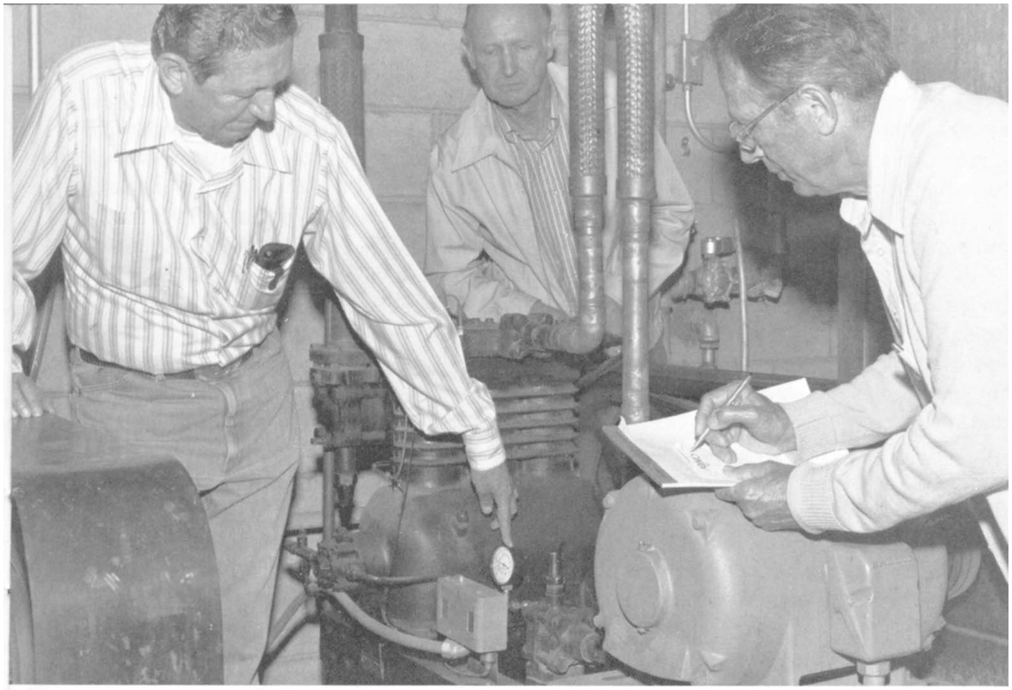

Above: Dairy Farm Advisor Richard Eide, Extension Agricultural Engineer William Fairbank, and Dairy Farm Advisor Herbert Etchegaray take note of refrigeration system head pressure to determine the limits of waste heat recovery. *Below:* Etchegaray reads the water meter installed by Hanford Dairyman Henry Veenendaal to record hot water usage.

Hot water consumption in milking parlors

A study by the Dairy Energy Committee of Fresno, Kings, and Tulare counties

William C. Fairbank
Richard N. Eide
Herbert S. Etchegaray
Gale G. Gurtle

Heating water for cleaning and sanitizing milking equipment is a twice-daily energy load that is uniform and quite independent of weather and farm events, and might be shifted to alternative sources of energy. Solar energy has been actively promoted by its advocates and has been intensively researched at the USDA Beltsville Agricultural Research Center and elsewhere. However, difference in climate and form of dairy operation in the west makes questionable the extrapolation of this research from eastern states.

Additionally, the general installation in California of very large pipeline milking systems (VLP) and automatic teat cup detachers (AD), and improved clean-in-place (CIP) techniques obviate previous estimations of how much hot water is required. For planned dairy energy use studies, it was necessary to measure hot water usage for cleaning purposes on typical contemporary dairies under actual conditions. (The majority of dairies in the four countries of this study do not use warm water for cow preparation; any hot water used routinely for this purpose was not included in the data.)

For energy use planning, evaluation of alternative energy sources, and on-dairy energy use management, a simple way to predict average hot water demand would be desirable. Allocation of limited fuels and the design of electrical distribution systems for the dairy load in rural areas could be facilitated if, for example, each dairy could be expected to have a hot water demand proportional to the number of cows in the milking herd. The number of milking units in use or planned is easily tallied and is obviously related in some way to cow populations and, perhaps, to hot water use. The "size" of each pipeline milking system (other than the number of milking units) would seem related to the use of hot cleaning water, independent of both herd size and the hours of operation per day.

The purpose of this study was to test the usefulness of number of cows, number of milking units in use, and size of the milking system to predict hot water use on a regional average.

Water meters were placed on the inlets to heaters in several representative milking parlors. Data were collected for 2 to 8 weeks at each installation from fall of 1976 to summer of 1977. Initially, meters were read daily but the uniformity of consumption suggested that weekly totals were adequate. Variation from day to day is attributable to many human and mechanical factors including, most notably, some less than daily cleaning of surfaces not in contact with milk. The averaging effect of weekly or even monthly totals of hot water use seems adequate for energy system planning (see table 1).

