ASHRAE Standard 15

Safe Design of VRF & Other Refrigeration Systems

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During this presentation

▪ Roots of refrigeration system safety
▪ Overarching goals of refrigeration system safety
▪ Standard 15 purpose, scope, and overview
▪ Current status
A bit of history,

Code expands to regulate refrigerating machines & refrigerants


ASRE engineers initiate development of 1st refrigeration safety code for NYC

ASRE publishes updated versions of ASA B9

ASRE re-designates B9 to B9.1 publishing updated versions.

Merger of ASRE and ASHAE leads ASHRAE to publish as B9.1

ANSI approves ASHRAE B9.1


Refrigeration System Safety Timeline

ASHRAE publishes 1st version of ANSI/ASHRAE 15

ASHRAE publishes revised versions of ANSI/ASHRAE Standard 15
ASHRAE 15 today

- **Purpose:** specifies safe design, construction, installation, and operation of refrigeration systems

- **Scope:** establishes safeguards for life, limb, health, and property and prescribes safety requirements

Fundamental goals of Std. 15

1. Keep refrigerants contained within the system

2. In the event when a refrigerant might be released, mitigate its impact on people
   a) By limiting refrigerant quantity in direct systems
   b) Locating refrigeration systems within machinery rooms when system charge is too large
ASHRAE 15

- **Applications:**
  
a) design, construction, test, installation, operation, and inspection of *mechanical* and *absorption* refrigeration systems, including heat-pump systems used in *stationary applications*;

b) *modifications*, including replacement of parts or components if they are not identical in function and capacity; and

c) *refrigerant substitutions* with a different designation.

ASHRAE 34

- **Companion to ASHRAE 15**

**Purpose:** establish a system to uniquely identify refrigerants, assign reference numbers to refrigerants, *establishes safety classification and refrigerant concentration limits.*
ASHRAE 15 and ASHRAE 34

- ASHRAE 15 defers to ASHRAE 34 on:
  - Refrigerant safety classifications
  - Refrigerant concentration limits (RCLs)
  - Key refrigerant property information that must be submitted with an application for designation

### ASHRAE 34

**TABLE 4-2 Data and Safety Classifications for Refrigerant Blends**

<table>
<thead>
<tr>
<th>Refrigerant Number</th>
<th>Composition (Mass %)</th>
<th>Composition Tolerances</th>
<th>OEL, ppm v/v</th>
<th>Safety Group</th>
<th>RCL^a (ppm v/v)</th>
<th>(lb/Mcf)</th>
<th>(g/m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zootropes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>408A</td>
<td>R-32/115/134 (55.0/40.0/5.0)</td>
<td>(±0.5, ±1.5, ±1.5, ±0.5)</td>
<td>1000</td>
<td>A1</td>
<td>140,000</td>
<td>26</td>
<td>420</td>
</tr>
<tr>
<td>408B</td>
<td>R-32/125/134 (45.0/55.0)</td>
<td>(±1.0, ±1.0, ±1.0, ±1.0)</td>
<td>1000</td>
<td>A1</td>
<td>140,000</td>
<td>27</td>
<td>430</td>
</tr>
</tbody>
</table>

^a RCL: Refrigerant Concentration Limit
**Toxicity classifications**

- **Class A** signifies refrigerants where toxicity has not been identified at concentrations ≥ 400 ppm, based on TLV–TWA data or consistent indices.

- **Class B** signifies refrigerants for which there is evidence of toxicity at concentrations < 400 ppm, based on TLV–TWA data or other consistent indices.

**Flammability classifications**

1 – No flame propagation
2 – Exhibits flame propagation, a LFL > 0.10 kg/m³ and heat of combustion < 19,000 kJ/kg
   - **2L** – burning velocity not greater than 10 cm/s*
3 – Exhibits flame propagation, a LFL ≤ 0.10 kg/m³ and heat of combustion ≥ 19,000 kJ/kg

* per ASTM E 681
ASHRAE 34

Refrigerant safety classifications

- A1
  - R22, R134a
- A2L
  - R32, R143a, R1234yf
- B2L
  - R717 (ammonia)
- A3
  - R600a (isobutane), R290 (propane)

<table>
<thead>
<tr>
<th>Safety Group Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Flammability</td>
</tr>
<tr>
<td>A3</td>
</tr>
<tr>
<td>Lower Flammability</td>
</tr>
<tr>
<td>A2</td>
</tr>
<tr>
<td>A2L</td>
</tr>
<tr>
<td>No Flame Propagation</td>
</tr>
<tr>
<td>A1</td>
</tr>
<tr>
<td>Lower Toxicity</td>
</tr>
</tbody>
</table>

The 2L refrigerants have a burning velocity of 10 cm/s or slower.

