

Green Maintenance

Needed to Keep HVAC Systems Green

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COURSE NAME: Green Maintenance
Needed to Keep HVAC Systems Green

by ASHRAE – Robert Baker

0090010462

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Approval date: 09/12/2013

Course ID:0090010462

Approved for:



General CE hours



LEED-specific hours

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What we will cover

- Reasons to Maintain HVAC Systems
- Types of maintenance approaches
- Economics of each approach
- How to design a Maintenance Program
- Examples of green and not-so-green maintenance results

Our Objective – Green Buildings

- Through design, construction, and operation

Green Design Elements (ASHRAE)

- Heat Exchange Enthalpy Wheels
- Night Precooling
- Gas-fired Chillers/heaters
- Gas-engine Driven Chillers
- Double-effect Absorption Chillers
- Thermal Energy Storage
- Water Loop Heat Pump Systems
- Ground Source Heat Pump
- Combination Space/Water Heating
- Combustion Air Preheating
- Low-NO_x Burners
- Variable Flow/speed Pumping Systems
- Hybrid Ventilation
- Dedicated Outdoor Air Systems
- Ventilation Demand Control Using CO₂
- Displacement Ventilation
- Run-around Systems
- Heat Pipe Systems
- VRF Systems

Green Features

- Are complex
- May require periodic calibration
- Must be maintained to deliver performance

Learning Objectives

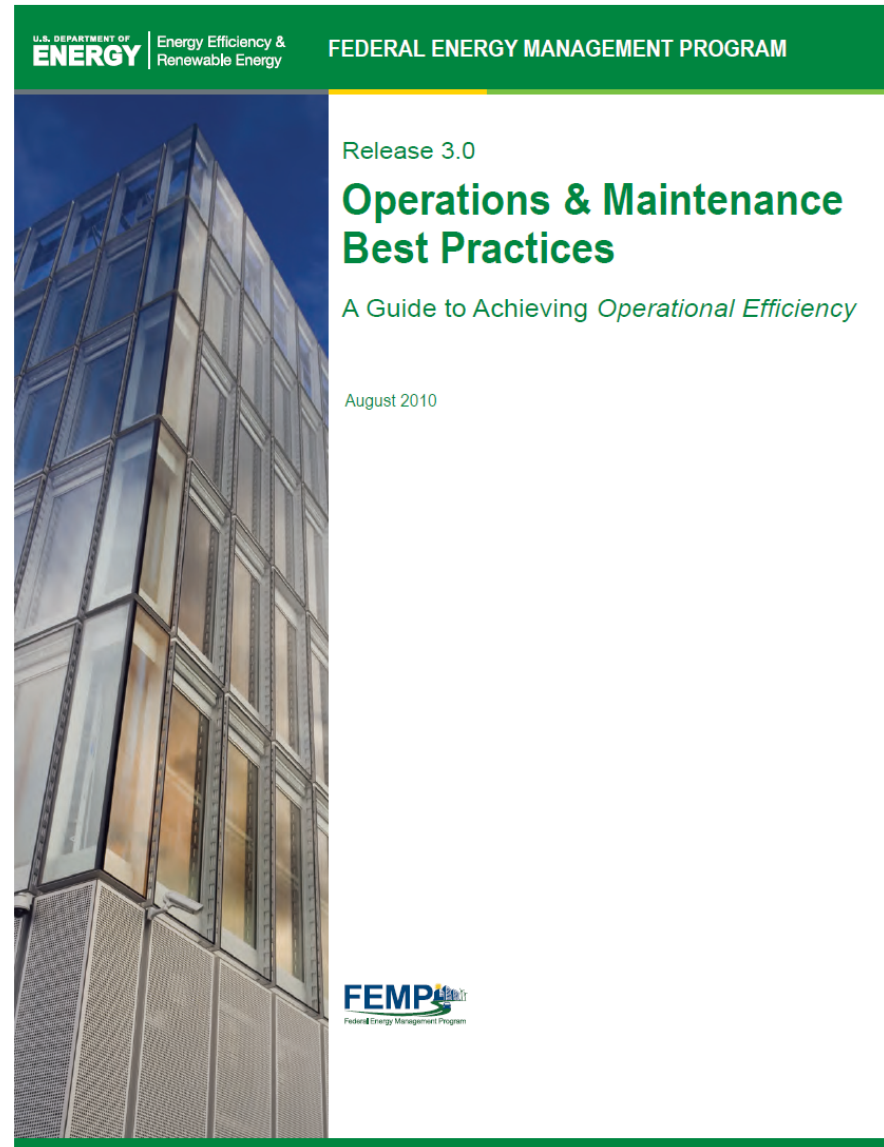
- 1. Recognize the maintenance approach used in a given building**
- 2. Explain the cost effectiveness of different maintenance approaches**
- 3. Describe the difference between effective and ineffective maintenance practices**
- 4. Design an outline for an effective HVAC maintenance program**

Why Maintain HVAC Systems?

