FEDERAL FACILITY ASSESSMENT GUIDE

**Boiler System Assessment Guidance**

**General Boiler System Assessment Procedure:**

1. Acquire copies of mechanical drawings (Determine boiler system layout)
2. Determine type of boilers *(open draft, forced draft, water tube, fire tube, condensing, etc.)*
3. Collect boiler name plate data and sketch out the system configuration (including pumping system)
4. Acquire a copy of the boiler engineering specifications
5. Take screen shots of the boiler system through the DDC control system
6. Specifically record – control sequences and set point temperatures

*Note: (The following retro-commissioning information was taken directly from PECI’s functional testing guide* [*http://www.peci.org/ftguide/*](http://www.peci.org/ftguide/) *and modified to accommodate the needs of the NREL energy assessment training course attendees.)*

The performance of a boiler and the hot water system is acceptable if it meets the design intent and specified operating sequence. Attention to the following actions during the commissioning process can result in significant improvements in system operation and energy efficiency:

**Actuation and Sequencing**

**\_\_\_\_**Verify that automatic isolation valves are installed and operate correctly, if applicable. *(Automatic isolation valves are typically installed when multiple boilers are connected to a common supply header. Boilers with dedicated pumps generally do not have automatic isolation valves.) When an individual boiler is not operating, the isolation valve should be closed to prevent water from circulating through the unit. This configuration reduces pumping energy and prevents dilution of the hot water temperature by blending unheated water, flowing through the non-operational boilers, with hot water, coming from the operating unit(s).*

**\_\_\_\_**Verify proper boiler staging under normal operation, as well as under all failure and emergency operating modes, especially if multiple units are installed which are unequal in size. *Close coordination between boiler staging and actual load will minimize energy usage. For example, it is beneficial to use a small boiler with good turn-down efficiency to meet low loads and to enable a larger boiler only when the load surpasses the heating capacity of the smaller boiler. When this occurs, the small boiler will be sequenced off until load exceeds the large boiler capacity, then both boilers would operate to meet the load.*

**\_\_\_\_**Verify that the boilers and primary/feed water pumps stage up and down per the sequence of operations under all operating modes.

**\_\_\_\_**Verify that the time delay between boiler start/stop commands are per design.

To remove residual heat from the boiler, the primary/feed water pump operation time delay, after the boiler is commanded OFF, is per design.

**\_\_\_\_**Verify that the automatic isolation valve(s) associated with the respective equipment opens fully upon start-up and closes fully upon shutdown after the specified time delay has expired.

**Setpoints and Reset Controls**

**\_\_\_\_**Verify that the system operates and maintains hot water supply temperature setpoint under all operating modes, including automatic, manual, and failure/emergency modes.

**\_\_\_\_**Verify proper coordination between individual setpoints and reset strategies. *For example, the hot water temperature reset and air handling unit discharge air temperature rest control strategies are compatible. Without coordination between hot water temperature reset and discharge air temperature reset, the air handler may be trying to make hotter air than is possible with the hot water supply temperature. This situation would result in boilers being staged ON even though there is no load on the system, wasting a significant amount of energy.*

**\_\_\_\_**Verify that the control algorithms generate the proper water temperature setpoint based on the reset parameters specifies in the sequence of operations.

**\_\_\_\_**Verify that the reset parameters are optimized for the system. *In addition, ensure the reset control strategy does not result in a return water temperature from the building loads, which can cause the flue gasses to condense in non-condensing boiler systems.*

**\_\_\_\_**Verify that the O2 trim controls, if applicable for a specific project, operate to ensure that excess oxygen in flue gas is maintained at setpoint. *If O2 trim controls are not installed, review flue gas report and verify the boiler was tuned at high-fire and at least one intermediate part-load operating point.*

**Control Accuracy and Stability**

**\_\_\_\_**Verify that all control loops stabilize within a reasonable amount of time (typically 2 to 5 minutes) after a significant load change such as start-up or automatic/manual recovery from shut down.

Some projects may require full-load capacity and part-load turndown performance testing. Tests should be performed when the loads generated can be dissipated adequately. Verify the boiler meets the manufacturer’s stated part load performance under actual operating conditions.

Final boiler system testing can be best achieved through trending under normal operation.

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**Boiler System Checklist**

**Install Small Modular Boilers**

Evaluate the opportunity to install multiple small boilers to meet the heating load of a given facility. It is more efficient to operate smaller boilers when the heating load is 25% to 50% of the design capacity and can significantly reduce heating system energy use. Specify minimum boiler efficiency 89% (AFUE)

**Install Condensing Gas Furnace**

For smaller facilities, condensing gas furnaces should be installed that have efficiencies on the order of 92%-96%. Small condensing gas furnaces are a great application for small facilities and can reduce overall natural gas use at a small facility by 10%-20%.