Standard 15 content

- Classifications
  - Section 4 – Occupancy
  - Section 5 – Refrigerating systems
  - Section 6 – Refrigerant safety
Standard 15 content

▪ Restrictions
  ▪ Section 7 – Refrigerant use
  ▪ Section 8 – Installation

▪ Design, construction, & operation
  ▪ Section 9 – Equipment and Systems
  ▪ Section 10 – Operation and testing

Standard 15 content

▪ General
  ▪ Section 11 – General requirements
  ▪ Section 12 – Precedence with conflicts
  ▪ Section 13 – Listed equipment

▪ Normative appendices
  ▪ Appendix B – References
  ▪ Appendix D – Relief vent line lengths
Restrictions on use

I. Determine refrigerant concentration from complete discharge of largest independent refrigerant circuit

II. Resulting concentration cannot exceed the refrigerant’s RCL from ASHRAE 34 (institutional occupancies @ 50% of RCL)

Exceptions:
1. Listed equipment not containing more than 6.6 lb.
2. Listed equipment for use in laboratories with more than 100 ft²/person

What is RCL?

- ASHRAE 34
  - RCL is the refrigerant concentration limit in air that is intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces
  - Concentration is based on
    - full vaporization of the refrigerant in the space to which it is released with complete mixing and no removal by ventilation, dissolution, reaction, or decomposition
Volume for determining RC

- Volume of space to which refrigerant disperses in the event of a refrigerant leak [§7.3]
- Occupied spaces that do not connect through permanent openings or HVAC ducts, use the volume of the smallest occupied space [§7.3.1]
- When refrigerant is in an air-handler, duct, or space served by mechanical ventilation, the entire air distribution system must be analyzed
What are some refrigeration safety implications for VRF systems?

▪ Ensure space(s) served do not exceed RCL
▪ Avoid prohibited locations of refrigerant piping [8.10.2]
  ▪ Refrigerant piping shall not be placed in any
    ▪ shaft that has openings to living quarters
    ▪ means of egress
    ▪ enclosed public stairway or stair landing

Example 1  Background

▪ Building has VRF with indoor units in a variety of locations (ceiling, wall, or floor) to directly condition the occupied space
▪ Facility includes a separate DOAS with ducted supply of OA and plenum return
▪ DOAS system does not operate continuously
Example 1  Background, cont.

- VRF terminal units take air from conditioned space and return air to condition (not connected directly to plenum or DOAS ducts)
- Because VRF units are not located in the supply ductwork or return plenum, refrigerant could leak directly into space

Example 1 – tentative interpretation

7.3.2.3 Supply and Return Ducts. The volume of the supply and return ducts and plenums shall be included when calculating the refrigerant quantity limit in the system.

- The volume of the supply ducts and return plenum can be used in the RCL calculation even if the potential for refrigerant leaks are not located in the ducts/plenums?

Is this interpretation correct?
ASHRAE 15 – Interpretation

**Answer:** No

**Comment:** The **Background** describes two independent refrigerating systems, namely a DOAS system and a VRF system employing multiple indoor terminal units. The refrigerant concentration in the occupied space is computed separately for each system and compared to the RCL. The **Background** states that the DOAS system is not operated continuously and may be ‘off’. The DOAS system is therefore controlled in such a way that it would not always act to disperse refrigerant that may leak from VRF indoor terminal units into the plenum or ductwork. If the refrigerant concentration is based on these additional volumes, leaking refrigerant from the indoor terminal units could concentrate in the occupied space alone, and could rise to a level that poses a danger to occupants who may be present.

Please note that there is an editorial error in Sections 7.3.2.2 and 7.3.2.3; “refrigerant quantity limit” should read “refrigerant concentration limit” or RCL.

March 5, 2015

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Example 2 - Background

**Background:** The definition of term permanent openings is a major consideration in the application of Section 7.3.1 of the standard.

