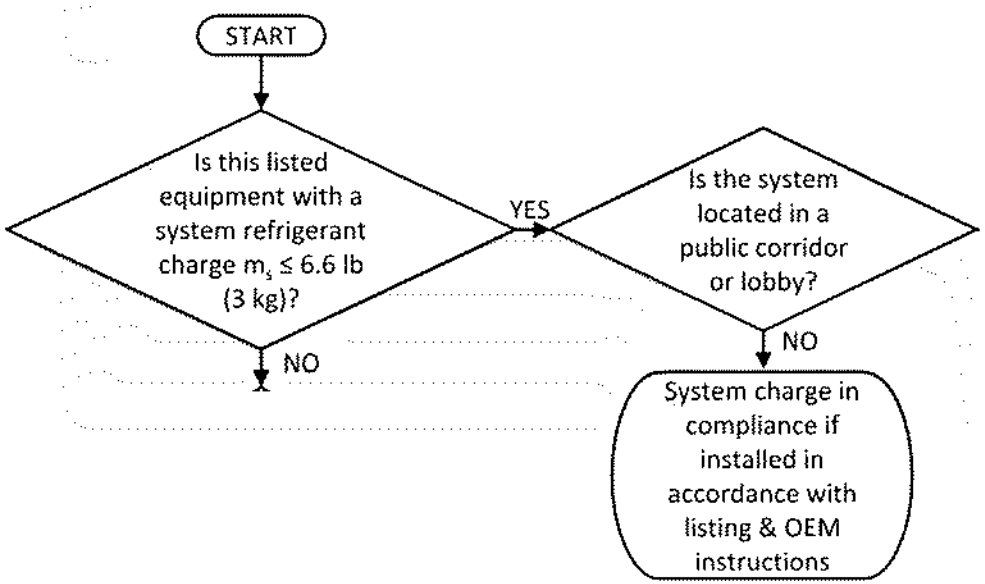
7.3.4* Releasable Refrigerant Charge (m_{rel}) Determination. The *releasable refrigerant charge* (m_{rel}) *shall* comply with the requirements of Section 7.3.1. The *releasable refrigerant charge shall* be determined in accordance with Sections 7.3.4.1 through 7.3.4.4. *Releasable refrigerant charge* determination in accordance with Sections 7.3.4.3 and 7.3.4.4 *shall not* be permitted for *institutional occupancies*.

ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7.3.1 – PAGE 13

Typical Compliance Pathway

- If the system charge is less or equal to 6.6 lbs and not located in a public corridor or lobby, the system is compliant.
- Mini-split systems may have less than 6.6 lbs.
- Verify with engineering manuals for system charges.
- For long line piping applications, determine total system charge.

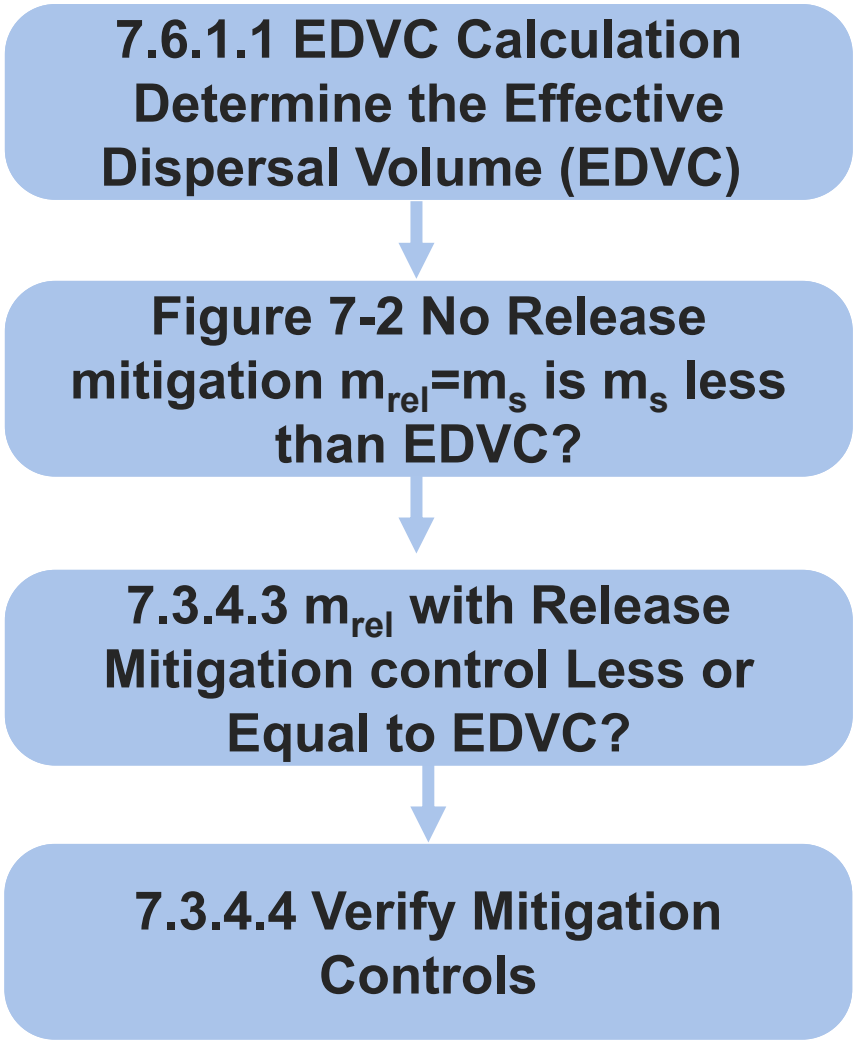


ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7.3.1 – PAGE 12

Typical VRF Compliance Pathway

- **7.6.1.1** The EDVC shall be determined per Section 7.6.1.1, using the occupied space identified by Section 7.2.2.1
- **7.3.4.3** Releasable charge of each independent circuit is determined and must be less than or equal to the EDVC to be in compliance
- **7.3.4.4** VRF may have mitigation controls complying with Section 7.3.4.4. These will include leak detectors and isolation boxes.



ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7.3 – PAGE 12

7.6.1.1 Determining the EDVC

- The EDVC shall be determined per Section 7.6.1.1, using the occupied space identified by Section 7.2.2.1
- Examples:
  - EDVC (lbs) = Space Volume(cu ft) x 18.5lb/1000ft^3 x 0.5 x 1
  - EDVC (lbs) = Space Volume(cu ft) x 18.5lb/1000ft^3 x 0.5 x 0.5, “Institutional”

$$EDVC = V_{eff} \times LFL \times \mathrm{CF} \times F_{occ} \qquad (7\text{-}8)$$

where

$EDVC$	=	*effective dispersal volume charge*, lb (kg)
V_{eff}	=	*effective dispersal volume*, ft^3 (m^3)
LFL	=	*lower flammability limit*, lb/ft^3 (kg/m^3)
CF	=	concentration factor, value of 0.5
F_{occ}	=	*occupancy* adjustment factor; (For all *occupancies* other than *institutional occupancies*, F_{occ} has a value of 1. For *institutional occupancies*, F_{occ} has a value of 0.5.)

ASHRAE 15-2022 Refrigerant Charge Limits for Design

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7.3.4 Releasable Charge Compliance

- Determine the cubic feet of the conditioned space.
  - Space area & ceiling height
- Verify the **Mrel** refrigerant amount is less or equal to the EDVC
- Connectivity via adjacent space opening can be used to adjust space volume*

7.3.4.3 Calculating Releasable Refrigerant Charge. For *releasable refrigerant charge*, release mitigation controls complying with Section 7.3.4.4 *shall* be provided to limit a release by automatically isolating leaking *piping* or equipment. The *releasable refrigerant charge* (m_{rel}) *shall* be determined based on a release of the volume of *refrigerant* that will occur prior to operation of the release mitigation control plus the volume of *refrigerant* contained downstream of a release mitigation control in accordance with Equation 7-4a or 7-4b:

$$m_{rel} = (t_{r1} \times 0.0062) + m_{r2} + m_{r3} \qquad \text{(7-4a [I-P])}$$

ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7.3.4.4 – PAGE 15

7.3.4.4 Verify Mitigation

- Depending on manufacturer, products will be equipped with mitigations controls.
- Refrigerant Solenoid Boxes to isolate refrigerant.
- Leak detection at the fan coil serving the occupied space.
- Control logic to close refrigerant isolation boxes in the event of refrigerant detection.

7.3.4.4 Release Mitigation Controls. Release mitigation controls used to limit the *releasable refrigerant charge* (m_{rel}) *shall* comply with the following:

a. Release mitigation systems *shall* be components of a refrigeration system that is *listed* per UL 60335-2-40 [5]/CSA C22.2 No. 60335-2-40 [6] or UL 60335-2-89 [7]/CSA C22.2 No. 60335-2-89 [8] and evaluated by the *nationally recognized testing laboratory* as part of the listing.

b. Release mitigation controls *shall* only be permitted for reducing the *releasable refrigerant charge* (m_{rel}) on a refrigeration system where each indoor unit has a cooling capacity of 5 tons (17.5 kW) or less.

c. Release mitigation controls *shall* be activated by a *refrigerant detection system*. A *refrigerant detector shall* be located either in all refrigeration equipment serving the spaces or in all spaces served by the release-mitigation-controlled circuit. The *refrigerant detector shall* activate the release mitigation controls and isolate all possible paths of *refrigerant* that can leak into the space(s).

d. In the event of a failure of the release mitigation controls or a *refrigerant detector*, the release mitigation controls *shall* isolate all possible paths of *refrigerant* that can leak into the space(s).

e. *Refrigerant detectors shall* comply with Section 7.6.2.4 and *shall* activate the mitigation controls per Section 7.6.2.5. For Group A1 *refrigerants*, 100% of *RCL shall* be substituted in place of 25% of *LFL*.

f. The location of *refrigerant* mitigation controls *shall* be marked in accordance with the requirements of ASME A13.1 [9].

g. Release mitigation controls *shall* be tested in accordance with Section 9.13.

ASHRAE 15-2022 Refrigerant Charge Limits for A2L Design

ASHRAE STANDARD 15-2022 CHAPTER 7.2.3.2.2 – PAGE 11

7.2.3.2.2 Natural Ventilation Opening

- ASHRAE defines a permanent opening for connected spaces.
- When using an opening to connect two spaces, determine the required square feet of the opening size.
- Volume of rooms can be combined if a permanent opening with a minimum size as calculated per 7-2a (Natural Ventilation Opening) is provided.

7.2.3.2 Connected Spaces via Natural Ventilation. *Connected spaces shall* be on the same floor. *Connected spaces shall* be provided with permanent natural ventilation opening(s). Permanent natural ventilation opening(s) *shall* be sized in accordance with Section 7.2.3.2.1 or 7.2.3.2.2. The lower edge of the natural ventilation opening between rooms *shall* be located a maximum of 12 in. (305 mm) above the finished floor. The area of any openings above 12 in. (305 mm) from the floor *shall not* be considered. The required size of opening(s) *shall* be based on the net free area.

ANSI/ASHRAE Addendum m to
ANSI/ASHRAE Standard 15-2022

$$A_{vent} = \frac{m_{rel} - m_{room}}{\mathrm{RCL} \times 0.417} \times \sqrt{\frac{A}{g \times m_{room}}} \times \frac{M_r}{M_r - M_a}$$

ASHRAE 15-2022 VRF Design & Application

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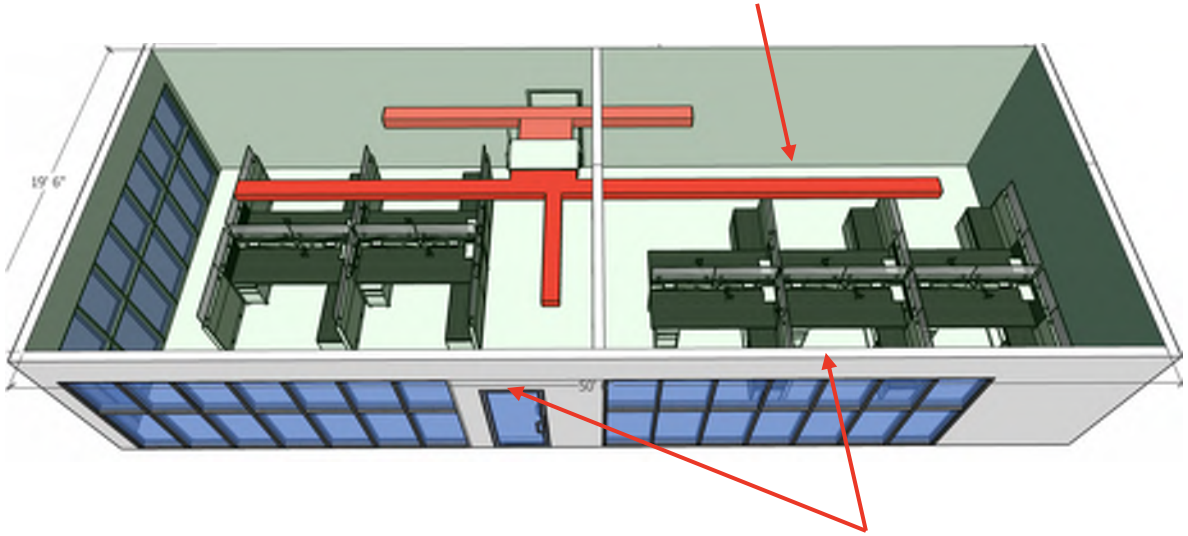
7.2.3.3 Connected Spaces via Ducted Air Distribution System

- Where a refrigeration system or a part thereof is located within an air distribution *duct* system or in a space served by an air distribution *duct* system, the entire air distribution system *shall* be analyzed to determine the worst-case distribution of leaked *refrigerant*.
- Ducted fan coils serving multiple offices for example, you include the cubic area for all spaces served to calculate the EDVC.
- **7.2.3.3.2** Include plenum space when it's a part of the air distribution system
- **7.2.3.4** Supply & Return Ducts volume shall be included in the EDVC

7.2.3.3 Connected Spaces via Ducted Air Distribution System. Where a refrigeration system or a part thereof is located within an air distribution *duct* system or in a space served by an air distribution *duct* system, the entire air distribution system *shall* be analyzed to determine the worst-case distribution of leaked *refrigerant*. The *effective dispersal volume* in which the leaked *refrigerant* disperses *shall* be used to determine the *EDVC* in the system, subject to the criteria in the following subsections.

