5. BOILER, STEAM GENERATOR AND PROCESS HEATER TUNING PROCEDURE

5.1 Inspection Procedure for Boilers, Steam Generators and Process Heaters

5.1.1 Using a thermometer and probe with a resolution and accuracy of ±5ºF or better and appropriate range, ensure that the insulation requirements of Section 9-7-310 are satisfied.

5.1.2 Record the stack gas temperature and the saturated steam temperature (for steam boilers) or the hot water temperature (for hot water boilers). Ensure that the stack gas temperature limits of Regulation 9-7-311 are not exceeded. Elevated stack gas temperature may be caused by too much excess air, which forces hot gases through the boiler without adequate heat transfer, or by fouling of heat transfer surfaces, which inhibits heat transfer.

5.1.3 Record the liquid blowdown rate and frequency and ensure that it conforms to manufacturer recommendations. Although some level of blowdown is necessary to maintain low concentrations of dissolved solids in the water and to remove solids that have settled out of the water, excessive blowdown wastes energy.

5.2 Tuning Procedure for Forced-Draft Boilers, Steam Generators and Process Heaters (based on a tune-up procedure developed by KVB, Inc for U.S. EPA)

Nothing in this Tuning Procedure shall be construed to require any act or omission that would result in unsafe conditions or would be in violation of any regulation or requirement established by Factory Mutual, Industrial Risk Insurers, National Fire Prevention Association, the California Department of Industrial Relations (Occupational Safety and Health Division), the Federal Occupational Safety and Health Administration, or other relevant regulations and requirements.

5.2.1 Operate the unit at the firing rate most typical of normal operation. If the unit experiences significant load variations during normal operation, operate it at its average firing rate.

5.2.2 At this firing rate, record stack gas temperature, oxygen concentration, and CO concentration (for gaseous fuels) or smoke-spot number (for liquid fuels), and observe flame conditions after unit operation stabilizes at the firing rate selected. The smoke-spot number can be determined with ASTM test method D-2156-80 or with the Bacharach method described in the tune-up kit available from the Bacharach company.

If the ~~excess~~ oxygen in the stack gas is at the lower end of the range of typical minimum values and if the CO emissions are low and there is no smoke, the unit is probably operating at near optimum efficiency - at this particular firing rate. However, complete the remaining portion of this procedure to determine whether still lower oxygen levels are practical. Typical minimum oxygen levels for boilers are:

Low firing rate	Natural gas	3% to 8%
	Liquid fuel	5% to 8%
High firing rate	Natural gas	0.5% to 3%
	Liquid fuel	2% to 4%

5.2.3 Increase combustion air flow to the furnace until stack gas oxygen levels increase by one to two percent over the level measured in Step 5.2.2. As in Step 5.2.2, record the stack gas temperature, CO concentration (for gaseous fuels) or smoke-spot number (for liquid fuels), and observe flame conditions for these higher oxygen levels after boiler operation stabilizes.

5.2.4 Decrease combustion air flow until the stack gas oxygen concentration is at the level measured in Step 5.2.2. From this level gradually reduce the combustion air flow, in small increments. After each increment, record the stack gas temperature, oxygen concentration, CO concentration (for gaseous fuels) and smoke-spot number (for liquid fuels). Also, observe the flame and record any changes in its condition.

5.2.5 Continue to reduce combustion air flow stepwise, until one of these limits is reached:

a. Unacceptable flame conditions - such as flame impingement on furnace walls or burner parts, excessive flame carryover, or flame instability.

b. Stack gas CO concentrations greater than 400 ppm.

c. Smoking at the stack.

d. Equipment-related limitations - such as low wind box/furnace pressure differential, built in airflow limits, etc.

5.2.6 Develop an O_2/CO curve (for gaseous fuels) or O_2/smoke curve (for liquid fuels) similar to those shown in Figures 1 and 2 using the ~~excess~~stack gas oxygen and CO or smoke-spot number data obtained at each combustion air flow setting.

