Land Development Services

Technical Bulletin

Subject: Variable Refrigerant Flow (VRF) System	**Date: 12/28/2020**	**No.: 20-06**

Summary: Variable refrigeration flow (VRF) heating, ventilation and air conditioning (HVAC) systems are employed extensively in both new construction and renovation projects due to their capability to achieve higher levels of comfort, energy efficiency and reliability. Since VRF systems are categorized as high-probability systems by the Virginia Mechanical Code (VMC) and typically have large refrigerant charges, it is critical that refrigerant safety requirements for these systems are code compliant. This technical bulletin will provide the necessary guidelines to calculate the maximum amount of refrigerant allowed in VRF systems. This Letter to Industry (LTI) supersedes and replaces LTI 17-04.

Effective Date: Immediately.

Background: A typical VRF system uses an outdoor condensing unit connected to multiple indoor evaporator units via an interconnected network of refrigerant piping. The refrigerant most commonly used in VRF systems is R-410A, which is a 50/50 blend of R-32 (Difluoromethane, aka Methylene Fluoride, or CH_2F_2) and R-125 (Pentafluoroethane or CHF_2CF_3). Although R-410A is non-flammable and non-toxic, its ability to displace oxygen poses a serious danger to occupants if released in large quantities into small-volume spaces.

In Chapter 11 (Refrigeration) of the 2015 VMC, the maximum design concentrations of R-410A for enclosed occupied spaces varies depending upon a building's designed occupancy. For Non-I Group (I-1, I-2, I-3, I-4) occupancies, the maximum concentration of refrigerant R-410A is 26 pounds per 1,000 cubic feet of volume. (See VMC Table 1103.1-Refrigerant Classification, Amount and Occupational Exposure Limits.) In institutional occupancies, such as hospitals and nursing homes, the maximum concentration of R-410A is reduced by 50 percent to 13 pounds per 1,000 cubic feet, with exceptions for kitchens, labs and mortuaries. (See VMC Section 1104.2.1-Institutional Occupancies.)

Guidelines:
To calculate the maximum amount of refrigerant within a VRF system, the following must be determined:

1. Total refrigerant charge (pounds) in the system
2. Volume (cubic feet) of each enclosed occupied space served by each indoor VRF unit.

Once these have been determined, divide the total refrigerant charge of the system by the volume of each enclosed occupied space.

If the refrigerant concentration in each space is 26 pounds per 1,000 cubic feet of volume or less, then the system is compliant. However, if any of the occupied spaces exceeds this maximum permissible amount, then modifications must be made to ensure that no space exceeds the maximum allowed concentration of 26 pounds per 1,000 cubic feet of volume. (This calculation method complies with VMC Section 1104.4.1-Noncommunicating Spaces.)

Bringing VRF Systems into Compliance:
If the design exceeds the maximum permissible amount of refrigerant for occupied spaces, the following solutions will bring a VRF system into compliance: (1) increase the space volume used in calculations; (2) relocate/remove piping or indoor fan coil unit from the space; (3) reduce the refrigerant charge by dividing the refrigerant system into multiple smaller systems; or (4) provide an alternative engineered system for county review and approval. Each are explained in more detail below:

1. Increase the Space Volume Used in Calculations

Add Permanent Openings: Increase the space volume by connecting the space to other space(s) by unobstructed openings (cased openings), thus joining two or more spaces together and making one large space.

Connecting spaces using louvers, transfer grilles, door undercuts or similar means is not an acceptable alternative for permanent openings. See the June 24, 2012, interpretation IC15-2010-1 of the ANSI/ASHRAE Standard 15-2010 (Safety Standard for Refrigeration Systems) for more information. Please note that doors are not considered permanent openings since they will be closed at least some of the time, thus the opening is non-permanent and is unacceptable.

Remove or Raise the Ceiling: Increase the space volume by removing the ceiling completely. Similarly, a suspended ceiling could be raised to a height that provides the required space volume.

2. Relocate/Remove Piping or Indoor Fan Coil Unit from the Space

Relocate the Indoor Fan Coil Unit and Duct It to Several Spaces: Install the indoor fan coil unit outside the undersized space and duct the supply air to two or more spaces. By doing this, the spaces would be considered connected so that if a leak occurs in the indoor fan coil unit, the refrigerant would be distributed by the air distribution system to all of the spaces it serves.

Locate the Indoor Fan Coil Unit in the Plenum Space Above a Suspended Ceiling: Install an indoor fan coil unit above a suspended ceiling and duct it to one or more spaces while similarly drawing unducted return air from the space and through the plenum area above the suspended ceiling. By doing this, the plenum may be included in the volume calculation. (For connecting plenum spaces, these must be permanent connections as described above “Increase the Space Volume Used in Calculations-Add Permanent Openings” above.)

Remove Indoor Fan Coil Unit from the System: Remove the indoor fan coil unit from the system and install a separate, split-system unit to handle the load in the space. Removing the unit from the system would also lower the total refrigerant charge in the VRF system.

Optimize the Piping Layout: Review the piping layout to see if it can be altered to reduce the total length of piping and thus the total amount of refrigerant in the system.

3. Reduce the Refrigerant Charge by Dividing the Refrigerant System into Multiple Smaller and Completely Separate Systems

Remove a space from the system and include it in another system so that a refrigerant leak into any space would not have a concentration greater than the maximum allowed in VMC Table 1103.1.

