PDHonline Course C123 (2 PDH)

Principles of Water Conservation and Reuse

Instructor: Robert P. Stevens, P.E., DEE

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

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Course Content

The amount of water used by any business or individual may seem minor compared to the total use of this resource. However, effective water resource management relies upon the cumulative impact of many small changes. Many water users have long standing practices to measure and control water consumption. Their ultimate focus is on the more efficient use of water, including the reduction of operating costs.

A successful water management program will use the following simple principles.

First Principle – Conserve water whenever possible
Second Principle – Reuse water whenever possible
Third Principle – Know where and how water is used
Fourth Principle – Continually evaluate water use requirements

This course first describes each of these principles, and this is followed with information and techniques to implement water conservation and reuse programs.

1.0 Principles of Water Management

1.1 First Principle – Conserve Water

According to Webster, **conservation** is "a careful preservation and protection of something, especially planned management of a natural resource to prevent exploitation, destruction, or neglect." There is a second meaning of the word, again per Webster, which is "the preservation of a physical quantity during transformations or reactions."

Ultimately, conservation can be considered using water more efficiently. Various ways to accomplish this include:

- Equipment changes
  - Use high-pressure, low-volume nozzles on spray washers
  - Install in-line strainers to prevent nozzle clogging
  - Replace high-volume hoses with high-pressure, low-volume cleaning systems
  - Equip hoses with spring loaded shutoff nozzles
  - Replace equipment (e.g., when it wears out) with water-saving models
  - Use fogging nozzles for cooling of products
  - Install controls on system overflows to control make-up water
  - Use air-to-air heat exchangers
  - Cover open top tanks to control evaporation
  - Check and control seal water for pumps

- Plumbing changes
  - Retrofit toilets with water-saving devices
  - Install high-efficiency toilets (e.g., during renovations)
  - Install faucet aerators
- Operation and maintenance
  - Detect and repair all leaks (including dripping faucets)
  - Turn off all flows during shutdowns
  - Use solenoid valves to shut off flows when production stops
  - Adjust flows to meet minimum requirements
  - Sweep or blow paved areas (e.g., plant floor) instead of hosing off

- Landscape and grounds maintenance
  - Check and repair irrigation systems
  - Adjust sprinklers to water only the landscape – not paved areas
  - Use drip irrigation to replace spray systems
  - Use mulch to reduce water needs
  - Select drought tolerant plants

It is especially noteworthy that many of these water conservation techniques are inexpensive. Some have no cost, such as turning off faucets and valves when not in use.

1.2 Second Principle – Reuse Water

Reuse, as defined by Webster, is "to use again, especially after reclaiming or processing". A second meaning listed is "further or repeated use." Both meanings of the term can be applied to water reuse.

Most manufacturing operations reuse water in some manner. A common example for manufacturing and commercial buildings is the use of recirculating cooling towers. These may support the air conditioning system for plant and office, as well as process water recirculation.

There are a wide variety of water streams where reuse opportunities are available, such as:

- Final rinse waters from equipment cleaning (e.g., tanks, fermenters)
- Bottle and can soak and rinse water
- Final rinse in wash cycles
- Pasteurizer and sterilizer water
- Condensate from air conditioning or from freezer defrosters
- Floor and gutter wash

Reuse of water should be considered where the quality meets requirements for the new use. Another approach is to consider a simple treatment scheme, for example, filtration where the water has a low solids level. This is often viable when there is a large water demand.

There is a limit to the extent that water can be reused. For example, recirculating cooling water systems use the cooling tower to remove heat by evaporation of water. The evaporation causes an increase in chemical concentration in the water, typically monitored as total dissolved solids, TDS. The TDS level must be maintained to avoid system problems, such as scaling in the pipes or foaming in the tower. The level of TDS is controlled by adding fresh water (make-up water) to replace evaporative losses and to replace intentional discharge of some of the recirculating water (blowdown). The blowdown discharges TDS at a high concentration, and the make-up water replaces this with a low TDS concentration. The quantity of blowdown required to maintain this level is dependent upon the TDS in the make-up water (lower TDS in the make-up water permits lower quantity of blowdown). If the reuse water TDS is much greater than the existing make-up water TDS, the water reduction will be less than expected.

