Water Conservation Best Management Practices

Best Management Practices for Industrial Water Users

Texas Water Development Board

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1.0 Introduction

BMPs for industrial water users are a combination of proven management, educational, and physical practices that a water user can use to achieve efficient and economical conservation of water. Water consumption by industries, whether supplied by others or self-supplied from surface or groundwater sources, can be varied in amount of use, rate of use, and opportunities for efficiency. For many industrial water users in Texas, water is an integral part of a product or a process. Another major use of water is for cooling, either removing heat from processes or providing a comfortable safe environment through air conditioning. Some industries use water as a conveyance or for rinsing and cleaning products and containers. Numerous industrial facilities use water for landscape irrigation. The quality of water used by industries in different processes varies widely from ultra-pure treated water to water which does not meet potable water standards.

The wide variety in the types of water uses, the size of facilities and the types of activities at different industrial facilities makes it difficult to compare one water user to another, although there are certain overall comparisons that can be made. In many industries, the water used to produce a product may be divided by the output to calculate the gallons per unit of production. Each industrial water user should evaluate water use and efficiency potential at its own facility(s). As a result, the initial recommended Best Management Practice for all industrial water users is the Industrial Water Audit BMP where the user identifies the relationships between all water coming into the facility and the various uses of water within.

The next Industrial BMP that should be considered is the Industrial Water Waste Reduction BMP, which focuses on the most economical changes to improve efficiency. By implementing the Industrial Submetering BMP, an industry may be able to identify significant opportunities for monitoring ongoing water use within specific parts of its facility.

Additional Industrial BMPs focus on the water uses most common among Texas industries and in which cost-effective measures for increasing water use efficiency are well understood. The Cooling Systems and Cooling Tower BMPs deal with specific measures for reducing water use in cooling.

Many water uses in industrial settings can use water of lower quality than that necessary for human consumption. The Industrial Alternative Sources and Reuse of Process Water BMP addresses reuse of water both within processes of the facility and from other sources that may be available near the facility.

For industrial users who rinse or clean products in their facilities numerous opportunities arise for water conservation through controlling flow rates and reusing water as outlined in the Rinsing/Cleaning BMP. Those with more sophisticated water treatment processes should consider the Water Treatment BMP as a means of increasing efficiency.

For industrial users which use steam as a motive force or in high temperature processes, the Boiler and Steam Systems BMP is provided. The Refrigeration (including Chilled Water) BMP provides a template for those with large cooling operations of greater sophistication than typical cooling towers. For large industrial plants using bays or lakes for cooling, the Once-Through Cooling BMP offers guidance on efficiency for their operations.

All industrial users can benefit from the Management and Employee Programs BMP that includes guidelines for increasing employee support and participation in conservation efforts. Many industrial users also irrigate a large landscaped area. The Industrial Landscape BMP presents approaches for reducing water use or irrigating with alternative sources of water.

For industrial users that do not find their specific process covered among the other BMPs, the Site-Specific Conservation BMP is offered to help in developing a BMP to address their unique needs.

Best-management practices contained in the BMP Guide are voluntary efficiency measures that save a quantifiable amount of water, either directly or indirectly, and can be implemented within a specified timeframe. The BMPs are not exclusive of other meaningful conservation techniques that an entity might use in formulating a state-required water conservation plan. At the discretion of each user, BMPs may be implemented individually, in whole or in part, or be combined with other BMPs or other water conservation techniques to form a comprehensive water conservation program. The adoption of any BMP is entirely voluntary, although it is recognized that once adopted, certain BMPs may have some regulatory aspects to them (e.g. implementation of a local city ordinance).

2.1 Cost Effectiveness Analysis

Introduction

The industrial water user should determine if implementation of each identified BMP measure to achieve water savings would be cost effective. The analysis should determine the cost effectiveness to the industrial water user of the lower direct costs of the saved water and other cost savings that may also accrue. Many operating procedures and controls that improve water use efficiency should be implemented simply as a matter of good practice. In other cases the industrial user may decide to implement BMPs based on non-cost factors such as public good will or political reasons. In evaluating equipment and process additions or changes, each industry should utilize its own criteria for making capital improvement decisions.

Cost Effectiveness Example

The following gives a simplified example of the process that an industrial water user can use to evaluate the cost effectiveness of making water savings investments and decisions under any applicable BMP. Each industry should utilize its own financial criteria for making capital improvement decisions.

A cooling tower efficiency audit of a small industrial facility resulted in three recommendations for water savings: increase the cycles of concentration in the cooling tower, improve the overall cooling system efficiency with regard to repairing facilities and overall system operations, and look for opportunities to reuse the cooling tower blowdown.

The system currently uses approximately 20,000 gallon per day (14 gpm). Increasing the cycles of concentration from two (2) to six (6) will reduce the amount of blowdown water by about 8,000 gallons per day. To effectively do that the system will require new monitoring and controls for pH and conductivity, automatic blowdown controls, chemical feed systems, and related piping and equipment modifications. Also, to maintain that level of operation, the industry will utilize the service of a professional water treatment firm to monitor the operation and supply appropriate chemicals to keep the facilities in good repair.

Estimated capital costs of retrofitting and installing conductivity controller, probes, valves, chemical injectors, relays, etc., will be about $7,500. For a medium size facility the cost of using a monthly water management consulting and chemicals firm would increase by approximately $250 per month ($3,000 per year). In this example, the water source is the company's own wells, and the overall average cost of supplying water and disposing of wastewater is $2 per 1000 gallons.

Estimated water savings = 8,000 x 360 days = 2,880,000 gal (8.84 ac ft)
Or $5,760 a year ($480 per month) or $652 per acre foot per year

1) The simple payback analysis for capital expenditures =

$7,500 / ($5,760 - $3,000) = 2.7 years

The payback method does not take into account the time value of money.

2) A simple present worth analysis, with the assumptions of a 6 percent rate over the estimated life of the controls of ten (10) years shows that it would be cost effective to implement the measure.

6%, 10 years		Amount	Years	P V
Capital Costs	$	7,500	0	($7,500)
O & M Contractor	$	250	per mo	($22,518)
Water Savings	$	480	per mo	$43,235
Net Present Value				$13,217

3) The second water savings recommendation is to increase the overall efficiency of the cooling system by such measures as coil cleaning, reducing heat load, making operations more efficient with variable speed fans and pumps, adjusting belts, replacing fill, repairing and replacing shielding, and generally keeping the system in good repair. Estimated water savings from these measures could be up to an additional 15 percent (Pacific Institute, 2003), which is about 1,800 gallons per day. If the company spends $5,000 in cleaning up the cooling tower operation initially, and then spends $1,000 every other year for a ten year period, the cost effective analysis shows that the measure would be effective, again assuming a ten (10) year life of the measure.

6%, 10 years		Amount	Years	P V
Capital Costs	$	5,000	0	($5,000)
Periodic cleaning, etc	$	1,000	every 2 yrs	($3,573)
Water Savings	$	108	per mo	$9,728
Net Present Value				$1,155

4) The next recommended water savings measure was to investigate opportunities for reuse of the blowdown water for other purposes within the facility. After savings from increasing the cycles of concentration, the quantity of water is relatively small, and quality of the water will not be suitable for every purpose. This facility requires relatively good quality of water for reuse in its manufacturing processes, so in order to use the approximately 2,000 gallons per day of blowdown, collection facilities, a tank, additional pumping, and a small membrane treatment unit will be needed for a cost of $10,000. Then operating costs are conservatively estimated to be approximately $100 per month. If the

facilities have a useful life of 10 years, then the analysis shows that the measure is not cost effective.

6%, 10 years	Amount	Years	P V
Capital Costs	$ 10,000	0	($10,000)
Treatment costs	$ 100	per mo	($9,007)
Water Savings	$ 108	per mo	$9,728
Net Present Value			($9,279)

Additional Considerations

The analyses in these examples are fairly straightforward and some assumptions to simplify the example were made. In a detailed, case by case evaluation of the water users facilities, there are additional cost components associated with the water savings measures that may be taken into consideration, including:

1) Initial efficiency evaluation and engineering costs.
2) Administration and other increased labor costs if significant.
3) Estimated energy savings.

The cost of water is also a very significant component of the analysis. In this example it was assumed to be the same for the entire period, and the production facilities were already in place. If the industry would have to consider the additional expansion of its water facilities, or obtaining alternate water supplies at some point in the future, the costs of water saved would be even greater. These costs would include:

1) Costs of water or contract purchase of water.
2) Construction of treatment or production facilities.
3) Operating costs.
4) Increased or alternative costs of waste disposal.

2.2 Industrial Site Specific Conservation

Applicability

This BMP applies to any industrial water user with facility or product-specific water-using processes. While other BMPs address most water uses in industrial facilities, this BMP is offered to assist the industrial water user in designing a BMP for process which is not covered by other industrial BMPs. The industrial water user can use the guidelines of this BMP to develop a site-specific BMP using appropriate elements from other BMPs. This BMP would also be useful for an industrial user that may be required to submit a conservation plan to a wholesale provider or other entity.

Description

Industrial conservation practices are essential for reducing water usage in the industrial sector. Under this BMP, the water user should conduct an industrial water-use survey as defined in BMP 3.1 (Industrial Water Audit). The water-use survey includes an evaluation of all water-using equipment and processes and will result in a report identifying potential conservation measures and their expected payback based on a cost-effective analysis. From the results of the survey a water conservation program should be developed that identifies performance goals, actions to meet the goals, and methods of measuring success and estimating water savings.

Those facilities which operate an Environmental Management System ("EMS") may already have water conservation as an environmental aspect and may have already adopted a conservation program. Facilities that have adopted ISO 14000 or other systems with a "Plan-Do-Check-Act" framework may already meet several of the elements of this BMP.

Because each facility is unique, the scope and formality of its conservation program will vary according to its size, sector, and complexity. Once all water uses are identified through a survey and potential conservation goals are identified, other industrial BMPs should be reviewed for applicability and those BMPs that would be beneficial to the water user should be selected.

If there are specific measures that should be implemented that fall outside already existing BMPs, a BMP can be developed following the Best Management Practice outline. All selected and developed BMPs should then be incorporated into the conservation program. A qualifying conservation program and site specific BMP should include the following essential elements:

1) Clear description of goals and implementation steps
2) Implementation schedule
3) Scope
4) Documentation
5) Information used to determine water savings
6) Cost-effectiveness analysis

For new facilities, design and construction should be accomplished with conservation in mind, and measures implemented should be documented to demonstrate efficiencies achieved, and water savings potential of such measures.

Implementation

Any industrial site specific water conservation program must have a fundamental starting point: to understand the water use at the facilities. The initial step is to perform an industrial water-use survey as described in BMP 3.1 (Industrial Water Audit). The water-use survey should include an evaluation of all water-using equipment and processes and identification of potential conservation measures along with their expected payback based on a cost/benefit analysis.

1) Access Information and Resources

   There are many sources of information available on all aspects of water conservation. Water conservation districts, water planning groups, industry trade associations, and the Texas Water Development Board ("TWDB") are all good sources for specific conservation guidance materials. A water user should first attempt to find available resources that will greatly reduce the time and cost of developing a site specific BMP. The easier and quicker the practice can be prepared the sooner implementation can commence and results can be obtained.

2) Define Performance Measures

   In order to set goals and monitor conservation success it is necessary to derive performance measures. Each facility audit should identify the appropriate performance measure of water usage. Examples of performance measures are gallons per unit of product, per employee, per process, per cycle, per unit of energy consumption, per unit of manufacturing area, or per time period. Those performance measures should be used in tracking the success of this Industrial Site-Specific Conservation Program BMP. Two examples are gallons per pound or ton produced and gallons per kWh of power produced.

3) Employee Education & Participation

   Employees can have a major effect on the success of a water conservation practice and the overall conservation program. Employees will be responsible for implementing efficient practices and are usually the first to notice a problem and/ or identify changes that can make the process more efficient. Therefore, it is imperative that they be kept informed about the program and made an integral part of all water reduction efforts. The steps outlined in BMP 3.12 (Management and Employee Programs BMP) can serve as a guideline for effectively informing employees of the BMPs in your program and enlisting their full support and participation on an ongoing basis.

