HVAC Maintenance Repair or Replace & Planned Replace Initiative

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Why Maintain Rooftop Units?

- Reduce Operating Costs
- Improve Comfort / Process Conditions
- Extend Equipment Life

Tough Life for a Rooftop Unit

- Regarded as Semi-Disposal Pieces of Equipment
- Operates in a Harsh Environment
  - High Ambient Temperatures
  - Brutal Radiant Heat
  - Leaves, dust, pollen, insects, rain, hail and snow.
Reduce Operating Costs

• Field Tests Have Shown that Rooftop Units Operate Well Below Stated EER Levels if Not Maintained

• A “Tune-Up” Can Improve the Efficiency
  • Savings Averaged 11% on 25 Rooftop Units in New England Study
  • Savings Ranged from 22 - 42% on 23 Rooftop Units in Louisiana Study

Air-Side Vs. Refrigerant-Side

• Two Fluid Loops to Deal With
  • Always Do Air-Side Maintenance & Repairs First
  • The Air-Side Can Effect the Refrigerant-Side, Such as Proper Air Flows

Air-Side Focus

• Filters
• Evaporator Coil
• Fan
• Belts
• Motor
• Outside Air Dampers
• Cabinet Integrity
Filters

- Maintain Indoor Air Quality
- Protect Downstream Components

Filters

- Changing Frequency
  - Maintain Air Flow
  - Reduce By-Pass Air
  - Indoor Air Quality
  - Filter Structural Failure

- Clean Vs. Dirty Filters
  - Effect on Energy Consumption

<table>
<thead>
<tr>
<th>Normal cooling &amp; dehumidification</th>
<th>60</th>
<th>60</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor input power (kW)</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Condenser fan input power (kW)</td>
<td>0.56</td>
<td>0.56</td>
<td>0.56</td>
</tr>
<tr>
<td>Gross cooling capacity (Btu/h)</td>
<td>112.79</td>
<td>110.10</td>
<td>105.14</td>
</tr>
<tr>
<td>Latent/sensible cooling ratio</td>
<td>0.095</td>
<td>0.129</td>
<td>0.159</td>
</tr>
</tbody>
</table>

| Total unit power (kW)            | 12.42 | 12.27 | 11.70 |
| EER (Btu/kW)                     | 9.08 | 8.97 | 8.98 |
| Annual run time (hours/year)     | 2,000 | 2,048 | 2,146 |
| Annual energy use (kWh/year)     | 24,840 | 25,129 | 25,102 |
| Total annual cost (US$)          | $1,987 | $2,010 | $2,008 |

- Annual dirty filter penalty
  - Base Line
  - $23
  - $21

Notes:
- a: Operating data from Carrier Corporation for unit # 48HJDO12 with standard fan.
- b: Assumed static pressure increase from dirty filter.
- c: Based on motor efficiency of 80 percent and belt drive efficiency of 95 percent.
- d: Sum of supply fan, compressor, and condenser fan power.
- e: Gross cooling capacity divided by total unit power.
- f: Assumed run time of 2,000 hours for a clean system; dirty systems run proportionately longer due to reduced cooling capacity.
- g: Total unit power times annual run time.
- h: Electricity price; 8 cent per kWh.
Filters

- Filter Types
- Filter Depth (1, 2 or 4 inch)

- Filter Media
  - Fiberglass Matt
  - Polyester Matt
  - Pleated

Filter Material Options

<table>
<thead>
<tr>
<th>Filter material options</th>
<th>pressure drop (in. wg)</th>
<th>Lifetime (months)</th>
<th>Unit cost ($/filter)</th>
<th>Annual cost ($/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental “EP40”</td>
<td>0.22</td>
<td>3</td>
<td>3.26</td>
<td>92.16</td>
</tr>
<tr>
<td>Farr 20/20 pleated</td>
<td>0.19</td>
<td>4</td>
<td>4.25</td>
<td>82.20</td>
</tr>
<tr>
<td>Farr 30/30 pleated</td>
<td>0.14</td>
<td>6</td>
<td>5.15</td>
<td>61.20</td>
</tr>
<tr>
<td>One-inch filters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiberglass matt</td>
<td>&lt;20%</td>
<td>2</td>
<td>0.94</td>
<td>82.56</td>
</tr>
<tr>
<td>Polyester matt</td>
<td>&lt;20%</td>
<td>2</td>
<td>0.94</td>
<td>82.56</td>
</tr>
<tr>
<td>Environmental “EP40”</td>
<td>25% to 30%</td>
<td>3</td>
<td>3.26</td>
<td>92.16</td>
</tr>
<tr>
<td>Two-inch filters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiberglass matt</td>
<td>&lt;20%</td>
<td>2</td>
<td>150</td>
<td>96.00</td>
</tr>
<tr>
<td>Polyester matt</td>
<td>&lt;20%</td>
<td>2</td>
<td>1.50</td>
<td>96.00</td>
</tr>
<tr>
<td>Environmental “EP40”</td>
<td>25% to 30%</td>
<td>4</td>
<td>3.51</td>
<td>72.12</td>
</tr>
<tr>
<td>Farr 30/30 pleated</td>
<td>30%</td>
<td>3</td>
<td>4.60</td>
<td>113.60</td>
</tr>
</tbody>
</table>