Calculate the EDVC for the entire area



Fan coil serving multiple spaces

ASHRAE 15-2022 Refrigerant Charge Limits for Design

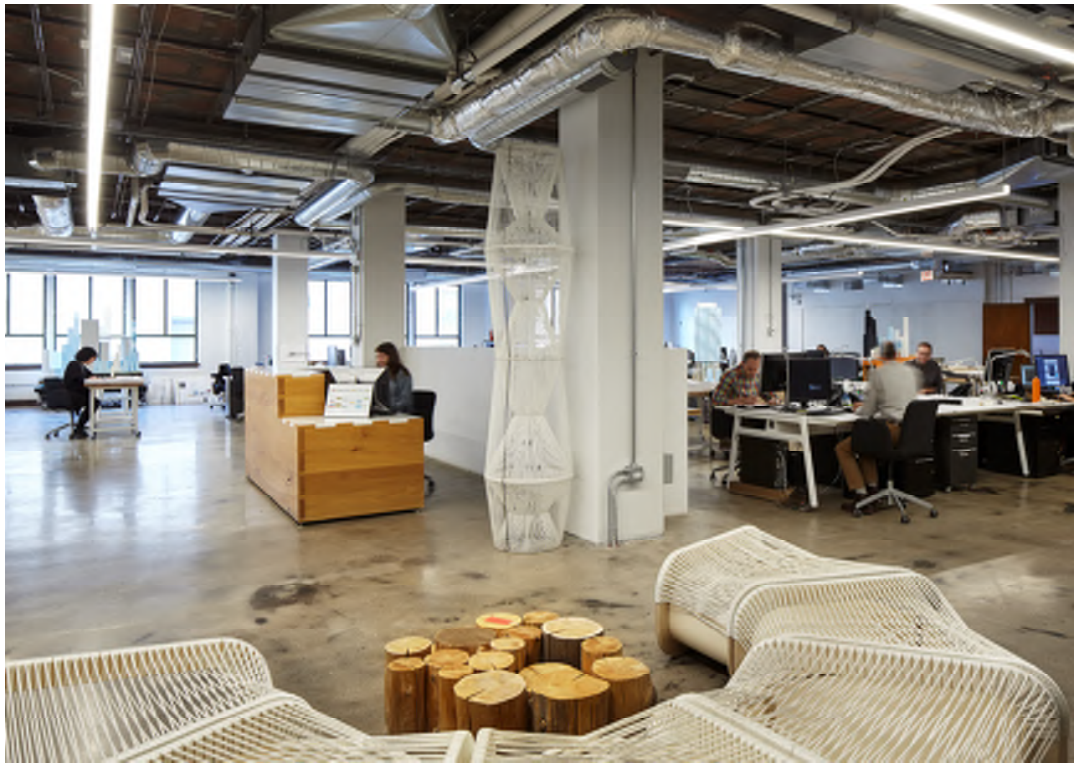
ASHRAE STANDARD 15-2022 CHAPTER 7

Considerations & Countermeasures

- 7.3.4.4 Mitigation controls shall only be on indoor units ≤ 5 tons nominal cooling capacity. For zones that require more than 5 tons, use multiple smaller indoor units.
- Mitigation isolation valves shall be installed in a space that can accommodate the full system charge.

7.3.4.4 Release Mitigation Controls. Release mitigation controls used to limit the *releasable refrigerant charge* (m_{rel}) *shall* comply with the following:

b. Release mitigation controls *shall* only be permitted for reducing the *releasable refrigerant charge* (m_{rel}) on a refrigeration system where each indoor unit has a cooling capacity of 5 tons (17.5 kW) or less.



Refrigerant Charge Limits for Design

- ASHRAE 15-2022 provides clarity for design.
- VRF does have a path to comply and may be used in most applications

ASHRAE 15-2022 Shafts & Shaft Ventilation

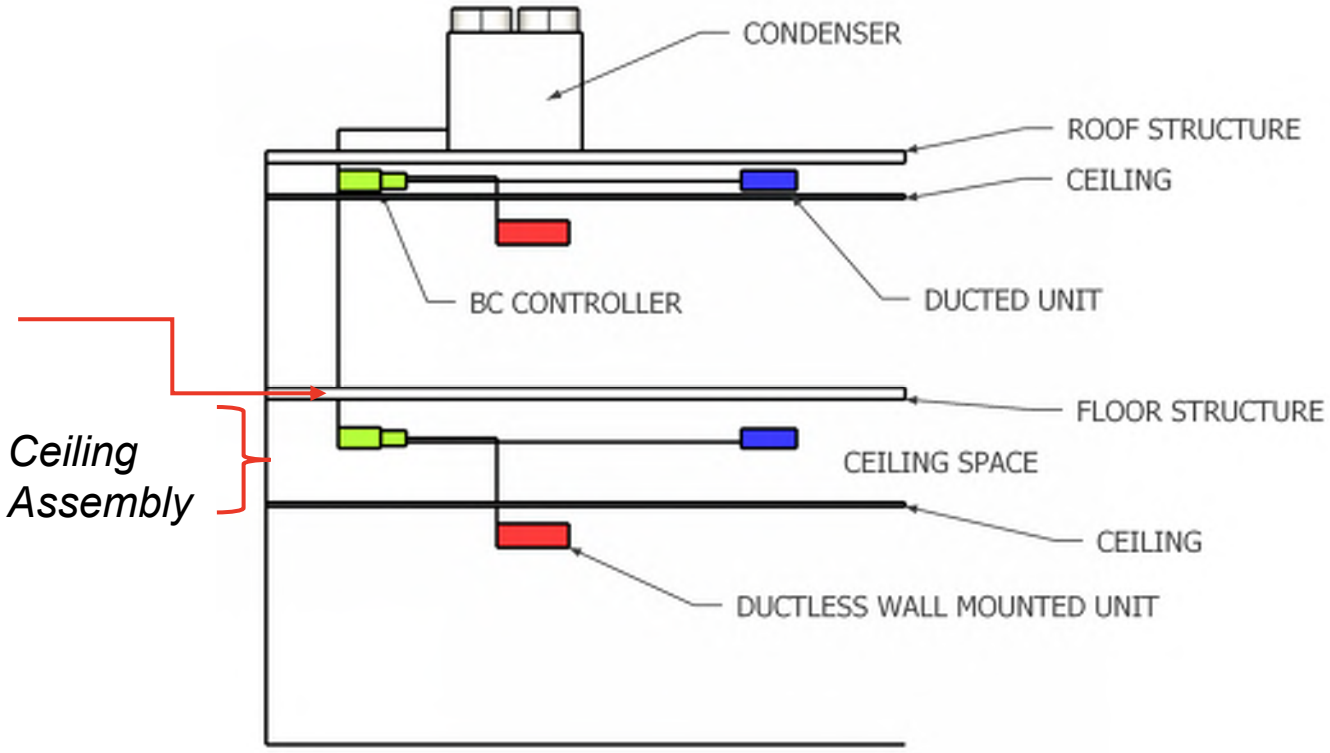
ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 54

Refrigerant Shafts & Ventilation

- **9.12.1.5** Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure.
- Refrigerant piping passing through 1 complete ceiling assembly does not require a fire-resistance-rated shaft.
- The roof structure assemblies is defined differently from floor/ceiling assemblies; therefore, is not considered one of the two floor/ceiling assemblies.

9.12.1.5 Refrigerant Pipe Shafts. *Refrigerant piping* that penetrates two or more floor/ceiling assemblies *shall* be enclosed in a *fire-resistance-rated* shaft enclosure. The *fire-resistance-rated* shaft enclosure *shall* comply with the requirements of the *building code*. Other building utilities or *piping* systems *shall* be allowed in the *refrigerant piping* shaft.



ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.5.1 – PAGE 54

Refrigerant Shafts & Ventilation

- **9.12.1.5.1 Shaft Alternative (b)**
  - Exception (b.) states where the refrigerant concentration does not exceed the RCL for the smallest occupied space through which the piping passes.
  - Mini-splits and VRF systems may run the refrigerant piping between 2 or more floors without a piping shaft IF the total charge does not exceed the RCL of the occupied space it passes through.

9.12.1.5.1 Shaft Alternative. A shaft enclosure *shall not* be required for the *refrigerant piping* for any of the following *refrigerating systems*:

a. Systems using R-718 (water) *refrigerant*

b. *Piping* in a high-probability system where the *refrigerant* concentration does not exceed the amounts shown in ASHRAE Standard 34 [3], Table 4-1 or 4-2, for the smallest *occupied space* through which the *piping* passes

c. *Piping* located on the exterior of the building where vented to the outdoors

*The 2024 IMC language *currently* limits this to A1 refrigerants only.*

1109.2.5: Refrigerant pipe shafts. CRP

Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure. The fire-resistance-rated shaft enclosure shall comply with Section 713 of the International Building Code.

Exceptions:

1. *Refrigeration* systems using R-718 refrigerant (water).
2. Piping in a direct refrigeration system using Group A1 refrigerant where the refrigerant quantity does not exceed the limits of Table 1103.1 for the smallest occupied space through which the piping passes.
3. Piping located on the exterior of the *building* where vented to the outdoors.

ASHRAE 15-2022 Shafts & Shaft Ventilation

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Refrigerant Shafts & Ventilation

- **9.12.1.5.1 Shaft Alternative (b)**
  - R454B: RCL is 4.6lbs/1000cuft
  - Example: 1.5 ton mini-split serving small condo/hotel.
  - Piping passing though occupied space within the wall.
  - RCL calculation for occupied space is 8.4lbs. System charge is 3.9lbs.
  - Refrigerant piping passes through more than 2 floor/ceiling assemblies

