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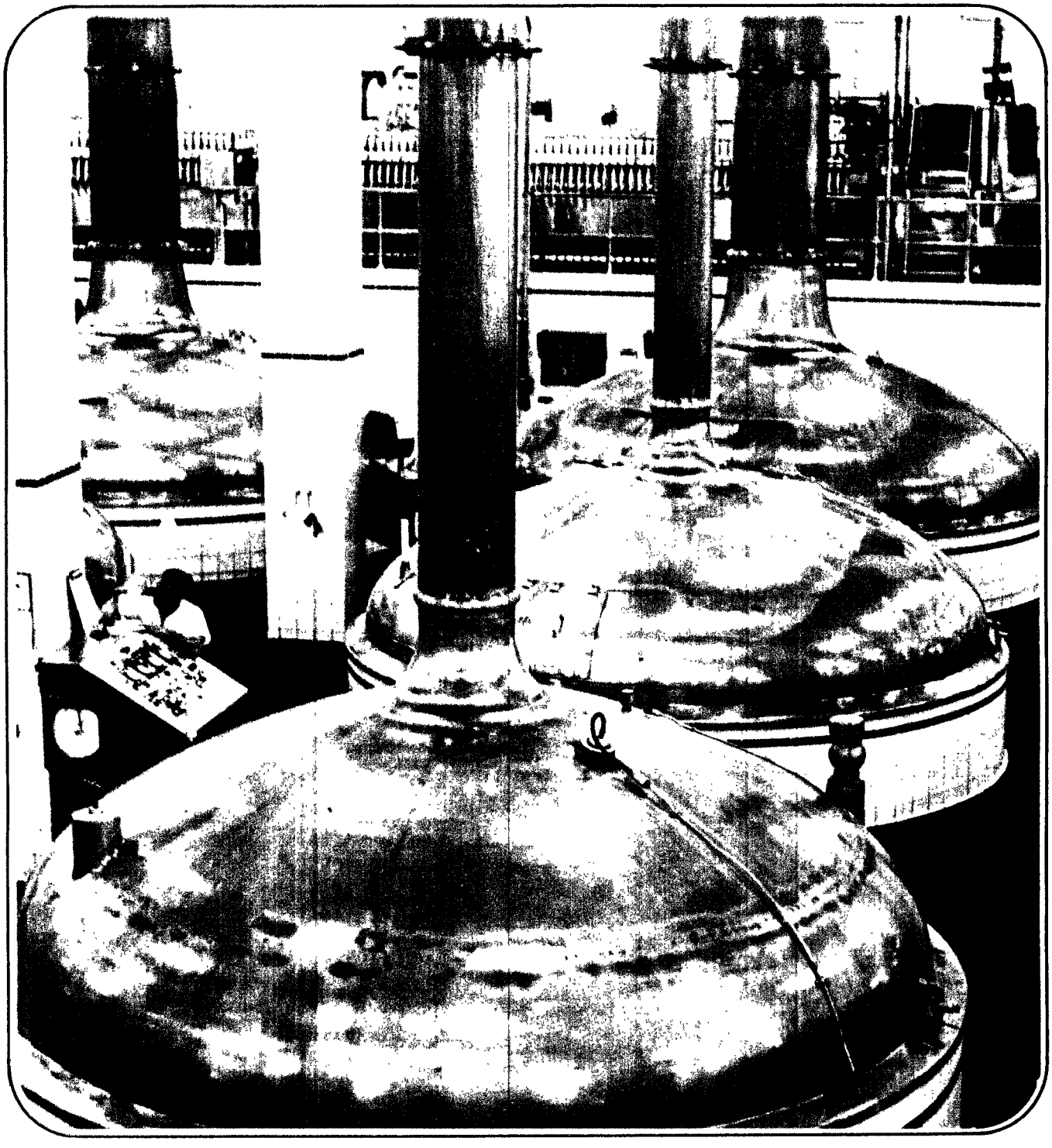
EPA TECHNOLOGY TRANSFER

CAPSULE REPORT

POLLUTION ABATEMENT IN A BREWING FACILITY

PREPARED BY U.S. ENVIRONMENTAL PROTECTION AGENCY



6 EPA TECHNOLOGY TRANSFER CAPSULE REPORT

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1. THE SIGNIFICANCE

The brewing industry in the United States is comprised of 185 facilities producing malt beverages including beer, ale, and "malt liquor". Half of these are large facilities with individual water consumption rates exceeding 20 million gallons each per year and a combined water usage rate of more than 140 billion gallons per year. About 60 billion gallons of the water used annually in these major facilities are discharged as wastewater. The mean raw waste loading levels for the large brewing facilities are 3.05 lb/bbl beer (1622 mg/l) Biochemical Oxygen Demand (BOD) and 1.24 lb/bbl beer (772 mg/l) suspended solids. These concentrations of oxygen-demanding organic materials and suspended solids in the wastewater, at the quantities discharged, are sufficiently high to potentially cause oxygen depletion and sedimentation buildup in streams unless adequate treatment is provided. Therefore, treatment must be provided at either the brewery facility or at a municipal waste treatment plant prior to discharge to a stream.