- Two views
 - FEMA
 - ASHRAE

US Federal Energy Management Program

Operations & Maintenance Best Practices
Published 2010

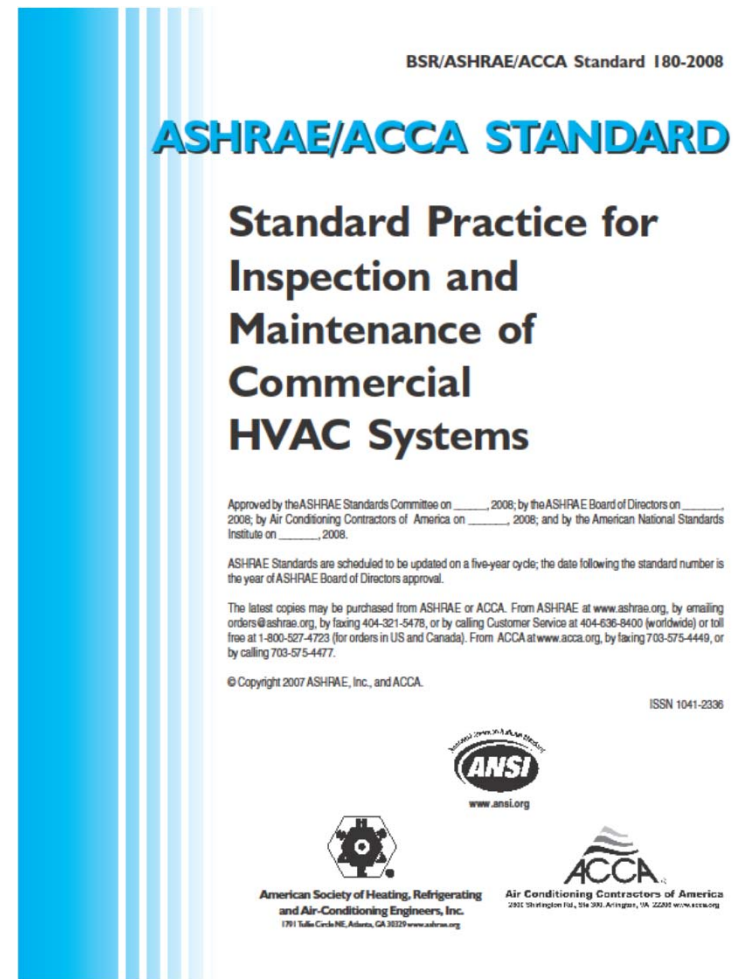


FEMA Reasons

- Increase safety – Maintained systems are safer (Atlanta 2007: Peachtree Center Chiller)
- Ensure comfort, health & safety of occupants through proper functioning (Tampa 2009: St Joseph's Hospital)
- Ensure design life expectancy is achieved
- Facilitate compliance with regulation (Clean Air, Clean Water, Carbon mitigation)

ASHRAE/ACCA/ANSI S-180

- Title
 - Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems
 - Published 2008
 - Updated 2012



What is Standard 180

- Purpose
 - The purpose of this standard is to establish minimum HVAC inspection and maintenance requirements that preserve a system's ability to achieve acceptable thermal comfort, energy efficiency, and indoor air quality in *commercial buildings*.

Maintenance Approaches

- Reactive (run to failure)
 - Little, if any maintenance is done (usually filter changes only)
 - Repair or replacement is done when components fail

Reactive Minimum

Sometimes, not even this much



Replace Filters

Condenser Coil Cleaning
• Clean finned surfaces

Maintenance Approaches

- Reactive
- Preventative
 - Checklist of activities
 - May be either time or cycle based
 - Often follows manufacture suggestions

Preventative Example

Comprehensive. Properly sequenced.

