O&M Should Be Considered First

- Typically, O&M measures are low-cost or no-cost in nature.
- Many O&M measures are easily installed by in-house personnel.
- O&M measures can have immediate payback.
- These measures rarely require the design time, bid preparation, evaluation, and response compared to capital projects that can take up to a year to implement.

Before We Start – Fundamental Questions?

- What kind of work is required? How often?
- How many man-hours will it take? How much will it cost?
- Who will authorize the work? At what level?
- When will the work get done?
- What records must be kept? By whom? For how long?

Fundamental Requirements – Cont'd

- Will there be an approval process? Who will be the decision maker?
- How will unscheduled outages be handled? Are contingency plans needed?

What is Maintenance?

- Maintenance is not a function to be completed in one swoop; rather it is a PROCESS whereby a series of functions are performed to bring about a particular end result.
- The end result is optimal output from the system without frequent break downs during RATED USEFUL LIFE of the system.

Types of Maintenance

- Though it can be described in very many ways – maintenance can be grouped into two basic classifications
  - Remedial
    - Which indicates the need for an outright repair
  - Preventive
    - Which address the manipulation of the subject in avoiding the need for an outright repair

Remedial Maintenance

- AKA – corrective maintenance, reactive maintenance.
- Philosophically speaking – If it's broke, fix it!

Reactive Maintenance

- Reactive maintenance is basically the “run it till it breaks” maintenance mode.
- No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached.

Reactive Maintenance

Advantages

- Low cost
- Less staff

Reactive Maintenance

Disadvantages

- Increased cost due to unplanned downtime of equipment.
- Increased labor cost, especially if overtime is needed.
- Possible secondary equipment or process damage from equipment failure.
- Inefficient use of staff resources.

Preventive Maintenance

- "Proactive" maintenance
- If it can break, fix it!
- Benefits are:
  - Lower operating cost while increasing their incidence of reliability,
  - improved safety,
  - extension of operating life,
  - reduction of capital expenditures for new equipment acquisitions and
  - stocking of spare parts.

Preventive Maintenance

Disadvantages

- Catastrophic failures still likely to occur.
- Labor intensive.
- Potential for incidental damage to components in conducting unnecessary maintenance.

Predictive Maintenance

- Nothing more than sophistication of the preventive maintenance
- If it's almost broke, fix it!
- It is based on the concept that most components give some warning of their impending failure. It stands to reason then that if such failures can be avoided, maintenance costs can be reduced and reliability increased.

Come on, you mean to tell me this happened overnight? If not, what are we waiting for, the middle of winter?

Predictive Maintenance

Advantages

- Increased component operational life/availability.
- Allows for preemptive corrective actions.
- Decrease in equipment or process downtime.
- Decrease in costs for parts and labor.
- Estimated 8% to 12% cost savings over preventive maintenance program.

Predictive Maintenance

Disadvantages

- Increased investment in diagnostic equipment.
- Increased investment in staff training.
- Savings potential not readily seen by management.

Reliability Centered Maintenance

- Basically, RCM methodology deals with some key issues not dealt with by other maintenance programs.
- It recognizes that all equipment in a facility is not of equal importance to either the process or facility safety.
- It recognizes that equipment design and operation differs and that different equipment will have a higher probability to undergo failures from different degradation mechanisms than others. (Not all types of equipment are made equal.)

Reliability Centered Maintenance

- It also approaches the structuring of a maintenance program recognizing that a facility does not have unlimited financial and personnel resources and that the use of both needs to be prioritized and optimized.
- RCM is highly reliant on predictive maintenance but also recognizes that maintenance activities on equipment that are inexpensive and unimportant to facility reliability may best be left to a reactive maintenance approach.

Reliability Centered Maintenance

Advantages

- Can be the most efficient maintenance program.
- Lower costs by eliminating unnecessary maintenance or overhauls.
- Minimize frequency of overhauls.
- Reduced probability of sudden equipment failures.
- Able to focus maintenance activities on critical components.
- Increased component reliability.