Time-temperature relationships for milking system cleaning are specified by dairy inspection agencies. (Recirculation of cleaning solution for 10 minutes above 120F at the return thermometer is the usual recommendation. T_{start} = 160F ±; T_{finish} = 120F ±; $T_{state\ min.}$ = 115F.) The operator, then, has no direct control over the basic quantity of hot water needed. Specific heat of stainless steel is 12 percent that of water. The energy represented by thermal come-up of tap water from 68F (± 3°) to 165F (assume the water temperature rise, ΔT, will be 100) is much greater than the sum of the ultimate heat content of the equipment plus the concurrent cooling effects of the air and parlor surroundings.

Ambient temperature variations during the several months of observations appeared to have only minor effect on hot water use. The washing procedure was not particularly varied and the time-temperature relationships were not noticeably different due to weather or seasonal changes. This reflects the average closeness of air and tap water temperatures in these parlors, and the uniformly high ground water temperature in these dairy regions.

Milk contact surfaces in a modern milking system are stainless steel, (synthetic) rubber, or certain approved plastics. Raising the temperature of the equipment from near ambient (or lower, as in plate coolers and milk tanks) to 140F or higher accounts for the initial heat loss from the hot wash water. Radiation and convection losses are relatively minor because the return flow temperature seldom exceeds 140F.

The volume of hot water for cleaning the system, then, is approximately proportional to the mass or surface area of the stainless steel (S/S equipment plus galvanized wash tanks). The measured or estimated total outer surface area of the clusters (assemblage of four teat cups, claw, connecting pulse, and milk tubes), all S/S tubing, milk receiver, plate-type cooler, milk tank, and wash tank is a close approximation of the heat loss surface, as well as being the most valid index of system size.

A milking unit cluster has an estimated surface area and equivalent heat loss factor of 1.0 square foot, and each CIP cluster washer station is estimated to be equivalent to .5 square foot. In-line milk filters are all 4 inches diameter and approximately 3 feet in height, giving an equivalent heat loss surface of 3.5 square feet. Milk receivers are calculated as right circular cylinders being of all S/S construction. Plate coolers are measured for overall thickness (proportional to their number of plates) and are then calculated as if they were a S/S box of this thickness, 1 foot wide and 3 feet tall.

Wash tank surface area is calculated from its specific dimensions plus a 1-inch wide lip flange around its periphery. Milk tank liner surface is calculated from the measured or from the manufacturer's specified inside dimensions and geometry. Late model tanks are right circular or elliptical cylinders; the heat loss surface area of lidded tanks includes area of the lids.

Dairy H (table 1) took shortcuts in the washing process and did not use an adequate volume of cleaning water. The data were analyzed with and without this non-conforming sample. The correlations of number of cows, number of milking units in use, washed surface area, and hours of milking per day with hot water consumption in the parlor (less any hot water used for cow preparation) were examined by regression analysis. These are summarized in table 2.

There was a significant correlation between the number of cows in the milking herd and the use of hot water. A milking system is normally totally washed twice each day, following the morning and evening milkings—regardless of the number of cows milked. Thus, milking the

TABLE 1. Hot Water Usage in Eight Dairies

Dairy	Parlor size and style	Milk pipeline configuration	No. of cows	No. of units	No. of cows per unit	Hours operation per day	AD/CIP	Average hot water usage	Washed surface	Gallons hot water per		
									square feet	cow	unit	square foot
A	2x10 HB	3-OCL	280	10	28	10.5	no	283	490	1.0	28	.58
B	2x16 FO	2½ WL	300	16	19	8.5	yes	338	670	1.1	21	.51
C	2x10 HB	2½ DCL	420	14	30	9	no	304	622	.72	22	.49
D	1x10 BO	3 OCL	385	10	39	9	no	225	546	.58	23	.41
E[1]	32PG	3 DCL	673	32	21	10.5	yes	520	878	.80	16	.59
F	2,2x4 SO	2½ WL	849	16	53	16	yes/no	518	956	.61	32	.54
G[2]	2x10 HB	3 WL	404	20	20	12.5	yes	205	581	.51	10	.35
H[2]	2,2x12 HB	3 DCL	1600	24	67	20	yes	491	1819	.31	20	.26

Code

HB—Herringbone
FO—Face-out
BO—Back-out
PG—Polygon
SO—Side opening

CL—Close loop
OCL—Overhead close loop
WL—Wide loop
DCL—Double close loops
AD/CIP—Auto detachers/clean-in-place

[1]No separate metering to water heater. Gallonage estimated from total water and electricity use.
[2]Dairy located in southern California.

largest number of cows per day (without enlarging the pipeline system) would be the most efficient use of the hot water.

In general, larger dairies use less hot water per cow because more cows are milked in a given size installation. The number of cows in the milking herd can, then, be used as a factor in hot water demand, at the average rate of about .8 gallon per day per cow for a dairy region. This range might be adjusted upward .2 gallon for dairies with considerably fewer than 500 cows, and downward .2 gallon for dairies with considerably more than 500 cows.

