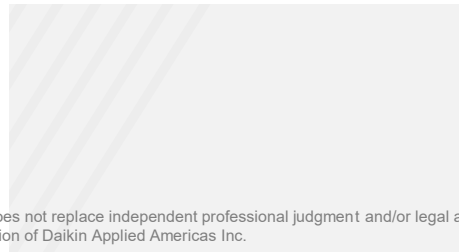


# ASHRAE Standards 15 and 34 Preparing for A2L Refrigerants

Sharon Haeg, HVAC Systems Business Development  
Manager



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- Always consult your state & local codes, which may take precedence over standards like ASHRAE Standards 15, 34, or other standards which vary in adoption, complete or partial, by state. Also note that a state may adopt a different year of the standard than the latest version.
- The local Authority Having Jurisdiction (AHJ) has the final authority in interpreting code requirements. When in doubt, contact the AHJ.

# Agenda to Address Common Questions

1

Regulations and standards driving changes for equipment

2

What is being done to ensure A2L refrigerants can be safely used?

3

What do I need to do to prepare?

- Design requirements
- Refrigerant detection / control signals
- Ventilation
- Refrigerant piping





The AIM Act gives authority to the EPA to phase down HFC refrigerants in the US

**Old news:** EPA must write rules to *phase down* production and consumption of bulk HFCs to 15% of baseline, maximize reclamation, minimize releases from equipment and facilitate transition through sector-based restrictions

## PHASEDOWN

via CO<sub>2</sub>eq Allocations of Bulk HFCs  
(Supply Side constraints)

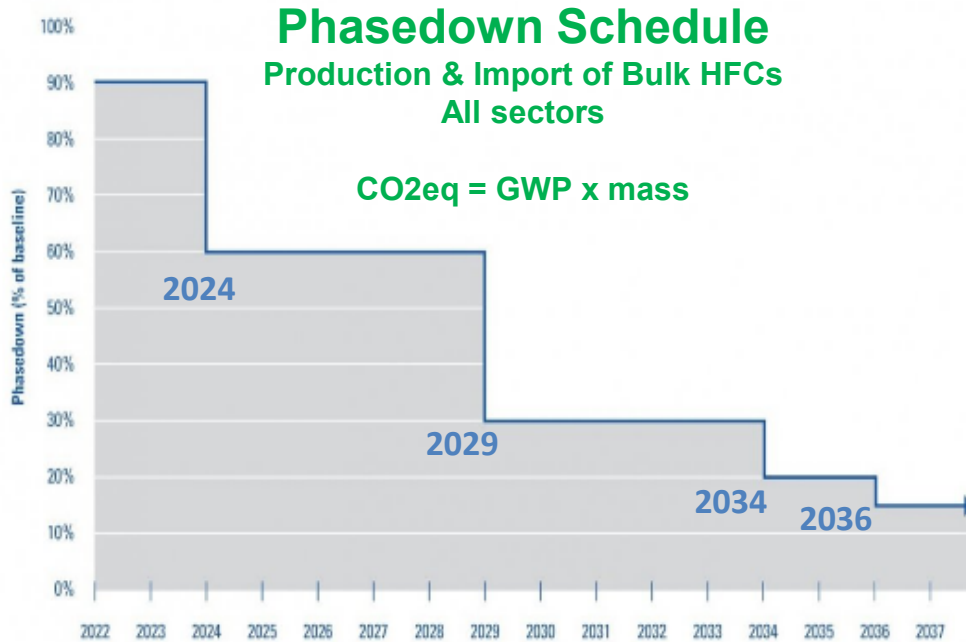
## TECHNOLOGY TRANSITIONS

Sector based controls  
SNAP restrictions

## REFRIGERANT MANAGEMENT

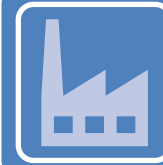
Minimizing leaks  
Maximizing recovery & reclamation

# AIM Act: EPA Phasedown and Allocations



### CO<sub>2</sub>eq Phasedown

- Baseline over 300 million metric tonnes CO<sub>2</sub> equivalency
- Phases down creating supply shortage of HFCs



### Not refrigerant specific – not a phaseout

- All bulk virgin HFCs in all sectors
- Produced in USA and imported



### Existing equipment may be serviced

- Installed base can be serviced
- Will need to transition to lower GWP refrigerants

# AIM Act: EPA Technology Transition

**Products - Factory-Charged Equipment**  
Chillers, RTUs, WSHP, PTAC  
3-year sell-through period

**Air conditioning equipment, including AC & HP, Chillers (comfort cooling), and ice rinks**

MFG and Import Deadline

Sell-through Deadline

**Data Centers**

MFG and Import Deadline

Sell-through Deadline

\*Installation deadline means charging the refrigeration circuit to full charge

1/1/2030

1/1/2028

1/1/2027

You Are Here

1/1/2026

MFG and Import Deadline

~~\*\*\*Installation Deadline~~

**Residential / Light Commercial Split system HPs and AC**

MFG and Import Deadline

\*Installation Deadline  
\*\*Potential Extension

**VRF**

1/1/2025

1/1/2024

Select states require chillers with GWP limit of 750

**Systems - Field-charged equipment:**  
Split systems, knock-down units  
Installation deadline instead of sell-through

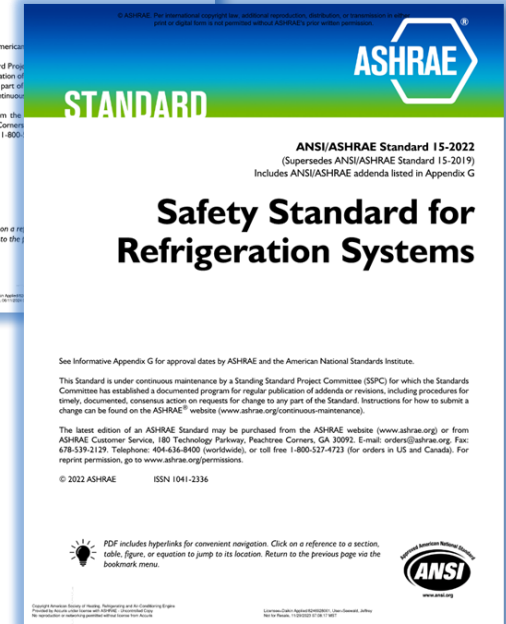
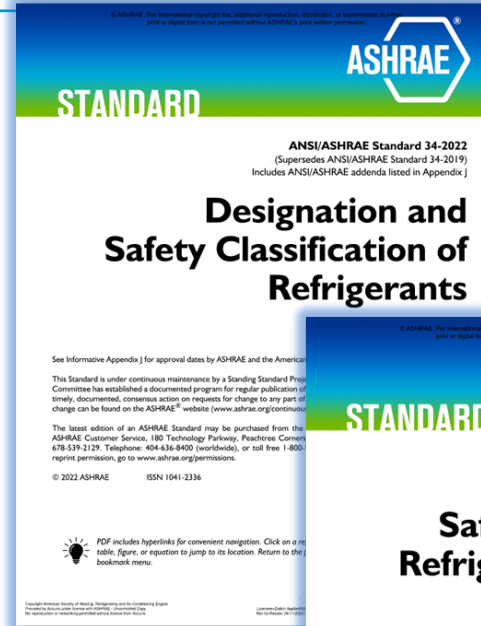
\*\*For projects that were issued a building permit which approved the use of an HFC or blend containing an HFC in a VRF system prior to October 5, 2023, installation is allowed until January 1, 2028.

\*\*\*Installation deadline for Residential / Light Commercial removed per Final Rule May 2026.

# Applicable ASHRAE Standards – 15 and 34

## Define Refrigerant Classes and Safety Requirements

- The standards are referenced by, or adopted in part/whole, or copied into various building codes
  - National model building codes are then adopted by individual jurisdictions
  - International Mechanical Code (IMC)
  - International Fire Code (IFC)
  - Uniform Mechanical Code (UMC)
- State/Local Building Codes
- Published every 3 years
- Note: Canada uses CSA B52 instead of ASHRAE 15



# Agenda to Address Common Questions

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- Ventilation
- Refrigerant piping




# ASHRAE Standard 34-2022

## Designation and Safety Classification of Refrigerants

ASHRAE Standard 34 describes a shorthand way of naming refrigerants, and it assigns safety classifications and refrigerant concentration limits based on toxicity and flammability data.

- Numbering and designation of refrigerants
- Safety group classifications
- Refrigerant concentration limits & other data

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# STANDARD

**ANSI/ASHRAE Standard 34-2022**  
(Supersedes ANSI/ASHRAE Standard 34-2019)  
Includes ANSI/ASHRAE addenda listed in Appendix J


## Designation and Safety Classification of Refrigerants


See Informative Appendix J for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website ([www.ashrae.org/continuous-maintenance](http://www.ashrae.org/continuous-maintenance)).

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 PDF includes hyperlinks for convenient navigation. Click on a reference to a section, table, figure, or equation to jump to its location. Return to the previous page via the bookmark menu.

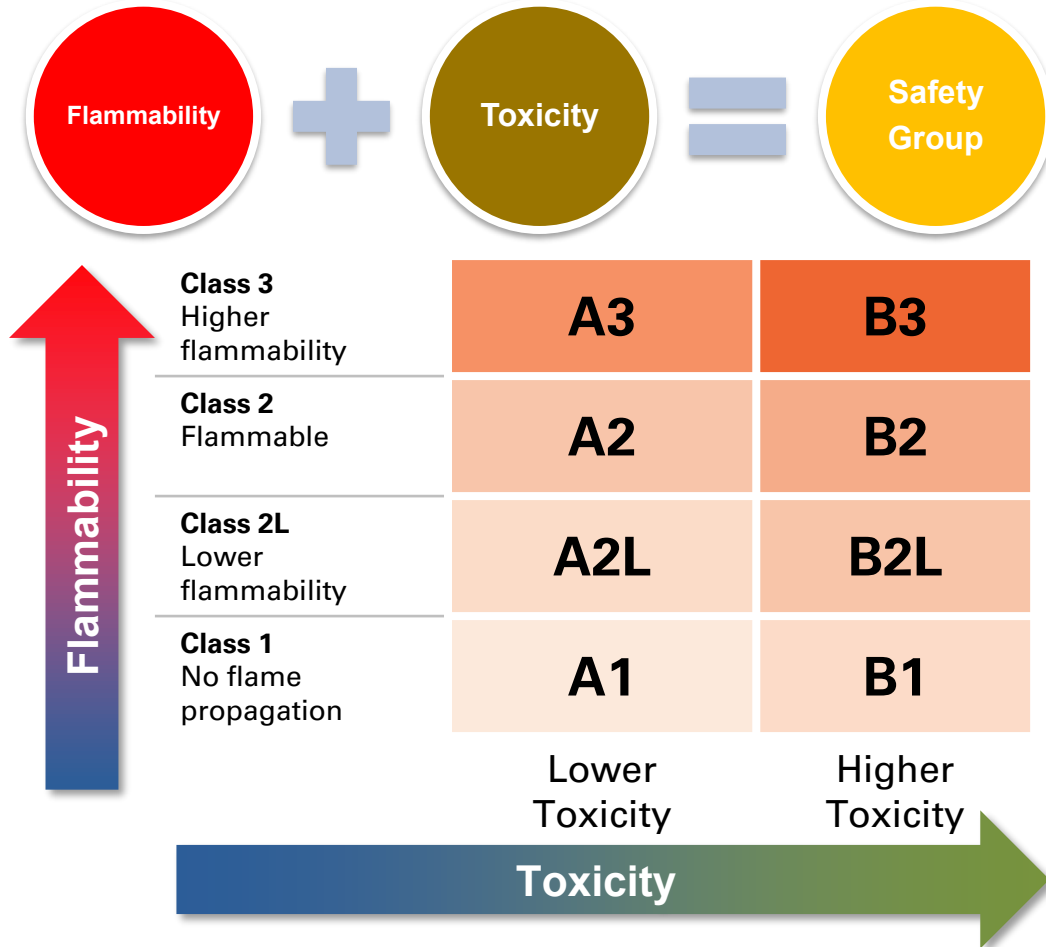


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ANSI/ASHRAE Standard 34-2022  
John Deane, Jeffrey  
Not for Resale, 06/11/2024 09:15:00 MDT

# ASHRAE Standard 34 Basics – Safety Groups

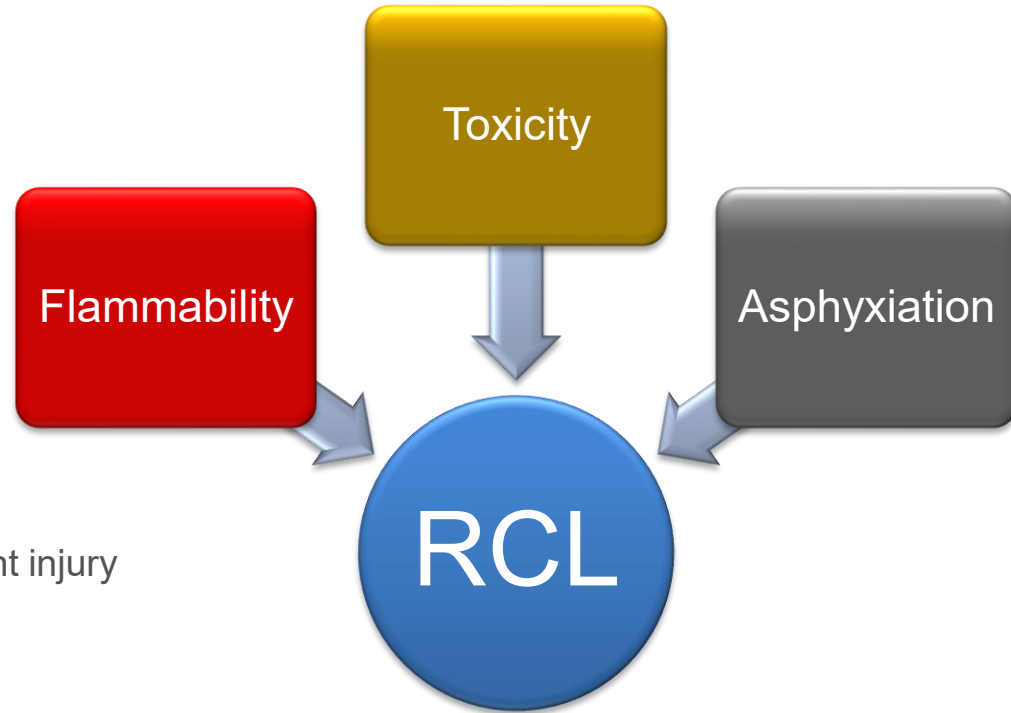


# ASHRAE Standard 34 Basics: RCL

## Refrigerant Concentration Limit

Establishes maximum allowable concentration of refrigerant based on worst case (lowest value) of:

- Flammability risk: FCL
  - With factor of safety,  $FCL = 25\%$  of LFL
- Acute toxicity risk: ATEL, worst case of:
  - Mortality
  - Cardiac sensitization
  - Anesthetic or central nervous system effects
  - Other escape impairing effects and permanent injury
- Asphyxiation risk: ODL
  - Oxygen deprivation limit



# A2L Refrigerants – How Flammable Are They?

## A2Ls have 'lower flammability'

### Burning Velocity ( $S_u$ )

- How fast does a flame propagate (<0.1 m/s)