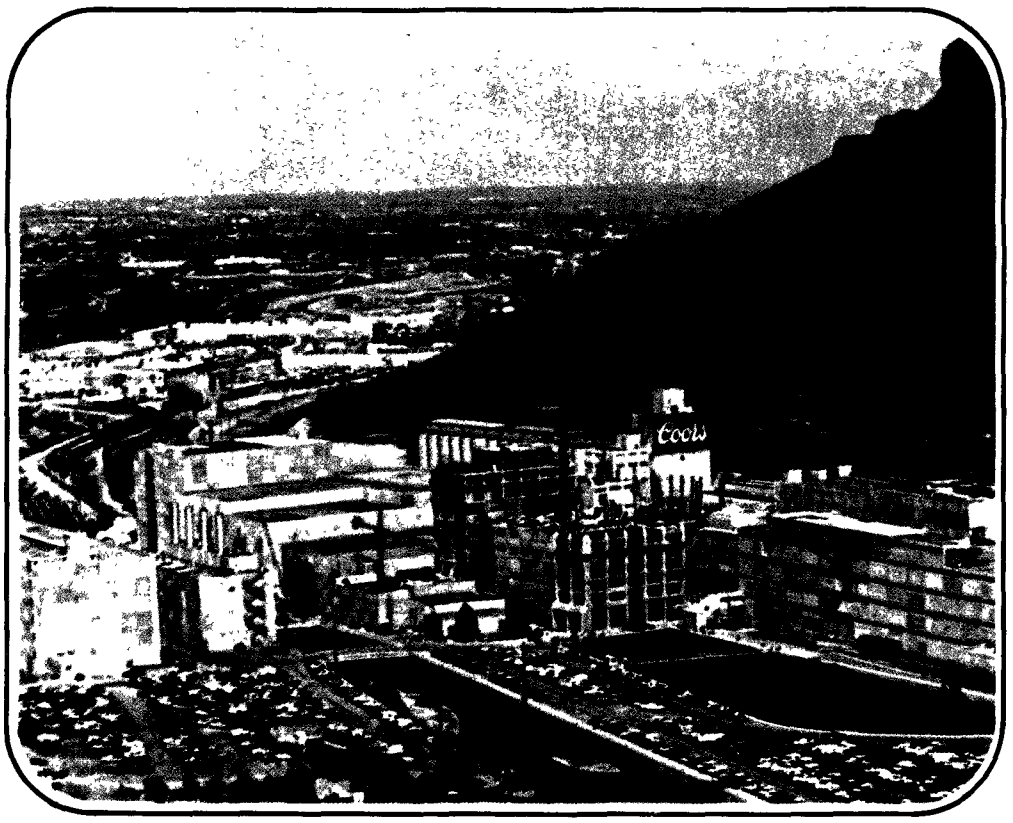
The Adolph Coors Company, now the fourth largest brewer in the United States, produces all of its malt beverages in one facility located at Golden, Colorado. The Golden facility is the largest single brewery in the world, presently producing in excess of 10.5 million barrels of beer per year.

Coors began its pollution control efforts in 1951 with the construction of a waste treatment facility and the initiation of a conservation program to reduce in-plant water usage and waste discharges. This success is due, in part, to the top priority given to the waste reduction and treatment effort by Coors management. During the past 22 years Coors has been successful in reducing the raw waste loading to less than half of the brewing industry mean raw waste levels through engineering design improvements and changes in operating practice. The raw waste from the plant is treated in the Coors waste treatment facility which provides both primary and secondary treatment. The effluent containing about 30 mg/l BOD and suspended solids is discharged from the waste treatment facility into Clear Creek, a tributary of the South Platte River, which passes through the plant site. Through these and other efforts, Coors has earned the U. S. Environmental Protection Agency's Region Eight environmental achievement award for its total environmental program which included aluminum and glass recycling, waste treatment, air and sound pollution control and environmental planning.

This report was written to show the degree of effluent reduction and savings in waste treatment facility capital and operating costs that can be achieved through a well planned and well executed environmental control program.

Coors Copper Brewing Kettles

2. THE PROCESS



Adolph Coors Company Brewery, Golden, Colorado.

The Coors plant at Golden is both a brewing and malting facility. The barley malt used in brewing is produced at the facility. The process flow diagram for the production of beer at the plant is shown in Figure 1.

Throughout the process care is taken to minimize water usage, prevent beer or by-products from entering the waste stream, and recover as much of the protein-rich by-product material as possible for marketing as animal feed or feed supplements. The recovery systems are economically feasible in addition to providing for a significant reduction in the waste load. In designing new facilities or modifying existing equipment considerable attention is given to conserving water and reducing waste loads.

The production of beer begins with the malting operation where barley is soaked in water in steeping tanks and transferred to germinating compartments for approximately one week to convert the starch in the barley into malt sugar. The germinated barley is transferred to the malt drying kiln where the heat stops the barley's growth and partly caramalizes the malt to produce the desired beer color and flavor. The malt, or dried sprouted barley, is then finely ground for use in the brewing operation. The malt sprouts and screenings are added to the dried waste solids and subsequently ground, pelletized, and marketed as animal feed.

In the brewing operation finely ground malt and brewers rice are added to water in the copper mash kettle, or mash tun, where the mixture is heated to complete the conversion of starch to malt sugar.

The mash is then filtered through a plate and frame filter and the extract is sent to the brew kettle. The spent grain filter cake drops from the filter into a hopper and is pumped away with no additional sluicing water required. Coors installed the plate and frame filter rather than the commonly used Lauter tub because the extract can be separated from the spent grain in the plate and frame filter with minimal water usage. The Lauter tub has the

