

PART 4:

Commissioning for VRF Systems— OCCUPANCY AND OPERATIONS

The final part of this feature series reviews the occupancy and operations phase of a VRF project.

BY BILL ARTIS, LEED AP BD&C

Images courtesy of Daikin Applied.

In last month's article, we looked at the basics of pre-functional testing, the necessity of performing a final walkthrough inspection to identify installation deficiencies, and basic procedures for equipment startup and functional testing.

In the final article of this series, we will look at aspects specific to the occupancy and operations phase of a project with emphasis on how these should be developed for projects where the HVAC system is variable-refrigerant flow. We will focus on:

- Reviewing deferred testing requirements, training of operations and maintenance (O&M) staff;
- VRF-specific information that should be included in the systems manuals for the O&M staff;
- Periodic reviews of system performance and operations; and
- General VRF maintenance considerations.

The occupancy and operations phase of a project begins at the substantial completion portion and, typically, lasts through the contractual warranty period. Ideally, the commissioning activities started in this portion of the commissioning process will continue through the entire operational life of the building with ongoing commissioning.

It is important to remember that this is not only related to VRF systems, but all HVAC systems as well. Emphasis during this period is for ongoing verification of system and facility energy usage and efficiency, indoor environmental quality, occupant comfort, and life-safety maintenance and documentation.

Deferred testing

In last month's article, we reviewed some of the key aspects that should be included with the startup and commissioning

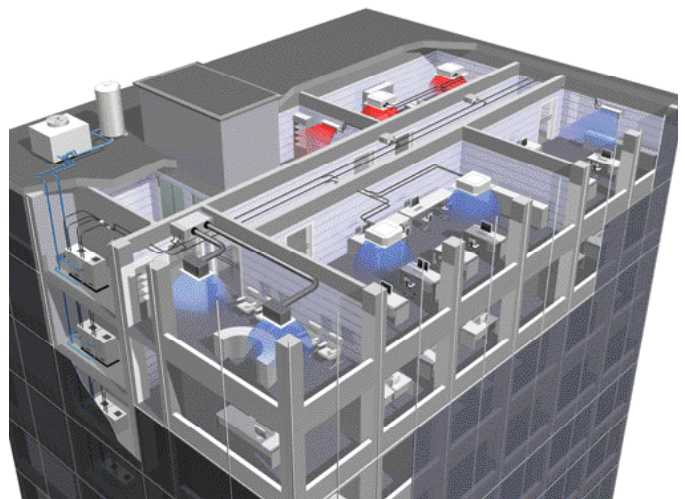


Figure 1 Example of a water-cooled VRF heat-recovery system.

of VRF systems. It is important to keep in mind the actual operating conditions during the startup and functional testing process. For instance, VRF systems will lockout the heating mode at the condenser when the ambient temperature reaches approximately 75°F. As a result, performing the functional testing for heating operation on a 95°F day will likely not yield acceptable results. To accommodate this, this testing must be delayed until operating conditions are acceptable to perform this type of test. Likewise, performing functional testing of the cooling operation during low ambient temperatures or very low-load conditions will also likely yield unacceptable results.

Beyond functional testing, is system performance testing. As mentioned in last month's article, VRF manufacturers provide data loggers and service software to view system operating data in real time, as well as save it for record and include it in the systems manuals later.

Keeping design conditions in mind is crucial when performing measurement and verification (M&V) for system performance. Because of the continually changing loads, either inside or outside, it is recommended that any M&V be performed at or as close to design conditions as possible. This

may require testing be deferred until a different season or until the actual space loads are near design conditions.

For heat-recovery systems, or systems integrating with additional heat sources (especially facility-operated hydronic or steam-heating systems), testing may need to be deferred until intermediate seasons when simultaneous heating and cooling may be required. This can include: heating and cooling solely from the VRF system; VRF cooling with integrated heating by other sources; or facility changeover from total facility cooling to heating or vice versa.

These tests should be equipment- and application-specific as they apply to the systems on the project and owners' project requirements and basis of design.

