4.1 Boiler and Steam Systems

Applicability

This BMP is intended for any water user that employs boiler and steam generators for heating or process steam. Commercial boiler and steam systems are primarily found in larger buildings, multiple-building institutions such as campuses, commercial cooking facilities, or in some cases where process steam is required. Large industrial steam boiler and steam systems typically use high pressure saturated or superheated steam for electric power generation or for processes or manufacturing needs. Due to their complexities large power boilers and large industrial steam systems are beyond the scope of this document to deal with in detail. Operators of such systems should use best operating practices specific to the process to achieve thermal and water use efficiency.

Frequently, the primary driving force for improving the efficiency of commercial boiler and steam systems is energy savings. Industrial steam generating systems are generally already designed to optimize overall thermodynamic efficiency. In most cases however, the measures taken to improve energy savings also result in water savings, and likewise water efficiency measures can also improve the energy efficiency of steam systems.

Description

A steam boiler system transfers energy from a fuel source such as natural gas, coal, lignite, nuclear, or fuel oil to water in a steam generator or process equipment. The heated water as steam is circulated through a distribution system to the manufacturing process, heat exchanger, or heating coil where it reverts back to liquid phase called condensate. Water is added through “make-up water” to replace lost steam and “blowdown water” that is periodically released to remove contaminants and reduce the level of dissolved solids in the boiler water. This BMP centers on the practices for optimizing the water-use efficiency of boiler and steam systems.

Three general types of measures can reduce the amounts of water used in boiler and steam systems:

1) optimized condensate recovery;
2) improved water treatment and monitoring to minimize boiler blowdown; and
3) good operation and maintenance programs for steam lines, steam traps, feed pumps, condensers, heat exchangers, and boilers.

Use of appropriate industrial standards for water chemistry is necessary both for equipment upkeep and for efficient water use. Operators of boiler and steam systems should also consult the Water Treatment BMP for possible interlocking efficiencies related to demineralizer or softener operations.

A major opportunity for water savings in boiler and steam systems is through improving the efficiency of condensate water return to the boiler. As more condensate is returned, less make up water is needed. The reuse of high purity condensate water reduces the amount of water required from the water treatment process. Insulating and maintaining return lines ensures that the higher temperature of the water will require less energy for reheating within the system. Maximizing the return of condensate must be carefully balanced with the potential for carryback of contaminants and scale particles.

In many smaller commercial and institutional steam systems “flash steam”, which occurs when saturated condensate is reduced to some lower pressure and some flashes off to steam again, is vented to the atmosphere. Flash tanks should be used to recover and return flash steam to the system along with the condensate.

Minimizing blowdown can be accomplished through use of chemicals and treatment to reduce scale buildup and minimize scale deposition. Automatic chemical feed and automatic control systems based on water quality are recommended as good options to reduce the amount of water released through blowdown. Another recommended practice where possible is installation of automatic controls that shut down boiler units when not in use for extended periods of time. Blowdown should be matched to meet the water quality standards required to minimize corrosion and scaling.

Most large industrial users should already have in place good maintenance practices to maintain boiler and steam systems and related equipment and facilities. It is recommended that commercial boiler steam system operators have an organized preventative maintenance program. Significant amounts of steam can be lost through leaking steam traps, holes in coils or steam lines, and faulty pressure release valves.

Water users considering replacement or retrofit options for boiler and steam systems should consider opportunities to optimize heat requirements within the facility and to determine the appropriate size of the system. Many institutional boiler and steam needs can be met through use of individual systems for different buildings or processes instead of central systems or through installation of secondary small load boilers for low use periods.

Opportunities should also be explored for internal reuse of steam or condensate within a facility or complex. Cogeneration facilities are becoming more widespread where industrial steam can also be used to generate electricity or where lower pressure steam can be extracted for process use.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation on each boiler and steam system within a facility to identify areas of improvement for water savings and optimization of heat loads. The water user may want to perform the water

efficiency evaluation in conjunction with an energy efficiency audit. The evaluation should review all aspects of boiler and steam operations including end use of steam requirements, sources and amounts of water used for make-up, blowdown, condensate recovery, concentration ratios, treatment techniques and chemicals used, metering, use of automated monitoring and controls, repair and maintenance schedules and procedures, and water quality characteristics.

2) Boiler and steam systems should be operated in a water efficient manner with consideration for:
   a. Maximizing condensate return;
   b. Optimal use of chemical additives and automatic blow-down techniques to minimize the required blow-down rates;
   c. Appropriate use of automatic shutdown when the system is not use; and
   d. Regular inspection and maintenance of steam lines, steam traps, condensate feed pumps, boilers, and other associated equipment. Contaminants should periodically be removed from boiler and steam units by cleaning the boiler chemically or mechanically.
3) Overall efficient operation of the steam delivery system including analysis of the end use requirements to optimize required heat loads; and cost-effectiveness evaluation of boiler and steam system replacement and retrofit options.