Reliability Centered Maintenance

Disadvantages

- Can have significant startup costs, training, equipment, etc.
- Savings potential not readily seen by management.

Periodic HVAC Maintenance:

Combustion Efficiency

Where does the heat (and money) go?

Appliance input rate = 100,000 Btu/hr. ($100.00)

Combustion Efficiency = 80%; then 80,000 Btu/hr are retained for heating while 20,000 Btu/hr are lost to venting. (-$20.00)

Distribution Efficiency = 85%; then 68,000 Btu/hr contribute to heating the building while 12,000 Btu/hr are lost to system inefficiency. (-$12.00)

If overall system efficiency = 68%:
For every $100.00 spent on fuel, $32.00 is lost.

Combustion Basics

- **Chemical reaction ("burning") in which carbon and hydrogen from fuel combines with oxygen from air, releasing heat.**

The Chemistry of Combustion

Fuel + Air + Heat = CO_2 + Water Vapor + Heat

Fuels and Combustion

- **Fuels are "Hydro-Carbons"**
- **Oxygen is 21% of air (78% is Nitrogen)**
- **HC + O2** →
  - ***Good, "complete" combustion***
  - CO2 + H20**(vapor)** + heat
  - ***Incomplete combustion of gas***
  - **CO2 +** CO **+ H2O + heat**
  - ***Incomplete combustion of oil***
  - **CO2 + CO +** C **+ H2O + heat**

Flame Quality

Carbon Monoxide Hazard

Soot = $ lost

Steady State Combustion Efficiency

- Test Instruments for
  - Smoke
  - Stack temperature
  - CO2 (or O2)
  - Draft
- Eliminate Smoke
- Adjustment of Air-Oil Ratio

Test-adjust is last step in annual tune-up

Permanent stack thermometer to monitor fouling

Effect of Soot on Fuel Consumption

Boiler Efficiency Reduction Due to Soot Deposits					
Boiler Efficiency Reduction *					
Soot Layer Thickness, inches					
1/32 2.50%		1/16 4.50%		1/8 8.50%	

* Extracted from the Energy Tips - Office of Industrial Technologies Energy Efficiency And Renewable Energy U.S. Department of Energy

Suggested Actions

Reduce fuel costs by periodically cleaning boiler heat transfer surfaces. Common causes of fouling include low air-to-fuel ratios, improper fuel preparation, or a malfunctioning burner. All boilers, including gas fired boilers should be inspected at the least once a year for soot deposits.

This is why I recommend taking a walk around a building to see things like this and then hopefully follow-up.

When you can see smoke coming out of chimney, you have accumulated lots of soot on the heat exchange surface.

What is soot doing on the gas boiler?

Effect of Scale on Fuel Consumption

Energy Loss Due to Scale Deposits*			
Scale Thickness, inches	Fuel Loss, % of Total Use		
	Scale Type		
	"Normal"	High Iron	Iron Plus Silica
1/64	1.0	1.6	3.5
1/32	2.0	3.1	7.0
3/64	3.0	4.7	-
1/16	3.9	6.2	-

Note:
"Normal" scale is usually encountered in low-pressure applications.
The high iron and iron plus silica scale composition results from high pressure service conditions.
Extracted from - Steam Tip Sheet # 7 -January 2006 - U.S. Department of Energy - Office of Industrial Technologies

Recording Test Results

Stack Temperature - ^{o}F

Flue gas analysis - % CO_2 or % O_2

Smoke spot - smoke spot number

Carbon monoxide (CO) - parts per million (ppm)

Draft - hundredths in. water column or pascals

Efficiency - %

Analyzing Steady State Efficiency (SSE) Results

- If percent CO2 remains constant, but the temperature of the flue gases increases, SSE decreases.
- If temperature remains constant, but the percent of CO2 increases, SSE increases.

