GUIDELINES ON AIRFLOW AND REFRIGERANT CHARGE VERIFICATION AND DIAGNOSTICS
Context

- Airflow and refrigerant charge defects in existing air conditioning systems are well documented
- Failure to address these problems represents a missed opportunity for home performance contractors
- To ensure cost-effective solutions, a systematic approach is needed to quickly and accurately diagnose and resolve problems
- Target:
  - Home performance contractors
  - HVAC contractors & technicians
Refrigerant systems are complex, measured parameters are interrelated, and faults can be difficult to identify.
The Impact of Defects

<table>
<thead>
<tr>
<th>Condition</th>
<th>EER Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-TXV</td>
</tr>
<tr>
<td>15% duct leakage(^1)</td>
<td>-18.10%</td>
</tr>
<tr>
<td>23% low airflow</td>
<td>-4.70%</td>
</tr>
<tr>
<td>50% condenser coil blockage</td>
<td>-5.80%</td>
</tr>
<tr>
<td>50% evaporator coil blockage(^2)</td>
<td>-4.60%</td>
</tr>
<tr>
<td>20% overcharge</td>
<td>-3.50%</td>
</tr>
<tr>
<td>20% undercharge</td>
<td>-29.40%</td>
</tr>
<tr>
<td>0.3% non-condensable</td>
<td>-18.20%</td>
</tr>
<tr>
<td>Liquid line restriction</td>
<td>-29.70%</td>
</tr>
<tr>
<td>Ducts, evap, 50' line in attic(^3)</td>
<td>-10.50%</td>
</tr>
<tr>
<td>Attic equipment, 25% low airflow, 10% undercharge, 30% duct leakage, 50% coil blockage</td>
<td>-53.50%</td>
</tr>
</tbody>
</table>

\(^1\)2% duct leakage baseline, 118°F attic

\(^2\)Equipment in conditioned space

\(^3\)118°F attic, compared to ducts & equipment in conditioned space

Technical Approach

- Preliminary Diagnostic by Home Performance Contractor
  - Correct serious duct leakage
  - Inspect overall system for obvious problems & correct or refer
  - Measure/verify airflow and check filter sizing
  - Measure Temperature Split (key diagnostic)
  - Referral to HVAC technician if warranted

- Comprehensive Diagnostic by HVAC Tech to identify & repair defects including:
  - Incorrect charge & refrigerant leaks
  - Liquid line restrictions
  - Non-condensables
  - Defective or improperly installed expansion device
  - Fouled evaporator coil
  - Equipment problems (contactor, capacitor, compressor)
Preliminary Diagnostic
by Home Performance Contractor

- Seal ducts (<15%)
- System inspection
  - Condenser coil
  - Exp. device & lines
- Calculate filter velocity (<300 fpm)
- Measure/diagnose airflow (>300 cfm/ton)
- Measure temperature split (±3°F of target)
- Documentation/referral

Airflow Diagnostic

1. Measure supply vs. return plenum pressure
   - yes > 190 Pa?
   - no System o.k.

2. Remove filter, measure supply vs. return plenum pressure
   - yes > 140 Pa?
   - no Filter / grille undersized

3. Measure ambient vs. return plenum pressure
   - no > 40 Pa?
   - yes Undersized or kinked return ducts

4. Measure supply plenum vs. ambient plenum pressure
   - yes Undersized or kinked supply ducts

5. Probable blocked evap coil
   - no > 40 Pa?
   - yes Undersized or kinked supply ducts
Temperature split (between return & supply plenums) is easy to measure and is used to determine whether refrigerant or other system defects are significantly affecting capacity and performance.
Comprehensive Diagnostic
by Qualified HVAC Technician

- Quick system inspection
  - Expansion valve
  - Refrigerant lines & site glass
  - Condenser & evaporator coils

- Take measurements (or obtain from PD)
  - Airflow (watch out for zoning)
  - Temperature Split
  - Subcooling & Superheat
  - Condensing over Ambient (COA)
  - Evaporation saturation temperature (EST)
  - Compressor power/current

- Compare to target values
- Diagnose & repair
- Retest & verify
Comprehensive Diagnostic

Fixed Orifice Systems

Temperature split more than 3° below target

Non-condensables
Fouled condenser coil
Overcharge
Liquid line restriction

COA > X

EST < Y

Liquid line restriction
Fouled evaporator coil
Low charge

Low Superheat
Exp. valve overfeed
Fouled evaporator coil

High

Low Superheat

High

Low Ambient temp.
Recommended Guidance

- Use accurate test equipment (calibrate regularly)
- Use proper measurement procedures
- Apply diagnostic methods published in the Guideline document & fine tune
- Use proper refrigerant charge procedures
- Train technicians
- In-the-field follow-up
Value

- **Value to practitioners**
  - Small time investment (< 1 hour for prelim. diagnostic)
  - Full realization of projected energy savings
  - Reduced liability through identification of health & safety risks
  - Increased per project revenues

- **Value to end users**
  - Improved comfort through improved system capacity and better air distribution
  - Reduced energy costs (average > 30% reduction in cooling energy)
  - Longer equipment life, reduced equipment replacement costs
Market Readiness

- Field trials completed but more needed
- Diagnostic procedures can be implemented using available tools and minimal additional training
- Key considerations:
  - Accuracy of test equipment
  - Correct test practices, charge procedures, and equipment maintenance
  - Training and follow-up
- Market ready? YES
Pros and Cons

- **Pros**
  - Eliminates missed opportunity for energy savings in course of home performance improvement projects
  - The cost is coincident with improvements that are needed to maintain proper system operation and therefore comfort
  - Easy sell for home performance contractors that yields more revenue
  - Requires minimal training

- **Cons (or barriers)**
  - Need programmatic support for training and field follow-up
  - Difficulty in getting techs to follow protocols
  - Pressure on techs to keep visits short
References