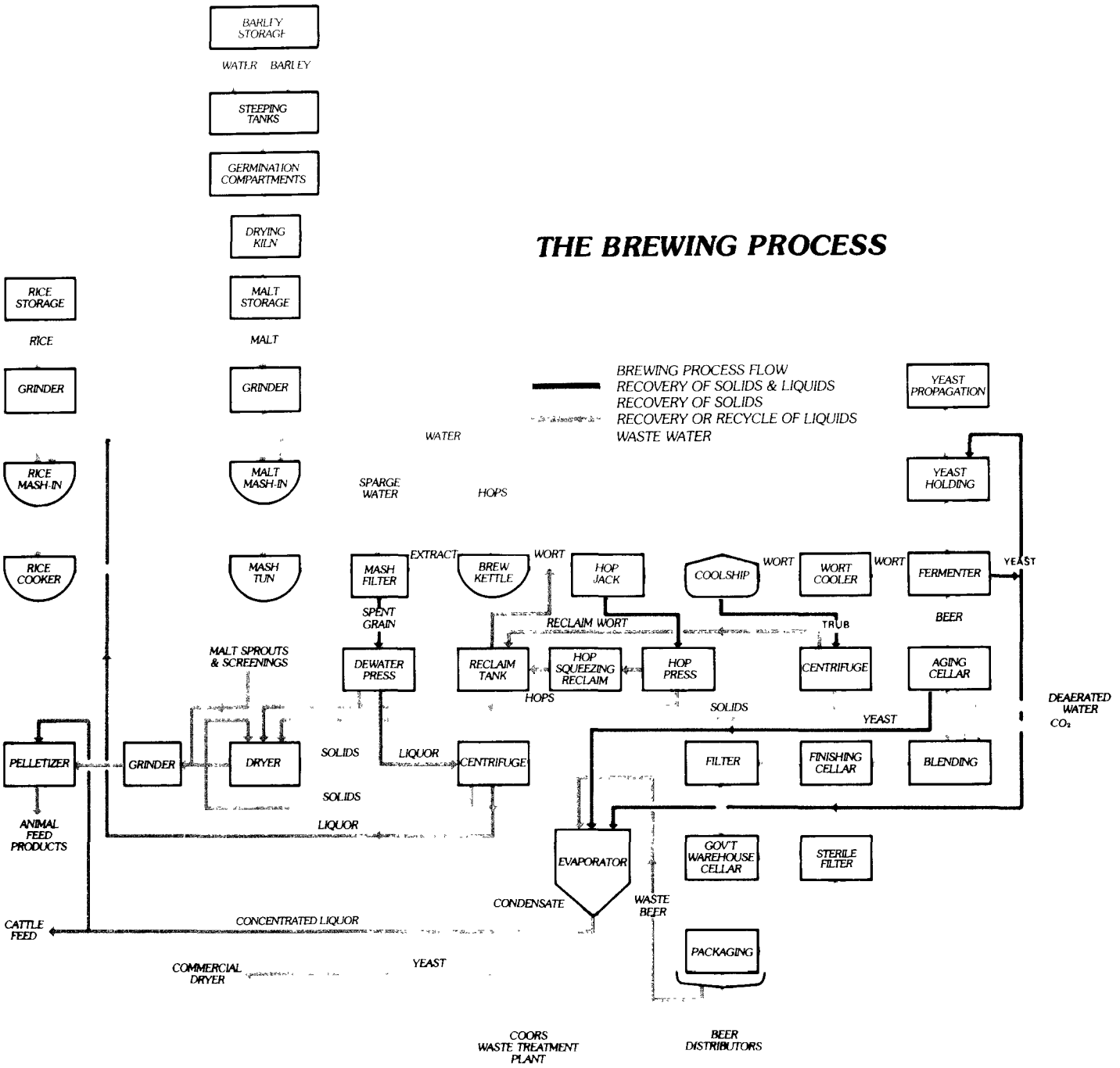

THE BREWING PROCESS
BREWING PROCESS FLOW
RECOVERY OF SOLIDS & LIQUIDS
RECOVERY OF SOLIDS
RECOVERY OR RECYCLE OF LIQUIDS
WASTE WATER
BARLEY STORAGE
WATER
BARLEY
STEEPING TANKS
GERMINATION COMPARTMENTS
DRYING KILN
MALT STORAGE
MALT
GRINDER
RICE STORAGE
RICE
GRINDER
YEAST PROPAGATION
YEAST HOLDING
WATER
SPARGE WATER
HOPS
RICE MASH-IN
MALT MASH-IN
RICE COOKER
MASH TUN
MASH FILTER
EXTRACT
BREW KETTLE
WORT
HOP JACK
COOLSHIP
WORT
WORT COOLER
WORT
FERMENTER
YEAST
BEER
SPENT GRAIN
RECLAIM WORT
TRUB
MALT SPROUTS & SCREENINGS
DEWATER PRESS
RECLAIM TANK
HOP SQUEEZING RECLAIM
HOP PRESS
CENTRIFUGE
AGING CELLAR
HOPS
SOLIDS
YEAST
DEAERATED WATER
CO_2
PELLETIZER
GRINDER
DRYER
SOLIDS
LIQUOR
CENTRIFUGE
FILTER
FINISHING CELLAR
BLENDING
SOLIDS
LIQUOR
ANIMAL FEED PRODUCTS
EVAPORATOR
GOV'T WAREHOUSE CELLAR
STERILE FILTER
CONDENSATE
WASTE BEER
CATTLE FEED
CONCENTRATED LIQUOR
PACKAGING
COMMERCIAL DRYER
YEAST
COORS WASTE TREATMENT PLANT
BEER DISTRIBUTORS