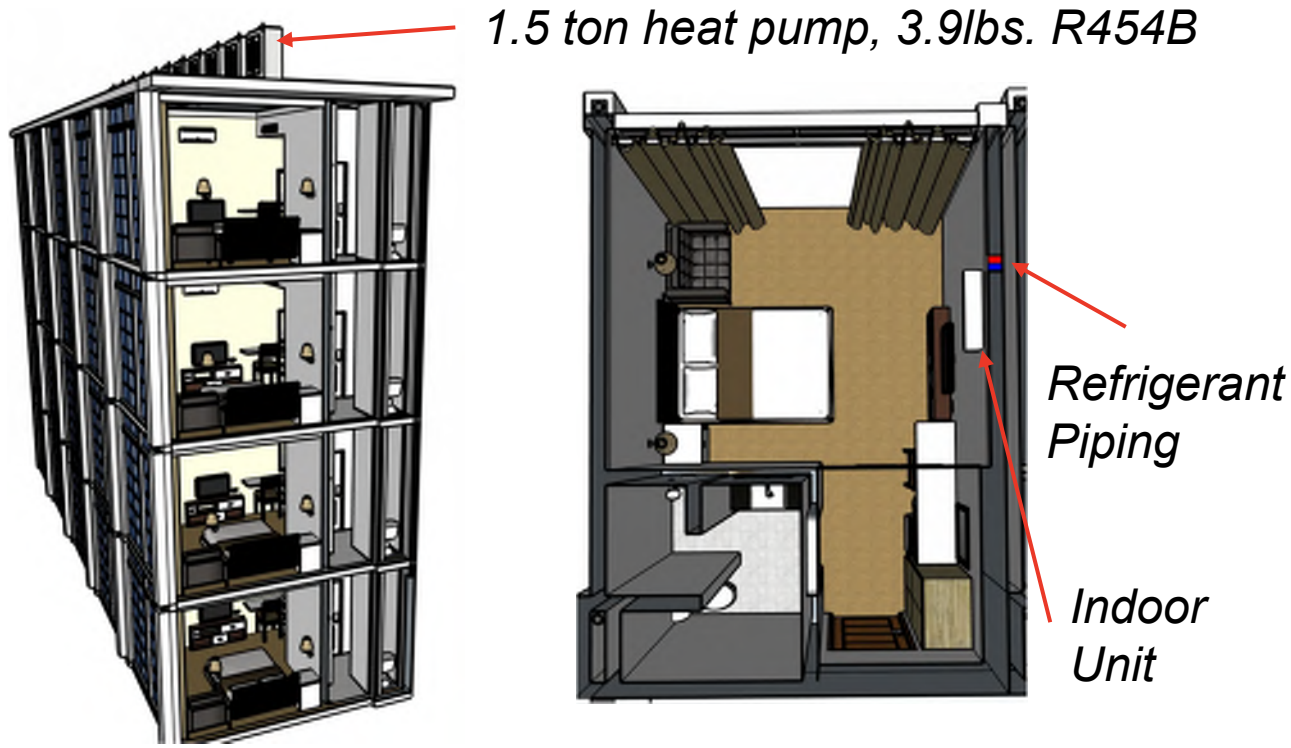
No shaft enclosure required

9.12.1.5.1 Shaft Alternative. A shaft enclosure *shall not* be required for the *refrigerant piping* for any of the following *refrigerating systems*:

a. Systems using R-718 (water) *refrigerant*

b. *Piping* in a high-probability system where the *refrigerant* concentration does not exceed the amounts shown in ASHRAE Standard 34 [3], Table 4-1 or 4-2, for the smallest *occupied space* through which the *piping* passes

c. *Piping* located on the exterior of the building where vented to the outdoors



ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 54

Refrigerant Pipe Shafts

No Ventilation Required

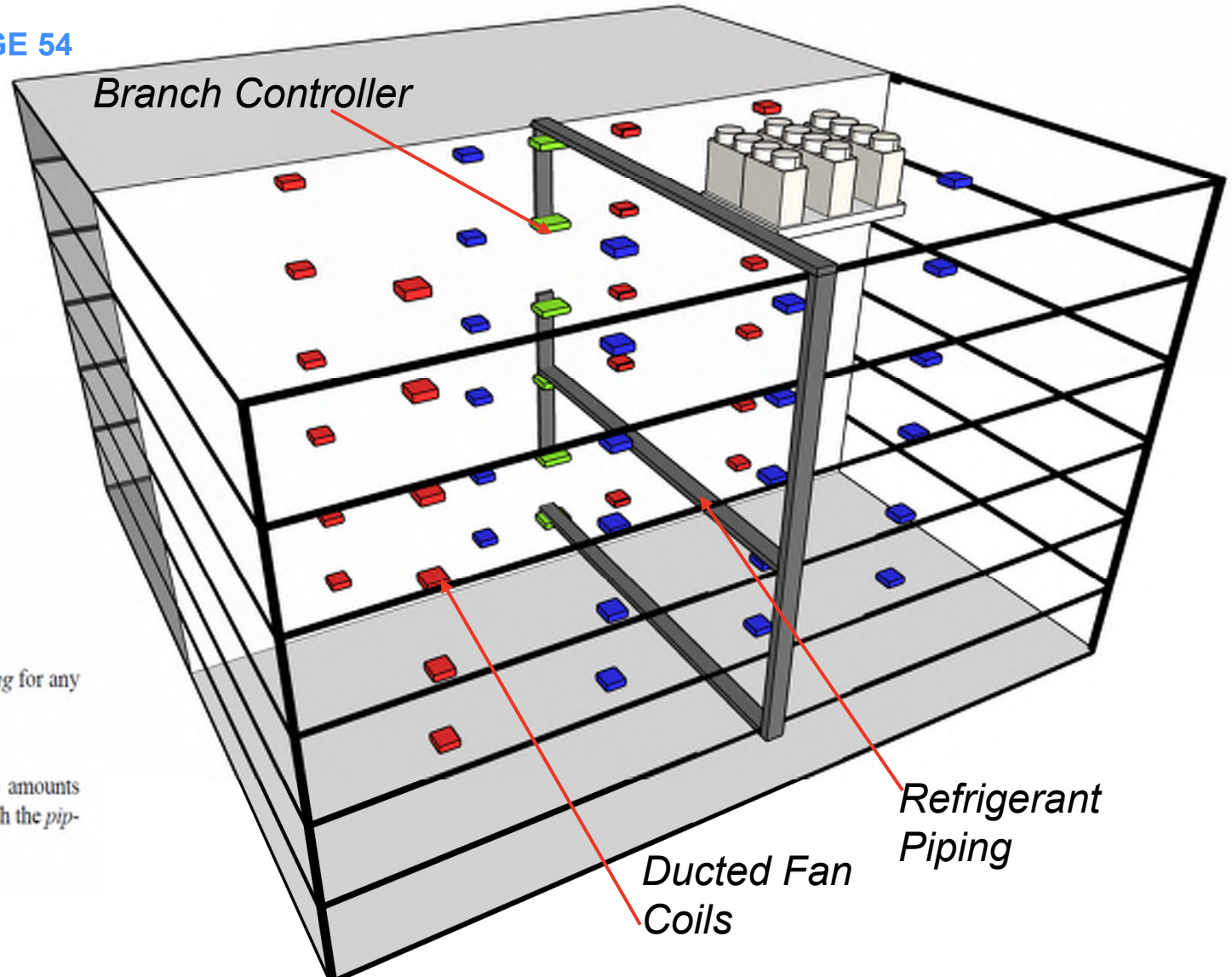
- Centrally roof mounted condensing units
- Natural or mechanical ventilation is not required when 9.12.1.5.1 conditions are meet.
- **9.12.1.5.1** Locate refrigerant piping chase outdoors, architecture louver

9.12.1.5.1 Shaft Alternative. A shaft enclosure *shall not* be required for the *refrigerant piping* for any of the following *refrigerating systems*:

a. Systems using R-718 (water) *refrigerant*

b. *Piping* in a high-probability system where the *refrigerant* concentration does not exceed the amounts shown in ASHRAE Standard 34 [3], Table 4-1 or 4-2, for the smallest *occupied space* through which the *piping* passes

c. *Piping* located on the exterior of the building where vented to the outdoors



ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 54

Refrigerant Pipe Shafts

No Ventilation Required

- Centrally roof mounted condensing units
- Natural or mechanical ventilation is not required
- **9.12.1.5.1** Locate refrigerant piping chase outdoors, architecture louver

9.12.1.5.1 Shaft Alternative. A shaft enclosure *shall not* be required for the *refrigerant piping* for any of the following *refrigerating systems*:

a. Systems using R-718 (water) *refrigerant*

b. *Piping* in a high-probability system where the *refrigerant* concentration does not exceed the amounts shown in ASHRAE Standard 34 [3], Table 4-1 or 4-2, for the smallest *occupied space* through which the *piping* passes

c. *Piping* located on the exterior of the building where vented to the outdoors

Exterior Architecture Louver Example

ASHRAE 15-2022 Shafts & Shaft Ventilation

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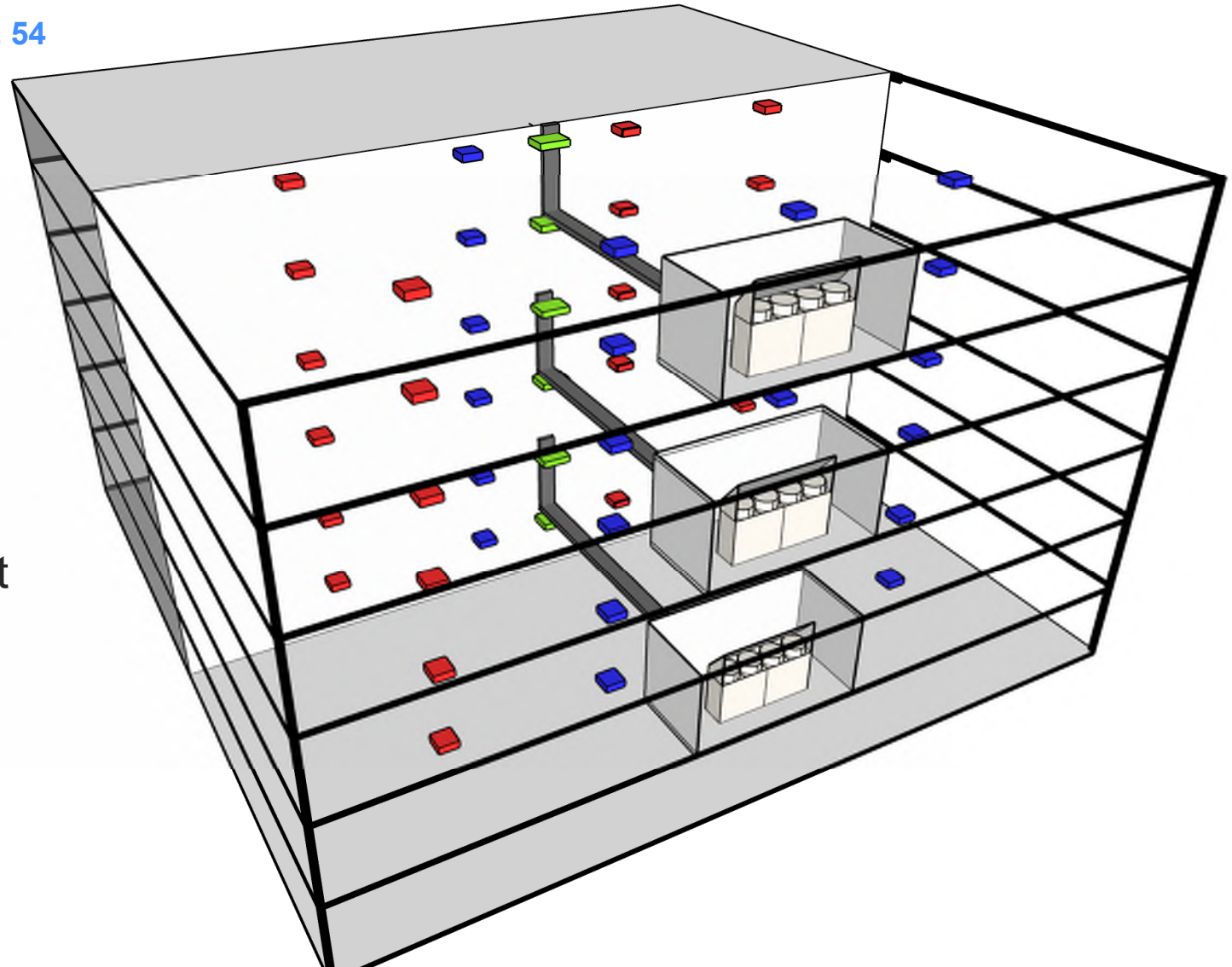
Refrigerant Pipe Shafts:

No Ventilation Required

- Locate condensing units outdoors to remove piping shafts.
- Natural or mechanical shaft ventilation is not required
- Reducing piping lengths and refrigerant volumes
- Condensing units serving the floor where they are located.



