Multi-Zone Testing of VRF Systems

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Collaborative VRF Performance Testing

- Construct performance maps of multiple manufacturers’ VRF heat pump & heat recovery VRF systems
- Work with software modeling developers to support their data needs
- Provide field test data for model vetting
VRF System

- Variable Refrigerant Flow (VRF) System
  - DX multi-split system, multiple indoor fan coil units (IDU)
  - Each IDU is capable of individual zone temperature control
  - At least one variable capacity compressor
  - VRF implies three or more steps of control on inter-connecting piping

- VRF Heat Recovery Multi-Split System (VRF-HR)
  - Split system capable of operating in AC mode or as a heat pump
  - System capable of providing simultaneous cooling and heating
  - Energy from IDU’s operating in one mode can be transferred to IDU’s operating in the other mode
VRF-HR Systems: 2-pipe and 3-pipe
Need for Lab Test Data

• ANSI / AHRI Standard 1230 specifies rating test conditions for VRF systems

• Provide comprehensive performance map based on independent lab testing

• Building energy modeling software's are incorporating VRF simulation capabilities

• Simulation tools require reliable and accurate data
Test Stand Design

- VRF systems are multi-zone systems
- Thermal Environmental Lab has dual zone climate chambers
- The indoor chamber can simulate one air condition at a time (T and RH)
- Each zone in multi-zone system will have different return air conditions
Multi-zone Test Stand

- Design & Construction of VRF HR Test Stand
  - Unique system capable of independent control of four indoor zones
Schematic of Indoor Unit Test Setup
Multi-Zone Test Setup

- HEATER
- HUMIDIFIER
- COOLING COIL
- FAN
- RETURN AIR
- SUPPLY AIR
- TEMPERATURE CONTROL
- RH CONTROL
- CFM CONTROL
Instrument Locations (Indoor Unit)

- Mass Flow Meter
- 7 Analog Inputs
- 2 TC Inputs
- 8 MODBUS Inputs
- Temperature
- RH
- Air Flow
- Electrical
- Supply Air Duct
- Return Air Duct
- Temperature
- RH
- Pressure
Instrument Locations (Outdoor Unit)

OUTDOOR CHAMBER

TEMPERATURE
RH

TEMPERATURE
PRESSURE

5 Analog Inputs
3 TC Inputs
8 MODBUS Inputs

ELECTRICAL
Air Side Calculation

\[ \Delta h = h_1(T, RH) - h_2(T, RH) \quad (BTU/lb_{da}) \]

Capacity = \( \dot{m} \times \Delta h \)
Test Procedure – Cooling Mode

• The outdoor chamber is controlled to a set dry bulb temperature (for example 95°F)

• The return air is controlled to a set dry bulb and wet bulb temperature (for example 80°F DBT / 67°F WBT)

• The VRF system temperature controller is set to the lowest allowable temperature (example 64°F DBT)

• Data for various combination ratios is obtained by turning indoor units ‘OFF’
Test Procedure – Heating Mode

• The outdoor chamber is controlled to a set dry bulb and wet bulb temperature (for example 47°F DBT / 43°F WBT)

• The return air is controlled to a set dry bulb temperature (for example 70°F DBT)

• The VRF system temperature controller is set to the highest allowable temperature (example 84°F DBT)

• Data for various combination ratios is obtained by turning indoor units ‘OFF’
Test Procedure – Simultaneous Cooling and Heating Mode

• The outdoor chamber is controlled to a set dry bulb and wet bulb temperature (for example 47°F DBT / 43°F WBT)

• Depending on the mode (cooling or heating) a particular indoor unit is in, return air is controlled to the set DBT and WBT

• The temperature controller on each indoor unit is set in accordance to the mode it is in

• A performance map is generated by changing indoor and outdoor conditions as well as the mode each indoor unit is operating in
Example Heating Capacity
70 deg F return air; 47 deg F outdoor air

[Bar chart showing heating capacity in BTU/HR for different numbers of indoor units operating in heating mode]
Example Results
- System heating capacity (70°F return air)
Example Results

![Graph showing COP versus OD-WBT (F) for different RAT conditions.](image-url)
*Example Results*

- **Outdoor Temperature**: 65°F
- **Return Air**
  - **Cooling Mode**: 80°F DBT/67°F WBT
  - **Heating Mode**: 70°F DBT

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**Operating Mode**

- **4 Cool**
- **3 Cool / 1 Heat**
- **2 Cool / 2 Heat**
- **1 Cool / 3 Heat**
- **4 Heat**

**Graph**

- **Heating Capacity**
- **Cooling Capacity**

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**Notes**

- The graph illustrates the capacity in BTU/hr for different operating modes under specified temperature conditions.
Questions?