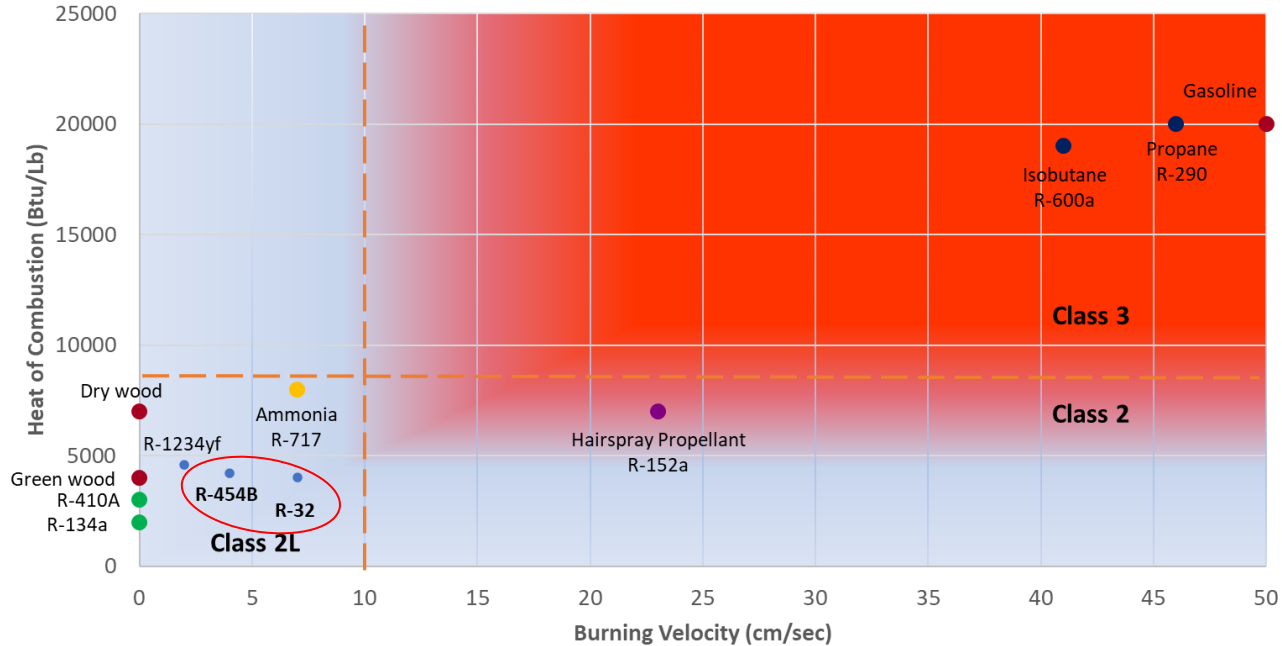
### Heat of combustion (HOC)

- How much energy is released by burning (< 1900 kJ/kg)

### Lower Flammability Limit (LFL)

- What is the concentration required to burn (> 0.1 kg/m<sup>3</sup>)

## Relatively lower burning velocity & heat generation



# A2L Refrigerants – How Flammable Are They?

## A2Ls have 'lower flammability'

### Burning Velocity ( $S_u$ )

- How fast does a flame propagate (<0.1 m/s)

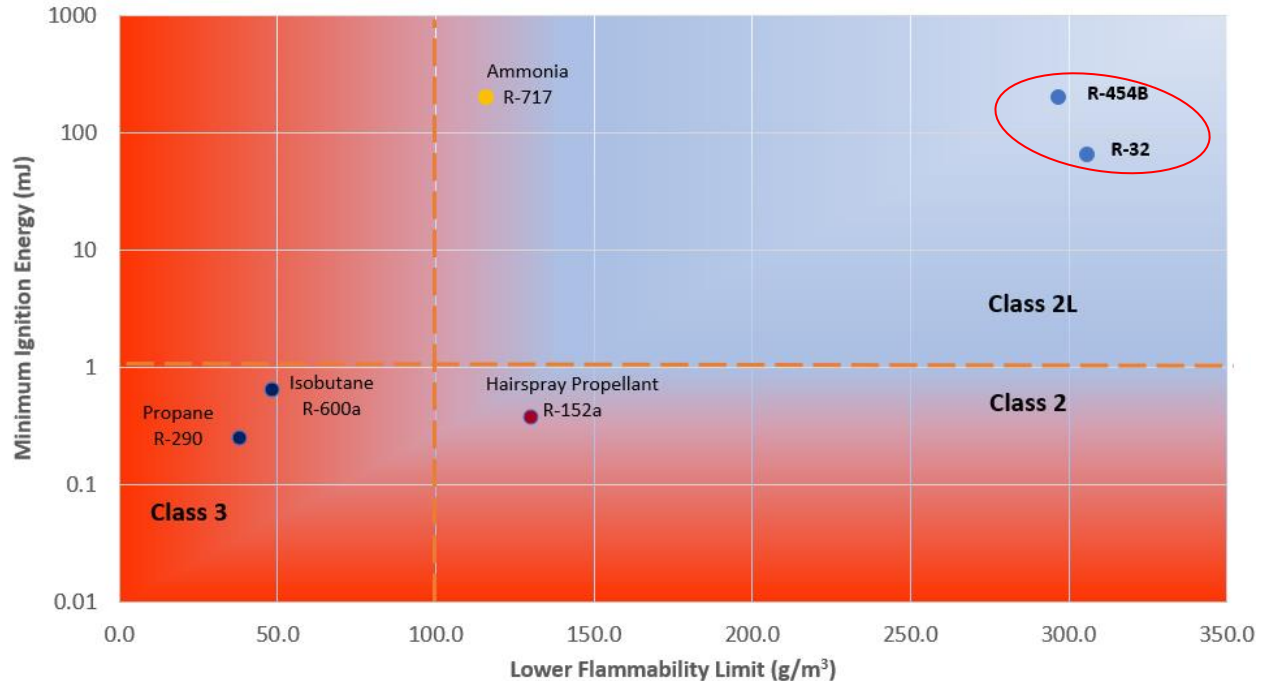
### Heat of combustion (HOC)

- How much energy is released by burning (< 1900 kJ/kg)

### Lower Flammability Limit (LFL)

- What is the concentration required to burn (> 0.1 kg/m<sup>3</sup>)

## More difficult to ignite / higher concentration required



# 'New' and Legacy Refrigerant Properties

## 'New' and Legacy Refrigerant Properties

Refrigerant	ASHRAE 34 Classification	GWP <sub>100</sub> (AR4)	RCL (g/m <sup>3</sup> )	Composition	Efficiency	Capacity	Toxicity
<b>R-410A Substitutes</b>							
R-410A	A1	2088	420	50% R-32 / 50% R-125			●
R-32	A2L	675	77	PURE 100% R-32	●	●	●
R-454B	A2L	466	74**	68.9% R-32 / 31.1% R-1234yf	●	●	●
<b>R-134a Substitutes</b>							
R-134a	A1	1430	210				●
R-513A	A1	630*	320	44% R-134a / 56% R-1234yf	●	●	●
R-515B	A1	292*	290	91.1% R-1234ze(E) / 8.90% R-227ea	●	●	●
R-1234ze(E)	A2L	1	76		●	●	●
<b>R-123 Substitutes</b>							
R-123	B1	77	57				●
R-1233zd(E)	A1	2*	85		●	●	●
R-514A	B1	2*	14	74.7% R-1336mzz(E) / 25.3% R-1130(E)	●	●	●

\*Refrigerant was not included in AR4, AR5 values are utilized in lieu of AR4

\*\*ASHRAE 34 previously listed an RCL of 49, but that value was later updated in Addendum "a" of Standard 34-2022

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- Refrigerant detection / control signals
- Ventilation
- Refrigerant piping



# ASHRAE Standard 15-2022

## Safety Standard for Refrigeration Systems

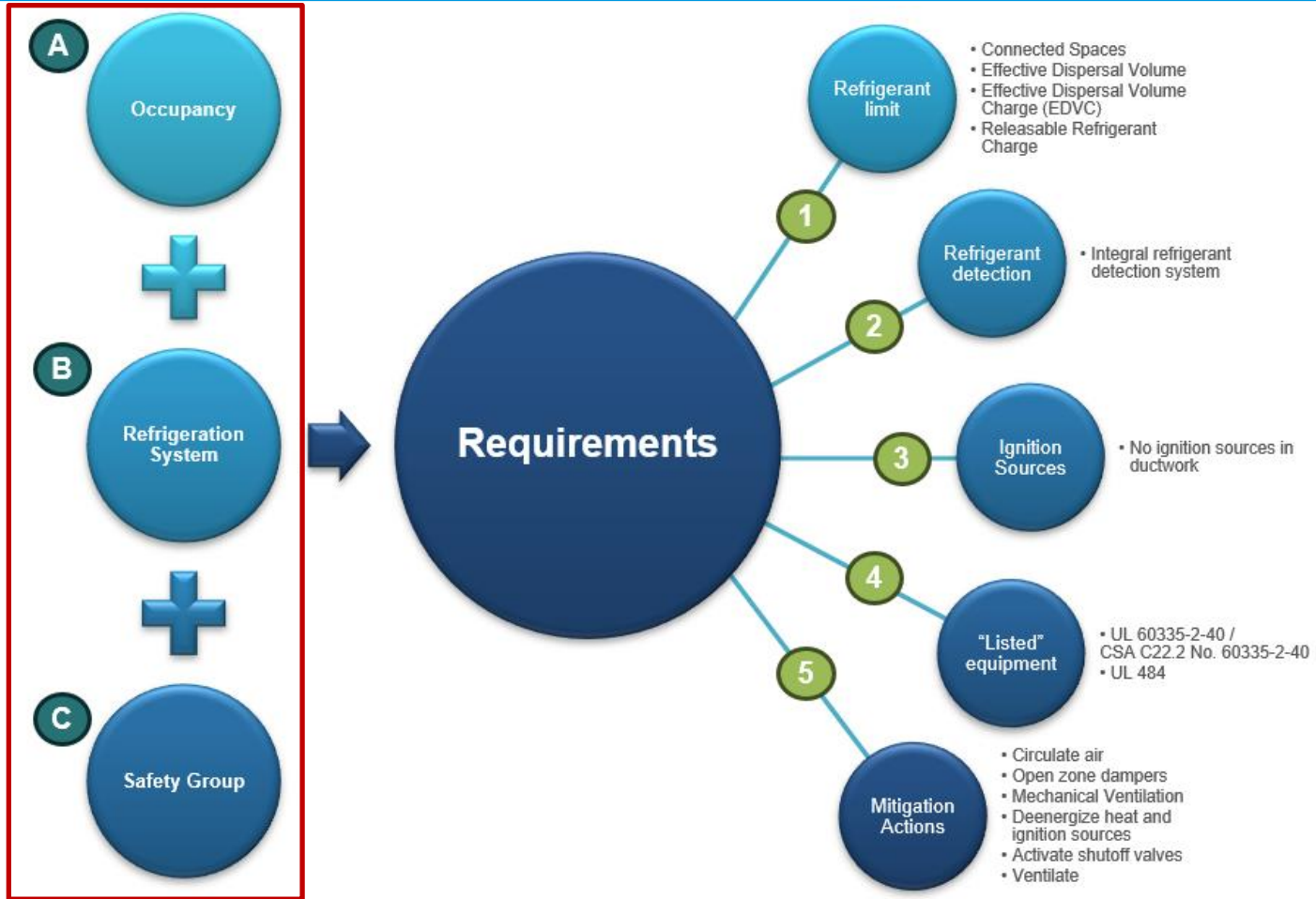
ASHRAE Standard 15 specifies requirements for the safe design, construction, installation, and operation of refrigeration systems.

- Changes to **refrigerant use restrictions**, especially for A2Ls
- Refrigerant overpressure protection and **pipng**
- Volume and **refrigerant charge limit** calculations
- **Refrigerant detector**/detection and mitigation actions
- Machinery room requirements

ASHRAE web site has errata sheet corrections and interpretations. Download them.



# ASHRAE Standard 15



# System Parameters

A

## Occupancy Classification

ASHRAE Standard 15, Section 4

Classification
Institutional
Public assembly
Residential
Commercial
Large mercantile
Industrial
Mixed

- Different occupancy types may require different actions

B

## Refrigeration System Classification

ASHRAE Standard 15, Section 5

Classification
High Probability
Low Probability

C

## Safety Group

ASHRAE Standard 15, Section 6  
Per ASHRAE Standard 34

Class 3 Higher flammability	<b>A3</b>	<b>B3</b>
Class 2 Flammable	<b>A2</b>	<b>B2</b>
Class 2L Lower flammability	<b>A2L</b>	<b>B2L</b>
Class 1 No flame propagation	<b>A1</b>	<b>B1</b>
	Lower Toxicity	Higher Toxicity

# System Parameters – Occupancy Classification

## Occupancy Classification

A

Classification	Definition A premise or that portion of a premise...	Examples
<b>Institutional</b>	from which, because they are disabled, debilitated, or confined, occupants cannot readily leave without the assistance of others	Hospitals, nursing homes, prisons
<b>Public assembly</b>	here large numbers of people congregate and from which occupants cannot quickly vacate the space	Auditoriums, ballrooms, classrooms, restaurants, theaters, depots
<b>Residential</b>	that provides the occupants with complete independent living facilities, including permanent provisions for living, sleeping, eating, cooking, and sanitation	Hotels, dormitories, apartments
<b>Commercial</b>	where people transact business, receive personal service, or purchase food and other goods	Office and professional buildings, markets (excluding large mercantile)
<b>Large mercantile</b>	where more than 100 persons congregate on levels above or below street level to purchase personal merchandise	Shopping malls
<b>Industrial</b>	is a premise or that portion of a premise that is not open to the public, where access by authorized persons is controlled, and that is used to manufacture, process, or store goods	Manufacturing plants, processing plants, storage facilities
<b>Mixed</b>	two or more occupancies are located within the same building	Combination of one or more of the above space types

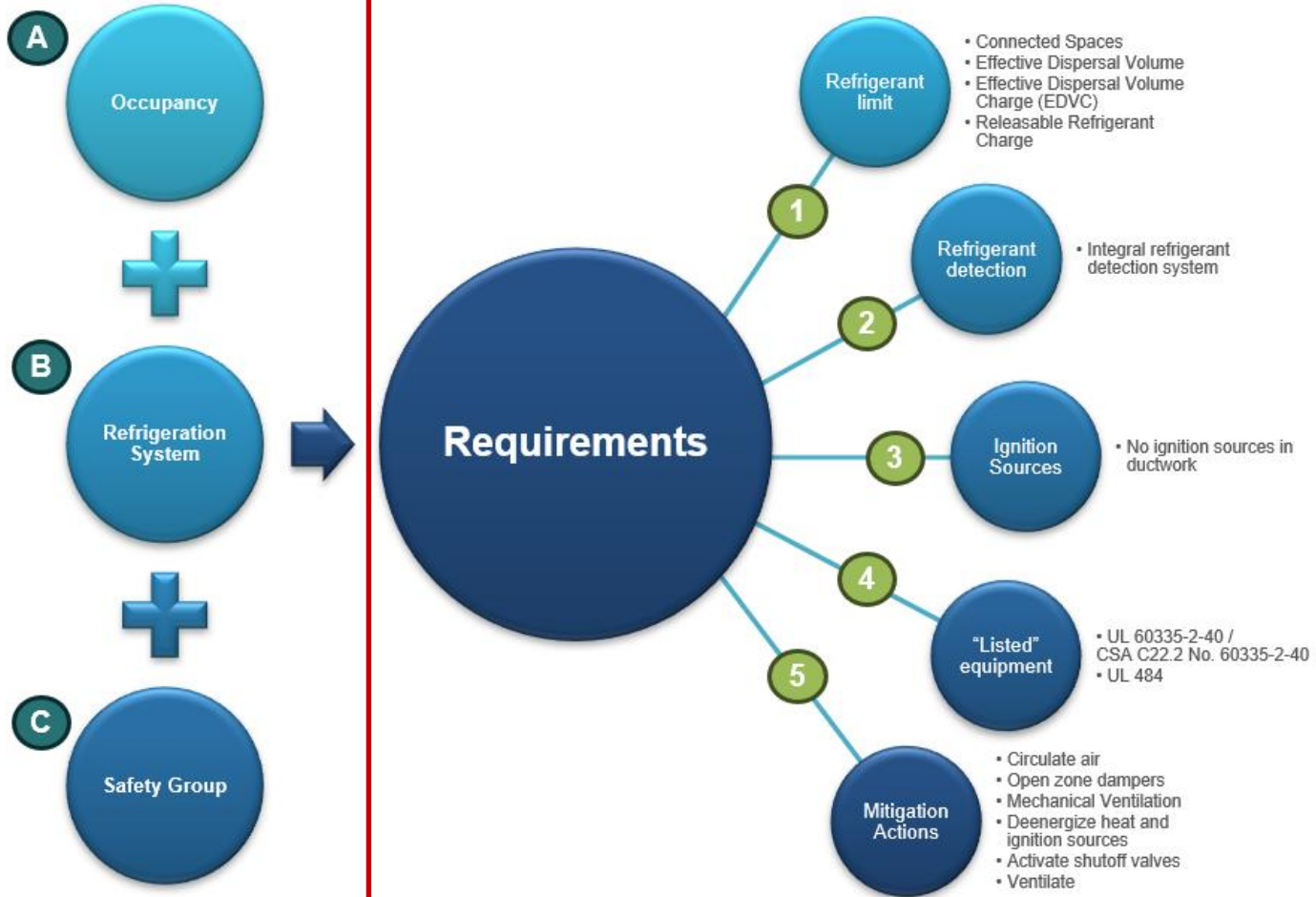
# System Parameters – Refrigeration System Classification