FIGURE 1

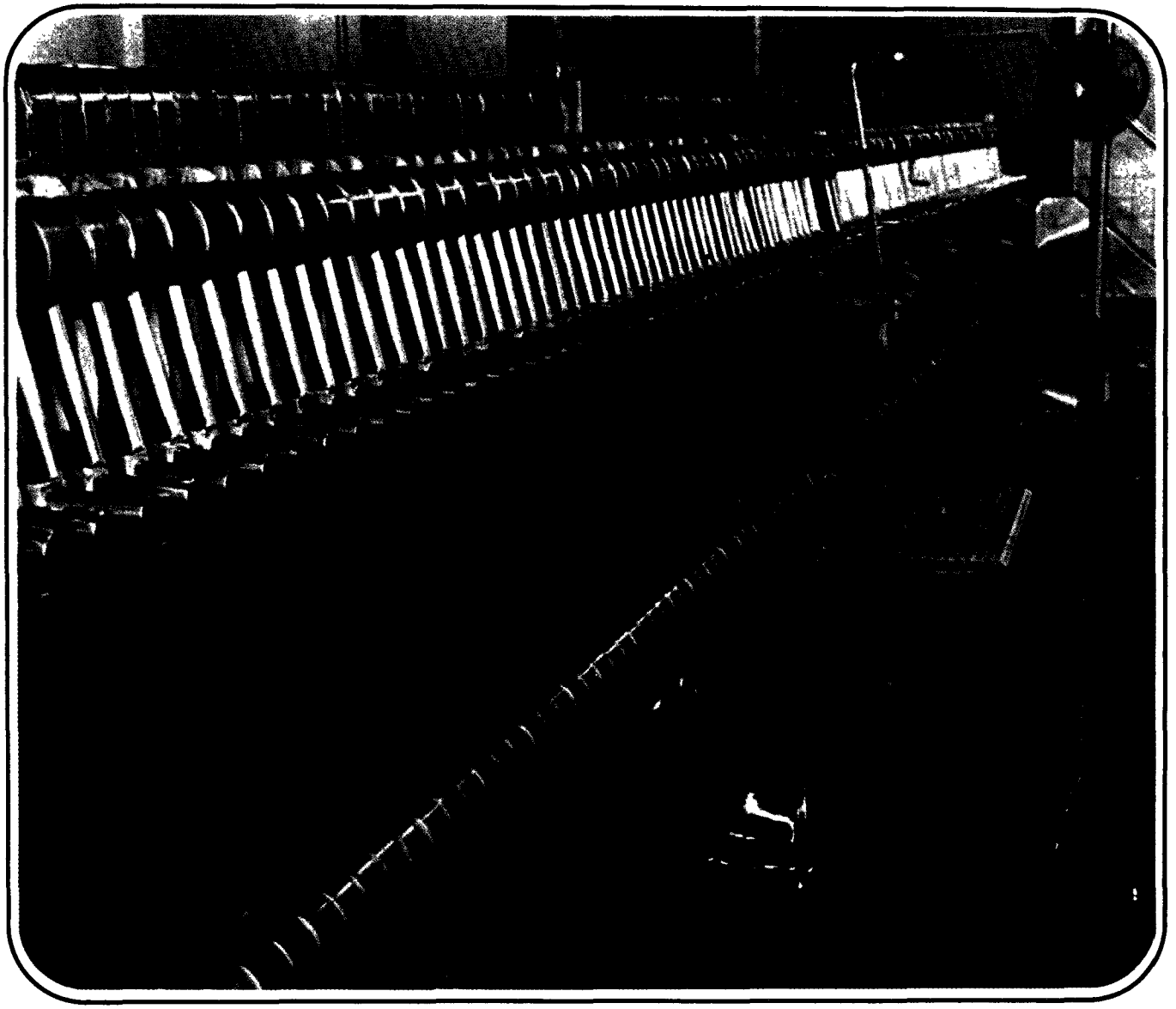


Plate and Frame Filter

disadvantage of requiring a considerable amount of water to sluice out the spent grain.

The spent grain is then dewatered in a screw press and dried in a steam drier. The spent grain liquor from the screw press is centrifuged to remove the solids. These solids are added to the spent grain which is marketed as cattle feed. The centrifuged liquor is then returned as make-up to the rice mash-in operation.

In the brew kettle, the malt extract is boiled vigorously with hops to add flavor and aroma. The hot malt extract, called wort, is then pumped to a large circular coolship (clarifier) where insoluble proteins coagulate and are settled out. This wet coagulate called trube is then sent to a centrifuge to separate the solids from the wort. The recovered liquid wort is recycled into the process and the trube solids are added to the spent grain. The wort flows from the coolship to a cooler where