The actual operation of water systems should be checked against the design for the system. Over time, there is a tendency to increase make-up water to recirculating systems, especially cooling towers, to fix a short-term problem or to avoid a potential problem. There are substantial cost savings when a system operates at the designed cycles of concentration, for reduced make-up water cost, reduced treatment chemical cost, lowered energy cost, and reduced wastewater disposal costs. Therefore, it is recommended that all recirculating water systems be routinely checked in a water management program.

1.3 Third Principle – Know How You Use Water

A common misconception is that you know "approximately" how much water is used and where it is used. This often leads to false expectations on the need to control water use and the opportunities to improve the effectiveness of water use. Developing a water balance is a simple approach to describe your entire water use program. A systematic approach for developing a water balance is described in Section 2 of this course.

1.4 Fourth Principle – Continually Evaluate Water Use

This principle is critical if water conservation and reuse is to be successful for the long-term. Techniques and practices continue to be developed for a wider range of water uses as economics change. The ability to effectively implement water saving programs improves as successes are documented. Also, potential restrictions mean that constant awareness of water reduction candidates makes good business sense.

2.0 Techniques to Prepare a Water Balance

The concept of a water balance is fairly obvious: Measure incoming water, identify where it is used, and check to see where it is disposed. The information below addresses these steps with some ideas to increase the effectiveness of the process.

2.1 Step 1 Identify Total Water Use

Sources for water can include groundwater wells, surface water wells, and even stormwater (intentionally by using holding ponds and unintentionally through precipitation or run-on into recirculation process water systems). This water may actually be delivered to the facility through a plant utility, or in most cases, from a public water system.

Most water supplied from a public utility is metered with a monthly bill identifying the amount of water use. Use these bills to keep track of the number of days in the billing cycle. You also will want to know the number of operating days for the billing cycle. (See Step 3 and 4 discussions on time periods.) Total water supplied to the facility from each source should be summarized for at least a full year, with a longer time frame preferred.

Comment: Why is a full year of data required? Why is a longer period recommended?
Water use is affected by season. For example, summer and hot weather increases water consumption for evaporative cooling systems, landscape maintenance, and even drinking water uses. Water use patterns also can change over time. For example, the make-up flow rate for a cooling tower system may increase in the summer but not be reduced for the winter. A longer record can identify these trends and help in identifying conservation opportunities.
Recommendation: Assemble and show total water use data in a "year over year" table. Typically, this will show months across the top of the table and years down the side. This helps show trends. This technique also can be used to track cost of water and will conveniently show savings when conservation and reuse approaches are implemented.
Advanced: Total water use data for shorter time periods (such as daily or even hourly) can be very useful in understanding water use patterns. These can be obtained by manually recording water meter readings or installing a recorder. The information from a shorter time period can supplement total water use, e.g., water use during the weekend compared to operating days, or water used by shift.

2.2 Step 2 Identify Individual Water Use Activities

There are two general approaches to identify water use activities within the facility. The simplest method is to tour the facility and identify <u>everything</u> that uses water. Typical uses of water include:

- Sanitary uses
    - Water fountains
    - Restrooms
    - Showers

    - Kitchens
- Process uses
    - Cooling systems
    - Heating systems
    - Steam systems
    - Process uses such as mixing, slurries, and reactions
    - Pump cooling and seals
    - Washing and cleaning operations
    - Pollution control equipment such as wet scrubbers
- Grounds and maintenance uses
    - Landscape watering
    - Vehicle cleaning

For complex facilities, it may be necessary and/or better to use plumbing and sewer drawings to identify water use activities. This approach can make it easier to understand the relationship between each water user and the overall facility water use program.