4) Measure Results & Publicize Success

The site-specific water conservation practice should include specific metrics on water use and water conservation strategies. Goals should be approved by management and be specific and measurable, and a timetable for compiling and reviewing information should be defined. Direct management involvement in the goal setting process should facilitate acceptance and improve the likelihood of success. The specifics of the conservation practice will dictate how quickly it can be implemented and how quickly water savings can be achieved. Generally, a conservation practice should not take more than one year to develop and implement. Water conservation should become a regular parameter that the management team reviews just as they regularly review revenue, costs, financial performance, safety, and environmental compliance. Toward that end, just setting expectations of water conservation without regular review or monitoring of the results will not result in a more water-use efficient facility.

In addition to saving water, energy and money, positive public opinion is an extremely important benefit. Because Texas is a very diverse state with a variety of climatic conditions, water conservation is of ongoing public interest. News media throughout the state routinely cover "good news" stories about companies, institutions, and industrial facilities that take a proactive stand on water conservation. Incorporating conservation efforts into qualifying for TCEQ's Environmental Excellence Program or Clean Texas Program are excellent methods of achieving this objective.

Schedule

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

1) The water-use survey should be conducted in a timely manner. Audits of very large or complex systems should be completed in the first three (3) months after initiating this BMP.
2) The selection and development of BMPs, cost-effectiveness analysis of water efficient alternatives, and the development of the conservation practice should be completed by the end of the first year. If determined to be necessary for very large or complex facilities, the schedule can be extended. BMPs should be initiated within the normal business cycle and continued until the targeted efficiency is reached.
3) Regular monitoring of water use and annual evaluation of water-use efficiency should be maintained.

Scope

To accomplish this BMP, the industrial applicant should:

1) Conduct an industrial water-use survey consistent with the guidelines and schedule above, and

2) Implement the site specific conservation practice.

Documentation

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

1) Water-use survey results and potential conservation measures identified through the survey;
2) A description of each BMP implemented;
3) A description of the measures implemented and estimated water use reductions achieved through these measures. The water user should document how savings were realized and the method and calculations for estimating savings; and
4) A copy of the site specific conservation practice and the conservation program, which includes all BMPs planned, estimated potential water savings and schedule for completion.

Determination of Water Savings

The industrial water user should calculate water savings based on the calculation methodology appropriate to the identified water efficiency measures adopted. Each industrial process will have its own potential for water savings. Studies have shown estimated overall water savings for implementing water audits have been in the range of 10 percent to 35 percent on average. Efficiency measures which included changing from high quality or potable water to recycling water have shown savings in the range of 50 percent to as high as 95 percent.[1]

Cost-effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified water savings opportunity, utilizing its own criteria for making capital improvement decisions. A cost effectiveness analysis under this BMP should consider, as appropriate, capital equipment costs, staff and labor costs, administrative materials and overhead, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs. The one-time-only costs of developing and implementing the facility evaluation survey and recommendations should also be included.

References for Additional Information

1) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
2) *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
3) Millwater Pumping System Optimization Improves Efficiency and Saves Energy at an Automotive Glass Plant, Office of Industrial Technology, Department of

Energy, March 2003.
http://www.oit.doe.gov/bestpractices/factsheets/gl_cs_visteon_nashville.pdf

4) *Water Efficiency Guide for Business Managers and Facility Engineers*, Sate of California Department of Water Resources, October 1994.
5) *Commercial and Institutional End Uses of Water*, AWWA Research Foundation, Summer 2000.
6) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003.
http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf
7) *Water Efficiency Manual for Commercial, Industrial and Institutional Facilities*, State of North Carolina, August 1998. http://www.p2pays.org/ref/01/00692.pdf

2.3 Industrial Water Audit

Applicability

This BMP is intended for industrial water users and should be thought of as the initial BMP for industrial water users to increase water efficiency at their facility. Under this BMP, the water user collects information about all water that enters a facility and an understanding of how that water is used within a facility. Once an industrial water user decides to adopt this BMP, the water user should follow the BMP process closely in order to achieve the maximum water efficiency benefit from this BMP.

Description

Water audits are effective methods to account for all water usage within a facility in order to identify opportunities to improve water use efficiency. Benefits from implementation of this BMP may include lower utility costs, energy savings, and reduced process costs. It will also provide information helpful in the implementation of related Industrial BMPs such as Water Waste Reduction BMP, the Industrial Submetering BMP, the Industrial Landscaping BMP, the Cooling Towers BMP, Cooling Systems (other than Cooling Towers) BMP, and the Industrial Alternative Sources and Reuse of Process Water BMP.

Facility water audits include accurate measurement of all water entering the facility, the inventory and calculation of all on-site water uses, any unused water sources or waste streams that may be available, calculation of water related costs, and identification of potential water efficiency measures. The information from the water audit should then form the basis for a comprehensive conservation program to implement specific water saving measures throughout the facility. The conservation program may consist of one or more projects in different areas of the facility.

The steps to conduct a water audit are listed sequentially in Section C. The order can be altered if it would be more effective at a particular facility. This BMP is the first step in implementing industrial water conservation. As the water user identifies opportunities for conservation, other BMPs will be indicated as listed below:

1) After completing this BMP, if unaccounted water is greater than 5 percent, the Water Waste BMP should be considered. At facilities, where no system of internal water measurement has been established, the determination to implement the Water Waste BMP should be delayed until the Submetering BMP is implemented.
2) The next step is to determine if the Submetering BMP needs to be implemented in order to be able to account for all water use within the facility.
3) If water use for irrigation represents a significant portion of demand, then the Landscape BMP should be considered and more detailed information on landscape irrigation and outdoor water use should be collected.

4) If the facility has a cooling tower, then the Cooling Towers BMP should be considered.
5) If there are cooling processes, then the Cooling Systems (other than Cooling Towers) BMP should be considered.
6) Finally, if there are opportunities to reuse water within the facility or reclaimed water is available from a utility provider, the Reuse of Process Water BMP should be considered.

Implementation

Generally following the guidelines as outlined in this section, the industrial water user should conduct a facility audit. References that provide more detailed audit procedures are listed in Section I.

1) Preparation and information gathering

The material collected should be used to implement this BMP and should be useful for other BMPs as well. Information that should be collected before beginning the audit includes maps of facilities with building sizes and locations of main water supply meters and any submeters, numbers of employees and work schedules, inventories of plumbing fixtures, inventories of water using equipment and processes including water quality limitations, and outdoor water use information including irrigation schedules and types and square footage of landscape materials. Also, water use and water quality data for the past three years should be collected such as utility records of water used and wastewater generated, actual water use on site including submetered use, and non-utility water use such as wells or storm water. Additionally, any prior water use surveys or energy audits should be obtained and reviewed since these reports may include useful and relevant information to determine the most appropriate water saving measures to implement. If the plant has a water right of greater than 1000 acre-feet per year, then it should have a water conservation plan submitted to the Texas Commission on Environmental Quality. If the plant has a waste discharge permit, the water balance diagram included with the permit should be obtained. All possible alternative sources of water should be inventoried.

2) Conduct facility survey

The on-site physical examination and water use survey should identify and verify all equipment that uses water, noting discrepancies to update the inventory. Equipment information should be verified or measured for hours of operation, meter calibrations, and manufacturers' listed flow rates. If appropriate, water quality should be analyzed so that reuse of water can be assessed. Daily water usage for each major water use area should be determined and, when added together, total facility usage calculated on a monthly basis and compared with the utility measured sales to the facility. The quantity of water used by specific processes should be considered in developing the priority list of facility areas for the audit.

If water use for irrigation represents a significant portion of demand more detailed information on landscape irrigation and outdoor water use should be collected. When applicable, a determination of irrigation schedules from irrigation controllers should be made along with a run of the irrigation system to measure the distribution efficiency as well as to identify leaks, overpressurization, and broken heads. The Landscape BMP should be considered if it is determined that improvements in irrigation practices may offer opportunities for significant water savings.

3) Prepare a facility audit report

The data gathering and the facility survey should be incorporated into a facility audit report that includes an updated set of facility diagrams and water flow charts broken down by water use areas, a current list of all water using equipment including actual and manufacturer recommended flow rates, a current schedule of operations for all manufacturing or process areas and equipment, a monthly landscaping irrigation schedule based on no more than 80 percent of historical ETo with recommended landscaping equipment repairs and upgrades, water use observations revealed by the walk-through of the facility, an analysis of water costs by operating area and for the entire facility, identification of waters that have the potential for conservation and reuse and calculations of the difference between water coming into the facility and a list of identified water uses throughout the facility. (Note: This is the amount of water that is potentially being lost by leaks, which could be underground.)

4) Prepare a cost-effectiveness analysis

The cost-effectiveness analysis should determine the water efficiency opportunities that are cost effective to implement. The analysis may also identify water efficiency opportunities that should be implemented even if not cost effective due to high visibility, ease of implementation, or general employee and customer goodwill. If landscaping water use is a large component of water use, or if high quality effluent from processes is available, consideration should be given for reuse water on the landscape. After confirming the cost effectiveness of the BMP, the action plan should then be prepared based on the water users' own decision criteria which may include considerations for available resources, safety, compatibility with manufacturing facilities, and management priorities.

5) Prepare recommendations for action

The facility audit report should contain proposals and a timetable to implement selected water efficiency measures. The report is the first step in preparing a water conservation plan. In addition to other BMPs which are indicated through the audit results, the plan should address a leak detection program if needed, installation of submeters if needed, a regular water audit checkup schedule (i.e., weekly during the spring and summer, and monthly during the cooler months) to check flow rates for specific equipment, and to identify leaks, to adjust irrigation equipment and schedules, communication of the action plan to employees, communication of successful implementation of plan to the public, and procedures and policies to repeat audit process on an annual basis.

Schedule

1) The audit should be completed in a timely manner. Very large or complex audits should be completed within the first twelve (12) months of implementing this BMP.

2) The recommendations should be implemented within the first normal budget cycle following the conclusion of the audit. For most facilities, this should be a reasonable time period to implement the recommendations. Major projects may take additional time for audit and implementation. Obvious water leaks and problems found during the course of the audit should be repaired as soon after discovery as possible.
3) If determined to be necessary for very large or complex facilities or for more comprehensive conservation plans, the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP:

1) Industrial water users with one facility, or several facilities with the same or very similar industrial processes, should conduct a water audit following the schedule outlined in Section D.
2) For industrial water users with multiple facility sites, or multiple industrial processes, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been audited and conservation measures implemented. Conservation measures implemented at one facility may not be applicable or cost-effective at another location.
3) Cost effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) The audit report;
2) Cost-effectiveness analysis;
3) The action plan;
4) Schedule for implementing the action plan;
5) Documentation of actual implementation of water efficiency measures contained in the action plan; and
6) Estimated water savings and actual water savings for each item implemented.

Determination of Water Savings

In order to calculate water savings, the industrial water user should use the methodology appropriate to the identified water efficiency opportunities. Estimated overall water savings for implementing the recommendations from the audit should be in the range of 10 percent to 35 percent if a similar audit process has not previously taken place .[1]

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade, utilizing its own criteria for making capital improvement decisions. The facilities survey and audit report may be conducted and prepared by either the industrial water user's own staff or by specialized outside consultants. There may be additional one-time costs for equipment such as flow meters and additional costs for periodic inspections and audit updates. Some of the water savings opportunities found by the audit may require only minor capital expenditures and should be done simply as a matter of good practice.

References for Additional Information

1) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
2) *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
3) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.
4) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf
5) *Commercial and Institutional End Uses of Water*, AWWA Research Foundation, Summer 2000.

3.1 Management and Employee Programs

Applicability

This BMP is intended as a supplemental BMP for the other Industrial BMPs and could apply to all industrial water users. The successful implementation of any of the Industrial BMPs requires the joint efforts of both management and employees. This BMP describes the process for involving both management and employees in accomplishing the water conservation efforts of the industrial water user. Once an industrial water user decides to adopt this BMP, the water user should follow the BMP process closely in order to achieve the maximum water efficiency benefit from this BMP.

Description

For any Industrial BMP to be successful, the employees should be involved in the development and implementation of the BMP. A joint management/employee committee should be formed to determine the water conservation BMPs that will be beneficial to the user and this committee should guide the implementation of the BMPs that are adopted.