Typical Test Results

Retention head oil burners:

Gross stack temp……350ºF - 500ºF

% CO_2……10% - 13%

% O_2……3.5% - 7.5%

Smoke……0 - trace

CO……..0 - 50 ppm

Combustion Efficiency…80% - 86%

Typical Test Results

Natural draft, atmospheric gas:

- **Gross stack temp……250°F - 500°F**
- **% CO_2……6% - 8%**
- **% O_2……7% - 10.5%**
- **CO……0 - 50 ppm**
- **Combust. Efficiency…...70% - 80%**
- **Smoke……0**

Periodic HVAC Maintenance

Daily - check water level in the boiler

Water quality can be easily assessed by checking the gauge glass

Record make-up water on daily basis

Daily – Check oil tank level

Daily –
Record stack temperature

Checking Domestic Hot Water Temperature

Daily – Record DHW Supply Temperature

Can this be right?

Temp. reading: 205!

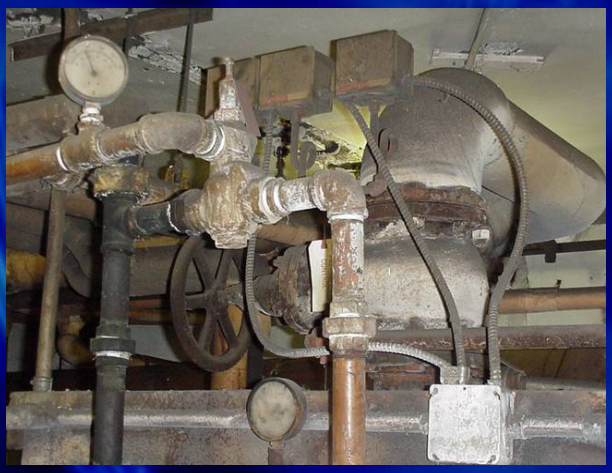
Temp. reading: 161!

Water Temperature and Scalding

Temperature hot water	Time to produce 2nd & 3rd degree burns
160 Degrees F	About 1/2 second
150 Degrees F	About 1 1/2 seconds
140 Degrees F	less than 5 seconds
130 Degrees F	About 30 seconds
120 Degrees F	More than 5 minutes

Gauges and Control Settings

Weekly – Check operating and limit controls



Do I need to clean the face plate?

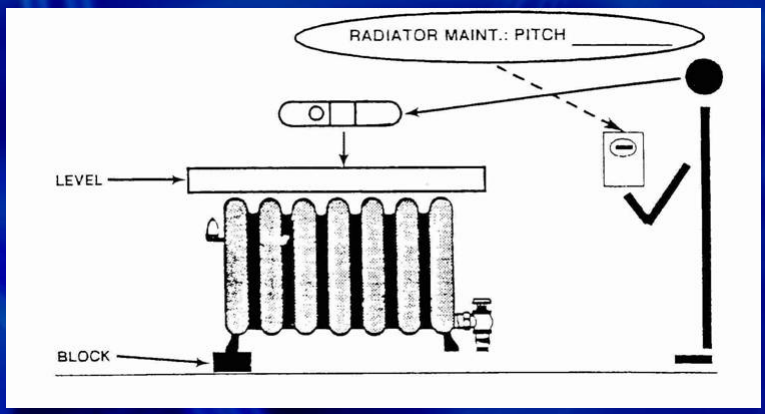
Monthly – Check/clean oil filter

Install gauges so we do not have to unnecessarily open the filter to check whether it needs cleaning or not