5.2.7 From the curves prepared in Step 5.2.6, find the stack gas oxygen levels where the CO emissions or smoke-spot number equal the following values:

Fuel	Measurement	Value
Gaseous	CO Emissions	400 ppmv
#1 and #2 oils	smoke-spot number	number 1
#4 oil	smoke-spot number	number 2
#5 oil	smoke-spot number	number 3
Other oils	smoke-spot number	number 4

The above conditions are referred to as the CO or smoke thresholds, or as the minimum ~~excess~~stack gas oxygen levels. Compare this minimum value of ~~excess~~stack gas oxygen to the expected value provided by the combustion unit manufacturer. If the minimum level found is substantially higher than the value provided by the combustion unit manufacturer, burner adjustments can probably be made to improve fuel and air mix, thereby allowing operations with less air.

5.2.8 Add 0.5 to 2.0 percent to the minimum ~~excess~~stack gas oxygen level found in Step 5.2.7 (unless the device is authorized by its operating permit to add a greater percentage) and reset burner controls to operate automatically at this higher stack gas oxygen level. This margin above the minimum oxygen level accounts for fuel variations, variations in atmospheric conditions, load changes, and nonrepeatability or play in automatic controls.

5.2.9 If the load of the combustion unit varies significantly during normal operation, repeat Steps 5.2.1 through 5.2.8 for firing rates that represent the upper and lower limits of the range of the load. Because control adjustments at one firing rate may affect conditions at other firing rates, it may not be possible to establish the optimum ~~excess~~stack gas oxygen level at all firing rates. If this is the case, choose the burner control settings that give best performance over the range of firing rates. If one firing rate predominates, settings should optimize conditions at that rate.

5.2.10 Verify that the new settings can accommodate the sudden load changes that may occur in daily operation without adverse effects. Do this by increasing and decreasing load rapidly while observing the flame and stack. If any of the conditions in Step 5.2.5 result, reset the combustion controls to provide a slightly

higher level of ~~excess~~stack gas oxygen at the affected firing rates. Next, verify these new settings in a similar fashion. Then make sure that the final control settings are recorded at steady-state operating conditions for future reference.