ASHRAE 15-2022 Shafts & Shaft Ventilation

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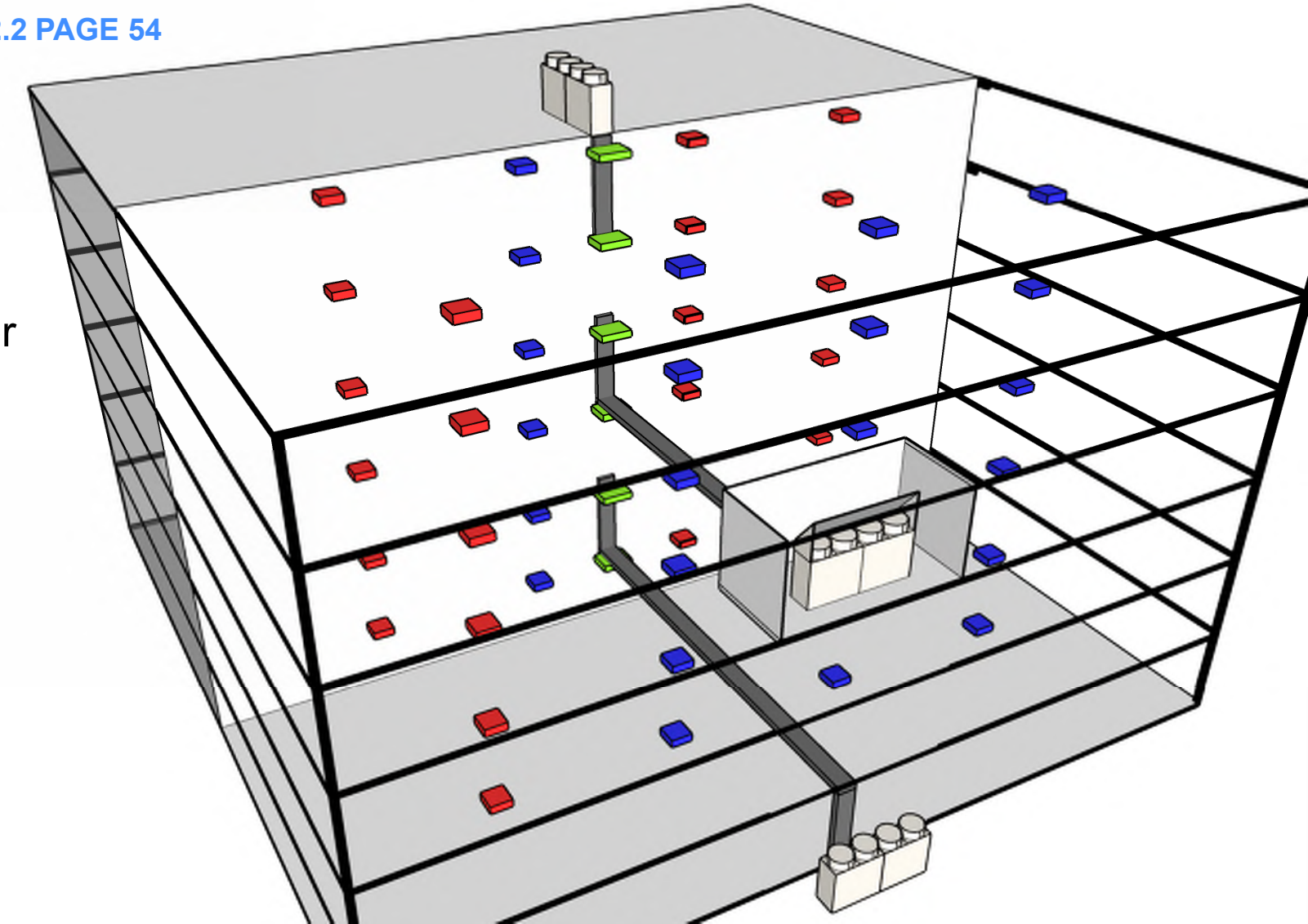
Refrigerant Pipe Shafts:

No Ventilation Options

- Locate condensing units where the piping does not penetrate 2 or more ceiling assemblies.
- Natural or mechanical shaft ventilation is not required.
- Reducing piping lengths and refrigerant volumes.
- Roof, exterior spaces, mezzanines, on-grade, parking garages are some example locations.



ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 55

Refrigerant Shafts & Ventilation

- **9.12.2.2** Refrigerant pipe shafts with systems using only Group A2L or B2L refrigerants shall be naturally or mechanically ventilated.
  - (a) Naturally ventilated shafts shall have a minimum of a 4” pipe/duct that connects at the lowest point of the shaft. Duct to be level or pitched down to the outdoors
  - (b) Mechanically ventilated shaft shall have a minimum air velocity table 9-12. Continuously operated fan or activated by a refrigerant detector located at the bottom of the shaft

9.12.2.2 Shaft Ventilation. *Refrigerant* pipe shafts with systems using only Group A2L or B2L *refrigerants shall* be naturally or mechanically ventilated. *Refrigerant* pipe shafts with one or more systems using any Group A2, A3, B2, or B3 *refrigerant shall* be continuously mechanically ventilated and *shall* include a *refrigerant detector*. The shaft ventilation exhaust outlet *shall* comply with the discharge location requirement *specified* in Section 9.7.8.2.

a. Naturally ventilated shafts *shall* have a minimum of a 4.0 in. (102 mm) diameter pipe, *duct*, or conduit that connects at the lowest point of the shaft and connects to the outdoors. The pipe, *duct*, or conduit *shall* be level or pitched down to the outdoors. A *makeup air* opening *shall* be provided at the top of the shaft.

b. When active, mechanically ventilated shafts *shall* have a minimum air velocity in accordance with Table 9-12. *Makeup air shall* be provided at the inlet to the shaft for mechanically ventilated shafts. The mechanical ventilation *shall* either be continuously operated or, for pipe shafts containing only systems using Group A2L or B2L *refrigerants*, activated by a *refrigerant detector*. *Refrigerant* pipe shafts utilizing a *refrigerant detector shall* have a set point not exceeding the *occupational exposure limit* (*OEL*) of the *refrigerant*. The detector, or a sampling tube that draws air to the detector, *shall* be located in an area where *refrigerant* from a leak will concentrate.

c. The shaft *shall not* be required to be ventilated for double-wall *refrigerant* pipe where the interstitial space of the double-wall pipe is vented to the outdoors in accordance with the discharge location requirements *specified* in Section 9.7.8.2.

ASHRAE 15-2022 Shafts & Shaft Ventilation

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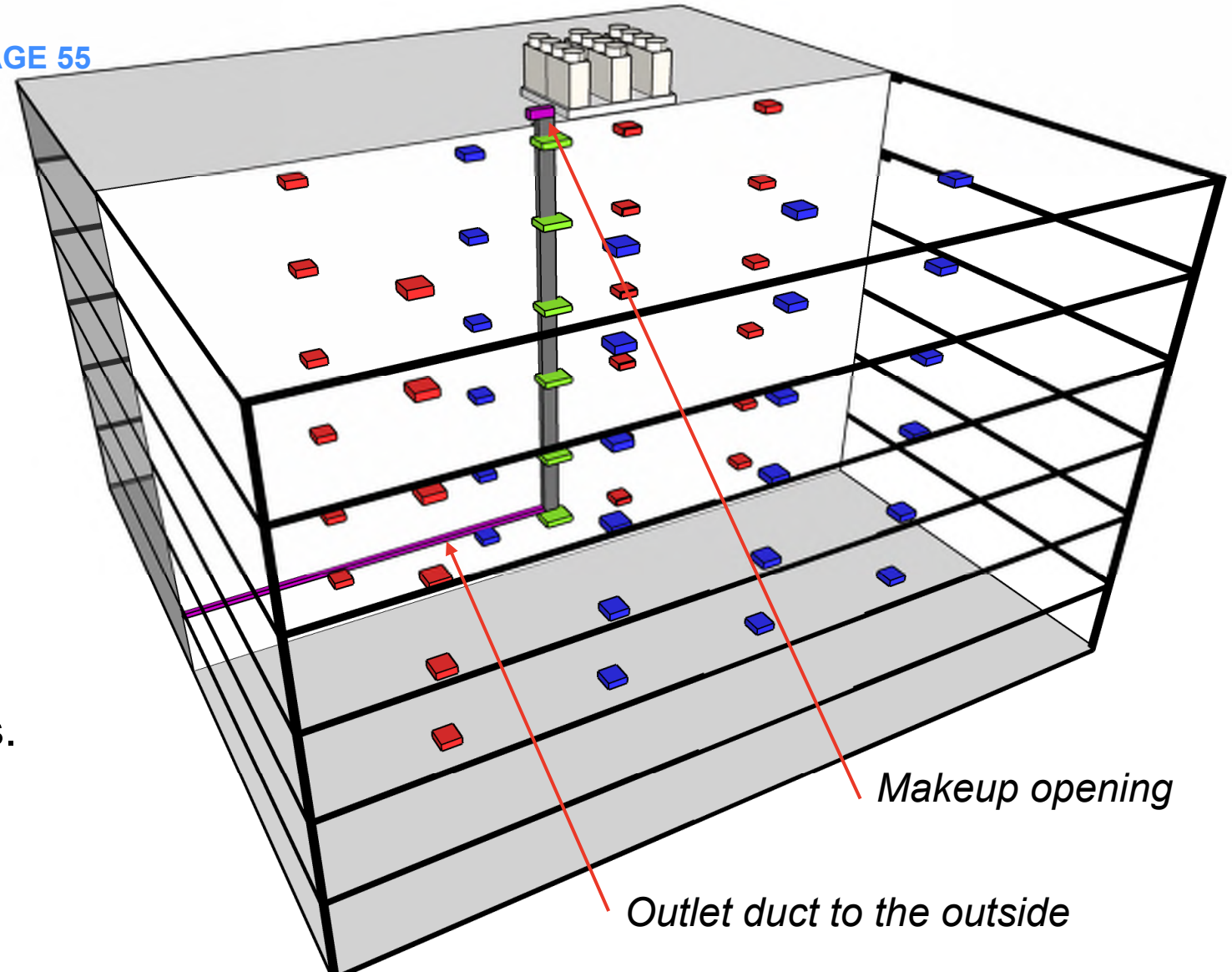
Refrigerant Pipe Shafts:

Natural Ventilation Required

- Condensing units centrally located
- Naturally ventilated shafts shall have a minimum of a 4.0 in. (102 mm) diameter pipe, duct, or conduit that connects at the lowest point of the shaft and connects to the outdoors.
- The pipe, duct, or conduit shall be level or pitched down to the outdoors. A makeup air opening shall be provided at the top of the shaft.



ASHRAE 15-2022 Shafts & Shaft Ventilation

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9.7.8.2 Discharging Location Exterior to Building

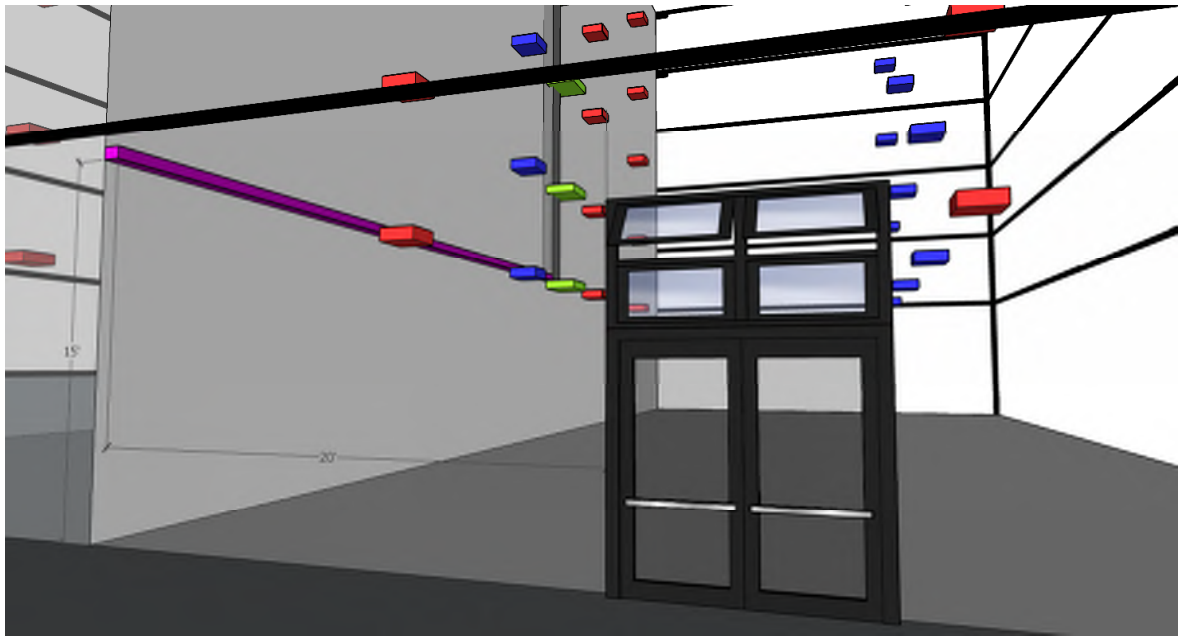
- The point of vent discharge shall be located not less than 15 ft (4.57 m) above the adjoining ground level.
  - *Option: End piping shaft at level 2 to keep the 15' above ground level.*
- The point of vent discharge shall be located not less than 20 ft (6.1 m) from windows, building ventilation openings, pedestrian walkways, or building exits

9.7.8.2 Discharging Location Exterior to Building. *Pressure relief devices* designed to discharge external to the refrigeration system *shall* be arranged to discharge outside of a building and comply with all of the following:

a. The point of vent discharge *shall* be located not less than 15 ft (4.57 m) above the adjoining ground level.
   Exception to (a): Outdoor systems containing Group A1 *refrigerant shall* be permitted to discharge at any elevation where the point of discharge is located in an access controlled area accessible to authorized personnel only.

b. The point of vent discharge *shall* be located not less than 20 ft (6.1 m) from windows, building ventilation openings, pedestrian walkways, or building exits.

c. For heavier-than-air *refrigerants*, the point of vent discharge *shall* be located not less than 20 ft (6.1 m) horizontally from below-grade walkways, entrances, pits, or ramps if a release of the entire system charge into such a space would yield a concentration of *refrigerant* in excess of the *refrigerant concentration limit* (*RCL*). The direct discharge of a relief vent into enclosed outdoor spaces, such as a courtyard with walls on all sides, *shall not* be permitted if a release of the entire system charge into such a space would yield a concentration of *refrigerant* in excess of the *RCL*. The volume for the *refrigerant* concentration calculation *shall* be determined using the gross area of the space and a height of 8.2 ft (2.5 m), regardless of the actual height of the enclosed space.



