Water Use in a Multiproduct Dairy

ABSTRACT

Water use was monitored in a multiproduct dairy plant by 25 cumulative use meters. Twenty-two of the meters were located in the building for product processing for study of selected operations. Fluid products accounted for 87% of production, and frozen products and by-products were 10 and 3%. Mean water use was 1.9 kg/kg product for fluid products, 10.5 kg/kg product for by-products, and 15.7 kg/kg product for frozen products. Cleaning and sanitizing operations accounted for 38% and utilities for 30% of the total process water. The milk case washer used 6.6% of the total plant water. The peak times of water use were for start-up in the morning hours and for clean-up in the early afternoon. Water saving suggestions are presented.

INTRODUCTION

Concern for our environment and increasing costs are forcing dairy processors to take a fresh look at a resource that has long been taken for granted - water. Drastic changes in water and sewage charges already have stunned a few processors, and most other plants can look forward to a rude awakening in the near future. Additional incentive for plant control of water and waste may come from governmental edicts such as the Water Pollution Control Act Amendments of 1972 (2). Scheel (5) emphasized the need for including water in analysis of plant cost. He stressed the need for management of water as a material since more water is required as operations expand; water costs are increasing because of shortages, treatment costs, and governmental restrictions; and regulations for pollution control require increased treatment of wastewater.

Most information concerning water use in dairy processing is survey data from various types of plants (3, 6). Our study was to determine water use for selected operations in a multiproduct plant. A companion paper (1) reports waste generation for this plant.

PROCEDURES

This study was at Pine State Creamery Company, a multiproduct dairy plant in Raleigh. Products included a complete line of packaged milk and cream, buttermilk, yogurt, sour cream, cottage cheese, fruit juices and drinks, ice cream, ice milk, and frozen novelties. Production volume and product mix varied considerably from day to day. During this study, daily milk use for processing ranged from zero on down days to a maximum of about 156,000 kg. Fluid milk products were processed Monday, Tuesday, Thursday, Friday, and Saturday while frozen products were processed Monday through Friday with limited novelty production on Saturday. This dairy had operated from its location for more than 50 yr and had undergone several major expansions and/or renovations.

Water was supplied through four municipal meters to: 1) processing plant, 2) office-sales complex, and 3) garage. Since the processing plant consumed the greatest volume of water, attention was focused on this area for more detailed study. The water supplied to the processing plant was delivered through a 10.1 cm compound meter. Twenty-one additional meters were installed at various locations in the processing area as in Figure 1. The meters varied in size from 1.6 to 5.1 cm and were all disc type, cumulative use meters. Meter locations were dictated by plant layout and accessibility to water line. Some meters supplied water to a group of operations which could not be isolated into separate operations. A water system designed for a new plant would offer more
appropriate locations for meters. Daily readings, except for weekends, were made of all the meters for 60 days. Special readings were on an hourly basis for 1 wk on one occasion and for 2 days on another occasion.

Production data were summarized from plant processing records for the 60 days during which water use was measured. This permitted calculation of water use in terms of unit production. Records included information on receipts, fluid milk, drinks, orange juice, cottage cheese, by-products, frozen products, and total processed products. The production day for plant records did not always correspond to the calendar day. Because of this complication, water use per unit product for a given day was not as accurate as values based upon weekly or monthly records.

Water meter data were used to calculate use for specific locations, operations, areas, or products. Considerable variation in water use per day and volume of product produced per day suggested that water use be considered in terms other than daily use. Therefore, water use data are presented either in kilograms of water use per kilogram of product or as percent of total use.

RESULTS AND DISCUSSION

Plant Water Use

Average water use in the processing plant, office complex, refrigeration shop, and garage are summarized in Table 1. The total use by this dairy was 3.57 kg of water/kg of total products. Total product was the sum of all processed product weights including fluid milks, juices, drinks, cultured products, and frozen products. Production was 87% fluid products, 10% frozen products, and 3% by-products as illustrated in Figure 2.

Probably the best comparative data on water use in the US dairy industry is the survey information presented by Harper et al. (3). Harper’s survey average of 2.52 kg wastewater/kg milk was based upon wastewater discharge rather than supply water and on receipts rather than processed product. A comparison study on wastewater has been reported (1).