Figure 1 – Oxygen / CO Characteristic Curve

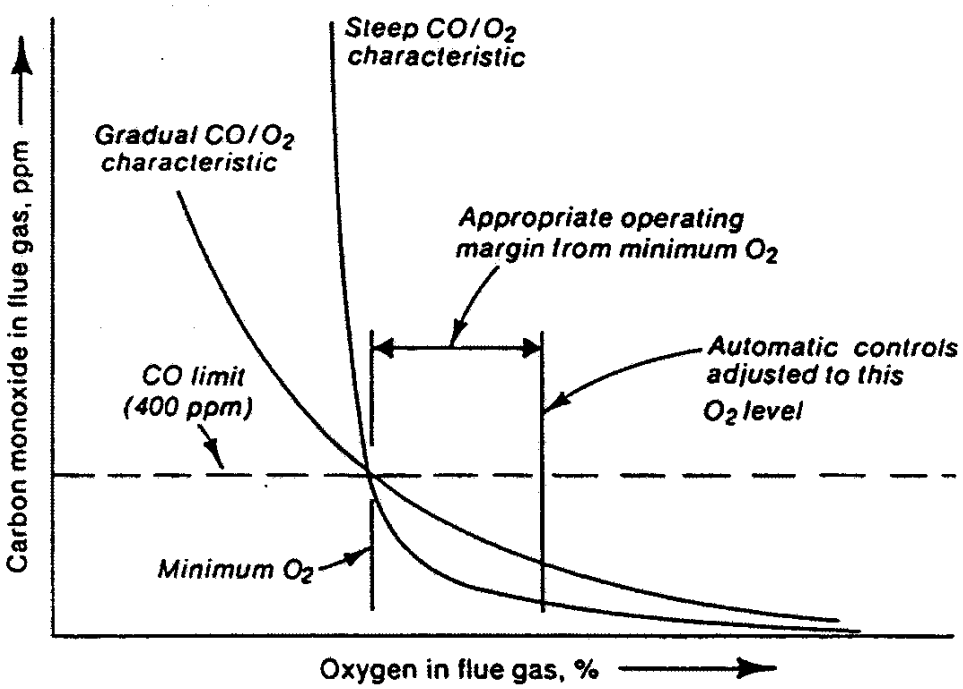
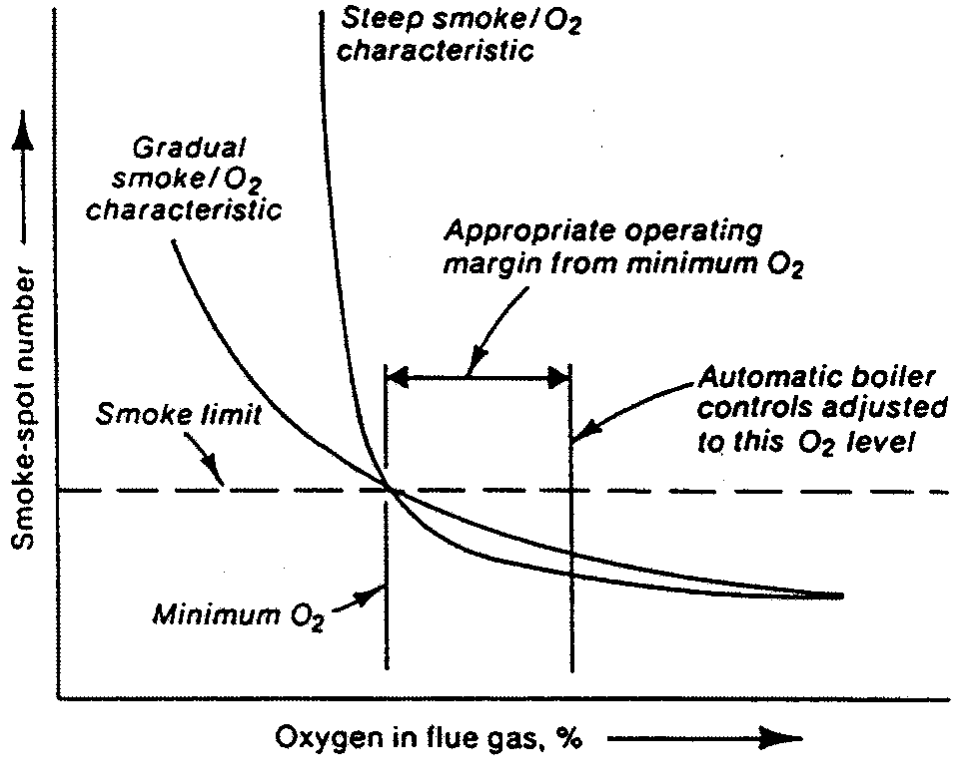


Figure 2 – Oxygen / Smoke Characteristic Curve



5.3 Tuning Procedure for Natural-Draft Boilers, Steam Generators and Process Heaters

Nothing in this Tuning Procedure shall be construed to require any act or omission that would result in unsafe conditions or would be in violation of any regulation or requirement established by Factory Mutual, Industrial Risk Insurers, National Fire Prevention Association, the California Department of Industrial Relations (Occupational Safety and Health Division), the Federal Occupational Safety and Health Administration, or other relevant regulations and requirements.