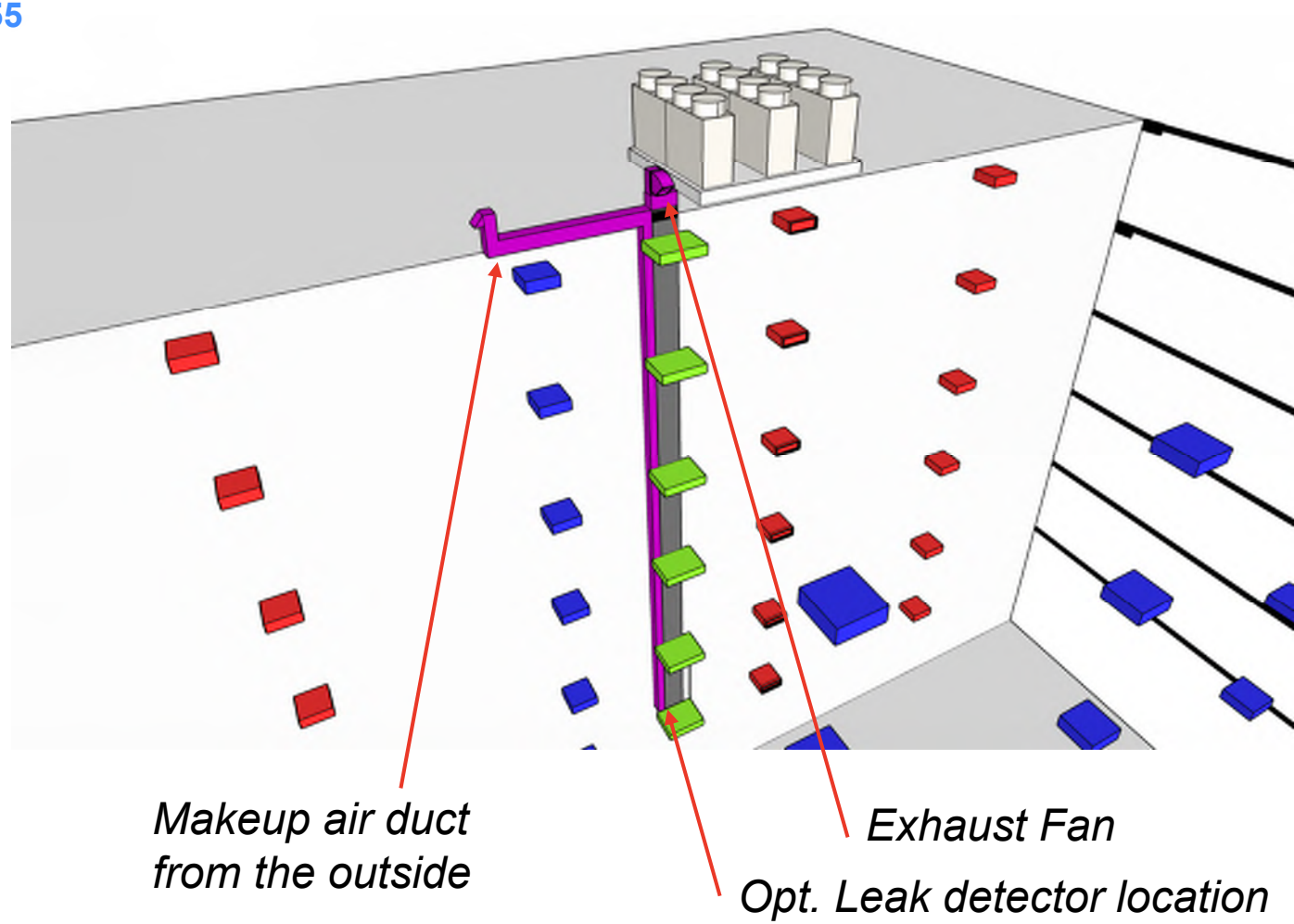
ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 55

Refrigerant Pipe Shafts:

Mechanical Ventilation

- Makeup air shall be provided at the inlet to the shaft
- A makeup air opening shall be provided at the bottom of the shaft.
- When active, mechanically ventilated shafts shall have a minimum air velocity in accordance with Table 9-12
- Continuously operated or, for pipe shafts containing only systems using Group A2L refrigerants, activated by a refrigerant detector.



ASHRAE 15-2022 Shafts & Shaft Ventilation

ASHRAE STANDARD 15-2022 CHAPTER 9.12.2.2 – PAGE 55

Refrigerant Pipe Shafts:

Mechanical Ventilation

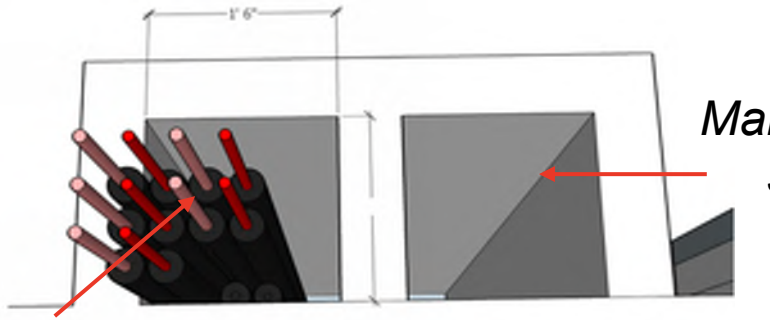
- When active, mechanically ventilated shafts *shall* have a minimum air velocity in accordance with Table 9-12.
- The mechanical ventilation *shall* either be continuously operated or, for pipe shafts containing only systems using Group A2L or B2L *refrigerants*, activated by a *refrigerant detector*.

Example:

- Cross-Sectional Area 18”x18”: 325”
- Requires 300 or greater ft/min
- CFM = (in^2 / 144 * (ft/min))
- 18”x18” Mech Shaft requires approx.: 677 CFM

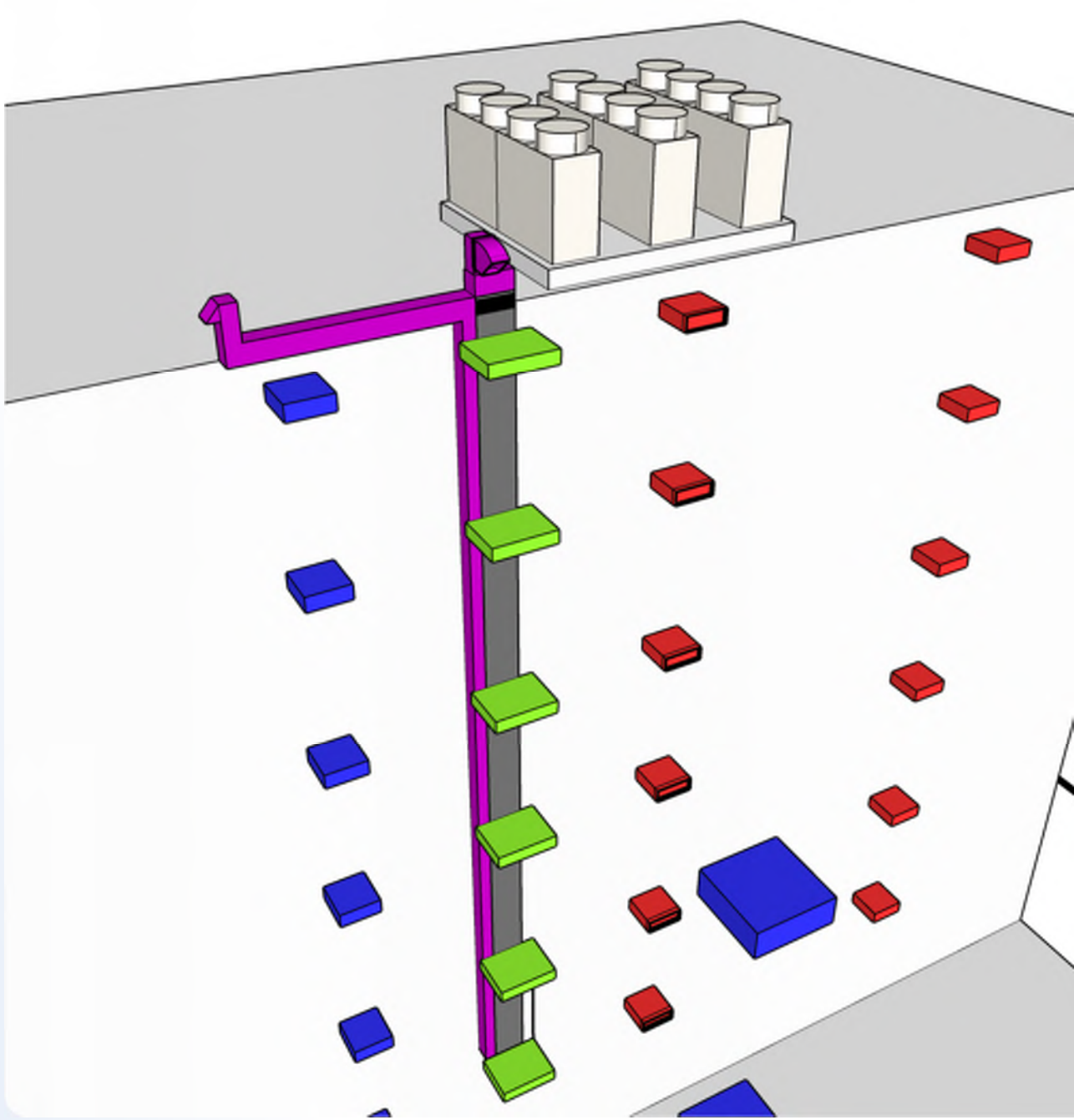
Table 9-12 Shaft Ventilation Velocity

Shaft Cross-Sectional Area, A		Minimum Ventilation Velocity, V	
$in.^2$	m^2	ft/min	m/min
$A \leq 20$	$A \leq 0.0129$	$100 \leq V$	$30.5 \leq V$
$20 < A \leq 250$	$0.0129 < A \leq 0.161$	$200 \leq V$	$61 \leq V$
$250 < A \leq 1250$	$0.161 < A \leq 0.806$	$300 \leq V$	$91 \leq V$
$1250 < A$	$0.806 < A$	$400 \leq V$	$122 \leq V$



Review Shaft Ventilation

- Refrigerant piping that penetrates two or more floor/ceiling assemblies shall be enclosed in a fire-resistance-rated shaft enclosure.
- Non-vented piping options are possible.
- Natural shaft ventilation requires exhaust vent to the outdoors at the lowest shaft point.



