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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Dairy

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Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small- and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. In an effort to assist these manufacturers, Waste Minimization Assessment Centers (WMACs) were established at selected universities, and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC team at the University of Tennessee performed an assessment at a plant manufacturing pasteurized milk, cream, buttermilk, chocolate milk, ice cream mix, fruit drinks, and plastic jugs—approximately 23,300,000 gal/yr of liquid product and 4,160,000 half gallon and 15,600,000 gallon plastic jugs/yr. Raw milk is delivered to the plant, filtered, then centrifuged to separate the cream from the skim milk which is then processed through a high temperature short time (HTST) press. After the press, the milk is bottled and shipped. Buttermilk is skim milk which has been inoculated with cultures in a special processing tank. Chocolate milk is made by adding chocolate powder and fructose to blended milk prior to processing in the HTST press. The team's report, detailing findings and recommendations, indicated that the majority of waste is wastewater generated from all processes in the plant and that the greatest savings could be obtained by instituting a wastewater management plan to reduce uncontained milk waste (38%) and wastewater (90%).

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from the authors. This brief provides only summary information and is not intended for use as a thorough analysis.

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Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, PA) has begun a pilot project to assist small- and medium-size manufacturers who want to minimize their formation of waste but who lack the in-house expertise to do so. Under agreement with EPA's Risk Reduction Engineering Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Tennessee's (Knoxville) WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The waste minimization assessments are done for small- and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $50 million, employ no more than 500 persons, and lack in-house expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, and reduced waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

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Methodology of Assessments

The waste minimization assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC staff locates the sources of waste in the plant and identifies the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report that details the WMAC's findings and recommendations (including cost savings, implementation costs, and payback times) is prepared for each client.

Plant Background

This dairy produces pasteurized milk (2% fat, 1% fat, 1/2% fat, whole, and skim), cream, buttermilk, chocolate milk, ice cream mix, and fruit juice drinks. The plant also manufactures milk jugs from HDPE (high density polyethylene) pellets. The plant operates 4,420 hr/yr to produce approximately 23.4 million gal of milk annually.

Manufacturing Process

Raw Milk Processing

The dairy receives fresh raw milk via 19 to 20 daily truck deliveries. Raw milk is pumped from the trucks through a centrifuge clarifier where undesirable solids in the milk are removed. Waste from the clarifier is collected in a holding tank and is trucked offsite daily to be used as fertilizer. After each delivery the truck tanks are cleaned with a Clean-In-Place (CIP) cleaning system which utilizes a spray system built into each tank. Initially a four-second burst of water at 60-80 psi is supplied to the tanks; the water/milk solution is pumped through the clarifier and processed with the milk initially pumped from the truck. That rinse is followed by an alkaline rinse, an acid rinse, and a rinse containing a sanitizing agent. The rinse solutions drain to the municipal sewer. During one CIP cycle each day the clarifier is also washed.

It is estimated that approximately 2% of the total amount of milk purchased annually is lost during processing. Solids removed from the milk in the clarifier account for part of the volume loss. The remainder results from milk spills and leaks from processing equipment, contamination of milk with the CIP sanitizer solution during HTST press washing, and spills of packaged product in the storage cooler. Spills and leaks of milk during processing are partially contained in equipment drip-pans; drip-pan waste is collected by a local farmer and is subsequently used as hog feed. The remaining milk lost annually is drained to the municipal sewer. It is not possible to quantify the amounts of waste milk associated with each piece of equipment.

Milk exiting the clarifier is cooled to 36°F in a cooling press. At this point a second CIP system is used to clean the raw milk lines. Drip-pan waste is generated and uncontained spills and leaks occur at the cooling press. Five percent of the milk from the cooling press is shipped to other dairies for further processing. The remaining 95% is transferred to one of three storage silos.

Milk in the storage silos contains on average 3.75% butterfat. Approximately 40% of the milk from the storage silos is directed through a centrifuge where cream is separated from the milk. The cream contains about 40% butterfat and the remaining skim milk has a butterfat content of approximately 0.25%. Each fraction is stored in its own tank. Cream from the cream storage tank is transferred to either the ice cream mix process or the filling machines where cream is packaged and transported to the storage cooler (33°F). Drip-pan waste is generated at the filling machines and uncontained spills and leaks occur at both the filling machines and in the storage cooler.

A fraction of the skim milk in the storage tank is transferred to the buttermilk process. Another fraction is transferred to the pasteurized milk process to be pasteurized and homogenized and sold. The remainder of the skim milk is blended with whole milk from the storage silos in a processing blender to obtain milk with different fat contents. Milk from the processing blender is then sent to the pasteurized milk process, chocolate milk process, and the ice cream mix process.