1) Set Goals & Obtain Management Support

Goals should be established depending on the set of Industrial BMPs adopted by the industrial water user. Costs drive business decisions so cost savings are very important in the goal setting process and in obtaining strong management commitment for implementing the specific BMPs. For purposes of this BMP, the set of BMPs that the industrial water user has decided to adopt should be called the water conservation program (program).

As with many other aspects of business management, ownership of the program by a member of the management team and routine management review of the results achieved are absolutely critical to successful implementation. A water conservation program will generate cost savings but will require funding and a time commitment to make the program work. It is very important that the funding and commitment are in place before the program is initiated.

2) Employee Education & Participation

Employees can have a major effect on the success (or failure) of a water conservation program. Therefore, it is imperative that they be an integral part of all water conservation efforts and are kept informed about the program. The following steps can serve as guidelines for effectively enlisting employees' full support, keeping employees informed of the progress being made, and seeking their participation on an ongoing basis.

a. Communication to all employees from a key management leader of the organization. The communication should announce the water conservation program, introduce the Water Conservation Manager on the leadership team, detail specific goals, ask for employee support, and invite feedback.

b. Establish an employee water use education program. The education program should communicate information about

- the importance of and need for water conservation in Texas, the local region of the state, and the industry;
- the overall aspects of the company's water conservation program, including specific goals and incentives;
- the importance of each individual's contribution to the success of the water conservation goals of the entire organization and, if appropriate, the region of Texas;
- how specific water-saving measures by individuals can reduce overall consumption;
- how specific water-saving measures by employees working together as a team can result in major water use reductions; and
- new procedures and water conservation equipment that should be implemented.

c. Use a wide variety of communication media to help keep the water conservation message current and to reinforce the importance of the organization's water conservation efforts. Potential communication vehicles include
    - company newsletter
    - internal website
    - memos
    - paycheck stuffers
    - email
    - posters and signs
    - water conservation "progress reports" and "score cards"
    - new and/or revised operating guides and manuals that describe changes made to implement water-saving measures

d. Establish a schedule for regular communication with employees about the water conservation program. The initial excitement of a new program will begin to fade unless the importance of the program is regularly communicated. Ensure that employees are kept abreast of the specific water reduction measures as they are being implemented as well as the associated water, energy and cost savings generated by those measures. Information about water and cost savings are especially useful to help tie water conservation to business results.

e. Get employees involved.
    - Establish incentive programs to encourage and reward participation. One example could be offering employees a percentage of the first year's direct savings resulting from water and energy conservation;
    - Create a "Water Conservation Ideas" box where employees can submit suggestions on how the organization can save water;
    - Promote slogan and poster contests;

- Create friendly team competition between shifts, operating areas, divisions, and/or locations;
- Reward employees with a pizza party or similar celebration when water conservation plan goals are met; and
- Reward employees who spot leaks and other instances of water waste.

f. Implement effective new ideas submitted by employees. Recognize and reward the contributions made by individual employees, groups, and the organization as a whole.

Benefits from implementing this BMP include lower utility costs, energy savings, reduced process costs and an enhanced public image.

Implementation

The industrial water user should follow these steps to implement this BMP:

1) Form a combined management/employee committee and determine which of the Industrial BMPs will be implemented.
2) Incorporate the selected BMPs into a water conservation program using the schedules and scope from the individual BMPs. The program should include a component to involve all employees in implementation of the program as described in Section B.

Schedule

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

1) The employee conservation team should be completed in a timely manner, within approximately three (3) months of implementing this BMP.
2) The water conservation program should be implemented based on the timelines of the individual Industrial BMPs adopted and in the normal business cycle.

Scope

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

1) Organizations with one facility, or several facilities with the same or very similar industrial processes, should organize a management/employee conservation committee and implement the program following the schedule outlined in Section D.
2) For organizations with multiple facility sites, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have established employee conservation teams and implemented the water conservation program developed by the team.

3) Organizations with multiple facilities should consider organizing conservation teams to include representatives from all facilities where the tasks are similar and where such cross-facility teams are feasible.

Documentation

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

1) List of members of employee conservation team and team minutes;
2) List of actions taken to educate all employees about the importance of water conservation and involve them in implementing the program;
3) Copy of the water conservation program;
4) Documentation of actual implementation of each item contained in the water conservation program; and
5) Estimated water savings and actual water savings for each item implemented and associated cost savings if appropriate.

Determination of Water Savings

The industrial water user should calculate water savings based on the calculation methodology appropriate to the identified water efficiency opportunities.

Cost-Effectiveness Considerations

It may be difficult to determine direct water savings and cost effectiveness of this BMP on its own. Costs that should be considered in this BMP include labor and staff costs, materials, and overhead. By implementing an employee water conservation program, the industrial water user will improve the efficiency of its overall water conservation efforts, ensure the success of other BMP efforts it may choose to undertake, enhance its public image, and increase employee goodwill. Some employee suggestions resulting from the program could be implemented with minimal cost impact. For suggestions with significant cost impacts, each industry should utilize its own criteria for making capital improvement decisions.

References for Additional Information

1) *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
2) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
3) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.
4) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003.

http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

5) *Commercial and Institutional End Uses of Water*, AWWA Research Foundation, Summer 2000.

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

4.2 Industrial Alternative Sources and Reuse of Process Water

Applicability

This BMP is intended for industrial water users that have the opportunity to reuse process water or other sources of nonpotable water such as treated effluent, rainwater collected on site, condensate, graywater, storm water, sump pump discharge or saline sources as a substitute for potable or raw water.

Once an industrial water user decides to adopt this BMP, the water user should follow the BMP process closely in order to achieve the maximum water efficiency benefit from this BMP.

Description

Replacing potable water use with an alternative water supply is an effective way to improve water use efficiency. The industrial water user should survey all water uses on site and determine if process water or other sources of nonpotable water such as treated effluent, rainwater collected on site, condensate from cooling, graywater, storm water, sump pump discharge or saline sources could be substituted for potable water uses. A feasibility analysis should be conducted to determine the cost-effectiveness of conversion to each potential alternative source of reuse water. Benefits from implementation of this BMP may include lower utility costs, energy savings, and reduced process costs. Water quality necessary for the intended end use should be understood as well as the engineering technology necessary for treatment of reuse water prior to use.

For an industrial water user within close proximity of a utility reclaimed water line, purchase of treated effluent or reuse water may also be an option for completing this BMP.

Implementation

To determine if the potential exists for using nonpotable water as an alternative source the industrial water user should conduct a facility survey and feasibility analysis generally following the guidelines outlined below. References that provide more detailed information are listed in Section I below.

1) <u>Preparation and information gathering</u>

Types of information that should be collected before beginning the survey include water use and water quality data for the past three years including utility records of water used and wastewater generated, actual water use on site including submetered use, and existing non-utility water use such as wells or storm water.

Any alternative sources that may be available such as municipal effluent, effluent from other industrial water users in the area, high quality process water that is being discharged, or brackish groundwater and storm water should be identified. Chapter 210 Reclaimed Water Rules of the Texas Commission on Environmental Quality should be reviewed. TCEQ authorization is required when industrial reclaimed water is received from or sent to others, but these rules may not apply if the reuse system is internal to the facility and not discharging to surface waters. This information is necessary for completing the facility alternative water use report as described below in C.3.

2) Conduct facility survey

The water use survey should include identification and verification of all equipment and processes that use water and the required water quality and quantity for the equipment or process. Water quality should be measured so that the water quality of a process discharge can be matched with the water quality of a process or equipment need. It should be noted whether the equipment or process consumes water or is a nonconsumptive use. All sources of water that could be potentially be reused such as process rinse water, water used for equipment cooling, rainwater, etc., should be catalogued for water quality and water quantity. If reclaimed water is available from the local utility, another plant, or from another source such as seawater or brackish water, the cost to bring alternative water to the facility should be determined and included in the facility alternative water use report described next.

3) Prepare a facility alternative water use report

After the survey data is collected, the alternative water use report should analyze the reliability of the alternative supply and the equipment and processes that have been identified that could use an alternative source of water. The cost of piping, storage and any additional treatment that would be required for the alternative source of water should be calculated. When poorer quality source water is substituted, careful evaluation of effluent water quality is important to ensure that water quality discharge constraints are met.

4) Prepare a cost-effectiveness analysis

The cost-effectiveness analysis should determine if each alternative source of water can replace water used from other sources and should be based on equipment costs and any treatment that might be required. Additional guidance is provided in Chapter 3.15.

5) Prepare an action plan

The facility evaluation action plan should contain the alternative reuse project proposals and a timetable for implementation.

Schedule

1) The survey, alternative water use report and cost-effectiveness analysis should be completed in a timely manner. Very large or complex surveys, reports and analyses should be completed within the first twelve (12) months of initiating this BMP.
2) The action plan should be implemented in the normal business cycle. For very large or complex facilities, the action plan should be implemented within twelve (12) months immediately following the completion of the cost-effectiveness report in order that the maximum water efficiency

benefit can be achieved in a reasonable time frame. Major projects may take additional time for implementation.

3) If determined to be necessary for very large or complex facilities, the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP:

1) Organizations with one facility, or several facilities with the same or very similar industrial processes, should conduct a facility survey following the schedule outlined in Section D.
2) For organizations with multiple facility sites, or multiple industrial processes, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been surveyed and alternative water sources implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) The facility survey report;
2) Cost-effectiveness analysis;
3) The action plan;
4) Schedule for implementing the action plan;
5) Documentation of actual implementation of alternative water sources contained in the action plan; and
6) Estimated potable water savings and actual potable water savings for alternative water source implemented.

Determination of Water Savings

The industrial water user should calculate potable and/or raw water savings based on metering of the alternative water sources implemented. Water savings estimates can be calculated based upon the percentage of water estimated to be replaced by reuse water:

$S = R \times Wp$

Where S = Savings in Acre-feet/year

Wp = water use prior to implementing BMP for specific processes targeted for reuse water, and

R = percentage efficiency of reuse system.

An industrial water user interested in implementing this BMP can get reasonable estimates of potential reuse efficiencies from manufacturers' estimates, comparisons with similar facilities, or the list of references in Section H of this BMP.

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade, utilizing its own criteria for making capital improvement decisions. A cost effective analysis under this BMP should consider not only the capital costs of any equipment or process changes and improvements, but also the one-time costs of the reuse opportunity survey and feasibility study, any water quality sampling and testing, and regulatory costs. Additional ongoing costs may include staff and labor, chemical and treatment costs, additional costs or savings in energy use, and potential savings in wastewater treatment costs.

References for Additional Information

1) *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
2) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
3) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.
4) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf
5) *Texas Guide to Rainwater Harvesting,* Texas Water Development Board, 1997. http://www.twdb.state.tx.us/assistance/conservation/Cons-image/Downloads/RainHarv.pdf NOTE: To be updated Fall 2004.
6) *Commercial and Institutional End Uses of Water*, AWWA Research Foundation, Summer 2000.
7) *TCEQ Chapter 210 Rules on Reclaimed Water.* http://www.tnrcc.state.tx.us/oprd/rules/pdflib/210a.pdf
8) *TCEQ Application to Use Industrial Reclaimed Water.* http://www.tnrcc.state.tx.us/permitting/forms/20094.pdf

4.3 Industrial Sub metering

Applicability

This BMP is intended for industrial water users that do not already have submeters on all significant water uses. Submeters are an effective method to account for all water usage within a facility in order to determine the amount of water used in specific processes and lost to leakage and to identify water efficiency opportunities. Before deciding to adopt this BMP, the applicant may want to determine the relative flow volumes to be measured by using estimation methods to determine the potential cost-effectiveness of installing a particular submeter.

Description

Submeters are an effective method for measuring all major water uses including but not limited to each process, subprocess or piece of equipment using water. Other methods of flow measurement that may be effective are engineering estimates, heat balance, installing a temporary meter, volumetric measurement and other intuitive methods. Meters should be installed permanently where the meters should be regularly read and the data used for water management purposes. Information from submetering can improve the effectiveness of leak detection methods and equipment inspections.

