Pollution Prevention for Power Plant Systems

Maintenance of campus power supply systems and cooling towers are associated with cooling and heating needs for buildings and in many cases power production for energy use. Pollution prevention (P2) and sound operating practices can go a long way to help schools reduce the amounts of hazardous materials used and their regulatory responsibilities. This fact sheet is by no means a complete list of P2 opportunities, but does illustrate some of the options power plant operators may wish to explore further.

Pollution prevention theory

Pollution prevention (P2) opportunities can be divided into three broad categories: change the practice, change the material, and change the technology. Many best management practices are considered P2 because they reduce the amount of waste by changing the way a task or process is done, which results in a reduction of the amount of materials used and/or amount of wastes generated. Changing operating practices are also the cheapest P2 alternative to implement. Changing materials used in a process can eliminate use of a toxic or hazardous chemical, which will reduce the amount of hazardous waste or harmful releases from a process. New technologies may be a move to more automation, such as automatic controllers that reduce or prevent process variations that result in reduced materials use or number of rejects.

Power plant P2

Large academic institutions may generate and distribute their own steam and electric power. Boilers used in these applications vary in age, type, and fuel used (i.e., coal, oil, and natural gas). Natural gas and fuel oils are typical fuel sources, with many schools using both. Size is also a factor, as larger boilers have the potential to create more pollution than smaller ones because of the higher through-put.

Sources of wastes and contaminants associated with power generation and HVAC operations include–

- fuel oil storage
- energy use and air emissions
- boiler blowdown and water quality
- cooling tower blowdown and water quality

Fuel oil storage

Fuel oils used to fire boilers must be managed carefully to reduce environmental impacts from spills and leaks. Storage of fuel oils is regulated by Resource Conservation and Recovery Act (RCRA) underground and aboveground storage tank regulations, and/or by the Oil Pollution Prevention Regulations, which require spill prevention control and countermeasure (SPCC) plans under certain conditions.

The following P2 practices can be applied to the management of fuel oil storage to help reduce wastes and environmental impacts:

- Monitor tank condition, materials, and maintenance schedules; check and test leak-detection systems frequently to make sure they are working.
- Assess the need for storage tanks. For tanks that are not needed, remove or decommission in accordance with local regulatory requirements.
- Aboveground tanks should have secondary containment. Keep the spill containment area clean and free of debris and cover the entire process if possible to eliminate storm water contamination. If rainwater collects in the containment area, drain water only if there is no sheen or discoloration on the surface. Use oil absorbents to remove sheen from the water surface, or have the containment area pumped by a waste-oil contractor. Lock the containment discharge valve in the closed position to prevent the accidental discharge of oil.
- Install spill buckets at fill points to contain drips and spills that may occur during delivery. Keep spill buckets clean and free of liquid and debris.
- Order the correct amount of product for delivery. Order only the amount of product that will fill the tank to 90% of capacity. Be sure to account for product already in the tank.
- Use overfill protection systems that include automatic shutoff devices, overfill alarms, or ball float valves. Be sure the delivery person knows what type of overfill protection your tank has.
- Monitor product delivery to ensure overfilling or spills do not occur.
- Be prepared to respond to releases. If an SPCC plan is not required for your fuel storage, develop plans ahead of time and be prepared to handle any spill scenario.
- Practice inventory control. Compare usage to inventory on hand and purchases. If the amount in inventory plus the amount purchased is not the same as the amount used during a specific time period, there may be a system failure that is causing a release.
- Maintain SPCC plans and employee training; include practice drills.
- Replace pump motors with high-efficiency units as budget allows to reduce electricity use.
- Replace old, two-pass boilers with three- or four-pass units if possible. The four-pass units will have higher efficiencies and lower fuel costs.

Energy use and air emissions

All boilers produce air emissions as a result of the fuel combustion process. Natural gas boilers burn cleaner than fuel oils and certain fuel oils burn cleaner than others. The following P2 options are suggested to help operators reduce the amount of fuel and energy use, and contaminants from their boiler operations:

- Stage boilers to meet the load. Operating several boilers at part load or on standby increases emissions and energy use.
- Keep burner tips in top condition. Establish a routine maintenance inspection program for burners in the boiler. Fouled or burned-out tips do not promote proper mixing of the fuel and primary air needed to ensure good combustion at the burner.
- Carefully track and monitor excess air in the flue gasses. “Excess air” is the extra air supplied to the burner beyond the theoretical amount required for complete combustion. Firing a boiler in a “fuel-rich” condition wastes fuel, is potentially dangerous, and may cause sooting which will further degrade performance. Firing with too much excess air reduces efficiency and increases nitrogen-oxide emissions. Most power burner designs will allow firing at excess air levels of 15%, or about 3% residual oxygen (O_2) in the flue gasses. Either use a flue gas oxygen reset controller or manually check O_2 each shift.