VRF Design & Application

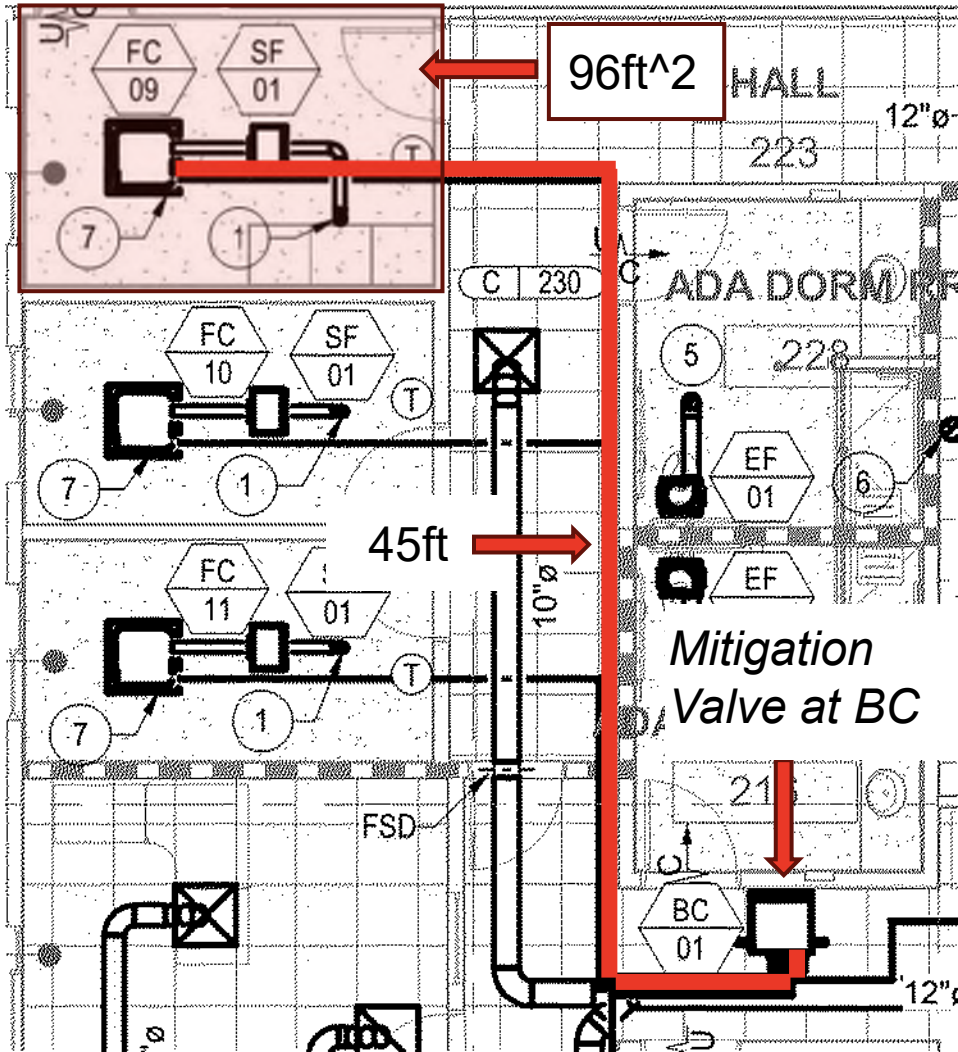
ASHRAE 15-2022 VRF Design & Application

ASHRAE STANDARD 15-2022 CHAPTER 7

Fan Coil Office Calculation Example:

- FC-9 w/ 8.5’ ceiling, Cubic Feet: 816ft^3
- EDVC: 816cuft / 1000cuft * 9.55lbs. = **7.8lbs. EDVC**
- Use Section 7.6.1.1 formula to calculate Mrel.
  - **Mrel = 2lbs.**
    - ¾ Ton Fan Coil
    - Mitigation valve located at the branch controller

- **2 Mrel < 7.8lbs**. EDVC: Zone Unit
  Compliance Check: **Complies**

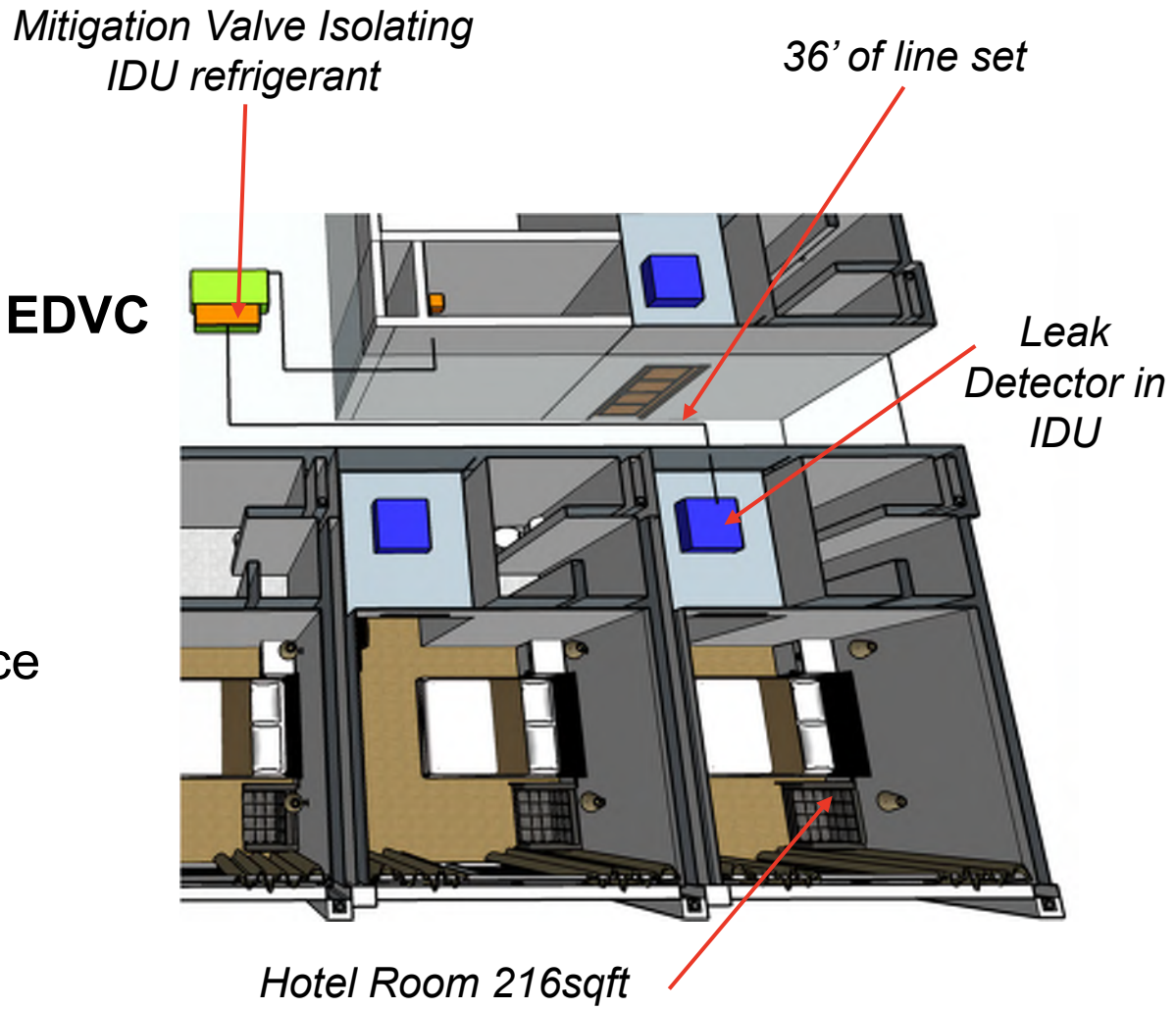


ASHRAE 15-2022 VRF Design & Application

ASHRAE STANDARD 15-2022 CHAPTER 7

Fan Coil Hotel Calculation Example:

- Cubic Feet: 1836ft^3
- EDVC: 1863cuft / 1000cuft * 9.55lbs. = **17.5 lbs EDVC**
- Use Section 7.6.1.1 formula to calculate Mrel.
  - **Mrel = 2.8lbs**.
    - 1 Ton Fan Coil
    - Mitigation valve located at the branch controller
- **2.8 Mrel < 17.5lbs**. EDVC: Zone Unit Compliance Check: **Complies**



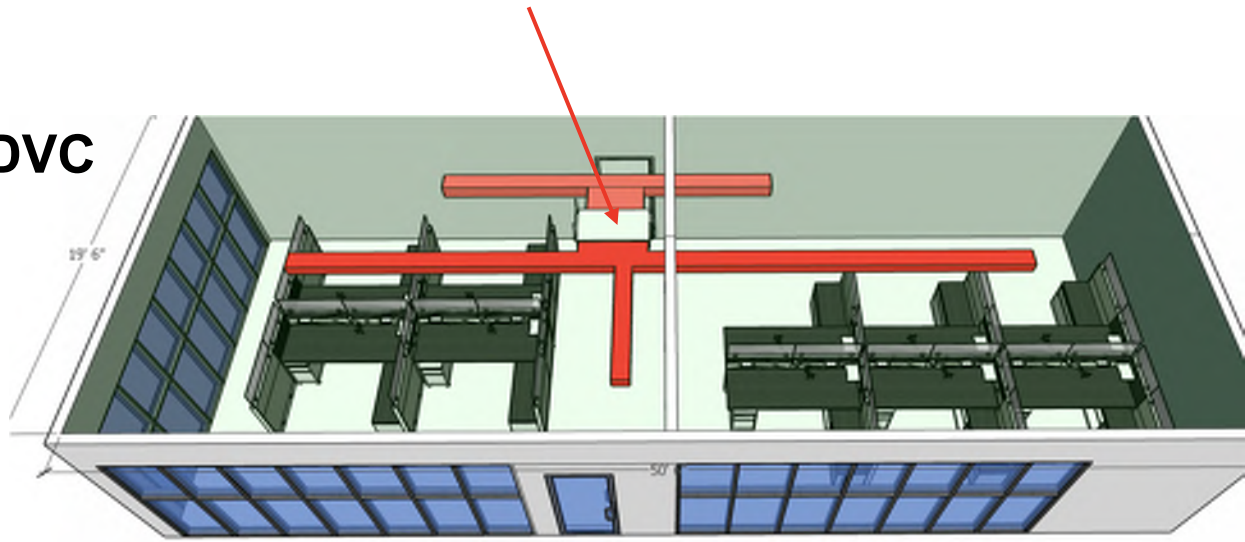
ASHRAE 15-2022 VRF Design & Application

ASHRAE STANDARD 15-2022 CHAPTER 7

Fan Coil Serving Multiple Spaces

- Ducted fan coil serving multiple spaces
- EDVC: 8500cuft * 9.55lbs / 1000cuft = **81lbs EDVC**
- Use Section 7.6.1.1 formula to calculate Mrel.
  - **Mrel = 42 lbs**
    - Total VRF System Charge: 42 lbs
- **42 Mrel < 81lbs**. EDVC: Zone Unit Compliance Check: **Complies**

Fan coil serving two separate spaces

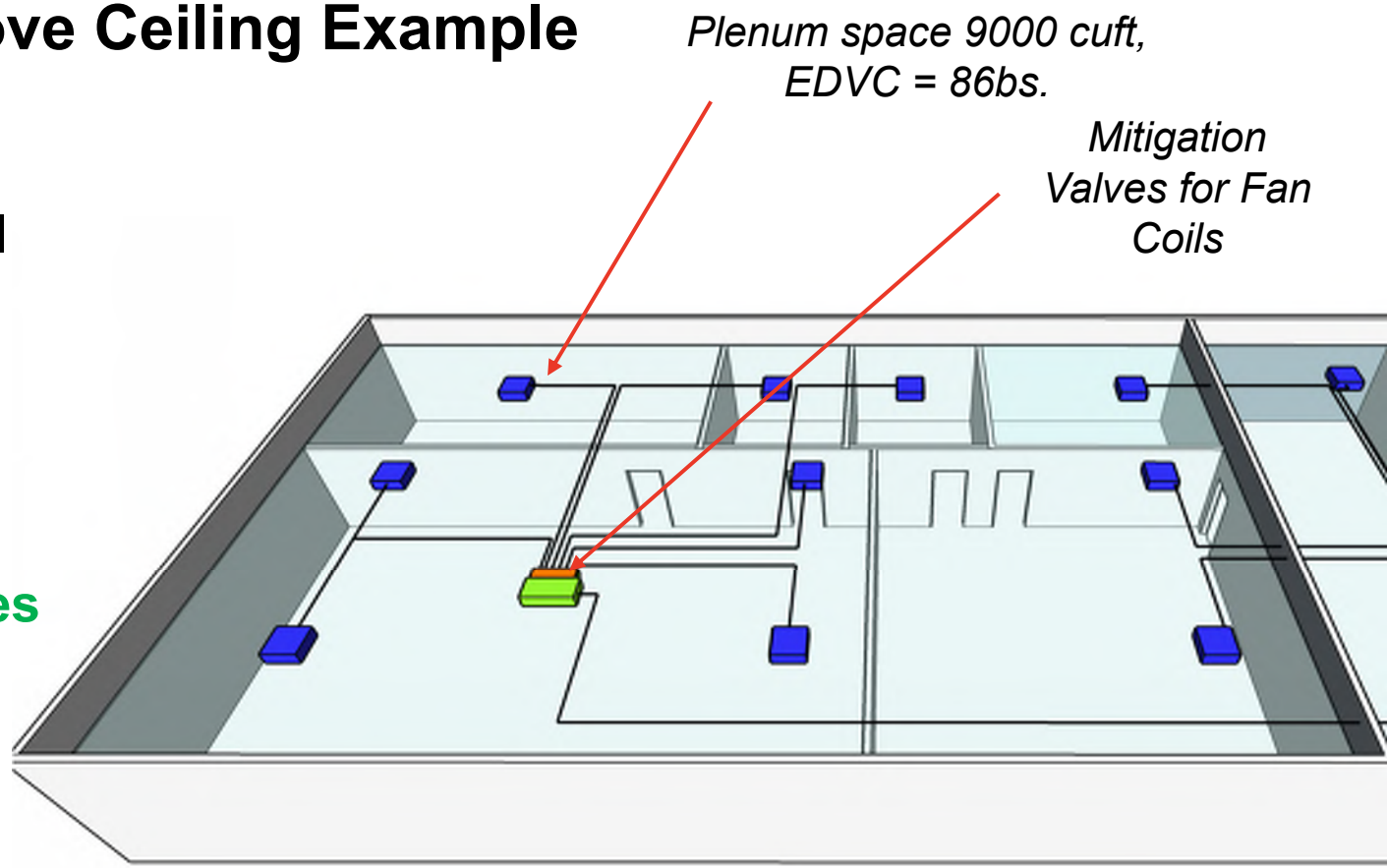


ASHRAE 15-2022 VRF Design & Application

ASHRAE STANDARD 15-2022 CHAPTER 7

Branch Controller Location – Above Ceiling Example

- Branch controllers can be installed within spaces that meet EDVC based on the full system charge.
- Mrel system charge: 65lbs.
- EDVC = 111.7lbs.
  - 9000* 9.55 / 1000
- **65lbs Mrel < EDVC: 111.7lbs**. - **Complies**