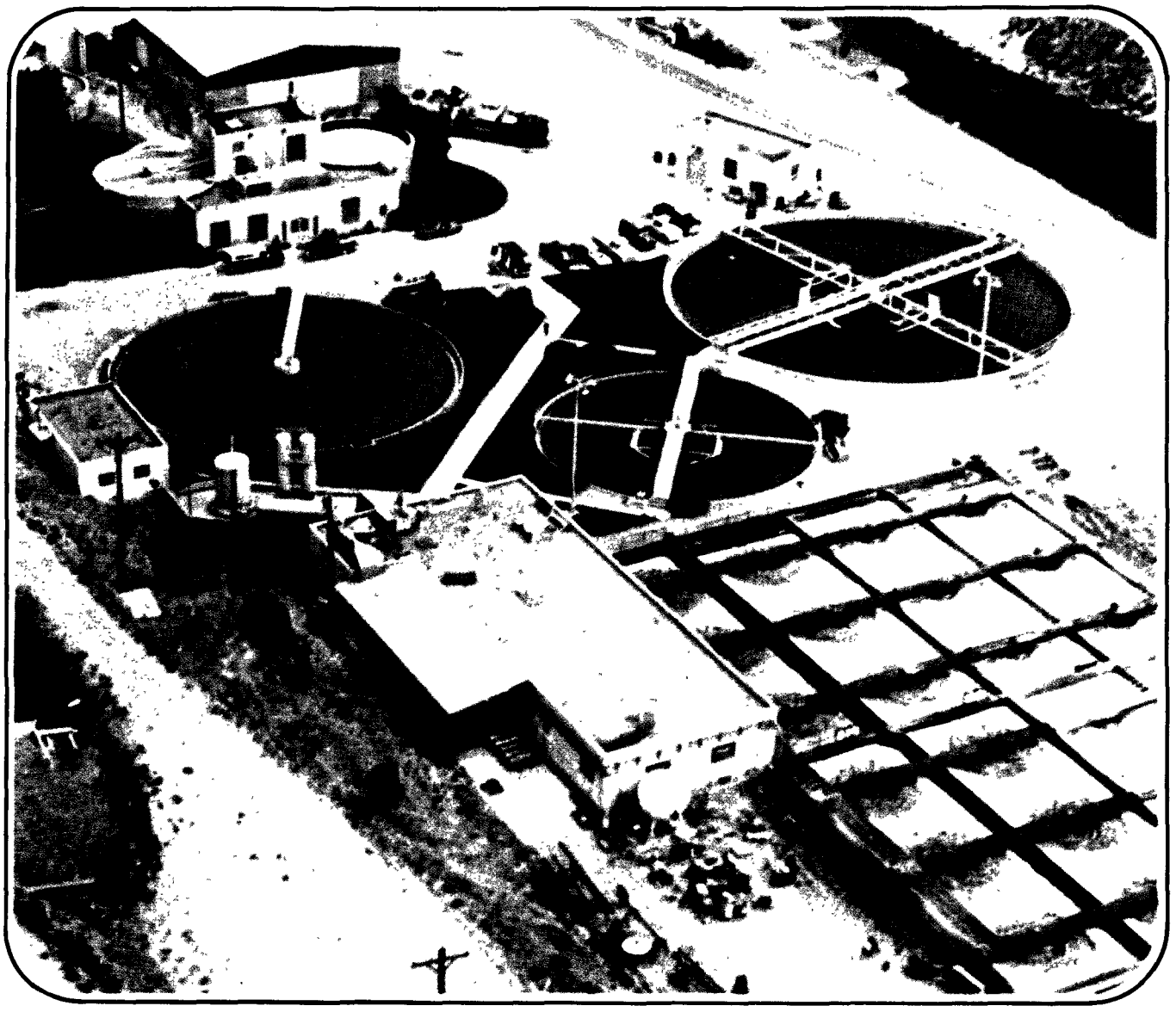
Coors Bottle Filling Room

it is cooled to achieve fermentation temperature.

Specially prepared yeast cultures grown at the plant are added to the cooled wort in the fermentation tanks. In the carefully controlled primary fermentation step, the yeast converts the malt sugar in the wort into alcohol and CO_2 gas. The fermented beer is then transferred to glass-lined aging tanks for its secondary fermentation and aging period. Aging under pressure permits beer to build up its own natural carbonation.

After aging, the beer is chilled and pumped through batteries of filters for clarification. The spent filter pads are removed and processed for reuse. The beer flows from the filters to sterile filling rooms for packaging.

3. THE RAW WASTE



Waste Treatment Facility

Wastes generated from the Coors combined brewing and malting operations amount to 3.3 million gallons per day at a BOD level of 825 mg/l. This is less than half the waste load produced by the average large brewery without malting facilities.

Table 1 shows the low rate of waste discharge achieved at Coors by a continuing program of water conservation, in-plant waste reduction and recovery of waste materials as by-products. The quantities of wastewater from in-plant sources contributing to the overall raw waste load are shown in Table 2. This table shows the significant reductions in raw waste volume that Coors has achieved relative to the brewing industry mean raw waste loads from in-plant sources including cooling water, cleaning, filtration, fermentation brewing and

OVERALL PLANT RAW WASTE CHARACTERISTICS

Parameter	Coors Raw Waste Loads [1]	Brewing Industry Mean Raw Waste Loads [2]
Raw Waste Volume	108.5 gal/bbl [3] beer	257 gal/bbl beer
Raw Waste BOD	0.75lb/bbl beer (825 mg/1)	3.05 lb/bbl beer (1622 mg/l)
Raw Waste Suspended Solids	0.26 lb/bbl beer (280 mg/l)	1.24 lb/bbl beer (772 mg/l)

[1] *Based on average at Coors for month of June 1973.*

[2] *Industrial Waste Survey of the Malt Liquor Industry SIC No. 2082 prepared for the Environmental Protection Agency, August 1971, by Associated Water and Air Resources Engineers, Inc.*

[3] *One barrel contains 31 gallons.*

Table 1

RAW WASTE CONTRIBUTIONS FROM IN-PLANT SOURCES

Source of Raw Waste	Coors Raw Waste Loads [1] (gal/bbl beer)	Brewery Industry Mean Raw Waste Loads [2] (gal/bbl beer)
Cooling Water	3.1	43.5
House Cleaning	15.5	21.8
Aging	24.8	12.4
Filtration	6.2	21.8
Fermentation	6.2	9.3
Brewing	9.3	37.3
Malting	40.3	—
Other	3.1	111.6
TOTAL	108.5	257.7

[1] *Based on average at Coors for month of June 1973.*

[2] *Industrial Waste Survey of the Malt Liquor Industry SIC. No. 2082 prepared for the Environmental Protection Agency, August 1971, by Associated Water and Air Resources Engineers, Inc.*