**Install Condensing Boiler Systems**

Evaluate the opportunity to install multiple small condensing gas boilers to meet the heating load of a given facility. Condensing boilers have good part load efficiencies and can have overall efficiencies as high as 98%. In addition the condensing boiler instillation, 180/120 F cooling coils (60 deg delta) should be installed with a supply water temperature reset.

**Convert Three Way Hot Water Valves to Two Way**

Check the configuration of each hot water valve on each heating coil (includes AHUs, Fan coils, etc.). If three way valves and constant volume pumps are installed, convert the valves to two-way and install VFDs on hot water pumps. Once the valve configuration is confirmed as correct, check that the static pressure set point controlling the pump VFD’s isn’t set artificially high.

**Reset Hot Water Supply Temperature Based on Heating Coil Valve Position**

Adjust the hot water supply temperature based on heating coil valve position. The hot water supply temperature should be reset based on manufacturer’s recommendations for the particular boiler. The control algorithm should be set up such that the coil with the largest cooling load maintains the valve at 90% open.

**Perform Combustion Efficiency Analysis and Install Automated O2 Trim System**

The efficiency of the combustion process is typically measured through the percent oxygen (O2) in the exhaust gas. The amount of oxygen (or excess air as it is often referred to) in the exhaust gas is defined as the amount of air, above that which is theoretically required for complete combustion. The boiler can be tuned by adjusting the air to fuel ratio linkages feeding the boiler burner. Combustion analysis and tuning should be conducted at least twice a year. For larger boilers, > 300 hp, a stack gas oxygen analyzer can be installed to continuously monitor excess air and adjust the boiler fuel-to-air ratio for optimum efficiency.

**Use Effective Boiler Management Techniques**

Operating on high fire settings or installing small boilers can save over 7% of a typical facility’s total energy use. Doing comprehensive tune-ups and correcting excessive air losses, high stack temperatures, and excessive smoking can result in fuel savings of up to 20%. Installing insulation on all hot water and steam pipes over 120 F will ensure that excessive heat is not lost in transmission.

**Set a Maintenance Schedule for the Boiler**

Periodic maintenance of a boiler should be set in place to ensure that the boiler is operating at the peak efficiency. The peak efficiency can be achieved can be achieved by optimizing the air-to-fuel ratio by using an oxygen trimming system. It is also important to clean the fire side of the boiler and the water side of the boiler, to make sure that there is no buildup of slag and scale to inhibit the transfer of heat. Checking the water quality is also important to limit the buildup of scale.

**Install Automatic Steam Trap Monitors**

Malfunctioning steam traps can cause much energy to be lost. By having an automatic monitor up to 16 steam traps can be monitored for malfunction, allowing them to be repaired before a large amount of energy is lost.

**Consider Using a Solar Ventilation Preheat for Combustion Air**

Using solar ventilation preheat will decrease the amount of energy needed to heat up combustion air. The solar preheat requires no maintenance and has a quick payback (6-7 years in some cases).

***Rule of Thumb Energy Savings***

* + *Load management measures, including optimal matching of boiler size and boiler load, can save as much as 50% of a boiler’s fuel use.*

***Rule of Thumb Energy Savings***

* + *An upgraded boiler maintenance program including optimizing air-to-fuel ratio, burner maintenance, and tube cleaning, can save about 2% of a facility’s total energy use with an average simply payback of 5 months.*

***Rule of Thumb Energy Savings***

* + *A comprehensive tune-up with precision testing equipment to detect and correct excess air losses, smoking, unburned fuel losses, sooting, and high stack temperatures can result in boiler fuel savings of 2% to 20%.*

***Rule of Thumb Energy Savings***

* + A 3% decrease in flue gas O2 typically produces boiler fuel savings of 2%.

***Rule of Thumb Energy Savings***

* + Every 40 deg F reduction in net stack temperature (outlet temperature minus inlet combustion air temperature is estimated to save 1% to 2% of a boiler’s fuel use.

***Rule of Thumb Energy Savings***

* + Removing a 1/32 inch deposit on boiler heat transfer surfaces can decrease a boiler’s fuel use by 2%; removal of a 1/8 inch deposit can decrease boiler fuel use by over 8%.

***Rule of Thumb Energy Savings***

* + For every 11 deg F that the entering feed-water temperature is increased, the boiler’s fuel use is reduced by 1%.