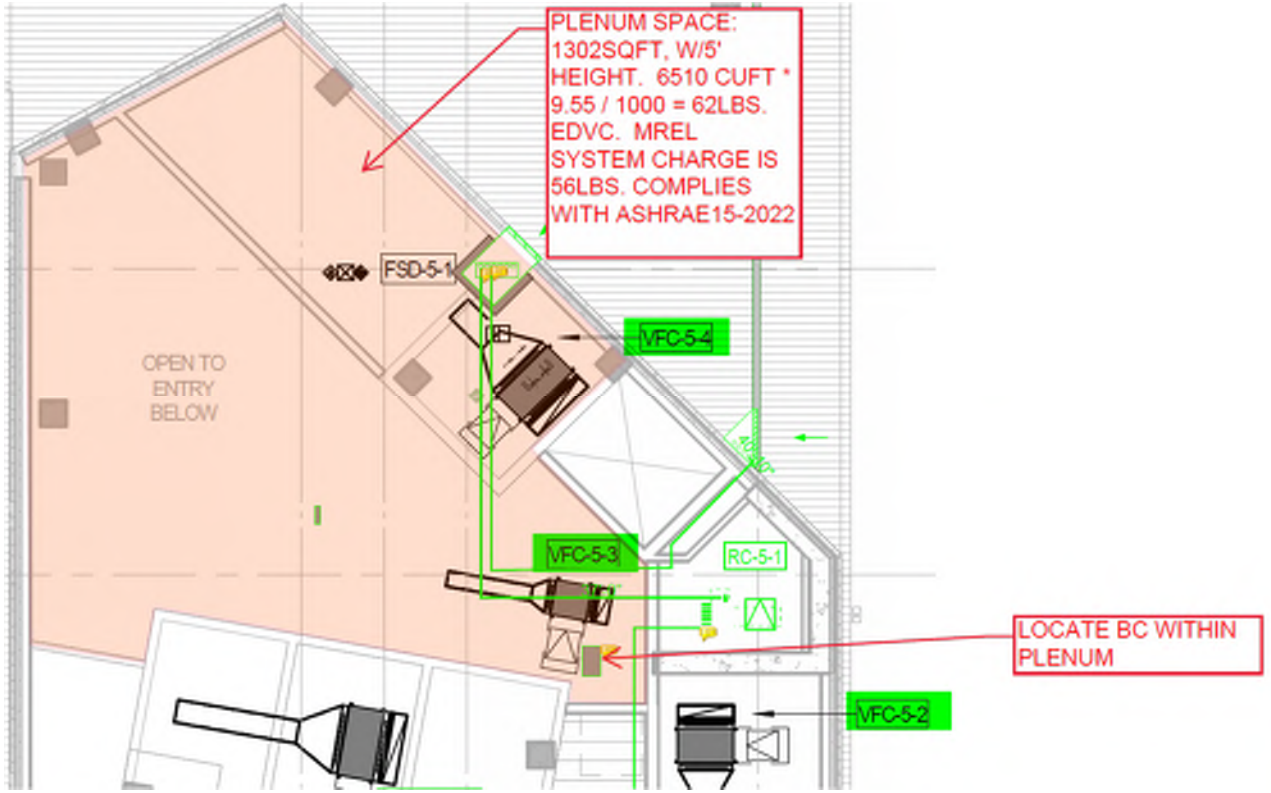
ASHRAE 15-2022 VRF Design & Application

ASHRAE STANDARD 15-2022 CHAPTER 7

Branch Controller Location – Plenum Space

Plenum space 6510 cuft,
EDVC = 62lbs.

- Branch Controllers can be installed within spaces that meet EDVC based on the full system charge.
- Mrel is entire system charge: 56lbs.
- EDVC = 62lbs.
  - 6510cuft * 9.55 / 1000
- **56lbs Mrel < EDVC: 62lbs**. - **Complies**



A2L VRF Design & Application

- With mitigation valves and leak sensors, complying with ASHRAE 15 is possible in most applications.
- The EDVC = (Cubic Area / 1000cuft * 9.55) (R-32)
- Branch controllers may be placed in mechanical closets and above ceilings if Mrel is less than the EDVC.

Final Thoughts / Questions

A2L VRF Design & Application

Challenge / Practice	Solution
Refrigerant piping that penetrates two or more floor/ceiling assemblies	*Refrigerant piping shafts may be designed using natural or mechanical ventilation*
Refrigerant piping that penetrates less than two floor/ceiling assemblies	*Refrigerant piping shafts may be designed without ventilation. Piping may be located outdoors.*
Calculate EDVC & Mrel	*The EDVC = (Cubic Area / 1000cuft * 9.55)*
Mrel is the releasable refrigerant charge	*Mrel may be the full system charge when no shut off valves are used.*

A2L VRF Design & Application

Challenge / Practice	Solution
Design for low system refrigerant volumes	*Select smaller tonnage systems to reduce refrigerant charge*
When natural ventilation is not an option	*Mechanical ventilation can be continuous or initiated by a refrigerant sensor.*
HVAC designs need to ensure that a portion of the system refrigerant charge that can be released into a space. Avoid machinery rooms	*With mitigation valves and leak sensors, complying with ASHRAE 15 Chapter 7 is possible in most applications.*
Mechanically ventilated shafts *shall* have a minimum air velocity in accordance with Table 9-12. Fan may run continuously without leak detection.	*The mechanical shaft provides exhaust and make-up air and is connected at the lowest point. Example: 18”x18” shaft would require 677 CFM*

Learning Questions:

1. What does GWP/HFC stand for?

2. What two refrigerants are VRF manufacturer's transitioning to?

3. What design considerations need to be applied with VRF systems?

4. What entity is enabling the EPA to administer the phasedown of HFC production and consumption?

5. What does EDVC stand for?

Thank You

Additional Slides/Info

ASHRAE 15-2022 Machinery Rooms

ASHRAE 15-2022 Machinery Room

ASHRAE STANDARD 15-2022 CHAPTER 7 – PAGE 16

7.4 Location in a Machinery Room or Outdoors

- If the **Mrel** exceeds the **EDVC**, all components containing refrigerant shall be located either in a machinery room or outdoors.
- The use of mitigation controls for fan coils and branch controllers will keep the **Mrel** <= the **EDVC**, which does not require them to be in a machinery room.
- **7.4.3*** Refer to chapter 8.9.1 – 8.9.4 and 8.11 for A2L machinery room requirements.
- Water-Source VRF condensers may need to be located in a machinery room when the **Mrel** exceeds the **EDVC**

7.4 Location in a Machinery Room or Outdoors. All components containing *refrigerant shall* be located either in a *machinery room* or outdoors, where the quantity of *refrigerant* needed exceeds the limits defined by Sections 7.2 and 7.3. Refrigeration systems located outdoors *shall* comply with Section 8.12.

7.4.3* Class 2L, Class 2, and Class 3 Refrigerants. *Machinery rooms* required by Section 7.4 and containing any Group A2, A3, B2, or B3 flammable *refrigerants shall* be constructed and maintained in accordance with Sections 8.9 and 8.10. *Machinery rooms* required by Section 7.4, containing any Group A2L or B2L flammable *refrigerants* and containing no Group A2, A3, B2, or B3 flammable *refrigerants*, *shall* be constructed and maintained in accordance with Sections 8.9.1 through 8.9.4 and Section 8.11.

ASHRAE 15-2022 Machinery Room

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8.11 Machinery Room, Special Requirements, A2L

- 8.11.6 – A2L machinery room shall comply with 8.11.6.1 for ventilation and 8.11.6.2 for refrigerant detection
- 8.11.6.1 – The exhaust fan may run continuously, and failure of the fan actuates an alarm OR, be activated by one or more refrigerant detectors, conforming to 8.11.8
- See 8.9.1 through 8.9.4 and 8.11.1 through 8.11.7 for additional room requirements

8.11 Machinery Room, Special Requirements, A2L and B2L. When a refrigeration system is located indoors, and a *machinery room* is required by Section 7.4.3, *machinery rooms shall* comply with Sections 8.11.1 through 8.11.7.

8.11.6 When any *refrigerant* of Groups A2, A3, B2, or B3 are used, the *machinery room shall* be designated as Class I, Division 2 hazardous (classified) electrical location in accordance with the *National Electric Code*® [4] (NFPA 70). When the only flammable *refrigerants* used are from Group A2L or B2L, the *machinery room shall* comply with both Section 8.11.6.1 for ventilation and Section 8.11.6.2 for *refrigerant* detection, or *shall* be designated as Class I, Division 2 hazardous (classified) electrical location in accordance with the NFPA 70.

8.11 Machinery Room, Special Requirements, A2L and B2L. When a refrigeration system is located indoors, and a *machinery room* is required by Section 7.4.3, *machinery rooms shall* comply with Sections 8.11.1 through 8.11.7.

8.11.6.1 The *machinery room shall* have a mechanical ventilation system in accordance with Section 8.11.11. The mechanical ventilation system *shall*

a. run continuously, and failure of the mechanical ventilation system actuates an alarm, or
b. be activated by one or more *refrigerant detectors*, conforming to requirements of Section 8.11.8.

ASHRAE 15-2022 Machinery Room

ASHRAE STANDARD 15-2022 CHAPTER 8 – PAGE 27

8.11.6.2 Refrigerant Detection

- Refrigerant detector shall de-energize the Water-Source VRF compressor.
- 8.11.7 – Remote OFF signal switch to the water-source VRF compressor. Remote control switch for the ventilation fan.
- 8.11.10.1 – Leak detection alarm shall have visual and audible alarms both in the machinery room and outside each entrance.

8.11.6.2 Detection of *refrigerant* concentration that exceeds 25% of the *lower flammability limit* (*LFL*) or the upper detection limit of the *refrigerant detector*, whichever is lower, *shall* automatically de-energize the following equipment in the *machinery room*:

a. *Refrigerant compressors*
b. *Refrigerant* pumps
c. Normally closed automatic *refrigerant* valves
d. Other unclassified electrical sources of ignition with apparent power rating greater than 1 kVA, where the apparent power is the product of the circuit voltage and current rating

8.11.7 Remote control of the mechanical equipment in the refrigerating *machinery room shall* be provided immediately outside the *machinery room* door solely for the purpose of shutting down the equipment in an emergency. Ventilation fans *shall* be on a separate electrical circuit and have a control switch located immediately outside the *machinery room* door.

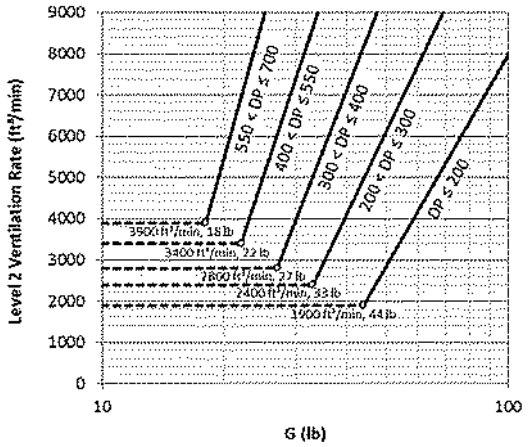
8.11.10.1 The alarm *shall* have visual and audible annunciation inside the refrigerating *machinery room* and outside each entrance to the refrigerating *machinery room*.

ASHRAE 15-2022 Machinery Room

ASHRAE STANDARD 15-2022 CHAPTER 8 – PAGE 28

8.11.11 Ventilation – Machinery Rooms

- See 8.11.11 for mechanical ventilation requirements.
  - (e) Inlets to exhaust ducts shall be within 1ft of the lowest point for A2L
  - See graphical method of figures 8-1 (I-P) or calculation method using table 8-3.