Table 2

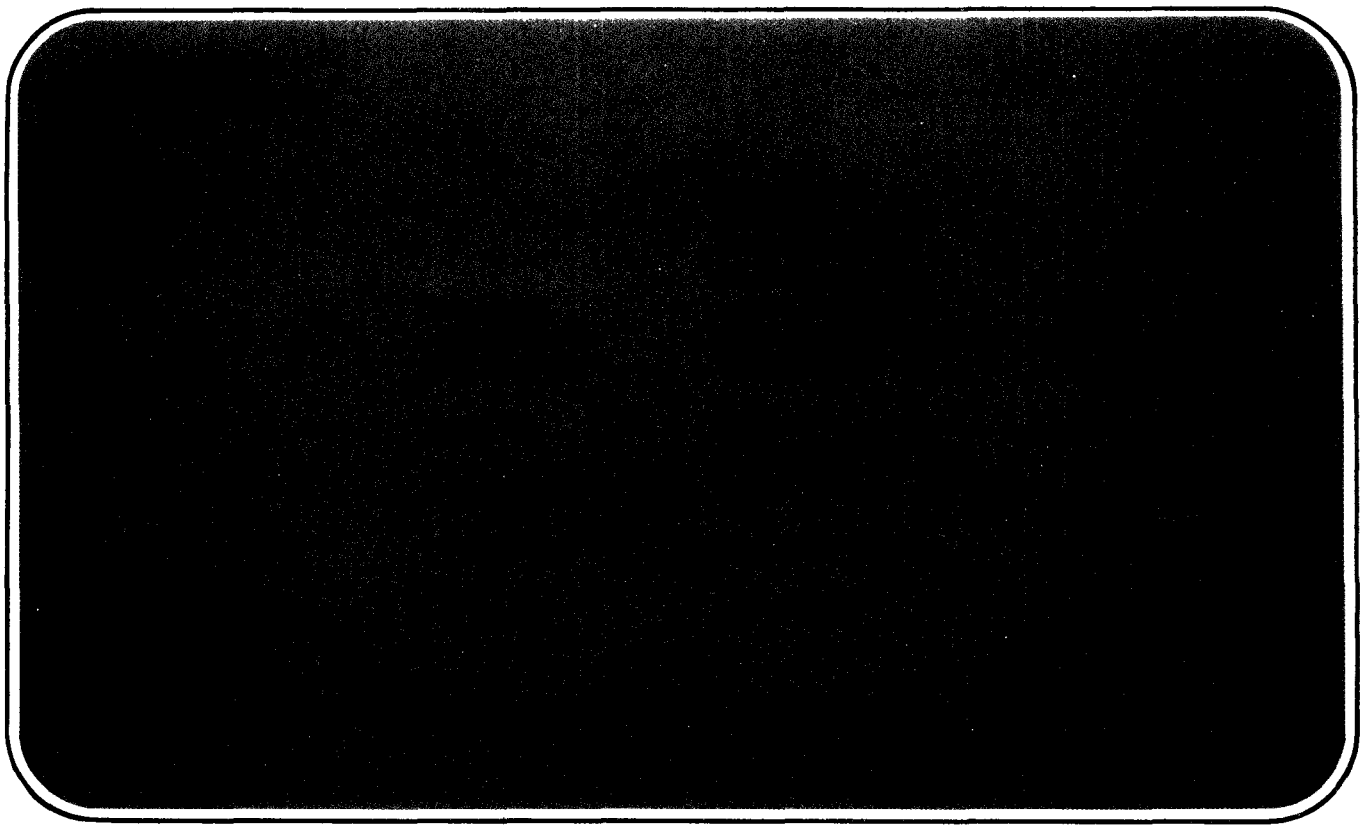
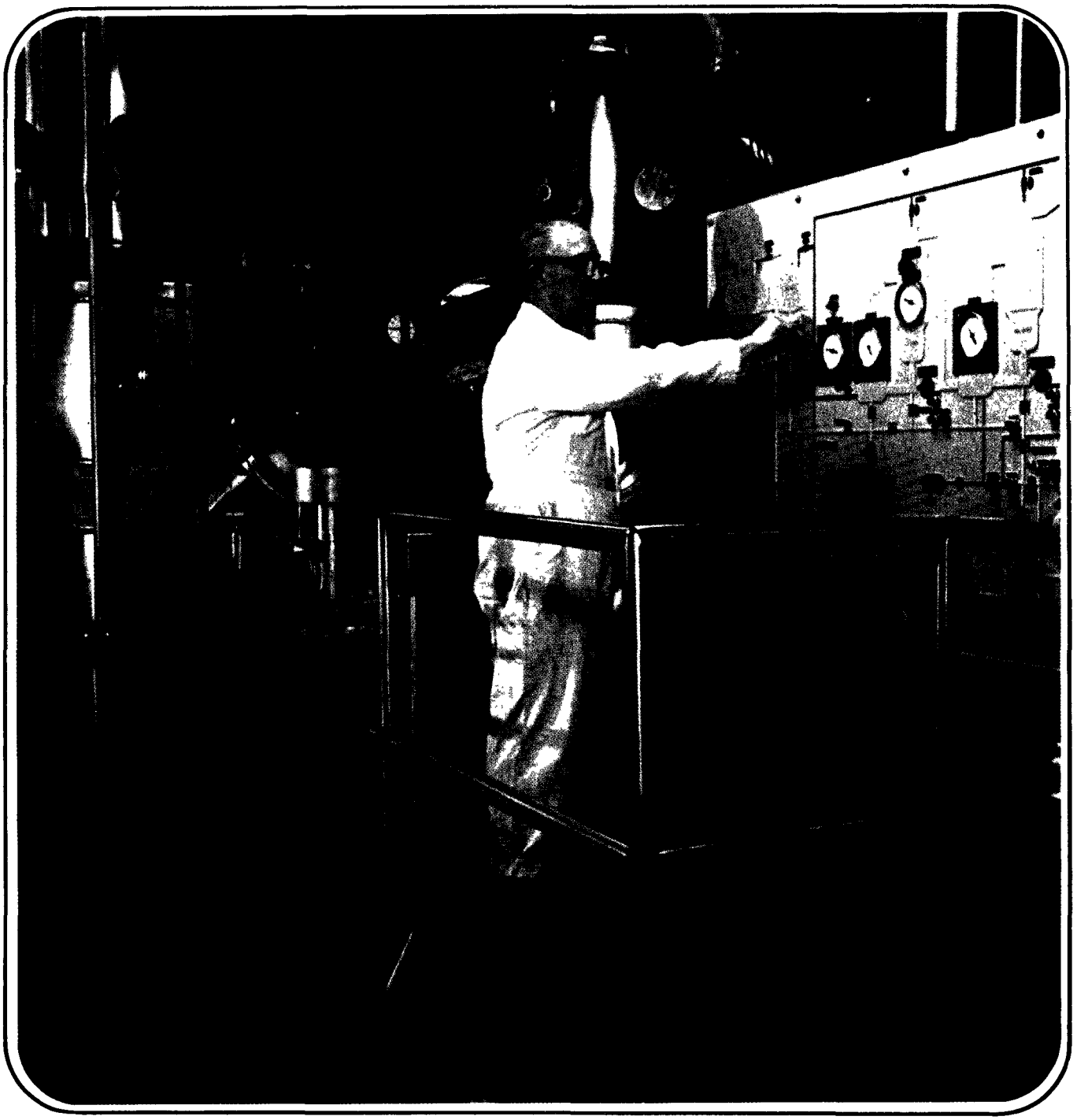


Table 3

other sources. Table 3 compares the present Coors raw waste quantities with the discharge that would be produced at the facility if the raw waste discharge per barrel of beer produced were equal to the mean levels for the brewery industry.