REFRIGERATION CONTROL PANEL

- Sequence test all controls
- Calibrate and clean controllers and safety controls
- Check setpoint of controls and limits

ELECTRICAL DISCONNECT

- Inspect contacts
- loose connections
- Check for proper operation

FILTER SECTION

- Replace media as required

FRESH AIR, RETURN, AND EXHAUST AIR

DAMPERS

- Check for unrestricted and proper operation and close-off
- Lubricate bearings as required

REFRIGERANT AND REFRIGERATION COMPRESSOR

- Check crankcase heater operations, refrigerant and oil level and condition
- Perform acid test
- Observe bearing and operating surface temps
- Measure vibration

COOLING COIL

- Inspect and clean as required
- Check condition of finned surfaces and straighten if bent
- Check for corrosion and leaks

CONDENSER FAN/MOTOR

- Perform vibration test
- Lubricate bearings
- Examine motor mount resiliency
- Check motor insulation resistance

CONDENSER COIL

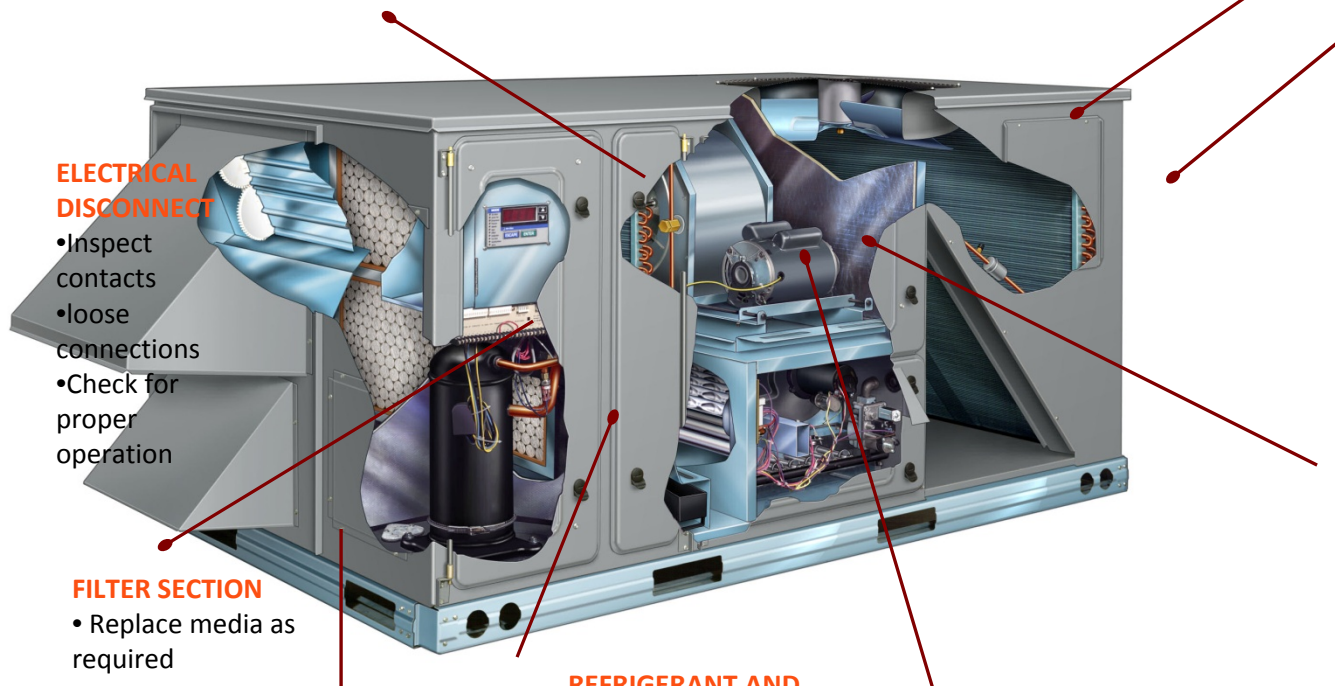
- Clean finned surfaces

BURNER SECTION

- Perform combustion and draft tests
- Inspect and clean nozzles
- Inspect, clean and lube burner fan (gun type burners)
- Test safety controls

RETURN AIR FAN/MOTOR & SUPPLY FAN/MOTOR

- Perform vibration test
- Lubricate more bearings
- Check motor insulation resistance
- Examine motor mount resiliency.
- Lubricate bearings and check for end play, excessive bearing temp and wear
- Check blower and clean dirt accumulation
- Check condition of drive couplings and belts
- Check for alignment, balance, security to shaft
- Check rotation