- Monitor excess air carefully during season changes as it is affected by the temperature of the air going to the burners. If the boiler is located outside, its efficiency will be reduced as ambient temperatures drop.
- Maintain a regular boiler water treatment and testing program to reduce scaling on boiler tubes, which reduces transfer of heat to the water.
- Inspect and replace boiler refractory when needed to reduce heat loss and fuel usage.
- Replace pump motors with high-efficiency units as budget allows to reduce energy use.
- Use low-sulfur high-grade fuel oils to reduce SOx and particulate emissions.
- Repair all steam leaks, including steam traps, to reduce steam losses.

Boiler blowdown

Boiler blowdown is water released from the boiler to remove impurities and sediment. If allowed to accumulate, these contaminants can reduce boiler performance. Blowdown water is an industrial wastewater and usually contains contaminants such as dissolved and suspended minerals, heavy metals (iron, copper), corrosion inhibitors, and oil. To limit the potential impact of a power plant's blowdown water (or "boiler blowdown") on the environment, reduce both the volume and hazardous makeup of blowdown water through one or more of the practices described below:

- Conduct frequent chemical analyses to determine the frequency and length of blowdown.
- Consider the addition of heat-recovery and surface blowdown systems for better boiler chemistry control.
- Use ultrasonic imaging, thermocouples, removable test strips, and fiberscopic inspections to determine the location and/or type of deposits in boiler tubes.
- Inspect the boiler tubes annually to track scale buildup.
- Return as much condensate as possible. Water lost through steam or condensate leaks must be made up, introducing contaminants with the makeup.
- Pre-treat makeup water to reduce mineral loadings of the makeup.
- Use a de-aerator or a hot-condensate well to minimize oxygen loading in the feedwater. This will reduce the amount of sodium sulfite needed to control residual oxygen at acceptable levels.
- Inspect and replace seals on steam-cycle system components to reduce the amount of oxygen that enters the system, which leads to faster corrosion and scale buildup and, in turn, the frequency of boiler cleanings.

Cooling tower operation and blowdown

Campus central plants often provide chilled water that is generated with centrifugal or absorption chillers. Chillers of this scale typically have water-cooled condensers and open-cooling towers to reject the heat. Heat is rejected to the atmosphere as air is drawn through a spray of condenser water. Some of the warm condenser water is evaporated, cooling the remaining water droplets as they fall into the tower sump. The sump water is then pumped back to the chiller condenser.

Because there is direct contact between the condenser water and ambient air, air-borne bacteria, dirt, and other impurities are collected in the water. During the evaporation process, minerals in the water remain in the cooling tower and are concentrated. In order to reduce condenser scaling and fouling, and control algae and bacteria growth in the system, cooling tower systems use chemical additives to control pH, metal and mineral deposits, and biocides.

Contaminants build up in cooling water systems just as they do in boiler water and require some of the "dirty" water to be released in order to bring in clean water. Cooling tower blowdown water is also considered industrial process water and as such must meet certain discharge criteria such as pH, metals, and temperature, to ensure that the receiving waters or POTWs are not adversely affected. Reducing the potential impact of a power plant's cooling water on the environment may be accomplished by one (or a combination of) of the maintenance and operational practices described below:

- Maintain the cooling tower properly, scheduling routine monitoring and maintenance activities on fans, pumps, and motors. Replace low-efficiency motors and fans with higher efficiency, multi- or variable-speed equipment when possible to reduce energy use.
- During repair or reconstruction of existing recirculating tower systems, limit use of copper-based, anti-fouling materials which will potentially reduce the metal content of cooling water discharges.
- Identify optimal chemicals for the prevention of biological growth and corrosion. For example, chlorinated biocides are less toxic than brominated biocide; and polyphosphate and organophosphate inhibitors are less toxic corrosion inhibitors.
- Consider using electrically powered water-conditioning units. For example, automatic bleed/feed controllers enable the facility to continuously monitor the concentration of dissolved material in the cooling water. When the concentration exceeds a pre-set level, the controller opens the bleed valve and activates the chemical feed pump, thereby keeping the tower at the optimal concentration at all times and unintentional discharge of active chemicals is eliminated.
- Consider pre-treating makeup water to reduce chemical treatment requirements for scale and corrosion control and increase the ability to recycle the water.
- Consider using materials of construction for cooling tower equipment and piping such as polyethylene, titanium, and stainless steel, which require less scale/corrosion inhibitors.
- Inspect condenser tubes at each tear-down to evaluate efficacy of the program.

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