5.3.1 Preliminary Analysis

a. Check the Operating Pressure or Temperature

Operate the boiler, steam generator, or heater at the lowest acceptable pressure or temperature that will satisfy the load demand. This will minimize heat and radiation losses. Determine the pressure or temperature that will be used as a basis for comparative combustion analysis before and after tuneup.

b. Check Operating Hours

Plan the workload so that the boiler, steam generator, or process heater operates only the minimum hours and days necessary to perform the work required. Fewer operating hours will reduce fuel use and emissions.

c. Check Air Supply

Sufficient fresh air supply is essential to ensure optimum combustion and the area of air supply openings must be in compliance with applicable codes and regulations. Air openings must be kept wide open when the burner is firing and clear from restriction to flow.

d. Check Vent

Proper venting is essential to assure efficient combustion. Insufficient draft or overdraft promotes hazards and inefficient burning. Check to be sure that vent is in good condition, sized properly and with no obstructions.

e. Combustion Analysis

Perform an "as is" combustion analysis (CO, O_2, etc.) with a warmed up unit at high and low fire, if possible. In addition to data obtained from combustion analysis, also record the following:

i. Inlet fuel pressure at burner (at high & low fire)

ii. Draft above draft hood or barometric damper (at high, medium & low fire)

iii. Steam pressure, water temperature, or process fluid pressure or temperature entering and leaving the boiler, steam generator, or process heater.

iv. Unit rate if meter is available.

With the above conditions recorded, make the following checks and corrective actions as necessary:

5.3.2 Checks and Corrections

a. Check Burner Condition

Dirty burners or burner orifices will cause boiler, steam generator, or process heater output rate and thermal efficiency to decrease. Clean burners and burner orifices thoroughly. Also, ensure that fuel filters and moisture traps are in place, clean, and operating properly, to prevent plugging of gas orifices. Confirm proper location and orientation of burner diffuser spuds, gas canes, etc. Look for any burned-off or missing burner parts, and replace as needed.

b. Check for Clean Heat Transfer Tubes and Surfaces

External and internal build-up of sediment and scale on the heating surfaces creates an insulating effect that quickly reduces unit efficiency. Excessive fuel cost will result if the unit is not kept clean. Clean tube surfaces, remove scale and soot, assure proper process fluid flow and flue gas flow.

c. Check Water Treatment and Blowdown Program

Soft water and the proper water or process fluid treatment must be uniformly used to minimize scale and corrosion. Timely flushing and periodic blowdown must be employed to eliminate sediment and scale build-up on a boiler, steam generator or process heater.

d. Check for Steam, Hot Water or Process Fluid Leaks

Repair all leaks immediately since even small high-pressure leaks quickly lead to considerable fuel, water and steam losses. Be sure there are no leaks through the blow-off, drains, safety valve, by-pass lines or at the feed pump, if used.

5.3.3 Safety Checks

a. Test primary and secondary low water level controls.

b. Check operating and limit pressure and temperature controls.

c. Check pilot safety shut-off operation.

d. Check safety valve pressure and condition.

e. Check limit safety control and spill switch.

5.3.4 Adjustments

While taking combustion readings with a warmed up boiler, steam generator, or process heater at high fire perform checks and adjustments as follows:

a. Adjust unit to fire at rate; record fuel manifold pressure.

b. Adjust draft and/or fuel pressure to obtain acceptable, clean combustion at both high, medium and low fire. Carbon Monoxide (CO) value should always be no higher than 400 ppmv at 3% oxygen. If CO is high make necessary adjustments.

Check to ensure boiler, steam generator, or process heater light offs are smooth and safe. A reduced fuel pressure test at both high and low fire should be conducted in accordance with the manufacturer's instructions and maintenance manuals.

c. Check and adjust operation of modulation controller. Ensure proper, efficient and clean combustion through range of firing rates.

When above adjustments and corrections have been made, record all data.

5.3.5 Final Test

Perform a final combustion analysis with a warmed up boiler, steam generator, or process heater at high, medium and low fire, whenever possible. In addition to data from combustion analysis, also check and record:

a. Fuel pressure at burner (at high, medium & low fire)

b. Draft above draft hood or barometric pressure (at high, medium & low fire)

c. Steam pressure or water temperature entering and leaving boiler, steam generator, or process heater.

d. Unit rate if meter is available.

When the above checks and adjustments have been made, record data and attach combustion analysis data to boiler, steam generator, or process heater records indicating name and signature of person, title, company name, company address and date the tune-up was performed.