## Refrigeration System Classification

B

Classification	Definition	Examples
<b>High Probability</b>	Any system where leakage of refrigerant has <b>high probability to enter the occupied space.</b>	<b>Direct Systems</b> <ul style="list-style-type: none"><li>• Direct expansion (DX) split system</li><li>• Packaged RTU</li><li>• Water source heat pump</li><li>• VRF</li><li>• PTAC</li></ul>
<b>Low Probability</b>	Any system where leakage of refrigerant <b>cannot enter the occupied space.</b>	<b>Indirect closed systems</b> <ul style="list-style-type: none"><li>• Water-cooled chiller in machinery room</li><li>• Air-cooled chiller outdoors</li><li>• Water-to-water heat pump in machinery room</li></ul>

# ASHRAE Standard 15



- Check the **releasable refrigerant charge ( $M_{rel}$ )** against the **Effective Dispersal Volume Charge (EDVC)**
  - The **smallest volume into which refrigerant disperses shall be used** when determining EDVC
  - For A2Ls, both occupied and non-occupied spaces must be considered (7.2.2.2)

$$M_{rel} \leq EDVC$$

- Equations to calculate EDVC vary depending on refrigerant safety group and system characteristics

**If you don't comply initially, you can consider additional mitigation strategies**

# Calculating EDVC

Establish *Effective Dispersal Volume* (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
- Determine if any spaces are 'connected spaces' via natural openings or through air circulation
- Consider closures (such as dampers that can close during a refrigerant leak)

Calculate Effective Dispersal Volume Charge **EDVC** per the equation in 7.3.1

- Or, apply 7.6.1.1 for an A2L refrigerant with detection and air circulation
- Or, apply 7.6.1.2 for an A2L refrigerant without detection and air circulation

Determine **releasable refrigerant charge  $M_{rel}$**

- Systems without release mitigation controls,  $M_{rel}$  is the system charge of the largest independent circuit.
- Systems with release mitigation controls,  $M_{rel}$  determined per section 7.3.4.3

$$M_{rel} \leq EDVC$$

## Establish *Effective Dispersal Volume* (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
- Determine if any spaces are 'connected spaces' via natural openings or through air circulation
- Consider closures (such as dampers that can close during a refrigerant leak)

### Exempted Spaces 7.2.3.1.1:

The areas that contain only continuous *refrigerant piping*, or contain only joints and connections that have been tested in accordance with Section 9.13, are exempt from the *effective dispersal volume* calculation unless these areas are part of *connected spaces* per Section 7.2.3.2.

## Establish *Effective Dispersal Volume* (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
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- Consider closures (such as dampers that can close during a refrigerant leak)

### Exempted Spaces 7.2.3.1.1:

The areas that contain only continuous *refrigerant piping*, or contain only joints and connections that have been tested in accordance with Section 9.13, are exempt from the *effective dispersal volume* calculation unless these areas are part of *connected spaces* per Section 7.2.3.2.

### Determine if any spaces are 'connected spaces'

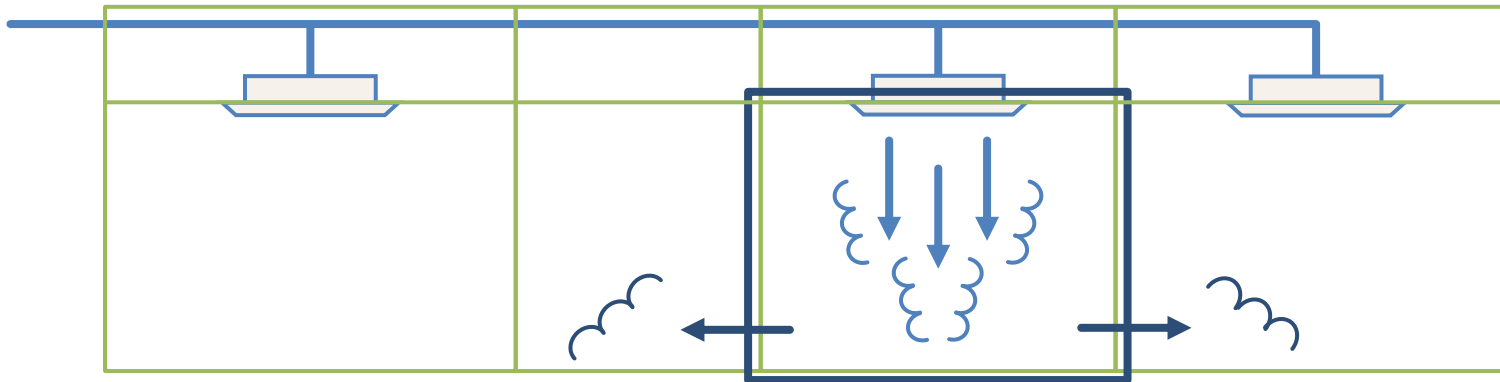
# Effective Dispersal Volume

## Natural Ventilation

1

### Connected spaces can help comply with EDVC requirements

- Natural ventilation openings may be used to increase the effective dispersal volume by connecting separate enclosed spaces with openings to allow refrigerant to disperse
- Size openings in accordance with sections 7.2.3.2.1 or 7.2.3.2.2
- Any openings above 12in from the floor shall not be considered



# Effective Dispersal Volume

## Ducted Air Distribution

1

### Connected spaces can help comply with EDVC requirements

- Ducted Air Distribution and Mechanical Ventilation Systems may be used to increase the effective dispersal volume by connecting separate enclosed spaces
- Follow guidelines for Connected Spaces via Ducted Air Distribution System 7.2.3.3 and/or Connected Spaces via Mechanical Ventilation 7.2.3.4



## Establish *Effective Dispersal Volume* (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
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The areas that contain only continuous *refrigerant piping*, or contain only joints and connections that have been tested in accordance with Section 9.13, are exempt from the *effective dispersal volume* calculation unless these areas are part of *connected spaces* per Section 7.2.3.2.

### Closures 7.2.3.3.1:

Closures in the air distribution system *shall* be considered. If one or more spaces of several arranged in parallel can be closed off from the source of the *refrigerant leak*, their volumes *shall not* be used in the calculation. Smoke dampers, fire dampers, and combination smoke/fire dampers that close only in an emergency not associated with a *refrigerant leak* shall not be classified as closure devices. Dampers, such as variable-air-volume (VAV) boxes, *shall not* be considered a closure, provided the airflow is not reduced below 10% of its maximum.

# Calculating EDVC

Establish **Effective Dispersal Volume** (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
- Determine if any spaces are 'connected spaces' via natural openings or through air circulation
- Consider closures (such as dampers that can close during a refrigerant leak)

Calculate Effective Dispersal Volume Charge **EDVC** per the equation in 7.3.1

- Or, apply 7.6.1.1 for an A2L refrigerant with detection and air circulation
- Or, apply 7.6.1.2 for an A2L refrigerant without detection and air circulation

**7.6.1.1 Refrigeration Systems with Air Circulation**

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ}$$

**7.6.1.2 Other Refrigeration Systems**

$$EDVC = M_{def} \times FLFL \times F_{occ}$$

# Calculating EDVC

1

Establish *Effective Dispersal Volume* (7.2.3.1 to 7.2.3.4)

- Identify exempted spaces (7.2.3.1.1)
- Determine if any spaces are 'connected spaces' via natural openings or through air circulation
- Consider closures (such as dampers that can close during a refrigerant leak)

Calculate Effective Dispersal Volume Charge **EDVC** per the equation in 7.3.1

- Or, apply 7.6.1.1 for an A2L refrigerant with detection and air circulation
- Or, apply 7.6.1.2 for an A2L refrigerant without detection and air circulation

Determine **releasable refrigerant charge  $M_{rel}$**

- Systems without release mitigation controls,  $M_{rel}$  is the system charge of the largest independent circuit.
- Systems with release mitigation controls,  $M_{rel}$  determined per section 7.3.4.3

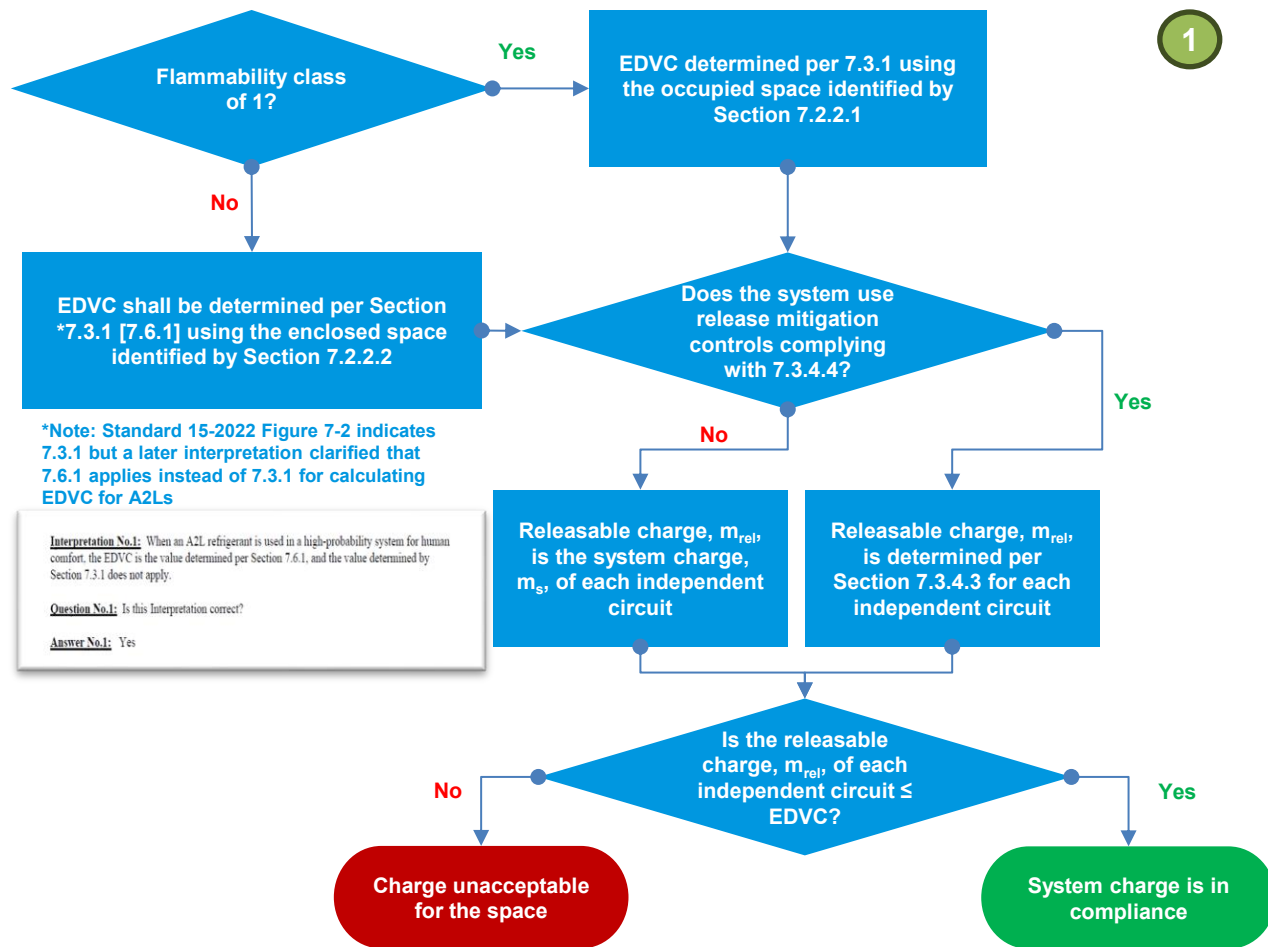
$$M_{rel} \leq EDVC$$

# Refrigerant Limits

## Simplified Flowchart

### Refrigerant System Charge Limit Compliance Path

- Simplified flowchart (Figures 7-1 and 7-2)
- Simplifying assumptions:
  - Unit has a refrigerant charge > 22 lb
  - The unit is not in a public corridor or lobby
  - High probability system for human comfort not in a machinery room or outdoors
  - Not in a laboratory
  - Not an industrial occupancy or refrigerated room



# Refrigerant Limits

## Notable Exceptions

1

### Listed equipment with refrigerant charge $\leq 6.6$ lb

- If in a public corridor or lobby, must be a unit system and if not an A1, have EDVC calculated
- If not in a public corridor or lobby, charge complies if installed in accordance with listing and OEM instructions

### Systems in industrial occupancy or refrigerated room

- If all conditions of Section 7.3.3 are met, are considered to have system charge in compliance

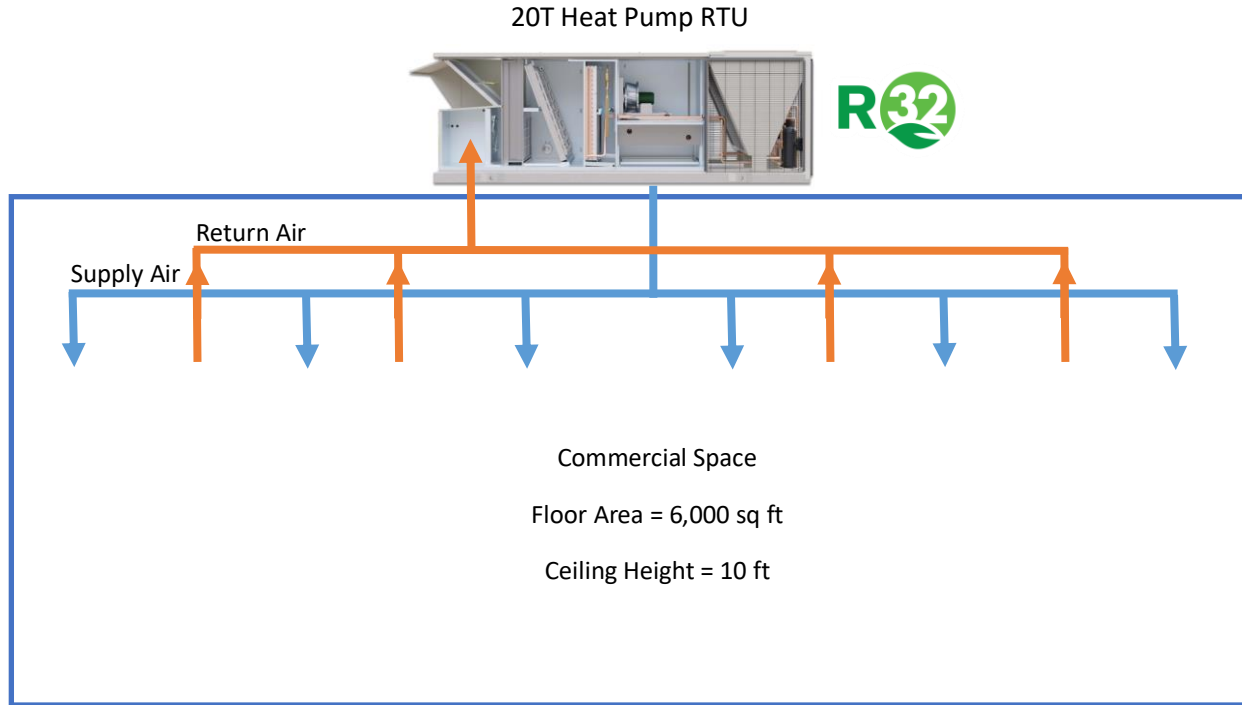
### Listed self-contained equipment in a commercial occupancy, not in a public corridor or lobby, with refrigerant charge $\leq 22$ lb