In addition to process equipment, submeters provide reliable water use data for cooling towers, boilers, rinsing or cleaning equipment, fountains, and irrigation systems. For new facilities or when cost-effective for existing facilities, sanitary uses should be submetered so that leaks and malfunctioning equipment can be identified and promptly repaired. Proper sizing of submeters is an important consideration. Many industrial facilities require large meters that do not accurately measure water usage during low-flow periods. In order to have more accurate accounting for low flow rates in a high water use system, the water user should determine the feasibility of installing compound water meters or similar technology so that periods of low flow are accurately metered. Compound water meters have two water meters, one for high flow rates and the other for low flow rates. Cooling systems that use evaporation ponds should calculate a potential water balance on the system to determine the value of using submeters for determining evaporation and other losses. Submetering data can be used to identify water use patterns and variability within a facility and relative consumptive and non-consumptive uses of water. As water efficiency measures are implemented, the user can monitor the impact and resulting water savings. For industrial water users who discharge to sanitary sewer systems, submetering data can often be provided to the utility to reduce sewer fees by documenting evaporation losses on the cooling tower and other processes and equipment that consumes or evaporates water.

Implementation

Generally following the guidelines as outlined below, the industrial water user should conduct a facility survey and cost-effectiveness analysis.

1) Conduct a facility survey: Conduct a survey of the facility to identify all major water use areas and locate all existing submeters (if any) for the major water use areas. Determine sizing and locations for submeters for major water use areas that are not currently submetered.
2) Complete a cost-effectiveness analysis for installation of submeters: Determine if installing the submeters is cost-effective by estimating the cost of installing submeters compared to the value of water conserved using appropriate benchmarks. For example, determine if it would be cost-effective if submeters resulted in a 10 percent, 20 percent, 30 percent, etc. savings. Amortize the cost of installing submeters over the life of the equipment or other appropriate time period.
3) Complete and implement an action plan: The action plan should include a timetable to install submeters as well as a plan to use the data from the installed submeters to do a comparative analysis of all major water use areas and determine the cost-effectiveness of switching to a more efficient process, changing to more efficient equipment, and/or reducing water lost or wasted.
4) Update internal audit as necessary.

Schedule

1) The facility survey and cost-effectiveness survey should be completed in a timely manner. Surveys of very large or complex facilities should be completed within the first twelve (12) months of implementing this BMP. This is considered a reasonable time period to complete the survey.
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 should 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) If determined to be necessary for very large or complex facilities the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP:

1) An industrial user should conduct surveys for each of its facilities following the schedule outlined in Section D.
2) For industrial water users with multiple facilities, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until submeters have been installed in all facilities.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or more of the facilities.

Documentation

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

1) The facility survey report;
2) The cost-effectiveness analysis;
3) The action plan;
4) Schedule for implementing the action plan;
5) Schedule of actual installation of submeters in the action plan; and
6) Estimated potential water savings for each major water use area for each submeter installed.

Determination of Water Savings

Industrial water users should use the installed submeters to determine a baseline level of water use for each major water use area. The water use should be linked to a performance measure, production level, production curve or other output. For facilities with a significant seasonal demand, it may take a longer period of time to determine baseline use. Use the data collected to determine the cost-effectiveness of equipment and process changes in the other Industrial BMPs. Regular record keeping and analysis of submetering data can also help identify the occurrence and quantity of water saved from early repair of unobserved leaks.

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade, utilizing its own criteria for making capital improvement decisions. Both the capital costs of installation of identified meters and the ongoing expenses for reading and maintaining the meters should be considered. In some cases, meters installed within an industrial site may be considered as part of implementation of other specific BMPs. Costs for meters generally range from $50 to $100 for those with smaller flow rates to several thousand for larger compound meters. Meters can be retrofitted for automatic or remote reading capability for a moderate additional expense which can be compared to savings in reading and data collection costs. Water meters have a typical design life of 10 to 15 years.

References for Additional Information

Resources that can assist an industrial water user in implementing this BMP:

1) *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
2) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.

4.4 Industrial Water Waste Reduction

Applicability

This BMP is intended for industrial water users that could increase water use efficiency at facilities by prohibiting specific wasteful activities such as wasteful irrigation practices and scheduling, single-pass cooling, non-recycling decorative fountains, discharge of process water and use of inefficient water softeners. In addition, if the facility has a substantial amount of unaccounted-for water, a leakage survey may need to be conducted. Once an industrial water user decides to adopt this BMP, the water user should follow the BMP process closely in order to achieve the maximum water efficiency benefit from this BMP.

Description

A comprehensive program to reduce water waste is an effective method of improving water use efficiency. Benefits from implementing this BMP include lower utility costs, energy savings, reduced process costs and an enhanced public image. If the Water Audit BMP has been completed, some of the information needed for this BMP will already be available.

The industrial water user should first conduct a pre-survey, which is a walk-through of the facility to find out if there are any obvious wasteful activities taking place. Then a facility survey should be conducted and the following questions should be addressed:

1) How much water is being used?
2) Where is the water being used?
3) When and for how long is water being used?
4) How is water being used?
5) Who is using water?
6) Why is water being used?
7) Do we need to be using water at all?
8) Can the water quality of a process discharge be matched with the water quality of another process or equipment need?

In addition, depending on the type of facility being surveyed, water wasting practices should be identified, including, but not limited to, water waste in single pass cooling systems or equipment; non-recirculating systems in all new conveyer or inbay automatic vehicle wash and commercial laundry systems; non-recycling decorative water fountains; discharge of process water that could potentially be reused within the facility for another process use or for irrigation; and use of inefficient water softeners. Other water waste practices may include wash and rinse processes which run for longer time periods or at greater flow rates than needed or processes in which water is used as a conveyance.

Irrigation use can also be a source of water waste. Water waste during irrigation includes water running down the gutter; irrigation heads or sprinklers spraying directly on paved surfaces such as streets, parking lots, and driveways; operating an automatic irrigation system without a functioning rain shut off device; operating an irrigation system that has misting heads due to broken heads or failure to install pressure reduction device; irrigating between 10 a.m. and 6 p.m. during seasons with high evapotranspiration; and irrigating more than required by actual or reference evapotranspiration.

Proper controls can limit water use to the minimum necessary in many facility processes. Limiting or eliminating the use of water in facility wash down operations is also another potential means to reduce water waste. Significant water savings can also be achieved through a proactive and frequent facility leak detection and repair program that addresses all facility pipes, valves, plumbing fixtures, and process equipment.

Implementation

The industrial water user should conduct a facility water use survey. References that provide more detailed audit procedures are listed in Section I below.

1) Conduct a facility water use survey of all equipment, processes and practices to determine all places where there could be wasting water, use of water inefficiently or possible sources of water lost to leakage. Next, possible remedial actions should be ranked, in ascending order of efficiency value. These include
a. Adjust equipment or process to use less water,
b. Modify equipment or install water saving devices,
c. Replace with more efficient equipment,
d. Recycle water within the process or plant by matching the water quality of a process discharge with the water quality of a process or equipment need, and
e. Change to waterless equipment or process.
2) Preparation of a report that details the results of the facility water use survey with calculations and costs of replacing water wasting equipment, processes and practices. For some practice changes, such as irrigation scheduling, the actual costs may be minimal.
3) Prepare a cost-effectiveness analysis for each type of equipment and each process or practice change. The cost-effectiveness analysis determines water efficiency opportunities that are cost-effective to implement. The analysis may also identify water efficiency opportunities that should be implemented even if not cost-effective due to high visibility, ease of implementation, or general employee and customer and community goodwill. After analyzing the cost-effectiveness of each potential action to eliminate a water wasting practice, the industrial water user should proceed to develop an Action Plan.
4) Prepare an Action Plan: The action plan contains proposals and a timetable to implement the selected equipment, processes and practices.

Schedule

1) The facility water use survey, report, cost-effectiveness analysis and action plan should be completed in a timely manner. Very large or complex facilities should complete the facility water use survey, report, cost-effectiveness analysis and action plan within the first twelve (12) months of beginning this BMP.
2) The action plan should be implemented in the normal business cycle. Major projects may take additional time for implementation.
3) If determined to be necessary for very large or complex facilities, the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP:

1) Organizations with one facility, or several facilities with the same or very similar industrial processes, should conduct a facility survey following the schedule outlined in Section D.
2) For organizations with multiple facility sites, or multiple industrial processes, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been surveyed and wasteful equipment, process and practices changed.

Documentation

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

1) The facility survey report;
2) Cost-effectiveness analysis;
3) The action plan;
4) Schedule for implementing the action plan;
5) Documentation of actual implementation of items contained in the action plan; and
6) Estimated water savings and actual water savings for each item implemented.

Determination of Water Savings

The industrial water user should calculate water savings based on the calculation methodology appropriate to the identified water efficiency opportunities.

Cost-effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade, utilizing its own criteria for making capital improvement decisions. Obvious water wasting practices should be corrected as soon as possible without a cost-effectiveness analysis. The water waste reduction survey and report may be conducted and prepared by either the industrial water user's own staff or by specialized outside consultants. There may be additional one-time costs for equipment such as flow meters or leak detection equipment.

References for Additional Information

1) *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
2) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
3) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.
4) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf
5) *Commercial and Institutional End Uses of Water*, AWWA Research Foundation, Summer 2000.

4.5 Refrigeration

Applicability

This BMP is intended for any water user which utilizes water as a primary refrigerant fluid to remove heat. Water conservation practices for cooling towers that use evaporation of water to remove the heat at the “condenser” where the refrigerant is changed from high temperature to a lower temperature are described in the Cooling Towers BMP. Additionally, the Cooling Systems (other than Cooling Towers) BMP covers processes that use a circulating flow of water at ambient temperatures as a coolant medium to convey heat away from machinery or a process. Examples of refrigeration processes that this BMP is intended for are primarily chilled water facilities that circulate refrigerated water for use in precision cooling of process units or large scale air conditioning systems of buildings or campuses.

Description

Using the latent heat properties of the refrigerant, mechanical refrigeration removes heat from a colder medium and rejects it to a warmer medium. A chilled water system is for all intents a refrigeration system that cools water. Most chillers are used as closed loop systems with the heat removed by air-cooling or through a cooling tower, and water consumption can be reduced. All chilled water systems require a reservoir for the returned fluid to act as a heat sink, but very little water is lost due to evaporation.

The major water use in these systems, other than at the cooling towers, occurs when water is replaced due to leaks or equipment problems. The primary maintenance recommendations for the closed chilled water loop include treatment of the water periodically with rust inhibitor and biocides, use of strainer screens and filters, and regular inspection and maintenance of pipes, valves, and pumps. For larger systems condensate water from the condenser coils can potentially be collected as an alternative to potable water for cooling tower make up or for some other use.

Water is not the only fluid that can be used as a liquid refrigerant. For example, direct cooling of deionized water, hydraulic oil, glycol solutions, and water soluble oils is possible in refrigerated systems.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation on each water-using refrigeration process within a facility to identify areas of improvement for water savings. The evaluation should review amounts of water used, use of automatic controls, repair and maintenance schedules and procedures, and water quality characteristics. Based on the requirements and uses of the system, alternative refrigerants should be considered.

2) Institute a routine schedule of optimal repair and maintenance measures for all equipment, such as using chemical additives to minimize corrosion. Make-up water to all closed loop systems should be metered to assist in evaluation for leaks. Chilled water systems or other refrigeration systems that use cooling towers should be operated following the guidelines of the Cooling Towers BMP.

Schedule

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

1) The facility survey and cost-effectiveness survey should be completed in a timely manner. Surveys of very large or complex facilities should be completed within the first twelve (12) months of implementing this BMP. This is considered a reasonable time period to complete the survey.
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 should 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) Water-using refrigeration equipment should be operated optimally at all times following the guidelines of this BMP.

Scope

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

1) Industrial water users with one or more chilled water or water-using refrigeration systems which are operated with the same or very similar parameters should perform an efficiency evaluation and perform upgrades or replacements as outlined in the schedule of Section D.
2) For industrial water users with multiple systems, or multiple sites that have systems with significantly different operational parameters, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) Operating information on the chilled water systems, including cooling capacity design heat loads, description of the process utilizing the refrigeration system, system requirements for cooling including temperature, volume, and duration of

flows (hr/day). Operating information should also include cooling system metallurgical design information for maximum levels of contaminants that can be tolerated while maintaining an acceptable corrosion rate;
2) Water use records for each refrigeration system that include the frequency and number of gallons of make-up water used;
3) Description of chemical compounds and amounts used for corrosion control; and
4) Description of and amounts used of any alternate refrigerant used or considered.