Operator training and systems manuals

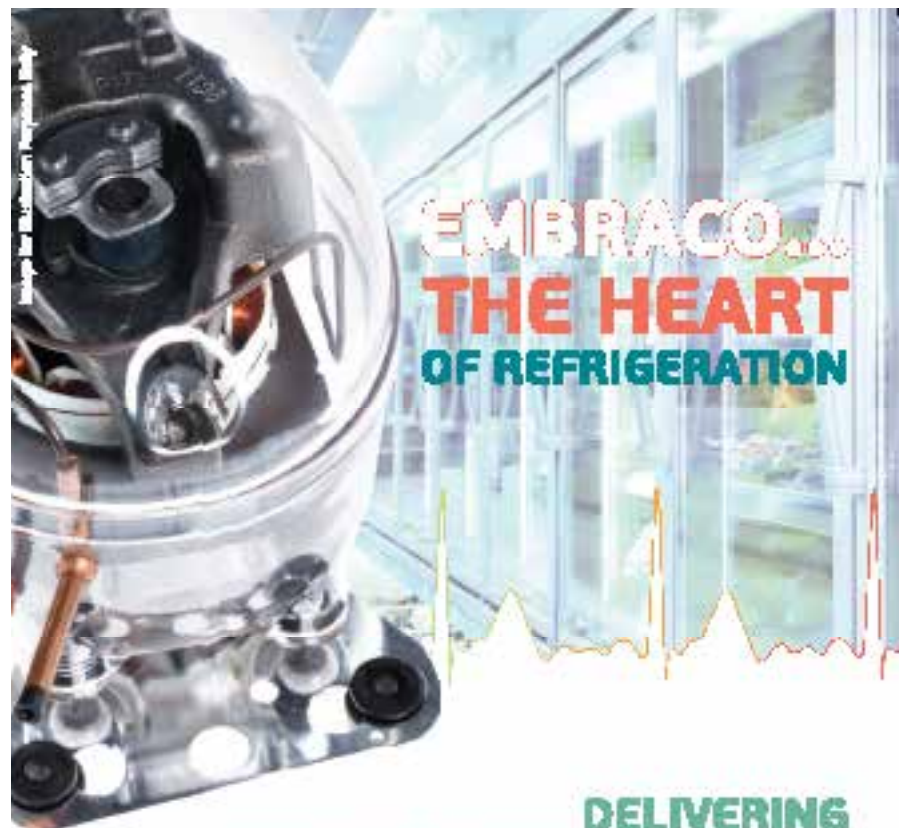
While it is often required by VRF manufacturers that the installing equipment contractor have certified installers and technicians onsite during installation and startup that have been through OEM product-specific training, it is typically a requirement for O&M staff that will inherit the facility unless specified in the commissioning plan.

It is strongly recommended that the O&M staff receive manufacturer training for operation of the specific equipment that they will be responsible for in their facility. However, if this is not possible, then onsite training provided by the installing contractor or manufacturer/manufacturer's representative needs to be included in the scope of the project.

The training objectives should be, at a minimum:

- VRF-system sequence of operation and sequence of operation for integrating with ancillary equipment;
- Local, centralized and BMS controls training; and
- Instructions for occupants and end-users.

It is recommended that a coordination meeting be arranged before the final turnover to the O&M staff that includes: the installing contractor; design engineer or representative;



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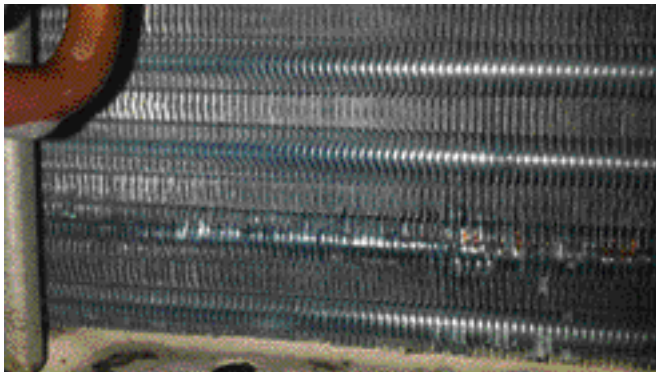
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commissioning agent, as needed; representative of the incumbent O&M staff; and controls contractor/integrator, as needed. In this meeting, the project requirements can be reviewed by all parties, functional testing and performance verifications reviewed, and sequence of operations reviewed. By doing this with all parties present, it ensures that everyone is on the same page and that everyone has an understanding of how the system will work and how it should be operated. This may also identify additional deficiencies that may have gone undetected during functional testing or performance review.

The system manuals are developed for use as a reference to provide the information needed for an owner to operate and maintain their building systems, as well as train their O&M personnel. As this article is focused on the commissioning process specific to VRF systems, we will not be focusing on the full systems manual. For more information on this, consult ASHRAE Standard 202-*Commissioning Process for Buildings and Systems* and the subsequent guidelines available for the standard.



⤴ **Figure 2** After a few years of neglected operation, leaves and debris piled up along the base of the coil on and around the bottom of the unit, preventing condensate to drain during the heating cycle. The result was ice heave that crushed the copper tubing in the coil.