Graph 8-1

8.11.11 Ventilation. *Machinery rooms*, in accordance with Section 8.11, *shall* be vented to the outdoors using mechanical ventilation in accordance with Sections 8.11.11.1 through 8.11.11.3.

8.11.11.1 Mechanical ventilation referred to in Section 8.11.11 *shall* be in accordance with all of the following:

a. Include one or more power-driven fans capable of exhausting air from the *machinery room*; multispeed fans *shall* be permitted.
b. Electric motors driving fans *shall not* be placed inside *ducts*; fan rotating elements *shall* be nonferrous or nonsparking, or the casing *shall* consist of or be lined with such material.
c. Include provision to supply *makeup air* to replace that being exhausted; *ducts* for supply to and exhaust from the *machinery room shall* serve no other area; the *makeup air* supply locations *shall* be positioned relative to the *makeup air* locations to avoid short circuiting.
d. Inlets to the exhaust *ducts shall* be located in an area where *refrigerant* from a leak will concentrate, in consideration of the location of the replacement supply air paths, refrigerating machines, and the density of the *refrigerant* relative to air.
e. Inlets to exhaust *ducts shall* be within 1 ft (0.3 m) of the lowest point of the *machinery room* for *refrigerants* that are heavier than air and *shall* be within 1 ft (0.3 m) of the highest point for *refrigerants* that are lighter than air.
f. The discharge of the *exhaust air shall* be to the outdoors in such a manner as not to cause a nuisance or danger.

8.11.11.4* Safety Group A2L, B2L. When required by Section 8.11.11.3, the total airflow for Level 2 ventilation *shall* be not less than the airflow rate determined by either the graphical method of Figures 8-1 (I-P) and 8-2 (SI) or the calculation method using the equations in Table 8-3. The total airflow rate for Level 2 ventilation *shall not* be less than Level 1 ventilation. The airflow rate (Q) per the calculation method *shall* be rounded up to the nearest value to two significant figures.

Table 8-3 Calculation Method Equations [a]

Charge Quantity	Airflow	Equation Number
$G < 0.1 \times G'$	$Q \geq Q' \times 0.102$ and $Q \geq Q_1$	8-3
$0.1 \times G' \leq G \leq G'$	$Q \geq Q' \times [1 + 0.39 \times \ln(G/G')$ and $Q \geq Q_1$	8-4
$G > G'$	$Q \geq Q'$	8-5

ASHRAE 15-2022 Machinery Room

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8.11.11 Ventilation – Exhaust Calculatic

- Ventilation calculation example (I-P):
  - Water-Source VRF systems greater than 27.5lbs, use equation 8-4.
  - Machinery Room: 6’x10’
  - Refrigerant Pressure (P): 425psig

Table 8-3

G =	30
P =	425
G' =	271.5788
Q' =	27531.74
Q1 =	40
Airflow Q (cfm) =	3876.706

Table 8-2

Machinery Room Area [sf] =	80
Min Airflow [cfm]	40

Exhaust Fan Requirement: 3876 CFM

Table 8-3 Calculation Method Equations [a]

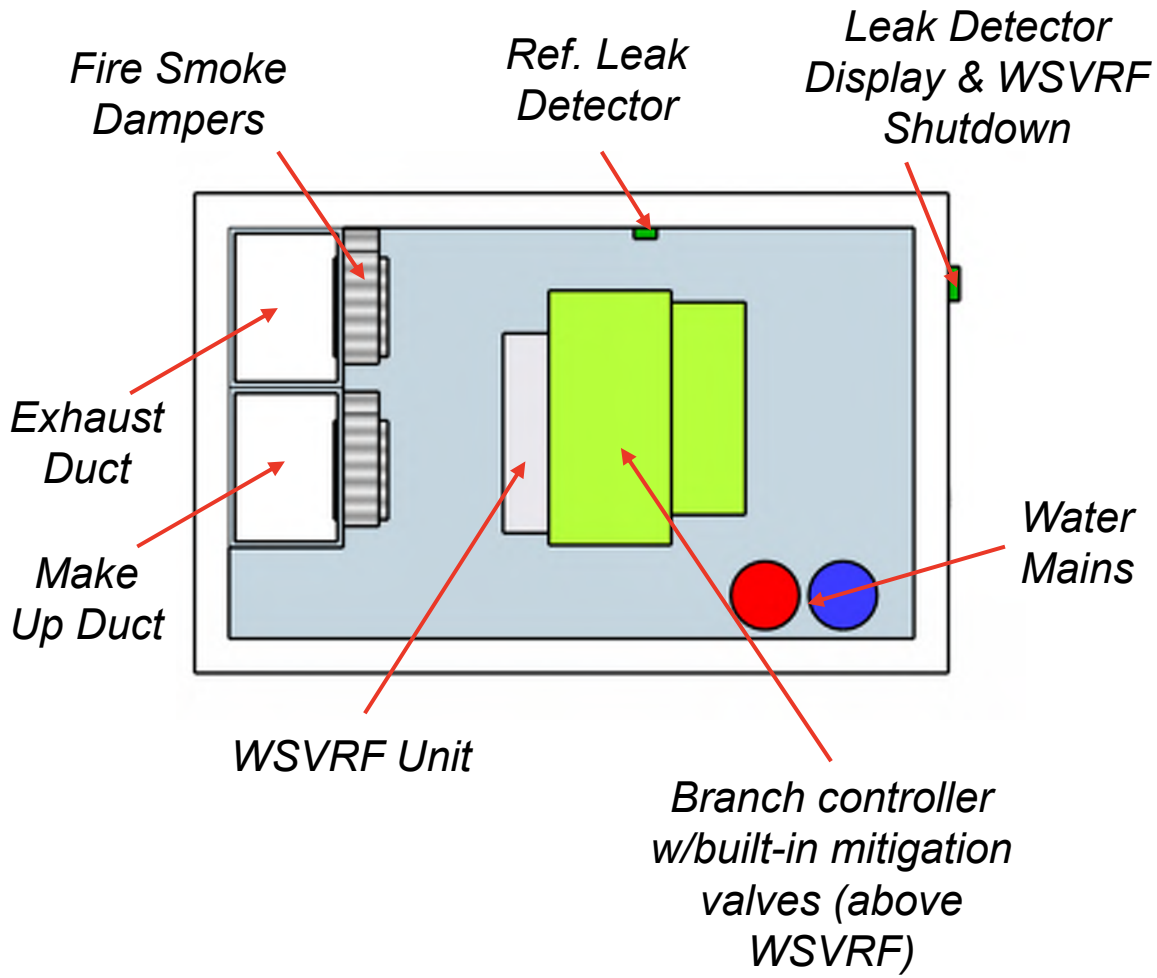
Charge Quantity	Airflow	Equation Number
$G < 0.1 \times G'$	$Q \geq Q' \times 0.102$ and $Q \geq Q_1$	8-3
$0.1 \times G' \leq G \leq G'$	$Q \geq Q' \times [1 + 0.39 \times \ln(G/G')$ and $Q \geq Q_1$	8-4
$G > G'$	$Q \geq Q'$	8-5

ASHRAE 15-2022 Machinery Room

ASHRAE STANDARD 15-2022 CHAPTER 9

Machinery Room Exhaust Example:

- Exhaust Fan: 4,000 CFM w/1.0 ESP
- Make-up air duct: 26”x18”, Exhaust duct: 26”x18”. Approx duct size, duct calcs by engineer.
- (2) 26”x18” Fire Smoke Damper Located 12” from floor
- Refrigerant leak detection display and shut off switch for WSVRF unit exterior to the room.
- Leak detection inside machinery room.
- Upon leak detection, open fire dampers, shutdown WSVRF, enable exhaust fan.



ASHRAE 15-2022 Machinery Room

ASHRAE STANDARD 15-2022 CHAPTER 9

Machinery Room Exhaust Example:

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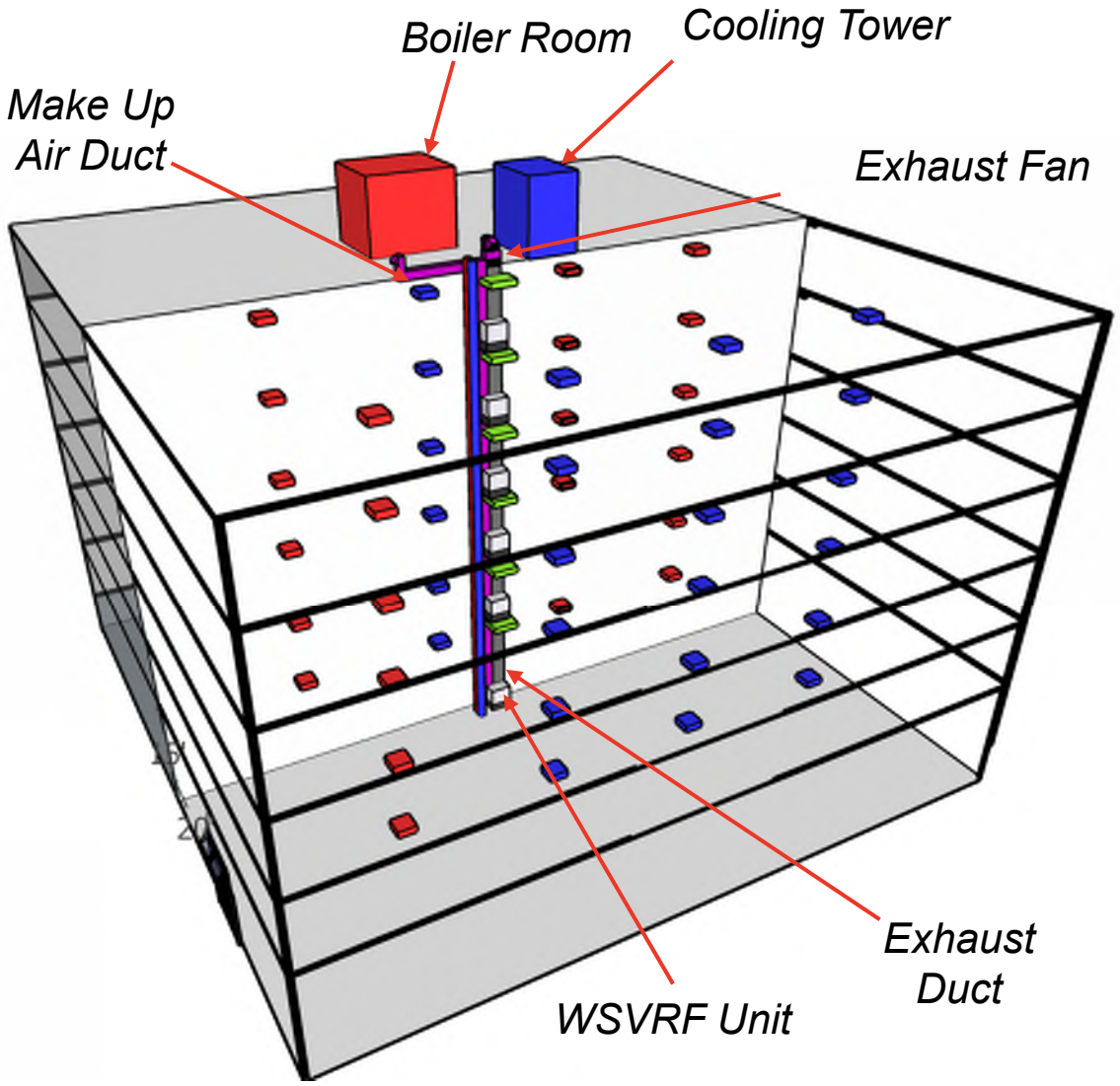

ASHRAE 15-2022 Additional Information

ASHRAE 15-2022 Refrigerant Charge Limits for Design

ASHRAE STANDARD 15-2022 CHAPTER 7- PAGE 16

7.5.1.2 Corridors and Lobbies

- Chapter 7.5.1.2, ASHRAE15-2022 has a section on corridors and lobbies, and it indicates that refrigerant systems serving these spaces can only be “unit systems” or a complete, self-contained system (no split system/VRF).
- ASHRAE12-2022 Definition:
  - ***Corridor***: an enclosed passageway that limits travel to a single path.
  - ***Lobby***: a waiting room or large hallway serving as a waiting room

7.5.1.2 Corridors and Lobbies. *Refrigerating systems* in a public *corridor* or *lobby shall* comply with the following:

a. *Refrigeration systems shall* be limited to *unit systems*.

corridor: an enclosed passageway that limits travel to a single path.

lobby: a waiting room or large hallway serving as a waiting room.

self-contained system: a complete, factory-assembled and factory-tested system that is shipped in one or more sections and has no *refrigerant*-containing parts that are joined in the field by other than *companion valves* or *block valves*.