Double Effect Evaporator Used for Concentrating Waste Beer and Spent Grain Liquor into Cattle Feed Syrup

4. THE WASTE TREATMENT SYSTEM

The Coors waste treatment facility shown in Figure 2, provides primary treatment through neutralization and solids removal, and secondary treatment through a high rate activated sludge system using a modification of the Hatfield Process.

The raw waste first flows through a bar screen and a grit chamber to remove coarse solids. The raw waste is continuously monitored and adjusted to a pH of 7 by an automatic control system. The effluent then flows into a 550,000 gallon surge chamber which is used to equalize the flow in the waste treatment plant. The batch processes used in producing beer make flow equalization and pH control necessary in order to provide for optimum performance of the treatment system. The waste is pumped out of the surge tank and into the primary clarifier at a constant rate.

Effluent from the primary clarifier then enters the activated sludge portion of the plant and is mixed in the aeration basins with return sludge from the secondary clarifier. Mixed liquor contact time in the aeration basins is about ten hours. Twenty-four surface aerators rated at 20 horsepower each are used to maintain the dissolved oxygen level at about 2 mg/1.

Mixed liquor then flows from the aeration basins to the secondary clarifiers. Clarified effluent is chlorinated and returned to Clear Creek.

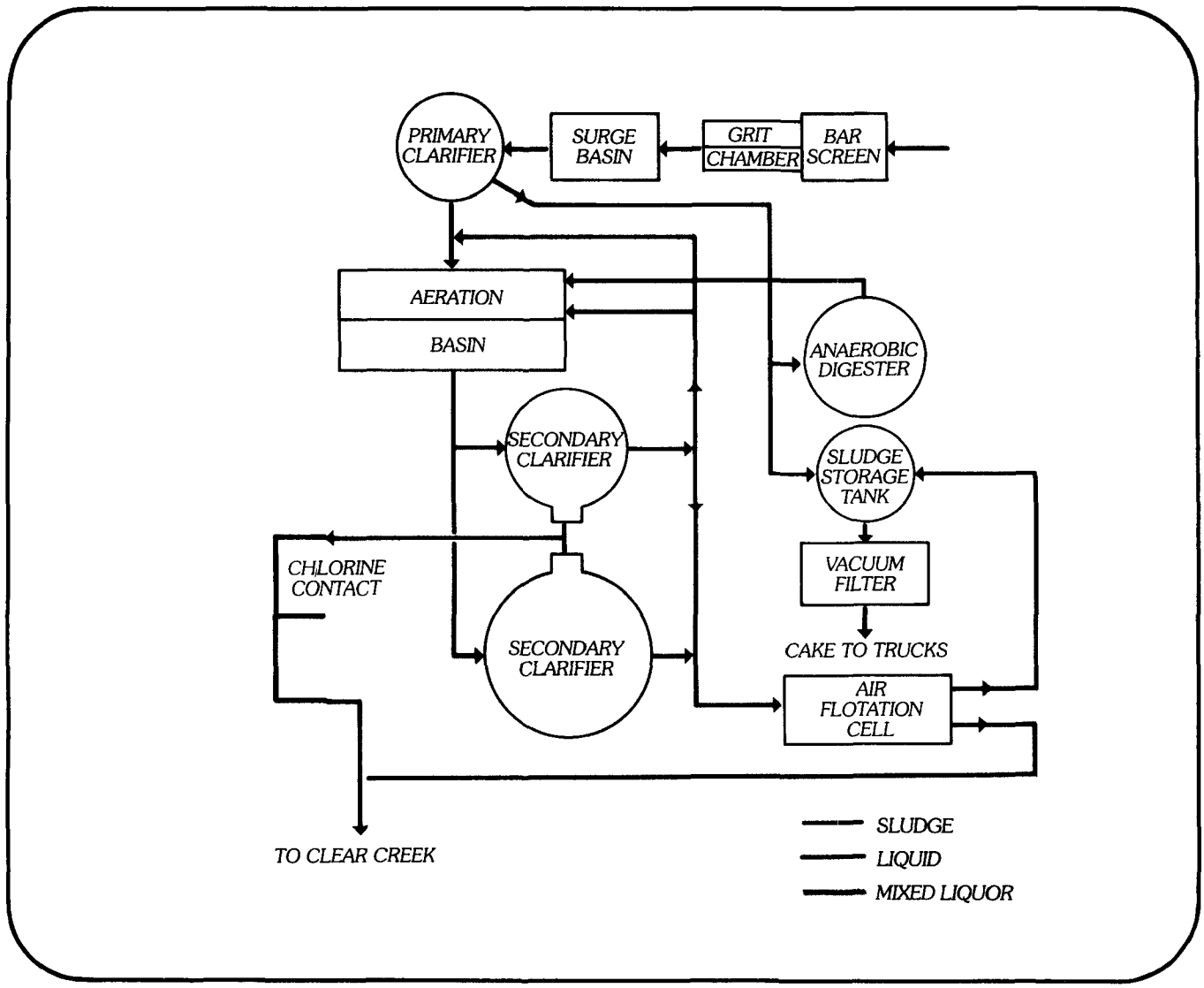


FIGURE 2 WASTE TREATMENT FACILITY

COORS RAW WASTE AND EFFLUENT PARAMETERS[1]

	Raw Waste	Treated Effluent
Flow	3.3 MGD	–
BOD	825 mg/l	34 mg/l
Suspended Solids	280 mg/l	29 mg/l
% Removal BOD	–	96
% Removal Suspended Solids	–	90

[1] *Based on average at Coors for month of June 1973.*

Table 4

The quality of the treated effluent and the percent removal of BOD and suspended solids is shown on Table 4.