Comment: Why is it important to list all operations that use water, even apparently minor uses?
One key to being successful in reducing water use is not to miss the "small stuff." One drip per minute from a faucet is about 50 gallons per year – and a steady stream from a faucet is about 300 drips per minute or almost 16,000 gallons per year! (Source: the AWWA water use site, www.waterwiser.org)
Recommendation: List the water uses in a table organized by location and type of use. For example, the location "manufacturing area" might list water use such as: "pump seal water; cleaning tanks; cooling system make-up." Include a column to add water use information (discussed in the next step).
Advanced: Collecting information on the age and relative condition of equipment can assist in choosing targets for a conservation and reuse evaluation. Older equipment (e.g., toilets) often was not designed for water conservation. Equipment in poor repair or nearly worn out (e.g., seals in older pumps) may consume more water than originally intended.

2.3 Step 3 Estimate Water Use

This is broken out as a separate step because it will often take two or more iterations to obtain the level of accuracy you want. During Step 2 described above, you will usually collect much water use information that will be used for the first estimate. It is recommended that the first estimate include best information on the relative magnitude of each water use activity. More information can then be obtained as needed on the larger water uses at the facility and the uses where the estimate has greatest uncertainty.

In making water use estimates, you need to understand flow rates and the duration for each use.

Example: A process uses 1 gallon per minute, and the process operates for two shifts (16 hours). Water use = 1 gpm x 16 hours x 60 minutes per hour = 960 gallon/day If operation is five days per week; Monthly use = 960 gallons/day x 22 operating days = 21,000 gallons (This uses 22 working days per typical month; use actual days).

In collecting data to improve the balance, use spot measurements to supplement your estimates. Flow measurement devices can be installed at key locations (e.g., flumes in open channels, meters on piping). Ask operators how they perform their work (e.g., how long do they use a hose for cleaning; how do they operate valves on water lines). Use the "bucket and stopwatch" method to estimate flow rates from hoses and other accessible equipment. These spot measurements can then be converted to a common basis for your analysis. Typically, this may be daily use, or monthly use.

Comment: How do you estimate water use when there are no water meters or other measuring devices?
Most process equipment will include water use in the specifications. Plumbing fixtures also specify flow amounts, such as gallons per flush. Pump curves can be used to estimate flow.
Recommendation: List the water use estimate and basis for the estimate on the chart from Step 2. You may want to include a range for those estimates where you have limited confidence.
Advanced: Water use data can also be presented on any time basis that has meaning for the facility. For example, use can be shown per minute, per hour, per shift, per operating day, per week, or even per year (although this tends to obscure the seasonal variations in the data).

2.4 Step 4 Complete the Water Balance

The complete water balance can be viewed in several ways:

(1) Water into the facility (total water use) = Sum of the individual uses.

(2) Sum of the individual uses = Wastewater discharges + Consumptive Losses

(3) Consumptive Losses = water sprinkling + evaporation losses + water going into product + etc

(4) Water into the facility (total water use) = Water leaving the facility

(5) Water into the facility = Wastewater discharges + Consumptive Losses

You should select a version that shows the balance consistent with your objectives. For example, if the goal is conservation to reduce activity water use, then focus on the first statement makes sense. When you are focusing on water savings through reuse, then the second statement which focuses on wastewater discharge and consumptive use may make more sense.

Obviously, you need to convert all water use information to a common time basis that is meaningful for the facility. This may be per operating day, week, month, etc.

After effort to refine the individual use estimates, the balance may not “balance” for several good reasons. For example:

- Balance between total use and individual use is good. However, water into the facility is higher than individual water uses for a few time periods. Potential reasons: “one-time” events, such as testing the fire system, flushing tanks, broken water line. Ask operations about the time period for unusual activity.
- Water into the facility is higher for the seasons. Individual use estimates do not change. There may be poor estimates for seasonal uses such as landscaping or cooling system use.
- Water into the facility and sum of individual uses does not balance. Difference is similar for all months. There may be errors in estimating flows for the individual water uses. This may be corrected by a selective measurement program.
- Water into the facility is always greater than the sum of individual users. If the difference is reasonably consistent, there may be a system leak, for example an underground pipe.

The need to continuously evaluate the water balance is discussed in a later section.

