Not Your Fathers Heat Pump
OR
WORKING WITH VARIABLE CAPACITY HEAT PUMPS

ENERGY STAR CERTIFIED HOMES PARTNER MEETING, 2017
Fun Fact!

Home Efficiency Forum

Chance Masterson
How Not to Get Snake Bit: The Design and Installation Process

- Deciding Ducted or Ductless
- Sizing and selection of equipment
- System design
- Commissioning and controls
Air Source Heat Pump
Zoology
Modern Mini-splits

All inverter systems
- Variable refrigerant flow

Ducted Systems
- Low profile - horizontal

Ductless Systems
- Wall Cassette
- Floor mount
- Ceiling Cassette
### VRF Benefits

<table>
<thead>
<tr>
<th></th>
<th>Conventional HP</th>
<th>VRF HP</th>
<th>Cold Climate VRF HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Capacity</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>COP at 5F*</td>
<td>1.1</td>
<td>1.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Noise*</td>
<td>60 dB</td>
<td>50 dB</td>
<td>50 dB</td>
</tr>
<tr>
<td>Capacity at 5Degrees*</td>
<td>25%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Typical Values - there are exceptions in all categories*
Comfortable customers if you do it right!

BetterBuilt™
Which are you thinking of?

Malort Face

DHP Face
Alternatives to “lump on the wall”

CEILING CASSETTES

Image courtesy of LG

Image courtesy of Mitsubishi
To Duct or not to Duct

That’s your first question
House has low UA. Very tight. 12K ductless heat pump and low-efficiency ERV. About 900 kWh/year for space heat.
Home Geometry and DHP Performance

- Low Load House: 18K min-split
- High Efficiency HRV
- What Could Go Wrong?
Home Geometry and DHP Performance

- Single Story Home
- 65 sq. ft. of glazing (26% of floor area)
- Five surfaces exposed to exterior

Design heat load around 2,700 BTU/hr. for this room alone
POP QUIZ

Q: How much 70° F air must you deliver to keep this room at or set point or 68 degrees?
A: Too much

- Avoid creating thermally isolated rooms
Which home is best suited for a ducted inverter driven heat pump and why?
SIZING AND SELECTION
Room by Room Loads

- If a room has 15% of the load, it needs 15% of the capacity.
- Without knowing the room by room heating and cooling loads, you can’t size the system.
Sizing heat pumps

Heat Pump Capacity and Outdoor Temperature

[Graph showing heat pump capacity across different outdoor temperatures for Cold Climate VRF, VRF, and Typical systems.]
Comparison of Nominal 2-ton DHP Models

SIZING VARIABLE CAPACITY UNITS

Turn Down Ratio: The ratio of the highest output to the lowest output
Why Turn Down Ratios Matter

DHP Sizing

Design load: 24 K@9F
Nom Size 24K

Hours in bin Boise
Hours in bin Seattle

10 K low output
4K low output

3300 hrs.
1529 hrs.
Mild Climates the Lowest Output is Extremely Important

DHP Sizing

Design load: 15 K@27°F: Nom size 18K

4375 hrs
2810 hrs

7 K low output
3K low output

Hours in bin Boise
Hours in bin Seattle

BTU/Hr
SYSTEM DESIGN - NO DUCTS
DHP System Design

- Orient heads to take advantage of throw and mixing
  - Place in largest, most open areas
  - Orient to blow down central hallways

- In rooms with high ceilings, place DHP $\leq 8'$ off the floor to minimize stratification effects

- Don’t set units set in “Auto” mode, leave in heating or cooling

- Set fan speed to auto fan, if lower capacity and efficiency will drop.
DHP System Design