The number of milking units in use has no relationship to hours of operation per day or number of cows in herd, and is not a realistic criterion of hot water requirement.

The washed surface area proved to have the strongest correlation to the actual use of hot cleaning water, as common knowledge of cleaning principles would suggest. Unfortunately, determination of the surface area requires considerable on-site measuring and calculation, and is not a quick and convenient energy demand factor.

TABLE 2. Significance of Various Hot Water Demand Factors

Hot water use vs.	r	Significance
		percent
No. of cows: All dairies	.6972	5
: excluding dairy H	.8346	1
No. of milk units: all dairies	.6414	10
Washed surface: all dairies	.6928	5
: excluding dairy H	.9358	.1
Hours milking per day	−.7168	5

Increasing the hours of milking time per day does not increase water use: milking more cows with a given system is therefore a means of water conservation.

Summary

There are innumerable variations in milking parlor design, size, pipeline configuration, and management. This study was limited to locations where the owner/operator already wanted to know how much hot water was being used and could be depended upon to assist in collecting reliable data, and where installation of water meters was relatively convenient.

Hot water use in modern milking parlors for cleaning and sanitation of pipeline milking systems with their ancillary equipment and including automatic teat cup detachers and CIP methods would appear to average about .8 gallon per day per cow in herd, on a regional basis.

Any specific milking machine installation appears to be using on a weekly average about .5 gallon of hot water per day per square foot of washed (milk contact) surface.

William C. Fairbank is Agricultural Engineer, Cooperative Extension, statewide. Richard N. Eide is Farm Advisor, Fresno County; Herbert S. Etchegaray is Farm Advisor, Kings County; Gale G. Gurtle is Farm Advisor, Tulare County.

Metering equipment and installation assistance for this energy use study was provided by Pacific Gas and Electric Company, Southern California Edison Company and the water departments of Fresno, Hanford and Visalia and is hereby gratefully acknowledged.

Control of Botrytis fruit rot in strawberry

Albert O. Paulus ■ Victor Voth ■ Jerry Nelson ■ Howard Bowen

Botrytis fruit rot, commonly known as gray mold rot, is the major fruit rot of southern California strawberries. It is caused by the fungus, *Botrytis cinerea*, which thrives in wet conditions and cool temperatures. Botrytis spores are produced in tremendous quantities and are carried by the wind. The fungus usually attacks through senescent dead petals, stamens, or other delicate plant tissue. Much of the infection of the fruit originates at the stem end, but the fungus is able to penetrate the unbroken skin of the berry. A trial to control botrytis fruit rot with fungicides was initiated in the spring of 1977.

1977 trial

The 1977 trial, using Tioga and Tufts strawberries, was conducted at the University of California South Coast Field Station near Santa Ana. Polyethylene mulch was used in all plots. Plots consisted of 12 strawberry plants and were replicated five times. Fungicide spray applications were made with a 2-gallon Hudson CO_2 sprayer at 30 psi. The plot was mist irrigated 4 times daily to enhance development of Botrytis fruit rot.

Sprays were applied on March 7, 17, and 27 and April 6, 15, and 25. Yield and counts of rotted fruits were taken on March 30 and April 6, 13, 20, and 27. The Tioga variety results are given in the table.

Effect of Various Fungicide Treatments on Strawberry Yield and Botrytis Fruit Rot Control, 1977-Tioga

Treatment*	Yield† (tons per acre)	No. of rot-affected fruit†
BASF 352 50W, 16 oz	16.26 a	47 a
Captan 50W, 3 lb + benlate 50W, 8 oz	14.81 ab	76 b
Captan 50W, 3 lb	14.27 b	111 b
Thiram 65W, 2 lb	13.92 b	98 b
Boots 7544 25% EC, 20 oz	13.1 b	100 b
Control (No treatment)	11.74 c	156 c

*Fungicide rates are per 100 gallons of water, and the fungicidal mixtures were applied at 200 gallons per acre.
†Significant at the 5% level. Treatments with the same letter are not significantly different.

BASF 352 and captan + Benlate gave the highest yield in the Tioga variety, but only BASF 352 produced the least number of rot-affected fruit. All fungicide treatments were significantly better than the control.

None of the fungicides used on the Tufts variety increased yield over the control, but BASF 352 gave significantly less Botrytis-affected fruit.

BASF 352 is commercially available in Europe for control of Botrytis fruit rot of strawberry and hopefully will become available in the United States. Captan, thiram, and Benlate are currently registered for Botrytis control.

Albert O. Paulus is Extension Plant Pathologist, and Jerry Nelson is Staff Research Associate, UC Riverside. Victor Voth, Pomologist, and Howard Bowen, Staff Research Associate, Department of Pomology, UC, Davis, are located at the South Coast Field Station, Santa Ana.