Comment: What is the best “time frame” to use in developing the water balance?
This depends on the facility. Typically, at least a summer and winter balance should be prepared since evaporative losses (comfort cooling, process cooling towers) and landscaping needs are higher in the summer. A shorter time frame (e.g., monthly) might be more useful to closely track water use patterns.
Recommendation: Prepare the water balance at least for summer and winter conditions.
Advanced: Collect information on wastewater discharge volumes and include this on the flow balance. Include estimates for consumptive losses (e.g., evaporation, process use, landscaping). Complete the balance for every time period to show a “difference”. Evaluate the “difference” similar to the examples included in the course.

3.0 Techniques to Reduce Water Use

The water balance tool is useful for understanding how and where water is used in the facility. This section focuses on how to use the information to identify opportunities for water conservation and reuse.

3.1 Evaluate Process Water Opportunities

The best approach is to start with the biggest uses and critically evaluate them. A typical series of questions for essentially every water use would be:

- Does this much water have to be used?
  - Who is using it (e.g., the people, the process)?
  - When is it used (e.g., continuous or intermittent, season or time of day)?
  - What will happen if it is reduced (e.g., affect product, affect equipment)? What can be done to minimize this impact?
  - How can water use be reduced (e.g., operating practice, control, policy)?
  - What is the target use versus current use?
- What is benefit of water use reduction?
  - Reduction in water use?
  - Purchased water cost savings?
  - Reduced chemical use?
  - Reduced energy use?
  - Disposal cost savings?
- What is cost to achieve water use reduction?
  - Operator training?
  - Controls?
  - Equipment?

In evaluating process water opportunities, an understanding of the role for water in the process should be developed. Some questions to consider include:

- What is the risk and how can this be controlled?
- Will process quality be affected?
- Will operating efficiency be affected?
- Will equipment be affected?

3.2 Evaluate Water Use Policies

As with any program intended to improve operations, management commitments are needed to establish and maintain water conservation and reuse as a priority. There are several company policies regarding water use that can strongly affect the outcome of a water management program. One major water use that represents a policy issue is landscape maintenance. There are options to balance the aesthetics of an attractive facility (or home) with water conservation and reuse principles. Examples of how to balance this include:

- Design landscaping to eliminate or reduce reliance on water.
- Mulch land to reduce reliance on water.
- Use water only at night to reduce evaporative losses.
- Use low flow irrigation systems, such as drip irrigation.
- Reuse spent water for landscape requirements (Note: wastewater regulations should be considered before reusing water in this manner.)

Typically conservation activities do not conflict with policy. There may be issues such as equipment cleaning, where good conservation techniques (such as controls on hoses and high pressure nozzles) can reduce water use. Other management issues can involve reuse of water in process activities. There may be process quality or customer expectations that preclude an otherwise good idea.

3.3 Do Not Ignore Minor Water Uses

Although the discussions on the water balance focus on the major water uses in collecting flow and use information, "minor" uses can contribute some of the easiest to obtain and substantial water reductions.

Example: a small steady stream from a faucet can account for 16,000 gallons per year!

Minor water uses typically are easy to address by improved maintenance and awareness techniques (e.g., report the faucet, turn off the faucet, fix the faucet; turn off the hose, get a spring-loaded shutoff nozzle for the hose). Minor uses also are often well served by relatively small cost improvements. These minor water conservation measures should be documented.

4.0 Achieving Success

Managing water use is an effective way to reduce operating costs. There are significant cost savings in addition to the cost of water, such as electric power, gas, chemicals, and wastewater disposal. Some of the key steps that can be taken to manage the process of water conservation and reuse include:

- Designate a water manager or coordinator
- Develop a plan with specific goals – water balance information provides an excellent starting point to benchmark improvement areas
- Educate and involve employees with the efforts
- Make water conservation and reuse a priority
- Report on success – post water use per unit production or daily water use

Reporting on success may be the most important management activity in the program. It is appropriate to report in terms that all employees can recognize (e.g., water used per day and per unit of production). But reporting also should consider cost savings. This is especially important to continue management support and to develop the "benefit" pattern when and if more advanced water saving opportunities are considered.

Finally, the sharing of successes can multiply the benefit. Individual employees can apply their improved knowledge of these principles to other aspects of their water-using lives and share their knowledge with others.