- Use an appropriate number of heads
  - In most homes, one head/floor

- An optimal system often consists of:
  - 1 unit in the main living area, +1 smaller unit in the master suite
  - 1 unit in the main living area, +1 ducted mini-split serving bedrooms
  - 1 unit in the main living area, plus small electric resistance heaters in the bedrooms
  - If using ER heaters, use smaller units (750w), control with digital wall T-stats
SYSTEM DESIGN - DUCTS
<table>
<thead>
<tr>
<th><strong>Total ESP</strong></th>
<th><strong>.50 IWC</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coil</strong></td>
<td>Included in heat pump fan curve</td>
</tr>
<tr>
<td><strong>Filter</strong></td>
<td>.12</td>
</tr>
<tr>
<td><strong>Return Grille</strong></td>
<td>.03</td>
</tr>
<tr>
<td><strong>Supply Grille</strong></td>
<td>.03</td>
</tr>
<tr>
<td><strong>Total Losses</strong></td>
<td>.18</td>
</tr>
<tr>
<td><strong>Available Static Pressure</strong></td>
<td>.32 IWC</td>
</tr>
</tbody>
</table>

The available static pressure is the amount of pressure left over to overcome the resistance of the duct system. Coils and filters have large pressure drops.
ECMs Are Not Magic

Watts VS Static Pressure

![Graph showing the relationship between Watts and Static Pressure for PSC and ECM. The graph indicates that as Static Pressure increases, Watts decrease for PSC and increase for ECM.](image)
Activity

What is the CFM in the ultra low ESP Setting at .08 I.W.C on high speed?

What is the rated flow?
Moving air hates to make hard turns

Relax: We will show you a short cut

- Step 1: Calculate the Total Equivalent Length (TEL)
- Step 2: Calculate the Available Static Pressure
- Step 3: Calculate the Friction Rate
- Step 4: Determine how much air each duct section is carrying
- Step 5: Size the ducts
Duct Design Rules

1. Don’t do stupid stuff
2. Pick a unit that can deliver required CFM at realistic IWC
3. No 90 degree turns
4. Stretch the flex
5. Don’t squish the flex
6. Use large return grilles and return ducts
7. MEASURE AIR FLOW
8. If you are counting: keep TEL below 300 feet
9. If using a Ductulator, use a .06 or .08 friction rate for design purposes.
AVOID CONTROL SYSTEM PITFALLS
THERMOSTATS/CONTROLLERS: NOT WHAT YOU’RE COMFORTABLE WITH
Setting the unit to sense temperature at the T-stat:

- Function 42 has to be set to “01” and the t-stat icon has to appear on the screen
- High Insulation setting needs to be activated
Controller pitfalls explained

1. If using a wall-mounted controller, make sure it senses temperature at controller and not at air handler.

2. If there is an option for efficient home, ensure it is selected.
   
   1. Always set to high insulation setting

3. Read the manual.
Commissioning

1. Put system in high heat or high cool mode if available
2. Measure external static pressure
3. Measure delivery at each register (if you have a flow hood)
4. Measure temperature
5. Conduct a duct leakage test if applicable
6. Check refrigerant charge against published values.
And there’s this...

HVAC Commissioning Checklist\textsuperscript{1, 2}
ENERGY STAR Certified Homes, Version 3 / 3.1 (Rev. 08)

Footnotes
1. This Checklist is designed to align with the requirements of ANSI / ACCA’s 5 Qi-2015 protocol, thereby improving the performance of HVAC equipment in new homes when compared to homes built to minimum code. However, these features alone cannot prevent all ventilation, indoor air quality, and HVAC problems (e.g., those caused by a lack of maintenance by occupants). Therefore, this Checklist is not a substitute for comprehensive, whole-building energy management. This Checklist applies to split air conditioners, unitary air conditioners, air-source heat pumps, and water-source (i.e., geothermal) heat pumps up to 65 kBtuh with forced-air distribution systems (i.e., ducts) and to furnaces up to 225 kBtuh with forced-air distribution systems (i.e., ducts). All other permutations of equipment (e.g., boilers, mini-split / multi-split systems) and distribution systems are exempt.
Thank You

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