Slide 17

BO2

There is an updated version of this slide - Beth to track down

Beth Offensend, 12/15/2011

Maintenance Approaches

- Reactive
- Preventative
- Predictive
 - Relies on tests and measurements to “predict” failure and act prior
 - Common Techniques
 - Thermal Imaging
 - Vibration analysis
 - Eddy Current study
 - Oil analysis
 - Air flow measurement

Maintenance Approaches

- Reactive
- Preventative
- Predictive
- Reliability Centered Maintenance
 - Combines Predictive with component reliability analysis
 - Effort varies
 - Rugged & non-critical components - ignored
 - Expensive or critical components – high attention

Cost of HVAC Operation

Under different approaches (US DOE)

- Reactive - \$18/hp/year
- Preventative - \$13/hp/ year
- Predictive - \$9/hp/year
- RCM* (Predictive-Preventative) - \$6/hp/year

- *Reliability Centered Maintenance

Maintenance as Implemented

2000 US Study

- 55% - Reactive
- 31% - Preventative
- 12% - Predictive
- 2% - Other (RCM)

Top Performing Facilities

- < 10% Reactive
- 25-35% Preventative
- 45-55% Predictive

Objective for 180

- The objective established for 180 was to identify conditions that would anticipate and act to forestall failure (predictive/preventative)
- Realize maintenance cost ~\$6-9/hp/year*

What About Energy?

- DOE: O&M enhancements cost ~20 times less yet achieve the same energy savings as a retrofit.
- DOE Forrestal Building - \$250,000 Steam leaks alone (Claridge, 1994)
- 1500 Broadway - \$250k annually maintenance enhancement (Montgomery; Baker; ASHRAE Journal, 2006)

Setting up Maintenance Program

- ASHRAE Standard 180 is referenced by the model codes (IMC & UMC) and is on the way to becoming the accepted “Standard of Practice” in North America.
- It provides a ‘model’ for establishing a maintenance program.

Content of the Standard

- Definitions
- Dialogue with the owner
 - Philosophy of the operation
 - Understanding (inventory)
 - Performance – Appendix A
 - Failure Points – Appendix B
 - Implementation (inside/outside)
 - Timing (now or at failure)
- Task listings
- Adjustment of inspection frequencies
- Documentation

Before you start -Inventory

- New Buildings –
 - Basis of design
 - Commissioning report
 - Specifications
- Existing Buildings
 - Re-commission (or better yet; continuous commissioning)

Lack of Inventory



<u>Table Number</u>	<u>Equipment/System</u>
<u>5.1</u>	<u>Air Distribution System</u>
<u>5.2</u>	<u>Air Handlers</u>
<u>5.3</u>	<u>Chillers—Absorption</u>
<u>5.4</u>	<u>Chillers—Air Cooled</u>
<u>5.5</u>	<u>Chillers—Water Cooled</u>
<u>5.6</u>	<u>Boilers</u>
<u>5.7</u>	<u>Condensing Units</u>
<u>5.8</u>	<u>Control Systems</u>
<u>5.9</u>	<u>Cooling Tower and Evaporative Cooled Devices</u>
<u>5.10</u>	<u>Dehumidification and Humidification Devices</u>
<u>5.11</u>	<u>Engines, Micro-Turbines</u>
<u>5.12</u>	<u>Free-Standing Heating or Cooling Coils</u>
<u>5.13</u>	<u>Free-Standing Fans (e.g., exhaust, transfer, return)</u>
<u>5.14</u>	<u>Fan Coils, Hot Water & Steam Unit Heaters</u>
<u>5.15</u>	<u>Furnaces, Unit Heaters</u>
<u>5.16</u>	<u>Indoor Section Duct-Free Splits</u>
<u>5.17</u>	<u>PTAC (Package Terminal Air Conditioners)</u>
<u>5.18</u>	<u>PTHP (Package Terminal Heat Pumps)</u>
<u>5.19</u>	<u>Pumps</u>
<u>5.20</u>	<u>Rooftop Units</u>
<u>5.21</u>	<u>Steam Distribution Systems</u>
<u>5.22</u>	<u>Terminal & Control Boxes (e.g., VAV, fan powered, bypass)</u>
<u>5.23</u>	<u>HVAC Water Distribution Systems</u>

“Players” in the Room

What Does Good Maintenance Look
Like?