Determination of Water Savings

Using historical records and manufacturers' data as appropriate, water savings can be estimated.

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or upgrade to refrigeration equipment and operations, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency, such as repair of leaks, should be implemented simply as a matter of good practice. 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.

References for Additional Information

1) There are many chemical vendors, equipment manufacturers, and consultants that specialize in refrigerated systems and chilled water systems. They can be an excellent source of information related to specific refrigeration applications. Many vendors have published literature available to assist an industry in optimizing its cooling water treatment systems.
2) *Process Cooling & Equipment,* magazine published by BNP Media. http//www.process-cooling.com
3) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is an international membership organization founded to advance the arts and sciences of heating, ventilation, air conditioning, refrigeration and related human factors. www.ashrae.org

4.6 Rinsing/Cleaning

Applicability

This BMP is intended for industrial water users that use rinsing or cleaning in processing, production or finishing operations.

Description

Rinsing and cleaning are important operations for a number of industries. Water conservation opportunities arise in improvements in flow rates, pressure, or timing. Many operations can also increase efficiency by recirculating water or by filtering contaminants and reclaiming water for reuse internally.

Specific processes in which this BMP can be implemented will have been identified in the Industrial Water Audit BMP. Each process requires careful evaluation to determine the most economical and efficient measures to implement. Initial cost-effectiveness analysis should begin with the simplest measures including adjusting operating parameters on existing equipment. Often reductions in water pressure, changes in timing or adjustments to nozzles can achieve measurable results in water savings. In container rinsing for reuse or disposal, immediate rinsing before products solidify or gel can reduce the amount of time and water required for cleaning. In multiple rinse processes, reducing the amount of "dragout" or contaminated rinse water carryover from one container to the next can reduce the total amount of water needed for the process.

Equipment upgrades can also be cost-effective, including use of smaller rinse or cleaning sinks and tanks, changes in pumps, nozzles, and pipes, and in the machinery that controls the timing of rinse or cleaning processes. Mechanical mixing, agitating rinse water in tanks, and counterflow rinsing processes have also been shown to improve effectiveness of cleaning and water use.

Reuse of water within a rinse or cleaning process is one of the most effective means of saving water. Sequential rinsing can often make use of spent water from one process in another. Filtering final rinse water for use in cleaning processes is also often done with minimal filtration.

When filtering of water is necessary, the simplest process is often just recirculation of water with dust or other solids removed in settling tanks. More sophisticated filtration may include oil/water separators, centrifugal separation, sand filters, bag filters, or even more sophisticated membrane filtration. In processes where ultra-pure or very high quality water is needed, careful engineering of treatment processes is necessary to ensure removal of organics and other materials which can damage membrane filters.

Adjusting the chemical requirements of the process can also lead to significant water savings. Often solids can be filtered from a cleaning process, leaving some detergents in the filtered water, thus reducing the addition of new cleaning chemicals while reusing the water. Some processes can be adjusted to use higher levels of chemicals in a process, reducing water pressure and flow volumes used to scour a product. In these cases careful evaluation of the effluent water quality is important to ensure that water quality discharge constraints are met.

In facilities that filter rinsing and cleaning water for reuse, the water used to backwash the filter or RO reject water should be considered for use in other processes where lower quality water can be utilized.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation of each rinsing/cleaning process within a facility to identify areas of improvement for water savings. The evaluation should review amounts of water used, use of automatic controls, repair and maintenance schedules and procedures, and water quality characteristics. Where manufacturers' specifications or industry specific information is not available, company engineers or third party contractors should perform an empirical evaluation of existing equipment. Based on the requirements and uses of the system, alternative water supplies should be considered.
2) Water-using rinsing/cleaning processes should be operated in a water efficient manner with consideration for:
    a. Optimal repair and maintenance of rinsing/cleaning equipment and facilities to keep rinsing/cleaning equipment, lines and related equipment in good repair;
    b. Timing of existing equipment, reduction in flow rates by changes in nozzles, changes in sizing of rinse or cleaning tanks, the installation of positive shutoff valves;
    c. Upgrades of apparatus including tanks or sinks, nozzles, valves, pumps, and timing equipment;
    d. Optimal use of chemical additives to minimize water use; and
    e. Use of water quality instrumentation for more accurate determination of when rinsing baths should be replaced or recharged.
3) Within the water user's budget cycle, install or upgrade to the most cost-effective reuse and reclamation equipment system, with highest water efficiency.
4) When cost effective, reuse and reclamation equipment should be operated in a water efficient manner with consideration for:
    a. Optimal repair and maintenance to keep reuse and reclamation equipment, lines and related equipment in good repair; and
    b. Potential use of filter backwash or reject water in other operations.

Schedule

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

1) The efficiency evaluation of the rinsing/cleaning systems should be in a timely manner, generally within three (3) months of beginning this BMP.
2) The opportunities for water savings indicated by the efficiency evaluation should be implemented in a normal business cycle, and it is recommended within twelve (12) months after completion of the evaluation in order that the maximum water efficient benefit can be achieved in a reasonable time frame.
3) Water using rinsing/cleaning equipment should be operated optimally at all times following the guidelines of this BMP.

Scope

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

1) Industrial water users with water-using rinsing/cleaning systems which are operated with the same or very similar parameters should perform an efficiency evaluation and perform upgrades or replacements as outlined in the schedule of Section D;
2) For industrial water users with multiple systems, or multiple sites that have systems with significantly different operational parameters, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented; and
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

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 rinsing/cleaning systems, including capacity design, description of the process the rinsing/cleaning system is used for, system requirements for temperature, volume, and duration of flows (hours/day). Operating information should also include design information for maximum levels of contaminants that can be tolerated while maintaining an acceptable cleaning rate.
2) Water use records for each rinsing/cleaning system that include the frequency and number of gallons of make-up water used;
3) Description of chemical compounds and amounts used to affect water quality; and
4) When applicable, description of reclaim and reuse system and water savings achieved.

Determination of Water Savings

The industrial water user should calculate water savings based on the calculation methodology appropriate to the identified water efficiency opportunities. Estimated overall water savings for implementing rinsing/cleaning efficiencies have been in the range of 10 percent to 15 percent for process adjustments and 50 percent to 85 percent for installing various reclaim systems. Actual water savings should be measured by comparing water use prior to implementation to water use after the measures are implemented.[1]

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement, equipment upgrade, or change to its rinsing/cleaning operations, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency of rinsing/cleaning processes should be implemented simply as a matter of good practice. A cost effectiveness analysis under this BMP should consider capital equipment costs, staff and labor costs, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs.

References for Additional Information

1) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
2) *A Water Conservation Guide for Commercial, Institutional and Industrial Water Users*. New Mexico Office of the State Engineer, July 1999. Available in PDF at http://www.seo.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf
3) *Water Efficiency Guide for Business Managers and Facility Engineers*, Sate of California Department of Water Resources, October 1994.

4.7 Water Treatment

Applicability

This BMP is intended for those industrial water users that use water treatment systems in processing, production or finishing operations. Water treatment is used to produce improved quality water such as softened or ultra-pure water to produce water of a specific quality necessary for a certain production process, to improve water quality for reuse within a facility, or for a second use within a facility. Industrial users who treat water for a rinsing or cleaning process should refer to the Rinsing/Cleaning BMP; users that treat water for cooling tower use should follow the Cooling Towers BMP; and those using boilers to produce steam should consult the Boiler and Steam Systems BMP.

Description

Most major industries and power plants and many commercial operations need water purity higher than that provided by the local municipal water supply. In addition, many industries use raw water directly from lakes, streams, or wells and require additional treatment before use in the process. The focus of this BMP is water efficiency in the provision of additional treatment of water for use within the facilities.

In addition to treatment for boiler feed, rinsing/cleaning processes, and cooling tower water, common examples of water treatment in industries include softening of water to prevent scaling and preparation of ultra-pure water. Specialized water treatment is important in such industries as metal finishing and plating, food and beverage, chemicals, pharmaceuticals, electronics and micro-chip production, and most other process industries requiring especially clean water.

On the commercial and institutional side, examples include soft water for the laundry industry, spot free car wash water for commercial car washes, hospital needs such as kidney dialysis, and high purity water for injection fluids in medical facilities.

Water conservation opportunities arise in increased efficiency through improvements in flow rates, pressure, temperature, chemistry, filtration or timing. Metering both inflow and outflow from the system provides the operator information to determine if the system is meeting design efficiencies. Process control is often an area where increased efficiency can be obtained. Many operations can also increase efficiency by recirculating water or by filtering contaminants and reclaiming water for reuse internally.

Specific processes in which this BMP can be implemented will have been identified in the Industrial Water Audit BMP. Each process requires careful evaluation to determine the most economical and efficient measures to implement. The initial cost-effectiveness analysis should begin with the simplest measures such as adjustment of operating parameters on existing equipment. Often reductions in water pressure, changes in timing, repair of leaks or other adjustments to plumbing can achieve measurable results in water savings.

Equipment upgrades can also be cost-effective, including use of smaller sinks and tanks, changes in pumps, nozzles, pipes, solenoid switches, and instrumentation or machinery that control the timing and volume of rinsing or cleaning processes. Reuse of water within a water treatment process is one of the most effective means of saving water.

When filtering of water is necessary, the simplest process is often just recirculation of water, with dust or other solids removed in settling tanks. Filtration may include oil water separators, centrifugal separation, sand filters, bag filters, or even more sophisticated membrane filtration. In processes where ultra-pure or very high quality water is needed, careful engineering of pre-treatment and treatment processes is necessary to ensure removal of organics and other materials which can damage membrane filters. Flocculation or coagulation can help prevent fouling of membranes.

Careful balancing of cost-effectiveness considerations should be considered when choosing between reverse osmosis ("RO"), nanofiltration, electrodialysis, ultrafiltration, microfiltration or other treatment processes. Issues such as membrane fouling, multiphase processes, organic and inorganic constituents in the feed stream, pressure levels, and discharge levels should all be considered. Careful evaluation of filter media should take into account the relative efficiency of the process in terms of the ratio of filter backwash to through-put and reject water to product water.

Adjusting the chemical requirements of the process can also lead to significant water savings. Coagulation should be optimized by adjustments to pH, coagulant type, and feed rate to achieve the most effective removal of turbidity, particulates, precursors and/or disinfection byproducts. Some processes can be adjusted to use higher levels of chemicals in a process, reducing water pressure and flow volumes used to scour a product. Corrosion control is another area where proper water treatment process selection can result in greater water use efficiency.

Where treated water is used for potable purposes, all applicable Texas Commission on Environmental Quality ("TCEQ") rules and regulations for design and operation of public drinking water systems must be followed. Although the underlying mission is to protect the public health, the TCEQ has the Texas Optimization Program ("TOP"), a voluntary, non-regulatory program designed to dramatically improve the performance of existing surface water treatment plants without major capital improvements.

Additionally, discharged effluent water quality must meet all TCEQ water quality discharge constraints. Instead of discharge, in facilities that use filters for treatment processes, filter backwash water or RO reject water should be considered for use in other processes where lower quality water can be utilized. (*See* the Industrial Alternative Sources and Reuse of Process Water BMP)

The level and type of treatment are dependent on the purity of water required and the end use needs, but reuse opportunities for the waste streams generated by treatment should be evaluated. Other than cartridge type filtration, almost all treatment processes produce both a product water and waste stream.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation on each water treatment process within a facility to identify areas of improvement for water savings. The evaluation should review amounts of water treated and produced, amounts and types of chemicals used, use of automatic controls, repair and maintenance schedules and procedures, and water quality characteristics. The efficiency evaluation should review the end use needs of the specific processes for which the treated water is used. Where manufacturers' specifications or industry specific information is not available, company engineers or third party contractors should perform an empirical evaluation of existing equipment.
2) Water treatment processes should be operated in a water efficient manner with consideration for:
   a. Optimal repair and maintenance of water treatment equipment and facilities to keep water treatment equipment, lines and related equipment in good repair.
   b. Timing of existing equipment, reduction in flow rates by changes in nozzles, changes in sizing of filters or holding tanks.
   c. Use of proper filters and settings for water quality necessary for end-use, including optimal timing of and amount of backwash water.
   d. Use of reject or backwash streams in other uses, where water quality is appropriate.
   e. Upgrades of apparatus including tanks or sinks, nozzles, valves, pumps, and control equipment.
   f. Optimal use of chemical additives to minimize water use.
   g. Use of water quality instrumentation to control when to recharge or regenerate the water treatment process.
3) Water softening processes should be operated in a water efficient manner with consideration for:
   a. Optimal repair and maintenance of water softening equipment and facilities to keep water treatment equipment, lines and related equipment in good repair.
   b. Timing for efficient use of existing equipment for optimal flow rates.
   c. Full knowledge of the chemistry of the water to be softened as well as the application uses of the softened water (laundry, boiler feed, process water, condensate polishing, etc.).

d. Optimum design for maximum water use efficiency, minimum pressure drop, minimum regeneration waste water discharge and lowest capital cost.

