Introduction

The increasing cost of potable water and wastewater treatment costs in particular are accelerating the need to address water recovery opportunities correctly and expediently. In many cases water is unnecessarily discarded when it could be reused elsewhere in the plant. The challenge is to be aware of the opportunities and to capture usable water for alternative purposes.

Water is generally purchased for two purposes in food production for either utility services or for incorporation as a food component to:

- Hydrate dried ingredients
- Dilute concentrates
- Aid mixing
- Prepare brines and pickles
- Package canned foods

Most utility water purchased by the plant is either discarded to the sewer or evaporated into the atmosphere. Examples of utility types of water applications include:

- Heating and cooling of the plant and processes
- Product or package heating or cooling
- Conveyance of solids, fruits and vegetables
- Personal hygiene
- Equipment and plant sanitation

The breadth and significance of water as illustrated by these various examples also illustrates the complexity inherent in minimizing the food plant’s water consumption. Most utility waters are chemically treated, rendering them useless for food contact applications. Food and microbial cross-contamination also limits the scope of water reuse. In spite of the challenges, the increasing cost of potable water supply and disposal will necessitate the development of water reuse strategies.

Trends in water costs

As a key utility for food production, food producers should be aware of trends affecting the supply and cost of potable water and wastewater treatment. The EPA reported in 1999 that the national average cost for potable water was $1.93/M gal\(^1\). This value compares very favorably to the high cost of water in the UK ($4.35/M gal) and in Germany ($6.89/M gal).

In decades past, water costs have trended with inflation. However, water in the U.S. may be artificially inexpensive, since the future costs for infrastructure replacement are not currently taken into account. Should the cost of infrastructure upgrades be passed along to the consumer, the cost of publicly supplied water in the U.S. may increase $1.70 to $2.70/M gal. to a total delivered cost of $3.60 to $4.70/M gal.\(^2,3\) (Figure 1)

But regardless of the future costs that these trends suggest, the water recovery systems discussed below can be justified economically at today’s costs to reduce expenses associated with purchasing and treating water.
Water Recovery In Food Processing Facilities

Water Regulations

Before undertaking any water conservation and reuse program, having an understanding of and adhering to the governing food regulations is imperative. Water reuse in this context is defined as water applied for either the same intended purpose or for some other purpose in and around the food processing plant. Reuse water as discussed in this paper does not contact edible products, is not used in a product formulation and should not create an unsanitary condition where used. Further guidance regarding water reuse restrictions may be found in CFR 416.2(g), and explained for the meat and poultry processor under FSIS Directive 11,000.1.

Water Conservation and Reuse Opportunity Identification

The first and most important step prior to water reuse implementation is water conservation. Conserved water is typically water that cannot be recovered or reused and is lost directly to the sewer. Examples of water conservation opportunities include:

- Repairing water and steam leaks
- Using low flow/high velocity water where possible for cleaning applications
- Replacing wasteful practices such as “water brooms” with the more appropriate dry clean-up that reduces both water and sewer expenses
- Installing water deduct meters to monitor fresh water flow to applications such as evaporative coolers to improve process control and to reduce billed sewer charges
- Installing solenoids to stop water flow when equipment is not operating, such as water-cooling for motors and bearings, or vacuum pump seal-fluid
- Steam system condensate return, including correct steam trap designs and a steam trap maintenance program
- Recycling cooling water back to chillers instead of one-pass cooling

Reuse water sources and applications can then include a wide variety of relatively clean water sources collected from throughout the plant:

- Process hot water and steam
- Process cooling
- Retort operations
- Steam barriers
- Sterilization rinse waters in ESL/UHT fillers
- Vacuum seal fluid
- Indirect contact cooling water for refrigeration compressors
- Pasta extruder barrels
- Coffee grinders
- Homogenizers and separators
- Air compressors
- HVAC cooling
- Conveyance of raw fruits and vegetables

A final but critical criteria to consider for successful long-term water reuse is to ensure that the water does not contain contaminants that will:

- Foul equipment
- Corrode the materials of construction
- Concentrate in equipment to hazardous levels

Reuse water may contain potentially harmful physical, chemical or biological components that cannot be economically treated, removed or controlled. Monitoring the reuse water conditions helps to reduce the risk so that the water recovery equipment and end-user equipment remains in good working order.
Water Recovery In Food Processing Facilities

Water Reuse Equipment

The equipment required to recover the reuse water should be simple in design and yet robust enough to handle a variety of water conditions and flow rates. Probably the most useful and widely used water recovery unit is a steam condensate return unit. In this application, as a water recovery unit (WRU), the system is composed of piping, a steam condensate receiver tank with level control, pumps to direct the reuse water to the end-users and a simple control panel for housing the electrical connections, motors starters, over-current protective device and run lights. (Figure 2)

![Figure 2: Typical Condensate Return Units](image)

All materials of construction for the WRU are dictated by the location of the equipment and chemical composition of the reuse water.

Stainless steel piping is often used to connect the source of the reuse water in the food processing areas with the WRU receiver tank.

The receiver tank and associated pumps, valves and piping could be stainless steel, black steel with or without epoxy lining, or galvanized steel, depending upon reuse water composition, end-user requirements, equipment location and room sanitation practices. Stainless steel is often the preferred choice when the WRU resides in the processing room, due to sanitation and external cleaning requirements.

The water level in the WRU receiver is controlled with a mechanical float, which cycles the WRU pump(s) on and off to discharge the reuse water to the end user. In some applications more than one pump might be installed to meet volume or multiple user requirements. Since a variety of reuse water sources may be feeding the receiver, the WRU is operated at atmospheric pressure with an air gap to minimize siphon backflow. Reuse water delivered in excess of the capacity of the WRU overflows into an adjacent hub drain.

Note that in some cases the reuse water temperature may need to be adjusted before pumping to the end-user. As illustrated in Figure 3, the steam condensate temperature is reduced with a shell and tube heat exchanger before pumping to an evaporative condenser sump. The heat exchanger cooling water is also collected in the WRU to meet part of the evaporative cooler’s total water demand.

![Figure 3: WRU Flow Diagram](image)
To illustrate the magnitude of savings possible consider the cooling water flow for one dairy homogenizer. At a flow rate of 5 gpm and a typical combined cost of $4.50/M gallons for fresh potable water delivery and sewer disposal, a cost savings of nearly $8,500 per year can be realized. The savings occur by collecting the homogenizer cooling water in a WRU and pumping the water to the facility’s evaporative coolers. The sewer disposal cost of the reuse water from the homogenizer is avoided, as is the purchase of fresh potable make-up water for the evaporative cooler. At an installed cost of approximately $7,500 and typical electrical operating cost of $250/year, the return on investment for the WRU would be less than one year. These returns and operating cost savings will become even more attractive as water and sewer costs begin to outpace the current inflationary trends.

Conclusions

With the cost of publicly supplied potable water and waste treatment expected to significantly increase over time, the food producer should incorporate water recovery and reuse strategies in their facilities. A condensate return unit installed as a WRU is a simple and yet robust tool for recovering non-potable waters and for substituting them for applications presently using fresh potable water. Plant utilities are prime examples of these applications. An additional benefit is a gallon for gallon reduction in sewer disposal and sewer surcharge costs associated with the disposal of relatively clean but non-potable water. In most cases, the payback on investment in water recovery and reuse is less than one year.

References