- System charge considered in compliance
- Self-contained system definition: 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

# Refrigerant Limits

## EDVC Calculation

1

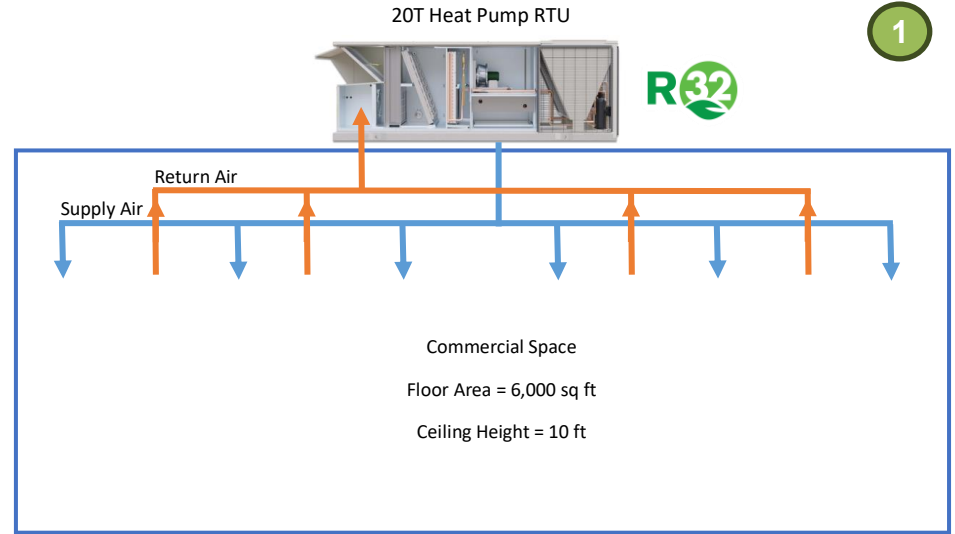


# Refrigerant Limits

## EDVC Calculation

### Determining Effective Dispersal Volume:

- **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)

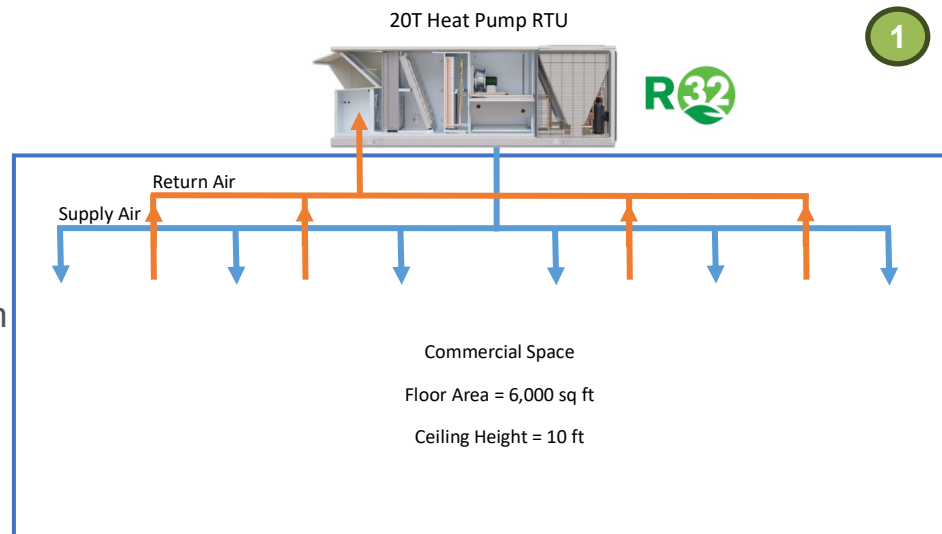


# Refrigerant Limits

## EDVC Calculation

### Determining Effective Dispersal Volume:

- **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)
- **Connected Spaces:** Ducted Air Distribution System
  - Total volume: spaces + duct volume

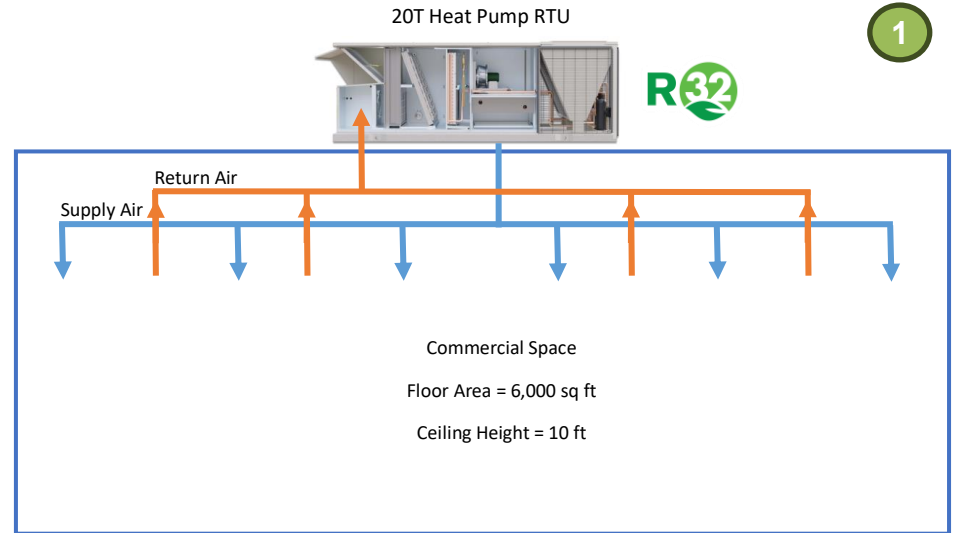


$$V_{eff} = 6,000 \text{ ft}^3 \times 10 \text{ ft} + 5,500 \text{ ft}^3 = 65,500 \text{ ft}^3$$

# Refrigerant Limits

## EDVC Calculation

- Determining Effective Dispersal Volume:
  - **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)
- Connected Spaces: Ducted Air Distribution System
  - 8 classrooms, 1 small group, 1 office
  - Total volume: spaces + duct volume
- Closures: no closures in the system



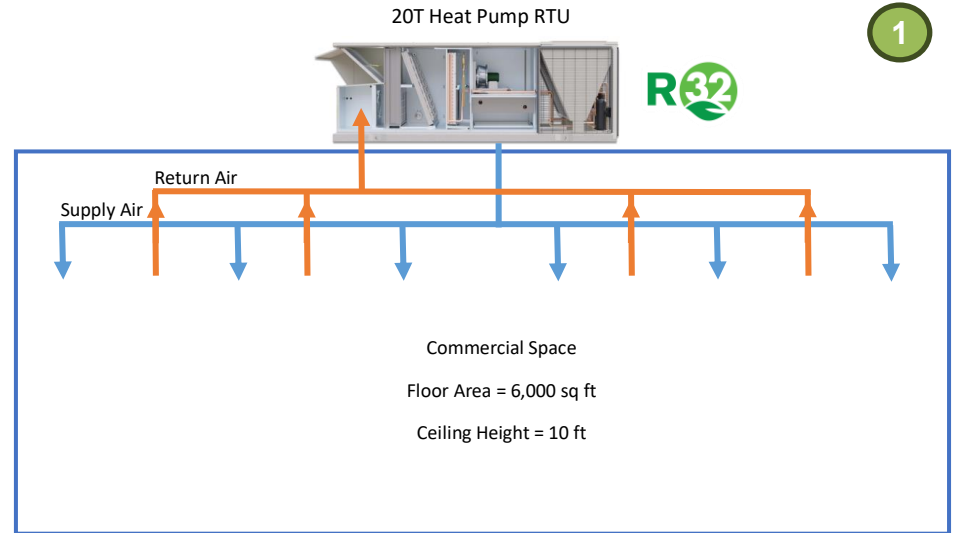
# Refrigerant Limits

## EDVC Calculation

- Calculate EDVC Equation 7.6.1.1

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ}$$

- $V_{eff} = 65,500 \text{ ft}^3$
- Refrigerant **LFL** (R-32) in ASHRAE Standard 34, Table 4-1 = **0.0191 lb/ft<sup>3</sup>**
- Concentration Factor, **CF = 0.5**
- Occupancy classification: **Commercial Occupancy**,  $F_{occ} = 1.0$



# Refrigerant Limits

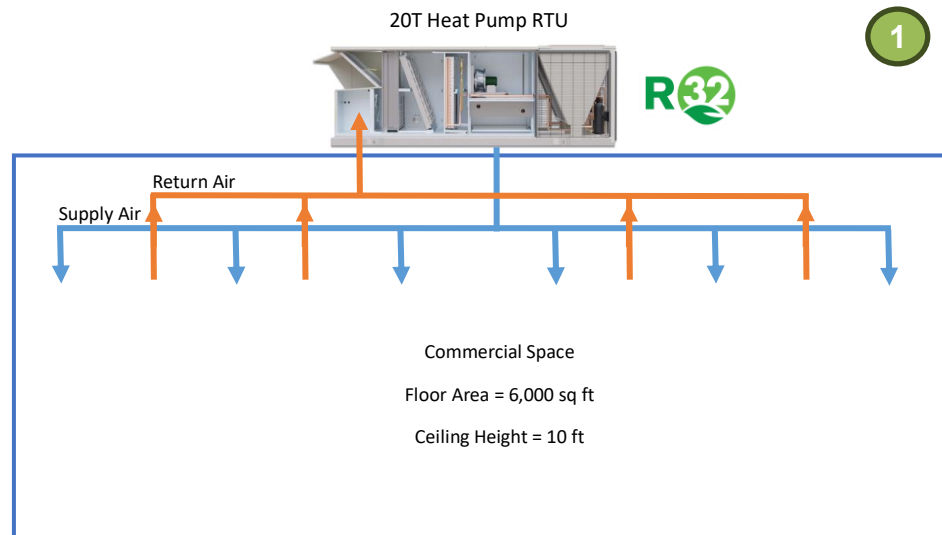
## EDVC Calculation

- Calculate EDVC Equation 7.6.1.1

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ}$$

- $V_{eff} = 65,500 \text{ ft}^3$
- Refrigerant **LFL** (R-32) in ASHRAE Standard 34, Table 4-1 = **0.0191 lb/ft<sup>3</sup>**
- Concentration Factor, **CF = 0.5**
- Occupancy classification: **Commercial Occupancy**,  $F_{occ} = 1.0$

$$EDVC = 65,500 \text{ ft}^3 \times 0.0191 \text{ lb/ft}^3 \times 0.5 \times 1.0 = 625 \text{ lbs}$$