Pasteurized Milk

Skim, 1/2% fat, 1% fat, 2% fat, and whole milk are received from the skim milk storage tank and blend tank and are pasteurized and homogenized in two HTST presses. The first stage of the HTST press is a regenerator (heat exchanger) section in which heat is transferred from milk already in the press to milk coming into the press. After passing through the regenerator, milk is steam-heated further to 172°F in a vacuumizer where bacteria in the milk are killed. Then it is subjected to a pressure of 1,900 psi in a homogenizer. Following the homogenizer, milk flows back through the regenerator transferring its heat to incoming milk. The milk is then cooled to 36°F in a chilled water heat exchanger and finally to 32°F in a glycol cooling unit. The dairy operates 150- and 180-HP boilers which are used to produce the needed steam. Steam condensate is disposed of to the municipal sewer as is the cooling water because of the risk of contamination. The HTST presses used in all of the dairy processes are washed a total of five times per day with a water rinse and three times per day with an acid wash. Wastewater is disposed of to the municipal sewer. During the washing process, milk remaining in the presses may be contaminated with the acid or it may be diluted with water. Diluted milk is reprocessed and contaminated milk is disposed of in the municipal sewer. Some waste milk is also collected in drip-pans under the presses.

The pasteurized and homogenized milk is then transferred to a 10,000-gal storage tank where it is stored at 33°F. Next, cardboard cartons and plastic jugs are filled with milk from the storage tank and transported to the storage cooler. A third CIP system is used to clean the pasteurized milk lines. This system generates waste cleaning solution which is disposed of in the municipal sewer. Drip-pan waste is generated at the filling machines and spill waste and leaks occur at both the filling machines and in the storage cooler (33°F).

Buttermilk

Skim milk is received from the skim milk storage tank and is pumped to a processing tank. In the processing tank the milk is steam-heated to 186°F for 30 min. (Steam condensate is disposed of in the municipal sewer.) The milk is then cooled to 75°F in the tank with chilled water. (Cooling water is disposed of in the municipal sewer.) At 75°F the milk is inoculated with "ready-set" culture to promote bacterial growth which thickens and flavors the milk. Finally, the processing tank is fed with chilled water to cool the milk to a temperature between 40 and

45°F As the buttermilk tank is emptied, drip-pan waste is generated and spills and leaks occur.

The buttermilk is then pumped to filling machines for packaging and is transported to the storage cooler. Drip-pan waste is generated at the filling machines and leaks and spills occur at both the filling machines and in the storage cooler (33°F). The pasteurized milk line CIP system is used to clean the processing tank and the filling machines.

Chocolate Milk

Milk from the blend tank is pumped to a mixing tank where chocolate powder and fructose are added to the milk. The raw milk line CIP system is used to wash the mixing tank as needed. After the ingredients are mixed, chocolate milk is pasteurized and homogenized in an HTST press, as described in the pasteurized milk process. Following pasteurization and homogenization, chocolate milk is stored in a tank until it is transferred to filling machines for packaging. Finally, packaged milk is transferred to the storage cooler. The pasteurized milk line CIP system is used to wash the storage tank and the filling machines. Drip-pan waste is generated at the filling machines and spills and leaks occur at both the filling machines and in the storage cooler (33°F).

Ice Cream Mix

Milk is received from the blend tank and is mixed in a blender with cream from the cream storage tank, milk powder, fructose, stabilizers, and vanilla. The mixture is then transferred to one of three holding tanks. The raw milk line CIP system is used to clean the blender and the holding tanks.

From the holding tanks the mixture is pumped to an HTST press as described in the pasteurized milk process. Following processing in the press, ice cream mix is stored in a storage tank at 33°F. The mix is then pumped from the storage tank to filling machines where it is packaged and is then transferred to the storage cooler. Drip-pan waste is generated at the filling machines and spills and leaks occur at both the filling machines and in the storage cooler. The pasteurized milk line CIP system is used to clean the storage tanks and the filling machines.

Fruit Drinks

In addition to milk-based products, this dairy also produces several different flavors of fruit drinks. City water is first pumped through a charcoal filter which removes debris and chlorine from the water. Periodic backwashing of the filter results in wastewater which is drained to the municipal sewer. Next, the de-chlorinated water is mixed in a steam-heated mixing tank (168°F) with preservative, liquid juice concentrate, and either sucrose or fructose. Spills of approximately 2,080 gal are drained to the municipal sewer each year.