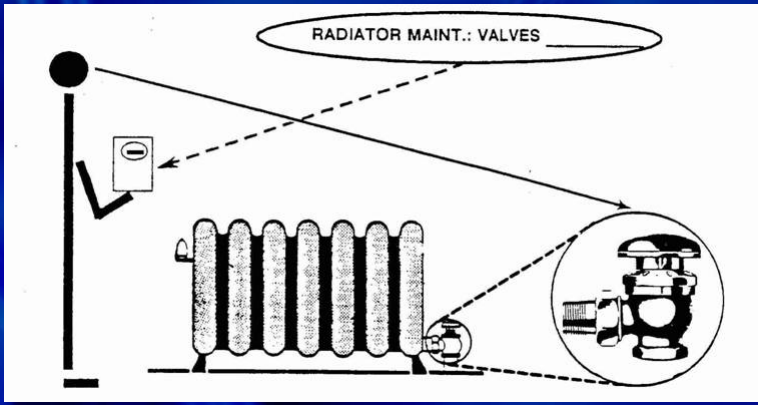
What is the reading on the gauges?

This is an air filter which plays important role in combustion process. This needs to be cleaned at the least on monthly basis.

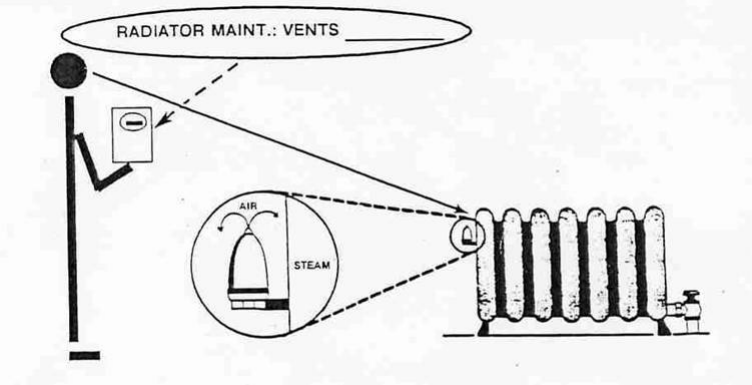
Radiator Maintenance: Pitch



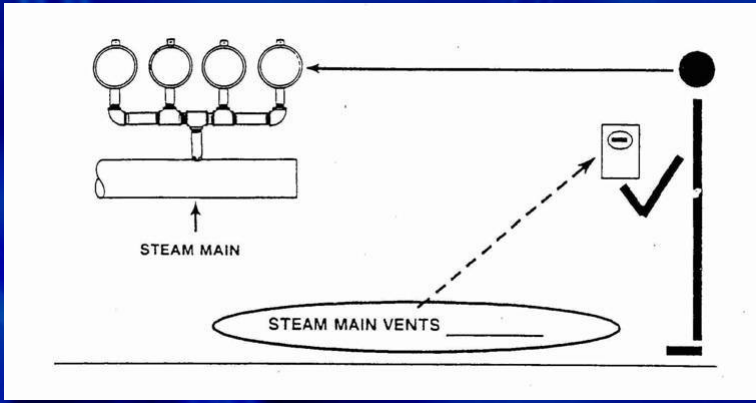
Radiator Maintenance: Valves



Radiator Maintenance: Vents



Steam Main Vents



Individual Heating O&M Checklist

- Clean and adjust burners
- Change/clean filters on forced air systems
- Turn off pilot lights in summer
- Inspect equipment for wear or damage
- Lubricate equipment

Central Boiler and Furnaces O&M Checklist

- Clean and adjust burners, air-to-fuel ratios
- Turn off pilot lights in summer
- Calibrate and adjust controls
- Clean fireside of boiler or furnace
- Remove scale build-up on heat exchanger
- Operate only as many boilers as needed
- Clean oil strainers
- Clean nozzle or rotary cup on burner (oil)
- Preheat fuel oil

Central Heating Distribution Systems O&M Checklist

- Check ductwork for leaks
- Keep radiators, hot air registers clean and unobstructed
- Operate manual vents in hot water radiators and baseboard units
- Check, repair, or replace air vents and steam traps
- Balance steam distribution
- Lower steam pressure
- Monitor make-up water consumption
- Check heating elements, controls, fans on electric distribution systems