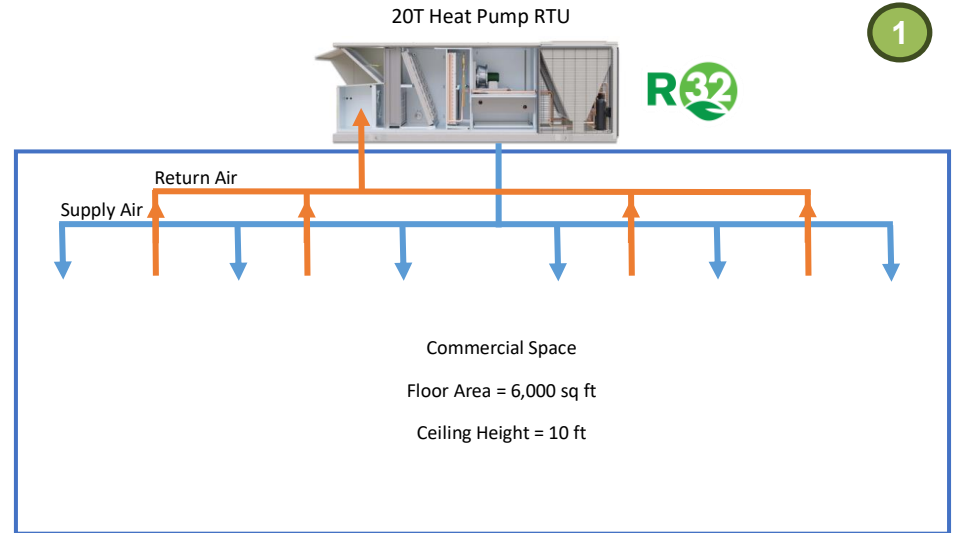


# Refrigerant Limits

## EDVC Calculation

- Determine  $M_{rel}$

$$M_{rel} = 31.2 \text{ lbs}$$



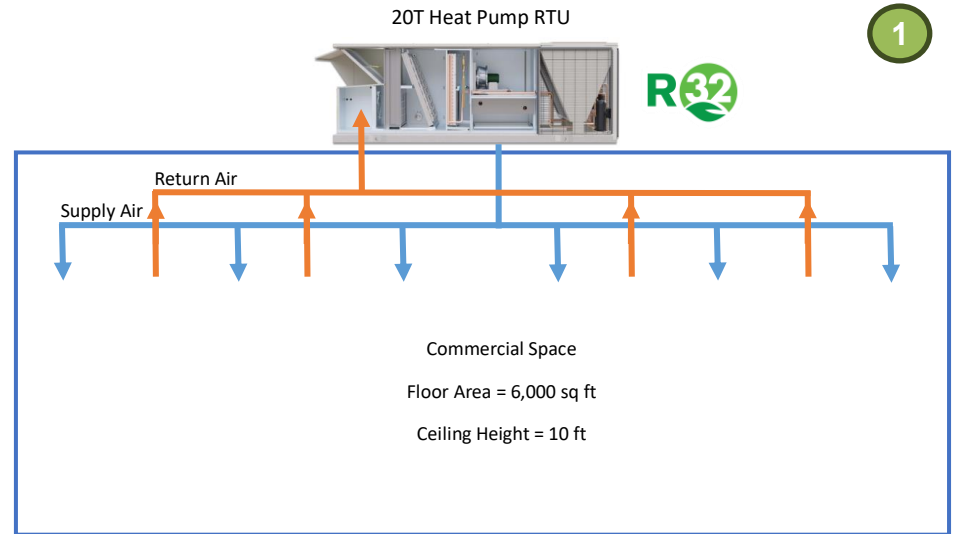
# Refrigerant Limits

## EDVC Calculation

- Determine  $M_{rel}$

$$M_{rel} = 31.2 \text{ lbs}$$

$$625 \text{ lbs} \geq 31.2 \text{ lbs}$$



# Refrigerant Limits

## EDVC Calculation

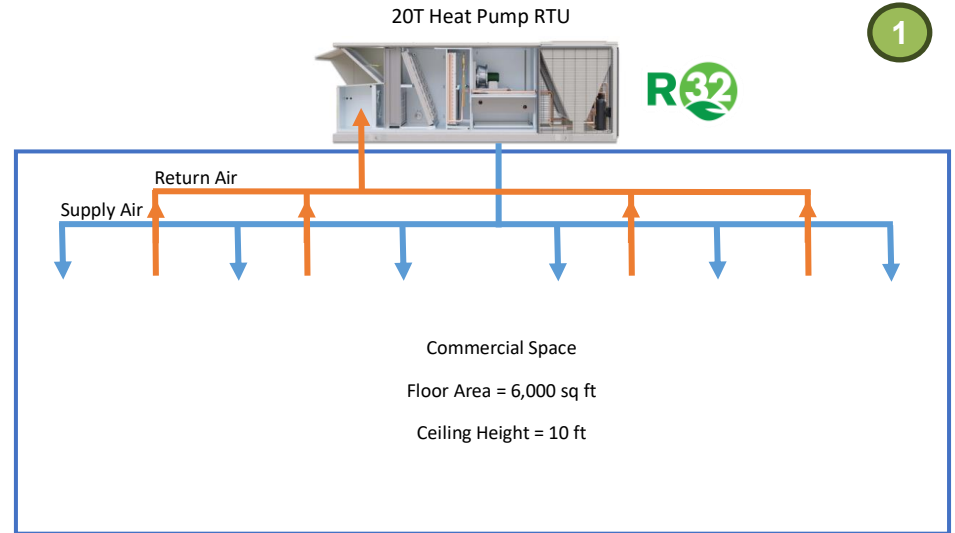
- Determine  $M_{rel}$

$$M_{rel} = 31.2 \text{ lbs}$$

$$625 \text{ lbs} \geq 31.2 \text{ lbs}$$

$$EDVC \geq M_{rel}$$

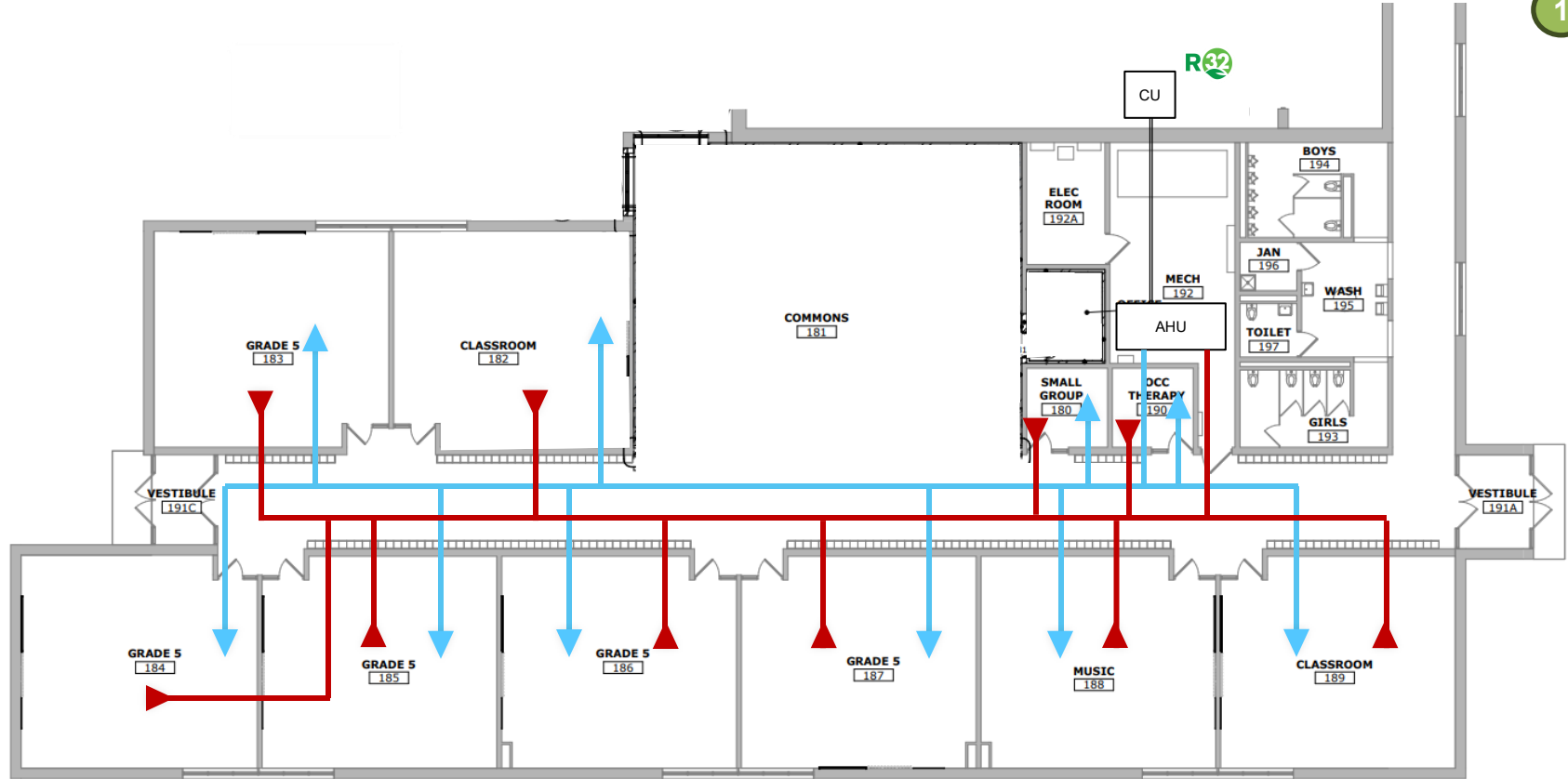
**System is in compliance with EDVC**



# Refrigerant Limits

EDVC Calculation

1

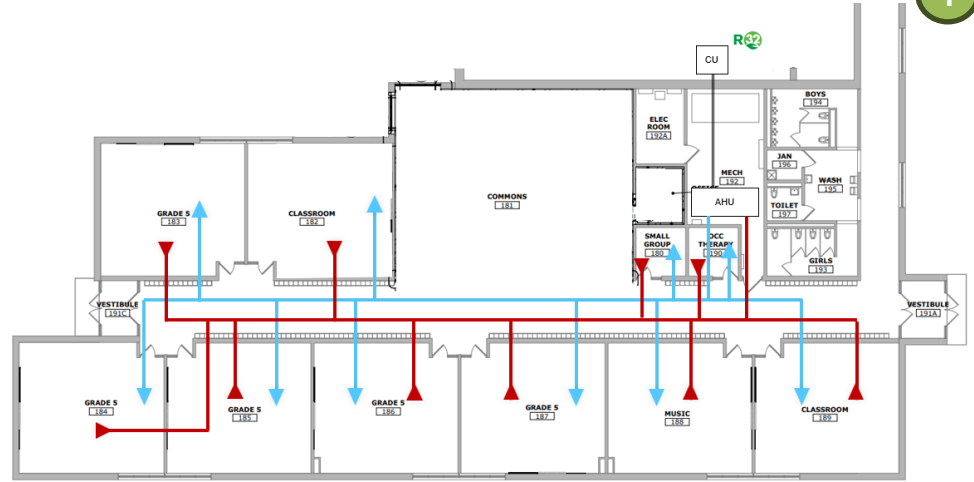


# Refrigerant Limits

## EDVC Calculation

### Determining Effective Dispersal Volume:

- **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)



# Refrigerant Limits

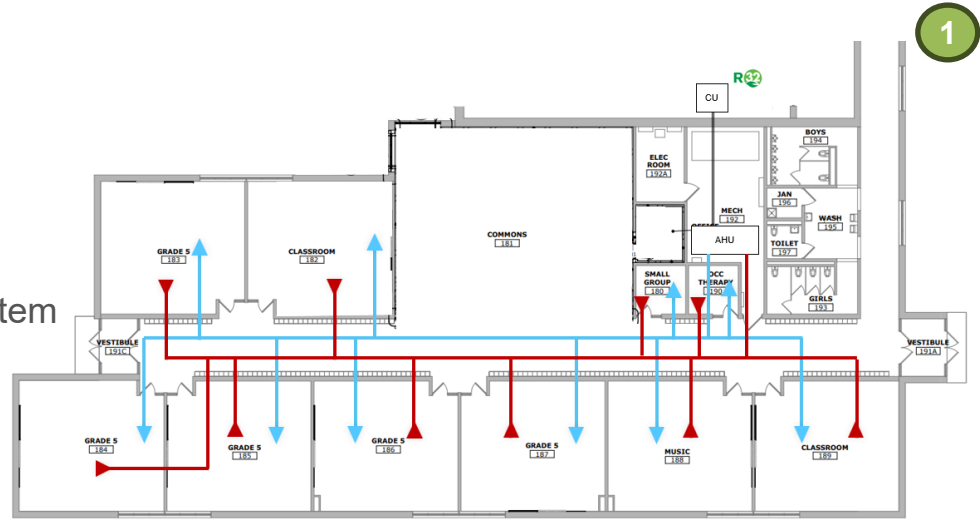
## EDVC Calculation

### Determining Effective Dispersal Volume:

- **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)
- **Connected Spaces:** Ducted Air Distribution System
  - 8 classrooms, 1 small group, 1 office
  - Total volume: spaces + duct volume

Space	Area (sq ft)	Ceiling Height (ft)	Volume (cu ft)
Classrooms	8000	9	72000
Office	120	8	960
<u>Small Group</u>	<u>120</u>	<u>8</u>	<u>960</u>
<b>Total</b>			<b>73920</b>

**Volume of Ductwork = 8,500 ft<sup>3</sup>**

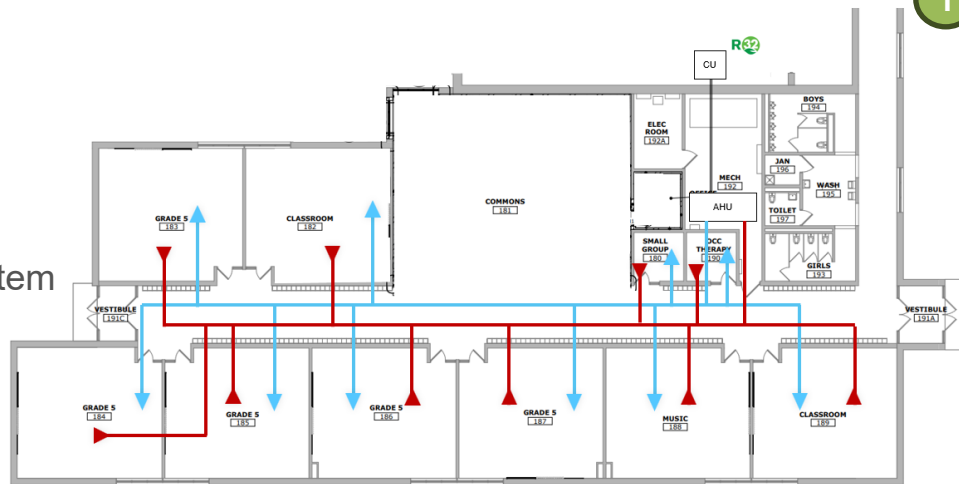


# Refrigerant Limits

## EDVC Calculation

### Determining Effective Dispersal Volume:

- **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)
- **Connected Spaces:** Ducted Air Distribution System
  - 8 classrooms, 1 small group, 1 office
  - Total volume: spaces + duct volume



Space	Area (sq ft)	Ceiling Heigh (ft)	Volume (cu ft)
Classrooms	8000	9	72000
Office	120	8	960
<u>Small Group</u>	<u>120</u>	<u>8</u>	<u>960</u>
<b>Total</b>			<b>73920</b>

**Volume of Ductwork = 8,500 ft<sup>3</sup>**

$$V_{eff} = 73,920 \text{ ft}^3 + 8,500 \text{ ft}^3 = \mathbf{82,420 \text{ ft}^3}$$

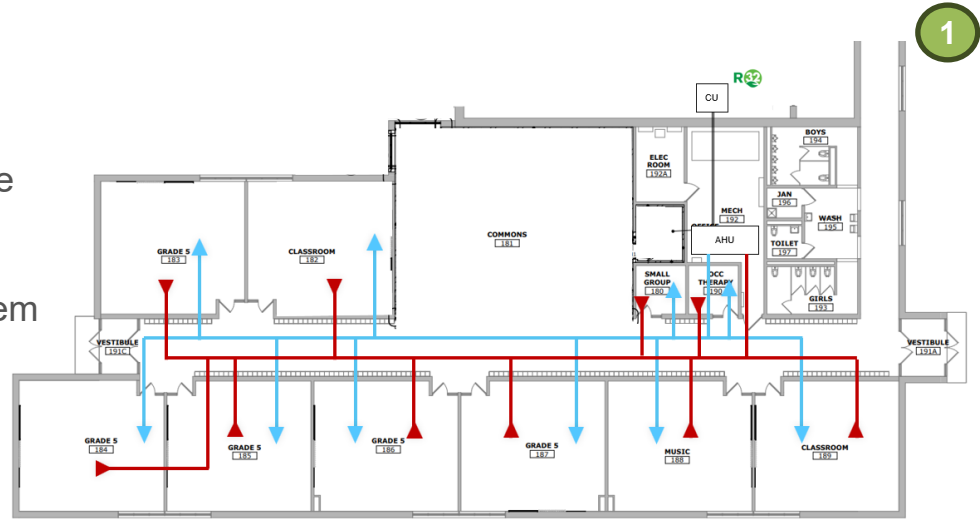
# Refrigerant Limits

## EDVC Calculation

- Determining Effective Dispersal Volume:
  - **Exempt spaces:** Mechanical Room (piping is tested in accordance with section 7.2.3.2 of the standard)
- Connected Spaces: Ducted Air Distribution System
  - 8 classrooms, 1 small group, 1 office
  - Total volume: spaces + duct volume

$$V_{eff} = 73,920 \text{ ft}^3 + 8,500 \text{ ft}^3 = 82,420 \text{ ft}^3$$

- Closures: no closures in the system



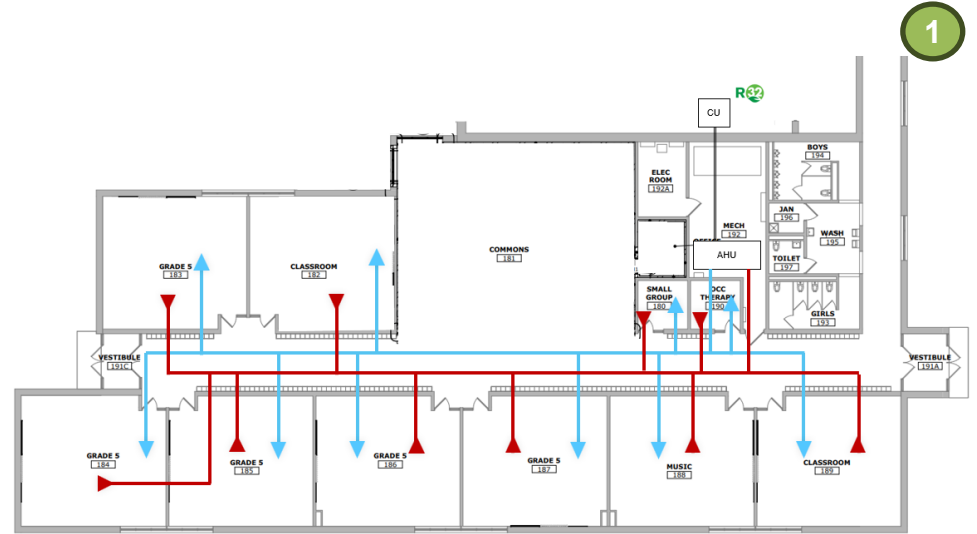
# Refrigerant Limits

## EDVC Calculation

- Calculate EDVC Equation 7.6.1.1

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ}$$

- $V_{eff} = 82,420 \text{ ft}^3$
- Refrigerant LFL (R-32) in ASHRAE Standard 34, Table 4-1 =  $0.0191 \text{ lb/ft}^3$
- Concentration Factor,  $CF = 0.5$
- Occupancy classification: **Public Assembly**,  $F_{occ} = 1.0$