It Starts With Access



Blocked



Before Cleaning

- Remove clutter



Example - Cleanliness



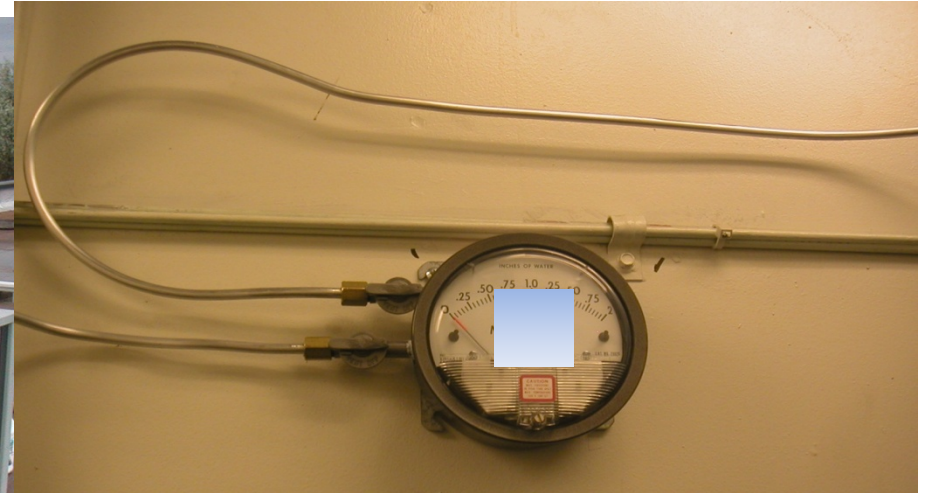
Restore Air Flow



Filter Bypass



Use Data for Maintenance



Often Occupants Say What is Needed



Too Cold/Draft?

Humidity High?

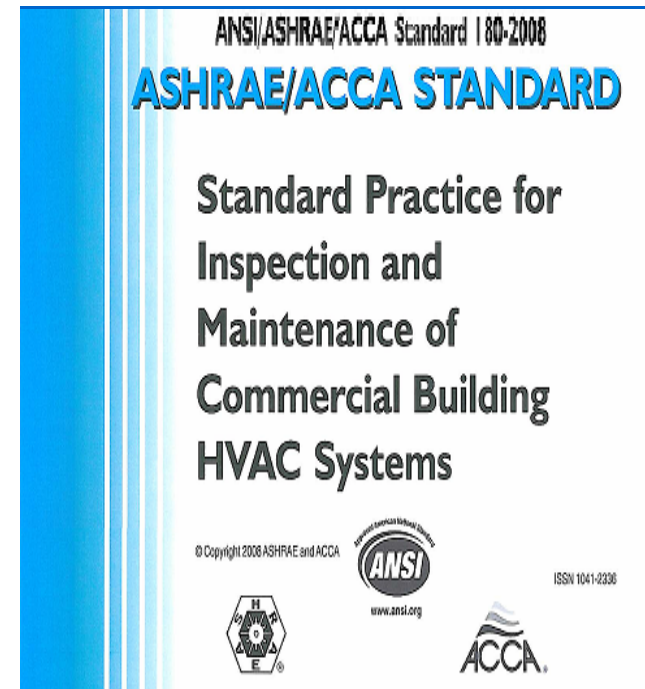
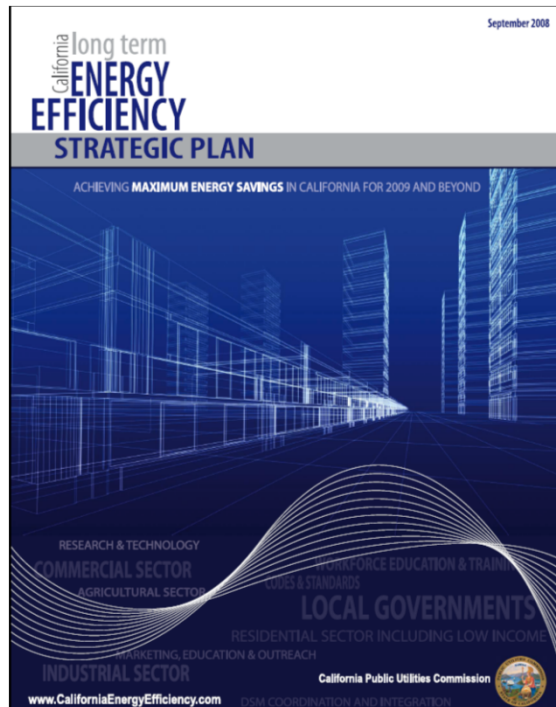


Clean Heat Transfer Surfaces



California; New York

Industry standard as basis for HVAC
market transformation



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Questions/Discussion

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