HVAC - Cooling

Maintenance and Operations:
The First Step to Energy Efficiency

HVAC - Air Conditioning

- Common Problems with Central Air Conditioners
  - Old (SEER 10 or below)
  - Low Freon
  - Running too long (left on)
  - Leakage in Duct Work
  - Condensation creating mold
  - Noisy
  - Dry Air

HVAC - Air Conditioning

- Best practices and solutions
  - Replace with High SEER (13 or above)
  - Seasonal maintenance
    - Equipment and duct work
  - Set controls to cool to 78° F or above
  - Tenant education
  - In dry climates
    - Add humidifier to equipment
    - Evaporative cooling

Cooling O&M Checklist

- Clean or change air filters
- Clean evaporator coils
- Clean condenser coils
- Clean blower
- Maintain chillers
- Maintain evaporative coolers
- Turn off cooling systems in unoccupied common areas

Domestic Hot Water Systems

Domestic Hot Water Systems

Burkay Type DHW Heater

Self-Contained DHW Heater

DHW Storage Tank

DHW Boiler

Common Problems with DHW Systems

- Temperature Set Too Low or Too High
- Distribution Losses
- Sizing DHW Heater
- Insulation
- DHW Heater Failure

Problem: DHW Temperature Set Too High

Troubleshooting Guide: DHW Temp. Low/High

Causes of Low/High DHW Temp.

- Inaccuracy of DHW tank controls
- Tenant demands for inappropriately high water temperatures

Solutions

- Measure actual DHW temperature and adjust controls accordingly
- Tenant education

Problem: Distribution Losses

Troubleshooting Guide: Distribution Losses

One type of demand control

Cause of Distribution Losses

- Continuous recirculation of constant temperature hot water results in energy wasted.

Solution

- Install control that regulates recirculation loop temperature based on actual system demand.

Troubleshooting Guide: Distribution Losses

Causes of Distribution Losses

- Broken or inadequate pump
- Long distances from DHW heater to some taps

Solutions:

- Repair or replace pump
- Consider installation of 2nd DHW heater

Problem: Sizing DHW Heater

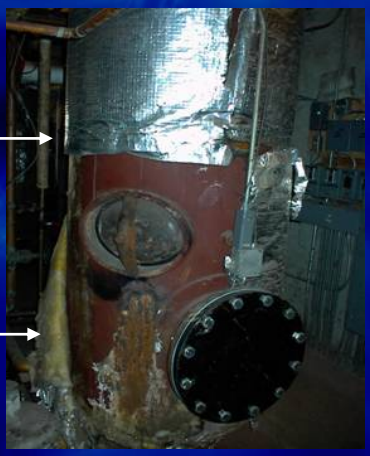
Solution:

- Install appropriate DHW heater for application

Problem: Insulation on DHW tank/lines

Poorly Attached Insulation →

No Insulation →



Troubleshooting Guide: Missing Insulation on DHW System

Causes of Poorly Insulated DHW Tanks and Distribution Pipes

- Insulation never installed
- Wrong insulation installed
- Installation lost or damaged over time

Troubleshooting Guide: Missing Insulation on DHW System

Solutions:

- Annually inspect DHW tank/distribution pipes, making an inventory of sizes and lengths of insulation needed
- Obtain appropriate insulation for DHW application
- Install insulation on tank/piping

Problem: DHW Heater Failure

Solution:

- Select high efficient DHW system at time of replacement

Summary of Benefits

- Decreases Maintenance Calls
- Reduces Likelihood of Catastrophic Equipment Failure
- Makes It Easier to Respond to Problems NOT Symptoms
- Improves Equipment Safety
- Provides Better Service to Tenants
  - Higher quality hot water
  - Reduced complaints
  - Fewer injuries due to scalding
- Reduces Energy Use and Costs

DHW O&M Checklist

- Lower water temperature
- Repair all leaks
- Insulate DHW pipes
- Turn off DHW to areas not needing hot water
- Reduce water pressure
- Flush tank-type water heaters
- Clean/adjust burners on gas and oil water heaters
- Check electrodes on electric water heaters