# Refrigerant Limits

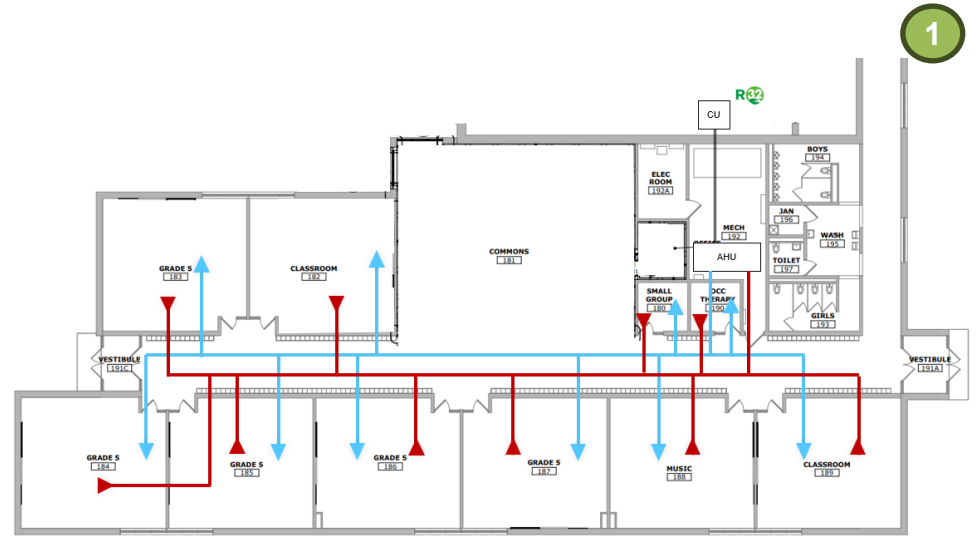
## EDVC Calculation

- Calculate EDVC Equation 7.6.1.1

$$EDVC = V_{eff} \times LFL \times CF \times F_{occ}$$

- $V_{eff} = 82,420 \text{ ft}^3$
- Refrigerant LFL (R-32) in ASHRAE Standard 34, Table 4-1 =  $0.0191 \text{ lb/ft}^3$
- Concentration Factor,  $CF = 0.5$
- Occupancy classification: **Public Assembly**,  $F_{occ} = 1.0$

$$EDVC = 82,420 \text{ ft}^3 \times 0.0191 \text{ lb/ft}^3 \times 0.5 \times 1.0 = 787 \text{ lbs}$$

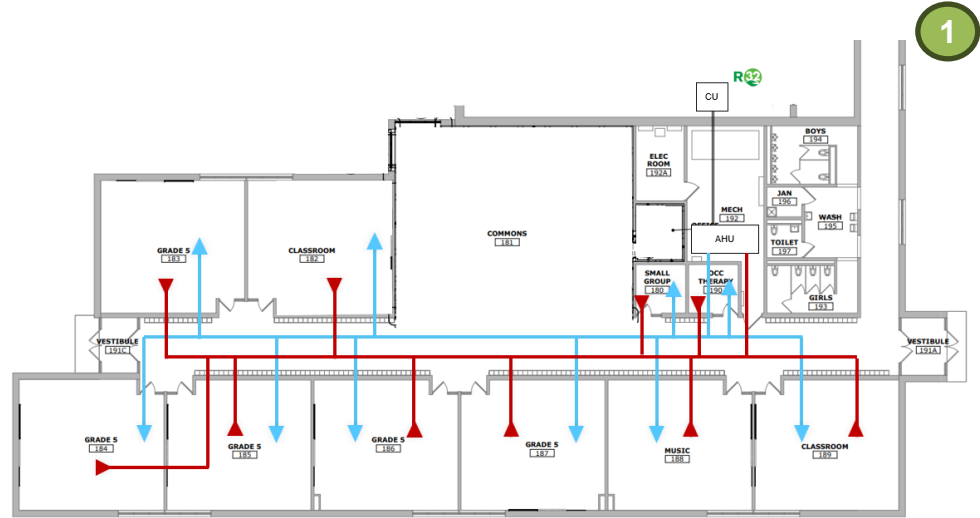


# Refrigerant Limits

## EDVC Calculation

- Determine  $M_{rel}$ 
  - Coil refrigerant charge circuit #1 = 6 lbs
  - Coil refrigerant charge circuit #2 = 5 lbs
  - Circuit #1 charge = 28 lbs
  - Circuit #2 charge = 27 lbs

$$M_{rel} = 6lbs + 28lb = 34lbs$$



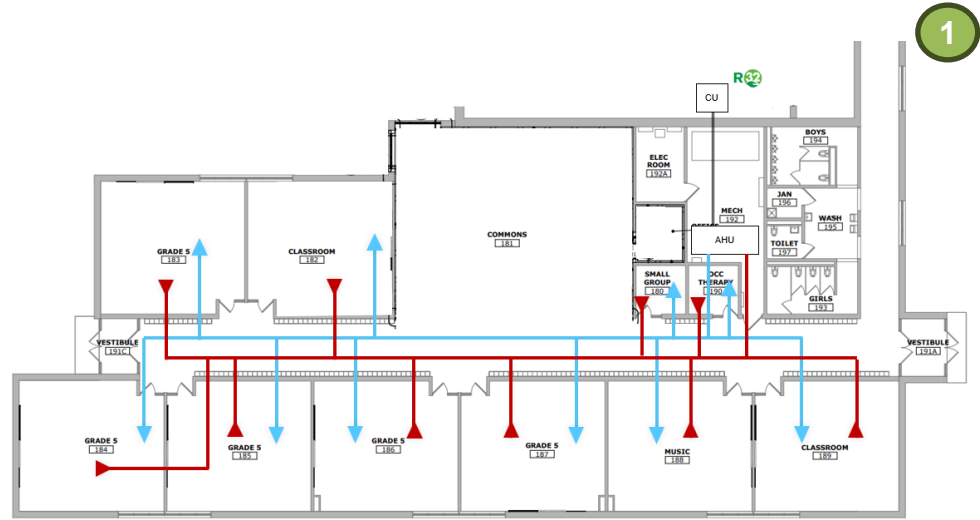
# Refrigerant Limits

## EDVC Calculation

- Determine  $M_{rel}$ 
  - Coil refrigerant charge = 10 lbs
  - Circuit #1 charge = 28 lbs
  - Circuit #2 charge = 27 lbs

$$M_{rel} = 10\text{lbs} + 28\text{lbs} + 27\text{lbs} = 65\text{lbs}$$

$$787\text{ lbs} \geq 34\text{ lbs}$$



System is in compliance with EDVC

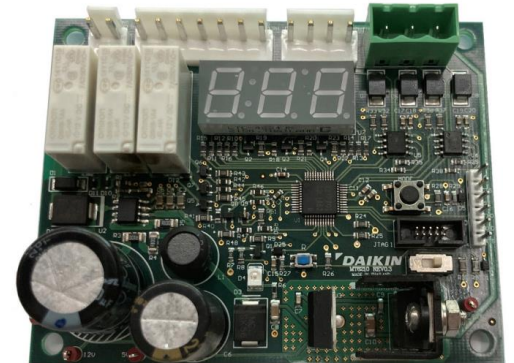
## Refrigerant Detection Systems (7.6.2.3)

### Refrigerant detectors required when:

- **Ducted HVAC systems with a releasable refrigerant charge ( $m_{rel}$ ) more than 4.0 lb (1.8 kg) and with any duct openings less than 5.9 ft (1.8 m) above the finished floor**
- Ducted HVAC systems where spaces connected to the same **supply air duct** are used as the dispersal floor area to calculate **volume** per Section 7.2
- Refrigeration systems installed where the occupancy classification is **institutional occupancy**

### Device output signals may need to be connected to other parts of the system (i.e. air dampers, blowers, etc) and must comply with the following:

- Setpoint is **not field adjustable**
- **Field recalibration** shall **not** be permitted.
- Be capable of detecting the presence of the refrigerant used in the system
- Have **access for replacement of refrigerant detection system components.**
- Have **self-diagnostics** to determine operational status of the sensing element.
  - **Energize air circulation fans of the equipment upon failure of a self-diagnostic check.**
- Generate an **output signal in no more than 30 seconds**

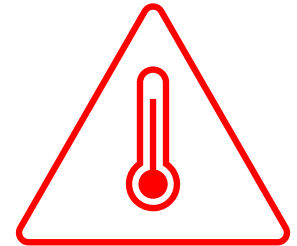


## Ignition Sources in Ductwork (7.6.3)

- Open flame producing devices shall not be permanently installed in ductwork
- Unclassified electrical devices shall not be located in ductwork
- No devices with hot surfaces exceeding 1,290°F
  - Unless air flow velocity exceeds 200 ft/min
  - And, there is proof of air flow when the device is energized



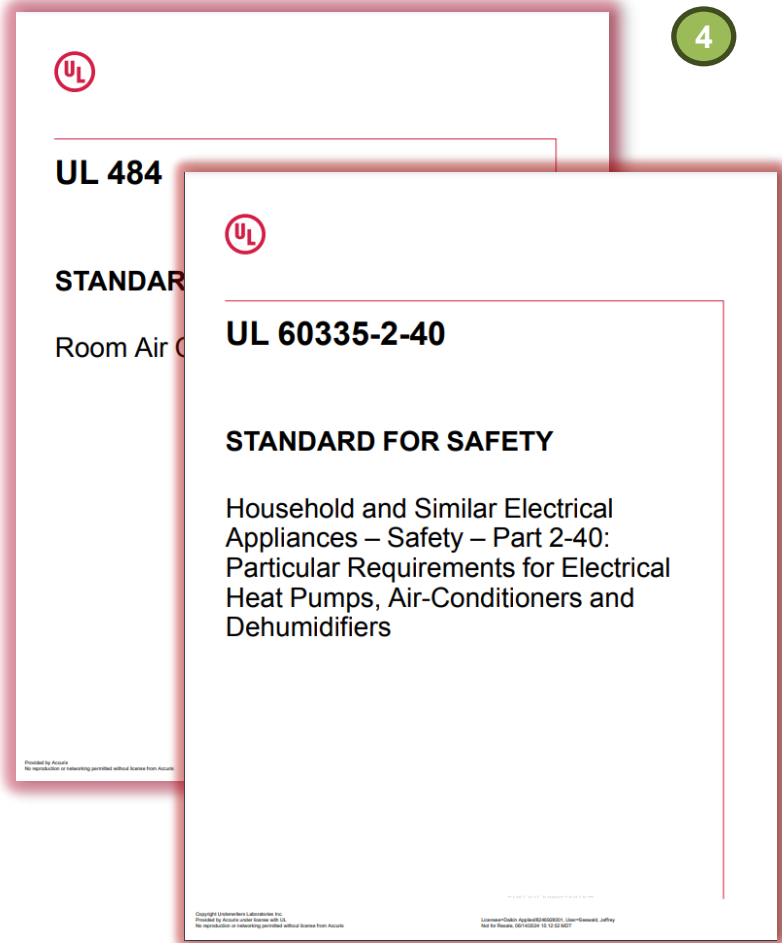
***Generally, the idea is to have heat sources in a listed unit, rather than separately in the ductwork***



# Listed Equipment

## Product Safety Standard(s)

- Refrigeration systems **must be listed** in accordance with **UL 60335-2-40** for HVAC equipment with A2L refrigerants
- Sets safety requirements for equipment manufacturers
  - Leak testing
  - Ignition source restrictions
  - Equipment markings
- Requires certain information that **OEMs must include in IOMs**. For example:
  - Instructions for installation including refrigerant piping and SSOVs
  - Handling, installation, cleaning, servicing and disposal of refrigerant
- **Always refer to the manufacturer's IOM for specific installation requirements!**





A

Air circulation

B

Open zone dampers

C

Mechanical Ventilation

D

Activate shutoff valves

E

Deenergize electric resistance heat and potential ignition sources

5

The following mitigation actions shall be **completed in not more than 15 seconds after the initiation of the output signal** of Section 7.6.2.4(g), and shall be maintained for at least 5 minutes after the output signal has reset

# Air Circulation and Zone Dampers

A

**7.6.2.5 a: Energize the *air circulation* fan(s) of the equipment per the *manufacturer's* instructions.**

B

**7.6.2.5 b: Open zoning dampers, or set zone dampers to full airflow setpoint, that are installed in the *air ducts* connected to the *refrigeration system*.**

**Minimum air circulation rates provided by the manufacturer** are set by UL 60335-2-40 based on refrigerant type and charge.

The minimum airflow shall be determined as:

$$Q_{\min} = 30 \times m_c / LFL \quad (\text{GG.15DV})$$

where

$Q_{\min}$  is the minimum circulation airflow circulated to the total conditioned space in m<sup>3</sup>/h

$m_c$  is the actual refrigerant charge for a single REFRIGERATING SYSTEM in kg

$LFL$  is the lower flammability limit in kg/m<sup>3</sup>

# Mechanical Ventilation (7.6.4)



## Mechanical Ventilation (when required)

Enable circulation fan

- For units with refrigerant detection, the unit's circulation fan must be enabled upon detection of a leak

Mechanical ventilation shall be provided that will remove leaked refrigerant from the space where refrigerant leaking from the refrigeration system is expected to accumulate.

- The space shall be provided with an exhaust or transfer fan. Fans used to exhaust air from the space or transfer air to a separate indoor space shall comply with Equation 7-10

Ventilation can be continuous or enabled via refrigerant detection system.