Specific to VRF systems, the systems manual should include:

- Submittal package that includes equipment design and performance information specific to the projects systems;
- VRF piping and wiring diagrams for each system, as well as contractor-provided as-built documentation of the same;
- Additional refrigerant charge information for each system;
- Detailed equipment sequence of operations for the VRF systems and any integration with ancillary equipment. Wiring diagrams should accompany these as needed;
- Pre-startup checklists completed during the installation and startup process;
- Startup reports;
- Configurations and field settings programmed at the indoor units and condensers during startup and commissioning, specific to each system/units as needed;
- Error codes and description list; and
- VRF unit points list and description for use with BMS systems.

It is the responsibility of the contractor and commissioning agent to prepare and develop the systems manuals for turnover to the O&M staff upon entering occupancy and operations. It is the responsibility of the O&M staff to update the systems manual as needed to maintain accuracy and relevancy.

Periodic review of system performance and operations

Periodic site inspections by the commissioning agent or installing contractor are recommended to identify any deficiencies or conflicts with the project requirements should occur during occupancy. The occupants and end-users can provide feedback by meeting with the O&M staff, who can then identify deficiencies and conflicts. For instance, feedback that zones are overshooting or lagging their controller's temperature setpoint can be used to identify a field setting to adjust a temperature differential or dead band, or the need to re-configure which sensor(s) the equipment is using to monitor space temperature or change modes of operation.

These visits can also be used to coordinate and review any contractor callbacks needed to resolve outstanding issues, as well as any further outstanding commissioning and testing issues. Another function of these site visits is to assist with integrating the commissioning processes into an ongoing maintenance procedure. This is also an opportunity to review any issues with equipment defects that would be considered warranty issues, to identify if they are truly warranty issues or the result of poor installation practices or application.

Maintenance considerations

Maintenance for VRF systems, albeit simplified in many aspects, still requires much of the attention to detail and care that conventional systems require. In order to develop a detailed maintenance program, it will require knowledge of the actual equipment operating conditions and usage the equipment will face, as well as the specific types of equipment used.

For the VRF units, the following should at least be checked annually, or more frequently, as needed:

- Check for air-flow obstructions for indoor units and condensers;
- Inspect pipe insulation for gaps, cracks or openings;
- Check and tighten all line voltage and control electrical connections;
- Check flare connections for tightness;
- Check and clean internal and external condensate pumps and reservoirs, drain pans, and float switches and overflow protection;
- Clean or change filters, clean any debris from fan blades, and from the face of the indoor and outdoor coils;
- Clean the condenser heat exchanger if air-cooled, and verify that there are no obstructions that would prevent water drainage while operating in heating at the condenser. Prevention of condensate draining can result in ice buildup in the bottoms of the outdoor units, leading to damage to the coil from ice heave (see Figure 2);

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While this is a general overview, remember to consult the manufacturer or their representative for a detailed list of maintenance requirements for specific models of equipment.

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- Verify cleanliness of water strainer and that there is no fouling the primary or secondary heat exchangers;
- Check piping connections from refrigerant oil near the condenser and indoor units; and
- For air-cooled condensers that use an air-cooled heat sink for their inverter circuit boards, verify that there is no debris collected on the surface that would prevent heat transfer.

While this is a general overview, remember to consult the manufacturer or their representative for a detailed list of maintenance requirements for specific models of equipment.

Coordination for success

In conclusion, we reviewed the basics behind commissioning for VRF systems at the occupancy and operations phase and the benefits of this process. The key points reviewed were:

- Importance of deferred testing and how it should be utilized for performing system M&V at as close to design conditions as possible to understand if the system is truly functioning as required;
- The need for training O&M staff and the basic training requirements that should be set;
- Periodically reviewing system operations and performance; and
- General VRF maintenance considerations.

In closing, I would also like to add that none of this will happen on its own. For the commissioning process to be effective, like any quality control process, it needs to start at the beginning of a project. By starting at the beginning of the project, it allows for the scopes of work for each party to be defined ahead of time, aids in coordination of the commissioning requirements and stages of a project, and also allows the for installing contractors and other trades to adequately include these testing requirements and the time involved into their bid package. ☁

References

- ASHRAE Guideline 0-2013: *The Commissioning Process*
- ASHRAE Guideline 1.1-2007: *HVAC&R Technical Requirements for the Commissioning Process*
- ASHRAE Standard 202-2013: *Commissioning Process for Buildings and Systems*
- HVAC Commissioning, ASHRAE Handbook of Fundamentals: HVAC Applications, 2015, Chapter 43. Print

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