In this North Carolina study, erroneous conclusions about water use could be drawn from milk receipts instead of processed product (4.16 vs. 3.57 kg/kg) because of practices in the

![Figure 1. Schematic diagram of water meter locations in processing area.](image)

<table>
<thead>
<tr>
<th>Area</th>
<th>Water use/total product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing plant</td>
<td>3.57</td>
</tr>
<tr>
<td>Office-sales complex</td>
<td>.03</td>
</tr>
<tr>
<td>Garage</td>
<td>.09</td>
</tr>
<tr>
<td>Total</td>
<td>3.69</td>
</tr>
</tbody>
</table>

2 Weight ratio of kg/kg is equal to lb/lb and approximately equal to liters/kg or gallons water use per gallon of fluid product processed.
plant. Milk receipts were only 87% of total product because of high production of juice and drink. Milk was not processed necessarily on the day received; some receipts were sold as bulk milk and not processed; and considerable non-milk-base product was processed such as fruit drinks.

Process Water Use

The water volume used to process various products is summarized in Table 2 and Figure 2. Water used in some operations (receiving, cold storage, boiler, cooling tower, some processing) could not be metered separately for each product. In these operations the portion of water assigned to a specific product group, such as frozen products, was estimated. Frozen products and by-products required far more water (15.7 kg of water used/kg of frozen product) than fluid products. The Vitaline®, a machine for producing frozen stick-type novelties used 28% of water required for frozen products. Vitaline production was seasonally higher than normal during this period. Water use for the Vitaline was 8.5 liters per dozen units of product processed. Improved design and proper management control would reduce water requirements for the Vitaline operation.

The major water uses in processing are in Figure 3. Cleaning and sanitizing required the largest input of water and accounted for 38% of the total water used in the plant. The utilities group, including the locker room, cooling tower, boiler, chill water, and ice water, was the next largest water use.

Average water uses are in Table 3 for selected operations and/or locations. The water use for the case washer totaled approximately 3.8 liters for each case of milk processed. The utilities group was again prominent as would be expected considering that 30% of the total water used in the plant is for utilities. Consumptive use (the water used in product formulation) represented about 5% of the total use. It was undoubtedly higher than normal because data collection occurred at the peak of drink production.

Numerous observations and recommendations for plant operation in relation to water use were made while data were collected. These observations support conclusions of other

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investigators (4, 7, 8, 9) that effective management of water resources is necessary to reduce excessive use. Water used by the case washer was excessive. Many cases were washed longer than is required for cleaning because of relatively slow destacking and use of washed cases. Automatic shut-off of the case washer could reduce the water use in this operation which was 6.6% of the total volume used in the plant.

Too much water was used for washing away spills, drips, and machine losses resulting from employee carelessness and equipment malfunctions. The goal of any dairy operation should be to operate on a dry floor except at the end of the day when final clean-up is required or at fixed intervals when clean-up is required for basic sanitation.

Filling and shipping schedules dictated intermittent operation of the HTST (high-temperature short-term pasteurization) system. Excessive water is used with frequent start-up and shut-down operation. Improved scheduling to minimize product changes would reduce water requirements.

Poor seals on chill water pumps caused leakage that produced exaggerated water use.
for chilling. Routine maintenance of pump seals, pipe fittings, and valves is mandatory in the management of water supplies.

The hourly average water use for 1 wk is in Figure 4. Extremely low uses for the non-production periods, such as Saturday afternoon, were eliminated before averaging. Graphically pictured is the water-use pattern during the average process day. The period of low use was in the early morning hours while the 0700 h use was more than 65% above the average use. The 1400 to 1500 h usage was high because the majority of plant clean-up began during these hours. Also, the hourly averages surely dampened the extreme periods of water use. High and low uses are hidden in these averages.

Recognition of the areas and operations with high water use are but a first step. Efforts to reduce water use may require modification of process or equipment and/or employee training to reduce careless actions and insure efficient use of water. As suggested by Zall and Jordan (9), the employment of “current technology” to reduce water use by 50% could benefit the entire industry. Harper et al. (3) and the EPA (6) have presented specific steps for any dairy plant to reduce their water use to supplement suggestions in this study. Financial gains from water control for dairy plants require knowledge in this paper, a commitment by management, and continuing action.

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REFERENCES