- Other energy codes may prohibit continuous fan operation

Ventilation does not have to be to the outdoors

- it can be to an alternative space

There are requirements for make-up air and disabling ignition sources

Requirements for locating openings to facilitate mixing and prevent exhaust recirculation

Equation 7-10:

$$Q_{min} = \frac{Q_{req}}{C_{LFL}}$$

Where,

$Q_{min}$  = minimum mechanical ventilation airflow rate, ft<sup>3</sup>/min (m<sup>3</sup>/h)

$Q_{req}$  = required ventilation as determined from Table 7-4

$C_{LFL}$  = lower flammability limit conversion factor as determined from Table 7-5

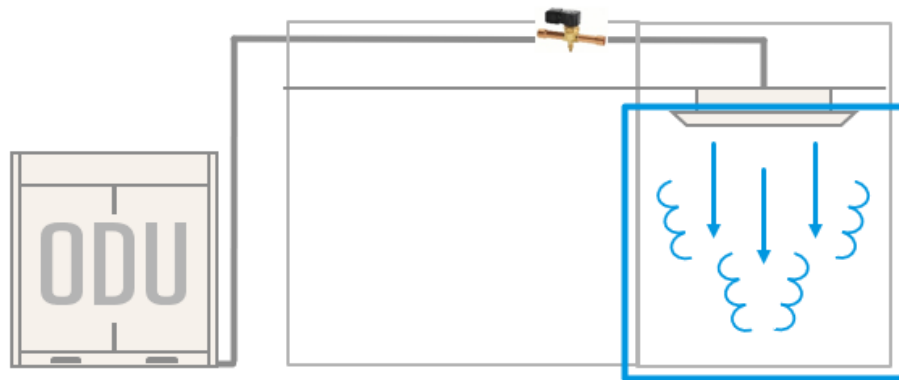
# Release Mitigation Controls

## Safety Shut Off Valves



### Release Mitigation Controls: Safety Shut Off Valves (7.3.4.4)

- Some equipment may include **Safety Shut Off Valves** (SSOV) to close when a leak is detected and limit the amount of refrigerant that can escape
- There are limits to when these devices can be used
  - 7.3.4.4(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.**
- These controls are used to provide a smaller 'releasable refrigerant charge' to help comply with EDVC



**7.6.2.5 d: De-energize electric resistance heat installed in an *air duct* that is connected to the *refrigeration system*.**

**7.6.2.5 f: De-energize potential ignition sources, including open flames and unclassified electrical sources of ignition with apparent power rating greater than 1kVA, where the apparent power is the product of the circuit voltage and current rating.**

# Refrigerant Piping

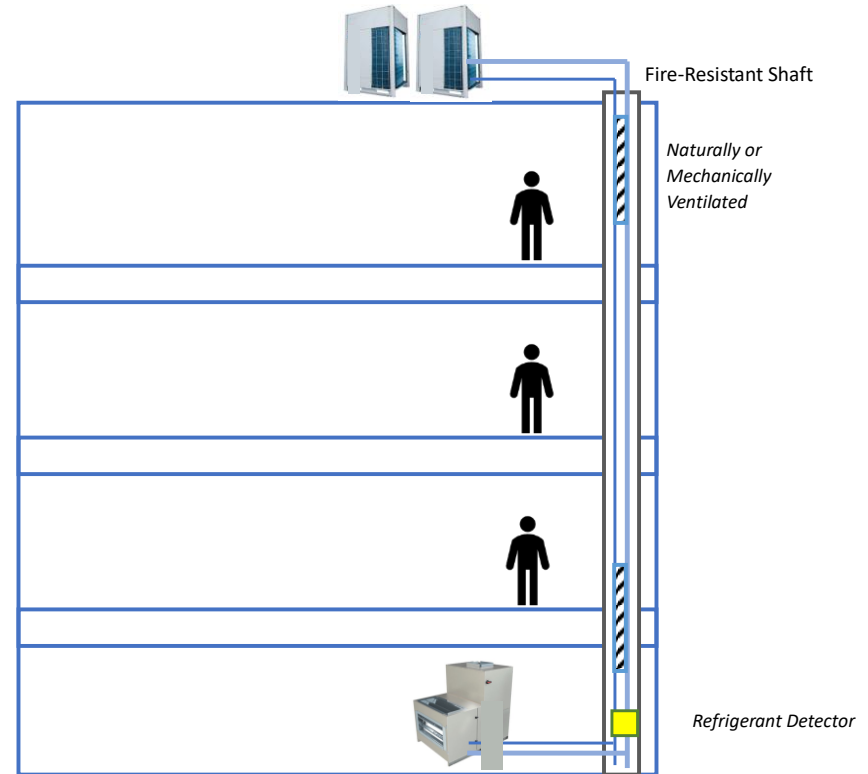
Are you penetrating two or more floor/ceiling assemblies?

Refrigerant piping requires special construction per ASHRAE Standard 15 Section 9.12. Some examples (there are more):

- Refrigerant piping that penetrates multiple floor/ceiling assemblies shall be permitted to be enclosed in a fire-resistance-rated shaft enclosure.
- Refrigerant pipe shafts with systems using only Group A2L or B2L refrigerants shall be naturally or mechanically ventilated.

## IMC 1109.2.5 Refrigerant pipe shafts

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



# ASHRAE Standard 15 - Machinery Rooms

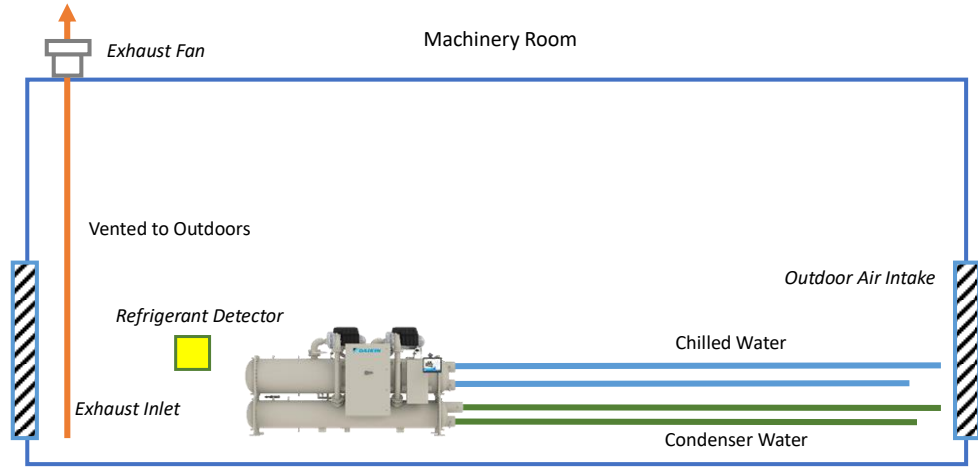
- **Some notable requirements:**
  - Tight fitting doors
  - Access restriction to authorized personnel
  - No airflow to or from an occupied space
  - Refrigerant detectors that can actuate an alarm and mechanical ventilation
- **8.11.1 to 8.11.7** define special requirements for A2L and B2L refrigerants.
- **Elimination or interlocks** of ignition sources
- Ventilation for 2 different alarm states
  - **Trouble** (set point  $\leq$  OEL): respond within 300 seconds, automatic reset of alarm and ventilation is permissible
  - **Emergency** (set point  $\leq$  RCL): respond within 15 seconds, manual reset required for alarm and ventilation, higher CFM requirements

## Machinery Room Requirements

Machinery Room Requirement	A1, B1	A2, B2, A3, B3	A2L, B2L
Equipment clearances with clear head room	Required (Section 8.9.1)	Required (Section 8.9.1)	Required (Section 8.9.1)
Tight-fitting, self-closing doors	Required (Section 8.9.2)	Required (Sections 8.9.2, 8.10.b)	Required (Sections 8.9.2, 8.11.2)
Exterior doors must not open under a fire escape or stairway	Not Required	Required (Section 8.10.d)	Required (Section 8.11.4)
No openings to building, tightly-sealed penetrations	Required (Section 8.9.2)	Required (Sections 8.9.2, 8.10.e)	Required (Sections 8.9.2, 8.11.5)
Gasketed ductwork/AHU panels and doors	Required (Section 8.9.3)	Required (Section 8.9.3)	Required (Section 8.9.3)
Restricted access, door signs	Required (Sections 8.9.4, 10.1.3)	Required (Sections 8.9.4, 10.1.3)	Required (Sections 8.9.4, 10.1.3)
Refrigerant detector	Required (Section 8.9.5)	Required (Section 8.9.5)	Required (Sections 8.11.8 - 8.11.10)
Mechanical ventilation to the outdoors	Required (Section 8.9.6 - 8.9.8)	Required (Sections 8.9.6- 8.9.8)	Requirement Varies (Sections 8.9.6 – 8.9.8 or 8.11.11)
No open flames or hot surfaces	Exceptions Allowed (Section 8.9.9)	No Exceptions (Section 8.10.a)	Exceptions Allowed (Section 8.11.1)
Non-combustable construction (walls, floor, ceiling)	Not Required	Required (Section 8.10.c)	Required (Section 8.11.3)
Conform to NEC Class 1, Division 2	Not Required	Required (Section 8.10.f)	May Not Be Required (comply with Section 8.11.6)
Remote control for shutting down equipment	Not Required	Required (Section 8.10.g)	Required (Section 8.11.7)

# Notable Requirements for Machinery Rooms

- Refrigerant detection
- Visible and audible alarms
- Vented to outdoors
  - Low inlet
  - Powered exhaust fan
- Outdoor air intakes
- Two ventilation rates (A2L & B2L):
  - Level 1: Trouble (> OEL)
  - Level 2: Emergency Alarm (> RCL)



- Machinery: Refrigerating equipment forming a part of the refrigerating system, including (but not limited to) any or all of the following: compressor, condenser, liquid receiver, evaporator, and connecting piping
- Machinery Room: A designated space meeting the requirements of Sections 8.9, 8.10, and 8.11 that contains one or more refrigerating systems or portions thereof, such as compressors and pressure vessels

# Machinery Room Ventilation Rates

Everything Except A2L and B2L

## General Ventilation Requirements

Status	Ventilation Rate
Operated whenever machinery room is occupied	Continuously, at <ul style="list-style-type: none"><li>0.5 cfm/ft<sup>2</sup> (0.00254 m<sup>3</sup>/s per m<sup>2</sup>) of machinery room floor area, OR</li><li>20 cfm (0.00944 m<sup>3</sup>/s) per person</li></ul>
Operated whenever machinery room is occupied	Intermittently, at the airflow rate required to not exceed the higher of: <ul style="list-style-type: none"><li>machinery room temperature 18°F (10°C) above the inlet air temperature, OR</li><li>machinery room temperature exceeding 122°F (50°C)</li></ul>
Ventilation during leak event (setpoint ≤ OEL)	<ul style="list-style-type: none"><li>CFM = 100 × G<sup>0.5</sup></li><li>G = largest circuit ref. charge (lbs)</li></ul>

# Machinery Room Ventilation Rates

A2L & B2L

## Refrigerant Detector Set Points, Response Times, Alarms, and Ventilation Levels

Limit Value	Response Time(s)	Alarm Type	Alarm Reset Type	Ventilation Level	Ventilation Reset Type
Set point $\leq$ OEL	$\leq 300$	Trouble	Automatic	Level 1	Automatic
Set point $\leq$ RCL	$\leq 15$	Emergency	Manual	Level 2	Manual

### Level 1: Occupied or Trouble

Status	Level 1 Ventilation Rate
Operated whenever machinery room is occupied, AND Operated if refrigerant detector indicates refrigerant concentration exceeds the “trouble alarm” setpoint (must be set $\leq$ OEL)	Continuously, at the higher of the following airflow rates: <ul style="list-style-type: none"><li>• 0.5 cfm/ft<sup>2</sup> (0.00254 m<sup>3</sup>/s per m<sup>2</sup>) of machinery room floor area, OR</li><li>• 20 cfm (0.00944 m<sup>3</sup>/s) per person</li></ul>
Whenever machinery room is occupied	Intermittently, at the airflow rate required to not exceed the higher of: <ul style="list-style-type: none"><li>• machinery room temperature 18°F (10°C) above the inlet air temperature, OR</li><li>• machinery room temperature exceeding 122°F (50°C)</li></ul>

# Machinery Room Ventilation Rates

## Level 2: Emergency (For A2Ls)

- Based on largest refrigerant charge & unit design pressure
- Cannot be less than the Level 1 rate
- A2Ls have more lenient mechanical room design requirements than class 2 or 3 refrigerants but may have higher ventilation rates during a Level 2 leak event
- Round **up** Q to 2 significant digits

## Sample Calculation

Refrigerant	R-515B (A1)	R-1234ze (A2L)
Charge / Pressure	Largest Circuit Charge = 1000 lb	Largest Circuit Charge = 1000 lb Pressure = 14.7 + 185 psig = 199.7 psia
Method	Section 8.9.8.1: $CFM = 100 \times G^{0.5}$	Section 8.11.11: Table 8-3 or Figure 8-1
Example	$Q = 100 \times G^{0.5} = 100 \times 1000^{0.5} = 3,162 \text{ cfm}$ <p style="text-align: center;"><b>Q = 3,200 cfm</b></p>	$G' = 21200 \times p^{-0.72} = 21200 \times 199.7^{-0.72} = 467.8 \text{ lb}$ $Q' = 646 \times p^{0.62} = 646 \times 199.7^{0.62} = 17,240 \text{ cfm}$ <p style="text-align: center;"><math>G &gt; G'</math>, therefore <math>Q \geq Q'</math></p> <p style="text-align: center;"><b>Q = 18,000 cfm</b></p>

Refrigerant Charge, G	Level 2 Ventilation Rate, Q
$G < 0.1 \times G'$	$Q \geq Q' \times 0.102$ And $Q \geq Q_1$
$0.1 \times G' \leq G \leq G'$	$Q \geq Q' \times [1 + 0.39 \times \ln (G/G')]$ And $Q \geq Q_1$
$G > G'$	$Q \geq Q'$

\*Note: See section ASHRAE Standard 15-2022, section 8.11

# Machinery Room Ventilation Rates

## Level 2: Emergency (For A2Ls)

- Based on largest refrigerant charge & unit design pressure
- Cannot be less than the Level 1 rate
- A2Ls have more lenient mechanical room design requirements than class 2 or 3 refrigerants but may have higher ventilation rates during a Level 2 leak event
- Round **up** Q to 2 significant digits

Refrigerant Charge, G	Level 2 Ventilation Rate, Q
$G < 0.1 \times G'$	$Q \geq Q' \times 0.102$ And $Q \geq Q_1$
$0.1 \times G' \leq G \leq G'$	$Q \geq Q' \times [1 + 0.39 \times \ln (G/G')]$ And $Q \geq Q_1$
$G > G'$	$Q \geq Q'$