4) When cost-effective, reuse and reclamation equipment should be installed or upgraded.

a. Optimal repair and maintenance of reclaim equipment and facilities to keep rinsing/cleaning equipment, lines and related equipment in good repair.

b. Install most cost-effective system, with highest water efficiency.

c. Consider potential use of filter backwash or reject water in other operations.

5) Based on the requirements and uses of the system, alternative water supplies should be considered.

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 on site water treatment systems in a timely manner. Most site evaluations should be completed within three (3) months of beginning this BMP.
2) The industrial water user should implement the opportunities for water savings identified in the efficiency evaluation during the normal business cycle or within twelve (12) months after completion so that maximum water efficiency benefits can be achieved in a reasonable time frame.
3) Water treatment equipment should be operated optimally at all times following the guidelines of this BMP.

Scope

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

1) Industrial water users with one or more water treatment systems operated with the same or very similar parameters should perform an efficiency evaluation and perform upgrades as outlined in the schedule of Section D.
2) For industrial water users with multiple systems, or multiple sites that have systems with significantly different operational parameters, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) Operating and design information on all on site water treatment systems, including capacity design, descriptions of the end use processes the water from the treatment system is used for, system requirements for temperature, volume, and duration of flows (hr/day). Operating information should also include design information for maximum levels of contaminants that can be tolerated while maintaining an acceptable water quality rate.
2) Water use records for each treatment system that include the volume of water treated and produced.
3) Description of chemical compounds and amounts used to improve water quality and the costs of chemical treatment before and after efficiency measures are implemented.
4) When applicable, description of reclaim and reuse system and water savings achieved.

Determination of Water Savings

The industrial water user should calculate water savings based on the calculation methodology appropriate to the identified water efficiency opportunities. For example, estimated overall water savings for implementing water treatment efficiencies have been in the range of 10 percent to 15 percent for process adjustments and 50 percent to 85 percent for installing some reclaim systems. Actual water savings should be measured by comparing water use prior to water use after the measures are installed.[1]

Cost-effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade to its water treatment processes, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency should be implemented simply as a matter of good practice. A cost effectiveness analysis under this BMP should consider capital equipment costs, increased staff and labor costs, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs.

References for Additional Information

1) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
2) *A Water Conservation Guide for Commercial, Institutional and Industrial Water Users*. New Mexico Office of the State Engineer, July 1999. Available in PDF at http://www.seo.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf
3) Water Efficiency Guide for Business Managers and Facility Engineers, State of California Department of Water Resources, October 1994.

4) *Rules and Regulations for Public Water Systems* (30 TAC Chapter 290, Subchapter D), Texas Commission on Environmental Quality.

5.1 Cooling Systems

Applicability

This BMP is intended for industrial water users that use circulated water to convey heat generated from industrial equipment and mechanical devices such as heat exchangers, condensers, process machinery, tools, air conditioning systems, appliances, vacuum pumps, x-ray or similar medical and dental equipment, welding machines, icemakers, and aircompressors. This BMP is not targeted to larger, once-through cooling systems on bodies of water such as lakes and bays that use and may recirculate water from within the same or adjacent water bodies or large once-through cooling systems that typically consume water by forced evaporation only.

Description

Cooling involves the removal of process energy in the form of heat. This BMP centers on the practices for optimizing the water-use efficiency of cooling systems other than large-scale evaporative cooling towers or large systems that typically consume water through forced evaporation (*See* Cooling Towers BMP). Water-cooling systems using single-pass water in a variety of industrial applications can use large amounts of water.

The single most significant opportunity for water reduction comes from eliminating or limiting the use of single-pass cooling systems. The use of single-pass cooling systems is prohibited by ordinance or legislation in numerous municipalities and states. Options for replacement of single-pass water cooling include the use of air cooling, the use of non-aqueous fluids and the use of recirculating and recycling water systems. If single-pass cooling cannot be eliminated, then opportunities should be explored for reuse of the cooling water for other on-site purposes.

Implementation

After identification of water-cooled equipment, implementation should consist of the following actions:

1) Performance of a water efficiency evaluation on each water-cooled system or process to identify areas or opportunities for reduction of water use. Information gathered should include types of equipment and processes, estimated or measured water use, water quality requirements, heat load and identification of opportunities to optimize the removal of heat within the process.
2) Replacement or upgrades of water-cooled systems with equipment that uses closed loop recirculating equipment.
3) Replacement or upgrades of water-cooled systems with equipment using alternative cooling modes such as air-cooling or non-aqueous systems.

4) Elimination of single-pass water cooling in facilities which have small evaporative coolers, sometimes known as “swamp coolers.” Swamp coolers are only effective in areas of low relative humidity and need recirculating systems in order to operate efficiently. Operating efficiency of recirculating evaporative coolers should be optimized by regular replacement of pads and maintenance of equipment.
5) When practical, installation of individual meters on all water-cooled systems and daily monitoring of use.
6) An evaluation of and use, if possible, of alternative sources of cooling water such as condensate, saline water, reclaimed water, harvested rainwater, graywater, or water used in other onsite processes.
7) Evaluation of opportunities for reuse of the cooling water for other processes on site.
8) Operation of the water-cooled processes and equipment in an efficient manner at all times and keeping equipment in optimal operating condition. This includes maximization of external air-cooling opportunities and optimization of heat exchange equipment.
9) Use of solenoid valves or other methods for shutting down of systems when not in use.

Schedule

The industrial water user should identify and complete an efficiency evaluation of water-cooled systems in a timely manner. Evaluations of very large or complex systems should be completed within six (6) months of beginning this BMP.

1) The industrial water user should eliminate or upgrade all single-pass cooling systems within a normal budget cycle to implement the BMP in order to achieve the maximum water efficiency benefit in a reasonable time frame.
2) If determined to be necessary for very large or complex facilities, the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

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

1) Industrial water users with one facility, or several facilities with the same or very similar industrial processes, should perform an efficiency evaluation and perform upgrades or replacements as outlined in Section D.
2) For industrial water users with multiple facility sites or multiple industrial processes, a progressive implementation schedule should be followed,

implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.

3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) List of water-cooled devices or systems and description of the process the cooling is used for, type of cooling process, water use stream, and heat load;
2) System requirements for cooling including temperature, volume, heat load and duration of flows (hours/day);
3) Where meters exist, the daily water use records for each system as appropriate for make-up water, discharge, and flow through the system;
4) Written details and records of all facility replacements, modifications, and upgrades of cooling systems made to meet the requirements of this BMP; and
5) Details of alternate water sources or water reuse opportunities considered.

Determination of Water Savings

Based on historical records, manufacturers' performance data, or observations and measurements, calculated water savings due to implemented changes in operating procedures or equipment replacements and upgrades can be estimated. For example, it is estimated that retrofitting of single-pass cooling equipment such as x-rays to recirculating water systems can cut water use by 90 percent (*See* Section I. References for Additional Information, 4).

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade to its cooling systems operations, utilizing its own criteria for making capital improvement decisions. A cost effectiveness analysis under this BMP should consider capital equipment costs, changes in staff and labor costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs. Many operating procedures and controls that improve the water use efficiency should be implemented simply as a matter of good practice.

References for Additional Information

1) *Process Cooling & Equipment*, monthly magazine published by BNP Media focuses specifically on cooling equipment, materials and supplies used during the manufacturing process. http//www.process-cooling.com

2) *Commercial and Institutional End Use of Water*, published by AWWA Research Foundation and American Water Works Association, 2000 (ISBN 1-58321-035-0).
3) *Handbook of Water Use and Conservation*, Amy Vickers, Waterplow Press, May 2001.
4) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.
5) *Waste Not, Want Not: The Potential for Urban Water Conservation in California (Appendix D),* Pacific Institute, November 2003. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

5.2 Cooling Towers

Applicability

This BMP is intended for any water user which employs cooling towers to remove heat by the evaporation of water. Cooling towers are used extensively from relatively small facilities such as office buildings, schools, and supermarkets to large facilities such as hospitals, electric power generation plants, and manufacturing and industrial plants.

Description

Cooling towers can be among the largest water using systems in industrial and commercial settings. A cooling tower uses evaporation to lower the temperature of water that conveys heat from mechanical equipment such as air conditioning systems, heat exchangers, condensers, or process machinery. Although recirculated within the system, water is lost due to evaporation, "blowdown", and drift or other losses. Water is added through "make-up water." This BMP centers on the practices for water-use efficiency of cooling towers by optimizing the water quality and the amount of blowdown.

Four general types of measures can reduce the amounts of water used in cooling towers: improved system monitoring and operation, optimal contaminant removal from cooling water, use of alternative sources for make-up water, and reducing heat load to evaporative cooling by either good energy management or by combining air and water cooling.

As water evaporates, the concentrations of dissolved solids become greater, affecting the operation and integrity of the facility. The most significant opportunity for water savings in cooling tower operation is by reducing the amount of highly concentrated water removed from the system as blowdown. One measure of water-use efficiency in a cooling tower is the concentration ratio, also known as cycles of concentration, which indicates the number of times water is used before being released as blowdown. There have been significant recent advances in both chemical treatment and monitoring technology which allow the concentration ratios in cooling towers to be increased, thus minimizing the amount of required make-up water needed to replace blowdown.

Other operating efficiency techniques may include careful use of acid or other pH lowering agents to reduce scale formation, sidestream filtration to filter out sediment and suspended particles that may clog lines, prevention of biogrowth by use of biocides and limiting exposure to sunlight, and use of ozonation to reduce chemical use. The entire heat transfer process should be kept in good order including, as applicable, coils, fans, condensers, and feed equipment.

Optimum concentration ratios for operation are highly dependent on the quality of the make-up water used, which can vary significantly from region to region. For evaporative cooling towers that use potable quality water, the minimum cycles of concentration should be at least four (4). With the modern water treatment chemical and monitoring technology available today, the potential exists for systems to be operated continuously at six (6) to eight (8) cycles or even greater, contingent upon system metallurgy and allowable corrosion rates. In cases where reuse and other non-potable sources are used for cooling tower water, a lower goal for cycles of concentration may be used since these non-potable sources typically have higher TDS or hardness than potable water. However, using reuse water or alternative sources is encouraged in that it reduces potable water use.

Implementation

Implementation of this BMP should consist of the following actions:

1) Perform a water efficiency evaluation on each cooling tower system within a facility to identify areas of improvement for water savings and optimization of heat loads. The evaluation should review all aspects of cooling tower operations including heat load requirements, sources and amounts of water used for make up and released as blow-down, 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) Cooling towers should be operated in a water efficient manner with consideration for:
    a. Calculation of and monitoring of cycles of concentration in order to optimize the blow-down rate;
    b. Optimal use of chemical additives and automatic blow-down techniques to optimize the cycles of concentration based on water quality. Use of contractors and vendors that specialize in cooling tower operations efficiency should be considered;
    c. Installation of meters to measure both make-up and blow-down water and daily monitoring of use;
    d. Location of blow-down points away from make-up supply and preferably in dead spots that have a minimal amount of circulation;
    e. Appropriate use of automated control procedures such as continuous blow-down, conductivity metering to control blow-down, pH monitoring, corrosion monitoring and automatic shutdown when the system is not use;
    f. Recovery for reuse of water that passes through cooling water instrumentation;
    g. Use of shielding or other equipment to minimize drift;
    h. Use of cooling water sequentially to cool a number of processes prior to being returned to the cooling tower;
    i. Evaluation of and utilization of alternative sources of water such as saline water, reclaimed water, harvested rainwater, gray water, or water used in other on-site processes; and
    j. Evaluation of the opportunities for reuse of the blow-down water for other processes on site. In many cases the reuse of cooling tower blow-down may require additional treatment of the water by processes such as lime softening

or reverse osmosis. Exceptions to that general rule would apply to waters used for dust suppression or plant wash down.

