ADDENDA

ASHRAE Addendum b to ASHRAE Guideline 41-2020

Design, Installation and Commissioning of Variable Refrigerant Flow (VRF) Systems

Approved by ASHRAE on June 14, 2021.

This addendum was approved by a Standing Guideline Project Committee (SGPC) 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 guideline. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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FOREWORD

Addendum b adds Section 6.12, "Energy Modeling," to the standard. The purpose of these changes is to offer guidance when modeling an HVAC system that includes variable-refrigerant-flow (VRF) equipment. Often, a VRF system is considered as a stand-alone product and is modeled accordingly. Instead, the committee feels the VRF product should be viewed holistically as a component of an integrated system. The following recommendations are intended to guide the design and modeling professional in the creation of their integrated model.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum b to Guideline 41-2020

Add new Section 6.12 as shown.

6.12 Energy Modeling. Energy modeling is critical to the design and operation of low-energy, high-performance buildings and development of U.S. federal and state level building energy goals. Some of the key factors to consider in modeling the variable-refrigerant-flow (VRF) system performance are zonal control, efficient part-load operation, and heat recovery of VRF systems. The DOE EnergyPlus VRF model simulates the performance of each individual component, such as indoor units, outdoor units, and their connecting piping network. Separate performance curves are used for each individual component. When modeling VRF, additional concerns are to view the system holistically within the system and not as an individual component. This offers benefits that may improve the model.

6.12.1 Important Factors to Consider in Modeling VRF Systems

a. **Zoning details.** VRF systems use a combination of indoor and outdoor units to provide cooling and heating to conditioned spaces within a building. In contrast to a variable-air-volume (VAV) system, which distributes air, a VRF system transports refrigerant between the outdoor and indoor units. Each thermal zone represents a room or series of rooms that may have a single or multiple HVAC control devices. With VRF systems, the tendency is to have more independent zones due to the availability of smaller VRF terminal units. Ideally, rooms that have been zoned together should be modeled as having the same or similar thermal characteristics. Further considerations include whether the local terminal device handles zone loads, and whether it also handles the ventilation load. These determinations should be reflected in the model control sequences.
b. **Occupancy schedules at zone level.** The occupants in each zone decide how to operate the indoor units. Compared with the full-time-full-space operation mode of the centralized HVAC system (e.g., VAV), VRF systems may operate only when needed and when the spaces are occupied. However, this must be reflected in the modeling schedules. The designer should follow ASHRAE/IES Standard 90.1, Normative Appendix G, which requires that the modeler use identical occupancy schedules when comparing dissimilar systems. This mitigates the possibility of incorrectly estimating the hours of operation. Further, the models should reflect the level of automation used. For example, if the system does not have occupancy sensors, then the model must include schedules. If the system does not have dual set-point controller, then the model should not recognize night setback.
c. **Load distribution.** It is important when modeling system diversity that this is not confused with a VRF systems combination ratio. Combination ratio is a design metric with no impact on the building model.
d. **Simultaneous heating and cooling.** Heat recovery VRF systems have the ability to operate simultaneously in heating-and-cooling mode. Typically, energy modeling is for a full year and should account for all seasons. While heat recovery does create a high coefficient of performance, there is an energy penalty. When modeling heat recovery systems, ensure that the energy model software is capable of accurately projecting operation at heating, mainly-heating, cooling, and mainly-cooling modes. Be cautious of software that only models heating and cooling.

e. **Heat sinks.** Generally, for most manufacturers, mainly-cooling mode can be the least efficient mode of operation, depending on usable waste heat sinks/heating zones, while mainly-heating mode can offer higher efficiency. If there is an absence of manufacturer test data for simultaneous operation, it is recommended at a minimum to evaluate ambient relief penalties in cooling by referencing manufacturer cooling ambient correction charts versus nominal 95°F ambient conditions. This will allow the user to construct an approximate cooling majority mode penalty factor.

f. **Controls.** Key information for VRF inputs include independent temperature set points and operating schedules for each zone. The VRF modeling should capture the approximate distribution of the thermostat set points. The more realistic the inputs, the more accurate simulation results. Additionally, ensure that the model represents the actual sequences for the VRF system.

g. **Performance data and curves.** AHRI test data are useful for comparing VRF systems versus other VRF systems. However, they may not accurately reflect performance over a broad range of inputs. Many modeling software programs use generic curves. When using these curves, it is best to validate for accuracy. The modeling software allows the modeler to build a custom curve for specific equipment. This also enables the modeler to review the reasonableness of the curve.

h. **System considerations.** When building the model, the VRF equipment is often only one component. An example is when using a decoupled dedicated outside air system (DOAS). In cooling mode, the DOAS has the benefit of sensible and latent cooling. However, in dehumidification mode, the DOAS has the capability of decoupling the system latent load from the VRF. In dehumidification mode, the DOAS will often use hot-gas reheat (HGRH). With HGRH, the discharge air temperature may be elevated to a neutral temperature condition. The challenge is that ASHRAE/IES Standard 90.1 states that when the majority of zones are in cooling mode, the reheat should be limited to 60°F leaving air temperature. These considerations must be captured in the model. Another example is during heating DOAS, tempering will decouple a significant amount of heating from the HVAC system. This should also be reflected in the model.

i. **Defrost.** As with all direct-expansion (DX) unitary heat pumps, defrost is an important consideration during the heating and mainly-heating modes. When developing the model, the designer should include defrost, as appropriate. The model should reflect the actual defrost sequence for the VRF product modeled.

j. **Fan operation.** With a typical VAV system, the zone equipment often drives down to the minimum ASHRAE Standard 62.1 building component ventilation. However, with VRF, the ventilation is often handled by a secondary piece of equipment. If the ventilation is conditioned or distributed by the VRF terminal unit, the fan must run continuously. If the ventilation is decoupled, the fan may operate on demand. This actual system operation should be reflected in the model.

k. **Modeling for heat.** A design may benefit from the use of a VRF heat recovery system where the system simultaneously conditions the perimeter in heating mode and the interior in cooling mode. It is then important that the model is capable of simulating all four modes of operation: heating, mainly heating, cooling, and mainly cooling.

l. **DOAS outdoor air tempering.** The model should reflect the DOAS supply air temperature as a component of the mixed-air calculation. This may reveal that the DOAS tempering provides a significant portion of the building heat. Including this calculation in the model may reveal opportunities for VRF systems in locations that may seem counterintuitive. The downside is that this may also reduce the model's use of heat recovery. Last, when designing for extreme conditions, it is not uncommon to include supplemental heat for use on design heating days. This model should reflect sequences for energy optimization in all operation modes.

m. **DOAS supply air temperature reset.** When a DOAS is used as a component of a VRF system, the modeler should carefully construct the model to operate the designers sequence of operation to accurately reflect the cooling, dehumidification, ventilation, and heating sequence of operations.

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ASHRAE · 180 Technology Parkway NW · Peachtree Corners, GA 30092 · www.ashrae.org

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6/21