Sludge is pumped from the bottom of the secondary clarifiers to the aeration basin at a rate of 30% of the total flow. The sludge is aerated for 19 hours with surface aerators. A small amount of digested anaerobic sludge is added to the aeration basin as a means of controlling filamentous organisms in the predominantly carbohydrate brewery waste.

Waste sludge is produced at the rate of about 13 tons/day. The waste activated sludge is concentrated in dissolved air flotation cells to 4% solids by weight. The concentrated waste activated sludge is mixed with primary sludge and dewatered on vacuum filters after being coagulated with lime and ferric chloride.

The filtered sludge containing 16% solids is presently disposed of on land owned by Coors. Because of high sludge handling costs and the difficulty in finding suitable disposal sites, Coors has decided to install a sludge drying system. This system will dry the sludge in a multiple effect evaporator using vegetable oil as a carrier liquid. The carrier oil will then be removed from the sludge by centrifuging and pressing and recycled within the system. When the sludge drying evaporator is in operation organic polymers will be used in place of ferric chloride and lime for coagulation of sludge, so that the sludge can be used as animal feed.

Preliminary feeding tests show that the dried sludge can be used successfully as a high protein animal feed supplement. The nutritional value of the sludge is further increased by its high vitamin content. Colorado State University scientists have found that the brewery waste is usable as a replacement for soybean meal and fish meal in poultry feeds.

5. THE SAVINGS IN TREATMENT COSTS

Coors has realized sizable savings in the capital and operating costs for its waste treatment facility by significantly reducing the raw wastes from the plant. Tables 5 and 6 compare the Coors waste treatment facility with the treatment facility that would be required for a brewery of equal size discharging at the brewing industry mean rate. These tables highlight the capital and operating cost savings being realized by Coors through their reduction of raw waste loads to their treatment plant.

It should also be noted that part of the Coors waste treatment facility was designed for the high loads and flows experienced before all the in-plant reductions were accomplished. Thus there is now excess capacity in the flotation cells and clarifiers. The BOD load on the waste treatment facility was formerly about 60,000 lb/day compared to the present load of about 22,700 lb/day. In spite of this excess installed capacity Coors is realizing a $1,575,000 savings in capital costs and $1,457,500 savings in annual operation costs relative to the costs they would have incurred if they were discharging raw wastes at the brewing industry mean levels.

CAPITAL COSTS SAVINGS

Item	Present Capacity and Loading Rate at Coors Facility	Additional Requirements Needed for Plant Discharging at the Brewing Industry Mean Rate	Savings in Capital Cost Realized by Coors
Primary Clarifier	one 90 ft diameter 500 gal/day-ft²	one 80 ft diameter	$ 150,000
Aeration Tanks	2.5 million gal capacity at 71 lb/day-100 ft³	6.7 million gal	$1,200,000
Secondary Clarifiers	14,800 ft² 200 gal/day-ft²	—	—
Vacuum Filters	one 509 ft² one 430 ft² used alternate weeks 16 hrs/day at 4.5 lb/hr-ft²	2,000 ft² filter plus piping and building	$ 100,000
Air Flotation Cells	one 700 ft² 32 lb/day-ft² one 1150 ft² 19 lb/day-ft² (used alternately)	700 ft²	$ 125,000
Total Savings in Capital Costs			$1,575,000

Table 5

OPERATING COST SAVINGS

Item	Present Requirements at Coors Facility	Additional Requirements Needed for Plant Discharging at the Brewing Industry Mean Rate	Savings in Operating Cost Realized by Coors
Aeration Horsepower	480 hp	1,340 hp	$ 134,000/yr
Chlorine	84 tons/yr	134 tons/yr ($131./ton)	17,500/yr
Lime	1,000 tons/yr	2,850 tons/yr ($34./ton)	97,000/yr
Ferric Chloride	900 tons/yr	2,500 tons/yr ($72./ton)	181,000/yr
Polymer	125,000 lb/yr	351,000 lb/yr ($.31/lb)	108,000/yr
H_2SO_4	120 tons/yr	190 tons/yr ($33./ton)	6,200/yr
Ammonia	35 tons/yr	98 tons/yr ($174/ton)	17,000/yr
Defoamer	12,000 gal	33,700 gal/yr ($2./gal)	67,000/yr
Deodorant	700 gal	2,000 gal/yr ($3.40/gal)	6,800/yr
Labor	2 men/shift	1 man/shift [1]	48,000/yr
Sludge Disposal	13 tons/day	37 tons/day [2]	675,000/yr
Maintenance	$50,000/yr	$100,000 (6% of Capital)	100,000/yr
Savings in Operating Costs			$1,457,500/yr

[1] One man/shift plus one relief man at $12,000/man-yr.

[2] 37 tons/day at a cost of $50/ton for vacuum filtration, power, hauling, landfill costs and overhead.

Table 6

6. AREAS OF APPLICATION

The techniques used by Coors to significantly reduce water usage and raw wastes, and recover by-products is directly applicable to the other malt liquor production facilities as well as other food processing industries. The reductions in the cost of waste treatment through reduction in raw waste loading can be realized whether the waste is treated in privately owned treatment plants or in municipal waste treatment plants. Savings in the cost of privately owned facilities can be realized as lower capital and operating costs, while saving in the cost of municipal waste treatment can be realized by the brewery as reduced user charges and reduced municipal waste treatment plant capital costs.

For Further Information Write:

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