Schedule

1) The industrial water user should complete the efficiency evaluation of the cooling towers in a timely manner. Very large or complex evaluations should be completed within six (6) months of initiating this BMP.
2) The industrial water user should implement the opportunities for water savings from the efficiency evaluation within the normal budget cycle after completion of the efficiency evaluation in order that the maximum water efficient benefit can be achieved in a reasonable time frame. Water saving measures for very large or complex systems should be implemented within twelve (12) months of completing the evaluation.
3) If determined to be necessary for very large or complex facilities the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

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

1) Industrial water users with one cooling tower, or several towers which are operated with the same or very similar parameters, should perform an efficiency evaluation and perform upgrades or replacements as outlined in the schedule of Section D.
2) For industrial water users with multiple cooling towers, or multiple sites with cooling towers that have significantly different operational parameters, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) Operating information on the cooling towers, including cooling capacity design heat loads for each tower, description of the process the cooling tower is used for, system requirements for cooling including temperature, volume, and duration of flows (hours/day). Operating information should also include cooling system metallurgical design information for maximum levels of contaminants that can be tolerated while maintaining an acceptable corrosion rate.

2) Water use records for each tower that include the number of gallons of blow-down and the number of gallons of make-up water used daily.
3) Number of cycles of concentration and calculation data.
4) Descriptions, operating manuals and procedures of any automatic controls used such as automatic meters and conductivity or pH sensors used to control blowdown.
5) Description of chemical compounds and amounts used to improve water quality for efficient cooling tower use to maximize cycles of concentration and optimize make-up requirements. Consideration must be given to system corrosion rates and scale forming potential.
6) Description of and amounts used of any alternate water source or system used or considered for composing make-up water, including an evaluation of both beneficial and detrimental effects.

Determination of Water Savings

Using historical records and manufacturers' data as appropriate, water savings due to increased concentration ratio and other implemented operating procedures can be calculated.

The concentration ratio (CR) is determined from the dissolved solids (or alternatively the conductivities) in the make-up water (CM) and blow-down water (CB):
CR = CB / CM
The percent of water expected to be conserved = (CR2 – CR1) / (CR2 x (CR1 – 1)

Where CR1 is concentration ratio before and CR2 is concentration ratio after increasing cycles. Source: Handbook of Water Use and Conservation (Vickers, 2001).

The chart below gives a graphic representation of water use at different cycles of concentration.

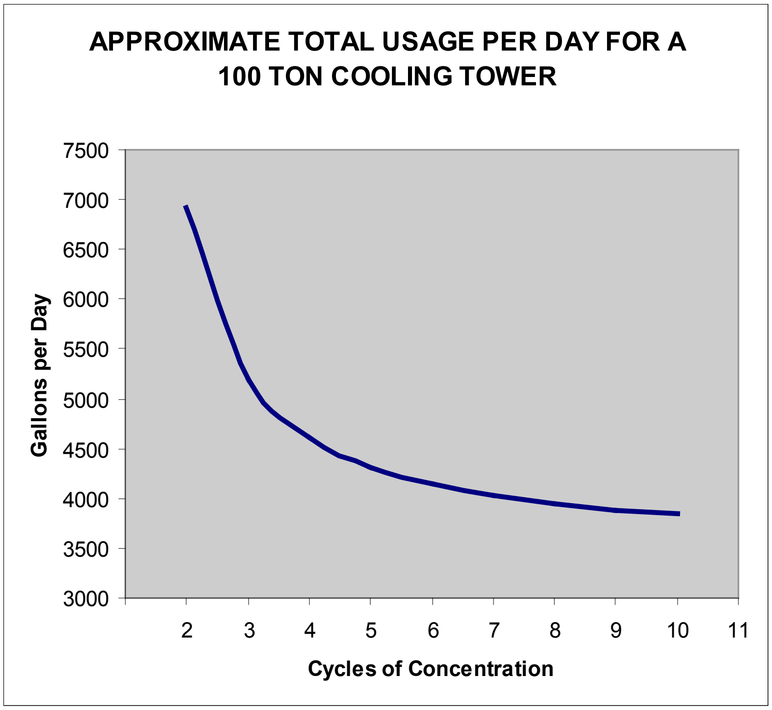

Figure 3.1 Cooling Tower Water User versus Cycles of Concentration

Cost-Effectiveness Considerations

A cost effectiveness analysis under this BMP should consider capital equipment costs, changes in staff and labor costs, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs. Many industries regularly use outside specialized consultants with 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.

The industrial water user should determine the cost effectiveness to implement each identified equipment replacement, upgrade, or change to its cooling tower operations, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency of cooling towers should be implemented simply as a matter of good practice.

References for Additional Information

There are many chemical vendors, equipment manufacturers, and consultants that specialize in industrial cooling towers. They can be an excellent source of information related to specific cooling tower applications. Many vendors have published literature available to assist an industry in optimizing its cooling water treatment systems.

1) Cooling Technology Institute, P. O. Box 73383, Houston, TX 77273 http://www.cti.org. The Cooling Technology Institute is a nonprofit self-

governing technical association dedicated to improvement in technology, design, performance, and maintenance of evaporative heat transfer systems.
2) *Process Cooling & Equipment,* magazine published by BNP Media. http//www.process-cooling.com
3) *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

5.3 Once-Through Cooling

Applicability

This BMP is intended for those industrial water users that circulate water from a lake or bay to remove heat generated from industrial equipment and mechanical devices such as heat exchangers, condensers, or process equipment. Water is consumed in the process by forced evaporation on the lake or bay. In addition a number of facilities with cooling lakes or ponds supplement the dependable yield of the plant reservoir by pumping water from another water source such as a lake or river.

Description

Cooling involves the removal of process energy in the form of heat. This BMP centers on the practices for optimizing the water-use efficiency of the once-through cooling systems and the makeup to the cooling reservoir from other sources.

The Environmental Protection Agency ("EPA") defines once-through cooling as water passed through the main condensers in one or two passes for the purpose of removing waste heat. This definition would also apply to other types of large heat exchangers that utilize cooling water to remove heat in one or two passes. Typically, large volumes of water at ambient temperatures are pumped from one arm of a lake or bay, through the heat exchange equipment where heat is transferred, and then are discharged to another arm of a lake or to a separate bay system. After the warm water is discharged to the receiving water body, heat is liberated from the once through cooling water primarily by evaporating a small portion of the total volume pumped. The cooled water then circulates back to the plant intake where it is again pumped back through the plant to provide cooling. For cooling reservoirs, the natural evaporation from the pond surface must also be made up or replenished.

Once-through cooling is the favored choice for cooling needs in electric power plants and many other large facilities such as petrochemical complexes, primarily for overall economical, operational, and reliability factors. Alternatives to once-through cooling in large facilities are recirculating evaporative cooling towers, dry cooling by induced air flow, and combination wet/dry (hybrid) cooling systems. Because of the significant amounts of capital investments and variability of operating expenses associated with each, cost effectiveness decisions on the type of cooling process to be used will generally be made during the planning and development of new facilities.

Water efficiency measures that should be implemented for existing once-through systems include:

1) sizing of pumps with cooling equipment to optimize heat transfer,
2) proper maintenance and repair of pipelines, intake and discharge structures, and
3) optimization of heat loading to the system.

For those plants that have an additional makeup supply to the cooling reservoir, the plant must carefully balance the makeup requirements to the cooling lake with the need to pump the additional water from the other sources. The cooling ponds should be optimally sized for efficient cooling with consideration for minimization of evaporative losses. For plants on cooling lakes that do not supply potable water, the use of alternative make-up water sources such as treated wastewater or reuse of water from other processes should be considered. At coastal locations, the use of saline water should be evaluated to provide complete or partial cooling for high heat load areas of the plant or as a replacement for higher quality water.

Implementation

After identification of water-cooled equipment, implementation should consist of the following actions:

1) Perform an equipment efficiency evaluation on each water-cooled system to optimize the effective heat transfer to the cooling water which thereby results in the optimum amount of cooling water being force evaporated.
2) Replacement or upgrades of small water-cooled systems with equipment using alternative cooling modes such as air-cooling or non-aqueous systems to reduce the heat load placed on the cooling reservoir.
3) Evaluate the cooling pond makeup requirements to optimize the amount of water required to be pumped to the plant reservoir.
4) Evaluate alternative sources of cooling pond makeup water such as reclaimed water from mining activities, wastewater from other industrial facilities, or wastewater from publicly owned treatment works.
5) Operation of the water-cooled processes and equipment in an efficient manner at all times. This includes maximization of external air-cooling opportunities, optimization of heat exchange equipment, use of solenoid valves or other methods for shutting down of systems when not in use, proper sizing of pumping equipment including consideration for variable speed drives, and keeping all structures and equipment maintained in optimal operating condition.
6) For industrial facilities located adjacent to coastal areas, consider utilizing saline water as a cooling source. Typically such a decision would be made during the design phase for a new process unit.

Schedule

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

1) The industrial water user should identify water cooled equipment and complete an efficiency evaluation in a timely manner. Evaluations of very large or complex systems should be completed within twelve (12) months of beginning this BMP.
2) The industrial water user should upgrade identified systems within a normal planning and budget cycle to implement the BMP in order to achieve the

maximum water efficiency benefit in a reasonable time frame. For changes implemented over multiple budget cycles, changes should be implemented in a progressive manner to increase efficiency.

3) Once-through cooling systems should be operated optimally at all times following the guidelines of this BMP.

Scope

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

1) Industrial water users with one facility, or several facilities with the same or very similar industrial processes, should perform an efficiency evaluation and perform upgrades or replacements as outlined in Section D.
2) For industrial water users with multiple facility sites, or multiple industrial processes, a progressive implementation schedule should be followed, implementing the BMP in successive facilities until all facilities have been evaluated and conservation measures implemented.
3) Cost effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) Number of once-through cooled devices or systems and description of the process the cooling is used for, type of cooling process, and water use stream;
2) System design requirements for cooling including temperature, volume, and duration of flows (hr/day);
3) Where meters exist, the daily water use records for each system as appropriate for make-up water, discharge, and flow through the system. If discharge permits are held, these records should be kept in conformance with the requirements of the Texas Commission on Environmental Quality or other appropriate regulatory authorities.
4) Written details and records of all facility replacements, modifications, and upgrades of cooling systems made to meet the requirements of this BMP; and
5) Details of alternate water sources opportunities considered.

Determination of Water Savings

Water savings should be calculated based upon a quantified water balance for the entire cooling lake and plant water use systems. Changes in cooling lake volumes resulting from historic inflows, surface evaporation, forced evaporation, return flows from plant operations, seasonal differences in evaporative demand, seepage, and rainfall contributions to the water in storage should all be evaluated in the water balance analysis. Based on this analysis the industry should optimize the amount of makeup water needed to properly operate their reservoir. While it is recognized that each site will have unique circumstances for water conservation, opportunities may exist to reduce surface evaporation or percolation losses from the lake and increase potential return flows from the plant. These water saving opportunities should be included as terms in the water balance.

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or equipment upgrade in its once-through cooling facilities or operations, utilizing its own criteria for making capital improvement decisions. A cost effective analysis under this BMP should consider not only the capital costs of any equipment or process changes and improvements, but also the one-time costs of any feasibility studies, water quality sampling and testing, and regulatory costs. Additional ongoing costs to be considered may include staff and labor, chemical and treatment costs, additional costs or savings in energy use, purchased water supply costs, and potential savings in wastewater treatment costs.