**Interpretation:** It is our interpretation that NOT only doorways without doors, or "cased openings", but undercut doors, and/or transfer grilles (if large enough) located near the floor could meet the requirement of this portion of the standard.

Also, there is NO indication of how to determine the required size of the permanent openings of any type. Any guidance the committee could provide in this area would be most helpful.

**Question:** Is this Interpretation correct?

June 24, 2012
Example 2 – Background

▪ The definition of “permanent openings” is a major consideration in the application of Section 7.3.1

ASHRAE 15-2010

▪ **7.3.1 Nonconnecting Spaces.** Where a refrigerating system or a part thereof is located in one or more enclosed occupied spaces that do not connect through permanent openings or HVAC ducts, the **volume of the smallest occupied space shall be used** to determine the refrigerant quantity limit in the system.

Where different stories and floor levels connect through an open atrium or mezzanine arrangement, the volume to be used in calculating the refrigerant quantity limit shall be determined by multiplying the floor area of the lowest space by 8.2 ft (2.5 m).
Example 2 – tentative interpretation

▪ **Undercut doors** and/or **transfer grilles** (if large enough) located near the floor constitute “permanent openings”.

Is this interpretation correct?

ASHRAE 15 – Interpretation

**Answer:** No.

**Comment:** The code is currently written in performance text and allows the designer to determine what constitutes suitably interconnected spaces. There are many factors to consider, and the code currently leaves this to the designer and the AHJ rather than specifying prescriptive considerations or rules.
Example 3 – Background

- Hotel/motel guest rooms typically consist of a sleeping room and connected toilet room.
- VRF systems applied to guest rooms have potential to discharge large quantities of refrigerant into the guest room.
- Greatest risk for life safety occurs when guests are sleeping and their location is within the bottom 3 ft of the guest room where heavier than air refrigerant would collect.

Example 3 – tentative interpretation

- It is Hilton Worldwide’s interpretation that the volume calculations should only include the lowest volume of the room which the guest is supine and sleeping when determining allowable refrigerant limits.

Is this interpretation correct?
ASHRAE 15 – Interpretation

Answer: No.

Comment: The designer is free to be more conservative, by using a smaller volume.

Example 4 - Background

Background: Most hotel/motel guest rooms include a bathroom connected to the guest room with a door. Toilet exhaust systems may be continuous or intermittently operated depending on the design. ASHRAE Standard 62.1-2007 allows continuous ventilation rates of 25 CFM (12.5 LPS) that could be considered for increasing the allowable limits of refrigerant R-410A in variable refrigerant flow systems. Similarly, the guest room may be equipped with ventilation supply air (0.04 CFM/ft² 0.3 LPS/m²) from a dedicated outdoor air system that would also increase the allowable limits. However, these supply and exhaust air systems are typically never provided with emergency power or supervised monitoring systems to maintain their operation continuously, and may be inoperative or shut off for various reasons.

Interpretation: It is Hilton Worldwide’s interpretation that increasing the allowable refrigerant limits for R-410A in a variable refrigerant flow system due to dilution by supply and/or exhaust air ventilation should not be considered due to risk of asphyxiation of the occupants.

Question: Is this Interpretation correct?
ASHRAE 15 – Interpretation

Answer: Yes.

Comment: The RCL is calculated on the basis of the room volume and permanently connected spaces, see Section 7.3.

January 30, 2011

A machinery room required when,

a. the quantity of refrigerant exceeds the limits for a given occupancy

b. direct-fired absorption equipment is used

When required, all refrigerant-containing components containing shall be located in a machinery room or outdoors
Highlights of changes in the 2013 edition:
- Clarifies requirements for machinery room ventilation (8.11.4)
- Explicitly states design pressure requirements are expressed as gauge pressure (Section 3)
- Adds locking cap requirement to harmonize with IMC (11.3)
- Removes methods for determining RCL and defers to Std. 34 (Appendix A)
- Removes requirement for manual discharge of ammonia “fireman’s control box” (8.13)
- Clarifies relief requirements (Addendum a)

Addendum a
- Clarifies safety relief system discharge requirements
- Removes requirements for sulfur dioxide because refrigerant is no longer in use
- Revised and clarified requirements for relief systems
Questions on Std. 15?