

Diagnostic Measurement and Performance Feedback for Residential Space Conditioning Equipment

-- An HVAC Equipment Manufacturer's Perspective

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Key HVAC Diagnostic Needs

- Installation
 - Furnaces
 - Low indoor airflow rate
 - Air Conditioners & Heat Pumps
 - Improper refrigerant charge
 - Refrigerant leaks
 - Low indoor airflow rates
 - Ductwork
 - Bad design (restricts indoor airflow)
 - Undersized
 - Poor connections to HVAC equipment
 - Air leakage
 - Conduction losses in unconditioned spaces
- Subsequent Operation
 - Refrigerant loss
 - Filter maintenance
 - Other

Refrigerant Charge Diagnostics

- Direct Refrigerant Charge Measurement
 - Requires refrigerant to be removed, weighed, and replaced
 - Correct charge depends on connecting line lengths and indoor/outdoor unit matches (split systems)
- Performance-Based Methods
 - Depends on Expansion Device
 - Fixed Restriction
 - charging charts based on evaporator superheat and outdoor temperature
 - Constant Superheat (TXV or EXV)
 - typically charge to desired condenser subcooling
 - Requires Allowable Operating Conditions
 - Typically Cooling above 65 F Outdoor Temperature

Automated Charge Diagnostic Algorithm

- Check for allowable outdoor temperature conditions
- Run system in proper mode (capacity and airflow rate) until steady-state conditions are achieved
- Check subcooling to see if within required range
 - TXV systems only
- Signal service technician to add or remove refrigerant as necessary
- If additional charge is necessary:
 - add refrigerant through restricted charge port to prevent overshoot
 - monitor subcooling until required level is obtained
 - signal technician to stop charging or turn off solenoid charging valve
- Return system to normal operation

Indoor Airflow Diagnostics

- Required Airflow Rate
 - depends on indoor/outdoor unit combination
 - an acceptable range usually exists
 - higher for more capacity
 - lower for more dehumidification
- Proper Motor Speed Setting
 - correct motor tap (PSC motors)
 - proper switch settings (ICM motors)
- Acceptable Static Pressure Rise on Air Handler
 - ensure that it is below manufacturer's upper limit
 - use manufacturer's performance tables to double check airflow rate
 - blower power measurement can also be used

Ductwork Diagnostics

- Proper duct sizing
 - check static pressure rise across air handler
 - lower is better, must be within OEM's specifications
- Proper duct sealing and insulation
 - return ductwork
 - compare temperature entering air handler to space temperature at thermostat
 - supply ductwork
 - visual inspection??

Communicating System Controls

- Can provide automatic system parameter selection (Plug-and-Play)
 - reduces installation and set-up errors
- Can provide useful information to the installer, service technician, and/or homeowner
- Allows sharing of sensor information between indoor and outdoor units

Diagnostic Sensor Needs

- Refrigerant Pressures (high and low side)
 - provide numerous diagnostics
 - refrigerant charge, expansion valve operation, heat exchanger performance, compressor problems, etc.
 - pressure sensors need further cost reductions
 - saturation temperature sensors provide less capability
- Airflow Rates
 - hard to measure cheaply and accurately
 - static pressure may be easier
 - need further cost reductions
- Air Temperature and Humidity
 - hard to get accurate averages
- Electrical Power
 - require complex diagnostic algorithms to be useful

Additional Diagnostic Issues

- Installation vs. Operational Diagnostics
 - most problems are created during installation and servicing
 - installation diagnostic equipment can be portable
 - operational diagnostics require permanent equipment
- Reliability Issues
 - diagnostic hardware and software must be significantly more reliable than the system being diagnosed
- Who Receives the Diagnostics?
 - should the homeowner receive as much information as the service technician?

Performance Feedback

- Difficult to Do Accurately and Reliably
 - Expected performance depends on many factors
 - indoor & outdoor unit combinations (split systems)
 - ductwork characteristics
 - indoor and outdoor conditions
 - Requires complex measurements
 - direct capacity calculations require flow rate measurements (air or refrigerant)
 - air-side calculations require *average* air temperature and humidity measurements
- Temperature and/or Pressure Measurements May be Sufficient
 - Requires equipment-specific algorithms

Who Will Pay for Diagnostics?

- Homeowners
 - Probably not – they just want it to work
- Service Technicians
 - Not much – only if it saves them time
- Utilities or Governments
 - Perhaps – if it saves energy
- Manufacturers
 - Yes – if it is justified by reduced warranty costs

Questions?