References for Additional Information

1) The Electric Power Research Institute ("EPRI"), a non-profit energy research consortium which provides science and technology-based solutions to the energy industry, has conducted or has several ongoing projects that address water use, water availability, and water utilization.
2) The U.S. Department of Energy's Office of Fossil Energy has ongoing research in multiple aspects of water management issues for industry. www.fossil.energy.gov/programs/powersystems/
3) *Process Cooling & Equipment,* monthly magazine published by BNP Media focuses specifically on cooling equipment, materials and supplies used during the manufacturing process. http//www.process-cooling.com
4) *Water Efficiency Guide for Business Managers and Facility Engineers*, State of California Department of Water Resources, October 1994.

6.1 Industrial Landscape

Applicability

This BMP is intended for industrial water users that irrigate landscape areas or use a significant amount of water in outdoor irrigation. Water conservation in the landscape can reduce water demands overall, reduce peak stress on water delivery systems, save energy, and reduce fuel and water costs. Landscape irrigation also offers the opportunity for water reclamation and reuse or useful disposal of water sometimes considered waste, such as air conditioning condensate.

For industrial water users, reducing water used for irrigation as an efficiency measure has the benefits of reduced water bills and landscape maintenance costs. Studies have shown that many plants that have undergone the stress of water constraints become more drought resistant and require less irrigation. Once an industrial water user decides to adopt this BMP, the water user should follow the process closely to achieve maximum water efficiency and other benefits this BMP offers. This BMP is not intended for cases where irrigation water is applied to mining reclamation projects, landfill closeouts, or other similar revegetation projects, but those projects should be done in an efficient manner with attention to water conservation.

Description

Under this BMP, the industrial water user with an irrigated landscape area will conduct a landscape water-use survey of its site and facilities. The water-use survey should at a minimum include measurement of the landscape area; measurement of the total irrigable area; irrigation system checks and distribution uniformity analysis; and review or development of irrigation schedules. In addition, the survey should identify currently irrigated areas where irrigation could be discontinued because such areas are not highly visible or the plant materials in these areas do not need supplemental irrigation. The survey should also identify areas in which return flow reuse, stormwater reuse, and use of treated wastewater effluent for irrigation might be environmentally, legally, and agronomically feasible.

If the water user has an automated irrigation system to irrigate turf grass, it will develop reference evapotranspiration (ETo)-based water-use budgets equal to a maximum of no more than 80 percent of reference evapotranspiration per square foot of irrigated landscape area. The statewide Texas Evapotranspiration Network (http://texaset.tamu.edu/) should be consulted for historical evapotranspiration data and methodology for calculating reference evapotranspiration and allowable stress. As the website indicates, those desiring greater water savings can utilize stress coefficients lower than 80 percent. If irrigated landscape area exceeds one (1) acre, the water user should install a dedicated irrigation meter or submeter.

Some industrial users have found that ceasing all irrigation and allowing native groundcovers to grow amidst an existing turf grass landscape is an effective means of reducing water use. Others have used rainwater harvesting, condensate reuse, cooling tower blowdown, RO reject water or stormwater recovery to irrigate landscape areas. These approaches could be considered a substitute means to accomplish the water saving goals of this BMP.

At the start and end of the irrigation season, irrigation systems should be checked and repaired and adjustments made as necessary. For companies with landscape managers on staff, training in landscape maintenance and irrigation system design should be required. In accordance with Texas law, individuals responsible for installing irrigation systems must be licensed by the State of Texas.

Large managed landscapes and commercial operations should prepare a written irrigation management site plan that clearly identifies responses and priorities during water-limited situations such as various stages of drought. The plan should be part of a comprehensive landscape management plan that addresses other management practices such as mowing, fertilizing, etc. On large sites, written landscape plans that include specifications for soil preparation, plant materials, irrigation design, mulch, and maintenance instructions are particularly important.

A landscape conservation program might also incorporate systematic upgrades to reduce water use, including irrigation system components, design and maintenance programs, and landscape design. Rainwater sensors, irrigation controllers, pipe specifications, and hydrozone specifications are all potential elements of an irrigation systems upgrade.

Landscape design emphasizing low-water-use plants should also be considered. Plants appropriate to the region in which they are being planted and with documented low water requirements should be given priority in the landscape design. All designs should be based on the seven principles of WaterWise landscaping (also known as Xeriscape principles).[1] Careful follow-up is essential to ensure that water is not applied in excess of plant needs. In addition to the references noted below, many landscape management companies in Texas now offer water-efficient landscape design and maintenance services.

Landscape design for new construction should use low-water-use plants appropriate to the region of Texas. For large landscape areas, an evapotranspiration (ET) controller or soil moisture sensors should be installed in order to use real-time input to determine plant water stress and needs. A new irrigation system will include a rain sensor shutoff mechanism and use drip or low-pressure irrigation heads in hydrozones where appropriate in order to achieve maximum water efficiency.

Soil improvement is an effective method for reducing irrigation water usage while maintaining healthy soils. Soil improvement programs on high visibility areas can demonstrate

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[1] Water Wise Landscape programs follow the seven principles of Xeriscape™, from the Texas A&M Horticulture Website (2), listed below and explained in greater detail in resources listed in the reference section:

1. Planning and design; 2. Soil analysis and improvement; 3. Appropriate plant selection; 4. Practical turf areas; 5. Efficient irrigation; 6. Use of mulches; and 7. Appropriate maintenance.

to the public the effectiveness of this method. For most landscapes, compost applications of 1/4 to 1/2 inch annually on turf areas and one inch annually on flower beds are recommended. Compost is most beneficial when applied in the fall.

Implementation

The initial step is an efficiency evaluation of the existing landscape area and irrigation systems. Recommended changes to the irrigation system will come from the evaluation report.

The evaluation should include:

1) a list of landscape areas, measurements, plant types, irrigation system hydrozones, controller(s);
2) a list of existing irrigation policies including maintenance and irrigation schedules;
3) a distribution uniformity analysis on irrigated turf areas; and
4) an initial report summarizing the results of the evaluation.

Based on the results of the evaluation, the water user develops and implements a program to maintain and operate its irrigation systems in a water-efficient manner. Maintenance programs include seasonal system checks, adjustment of irrigation timers when necessary, installation of rain sensors, and regular review of irrigation schedules. Internal reporting should be done to confirm that regular seasonal maintenance of the irrigation systems is achieved. When landscape management companies are utilized, contracts should include a required report showing regularly scheduled maintenance and seasonal adjustments to irrigation systems controllers.

In its landscape management programs, the water user should consider installation of climate-appropriate water-efficient landscaping; installation of an ET-based irrigation controller; and dual metering. Another measure to consider is the training of personnel in landscape maintenance, irrigation system maintenance, and irrigation system design. Implementation of Integrated Pest Management strategies can also result in reduced use of pesticides and fertilizers, thereby reducing the amount of water required.

For users that do not have an ET-based controller collecting real-time data, evapotranspiration data is available for numerous parts of the state from the Texas Evapotranspiration Network (Network). This Network will expand over time, as more weather stations are added. If the water user is located in a part of the state not covered by the Network, then it can use the methodology on the Network Website (http://texaset.tamu.edu/) and weather data available from federal agencies such as the National Oceanic and Atmospheric Administration ("NOAA") or the United States Geological Survey ("USGS"). While this BMP sets 80 percent ETo as the minimal allowable stress ("AS") to achieve water conservation, lower irrigation amounts are achievable by reducing the AS coefficient further. A preferred alternative approach is to utilize the methods for reducing irrigation quantities as outlined in this BMP and on the Network, but collect evapotranspiration data on site by purchasing a weather station.

If significant changes to irrigation systems or landscape design are implemented, these should be planned with a licensed irrigation professional or a professional landscape designer for optimal water savings. Ceasing irrigation of the landscape and allowing native groundcovers to flourish or converting to an alternative water source are also acceptable means of implementing this BMP.

Schedule

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

1) The irrigation systems evaluation should be completed in a timely manner. Efficiency evaluations of very large or complex systems should be completed within the first twelve (12) months of implementing this BMP. This is a reasonable time period to complete a thorough evaluation.
2) Develop ETo-based water-use budgets for all landscape zones no more than two years after the implementation start date.
3) Within two years of the implementation start date, install a dedicated landscape meter if landscape use is determined to exceed one (1) acre.
4) If irrigation systems upgrades are indicated or new landscape designs are planned, the changes should be initiated immediately after the landscape report is concluded and be completed within twelve (12) months.
5) The Landscape BMP shall be fully implemented within two years of the start date. If determined to be necessary for very large or complex facilities, the schedule can be extended. BMPs should be initiated in the second year and continued until the targeted efficiency is reached.

Scope

To accomplish this BMP:

1) Industrial water users with several facilities with the same or very similar landscape irrigation systems should conduct a landscape evaluation following the schedule outlined in Section D.
2) Industrial water users with several facility sites with very different landscape irrigation systems at the various sites should follow a progressive implementation schedule, implementing the BMP successively until all facilities have been audited and conservation measures implemented.
3) Cost-effectiveness considerations may result in partial implementation of this BMP at one or several of a large number of facilities.

Documentation

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

1) Summary report of the initial landscape survey;
2) Estimated ETo-based budget and annual water savings using the method described in Section G below;
3) Records of monthly landscape water use, personnel training, and changes to equipment and performance specifications;
4) Demonstrated water use reduction in targeted landscapes; and
5) Data on program progress, water savings, and expenditures.

Determination of Water Savings

Estimated water savings should be based on the assumption that a landscape survey and resulting programs will result in a 15 percent reduction in the amount of water used for landscape purposes. Calculating savings can be more accurately achieved after implementing the BMP.

Water savings calculation: $S = I_{(h)} - I_{(BMP)}$

Where S is savings in acre-feet/year
$I_{(h)}$ is annual irrigation average prior to implementing BMP
$I_{(BMP)}$ is annual irrigation after implementing BMP

80 percent ETo calculation: $I = ETo \times Kc \times AS$

Where I is the irrigation amount to be applied for a given period (daily, twice weekly, weekly, etc.) in inches or centimeters
ETo is the measured reference evapotranspiration over the irrigation period
Kc is a turf coefficient for turf grasses, and can be found at http://texaset.tamu.edu/
AS is allowable stress of 0.8 (or less if the landscape manager wishes)

When applying irrigation, the equation should be modified to gain greater water savings, by accounting for precipitation: $I = (ETo \times Kc \times AS) - P$
Where P is precipitation in inches or cm.

Cost-Effectiveness Considerations

The industrial water user should determine the cost effectiveness to implement each identified replacement or upgrade to its landscape irrigation equipment and procedures, utilizing its own criteria for making capital improvement decisions. Many operating procedures and controls that improve the water use efficiency should be implemented simply as a matter of good practice. A cost effectiveness analysis under this BMP should consider capital equipment costs and changes in staff and labor costs.

References for Additional Information

1) *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

2) *EARTHKIND™ Environmental Landscape Management* http://aggie-horticulture.tamu.edu/earthknd/earthknd.html 2004.

3) *Landscape Irrigation Scheduling and Water Management,* Water Management Committee of the Irrigation Association, September 2003. http://www.irrigation.org/PDF/IA_LIS_AND_WM_SEPT_2003_DRAFT.pdf

4) *Turf and Landscape Irrigation Best Management Practices*, Water Management Committee of the Irrigation Association, September 2003. http://www.irrigation.org/PDF/IA_LIS_AND_WM_SEPT_2003_DRAFT.pdf

5) *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* Pacific Institute, November 2003. http://www.pacinst.org/reports/urban_usage/waste_not_want_not_full_report.pdf

6) *WaterWise Council of Texas.* http://www.waterwisetexas.org/

7) *San Antonio Water System Conservation Program.* http://www.saws.org/conservation/

8) *ET and Weather Based Controllers CUWCC Web Page.* http://www.cuwcc.org/Irrigation_Controllers.lasso

9) *Smart Water Technology Initiative Web Page.* http://www.irrigation.org/swat1.asp

10) *Austin Green Gardening Program.* http://www.ci.austin.tx.us/greengarden/

11) *City of Corpus Christi Xeriscape Landscaping.* http://www.cctexas.com/

12) *Texas Cooperative Extension for El Paso County.* http://elpasotaex.tamu.edu/horticulture/xeriscape.html