4. Provide an Alternative County-Approved Engineered System

Applicants also can propose an alternative engineered system for county review and approval. To be approved, the system must demonstrate that a refrigerant leak would be prevented from exceeding the maximum permissible concentration into an enclosed occupied space as per VMC Table 1103.1. A code modification request should be submitted for any proposed alternative engineered system. The request should include details demonstrating equivalence to the spirit and functional intent of current code requirements (VUSBC 106.3). Requests may be submitted in letter form to Code Modification Review Committee, 12055 Government Center Parkway, Suite 216, Fairfax, Virginia 22035-5504, or complete the code modification request form and email it to buildingofficial@fairfaxcounty.gov.

For example, an acceptable alternative solution might employ an engineered design that include a refrigerant leak detector, automatic shutoff valves and an alarm. When activated, the refrigerant leak detector located within the occupied space sends a shut off signal to the VRF system and respective shutoff valves located just outside the space. This would limit the leak of refrigerant downstream of the valves. The refrigerant leak detector also would activate an alarm (both visible and audible) that would inform occupants and building personnel that a refrigerant leak has occured, and immediate evacuation is necessary. In addition, the refrigerant leak detector should include emergency backup power. This alternative design will be acceptable in occupancies other than residential and institutional use groups.

Use of a VRF System in Conjunction with a Dedicated Outside Air System (DOAS)

According to the ANSI/ASHRAE Standard 15-2013, Safety Standard for Refrigeration Systems, volume calculations are based on the volume of space(s) into which the refrigerant disperses in the case of a leak. Therefore, when occupied spaces are served by a mechanical ventilation system, the entire air distribution system must be analyzed to determine the worst-case distribution of leaked refrigerant.

For example, if the refrigerant were to leak inside an air handler or within the air distribution system, refrigerant will be distributed throughout the entire system and to all of the spaces it serves. In such a case, the volume of all spaces being served by the system and the volume of the system itself will be used to determine the maximum permissible amount of refrigerant in the system. However, when the combination of a DOAS and a VRF system have been implemented together, these two systems are independent of each other and will be considered and analyzed independently.

It should be noted that VMC Section 1104.4.2, which describes volume calculations for communicating spaces, cannot be used for VRF system refrigerant load calculations unless the refrigerant containing parts are inside an air distribution duct system:

> *"Where an evaporator or condenser is located in an air duct system, the volume of the smallest, enclosed occupied space served by the duct system shall be used to determine the maximum allowable quantity of refrigerant in the system.*
>
> ***Exception:*** *If airflow to any enclosed space cannot be reduced below one-quarter of its maximum, the entire space served by the air duct system shall be used to determine the maximum allowable quantity of refrigerant in the system."*

In this case, if a refrigerant leak were to occur in the mechanical space housing a DOAS, the maximum permissible amount of refrigerant allowed in the system would be calculated by multiplying the maximum permissible concentration of refrigerant by the total volume of all of the spaces served by the DOAS plus the volume of the air distribution system which includes the volume within the supply air ductwork, return air ductwork or return air plenum.

However, this is not applicable to an indoor VRF cassette unit located within an enclosed occupied space. These systems are not "located in an air duct system" that serves multiple spaces such as a DOAS. If there were a refrigerant leak within the enclosed space containing the VRF cassette, all of the refrigerant charge would be released directly into that particular space, not distributed to multiple spaces.

Moreover, according to the January 30, 2011, interpretation IC 15-2007-3 of ANSI/ASHRAE Standard 15-2007, Safety Standard for Refrigeration Systems, increasing the allowable refrigerant limits due to dilution by supply and/or exhaust air ventilation, as with a DOAS, is prohibited.

If you have any questions, please contact Parisa Daghigh Shoaei in the Building Division at **703-324-1932, TTY 711.**

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Attachments: IC 15-2010 of ANSI/ASHRAE STANDARD 15-2010
IC 15-2007 ANSI/ASHRAE STANDARD 15-2007

INTERPRETATION IC 15-2010-1 OF
ANSI/ASHRAE STANDARD 15-2010
SAFETY STANDARD FOR REFRIGERATION SYSTEMS

Date Approved: 24-Jun-2012

Request from: David L. Smith, PE (DLSmithPE@aol.com), Building Infrastructure Design Services, LLC, 19031 Rock Maple Drive, Hagerstown, MD 21742.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE Standard 15-2010, Section 7.3.1, regarding volume calculations and "permanent openings".

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 requirment of this portion of the standard.

Also, there is NO indication of the 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?

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.

INTERPRETATION IC 15-2007-3 OF
ANSI/ASHRAE STANDARD 15-2007
SAFETY STANDARD FOR REFRIGERATION SYSTEMS

Date Approved: January 30, 2011

Request from: Norman L. Nelson, PE (norman.nelson@hilton.com), Hilton Worldwide, 8311 Brier Creek Pkwy Ste 105-505, Raleigh, NC 27617.

Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE Standard 15-2007, Section 7.3.2, regarding ventilated spaces and volume calculations.

Background: Most hotel/motel guest rooms include a bathhroom 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/ft^2 0.3 LPS/m^2) 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?

Answer: Yes.

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