Notes:

a: Efficiency based on ASHRAE Standard 52.1.

b: Pressure drop: Fiberglass and polyester information based on satalog data at 300 feet per second face velocity. All others based on independent test data at 375 feet per face velocity.

c: Lifetime based on recommendations from filter vendor. Lifetime of fiberglass and polyester filters is short to prevent migration of dirt through the filter into the coil. Lifetime of pleated filters is based on changeout at a specified pressure drop.

d: Single filter unit cost based on HVAC contractor order, case-lot purchase (at least a dozen filters), FOB Denver, size 20 x 20 inches.

e: Annual cost based on replacement for a typical 10-ton unit at end of relative lifetime, four panels (20 x 20 inches), $10 labor cost for each filter change.

How To Determine Filter Change Frequency?

- Time & Experience
- Measure Pressure Drop
- Install Transducers & Tie to EMS
- Install Pressure Differential Switch
Evaporator Coil

Dirt on Evaporator Coil
- Reduces Air Flow
- Reduces Coil's Capacity to Transfer Heat

Louisiana Field Test
- 87% of Units Needed Evaporator Coil Cleaning

Clean Evaporator Coil Yearly?
- Measure Fan Amp Draw & Pressure Difference

Dirty vs. Clean Evaporator Coils

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Fan

- Bearing Lubrication
- Blade Cleaning
- Blade Rotation
- Measure Air Flow
Belts

- 5-10% Loss in Energy Transfer
- Proper Belt Tension, Change Belts Regularly
- Belt Alignment
- Spare Belt in Unit
- Standard V-Belt Vs. Cogged V-Belts
  - Increase Drive Efficiency 2-10% with Cog Belts

Motors

- Sealed Bearings
- Specify Energy Efficient Motors
  - New
  - Replacement

Comparison of Standard vs. Premium Efficient Supply Fan Motors

<table>
<thead>
<tr>
<th></th>
<th>Standard-efficiency motor</th>
<th>Premium-efficiency motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal size (hp)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Motor efficiency a</td>
<td>82.50%</td>
<td>90.20%</td>
</tr>
<tr>
<td>Motor power (watts)</td>
<td>1,938</td>
<td>1,795</td>
</tr>
<tr>
<td>Motor cost c</td>
<td>$325</td>
<td>$410</td>
</tr>
<tr>
<td>Marginal upgrade cost n/a</td>
<td>$85</td>
<td></td>
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</table>

Economic comparison

<table>
<thead>
<tr>
<th></th>
<th>Standard-efficiency motor</th>
<th>Premium-efficiency motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual energy use (kWh)</td>
<td>9,691</td>
<td>8,975</td>
</tr>
<tr>
<td>Annual energy cost d</td>
<td>$775</td>
<td>$718</td>
</tr>
<tr>
<td>Annual energy cost savings n/a</td>
<td>$57</td>
<td></td>
</tr>
<tr>
<td>Payback (years)</td>
<td>n/a</td>
<td>1.5</td>
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</table>
Outside Air Dampers

- Economizer Cooling
  - Dry Bulb Sensor
  - Increase Set Point to Save Energy
- Enthalpy Control (Reference & Comparative)
  - Ultimate in Energy Savings
  - Old Versions are Hard to Maintain

Cabinet Integrity

- Many Access Panels
- Too Many Screws
- Old Gaskets & Seals
- Leaks in Cabinet Costs More than $100/Year

Refrigerant-Side Focus

- Refrigerant Charge
- Compressor
- Condenser Coil
- Condenser Fan & Motor
Refrigerant Charge

- Undercharged Systems-Caused by Leaks
  - Reduces Energy Efficiency
  - Low Pressures on both High & Low Sides
  - Frosting on Evaporator Entrance
  - Warm Suction Line, Cool Liquid Line
  - Warm Supply Air
  - Continuous Compressor Operation

Refrigerant Charge

- Overcharged Systems
  - Caused by
    - Charging Method
    - Air-Side Problems
    - Does Not Effect Efficiency as Severely

Effect of Refrigerant Charge on Efficiency
Field Test of Refrigerant Charges

Charging System Correctly
- Measure Superheat & Sub-Cooling
- Weighing Refrigerant Charge

Compressor
- Meg Test Motor
- Test oil for acid, especially after compressor failures
- Measure Compressor Heat with EMS System
- Low Voltage
Condenser Coil

