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VRF on-site Measurement by Compressor Curve Method and Its Application

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1. Background and Purpose of This Study

【Background】 Stereotype of VRF from Architectural Side

<VRF is not suitable for Commissioning (Cx) ?

<Examples>

Problems of VRF operation

➢ Hard to know the VRF performance.
➢ Tendency to select machines with excessive capacity.

Problems on operation evaluation process

➢ Large number of VRF equipment should be tested and inspected.

【Purpose】

1) Clarify the evaluation criteria and indicators of VRF management for proceeding Cx.
2) Decide the report format and increase the case study of VRF Cx.
2. VRF Cx (1)

Techniques for VRF Cx

- Air flow simulation
- Energy simulation
- Equipment replacement and repair
- Conception or pre-design
- Design
- Construction/Installation
- Operation
- Improvement

Energy Management

Visualization

Analysis and diagnosis

Model

Result
## Indicators and Evaluation Criteria for VRF Management

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<th>Items</th>
<th>Overview and Definition</th>
<th>Management and evaluation content</th>
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<tr>
<td>1. <strong>Operation mode (Cooling/Heating)</strong></td>
<td>Changes of Cooling and Heating on the Remote Controller</td>
<td>If the season whether cooling or heating operation is really needed</td>
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<td>2. <strong>Operation Time (On/Off)</strong></td>
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<td>Presence of long time operation</td>
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<td>Suction Temperature of Each Outdoor Unit (≒Outside Temperature)</td>
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<td>Suction Temperature of Each Indoor Unit (≒Room Temperature)</td>
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<td>Amount of Heat Processed by VRF in Each System</td>
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<td>Presence of the operating time by forgetting to turn off the air conditioning</td>
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<td>System COP calculation</td>
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3. Compressor Curve Method (1)

Cooling and Heating Capacity ($Q$) = Enthalpy Difference ($\Delta H$) × Refrigerant Flow ($G$)

\[\Delta H = f(T_c, T_e, T_s, T_b)\]

- $T_e$: Evaporating pressure equivalent saturation temperature
- $T_c$: Condensing pressure equivalent saturation temperature
- $T_s$: Compressor suction temperature
- Frequency: Number of rotations of a compressor

Enthalpy difference (heating) = $T_b - T_s$

Enthalpy difference (cooling) = $T_s - T_e$

Mollier Chart

Pressure ($P$) vs. Enthalpy ($h$)
3. Compressor Curve Method (2)

Piping diagram and sensor location (the case of a system with 2 compressors)
4. How to Get the VRF Operating Data

Remote Monitoring system

Target buildings

Remote Monitoring Center

Server

Communication line:
VRF Operating Data
(1 data/day)

Operating data detail analysis

- Big Data -
  - about 4700 buildings
  - about 40,000 systems

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5. Expansion of Cx case study (1)

■ Decide the report format of VRF Cx

I. Overview of the VRF System
   1. Construction and layout of the target VRF.
   2. Total operating time

II. Status of Power Use
   1. Power consumption of the whole building
      (when building’s total consumption is known)
   2. Evaluation for the operation of VRF

III. Floor Comparison of VRF Operation

IV. VRF Which Needs Operation Improvements or Repair
   1. Rankings of outdoor units’ operating data
   2. Rankings of indoor units’ operating data

V. Detail Analysis of the High Priority Outdoor and Indoor Units
5. Expansion of Cx case study (2)

■ Total operating time

[Purpose]

To chose the target equipment which needs maintenance like overhaul.
5. Expansion of Cx case study (3)

Breakdown of Monthly Energy Consumption

[Purpose]
To chose which season, cooling or heating, needs improvements.

![Diagram showing monthly energy consumption breakdown]

- Cooling: 51%
- Heating: 24%
- Indoor unit: 17%
- Off time (crank case heater): 8%

Total Energy Consumption: 137,810 kWh
5. Expansion of Cx case study (4)

Rankings of Outdoor Units

[Purpose]

To find the outdoor units which needs more detail analysis

Ex1.) Total power consumption

Ex2.) Total operating time
5. Expansion of Cx case study (5)

**Rankings of Indoor Units**

**[Purpose]**

To find the indoor units which needs operation improvements

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**Average set point temperature**

**The number of changes for set point temperature**
5. Expansion of Cx case study (6)

- Detail analysis of the high priority outdoor unit

[Purpose]

To find the time of peak load and margin of the VRF capacity

Cooling operation of the week which record a peak load

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6. Conclusion

VRF is suitable for Commissioning.

Facts appeared through this study.

✓ The contribution by the improvements in VRF operation toward the power reduction of the whole building is clarified.

✓ The priority of the VRF which needs maintenance is clarified by looking the total operating time.

✓ The priority of the VRF which needs improvements is clarified from the ranking data.

✓ Indoor units’ information from remote controller is useful for operation improvements.

✓ The efficiency and the margin of VRF capacity are clarified from the amount of heat processed by VRF.
Thank you for your attention.