\*Note: See section ASHRAE Standard 15-2022, section 8.11

## Sample Calculation

Refrigerant	R-515B (A1)	R-1234ze (A2L)
Charge / Pressure	Largest Circuit Charge = 1000 lb	Largest Circuit Charge = 1000 lb Pressure = $14.7 + 185 \text{ psia} = 199.7 \text{ psia}$
Method		Figure 8-1
Example		$17240 \text{ cfm} \times 1.05 = 18102 \text{ cfm}$ $18102 \text{ cfm} \times 1.05 = 19007 \text{ cfm}$ $19007 \text{ cfm} \times 1.05 = 19957 \text{ cfm}$ $19957 \text{ cfm} \times 1.05 = 20955 \text{ cfm}$ $20955 \text{ cfm} \times 1.05 = 22003 \text{ cfm}$ $22003 \text{ cfm} \times 1.05 = 23103 \text{ cfm}$ $23103 \text{ cfm} \times 1.05 = 24258 \text{ cfm}$ $24258 \text{ cfm} \times 1.05 = 25471 \text{ cfm}$ $25471 \text{ cfm} \times 1.05 = 26735 \text{ cfm}$ $26735 \text{ cfm} \times 1.05 = 28052 \text{ cfm}$ $28052 \text{ cfm} \times 1.05 = 29415 \text{ cfm}$ $29415 \text{ cfm} \times 1.05 = 30826 \text{ cfm}$ $30826 \text{ cfm} \times 1.05 = 32287 \text{ cfm}$ $32287 \text{ cfm} \times 1.05 = 33801 \text{ cfm}$ $33801 \text{ cfm} \times 1.05 = 35361 \text{ cfm}$ $35361 \text{ cfm} \times 1.05 = 36969 \text{ cfm}$ $36969 \text{ cfm} \times 1.05 = 38628 \text{ cfm}$ $38628 \text{ cfm} \times 1.05 = 40339 \text{ cfm}$ $40339 \text{ cfm} \times 1.05 = 42106 \text{ cfm}$ $42106 \text{ cfm} \times 1.05 = 43931 \text{ cfm}$ $43931 \text{ cfm} \times 1.05 = 45817 \text{ cfm}$ $45817 \text{ cfm} \times 1.05 = 47764 \text{ cfm}$ $47764 \text{ cfm} \times 1.05 = 49772 \text{ cfm}$ $49772 \text{ cfm} \times 1.05 = 51841 \text{ cfm}$ $51841 \text{ cfm} \times 1.05 = 53971 \text{ cfm}$ $53971 \text{ cfm} \times 1.05 = 56163 \text{ cfm}$ $56163 \text{ cfm} \times 1.05 = 58418 \text{ cfm}$ $58418 \text{ cfm} \times 1.05 = 60738 \text{ cfm}$ $60738 \text{ cfm} \times 1.05 = 63124 \text{ cfm}$ $63124 \text{ cfm} \times 1.05 = 65577 \text{ cfm}$ $65577 \text{ cfm} \times 1.05 = 68099 \text{ cfm}$ $68099 \text{ cfm} \times 1.05 = 70691 \text{ cfm}$ $70691 \text{ cfm} \times 1.05 = 73355 \text{ cfm}$ $73355 \text{ cfm} \times 1.05 = 76094 \text{ cfm}$ $76094 \text{ cfm} \times 1.05 = 78901 \text{ cfm}$ $78901 \text{ cfm} \times 1.05 = 81778 \text{ cfm}$ $81778 \text{ cfm} \times 1.05 = 84728 \text{ cfm}$ $84728 \text{ cfm} \times 1.05 = 87754 \text{ cfm}$ $87754 \text{ cfm} \times 1.05 = 90851 \text{ cfm}$ $90851 \text{ cfm} \times 1.05 = 94022 \text{ cfm}$ $94022 \text{ cfm} \times 1.05 = 97270 \text{ cfm}$ $97270 \text{ cfm} \times 1.05 = 100597 \text{ cfm}$ $100597 \text{ cfm} \times 1.05 = 103997 \text{ cfm}$ $103997 \text{ cfm} \times 1.05 = 107471 \text{ cfm}$ $107471 \text{ cfm} \times 1.05 = 111019 \text{ cfm}$ $111019 \text{ cfm} \times 1.05 = 114641 \text{ cfm}$ $114641 \text{ cfm} \times 1.05 = 118337 \text{ cfm}$ $118337 \text{ cfm} \times 1.05 = 122108 \text{ cfm}$ $122108 \text{ cfm} \times 1.05 = 125956 \text{ cfm}$ $125956 \text{ cfm} \times 1.05 = 130884 \text{ cfm}$ $130884 \text{ cfm} \times 1.05 = 135896 \text{ cfm}$ $135896 \text{ cfm} \times 1.05 = 140996 \text{ cfm}$ $140996 \text{ cfm} \times 1.05 = 146187 \text{ cfm}$ $146187 \text{ cfm} \times 1.05 = 151471 \text{ cfm}$ $151471 \text{ cfm} \times 1.05 = 156851 \text{ cfm}$ $156851 \text{ cfm} \times 1.05 = 162328 \text{ cfm}$ $162328 \text{ cfm} \times 1.05 = 167906 \text{ cfm}$ $167906 \text{ cfm} \times 1.05 = 173588 \text{ cfm}$ $173588 \text{ cfm} \times 1.05 = 179368 \text{ cfm}$ $179368 \text{ cfm} \times 1.05 = 185249 \text{ cfm}$ $185249 \text{ cfm} \times 1.05 = 191234 \text{ cfm}$ $191234 \text{ cfm} \times 1.05 = 197326 \text{ cfm}$ $197326 \text{ cfm} \times 1.05 = 203528 \text{ cfm}$ $203528 \text{ cfm} \times 1.05 = 209842 \text{ cfm}$ $209842 \text{ cfm} \times 1.05 = 216271 \text{ cfm}$ $216271 \text{ cfm} \times 1.05 = 222818 \text{ cfm}$ $222818 \text{ cfm} \times 1.05 = 229486 \text{ cfm}$ $229486 \text{ cfm} \times 1.05 = 236278 \text{ cfm}$ $236278 \text{ cfm} \times 1.05 = 243198 \text{ cfm}$ $243198 \text{ cfm} \times 1.05 = 250248 \text{ cfm}$ $250248 \text{ cfm} \times 1.05 = 257431 \text{ cfm}$ $257431 \text{ cfm} \times 1.05 = 264741 \text{ cfm}$ $264741 \text{ cfm} \times 1.05 = 272181 \text{ cfm}$ $272181 \text{ cfm} \times 1.05 = 279755 \text{ cfm}$ $279755 \text{ cfm} \times 1.05 = 287468 \text{ cfm}$ $287468 \text{ cfm} \times 1.05 = 295314 \text{ cfm}$ $295314 \text{ cfm} \times 1.05 = 303298 \text{ cfm}$ $303298 \text{ cfm} \times 1.05 = 311414 \text{ cfm}$ $311414 \text{ cfm} \times 1.05 = 319566 \text{ cfm}$ $319566 \text{ cfm} \times 1.05 = 327858 \text{ cfm}$ $327858 \text{ cfm} \times 1.05 = 336284 \text{ cfm}$ $336284 \text{ cfm} \times 1.05 = 344839 \text{ cfm}$ $344839 \text{ cfm} \times 1.05 = 353528 \text{ cfm}$ $353528 \text{ cfm} \times 1.05 = 362346 \text{ cfm}$ $362346 \text{ cfm} \times 1.05 = 371298 \text{ cfm}$ $371298 \text{ cfm} \times 1.05 = 379379 \text{ cfm}$ $379379 \text{ cfm} \times 1.05 = 387584 \text{ cfm}$ $387584 \text{ cfm} \times 1.05 = 395918 \text{ cfm}$ $395918 \text{ cfm} \times 1.05 = 404386 \text{ cfm}$ $404386 \text{ cfm} \times 1.05 = 412984 \text{ cfm}$ $412984 \text{ cfm} \times 1.05 = 421708 \text{ cfm}$ $421708 \text{ cfm} \times 1.05 = 430553 \text{ cfm}$ $430553 \text{ cfm} \times 1.05 = 439524 \text{ cfm}$ $439524 \text{ cfm} \times 1.05 = 448626 \text{ cfm}$ $448626 \text{ cfm} \times 1.05 = 457854 \text{ cfm}$ $457854 \text{ cfm} \times 1.05 = 467203 \text{ cfm}$ $467203 \text{ cfm} \times 1.05 = 476678 \text{ cfm}$ $476678 \text{ cfm} \times 1.05 = 486284 \text{ cfm}$ $486284 \text{ cfm} \times 1.05 = 496016 \text{ cfm}$ $496016 \text{ cfm} \times 1.05 = 505871 \text{ cfm}$ $505871 \text{ cfm} \times 1.05 = 515844 \text{ cfm}$ $515844 \text{ cfm} \times 1.05 = 525931 \text{ cfm}$ $525931 \text{ cfm} \times 1.05 = 536137 \text{ cfm}$ $536137 \text{ cfm} \times 1.05 = 546468 \text{ cfm}$ $546468 \text{ cfm} \times 1.05 = 556919 \text{ cfm}$ $556919 \text{ cfm} \times 1.05 = 567496 \text{ cfm}$ $567496 \text{ cfm} \times 1.05 = 578194 \text{ cfm}$ $578194 \text{ cfm} \times 1.05 = 589019 \text{ cfm}$ $589019 \text{ cfm} \times 1.05 = 599967 \text{ cfm}$ $599967 \text{ cfm} \times 1.05 = 611044 \text{ cfm}$ $611044 \text{ cfm} \times 1.05 = 622246 \text{ cfm}$ $622246 \text{ cfm} \times 1.05 = 633569 \text{ cfm}$ $633569 \text{ cfm} \times 1.05 = 645019 \text{ cfm}$ $645019 \text{ cfm} \times 1.05 = 656592 \text{ cfm}$ $656592 \text{ cfm} \times 1.05 = 668284 \text{ cfm}$ $668284 \text{ cfm} \times 1.05 = 680099 \text{ cfm}$ $680099 \text{ cfm} \times 1.05 = 692033 \text{ cfm}$ $692033 \text{ cfm} \times 1.05 = 704082 \text{ cfm}$ $704082 \text{ cfm} \times 1.05 = 716251 \text{ cfm}$ $716251 \text{ cfm} \times 1.05 = 728546 \text{ cfm}$ $728546 \text{ cfm} \times 1.05 = 740963 \text{ cfm}$ $740963 \text{ cfm} \times 1.05 = 753508 \text{ cfm}$ $753508 \text{ cfm} \times 1.05 = 766176 \text{ cfm}$ $766176 \text{ cfm} \times 1.05 = 778973 \text{ cfm}$ $778973 \text{ cfm} \times 1.05 = 791894 \text{ cfm}$ $791894 \text{ cfm} \times 1.05 = 804934 \text{ cfm}$ $804934 \text{ cfm} \times 1.05 = 818099 \text{ cfm}$ $818099 \text{ cfm} \times 1.05 = 831384 \text{ cfm}$ $831384 \text{ cfm} \times 1.05 = 844794 \text{ cfm}$ $844794 \text{ cfm} \times 1.05 = 858324 \text{ cfm}$ $858324 \text{ cfm} \times 1.05 = 871979 \text{ cfm}$ $871979 \text{ cfm} \times 1.05 = 885764 \text{ cfm}$ $885764 \text{ cfm} \times 1.05 = 899674 \text{ cfm}$ $899674 \text{ cfm} \times 1.05 = 913704 \text{ cfm}$ $913704 \text{ cfm} \times 1.05 = 927859 \text{ cfm}$ $927859 \text{ cfm} \times 1.05 = 942144 \text{ cfm}$ $942144 \text{ cfm} \times 1.05 = 956554 \text{ cfm}$ $956554 \text{ cfm} \times 1.05 = 971084 \text{ cfm}$ $971084 \text{ cfm} \times 1.05 = 985829 \text{ cfm}$ $985829 \text{ cfm} \times 1.05 = 1000694 \text{ cfm}$ $1000694 \text{ cfm} \times 1.05 = 1015684 \text{ cfm}$ $1015684 \text{ cfm} \times 1.05 = 1030794 \text{ cfm}$ $1030794 \text{ cfm} \times 1.05 = 1045929 \text{ cfm}$ $1045929 \text{ cfm} \times 1.05 = 1061184 \text{ cfm}$ $1061184 \text{ cfm} \times 1.05 = 1076554 \text{ cfm}$ $1076554 \text{ cfm} \times 1.05 = 1092044 \text{ cfm}$ $1092044 \text{ cfm} \times 1.05 = 1107659 \text{ cfm}$ $1107659 \text{ cfm} \times 1.05 = 1123394 \text{ cfm}$ $1123394 \text{ cfm} \times 1.05 = 1139254 \text{ cfm}$ $1139254 \text{ cfm} \times 1.05 = 1155234 \text{ cfm}$ $1155234 \text{ cfm} \times 1.05 = 1171339 \text{ cfm}$ $1171339 \text{ cfm} \times 1.05 = 1187564 \text{ cfm}$ $1187564 \text{ cfm} \times 1.05 = 1203914 \text{ cfm}$ $1203914 \text{ cfm} \times 1.05 = 1220384 \text{ cfm}$ $1220384 \text{ cfm} \times 1.05 = 1236979 \text{ cfm}$ $1236979 \text{ cfm} \times 1.05 = 1253694 \text{ cfm}$ $1253694 \text{ cfm} \times 1.05 = 1270534 \text{ cfm}$ $1270534 \text{ cfm} \times 1.05 = 1287494 \text{ cfm}$ $1287494 \text{ cfm} \times 1.05 = 1304569 \text{ cfm}$ $1304569 \text{ cfm} \times 1.05 = 1321764 \text{ cfm}$ $1321764 \text{ cfm} \times 1.05 = 1339084 \text{ cfm}$ $1339084 \text{ cfm} \times 1.05 = 1356524 \text{ cfm}$ $1356524 \text{ cfm} \times 1.05 = 1374089 \text{ cfm}$ $1374089 \text{ cfm} \times 1.05 = 1391774 \text{ cfm}$ $1391774 \text{ cfm} \times 1.05 = 1409584 \text{ cfm}$ $1409584 \text{ cfm} \times 1.05 = 1427514 \text{ cfm}$ $1427514 \text{ cfm} \times 1.05 = 1445569 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# ASHRAE Standard 34

## Terminology

Term	Definition
<b>Burning velocity</b>	The maximum velocity (in/s [cm/s]) at which a laminar flame propagates in a normal direction relative to the unburned gas ahead of it.
<b>HOC</b>	The heat released when a substance is combusted, determined as the difference in the enthalpy between the reactants (refrigerants and air) and their products after combustion as defined in Section 6.1.3.6. The heat or enthalpy of combustion is often expressed as energy per mass (e.g., Btu/lb [kJ/kg]).
<b>LFL</b>	The minimum concentration of a substance, e.g. a refrigerant, that is capable of propagating a flame through a homogeneous mixture of the substance and air under specified test conditions.
<b>FCL</b>	Flammable Concentration Limit, the refrigerant concentration limit, in air, intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces, $FCL = 25\% \times LFL$
<b>MIE</b>	Minimum Ignition Energy (MIE) is the lowest energy required to ignite the flammable material in air or oxygen. The lowest value of the Minimum Ignition Energy is found at a certain optimum mixture of fuel and air.
<b>OEL</b>	The time-weighted average (TWA) concentration for a normal eight-hour workday and a 40-hour workweek to which nearly all workers can be repeatedly exposed without adverse effect, based on the OSHA PEL, ACGIH TLV-TWA, TERA OARS-WEEL, or consistent value.
<b>RCL</b>	The refrigerant concentration limit, in air, determined in accordance with this standard and intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces.
<b>ATEL</b>	Acute Toxicity Exposure Limit, a concentration limit intended to reduce the risks of acute toxicity hazards in normally occupied, enclosed spaces
<b>ODL</b>	Oxygen Deprivation Limit, the concentration of a refrigerant or other gas that results in insufficient oxygen for normal breathing

# ASHRAE Standard 15

## Terminology

Term	Definition
<b>EDVC</b>	Effective dispersal volume charge (EDVC), or the maximum refrigerant charge permitted for an effective dispersal volume.
<b>Occupancy Classification</b>	Characterizes the ability of people to respond to potential exposure to refrigerant, where classifications include institutional, public assembly, residential, commercial, large mercantile, industrial and mixed occupancy.
<b>Refrigerating System Classification</b>	Characterizes the refrigerating system, and in particular the method of extracting/delivering heat: direct or indirect, high-probability or low-probability.

# Where Can I Go for Information?

## Applying A2L Refrigerants:

- [A2L Refrigerant Engineering Guide](#)
- [Navigating Retrofits and Replacements for High GWP Refrigerants Engineering Guide](#)
- [Navigating Retrofits and Replacements for High GWP Refrigerants Video](#)
- [Navigating the Hurdles of Low GWP Refrigerant Retrofits](#)



## Building Codes:

- [ASHRAE Standards 15 and 34](#)
- <https://www.ashrae.org/technical-resources/bookstore/ashrae-refrigeration-resources>
- <https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards>



## General Guidance:

- [Preparing Buildings for A2L Refrigerants](#)
- <https://www.daikinapplied.com/decarbonization/refrigerants>

# Where Can I Go for Information?

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## General Guidance:

- AHRI Webcast Series
  - [An Introduction to A2L Refrigerants](#)
  - [A2L Refrigerants Webinar Series Part 2 - Updates to Standards and Model Codes](#)
  - [A2L Refrigerants Webinar Series Part 3: State and Local Codes and Available Resources](#)
- <https://www.iccsafe.org/products-and-services/i-codes/a2l-refrigerants-transition/>
- <https://www.ashrae.org/news/ashraejournal/ashrae-journal-podcast-episode-3>
- <https://www.ahrinet.org/saferefrigerant>
- <https://www.acca.org/education/a2l-refrigerants>
- <https://www.rses.org/training/>
- <https://www.achrnews.com/articles/153195-understanding-a2l-refrigerants>
- <https://www.esmagazine.com/articles/99996-a2l-refrigerants-safely-addressing-refrigerant-flammability-concerns>

# Where Can I Go for Information?

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For more information, contact:

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**Thank you!**