- Exposed to the Outdoor Elements
- A Dirty Coil Raises the Condenser Temperature by 10 degrees Can Cost Over $250/Year in Energy
- Best Money You Can Spend on Maintenance
- Clean Coils Annually

Condenser Fans

- No Maintenance Required
- Watch Out for Rapid On-Off Cycling of Fan

Repair or Replace

- Points to consider when evaluating Repair or Replace
  - The life expectancy of HVAC Equipment is 12 to 15 years
  - What is the condition of your HVAC
  - Due to recessionary issues routine maintenance has been lax
  - This reduces life expectancy
  - Is your equipment R22, refrigerant price escalating
  - New HVAC is far more energy efficient and will save you money
Repair or Replace

- Establish a History Data Base on Your HVAC
  - If history does not exist perform an accurate survey of your HVAC
  - Build a data base of asset information
  - Installation date, brand, model, serial # capacity, voltage, type and capacity of heat, blower motor hp.
  - Additional information to meet municipality codes
  - Maintenance records and warranty information

Repair or Replace

- Current Condition of HVAC Perform an Inspection
  - Cabinetry must be intact, fastened properly to minimize air leakage
  - Quality of equipment, reputable brand, or builders model
  - Number of breakdowns, keep records
  - Poorly maintained, inferior quality, and frequent breakdowns Replace
  - If Rooftop Unit costs more than 50% to fix... replace the rooftop unit

Planned Replacement Program
Something You Should Consider.
Planned Replacement Program

Market Data

Industry shipments & construction starts indicate that the HVAC replacement market has been on a growth curve since 2009.

Traditionally this has not been the case, HVAC shipments would track with commercial building starts.

This data points to a strong replacement market in both Unitary & Applied unit shipments.

During the recession maintenance took a back seat.

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Planned Replacement Program

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Planned Replacement Program Benefits

The Planned Replacement Program is designed to address HVAC equipment that was installed in the mid-to late 1990's.

Most equipment is nearing the end of their service life of 12 to 15 years in retail applications.

Older units were also developed prior to significant advances in efficiency technology. New HVAC equipment can lower energy costs by up to 40%.
Replacement Program Cost of Older Equipment

Older equipment is more prone to breaking down, repair costs are also generally higher and more frequent with an older system. Spending capital to patch an older system – whether it’s for a $1,500 condenser coil or a $500 blower motor, plus labor costs – adds up over time and doesn’t improve operational efficiency.

Avoid spending more money repairing old equipment, which may require only more repairs with age. Invest current and future repair costs in new equipment, which has the added benefit of higher efficiency, increased durability & service-friendly features.

Planned Replacement Program Key Benefits

• Avoid Expensive Emergency Replacement Situations
• Lower Replacement Costs
• Control the Timing of Capital Expenditures
• High-Efficiency Equipment Offsets the Rising Costs of Energy

Replacing older units from the 1990’s with new equipment delivers instant energy savings. As energy costs escalate, the return on investment is quicker.

Planned Replacement Program More than Efficiency

Replacing older equipment can also help improve comfort & indoor air quality.
Proper sizing & duct design eliminate hot & cold spots, while humidity control equipment & high-efficiency filters can minimize mold growth that can trigger health concerns.
Enhanced comfort & air quality deliver a better customer experience & satisfaction and increased sales.
Between higher efficiency, reduced costs and better environment, a planned replacement unit is the smart and affordable decision.
Planned Replacement Program
Utility Inflation

Projected electric rates also play into the Planned Replacement process. Industry projections notes gradual increases in electrical rates through 2030. Within modeling programs there is typically an input that allows for projected increases in electrical rates to be factored into the ROI calculation.

Planned Replacement Program Mechanics

Program Mechanics
Facilities teams need to identifying older equipment (>12-15 years) on active properties. Prioritization of HVAC assets can have many drivers (repair cost, operating hours, equipment age, & facility remodeling) however the metric is determined the financial calculation begins to take shape.

Planned Replacement Program Modeling Tools

Restaurant (3,000 S.F.)
25 Tons (3 5 Ton RTU’s)
6.0 EER Existing Unit
11.0 EER Replacement Unit
Replacement Program Implementation

HVAC fleet management is a constant issue for retail facilities teams & also represents approximately 30 to 40 percent of electrical consumption. The Planned Replacement Program should become an annual process. The timing of your program is set to coincide with the restaurateurs capital funding processes & sustainability planning.

Rebates & Incentives

- Percentage of Existing Programs Which include Incentives
  - Packaged Units – 79%
  - Controls – 77%
  - Unitary – 73%
- Typical Payouts
  - 50% - 90% of the Incremental Cost of Higher Efficiency Equipment Vs. Standard
  - Usually Capped Out at 95% of the Total Installed Cost
  - Purpose is to Reward Improvement of Local or ASHRAE Code
- Who is Eligible?
  - All Rate Payers Paying the “Systems Benefits Charge”
  - Government Entities are Eligible