The drink mixture then enters the small HTST press. Spills, leaks, and contaminated product from the presses are drained to the municipal sewer. There is no drip-pan waste associated with this process.

Drink mixture from the HTST press is then transferred to a surge tank. Finally, the drink mixture is pumped to filling machines where it is packaged in cartons or jugs and transferred to a storage cooler. Spills from the filling machines and the storage cooler are drained to the municipal sewer.

Waste Water

Wastewater streams from the entire dairy are collected in a wastewater collection pit before discharge to the municipal sewer. Most of the waste streams were described previously. Wastewater is also generated in floor washing operations, partially from cleaning up milk spills as they occur throughout the day, but mainly from the practice of turning water hoses on during the entire cleanup shift. The cooling water for the chiller system is also treated as is the daily sanitizing waste from the cleaning of all tanks in the plant during the cleanup shift.

Blow Molding

This dairy produces 1-gal and 1/2-gal jugs used in packaging product. High density polyethylene (HDPE) pellets from a storage silo enter a blend hopper where they are mixed with regrind pellets. Following the blend hopper, the pellets are gravity fed into the extruder barrel, melted at 325°F. and then extruded into molds for blow-molding with compressed air. Jugs are automatically ejected from the mold and trimmed of excess plastic. Next, the jugs are leak tested. Defective jugs and trimming are reground for reuse which results in the generation of dust. Finally, the jugs are labeled and transferred to the filling line.

Existing Waste Management Practices

- Milk solids from the clarifier are trucked offsite by a local farmer for use as fertilizer.
- Drip-pans have been installed to contain milk spills and leaks. The collected waste milk is then transported offsite by a local farmer for use as hog feed.
- Wastewater streams and milk-contaminated waste streams are combined to achieve dilution before discharge to the municipal sewer.

Waste Minimization Opportunities

The type of waste currently generated by the plant, the source of the waste, the quantity of the waste, and the annual management costs are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The type of waste, the minimization opportunity, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given in the table. The quantities of waste currently generated by the plant and possible waste reduction depend on the production level of the plant. All values should be considered in that context.

It should be noted that, in most cases, the economic savings of the minimization opportunities result from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. Other savings not quantifiable by this study include a wide variety of possible future costs related to changing emissions standards, liability, and employee health. It should also be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-814903 by the University City Science Center under the sponsorship of the U.S. Environmental Protection Agency. The EPA Project Officer was Emma Lou George.

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Table 1. *Summary of Current Generation*

Waste Generated	Source of Waste	Annual Quantity Generated (gal)	Annual Waste Management Cost ($)
Milk solids	Clarifier in the raw milk processing line. Milk solids are shipped offsite for use as fertilizer.	65,000	8,800
Drip-pan milk waste	Milk spills and leaks from various processes. The milk is collected in drip-pans; a local farmer transports the waste offsite for use as hog feed.	65,000	790
Uncontained milk waste	Milk spills and leaks from various processes. Uncontained and contaminated milk is sent to the plant's waste collection pit and is discharged into the municipal sewer.	394,000	(see wastewater)
Wastewater	Truck and clarifier washing, milk line washing, HTST press washing, steam condenser water. Wastewater is collected in the plant's waste collection pit and is discharged into the municipal sewer.	37,299,660	194,190 [1]
Spilled fruit juice	Fruit juice spills from process line. Waste fruit juice is collected in the plant's waste collection pit and is discharged into the municipal sewer.	6,340	(see wastewater)
High density polyethylene dust	Blow molding of jugs. Dust is generated during regrind of defective jugs.	1,300	0 [2]

[1] Includes costs for monitoring plant effluent; plant labor costs for sampling, testing, handling, and record keeping; surcharges imposed by the POTW; and sewer charges.
[2] The plant reports no cost associated with the disposal of this waste.

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Waste Generated	Minimization Opportunity	Annual Waste Reduction Quantity (gal)	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Payback Years
Uncontained milk waste	Institute a wastewater management plan.	147,810	38	$320,810	$661,200	2.1
Wastewater	• Begin an ongoing employee training and awareness program to minimize milk spills due to human error and to minimize water usage due to lazy maintenance practices. • Minimize the use of water for clean-up through the use of high pressure nozzles and automatic shut-off nozzles on hoses. • Install an activated sludge treatment system to treat the wastewater collected in the waste pit before discharge to the POTW. Currently, the effluent does not meet the POTW's standards and surcharges are being assessed.	14,601,600	39			

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