Schedule

If the water user chooses this BMP, the following is a recommended schedule:

1) The industrial water user should complete the efficiency evaluation of its boiler and steam systems in a timely manner or within twelve (12) months of beginning this BMP.
2) The action plan should be completed and implemented in the normal business cycle immediately following the completion of the facility survey and cost effectiveness analysis. For most facilities, twelve (12) months will be a reasonable time period to implement the action plan. Major facilities may need additional time for completion and implementation of the action plan.
3) Boiler and steam systems will be operated optimally at all times following the guidelines of this BMP.

Scope

To accomplish this BMP, the industrial water user must do the following:

1) Industrial water users with one or more boiler and steam systems should perform an efficiency evaluation and perform upgrades or replacements as outlined in the schedule of Section D.

2) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.
3) Have in place an organized preventive maintenance program that includes regular inspection and repair of all equipment and facilities associated with the boiler and steam system.

Documentation

To track this BMP, the industrial water user gathers and maintains the following documentation and can utilize industry accepted practices:

1) Operating information on the boiler and steam systems including boiler and steam efficiencies and end use load information for each system;
2) System operating hours;
3) Energy and water use records for each boiler and steam system that include the number of gallons of blow-down water and the number of gallons of make-up water used monthly;
4) Number of cycles of concentration and calculation data;
5) Documentation of appropriate steam system water chemistry standards and controls that are used. There are several resources for standards related to boiler and steam systems included in Section I; and.
6) Descriptions of equipment or process changes, equipment operating manuals and procedures for any controls used such as automatic meters and conductivity or pH sensors used to control blow-down and automatic shut down equipment.

Determination of Water Savings

Using operating observations, historical records and manufacturers' data as appropriate, water savings due to increased condensate return and increased concentration ratios can be calculated.

1) Water use in boiler and steam systems, where temperatures and pressures vary, is typically accounted for in units of pounds (lbs) per hour. When condensate return is implemented or improved and operating hours are known, the amount of water saved in gallons can be found by: = (condensate load in lbs/hr) x (operating hours) / 8.34
   If flash steam is not recovered, adjustments must be made for "flash steam loss" which can be 10 percent or more of the condensate load depending on the temperature and pressure differential.
   Source: U.S. Department of Energy
2) The percent of water expected to be conserved through increased concentration ratio (CR) is = (CR2 – CR1) / (CR2 x (CR1 – 1))
   Where CR1 is concentration ratio before and CR2 is concentration ratio after increasing cycles.

The CR is determined from the dissolved solids (or alternatively the conductivities) in the makeup water (CM) and bleed-off water (CB):
CR = CB / CM

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade to boiler and steam equipment, utilizing its own criteria for making capital improvement decisions. A cost effectiveness analysis under this BMP should consider capital equipment costs, staff and labor costs, chemical and treatment costs, and additional costs or savings in energy use. Many industries regularly use outside specialized water quality consultants at fees starting at a few hundred dollars per month depending on the size and scope of the operation. Or the water treatment chemical suppliers may provide consulting services as part of the chemical costs.

Many operational procedures and controls that improve both water and energy use efficiency in boiler and steam systems should be implemented simply as a matter of good practice. In addition to water savings, increasing the amount of condensate returned to the boiler saves significant amounts of energy. Heat energy remaining in the condensate can be more than 10 percent of the total steam energy content of a typical steam system.

Resources

1) There are many equipment manufacturers, chemical vendors, and consultants that specialize in manufacturing and operating boiler and steam systems. They can be an excellent source of information related to specific applications. Many vendors and boiler equipment manufacturers have published standards and other literature available to assist an industry in optimizing its steam boiling systems.
2) Office of Industrial Technologies Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, D.C. 20585-0121. www.oit.doe.gov
3) Steam Boiler Practices and Standards have been developed by The American Society of Mechanical Engineers www.asme.org
4) The Electric Power Research Institute (EPRI), a non-profit energy research consortium which provides science and technology-based solutions to the energy industry, has developed standards for operation and has conducted or has ongoing several projects that address all aspects of boiler and steam systems in electric power generation. www.epri.com
5) The American Boiler Manufacturers Association (ABMA) is a national, non-profit trade association of manufacturers and users of commercial/institutional, industrial and power-generating boilers and boiler and steam-related equipment, 4001 North 9th Street, Suite 226, Arlington, VA 22203-1900 www.abma.com
6) The National Association of Corrosion Engineers (NACE) is an association dedicated to the control and prevention of corrosion. NACE has standards

prepared by the Association's technical committees to serve as voluntary guidelines in the field of prevention and control of corrosion. www.nace.org

7) *A Water Conservation Guide for Commercial, Institutional and Industrial Water Users*, New Mexico Office of the State Engineer, July 1999. http://www.seo.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf