A STUDY OF THE TECHNICAL AND ECONOMIC FEASIBILITY OF USING GEOTHERMAL WATER IN THE DAIRY INDUSTRY

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INTRODUCTION

1.1 Objectives

This study was initiated to determine (a) the amount and type of energy used in the dairy industry, and (b) technical and economic limitations to the utilization of geothermal energy in the dairy industry.

1.2 Scope of work

The following tasks were undertaken to achieve the stated objectives:

1. Prepare a map and legend showing locations, volume of production, current energy sources and energy consumption of dairy processing plants (> 500,000 # milk/week) in Idaho, Oregon, Nevada, Utah, and California.
2. Identify dairy processing plants where geothermal energy is currently being utilized.
3. Assemble a complete bibliography and as far as possible a library collection of publications dealing with energy usage in the dairy industry.
4. Prepare material and energy flow diagrams for the processing of each of the major dairy industry products. These flow diagrams would specify mass or volume flow rates, resources utilized per unit product, types of energy used in each step, and relevant pressure or temperature levels at each step.
5. Identify specific areas where geothermal energy could or could not be utilized for technical reasons.

6. Conduct a cost effectiveness study of geothermal energy utilization in the dairy industry using economic models based on best available information. Factors such as present and projected energy costs, transportation costs, and capital investment would be taken into account.
7. Prepare a final report.

1.3 Procedure

Pertinent literature dealing with the dairy industry was identified and reviewed. Representative dairy processing plants were visited and energy flows monitored where possible. A survey requesting production level and energy use information was prepared and mailed to over 400 dairy processors. Detailed material and energy flow charts were prepared for the following products:

1. Fluid milk
2. Cheddar cheese
3. Cottage cheese
4. Sour cream
5. Cream cheese
6. Cultured milk
7. Dried whey powder
8. Butter
9. Dried milk
10. Instantized dry milk
11. Dried buttermilk
12. Evaporated milk
13. Ice cream
14. Processed cheese

An economic analysis was made to determine the capital investment which could be justified in replacing conventional energy sources with geothermal

1.4 Explanatory comments

Dairy processing is extraordinarily competitive, often operating on relatively thin margins of profit. Company management tend to assume a rather protective stance regarding production levels and techniques. Production level-data, for individual plants, are collected by state agencies with the understanding that the data would be released only in aggregate form. Thus, while state-wide production levels of a given dairy product such as cheddar cheese are readily available, it is much more difficult to obtain production data for individual plants.

Another difficulty is in identifying actual energy requirements for a given plant. Plant operators usually are able to monitor total plant energy requirements and inputs to major pieces of equipment but are not prepared to determine the energy requirements for individual processes. Surprisingly, very few reports on energy in dairy processing have been reported in the general literature. These factors combined to necessitate a rather lengthy detailed energy use analysis for each of the many processes involved in order to achieve the desired objectives of the study.

We suggest that this study represents a pioneering effort to establish a truly comprehensive analysis in this important area. The bulk of the report, therefore, deals with Task 4 which is to provide a detailed description of material and energy flows in each process. Procedures, temperatures, pressures, and energy cost data are identified only for representative dairy products. A number of product varieties are lumped into a single category to keep the study within realistic limits. For example, three major types of aged cheese, i.e., cheddar, Italian, and Swiss have similar production procedures although there is variation in the cooking temepratures, aging time, and cheese yield. The net difference in energy requirements is small. Whole milk, lowfat milk, chocolate milk, and half-and-half are subjected to approximately the same processing procedures and are categorized in this report as fluid milk.

It should perhaps be noted that there are significant variations in specific processes. For example, electrical energy inputs to skim milk are about 20% less than to whole milk because skim milk is not homogenized. Similarly, the electrical requirements for yogurt exceed that of cultured milk by about 20% for the same reason. Processed cheese production procedures are similar to those of cheese food or cheese spread but the cooking temperatures vary slightly. Steam requirements for process cheese appear to be 5 to 10% less than for cheese spread. With these and other similar simplifications all the major dairy products manufactured in the Intermountain area can be classified into the fourteen product groups mentioned in the procedures section.

Of the 400 questionnaires regarding production and energy use, which were sent to dairy processors, only 36 were completed and returned. The information returned, while not statistically sufficient, did provide valuable information and a basis for comparison with the figures arrived at by analysis. We believe the energy use numbers generated in the analysis section of the report tend to be conservative. Recognizing that there is wide variation in the efficiency of energy use from plant to plant, such comparisons as were possible, generally indicated a somewhat greater energy use than the calculated value.

It also is observed that the units in this report are those typical to the dairy industry. The metrication process, while underway in the industry, is not moving rapidly. The familiar engineering units are used in this report.

Section 2

OVERVIEW OF RESULTS

2.1 Potential for energy savings

Two questions of major importance, which this study attempted to address, are: (1) "How much energy is utilized by the dairy industry in California, Oregon, Utah, Idaho, and Nevada?" and (2) "If a major effort were devoted to utilize geothermal energy in the dairy industry of this 5-state area, would the resultant reduction in the use of fossil fuels be significant?"

The data presented in Section 3 indicate that approximately 7.1×10^{12} BTU/year are expended in dairy processing in the 5-state area. This figure is expressed in fossil fuel equivalent and includes 63% thermal heating, 17% refrigeration, and 20% other electrical.

If there were a 100% conversion of thermal heating and refrigeration to geothermal energy, the potential for energy savings in the 5-state study area would be equivalent to about 1 million barrels of oil per year. Of course, the conversion to geothermal under even the most optimistic scenario would be only a fraction of this amount.

Also, it is pointed out in Section 3.3 that processing energy represents only about 4% of the total societal energy inputs to fluid milk and about 27.0% of the total societal energy inputs to cheddar cheese. For fluid milk and cheddar cheese, the societal fossil fuel energy inputs amount to about 5 times the digestable energy produced. This may be compared to a product such as canned corn for which the ratio of energy input to output is 14 to 20. Thus, in terms of simple energy input/output ratios the dairy industry appears to be in a relatively favorable position as compared with many other segments of the processed food industry.

2.2 Technical limitations

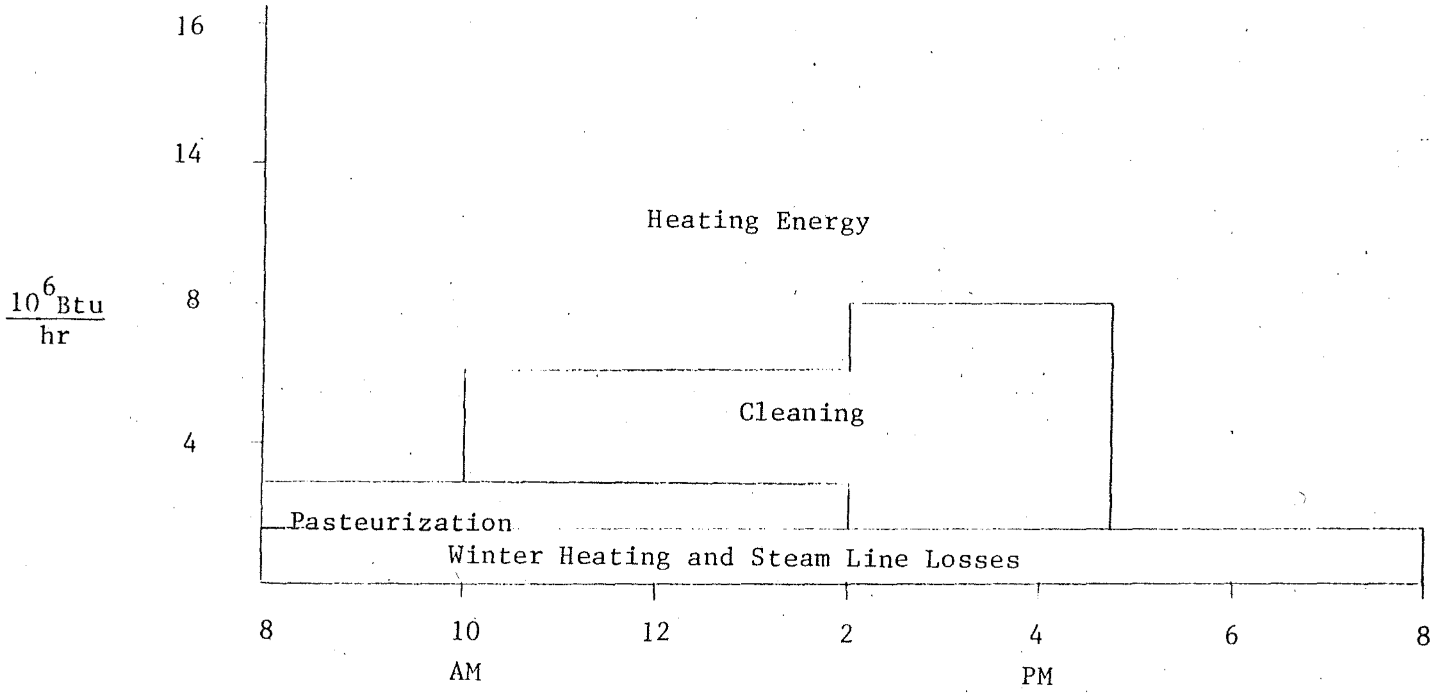
The maximum temperature to which a product is heated in most dairy processing operations is 205°F. The only exceptions are sterilizzation of canned evaporated milk at 245°F and spray drying where the temperature of the air introduced into the drier ranges from 200°F to 500°F. Equipment for the production of fluid milk, cheese and ice cream, generally requires 10 psig (240°F) to 20 psig (260°F) steam. Very few, if any, dairy processors operate their boilers at greater than 100 psig (338°F). Most spray driers, as presently designed, can utilize air temperatures less than 300°F.

Utilization of geothermal energy in the dairy industry faces the same technological barrier as other process industries, namely, the development of appropriate heat transfer equipment. The corrosive nature of many geothermal waters requires a innovative approach to heat exchanger design. Low temperature differences combined with secondary loop requirements for contamination protection, present challenging design problems.

Figures 2-2a through 2-2f show typical cooling and heating loads. The values were derived by applying the energy valued from Section 5 to assumed operating schedules. The derived loads are felt to be conservative values. The heating loads are the steam and natural gas loads in fossil fuel equivalent. The refrigeration load is given as the tons of cooling needed. We estimate that 37.5 tons of refrigeration may be provided by 10^6 BTU/hr of 300°F steam through an absorption refrigeration system. The geothermal water flow rates needed for a given load were calculated. It was assumed that 430°F geothermal water is brought to the surface under 350 psia pressure and then allowed to flash to 300°F saturated steam. This is demonstrated in Figure 2-2g which shows the flow rates required for each million BTU/hr of energy extracted from the water. Greater efficiency in the use of geothermal water can be made by using the lower temperature liquid water for heating purposes before reinjecting it into the ground. If the water temperature is reduced to 150°F, an additional 10^6 BTU/hr is provided. However, a system producing steam would fit into existing dairy plants without major modification of the dairy plant equipment. The results indicate a hot water flow of 15.7 GPM is needed per million BTU/hr of heating load if only the steam at 300°F is utilized. For example, for a dried milk plant producing about 9.6 million pounds of powder per year (a very typical production size) we calculate a peak heating load of 20 million BTU/hr. This would require a geothermal water flow rate of 314 GPM (or 157 GPM if hot water is utilized as explained above). The cooling and refrigeration requirements for that same plant would require an additional flow rate of 16 GPM.

2.3 Economic limitations

The economic analysis is described in detail in Section 4. Briefly, the approach was to consider three scenerios. The first scenerio assumes fuel costs remain near present levels. The second scenerio assumes fuel costs increase at the rate of 5% per year (14 year doubling time) for an assumed equipment life of 20 years while the third assumes an increase



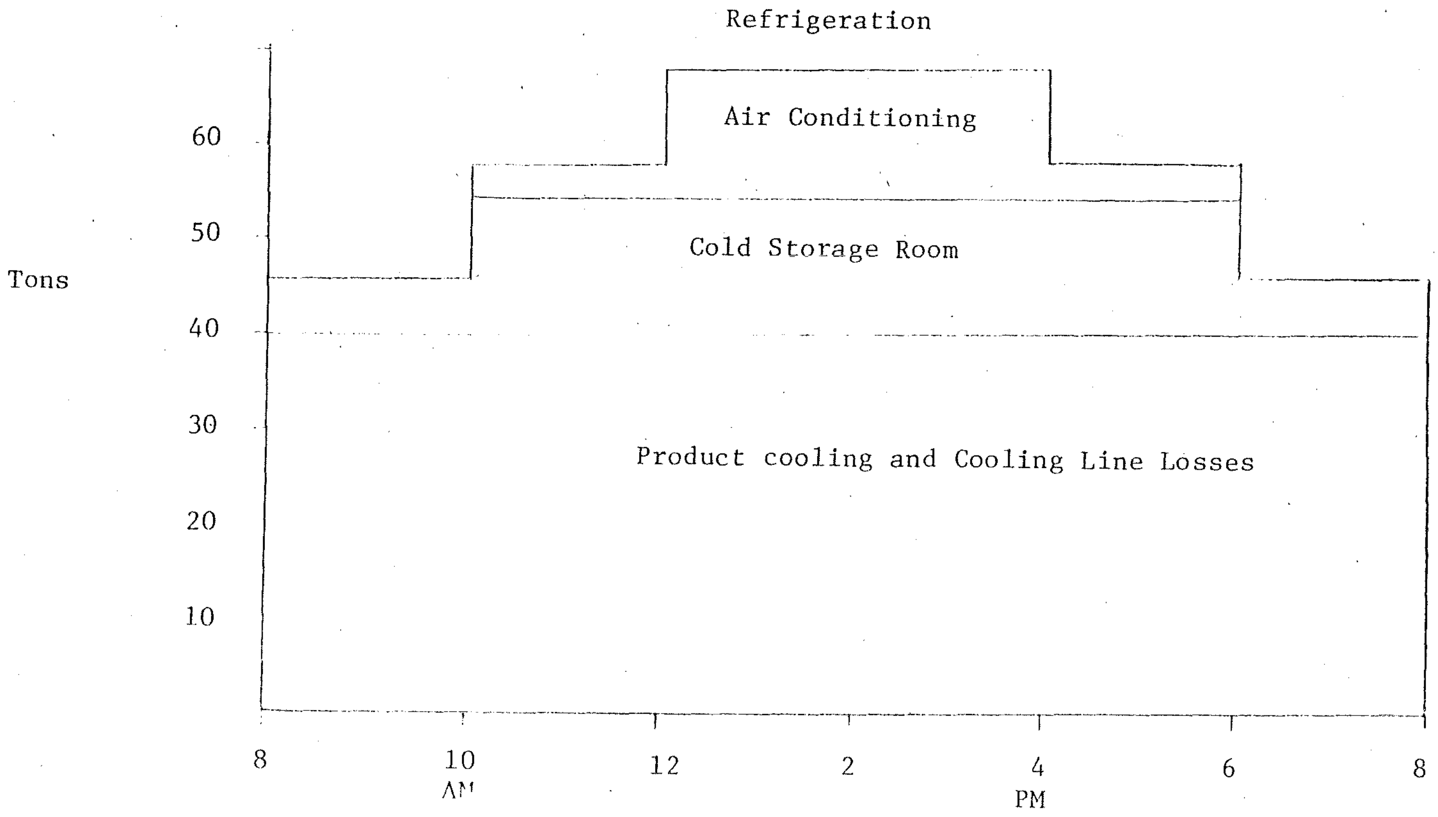
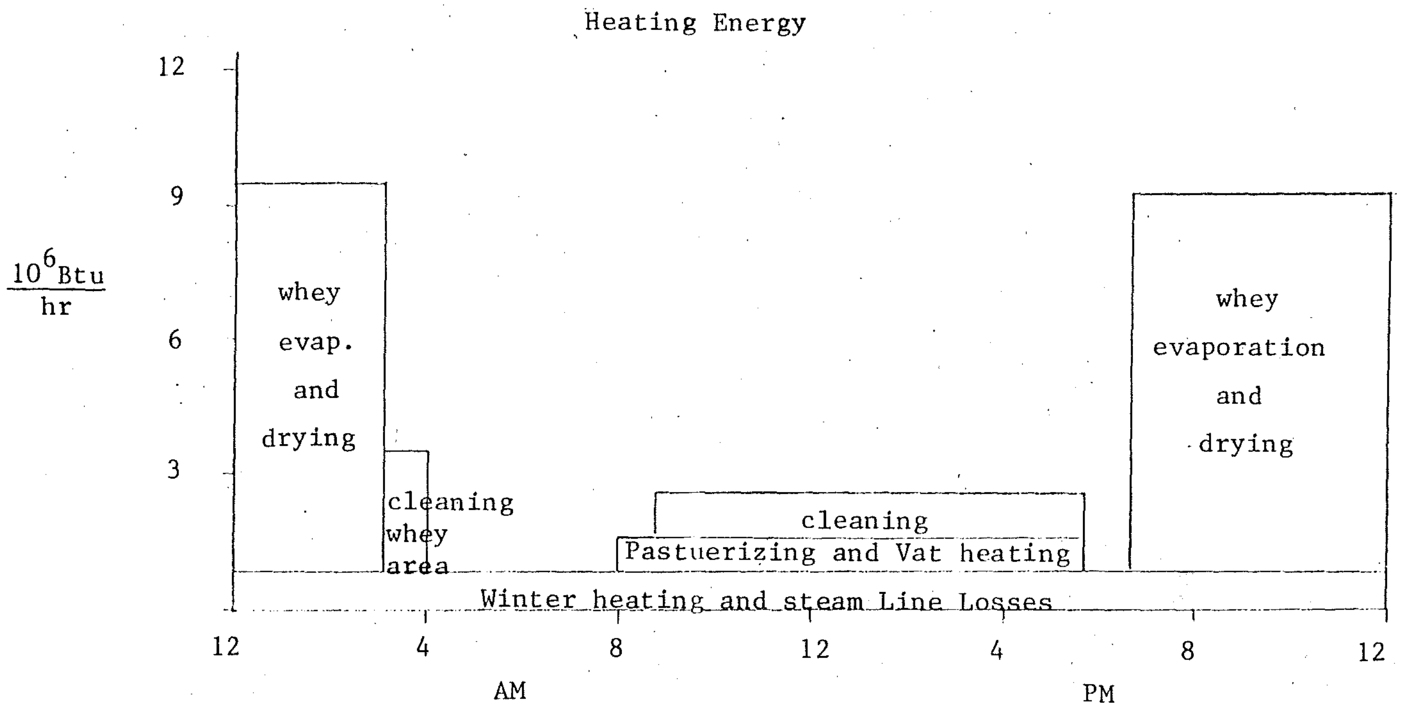


Figure 2-2a. Typical Heating and Cooling loads in a Fluid Milk Plant processing 105,000 gallons per week.



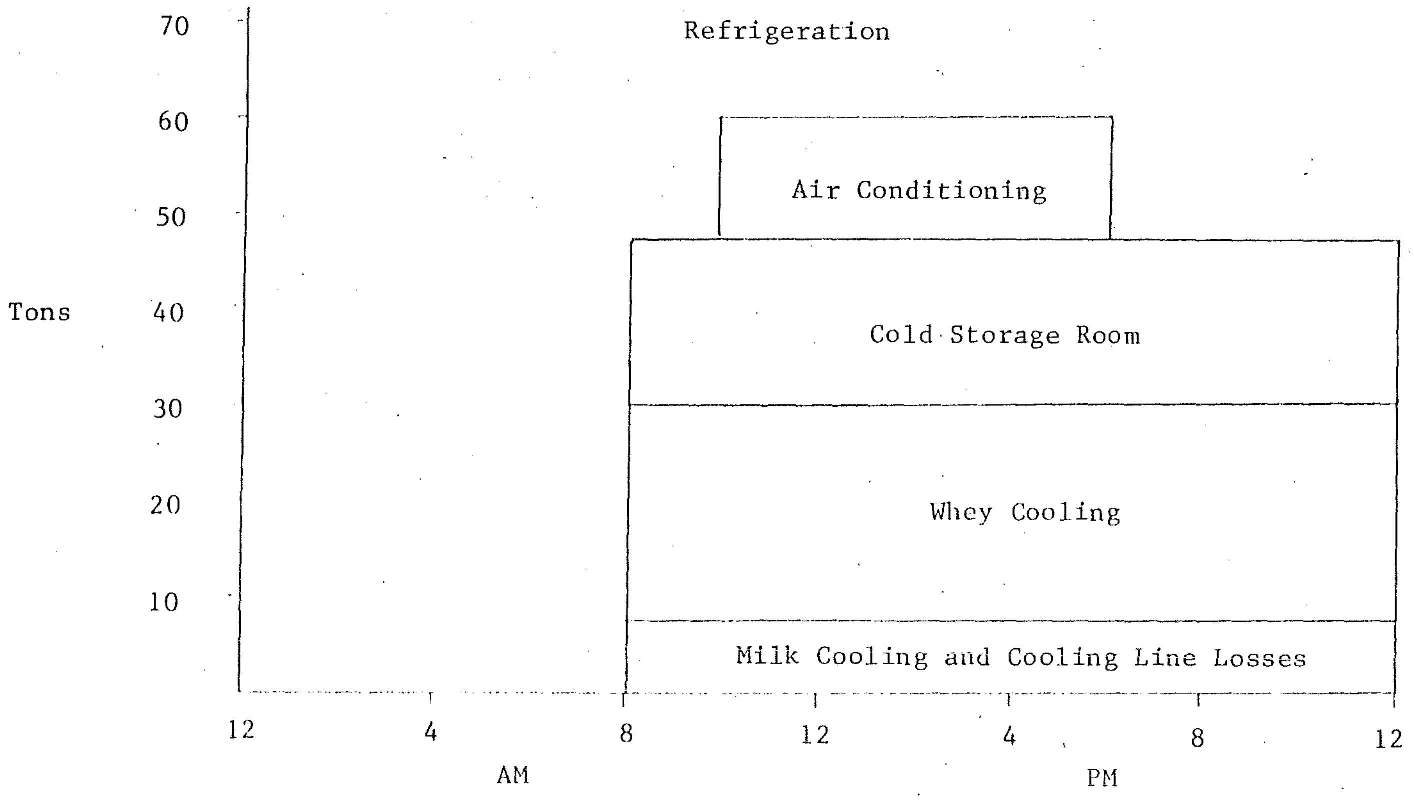
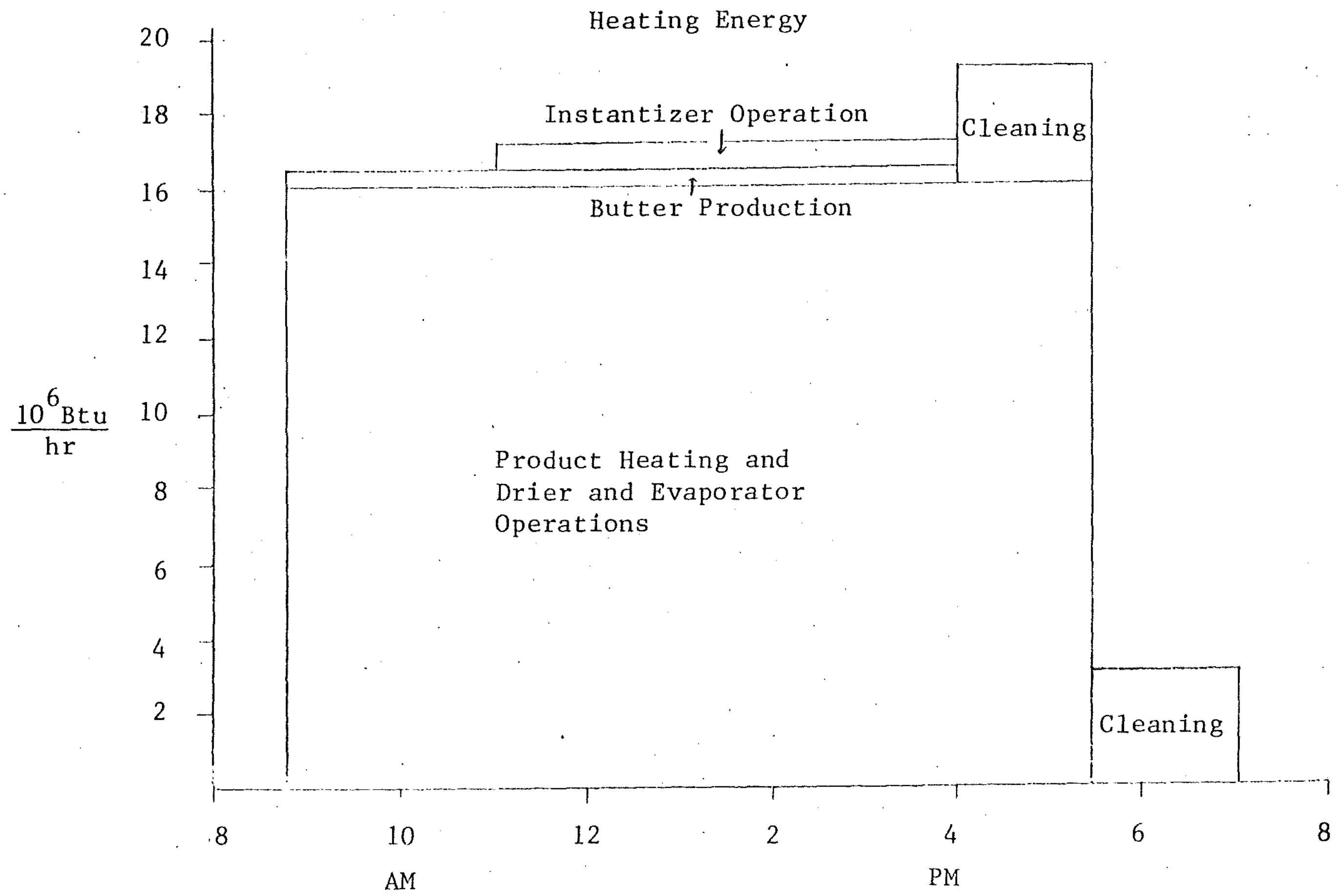


Figure 2-2b. Typical heating and cooling loads in a cheddar cheese plant which produces 80,000 lbs of cheese per week.



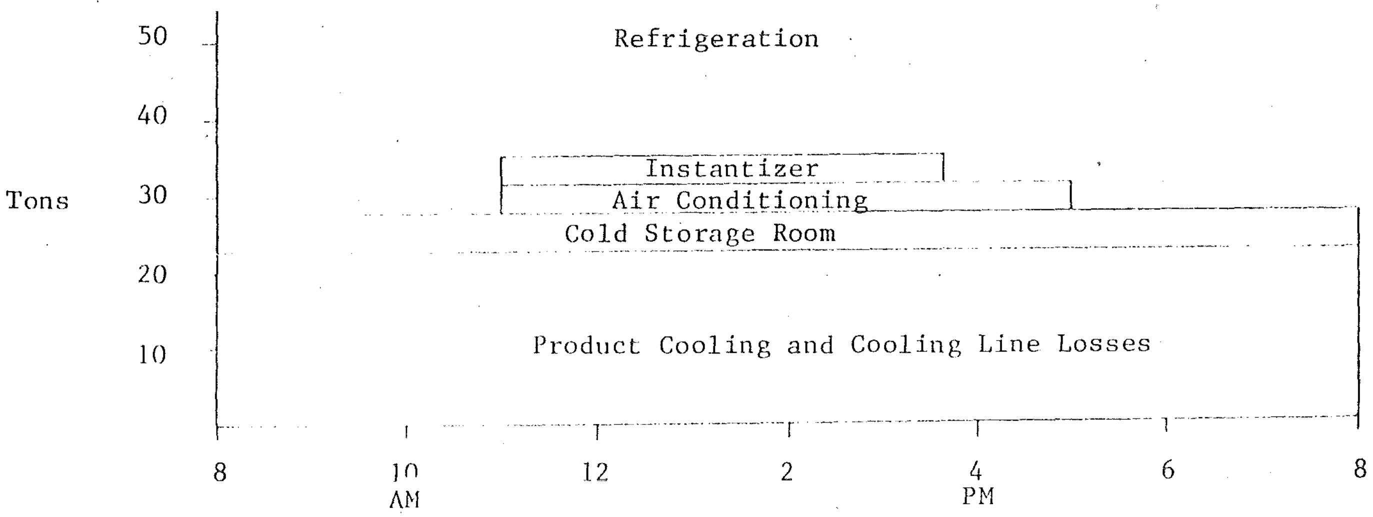


Figure 2-2c. Typical heating and cooling loads in a dried milk and butter plant which produces 26,300 lbs of powder and 11,222 lbs of butter each day.

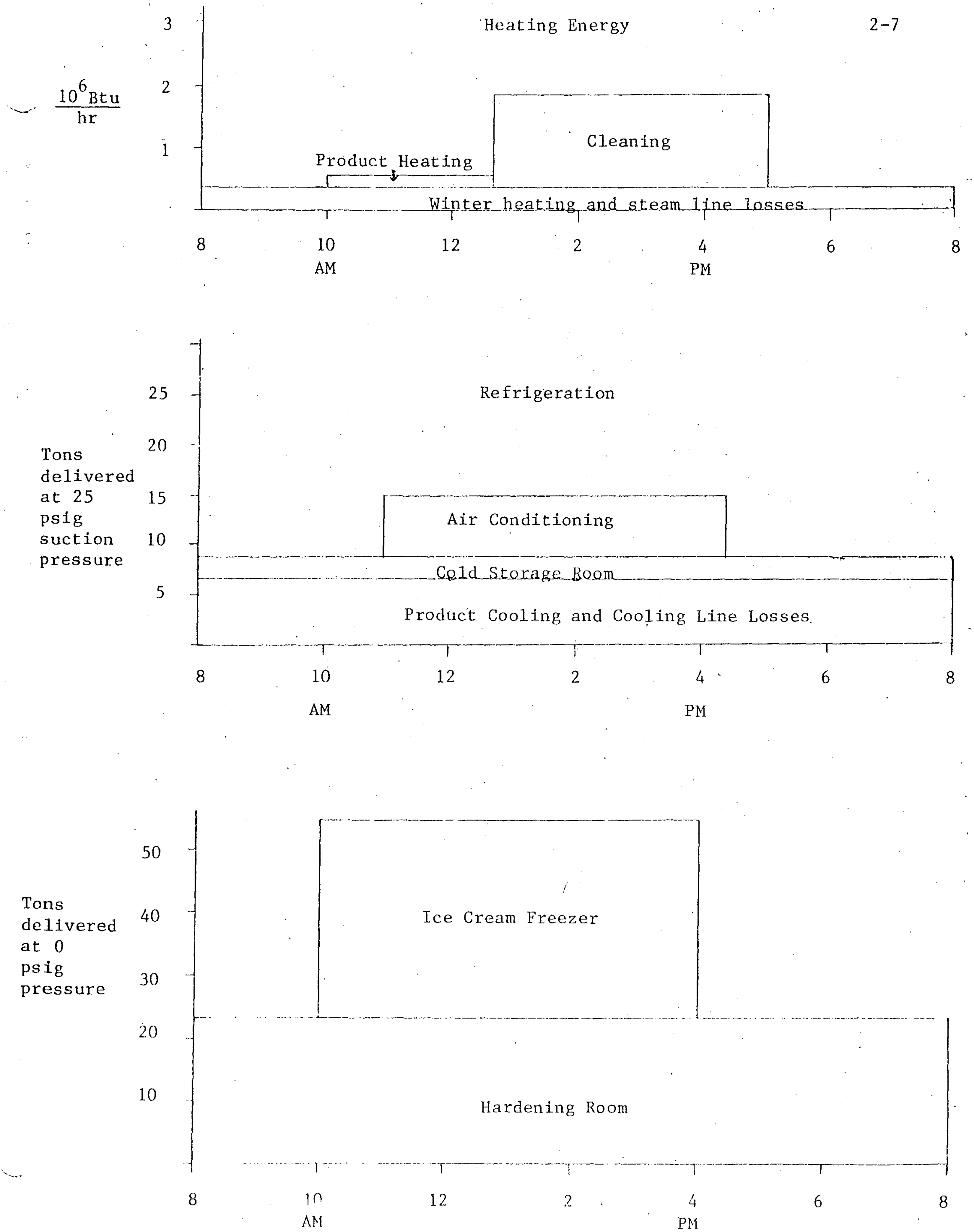
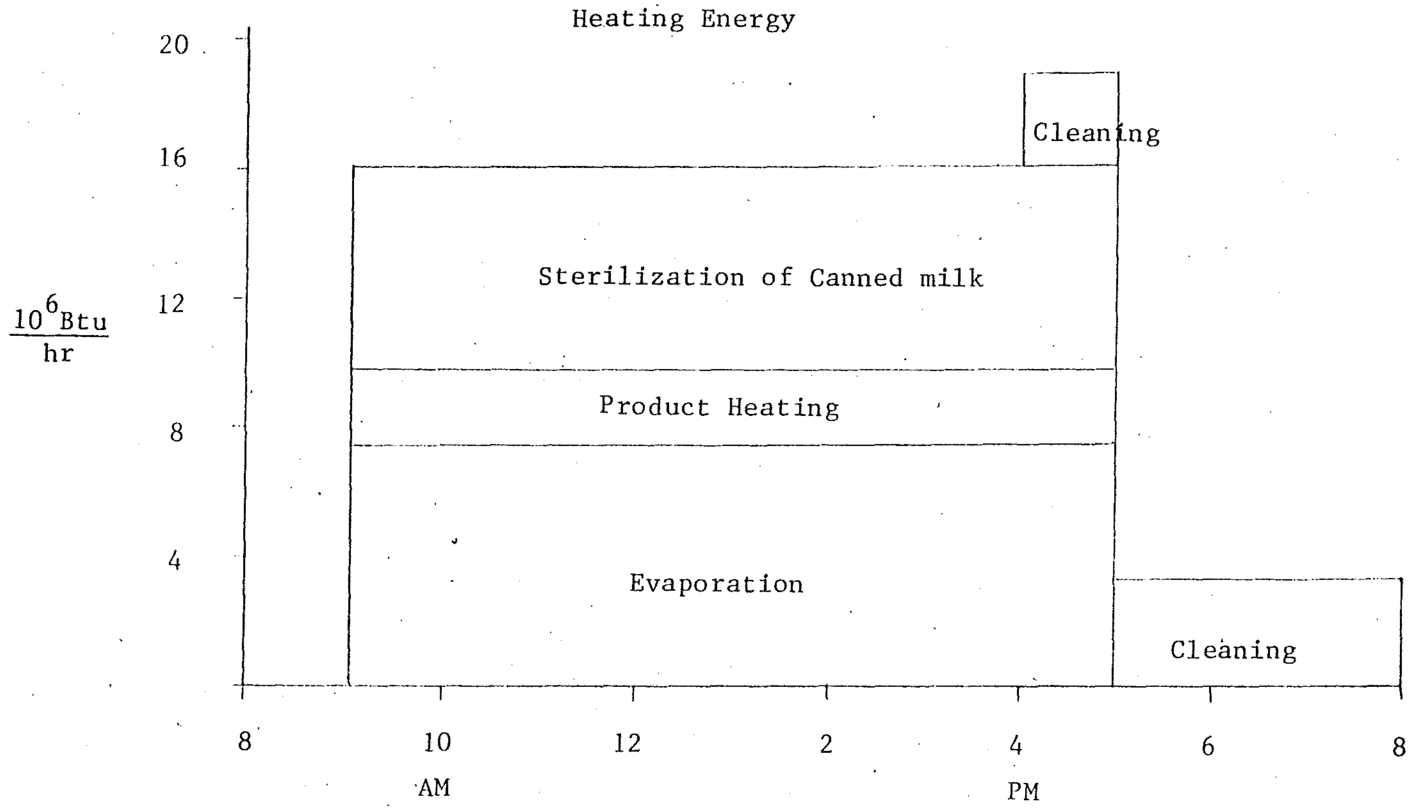


Figure 2-2d. Typical heating and cooling loads in a ice cream plant which produces 19,000 gallons of ice cream per week.



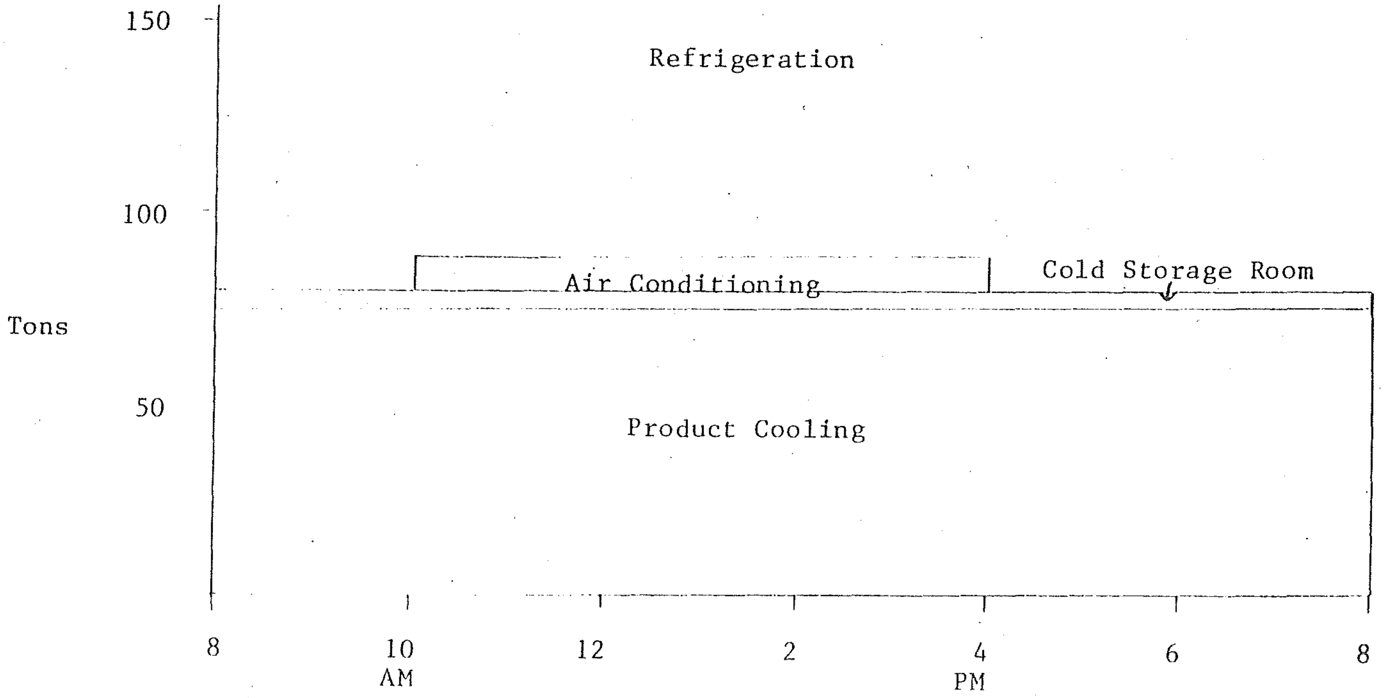
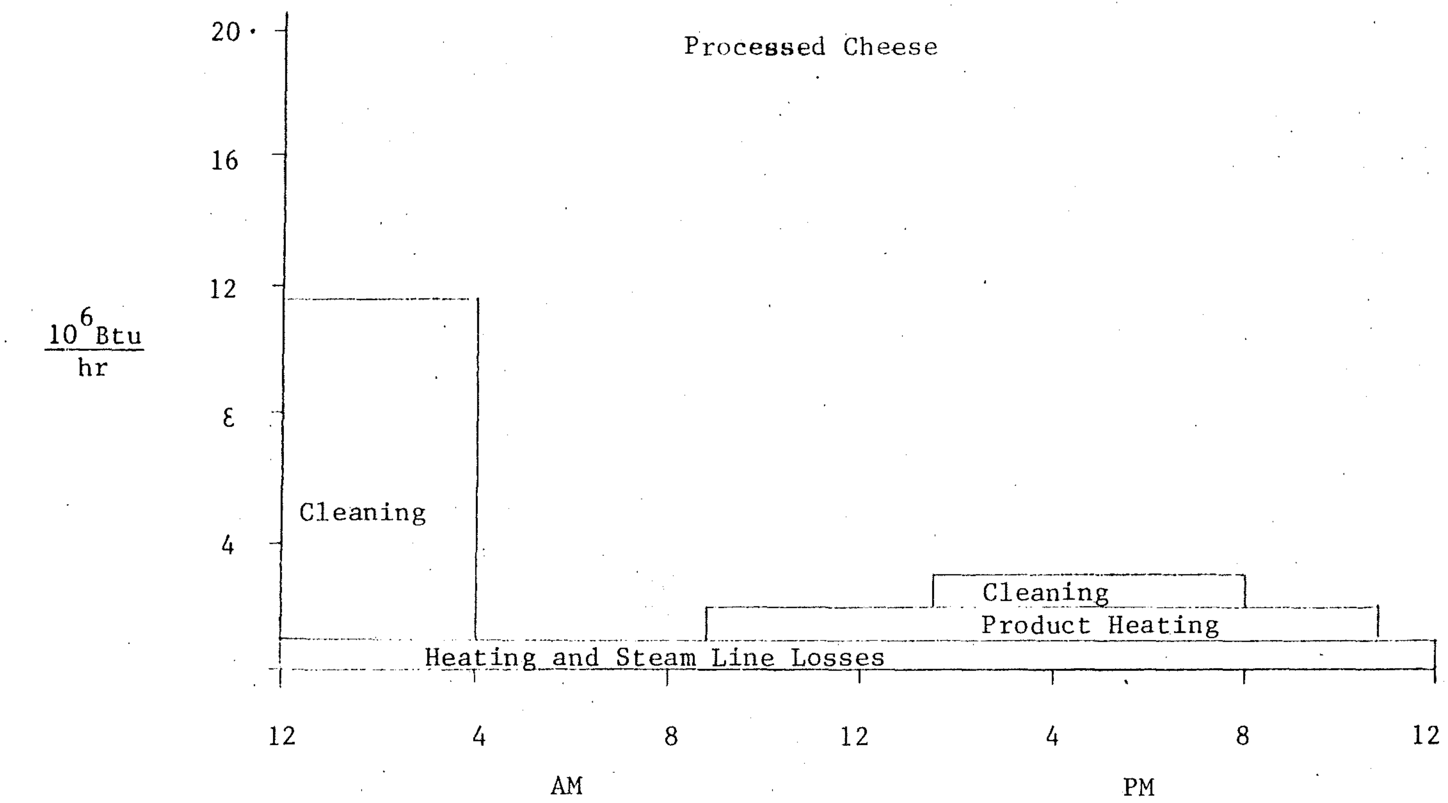


Figure 2-2e. Typical heating and cooling loads in an evaporated milk plant which produces one million pounds of evaporated milk per week.



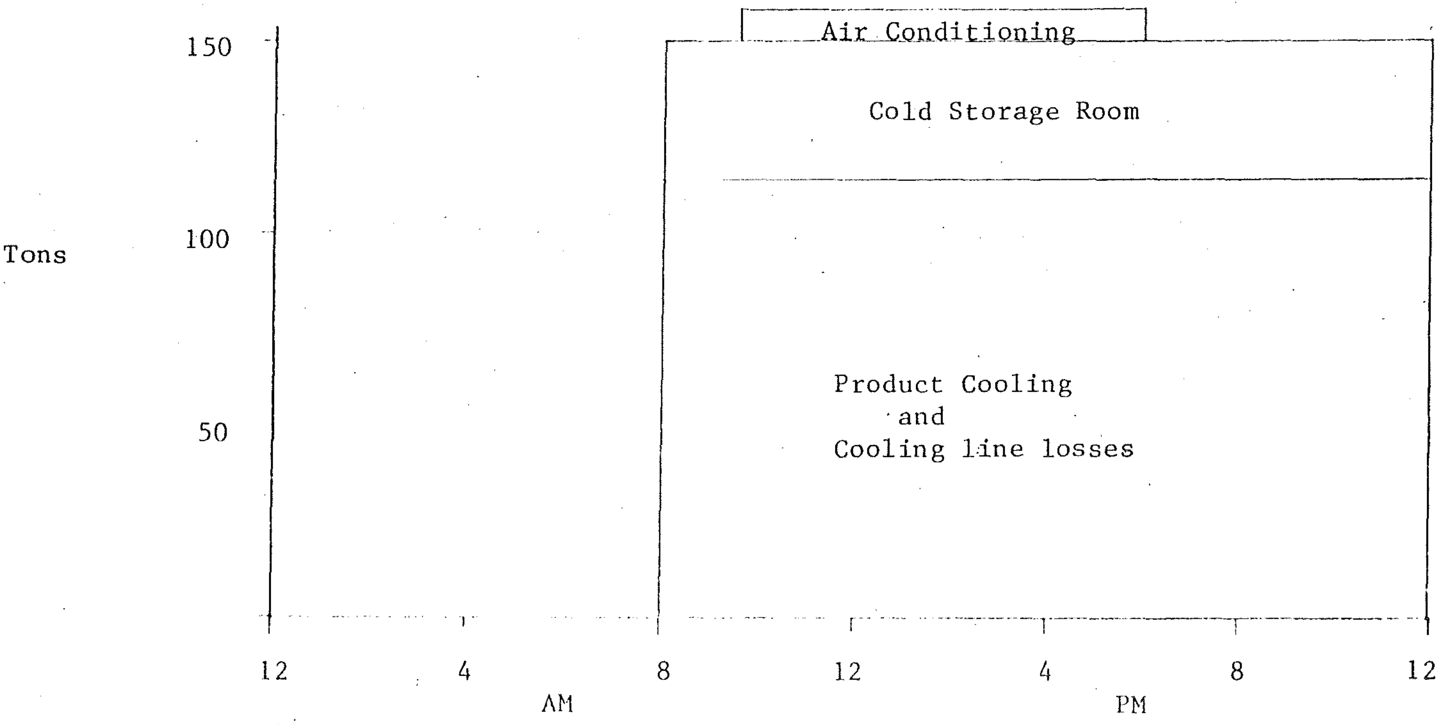


Figure 2-2f. Typical heating and cooling loads in a processed cheese plant which produces 280,000 lbs of cheese each day.

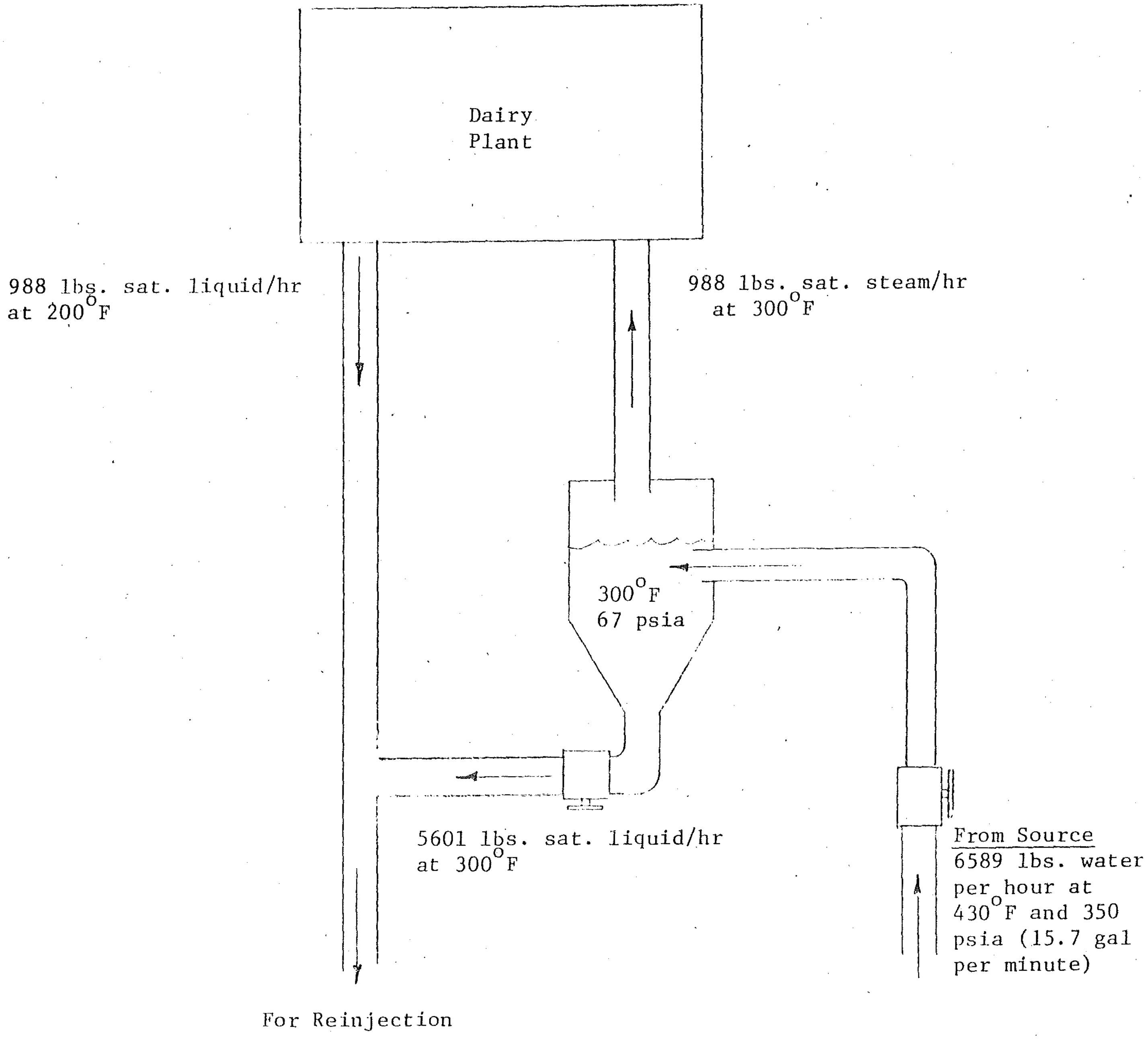


Figure 2-2g. Water flow rates required for each 10^6 Btu/hr of energy extracted from geothermal water due to condensing steam. By reducing the liquid temperature to 150°F an additional 10^6 Btu/hr could be provided by the 15.7 GPM flow rate.

of 10% per year (7 years doubling time) over the 20 year period. The justifiable investment was defined simply as the present value of the expected fuel costs during the 20 year life of the equipment with interest on borrowed capitol of 10%. Figures 2-3a and 2-3b summarize the results for a few selected products the second scenerio. By selecting the dairy product and the annual production Figure 2-3a gives an estimated justifiable investment for replacing conventional heating with geothermal sources. Similarly, Figure 2-3b provides an estimate for the justifiable investment for replacing conventional refrigeration units with absorption system using geothermal water. The figures also indicate the range of production levels for individual plants located within the 5-state study area. It may be observed that whenever drying operations are involved, as in dried milk or whey, that rather sizeable investments are justified. For products such as process cheese the justifiable investment level is not nearly so great.

Additional perspective may be obtained from Table 2-3a which gives the fraction of the total product price represented by energy costs at present fuel prices.

The data presented here causes us to conclude that the conversion of dairy processing plants to geothermal energy sources will be economically feasible only for a relatively few products. With such a small fraction of the total product cost attributable to process energy the requisite incentive for seeking energy from geothermal sources may be a total nonavailability of conventional alternatives.

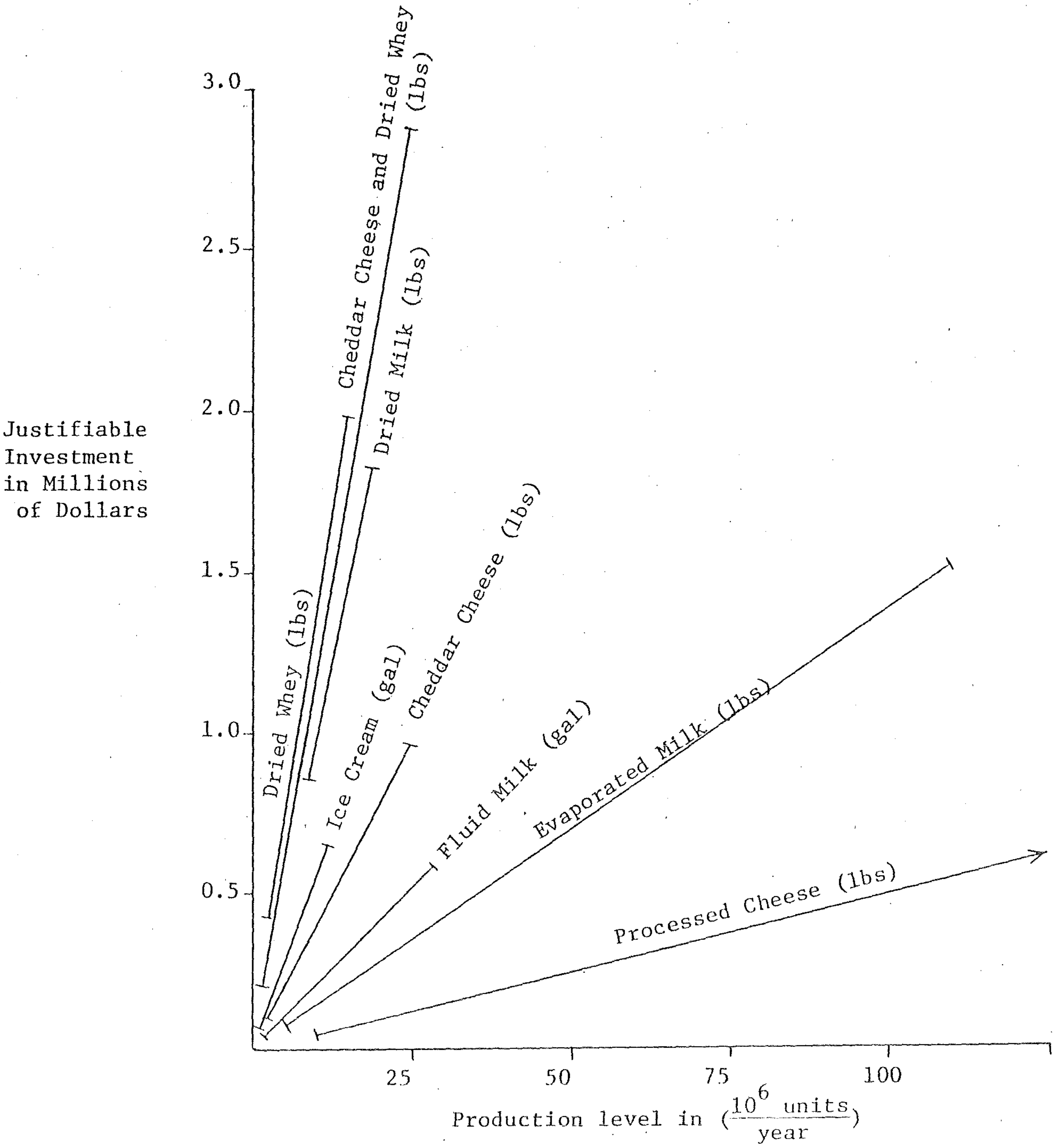


Figure 2-3a. Justifiable geothermal heating investment as a function of annual production levels for various dairy products. (Energy costs are assumed to increase 5% per year over a 20 year investment period.)

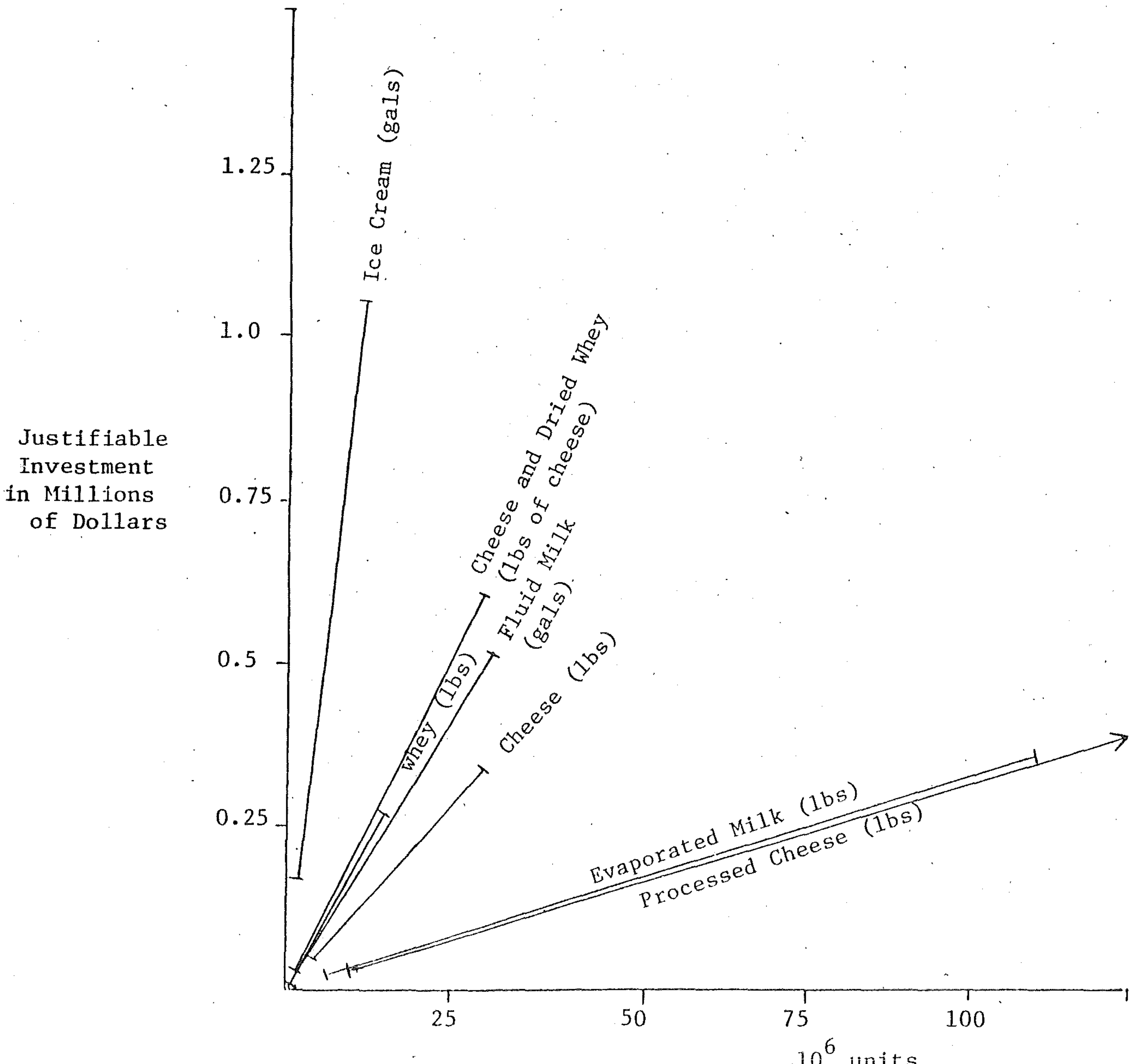


Figure 2-3b. Justifiable investment versus production level for dairy plants converting to geothermal energy for cooling. (Energy costs are assumed to increase 5% per year over a 20 year investment period.)

Table 2-3a. Comparison of energy costs to wholesale prices (dollars).

Product	Approximate Wholesale Price per unit	Steam Cost per unit	Total Energy Cost per unit	Steam Cost / Wholesale Price	Total Energy Costs / Wholesale Price
Fluid Milk	1.00/gal	.0017	.0052	.0017	.0052
Cheddar Cheese	1.50/lb	.0031	.0070	.0021	.0050
Whey Powder	.06/lb	.0074	.0137	.123	.228
Cottage Cheese	.40/lb	.00115	.00227	.0029	.0057
Sour Cream	.80/lb	.00036	.00110	.0005	.0014
Cultured Milk	1.20/gal	.00072	.00158	.0006	.0013
Cream Cheese	1.00/lb	.0015	.0023	.0015	.0023
Dried Milk	.60/lb	.0083	.0106	.0138	.0177
Instantized Milk	.90/lb	.00087	.0013	.0010	.0041
Butter	1.00/lb	.00082	.00168	.0008	.0017
Ice Cream	1.80/gal	.0043	.0205	.0024	.0114
Evaporated Milk	.35/lb	.00112	.00170	.0032	.0049
Processed Cheese	1.40/lb	.00039	.00118	.0003	.0008
Dried Buttermilk	.60/lb	.0083	.0109	.0138	.0182

2.4 Conclusions and recommendations

This study has led to the following conclusions:

1. Energy consumption by the dairy processing industry in the 5-state area is essentially insignificant on a national scale. A potential annual energy savings of 1 million barrels of oil energy equivalent represents only about 1/6000th of the total oil consumption in the United States.
2. Whey drying in the study area consumes the equivalent of about 1.7 billion cubic ft of natural gas per year. This amount of gas would provide heat for approximately 11000 homes in a climate such as northern Utah.
3. The greatest potential for using geothermal energy in dairy processing lies in the energy intensive drying operations. It should be noted, however, that alternative processes such as ultrafiltration and reverse osmosis techniques for obtaining whey solids are rapidly being developed and implemented. Such processes may render geothermal drying economically noncompetitive.
4. The potential for geothermal energy substitution in processes other than drying appears substantially less attractive. The economic incentive is missing from products such as milk, cheese, butter, and ice cream where processing energy costs represent less than 1% of the wholesale price.
5. A strong incentive for utilizing geothermal energy in dairy processing may be provided if no viable alternatives are developed. Most drying operations utilize natural gas on

an interruptible service basis. If natural gas and natural gas liquids become unavailable, considerable equipment modification will be necessary to adapt to alternate fuels such as coal.

Recommendations resulting from this preliminary study are:

1. Technical and economic feasibility of utilizing geothermal energy in dairy processing be evaluated further particularly where drying operations are involved.
2. Specific geothermal sites be evaluated for temperature, water quality and quantity and proximity to existing dairy plants.
3. Cooperation of plant management be secured in preparing and evaluating a specific design for heat exchange equipment to replace or supplement conventional fossil fuel fired plant operations.
4. If the design evaluation results are faborable, negotiate with plant management regarding a demonstration project.

Section 3

ENERGY USE IN THE DAIRY INDUSTRY

3.1 Plant location and production levels

There are more than 500 dairy processors located in the 5-state area of California, Utah, Idaho, Oregon, and Nevada. Production levels are not easily determined for individual plants, however, we have categorized them as handling less than 500,000 lbs of milk per week; between 500,000 lbs and 1,000,000 lbs of milk per week; and more than 1,000,000 lbs of milk per week as shown in Section 8. Because processed cheese and ice cream plants do not necessarily handle raw milk, care must be taken in interpretation. Also shown in Table 3-1a are state production totals for the states in question. Figure 3-1a indicates the location of larger dairy plants in those states while Figure 3-1b gives the locations of warm springs in the west. The proximity of the surface manifestations of geothermal energy to the present locations of dairy plants is rather striking on this scale map.

3.2 Energy inputs

It was not possible to directly determine the energy inputs to dairy processing in California, Utah, Idaho, Oregon, and Nevada. We, therefore, determined the total production levels of various dairy products for each state as indicated previously. We then multiplied those production levels by the appropriate energy use factor as calculated in Section 6 of this report. We believe that the results as shown in Tables 3-2a, b, c, d, e, and f present a reasonably accurate picture.

Table 3- 1a Production of manufactured dairy products, California, Idaho, Nevada, Oregon, and Utah - 1975*.

Product	Unit	California	Idaho	Nevada	Oregon	Utah	Total
		Million					
Butter	lbs	136	13		12	7	168
Cheese	lbs	93	75		23	58	249
Cottage Cheese	lbs	145	5		15	9	172
Evaporated and Condensed Milk	lbs	256					256
Dried Products	lbs	159	18			21	198
Frozen Products	gals	126	5		12	10	153
All Mfg. Products:							
Whole Milk Equivalent	lbs	5,180	1,073	25	613	768	7,659
Skim Milk Equivalent	lbs	2,681	228	5	153	60	3,127

*Data are not included when less than three plants reported, or when individual plant operations might be disclosed.

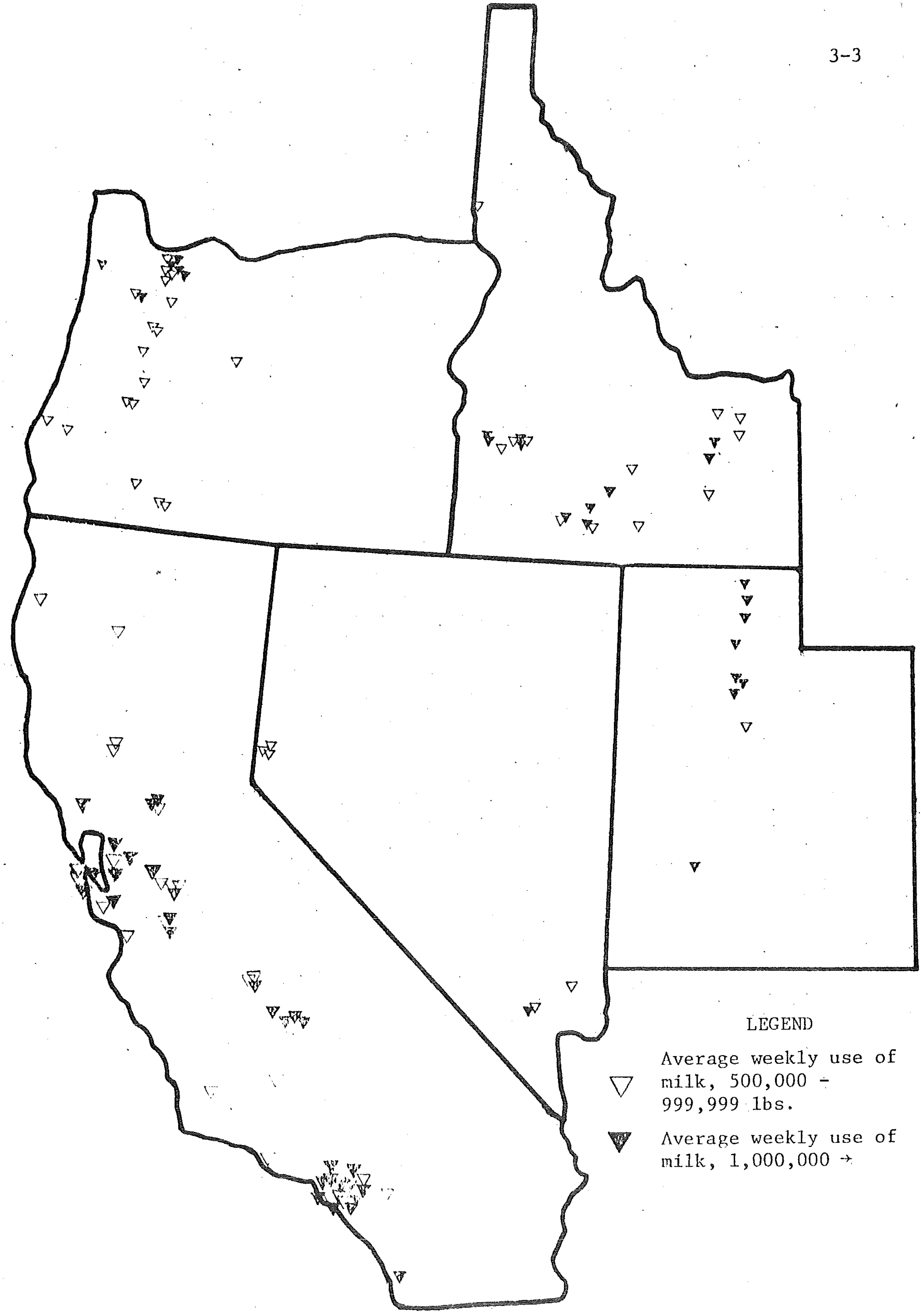


Figure 3-1a. Location of dairy plants handling more than 500,000 lbs of milk per week in a five-state area.

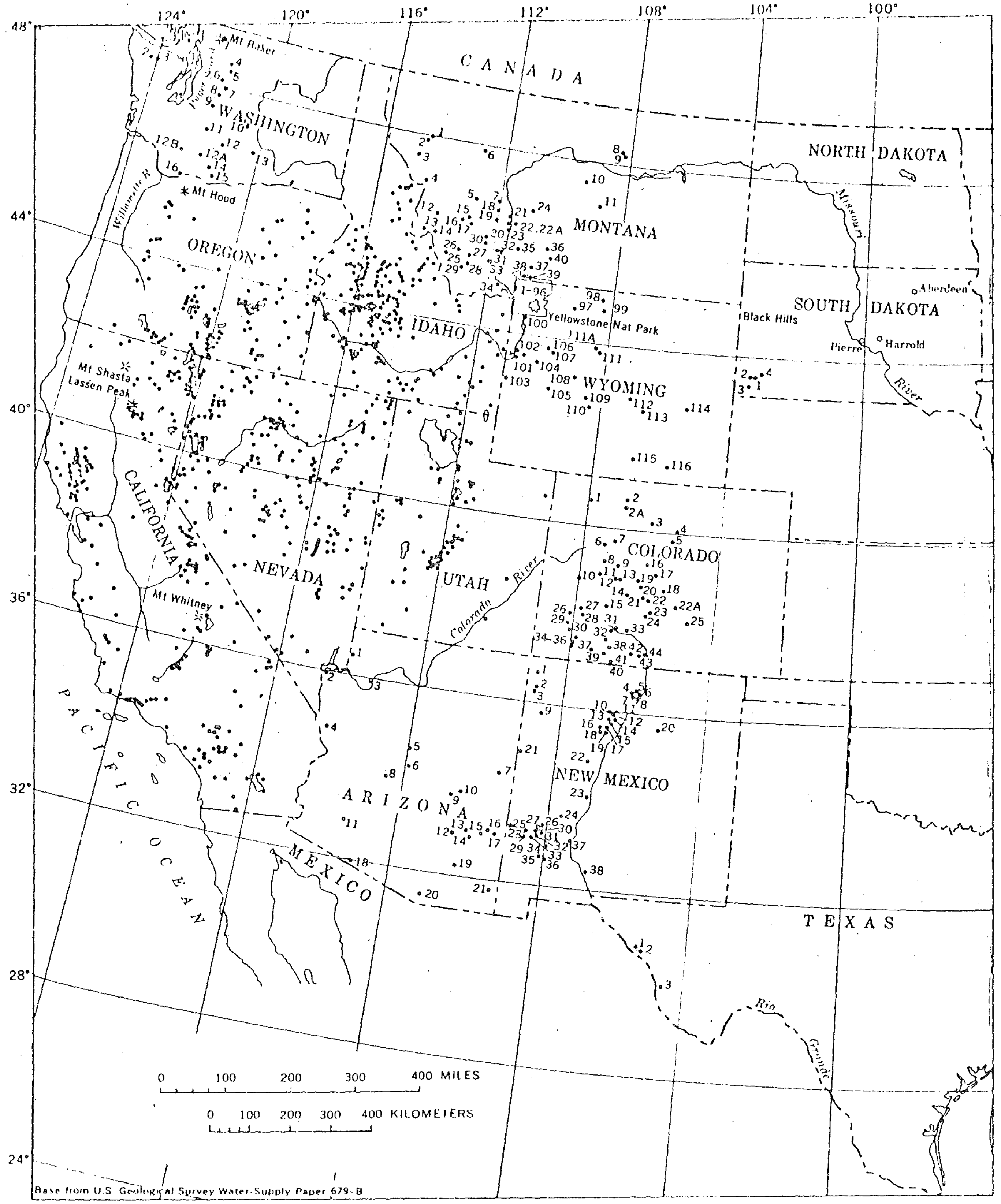


Figure 3-1b. Location of warm springs in the United States (from reference 18).

Table 3-2a. Energy inputs to dairy processing in California.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	136	100	36	12
Cheese	93	260	42	110
Cottage Cheese	145	150	28	39
Evap. and Cond. Milk	256	260	28	34
Dried Products*	159	1400	61	120
Frozen Products**	126	490	370	460
Fluid Milk Products***	2992	800	370	260
TOTAL		3460	935	1035

*Dried products includes dried milk, instantized dried milk, and dried whey.

**Frozen products includes ice cream, sherbet, ice milk, and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk, sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

Table 3-2b. Energy inputs to dairy processing in Idaho.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	13	10	3	1
Cheese	75	210	34	86
Cottage Cheese	5	5	1	1
Evap. and Cond. Milk	---	---	---	---
Dried Products*	18	160	7	13
Frozen Products**	5	19	15	18
Fluid Milk Products***	234	63	29	20
TOTAL		467	89	139

*Dried products includes dried milk, instantized dried milk, and dried whey.

**Frozen products includes ice cream, sherbet, ice milk and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk, sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

Table 3-2c. Energy inputs to dairy processing in Nevada.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	---	---	---	---
Cheese	---	---	---	---
Cottage Cheese	---	---	---	---
Evap. and Cond. Milk	---	---	---	---
Dried Products*	---	---	---	---
Frozen Products**	---	---	---	---
Fluid Milk Products***	137	37	17	12
TOTAL		37	17	12

*Dried Products includes dried milk, instantized dried milk, and dried whey.

**Frozen products includes ice cream, sherbet, ice milk, and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk, sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

Table 3-2d. Energy inputs to dairy processing in Oregon.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	12	9	3	1
Cheese	23	64	10	26
Cottage Cheese	15	16	3	4
Evap. and Cond. Milk	---	---	---	---
Dried Products*	---	---	---	---
Frozen Products**	12	46	35	44
Fluid Milk Products***	224	60	28	19
TOTAL		195	79	94

*Dried products includes dried milk, instantized dried milk, and dried whey.

**Frozen products include ice cream, sherbet, ice milk, and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk, sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

Table 3-2e. Energy inputs to dairy processing in Utah.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	7	5	2	1
Cheese	58	160	26	67
Cottage Cheese	9	9	2	2
Evap. and Cond. Milk	---	---	---	---
Dried Products*	21	180	8	15
Frozen Products**	10	39	29	37
Fluid Milk Products***	91	24	11	8
TOTAL		417	78	130

*Dried products includes dried milk, instantized dried milk, and dried whey.

**Frozen products include ice cream, sherbet, ice milk, and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

Table 3-2f. The total energy inputs to dairy processing in California, Idaho, Nevada, Oregon, and Utah combined.

Product	Annual Production (10^6 lbs)	Heating 10^9 BTU†	Refrigeration 10^9 BTU†	Other Electrical 10^9 BTU†
Butter	168	120	44	15
Cheese	249	690	110	290
Cottage Cheese	172	180	34	48
Evap. and Cond. Milk	256	260	28	34
Dried Products*	198	1700	76	140
Frozen Products**	153	590	450	560
Fluid Milk Products***	3678	990	450	320
TOTAL		4530	1192	1407

*Dried products includes dried milk, instantized dried milk, and dried whey.

**Frozen products includes ice cream, sherget, ice milk, and novelties.

***Fluid milk products includes whole, lowfat, and skim milk, cultured milk, sour cream, and yogurt.

†Energy is expressed in fossil fuel equivalent.

The total of 7.1 trillion BTU which we estimate is expanded annually in dairy processing plants of Utah, Idaho, California, Oregon, and Nevada compares with 140 trillion BTU devoted to dairy processing nationwide as reported by the Census of Manufactures. The raw milk production level from these 5 states is 12% of the total raw milk production in the nation. This comparison provides additional evidence that while our energy use numbers are reasonable they tend to be conservative. The basic conclusions of the report, however, would not be changed by a doubling of the calculated energy requirements.

3.3 Relationship of processing energy to other energy inputs

It is of interest to examine not only the energy inputs to processing of dairy products but also the inputs to production, transportation packaging, distribution, and consumption. These various inputs are summarized for fluid milk and cheddar cheese in Tables 3-3a through 3-3h and Figures 3-3a and 3-3b.

According to the results of this study, energy inputs to processing comprise only about 5% of the total societal energy inputs required to bring fluid milk to the consumer's table. This strongly suggests that other sectors of the dairy industry need to be closely examined for possible ways of reducing fossil energy inputs. The purpose of the information included in the following figures and tables is to help place in perspective the processing energy requirements and the potential for energy savings by geothermal substitution.

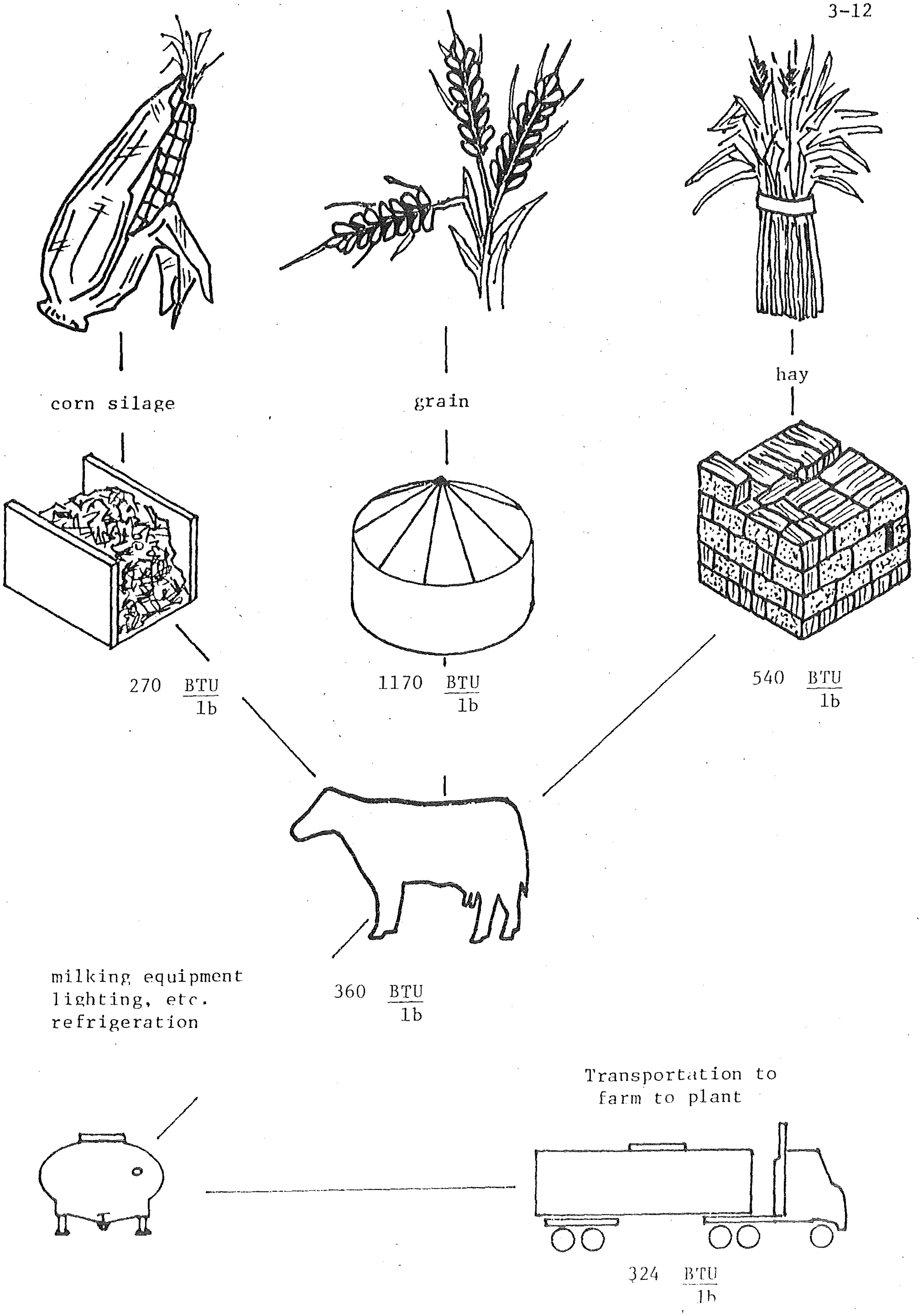


Figure 3-3a. On Farm Energy Inputs to Milk Production.

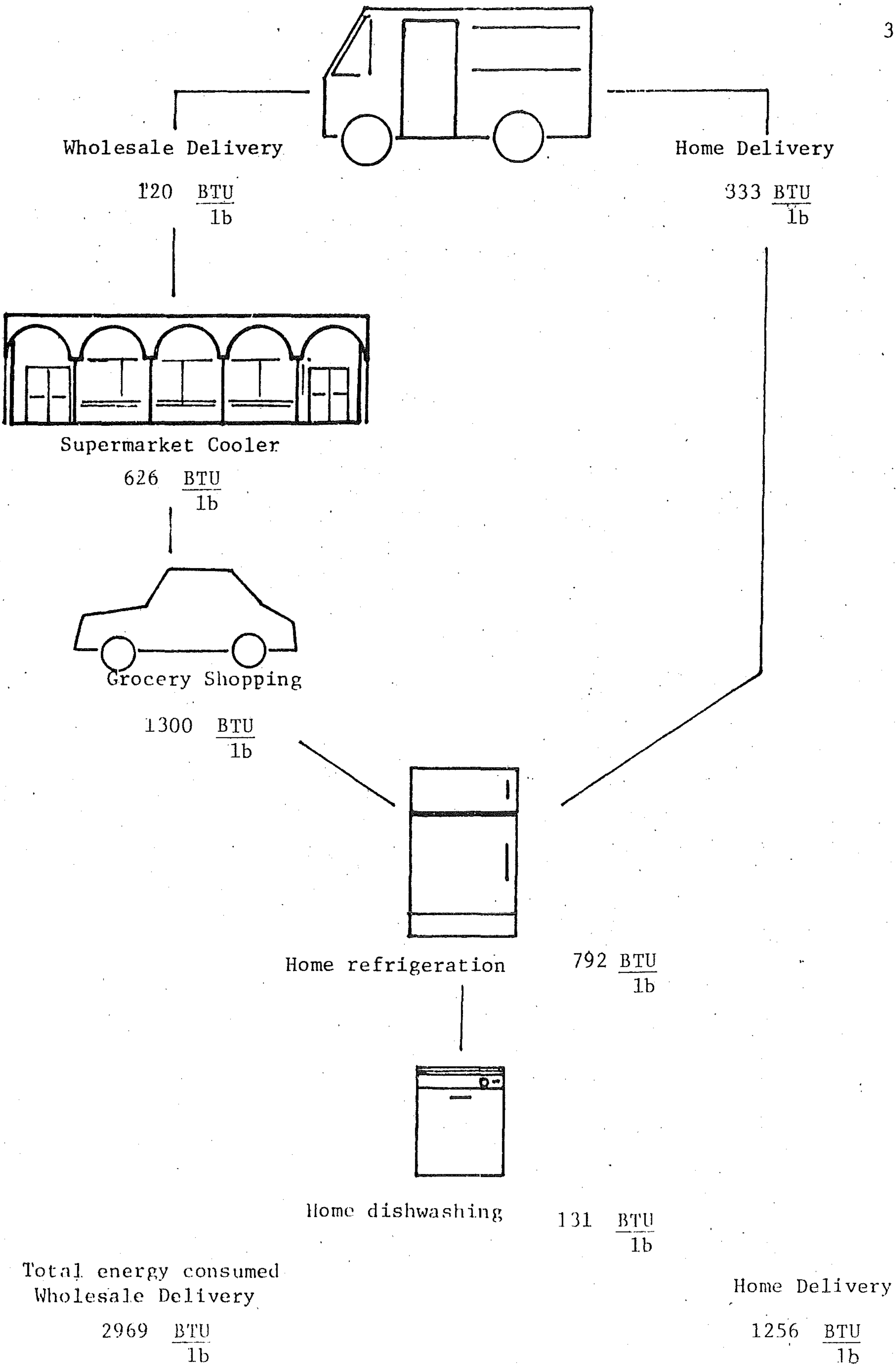


Figure 3-3b. Energy Inputs to the Distribution of Fluid Milk

Table 3-3a Energy Inputs to Inplant Processing of Fluid Milk (BTU of Fossil Fuel Equivalent per lb of Milk)

	BTU/lb
Cooling	73
Homogenization	33
Pasteurization	26
Cleaning	82
Lighting and Heating	137
Total	351

Table 3-3b Use of Energy in the Manufacture of Paper Milk Cartons (BTU of fossil fuel Equivalent per lb of milk produced)

	BTU/lb
Acquisition of Raw Material	79
Manufacture of Paper	533
Transportation to Manufacturer	11
Manufacture of Container	25
Handles for the Container	52
Transportation to Milk Processor	11
Transportation to Home	9
Collection	5
Disposal	5
Total	730

Table 3-3c Use of Energy in the Manufacture of Plastic Pouch Containers for Milk (BTU of fossil fuel equivalent per lb of milk produced)

	BTU/lb
Acquisition of Raw Materials	227.5
Transportation to Manufacturer	4.0
Manufacture of Containers	23.4
Transportation to Milk Processor	2.0
Transportation to Home	1.3
Collection	0.4
Disposal	0.7
Total	259.3

Table 3-3d Use of Energy in the Manufacture of a Returnable Glass Milk Bottle (BTU of fossil fuel equivalent per lb of milk produced)

	BTU/lb
Acquisition of Raw Material	14.0
Shipping Raw Material	1.8
Manufacture of Glass	109.1
Transportation to Milk Processor	1.3
Bottle Washing	37.8
Collection and disposal	3.8
Total	167.8

Table 3-3e Use of Energy in the Manufacture of Plastic Milk Bottles (BTU of fossil fuel equivalent per lb of milk produced)

	BTU/lb
Acquisition of Raw Material	1087
Transportation to Manufacturer	20
Manufacture of Bottle	45
Transportation to Milk Processor	9
Transportation to Home	7
Manufacture of Closure	99
Transportation to Milk Processor	2
Collection	9
Disposal	4
Total	1282

Table 3-3f Summary of total energy inputs into production of fluid milk

	BTU/lb	%
Farm production	2340	35
Transport farm to plant	324	5
Processing	351	5
Packaging (paper)	730	11
Distribution	2969	44
Total	6714	100

Table 3-3g Summary of Energy Inputs to Cheddar Cheese

	BTU/lb Cheese	%
Farm	23,400	59.7
Transport raw milk	3,240	8.3
Processing with whey drying	10,563	26.9
Distribution	2,000	5.1
Total	39,203	100.0

Table 3-3h Ratios of Total Societal Energy Inputs to Digestable Food Energy Produced for Fluid Milk and Cheddar Cheese

	Fluid Milk	Cheddar Cheese
Total Energy Input expressed in BTU of fossil fuel equivalent per lb of product.	6714	39,203
Digestable Food Energy of product expressed in BTU per lb	1170	7,164
Ratio of input energy to output energy	5.7	5.5

3.4 Dairy processors currently using geothermal energy

We carefully checked with many of our extensive contacts through the dairy industry and were able to identify only one processor currently utilizing geothermal energy. Medo-Bell Dairy in Klamath Falls, Oregon, is that processor.

Section 4

ECONOMIC MODEL

The purpose of the economic part of this study was to ascertain the feasibility of converting an operational plant to a geothermal dependent system on the basis of present fuel expenditures for steam production.

4.1 Model 1

The first model implemented was based on the assumption that there would be no appreciable increase in cost of fuel over the next twenty years or that due to technological changes the annual cost per 10^5 units produced would remain relatively constant. The justifiable investment to be ammortized over a period of N years at an interest rate of i percent is given by the equation,

$$C \times PVa = IV,$$

where

C = present cost per 10^5 units produced
PVa = present value of $1.00 paid annually for N years at i percent interest, or

$$= \frac{1 - \frac{1}{(1+i)^N}}{i}$$

i = interest or borrowed capital
IV = justifiable investment

The probability that costs will remain constant is very small and unrealistic. Therefore, a second model that accounts for an annual percent increase in the cost of fuel was devised.

4.2 Model 2

This model is based on the assumption that fuel costs will increase at either five or ten percent per year for the next twenty years.

The justifiable investment is given by the equation,

$$\sum_{n=1}^{N} C_n \times PV_n = IV$$

where

$C_n = C =$ initial or present cost per 10^5 units produced over a period of N years with $C_n = C_{n-1} + [C_{n-1} \times I]$ when $n > 1$, with $I =$ annual increase in fuel costs.

$$PV_n = \frac{1 - \frac{1}{(1 + i)^n}}{i}$$

where

$i =$ the interest rate on borrowed capital
$n =$ the year in question

IV = justifiable investment

The assumption that fuel costs increase annually at 5% or 10% increases the justifiable investment obtained using model one approximately 1.5 and 2 times respectively.

Tables 4a and 4b are the summation of the results of the application of both models per dairy product. Each product is identified and each unit of measure specified in the adjacent column. A cost column identifies the present cost per 10^5 unit produced. Adjacent to the cost column are the justifiable investments based on assumptions of constant fuel costs, 5%/yr increase and 10%/yr increase in fuel costs. Table 4a deals with the conversion of the heating system to geothermal energy while Table 4b addresses the conversion of the refrigeration. Interest on borrowed capital was assumed to be 10% per annum.

Table 4-a. Justifiable investments per product in conversion to geothermal steam heating system.

Product	Units of Measure	Typical Annual production range (10^5 units)	cost per 10^5 units produced	Investment/10^5 units/yr. present fuel cost	Investment/10^5 units/yr. 5%/yr fuel cost rise	Investment/10^5 units/yr. 10%/yr fuel cost rise.
fluid milk	gal	3.0 - 276.0	170.00	1450.00	2060.00	3090.00
cheddar cheese w/o whey drying	lb	3.0 - 250.0	310.00	2640.00	3750.00	5635.00
whey powder	lb	15.0 - 150	1070.00	9110.00	12960.00	19450.00
cottage cheese w/o whey drying	lb	8.0 - 21.0	120.00	1030.00	1450.00	2180.00
sour cream	lb	2.0 - 25.0	36.00	310.00	440.00	655.00
cultured milk	qt	0.2 - 36.0	72.00	630.00	870.00	1310.00
cream cheese w/o whey drying	lb	0.3 - 10.0	150.00	1280.00	1820.00	2725.00
dried milk	lb	75.0 - 180.0	830.00	7070.00	10050.00	15100.00
instantized milk	lb	12.0 - 60.0	87.00	740.00	1050.00	1580.00
butter	lb	0.7 - 55.0	82.00	700.00	990.00	1490.00
ice cream	gal	0.1 - 120.0	430.00	3660.00	5210.00	7820.00
evaporated milk	lb	20.0 - 1100.0	112.00	950.00	1360.00	2040.00
processed cheese	lb	100.0 - 6000.0	39.00	330.00	470.00	710.00
dried buttermilk	lb	0.6 - 6.0	830.00	7070.00	10050.00	15100.00

Table 4-b. Justifiable investments per product in utilization of geothermal steam in an absorption refrigeration system.

Product	Units of Measure	Typical Annual production range (10^5 units)	cost per 10^5 units produced	Investment/10^5 units/yr. present fuel cost	Investment/10^5 units/yr. 5%/yr fuel cost rise	Investment/10^5 units/yr. 10%/yr fuel cost rise
fluid milk	gal	3.0 - 276.0	150.00	1280.00	1820.00	2730.00
cheddar cheese w/o whey drying	lb	3.0 - 250.0	110.00	940.00	1330.00	2000.00
whey powder	lb	15.0 - 150.0	150.00	1280.00	1820.00	2730.00
cottage cheese w/o whey drying	lb	8.0 - 21.0	47.00	400.00	570.00	850.00
sour cream	lb	2.0 - 25.0	48.00	410.00	580.00	870.00
cultured milk	qt	0.2 - 36.0	52.00	440.00	630.00	950.00
cream cheese w/o whey drying	lb	0.3 - 10.0	80.00	680.00	970.00	1450.00
dried milk	lb	75.0 - 180.0	30.00	260.00	360.00	550.00
instantized milk	lb	12.0 - 60.0	10.00	90.00	120.00	180.00
butter	lb	0.7 - 55.0	64.00	540.00	780.00	1160.00
ice cream	gal	0.1 - 120.0	720.00	6130.00	8720.00	13100.00
evaporated milk	lb	20.0 - 1100.0	26.00	220.00	315.00	470.00
processed cheese	lb	100.0 - 6000.0	26.00	220.00	315.00	470.00
dried buttermilk	lb	0.6 - 6.0	50.00	430.00	610.00	910.00

Section 5

PRODUCTS SECTION

The purpose of this section is to describe the process procedures and production energy requirements of fourteen different dairy products.

A process description, flow chart, and tables of energy inputs to the production of each product are contained in a sub-section for each of the different dairy products. A maximum temperature and percent energy consumption bar graph follows each sub-section's energy input tables. Some of the products, such as butter and ice cream, also have a plant layout description inserted in their respective sub-sections. From these plant layout descriptions square feet of floor space in a typical plant was estimated.

A comparison of the energy requirements of some products tabled in this section versus the average survey values for these products concludes this section.

Section 5-1

FLUID MILK PRODUCTION

Description

Raw milk is received intermittantly throughout the day. Upon receipt, milk is cooled as it is pumped to the cold storage tank by a plate heat exchanger to keep the milk temperature at or below 40°F. The milk is tested while in the storage tank to determine its fat content.

Milk is pumped from the raw storage tank and through a clarifier. The clarifier's purpose is to remove extraneous material. A portion of the milk enters the separator before going to the raw standardizing tanks while the remainder of the milk is fed directly to the standardizing tanks. Enough skim milk is separated so that its combinations with whole milk in the standardizing tanks gives low fat milk at 2.0% butterfat and the whole milk at about 3.5% butterfat. Excess cream from the separator is used in other products or sold to other processing plants.

From the raw standardizing tanks the milk is pumped to a balance tank and then through the high temperature short time pasteurizer. In the regeneration section of the pasteurizer the milk is heated from about 38°F to 138°F. The heating media in the regenerator is previously heated milk. A timing pump controls the flow rate in the system. After leaving the pasteurizer the milk flows through the homogenizer whose purpose is to stabilize the cream in the milk. This is accomplished by compressing the milk to 2000-3000 psig and expanding it through a small orifice. Expansion in the orifice breaks up the fat globules and produces a 5°F temperature rise in the milk. The milk returns to the pasteurizer to flow through the heating section where the temperature is increased from 143°F to 165°F.

Milk, at the desired pasteurizing temperature. travels through a pipe of sufficient length to give it at least a 15 second holding time. It then enters the flow diversion valve which directs the flow of milk according to temperature. If the milk is below the desired minimum, (161°F is the legal minimum) it is diverted back to the balance tank to be recirculated through the system. If the temperature is above the desired minimum, the flow is directed back to the regenerator. In the regenerator the milk loses heat to incoming cold milk, thus reducing its temperature from 165°F to 66°F. The milk then enters the cooling section of the pasteurizer where its temperature is lowered from 66°F to 38°F.

The cooled and pasteurized milk is stored in a tank to await packaging. The milk is fed into fillers which package the milk into paper, glass, or plastic containers. The containers are sealed and placed in the cold storage room until shipment.

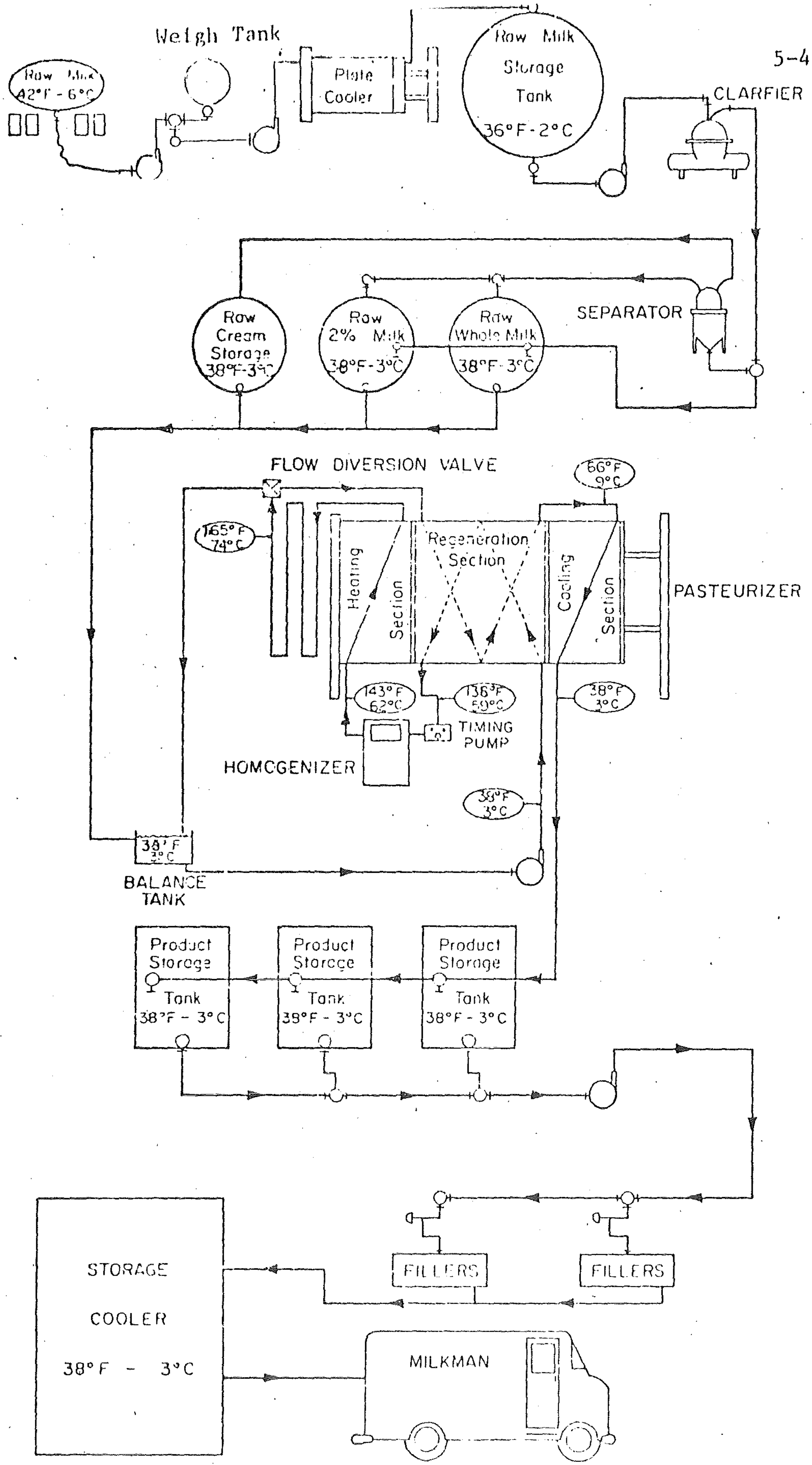


Figure 5-1a. Flow chart showing the production of fluid milk.

Energy inputs into fluid milk processing

The energy inputs for fluid milk processing will be based on a plant processing 105,000 gallons of milk per week.[11] The plant will operate 5 days a week, processing an average of 21,000 gallons per day. Other assumptions made about the plant are:

1. Only fluid milk products will be produced i.e; whole milk, lowfat, skim milk, and chocolate milk.
2. Equal energy inputs are required to produce each of the above products.
3. Only one-third of the milk entering the plant will be separated.
4. The total air circulation rate for the entire plant is 35,000 CFM.
5. The climate of the plant's geographic locale is similar to the Salt Lake City, Utah area.
6. The following CIP cleaning cycles are needed each processing day

    1 - HTST pasteurizer (Acid Wash)
    11 - Tanks and milk pipe lines
    7 - Tanker trucks
    19 cycles/day

7. The following batches of items must be cleaned manually each day.

    1 - all filling machines parts
    1 - separator and clarifier
    1 - automatic valves and positive displacement pumps
    3 batches/day

8. Only 25% of the total product is packaged in returnable glass bottles.

9. Four - 1/2 horsepower fans circulate air in the cold storage room.

10. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Processing rooms	5349	74,886
Dry storage rooms	5931	83,034
Offices, lunch, locker and restrooms	6860	68,600
Cold storage room	3200	32,000
Boiler and refrigeration rooms	2440	34,160
Tanker receiving and garage	3409	47,726
Hallways	404	4,040
TOTALS	27,593	344,446

The following tables represent estimates of most of the energy requirements for processing fluid milk. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A layout of the plant showing dimensions and components is located after the energy use tables.

A.W. Farrall estimates 20 lbs. of steam are required per 100 lbs. of milk which translates to about 1700 BTU per gallon.[8]

Table 5-1a. Typical electrical energy use per gallon of fluid milk.

Process	Calculation Number	Energy Use (BTU/gal.)	%
Pumping Milk	1.01	4.3	1.5
Clarification	2.01	8.6	3.1
Separation	3.01	2.9	1.0
Homogenization	4.01	96.0	34.5
CIP pumps	5.01	10.8	3.9
Air Compressor	8.01	3.5	1.3
Cold Storage Room Fans	9.01	5.4	1.9
Heating and Air Conditioning Fans	10.01	44.7	16.1
Boiler Fan	11.01	23.1	8.3
Cooling Tower Fans	12.01	7.8	2.8
Lights and Misc. Motors	13.01	71.2	25.6
Total		278.2	100.0

Table 5-1b. Typical steam energy use per gallon of fluid milk.

Process	Calculation Number	Energy Use (BTU/gal.)	%
Cleaning - CIP	15.01	561	44.6
Cleaning - Manual	16.01	27	2.2
Heating the Plant	18.01	229	18.2
Product Heating	19.01	189	15.0
Steam Line Losses	20.01	189	15.0
Bottle washing	21.01	62	4.9
Total		1257	100.0

Table 5-1c. Uses of refrigeration energy per gallon of fluid milk.

Uses of Refrigeration	Calculation Number	Cooling Required (BTU/gal)	% Total
Cold Storage Room	22.01	143	26.3
Air Conditioning	23.01	41	7.5
Product Cooling	24.01	293	53.8
Cooling Line Losses	25.01	67	12.4
	Total	544	100.0

With a coefficient of performance of 2.86 for the refigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{(544 \frac{\text{BTU}}{\text{gal milk}})}{(2.86)} = 190 \frac{\text{BTU}}{\text{gal milk}}$$

Table 5-1d. Total energy cost per gallon of fluid milk.

Type of Energy	Energy Used $\frac{\text{BTU}}{\text{gal milk}}$	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Cost $\frac{\$}{\text{gal milk}}$	Fossil Fuel Equivalent* $\frac{\text{BTU}}{\text{gal milk}}$
Electrical				
1. Lights and Motors	278	7.32	0.0020	834
2. Refrigeration	209	7.32	0.0015	627
Steam	1257	1.33	0.0017	1508
		Total	0.0052	2969

*Unit prices and fossil fuel equivalent factors are derived in Energy Calculations Nos. 28.01-28.06.

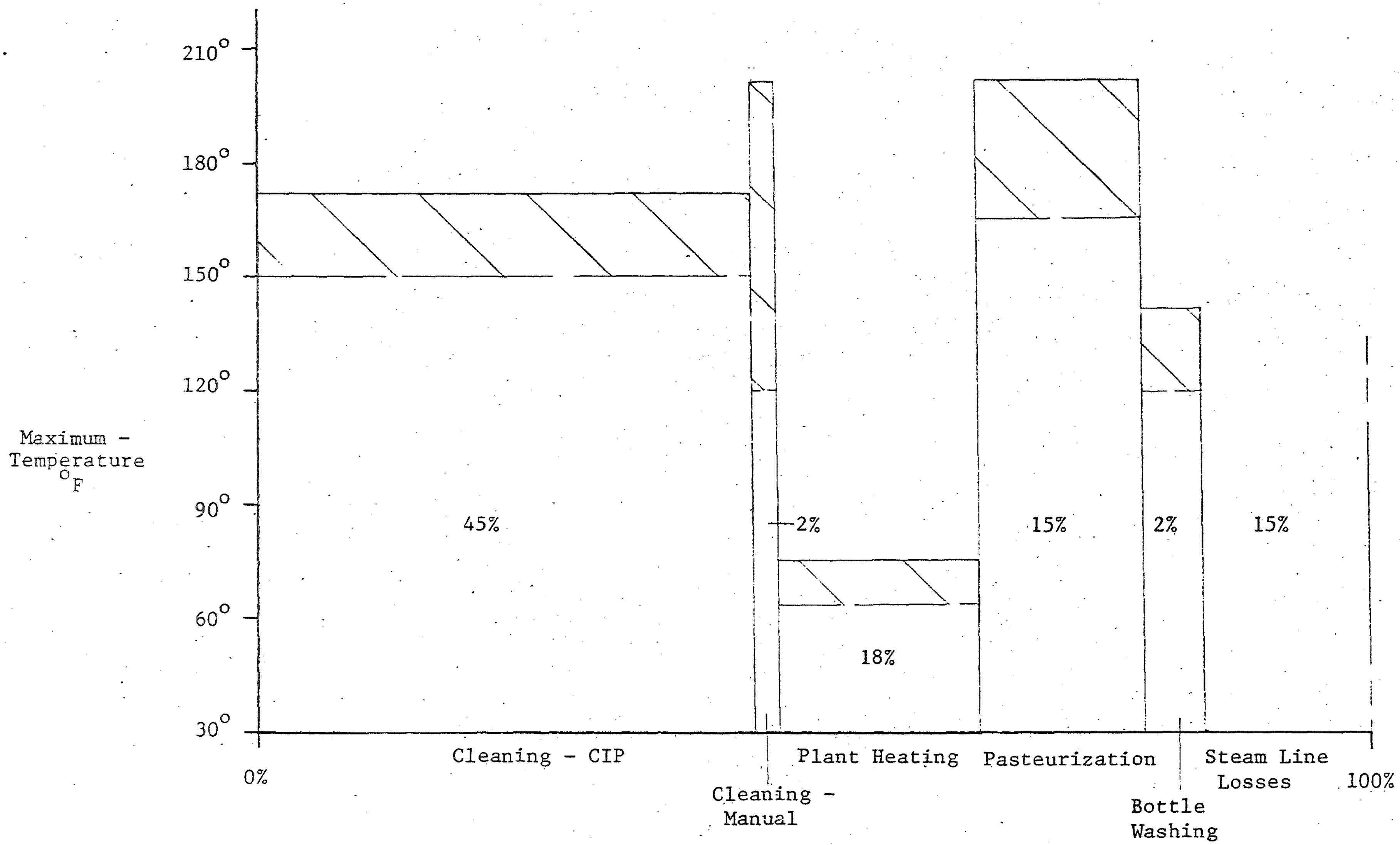
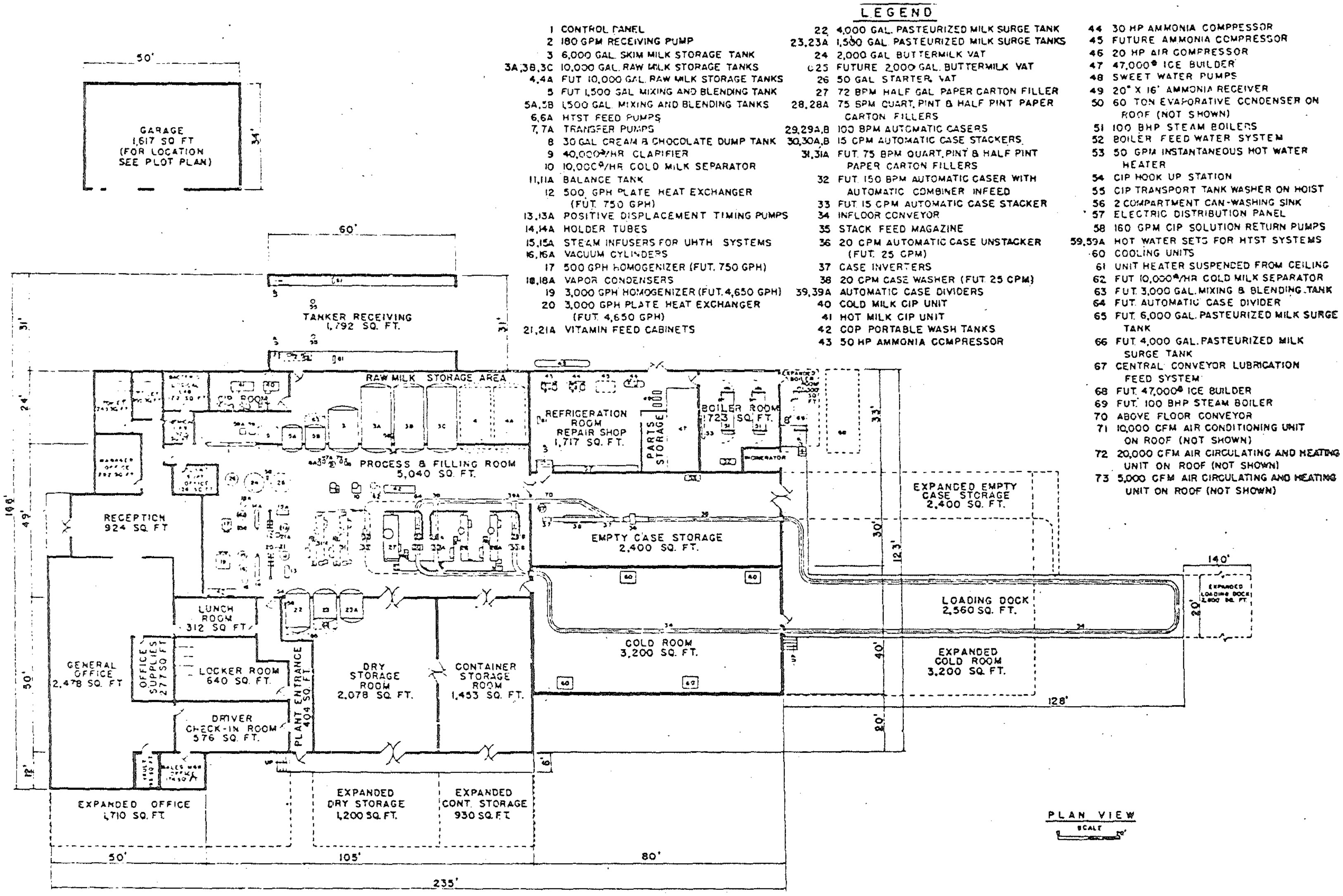


Table 5-1e. Maximum process temperature and percent of total heating energy consumption in fluid milk production. (Cross hatched represents the maximum temperature range per process.)



LEGEND

1	CONTROL PANEL
2	180 GPM RECEIVING PUMP
3	6,000 GAL. SKIM MILK STORAGE TANK
3A,3B,3C	10,000 GAL. RAW MILK STORAGE TANKS
4,4A	FUT 10,000 GAL. RAW MILK STORAGE TANKS
5	FUT 1,500 GAL MIXING AND BLENDING TANK
5A,5B	1,500 GAL. MIXING AND BLENDING TANKS
6,6A	HTST FEED PUMPS
7,7A	TRANSFER PUMPS
8	30 GAL CREAM & CHOCOLATE DUMP TANK
9	40,000#/HR CLARIFIER
10	10,000#/HR COLD MILK SEPARATOR
11,11A	BALANCE TANK
12	500 GPH PLATE HEAT EXCHANGER (FUT. 750 GPH)
13,13A	POSITIVE DISPLACEMENT TIMING PUMPS
14,14A	HOLDER TUBES
15,15A	STEAM INFUSERS FOR UHTH SYSTEMS
16,16A	VACUUM CYLINDERS
17	500 GPH HOMOGENIZER (FUT. 750 GPH)
18,18A	VAPOR CONDENSERS
19	3,000 GPH HOMOGENIZER (FUT. 4,650 GPH)
20	3,000 GPH PLATE HEAT EXCHANGER (FUT. 4,650 GPH)
21,21A	VITAMIN FEED CABINETS
22	4,000 GAL. PASTEURIZED MILK SURGE TANK
23,23A	1,500 GAL. PASTEURIZED MILK SURGE TANKS
24	2,000 GAL BUTTERMILK VAT
25	FUTURE 2,000 GAL. BUTTERMILK VAT
26	50 GAL STARTER VAT
27	72 BPM HALF GAL PAPER CARTON FILLER
28,28A	75 BPM QUART, PINT & HALF PINT PAPER CARTON FILLERS
29,29A,B	100 BPM AUTOMATIC CASERS
30,30A,B	15 CPM AUTOMATIC CASE STACKERS
31,31A	FUT. 75 BPM QUART, PINT & HALF PINT PAPER CARTON FILLERS
32	FUT. 150 BPM AUTOMATIC CASER WITH AUTOMATIC COMBINER INFEED
33	FUT. 15 CPM AUTOMATIC CASE STACKER
34	INFLOOR CONVEYOR
35	STACK FEED MAGAZINE
36	20 CPM AUTOMATIC CASE UNSTACKER (FUT. 25 CPM)
37	CASE INVERTERS
38	20 CPM CASE WASHER (FUT. 25 CPM)
39,39A	AUTOMATIC CASE DIVIDERS
40	COLD MILK CIP UNIT
41	HOT MILK CIP UNIT
42	COP PORTABLE WASH TANKS
43	50 HP AMMONIA COMPRESSOR
44	30 HP AMMONIA COMPRESSOR
45	FUTURE AMMONIA COMPRESSOR
46	20 HP AIR COMPRESSOR
47	47,000# ICE BUILDER
48	SWEET WATER PUMPS
49	20" X 16' AMMONIA RECEIVER
50	60 TON EVAPORATIVE CONDENSER ON ROOF (NOT SHOWN)
51	100 BHP STEAM BOILERS
52	BOILER FEED WATER SYSTEM
53	50 GPM INSTANTANEOUS HOT WATER HEATER
54	CIP HOOK UP STATION
55	CIP TRANSPORT TANK WASHER ON HOIST
56	2 COMPARTMENT CAN-WASHING SINK
57	ELECTRIC DISTRIBUTION PANEL
58	160 GPM CIP SOLUTION RETURN PUMPS
59,59A	HOT WATER SETS FOR HTST SYSTEMS
60	COOLING UNITS
61	UNIT HEATER SUSPENDED FROM CEILING
62	FUT 10,000#/HR COLD MILK SEPARATOR
63	FUT. 3,000 GAL. MIXING & BLENDING TANK
64	FUT. AUTOMATIC CASE DIVIDER
65	FUT. 6,000 GAL. PASTEURIZED MILK SURGE TANK
66	FUT. 4,000 GAL. PASTEURIZED MILK SURGE TANK
67	CENTRAL CONVEYOR LUBRICATION FEED SYSTEM
68	FUT. 47,000# ICE BUILDER
69	FUT. 100 BHP STEAM BOILER
70	ABOVE FLOOR CONVEYOR
71	10,000 CFM AIR CONDITIONING UNIT ON ROOF (NOT SHOWN)
72	20,000 CFM AIR CIRCULATING AND HEATING UNIT ON ROOF (NOT SHOWN)
73	5,000 CFM AIR CIRCULATING AND HEATING UNIT ON ROOF (NOT SHOWN)

Figure 5-1b. Fluid milk plant layout as given by Tracy[11]

Section 5-2

CHEDDAR CHEESE PRODUCTION

Description

Cheddar cheese production starts with the delivery of raw milk. As the milk is received it is pumped to a weigh tank and then to the raw storage tank via a plate cooler. The milk must be maintained at or below 40°F during the storage stage. This may be accomplished via a plate exchanger or by refrigeration of the storage tank.

The milk is clarified on its way to the balance tank of the HTST pasteurizer. The milk enters the pasteurizer at 38°F, and leaves the regeneration section of the pasteurizer at 110°F, having been warmed by previously pasteurized milk. It then flows through the timing pump to the heating section and holding tubes of the pasteurizer. If the temperature of the milk is below the desired minimum pasteurizing temperature when it reaches the flow diversion valve, it is diverted back to the balance tank. If the temperature is above the desired minimum (161°F is the legal minimum), the milk returns back to the regenerator to be cooled to approximately 90°F. The milk next enters the cooling section of the pasteurizer where its temperature is lowered to 88°F through the use of culinary water as a heat sink.

Once the milk has been pasteurized it is pumped to a cheese vat where color and starter are mixed with the incoming milk. Starter, a bacterial culture, makes up 1% to 2% of the total mass of the mixture. Three ounces of rennet, a milk coagulating enzyme, diluted with a half gallon of chlorinated water is added for every 1000 pounds of milk in the vat. The rennet and starter are mixed uniformly throughout the vat by a paddle agitator which operates for 2-3 minutes, after which the paddles are immediately removed and the milk is allowed to coagulate.

About 20 to 25 minutes after adding the rennet, the curd is cut into 1/4 inch cubes using curd knives consisting of piano wire stretched across a rectangular frame. About 20 minutes after cutting the curd, the paddles are replaced in the agitator to stir the curd and help with the expulsion of whey. Steam is admitted to the jacketed vat and the temperature of the curd is slowly raised from 88°F to 102°F at a rate of 2°F per 5 minutes.

About one hour after cutting the curd, an acidity test is run on the whey. If the acidity has reached 0.13 to 0.15 per cent (expressed as lactic acid), then half of the whey is withdrawn from the curd. The curd is again agitated for 5 minutes and the remaining whey is allowed to drain. During the draining of the whey, the curd is pushed to the sides of the vat to form a narrow trench down the center.

The cheddaring process begins after the curd is matted together forming long slabs of cheese. The curd is cut manually into slabs about 18 inches long and 2 inches wide. The slabs are flipped over several times and then stacked on each other to help with further expulsion of whey. The cheddaring process is continued until the whey from the cheese reaches 0.50 to 0.60 percent acidity.

The curd blocks are fed into a curd mill which slices them. Salt is added at the rate of 4 pounds per 1000 pounds of milk processed. The curd is mixed to evenly dissolve the salt and is dumped into hoops lined with cloth or paper bandages. The filled hoops are transferred to the curd press and pressurized to force the whey from the cheese.

The pressure is released after 30 minutes to allow "dressing" or pulling the bandages tight around the cheese. Then the pressure is reapplied and left overnight.

The following morning, the hoops are removed and the cheese is placed in the drying room for 48 hours.

After the drying process is completed the cheese is either dipped in paraffin or sealed in a paraffin coated paper wrapper via a heated press and packed in cardboard boxes which are moved to a 40°F cold storage room for curing.

The length of the curing period is dependent upon the type of cheese desired. Mild cheddar flavor requires 2 to 3 months storage. Six months in a 50°F storage room is required for sharp flavor.

Starter making can be a lengthy procedure and will not be described completely here. However, from an energy standpoint, the making of bulk starter is of interest. The bulk starter is made from special dried starter media. The media is mixed with water and heated from 70°F to 190°F destroying most of the microorganisms in it, and then cooled back to 70°F. The media is innoculated with a mother culture and incubated for 12 hours. It is then cooled to 40°F to await addition to the cheese milk.

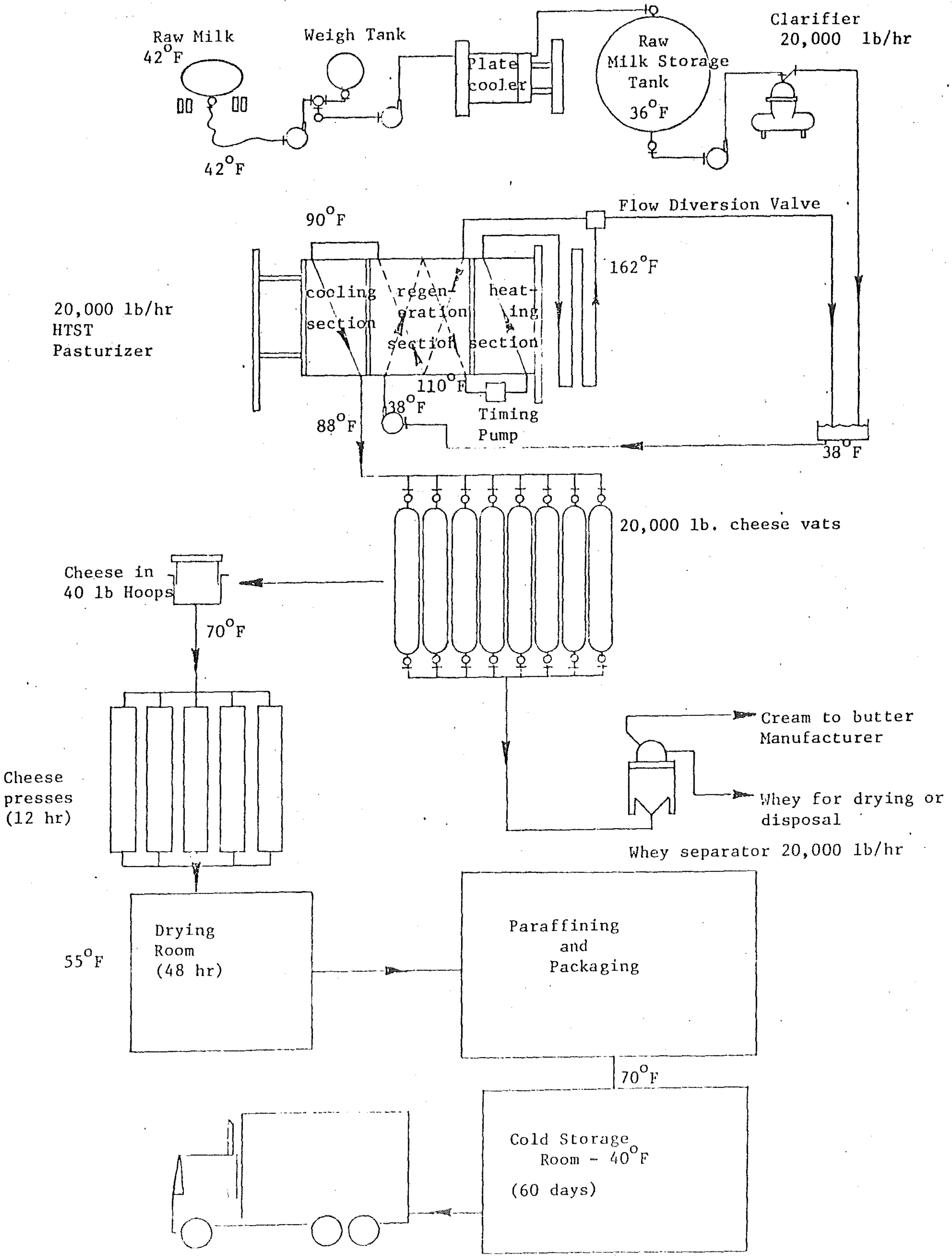


Figure 5-2a. Flow chart showing cheddar cheese production.

Energy Inputs Into Cheddar Cheese Production

The energy inputs for cheddar cheese production will be based on a plant processing 800,000 pounds of milk per week.[12] The plant will operate 6 days a week making 80,000 pounds of cheese each week. The following assumptions will be made about the plant.

1. The processing energy requirements will not include any whey concentrating or drying. However, the total energy use will show two options, one with whey being ignored and the other with whey being dried. The individual energy requirements for drying whey are shown in the Dried Whey Section.
2. Ten pounds of milk will yield one pound of cheese.
3. There is 0.56 pounds of whey powder produced per pound of cheese.
4. Provision will be made to store the cheese 60 days before shipment.
5. Only cheddar cheese will be produced in this plant.
6. The total air circulation rate for the entire plant is 86,500 CFM.
7. The climate of the plant location will be similar to that of the Salt Lake City, Utah area.
8. The following CIP cleaning cycles are needed each day

    1 - HTST Pasteurizer (Acid Wash)
    7 - Tanker trucks
    5 - Milk tanks and pipeline systems
    13 cycles/day

9. The following batches of items must be cleaned manually each day

1	- clarifier and whey separator
1	- curd knives, stirrers, strainers, etc.
3	- soiled cheese hoops
1	- positive displacement pumps and automatic valves
7	- cheese vats
13	batches/day

10. Eight - 1 horsepower fans circulate air in the cold storage room.

11. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Processing rooms	15,354	245,664
Offices, lunch, locker, and restrooms	4,972	49,720
Dry storage and drying room	3,230	51.680
Starter rooms	1,159	18,544
Cold Storage room	9,440	160,480
Receiving shelter	1,600	25,600
Boiler and refrigeration rooms	3,255	52,080
Hallways	4,145	66,320
TOTALS	43,155	670,088

The following tables represent estimates of most of the energy requirements for producing cheddar cheese. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A typical cheddar cheese plant layout is found after the energy use tables.

Table 5-2a. Typical electrical energy use per pound of cheddar cheese.

Process	Calculation Number	Energy Use (BTU/1b)	%
Pumping Milk	1.02	5.0	1.3
Clarification	2.02	10.0	2.6
Whey Separation	3.02	9.0	2.3
CIP Pumps	5.02	11.6	3.0
Air Compressors	8.02	4.6	1.2
Cold Room Fans	9.02	28.5	7.4
Heating and Air Cond. Fans	10.02	144.9	37.8
Boiler Fan	11.02	30.4	7.9
Cooling Tower Fans	12.02	5.6	1.5
Lights and Misc. Motors	13.02	133.5	34.8
Total		383.1	100.0

Table 5-2b. Typical steam energy use per pound of cheddar cheese.

Process	Calculation Number	Energy Use (BTU/1b)	%
Cleaning - CIP	15.02	611	26.3
Cleaning - Manual	16.02	187	8.1
Heating the Plant	18.02	495	21.3
Product Heating	19.02	684	29.5
Steam Line Losses	20.02	342	14.7
Total		2319	100.0

Table 5-2c. Uses of refrigeration per pound of cheddar cheese.

Process	Calculation Number	Cooling Needed (BTU/lb)	%
Cold Storage Room	22.02	301	70.3
Air Conditioning	23.02	40	9.3
Product Cooling	24.02	66	15.4
Cooling Line Losses	25.02	21	4.9
Total		428	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(428 \frac{\text{BTU}}{\text{lb cheese}}\right)}{2.86} = 150 \frac{\text{BTU}}{\text{lb cheese}}$$

Table 5-2d. Total energy cost per pound of cheddar cheese neglecting whey spray drying costs.

Type of Energy Used	Energy Used (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	383	7.32	0.0028	1149
2. Refrigeration	150	7.32	0.0011	450
Steam	2319	1.33	0.0031	2783
Total			0.0070	4382

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

Table 5-2e. Total energy cost per pound of cheddar cheese including whey drying costs.

Type of Energy Used	Energy Used (BTU/lb)	Unit Price* $/10^6 BTU	Dollar Cost $/(lb)	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	498	7.32	0.0036	1494
2. Refrigeration	268	7.32	0.0020	804
Steam	5440	1.33	0.0072	6528
Natural Gas (for spray drying)	1737	1.06	0.0018	1737
Total			0.0146	10,563

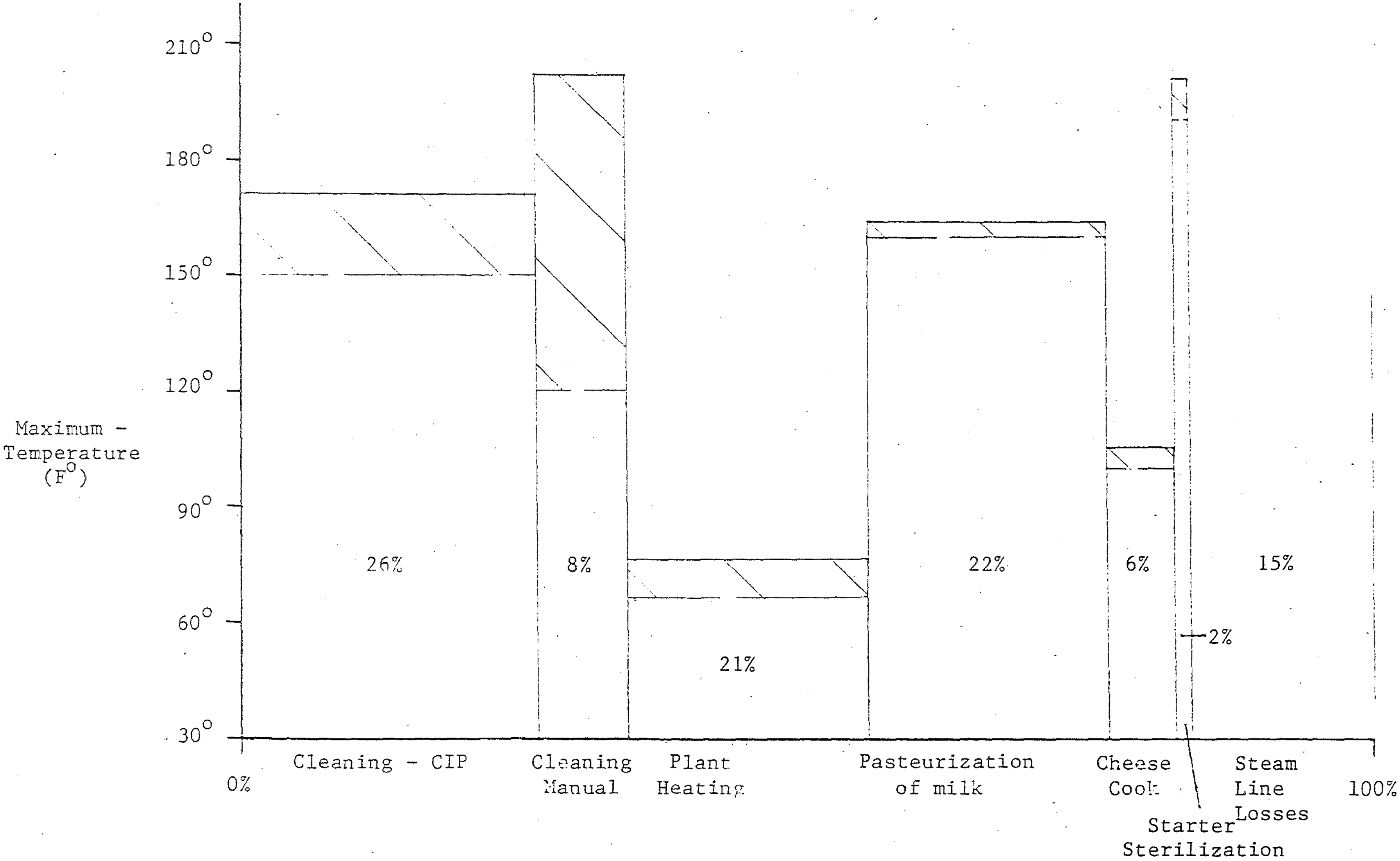


Table 5-2f. Maximum process temperature and percent of total heating consumption in Cheddar Cheese production neglecting whey drying. (Cross hatching represents the maximum temperature range per process.)

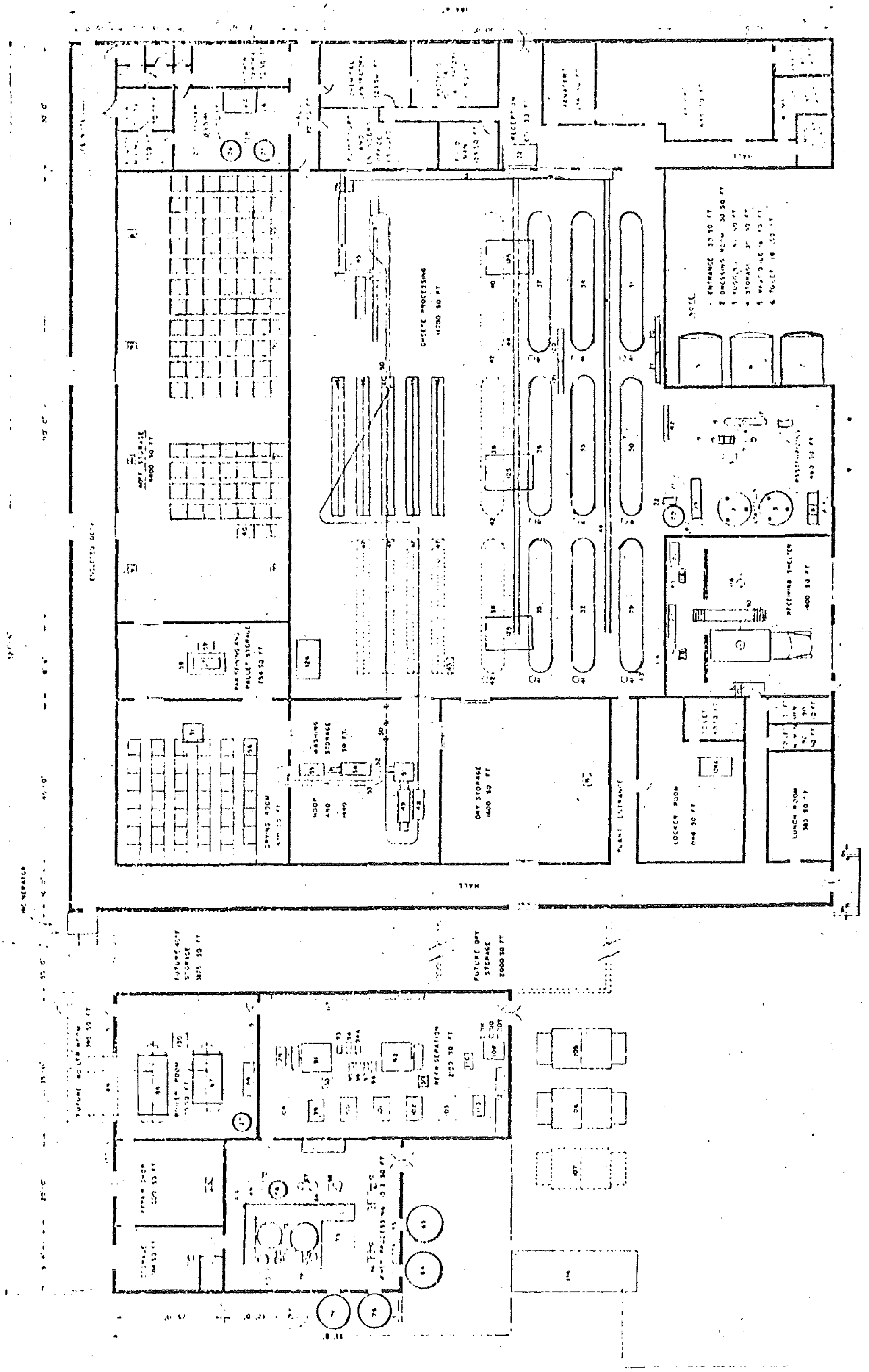


Figure 5-2b. Cheddar cheese plant layout as given by Tracy[13]

Section 5-3

COTTAGE CHEESE PRODUCTION

Description

Upon the receipt of raw milk from bulk tankers, it is weighed, cooled and pumped to the raw storage tanks. To start the cheese making process, raw milk from the storage tank is pumped through a clarifier, a tubular preheater, and then a separator. The clarifier removes extraneous material. The tubular preheater increases the milk temperature to 90°F to improve the efficiency of separation.

Skim milk from the separator flows to a separate HTST Pasteurizer where it is heated to 151°F in the regeneration section and to 162°F in the heating section. It is then cooled to 101°F in the regeneration section and 88°F in the cooling section. This pasteurizer description is similar to the one given in the Cheddar Cheese Section. The 40% fat cream from the separator flows to its own HTST pasteurizer where it is heated to 170°F for 15 seconds and then cooled to 38°F. The cream is pumped to a storage tank to await processing into cottage cheese dressing or other dairy products.

Skim milk coming from the HTST pasteurizer at 88°F is pumped to a cheese vat to be mixed with starter and rennet. Enough starter is added to make up 5% of the total mass added. The mixture is agitated and then allowed to incubate till a pH of 4.7 is attained at which time the coagulum is quite firm and is cut into 1/4 to 1/2 inch cubes. The elapsed time from the adding of starter to the cutting the curd is about two and a half hours.

The cut curd is allowed to set for 15 minutes. The cook begins when hot water is circulated in a jacket around the vat. This increases the temperature of the vat contents 2°F every five minutes. Agitation of the curd is started about 20 minutes after cutting. The cook continues until the temperatures reaches approximately 125°F and the curd expels sufficient whey to give it the desired firmness. The cooking process takes about two hours.

After the cook is completed, the hot water in the jacket and the whey is drained. The remaining curd is washed with 70°F water to lower the curd temperature to 80°F or 85°F. After the water and curd mixture is agitated, it is drained and a second wash with 60°F water is added. A third wash with 34°F water is added to lower the curd temperature to about 40°F.

With the curd still containing the third wash water, the curd-water mixture is pumped to the draining and creaming vats. The final wash water is then drained and the desired amount of cottage cheese dressing is added. The dressing and curd are thoroughly mixed before being conveyed to the packaging machines and the cold storage room.

Cottage cheese dressing is made from a mixture of 40% fat cream, whole milk, salt, and stabilizer. The ingrediants are blended together in a vat and heated to 170°F for 30 minutes to pasteurize the dressing. At the completion of the heating period, the dressing is homogenized and cooled back to 38°F. The dressing is then stored to await further use.

The total time required per vat of cottage cheese is about six hours. The energy intensive procedures in making starter is the same as described in the Cheddar Cheese Section.

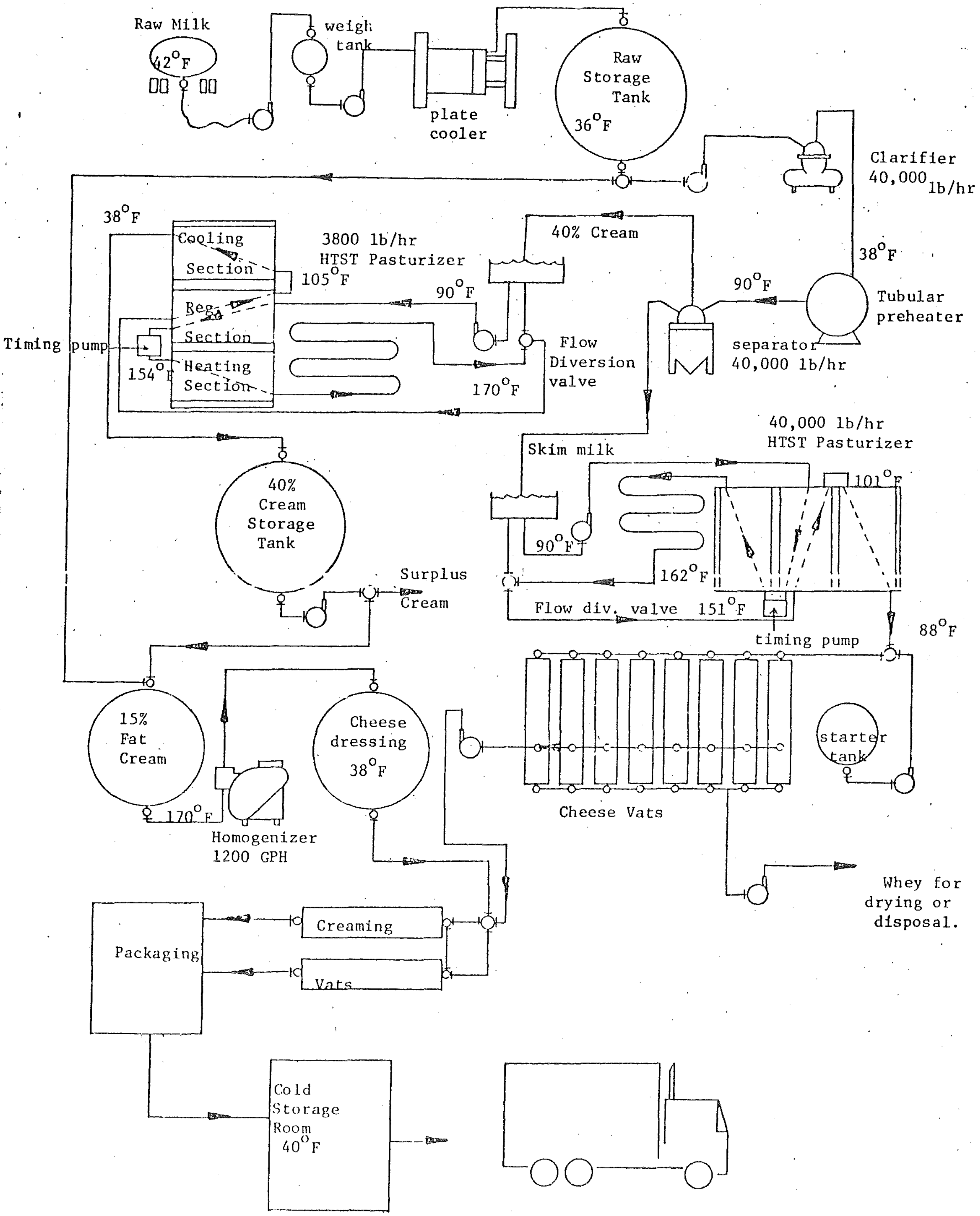


Figure 5-3a. Cheddar cheese plant layout as given by Tracy[13].

Energy Inputs Into Cottage Cheese Production

The energy inputs for cottage cheese production will be based on a plant processing 1,200,000 pounds of milk per week.[13] The plant will operate 5 days a week making 219,750 pounds of cottage cheese each week. The following assumptions will be made about the plant.

1. The plant will also produce cream cheese, sour cream, and cultured milk.
2. The weekly consumption and production figures are as follows; 825,500 lbs. of skim milk will be made into 146,500 lbs. of curd which will be combined with 73,250 lbs. of 15% fat dressing made from 50,875 lbs. of whole milk and 22,375 lbs. of 40% cream. This makes 319,750 lbs. of cottage cheese.
3. The processing costs will not contain any whey concentrating or drying costs. However, the total energy cost will show two options, one with whey being ignored and the other with whey being dried. The individual costs of drying whey are shown in the Dried Whey Section.
4. There are 0.19 lbs. of whey powder which can be produced per pound of cottage cheese.
5. The total air circulation rate for the entire plant is 73,500 CFM.
6. The climate where the plant is located is similar to the Salt Lake City, Utah area.

7. The following CIP cleaning cycles are needed each day.

1	- HTST Pasteurizer (Acid Wash)
4	- Tanker Trucks
8	- Milk tanks and pipeline systems
13 cycles/day	

8. The following batches of items must be cleaned daily.

1	- clarifier and separator
2	- shovels, stirrers, etc.
1	- positive displacement pumps and automatic valves
1	- packaging equipment parts
8	- cheese vats
6	- creaming vats
19 batches/day	

9. Six - 1/2 horsepower fans circulate air in the cold storage room.

10. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Offices, lunch, locker, and restrooms	3544	49,616
Dry Storage	2400	33,600
Processing Rooms	8229	91,990
Cold Storage Room	2800	36,400
Boiler and Refrigeration Rooms	2909	40,726
Culture Rooms	3857	43,370
Packaging rooms	2306	27,672
Receiving Shelter	2400	33,600
TOTALS	28,445	356,974

The following tables represent estimates of most of the energy requirements for producing cottage cheese. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A plant layout of a cottage cheese, cream cheese, sour cream, and cultured milk producing plant is given after the tables.

Table 5-3a. Typical electrical energy uses per pound of cottage cheese.

Process	Calculation Number	Energy Use (BTU/1b)	%
Pumping Milk	1.03	2.5	2.8
Clarification	2.03	4.1	4.6
Separation	3.03	4.0	4.5
Homogenization	4.03	3.7	4.1
CIP Pumps	5.03	3.5	3.9
Air Compressor	8.03	1.2	1.3
Cold Storage Room Fans	9.03	2.0	2.2
Heating and Air Cond. Fans	10.03	33.6	37.6
Boiler Fan	11.03	8.3	9.3
Cooling Tower Fan	12.03	2.4	2.7
Lights and Misc. Motors	13.03	24.0	26.9
Total		89.3	100.0

Table 5-3b. Typical steam energy uses per pound of cottage cheese.

Process	Calculation Number	Amount Used (BTU/1b)	%
Cleaning - CIP	15.03	185	21.5
Cleaning - Manual	16.03	83	9.6
Heating the Plant	18.03	89	10.3
Product Heating	19.03	434	50.3
Steam Line Losses	20.03	71	8.2
Total		862	100.0

Table 5-3a. Typical electrical energy uses per pound of cottage cheese.

Process	Calculation Number	Energy Use (BTU/lb)	%
Pumping Milk	1.03	2.5	2.8
Clarification	2.03	4.1	4.6
Separation	3.03	4.0	4.5
Homogenization	4.03	3.7	4.1
CIP Pumps	5.03	3.5	3.9
Air Compressor	8.03	1.2	1.3
Cold Storage Room Fans	9.03	2.0	2.2
Heating and Air Cond. Fans	10.03	33.6	37.6
Boiler Fan	11.03	8.3	9.3
Cooling Tower Fan	12.03	2.4	2.7
Lights and Misc. Motors	13.03	24.0	26.9
Total		89.3	100.0

Table 5-3b. Typical steam energy uses per pound of cottage cheese.

Process	Calculation Number	Amount Used (BTU/lb)	%
Cleaning - CIP	15.03	185	21.5
Cleaning - Manual	16.03	83	9.6
Heating the Plant	18.03	89	10.3
Product Heating	19.03	434	50.3
Steam Line Losses	20.03	71	8.2
Total		862	100.0

Table 5-3c. Uses of refrigeration per pound of cottage cheese.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Cold Storage Room	22.03	22	12.1
Air Conditioning	23.03	12	6.6
Product Cooling	24.03	121	66.5
Cooling Line Losses	25.03	27	14.8
Total		182	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{(182 \frac{\text{BTU}}{\text{lb cheese}})}{2.86} = 64 \frac{\text{BTU}}{\text{lb cheese}}$$

Table 5-3d. Total energy cost per pound of cottage cheese neglecting whey spray drying costs.

Type of Energy Used	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6 \text{ BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	89	7.32	0.00065	267
2. Refrigeration	64	7.32	0.00047	192
Steam	862	1.33	0.00115	1034
Total			0.00227	1493

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

Energy Inputs Into Sour Cream Production

The energy inputs for sour cream production will be based on a plant processing 1,200,000 pounds of milk per week.[13] The plant will operate 5 days a week making 60,000 pounds of sour cream each week. The following assumptions will be made about the plant.

1. The plant will also produce cream cheese, cottage cheese, and cultured milk.
2. Each week, 23,335 lbs. of 50% fat cream and 36,665 lbs. of whole milk will be combined to make 60,000 lbs. of sour cream.
3. The total air circulation rate for this plant is 73,5000 CFM.
4. The climate the plant is located in is similar to that of the Salt Lake City, Utah area.
5. Only one CIP cleaning cycle is needed each day because much of the pipelines and tanks holding cream and milk going for sour cream also are used for other products and the cleaning requirements are shared between them. The one cycle is assumed to be an acid wash.
6. The packaging equipment and processing pumps are the only equipment cleaned manually and it all can be cleaned in one batch.
7. Six - 1/2 horsepower fans circulate air in the cold storage room.

Table 5-3c. Uses of refrigeration per pound of cottage cheese.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Cold Storage Room	22.03	22	12.1
Air Conditioning	23.03	12	6.6
Product Cooling	24.03	121	66.5
Cooling Line Losses	25.03	27	14.8
Total		182	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(182 \frac{\text{BTU}}{\text{lb cheese}}\right)}{2.86} = 64 \frac{\text{BTU}}{\text{lb cheese}}$$

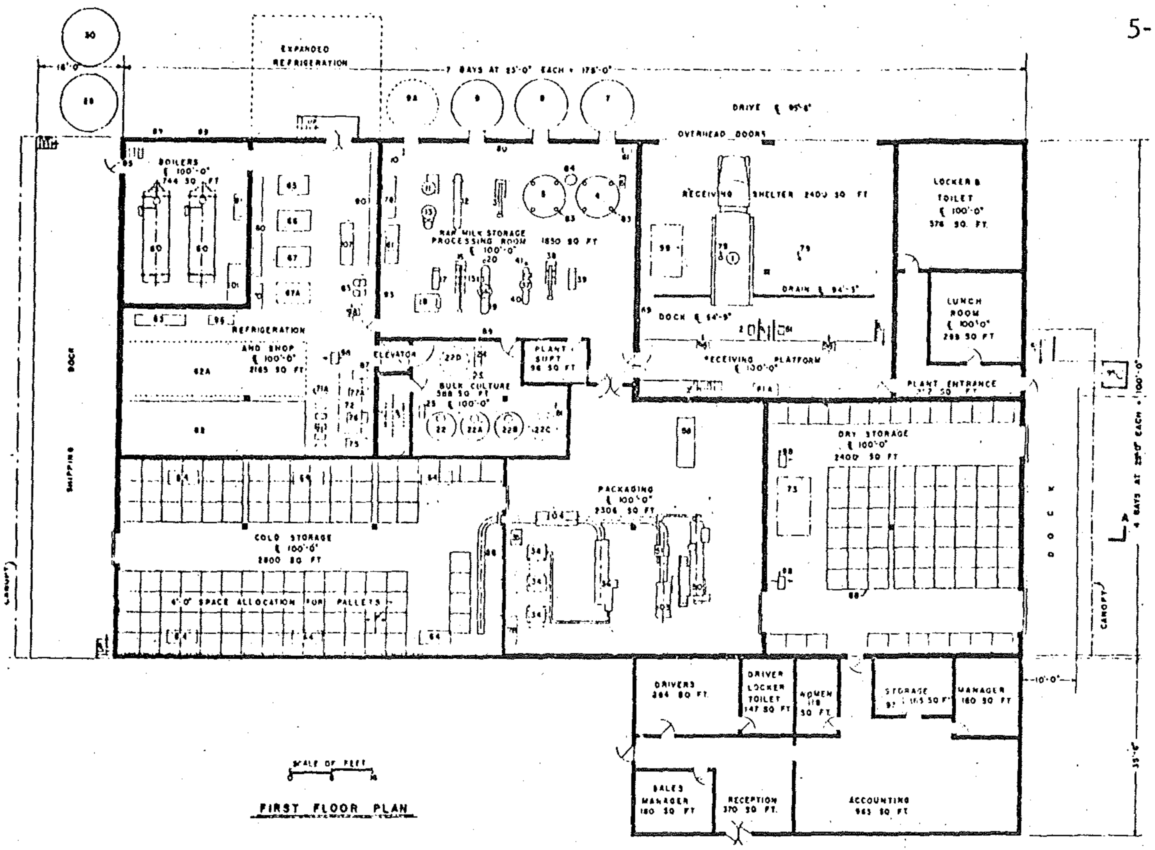
Table 5-3d. Total energy cost per pound of cottage cheese neglecting whey spray drying costs.

Type of Energy Used	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6 \text{ BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	89	7.32	0.00065	267
2. Refrigeration	64	7.32	0.00047	192
Steam	862	1.33	0.00115	1034
Total			0.00227	1493

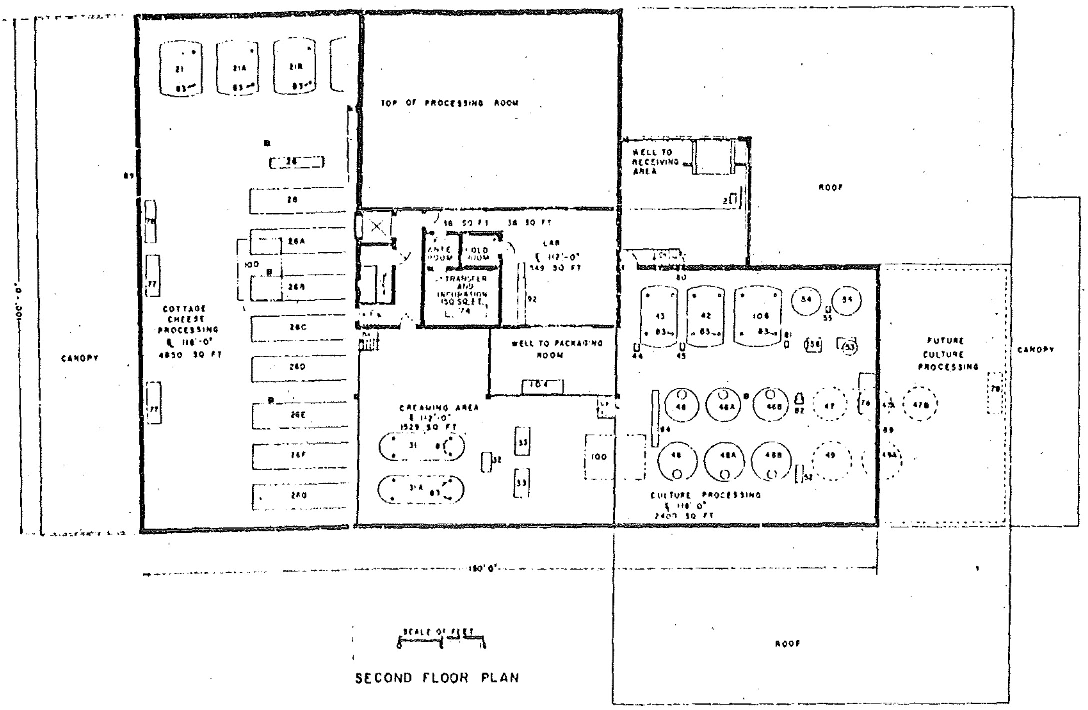
*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

Table 5-3e. Total energy cost per pound of cottage cheese including whey drying costs.

Type of Energy Used	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	128	7.32	0.0009	384
2. Refrigeration	104	7.32	0.0008	312
Steam	1921	1.33	0.0026	2305
Natural Gas (for spray drying)	589	1.06	0.0006	589
Total			0.0049	3590



FIRST FLOOR PLAN



SECOND FLOOR PLAN

Figure 5-3b Cottage Cheese Plant Layout as given by Tracy[13]

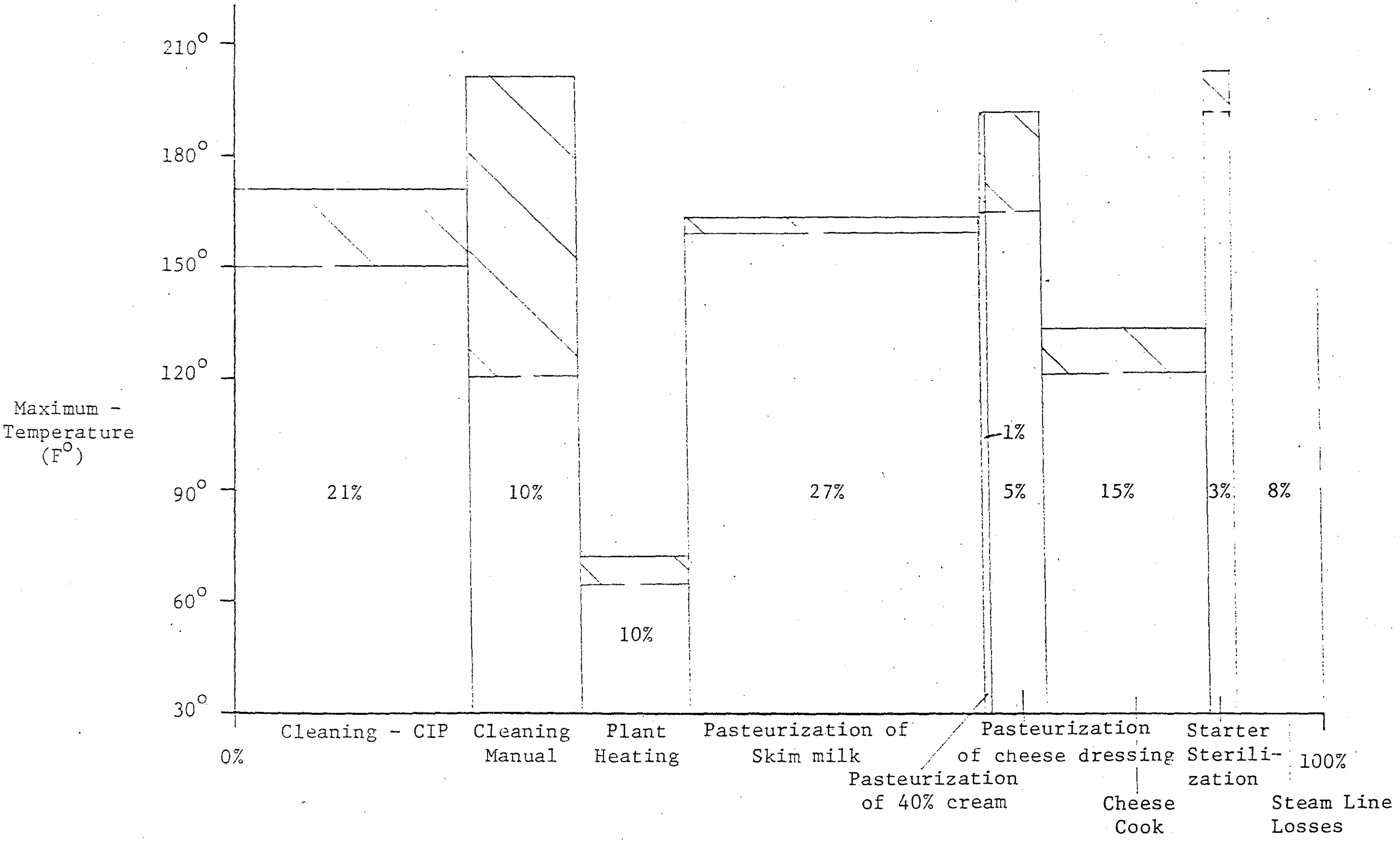


Table 5-3f. Maximum process temperature and percent of total heating energy consumption in Cottage Cheese production neglecting whey drying. (Cross hatching represents the maximum temperature range per process.)

Section 5-4

SOUR CREAM PRODUCTION

Description

Since sour cream production consumes a large amount of cream, it is commonly made in conjunction with a product such as cottage cheese which requires a large volume of skim milk. Therefore this description will assume that the sour cream production procedure is a branch of the cottage cheese production process.

Incoming raw milk is weighed, cooled, and stored until further processing. The processing begins by pumping the stored raw milk through a clarifier to remove extraneous particles. Then after the milk is warmed to 90°F in a tubular preheater to improve separator efficiency it is separated into skim milk and 40% fat cream. The skim milk is used in the production of cottage cheese while the 40% cream is pumped through a HTST pasteurizer. In the pasteurizer the cream is heated to 154°F in the regeneration section and to 170°F in the heating section. After the appropriate holding time, the milk is cooled to 105°F and to 38°F in the regeneration and cooling sections respectively. The pasteurized cream can now be stored until it is desired to use the cream in the production of sour cream.

The 40% fat cream and raw whole milk are blended together to form an 18% fat cream mix. This cream is heated to 170°F and is held for 30 minutes. At the end of the holding period, the cream is homogenized at 3000 psig and then cooled down to 70°F by circulating sweet-water in the jacket surrounding the tank holding the cream.

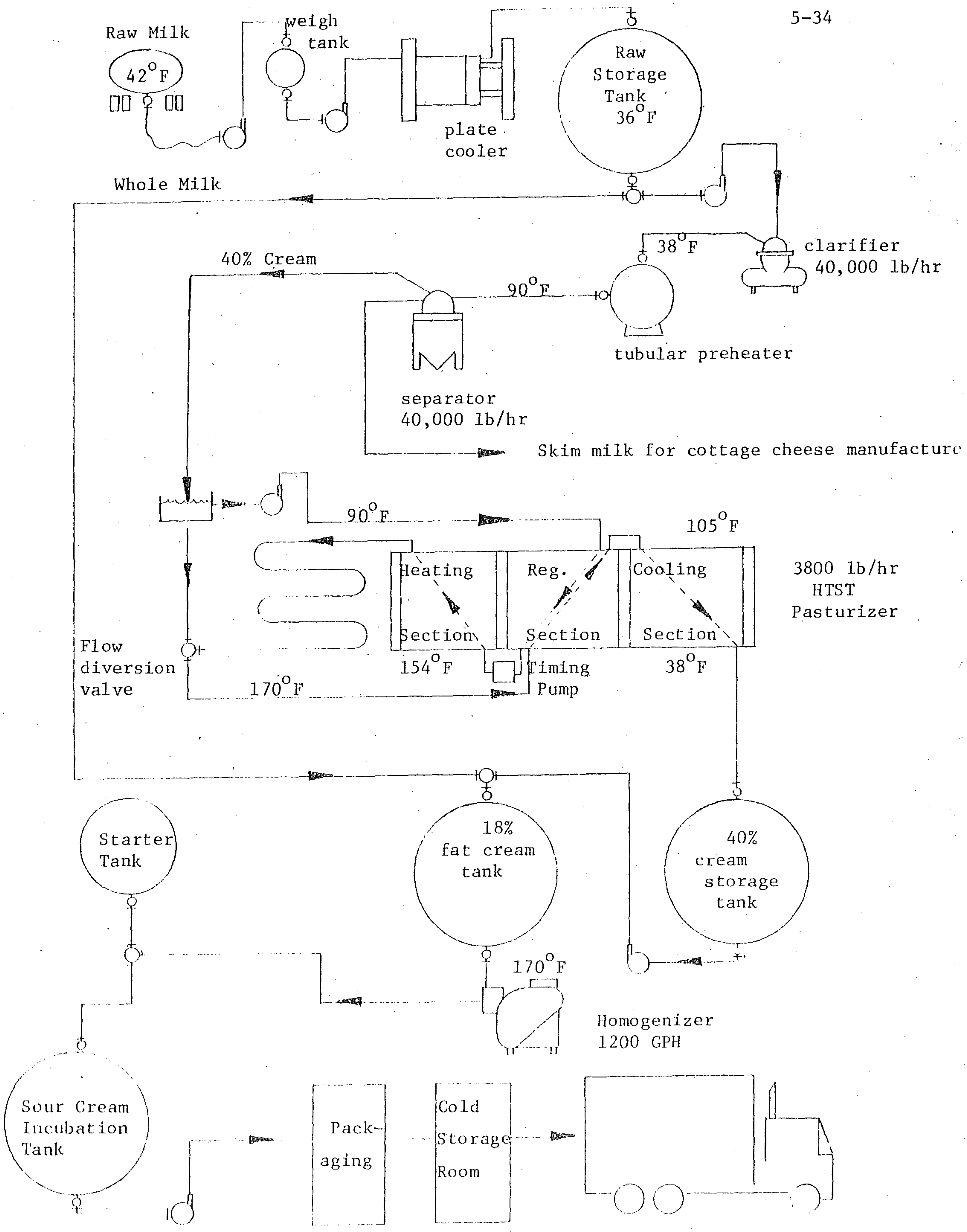


Figure 5-4a. Flow chart showing sour cream production.

Starter is added until it represents 1 to 2 percent of the total mass. The mixture is incubated about 16 hours or until the acidity reached 0.6% (expressed as lactic acid). At this point the curd is broken and the coagulum is cooled to 65°F and forced by pumps or air pressure into packaging machines.

The packaged sour cream is placed in the cold storage room to finish cooling to 40°F.

A detailed description of a high temperature short time pasteurizer and the method of making starter is given in the Cheddar Cheese Section.

Energy Inputs Into Sour Cream Production

The energy inputs for sour cream production will be based on a plant processing 1,200,000 pounds of milk per week.[13] The plant will operate 5 days a week making 60,000 pounds of sour cream each week. The following assumptions will be made about the plant.

1. The plant will also produce cream cheese, cottage cheese, and cultured milk.
2. Each week, 23,335 lbs. of 50% fat cream and 36,665 lbs. of whole milk will be combined to make 60,000 lbs. of sour cream.
3. The total air circulation rate for this plant is 73,5000 CFM.
4. The climate the plant is located in is similar to that of the Salt Lake City, Utah area.
5. Only one CIP cleaning cycle is needed each day because much of the pipelines and tanks holding cream and milk going for sour cream also are used for other products and the cleaning requirements are shared between them. The one cycle is assumed to be an acid wash.
6. The packaging equipment and processing pumps are the only equipment cleaned manually and it all can be cleaned in one batch.
7. Six - 1/2 horsepower fans circulate air in the cold storage room.

8. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Offices, lunch, locker and restroom	3544	49,616
Dry Storage	2400	33,600
Processing Rooms	8229	91,990
Cold Storage Room	2800	36,400
Boiler and Refrigeration Rooms	2909	40,726
Culture rooms	3857	43,370
Packaging Rooms	2306	27,672
Receiving shelter	2400	33,600
TOTALS	28,445	356,974

The following tables represent estimates of most of the energy requirements in producing sour cream. The estimating procedure for each energy use is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A plant layout of a cottage cheese, cream cheese, sour cream, and cultured milk producing plant is shown in the section describing cottage cheese production.

Table 5-4a. Typical electrical energy uses per pound of sour cream.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Pumping Milk	1.04	0.6	1.7
Clarification	2.04	1.0	2.9
Separation	3.04	0.4	1.1
Homogenization	4.04	11.3	32.3
CIP Pumps	5.04	1.0	2.9
Air Compressor	8.04	0.3	0.9
Cold Storage Room Fans	9.04	2.0	5.7
Heating and Air Conditioning Fans	10.04	8.2	23.4
Boiler Fan	11.04	2.0	5.7
Cooling Tower Fans	12.04	2.4	6.9
Lights and Misc. Motors	13.04	5.8	16.6
Total		35.0	100.0

Table 5-4b. Typical steam energy uses per pound of sour cream.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Cleaning - CIP	15.04	75	27.4
Cleaning - Manual	16.04	16	5.8
Heating the Plant	18.04	22	8.0
Product Heating	19.04	144	52.6
Steam Line Losses	20.04	17	6.2
Total		274	100.0

Table 5-4c. Uses of refrigeration per pound of sour cream.

Use of Refrigeration	Calculation Number	Cooling Required (BTU/lb.)	%
Cold Storage Room	22.04	41	22.0
Air Conditioning	23.04	3	1.6
Product Cooling	24.04	118	63.4
Cooling Line Losses	25.04	24	12.9
Total		186	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(186 \frac{\text{BTU}}{\text{lb. Sour Cream}}\right)}{2.86} = 65 \frac{\text{BTU}}{\text{lb. Sour Cream}}$$

Table 5-4d. Total energy cost per pound of sour cream.

Type of Energy	Energy Used BTU/lb Sour Cream	Unit Price* $/10⁶ BTU	Dollar Cost ($/lb.)	Fossil Fuel Equivalent* (BTU/lb.)
Electrical				
1. Lights and motors	35	7.32	0.00026	105
2. Refrigeration	65	7.32	0.00048	195
Steam	274	1.33	0.00036	329
Total			0.00110	629

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

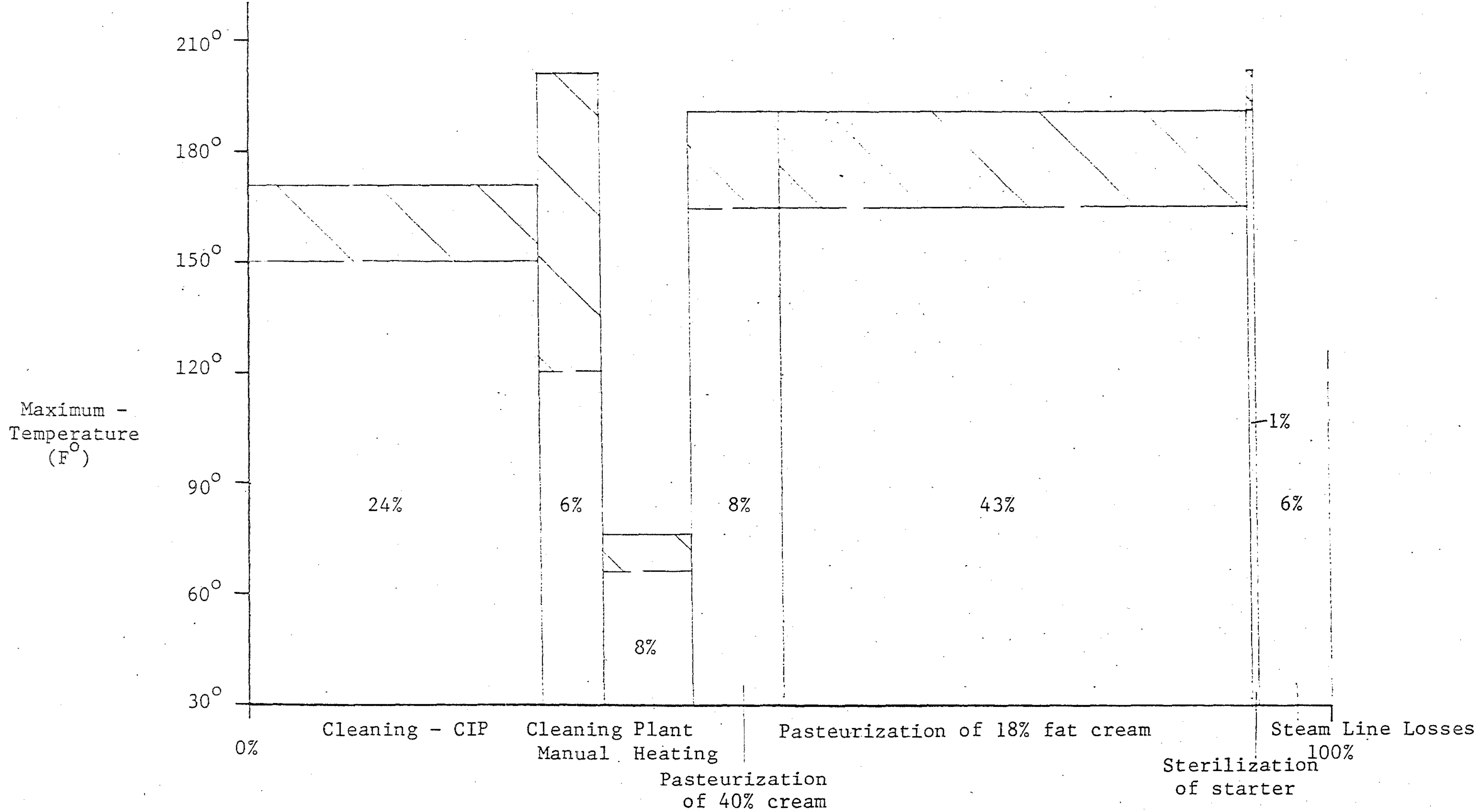


Table 5-4e. Maximum process temperature and percent of total heating energy consumption in Sour Cream production. (Cross hatching represents the maximum temperature range per process.)

Section 5-5

CREAM CHEESE PRODUCTION

Description

Since cream cheese production consumes a large amount of cream, it is commonly made in conjunction with a product such as cottage cheese which consumes a very large volume of skim milk. Also there are several variations in the procedure of making cream cheese. Thus, the procedure presented here will be a branch of a cottage cheese operation, typical of a modern dairy plant.

Incoming raw milk is weighed, cooled, and stored until further processing. The processing begins by pumping the stored raw milk through a clarifier to remove extraneous particles. Then, after the milk is warmed to 90°F in a tubular preheater, it is separated into skim milk and 40% fat cream. The skim milk is sent into the cottage cheese production line while the 40% cream is pumped through a HTST pasteurizer. In the pasteurizer the cream is heated to 154°F in the regeneration section and to 170°F in the heating section. After the appropriate holding time the cream is cooled to 105°F and to 38°F in the regeneration and cooling sections of the pasteurizer respectively. The pasteurized and cooled cream may now be stored before being processed into cream cheese.

The 40% cream and raw whole milk are mixed together forming a 5% fat cream. This cream is heated to 170°F for 30 minutes for pasteurization. It is then cooled to 79°F with culinary water and sweet water used as a heat sink. Starter is added until it represents 1% of the total mass. The mixture is allowed to incubate for 16 hours at 70°F or until the coagulum reaches 0.83% acidity (expressed as lactic acid).

The coagulum is broken up by agitation and cooled to 65°F. It is then slowly pumped through a preheater which raises the temperature to 120°F before entering the curd concentrator. Whey is removed in the curd concentrator, and the curd is pumped to a tank to be combined with 40% cream, non-fat dry milk, salt and stabilizer.

The cream cheese mixture is standardized to 33% fat and 45% total solids. The standardized mix is then heated to 150°F, homogenized at about 3000 psig, packaged, and put in the cold storage room to cool.

A detailed description of the high temperature short time pasteurizer operation and the method of making starter is given in the Cheddar Cheese section.

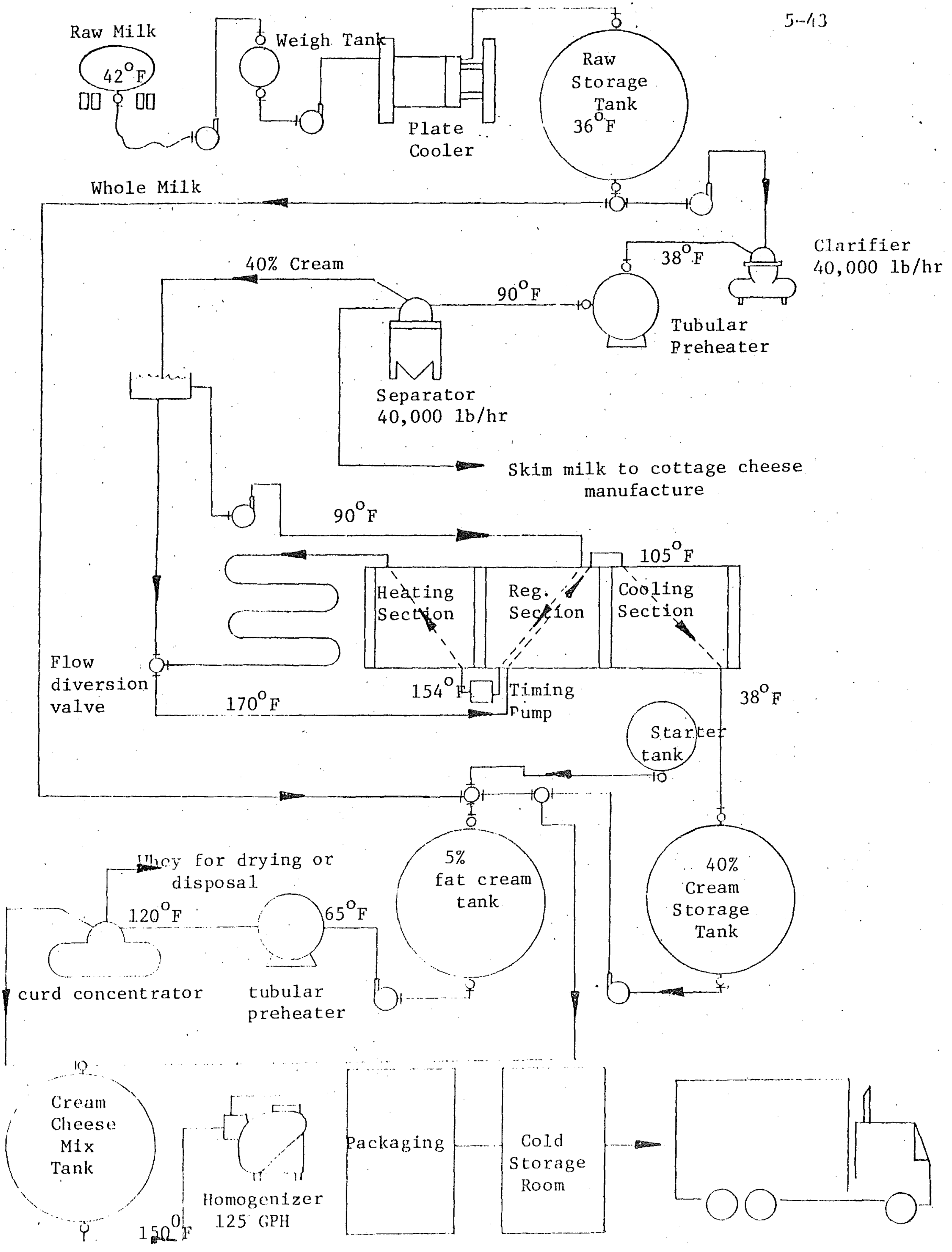


Figure 5-5a. Flow chart showing cream cheese production.

Energy Inputs Into Cream Cheese Production

The energy inputs for cream cheese production will be based on a plant processing 1,200,000 pounds of milk per week.[13] The plant will operate 5 days a week making 18,000 pounds of cream cheese every week. The following assumptions will be made about the plant.

1. The plant will also produce cottage cheese, sour cream, and cultured milk.
2. Each week, 43,758 lbs. of whole milk and 1242 lbs. of 40% cream are combined to make 45,000 lbs. of 5% fat cream. The 5% fat cream will yield 5400 lbs. of curd and 39,600 lbs. of whey. The curd is combined with 12,600 lbs. of 40% cream and small amounts of non-fat dry-milk, salt and stabilizer to form 18,000 lbs. of cream cheese every week.
3. The processing energy requirements will not include those for whey concentrating or drying. However, the total energy requirement will show two options, one with whey being ignored and the other with whey being dried. The individual requirement costs for drying whey are shown in the Dried Whey Section.
4. There are 0.14 lbs. of dried whey powder which can be produced per pound of cream cheese.
5. The total air circulation rate for the entire plant is 73,500 CFM.
6. The climate which the plant is located in is similar to that of the Salt Lake City, Utah area.

7. Only 2 CIP cleaning cycles will be needed each day, one of which will be an acid wash. This is because most of the pipelines and tanks used for cream cheese production are also used for other dairy products and the cleaning costs are shared between them.
8. The curd concentrator and the packaging equipment are the only equipment to be cleaned manually and it all can be done in one batch.
9. Six- 1/2 horsepower fans circulate air in the cold storage room.
10. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Offices, lunch, locker, and restrooms	3544	49,616
Dry Storage	2400	33,600
Processing Rooms	8229	91,990
Cold Storage Room	2800	36,400
Boiler and Refrigeration Rooms	2909	40,726
Culture Rooms	3857	43,370
Packaging Rooms	2306	27,672
Receiving Shelter	2400	33,600
TOTALS	28,445	356,974

The following tables represent estimates of most of the energy costs of producing cream cheese. The estimating procedure for each energy use is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A plant layout of a cottage cheese, cream cheese, sour cream, and cultured milk producing plant is shown in the section describing cottage cheese production.

Table 5-5a. Typical electrical energy uses per pound of cream cheese.

Process	Calculation Number	Amount (BTU/lb)	%
Pumping Milk	1.05	1.9	1.4
Clarification	2.05	3.2	2.3
Separation	3.05	0.8	0.6
Homogenization	4.05	11.5	8.2
CIP Pumps	5.05	6.6	4.7
Air Compressor	8.05	2.0	1.4
Cold Storage Room Fans	9.05	2.0	1.4
Heating and Air Cond. Fans	10.05	54.7	39.2
Boiler Fan	11.05	13.5	9.7
Cooling Tower Fans	12.05	4.1	2.9
Lights and Misc. Motors	13.05	39.1	28.0
Total		139.4	100.0

Table 5-5b. Typical steam energy uses per pound of cream cheese.

Process	Calculation Number	Amount (BTU/lb)	%
Cleaning - CIP	15.05	417	36.6
Cleaning - Manual	16.05	53	4.6
Heating the Plant	18.05	135	11.8
Product Heating	19.05	419	36.8
Steam Line Losses	20.05	116	10.2
Total		1140	100.0

Table 5-5c. Uses of refrigeration.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Cold Storage Room	22.05	117	37.3
Air Conditioning	23.05	20	6.4
Product Cooling	24.05	144	45.8
Cooling Line Losses	25.05	33	10.5
Total		314	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(314 \frac{\text{BTU}}{\text{lb. cream cheese}}\right)}{2.86} = 110 \frac{\text{BTU}}{\text{lb cream cheese}}$$

Table 5-5d. Total energy cost per pound of cream cheese neglecting whey spray drying costs.

Type of Energy Used	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	139	7.32	0.0010	417
2. Refrigeration	110	7.32	0.0008	330
Steam	1140	1.33	0.0015	1368
Total			0.0023	2115

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*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

Table 5-5e. Total energy cost per pound of cream cheese including whey drying costs.

Type of Energy Used	Amount Used (BTU/lb)	Unit Price* $/$10^6$ BTU	Dollar Cost $/(lb)	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	168	7.32	0.0012	504
2. Refrigeration	140	7.32	0.0010	420
Steam	1920	1.33	0.0026	2304
Natural Gas (for spray drying)	434	1.06	0.0005	434
Total			0.0053	3662

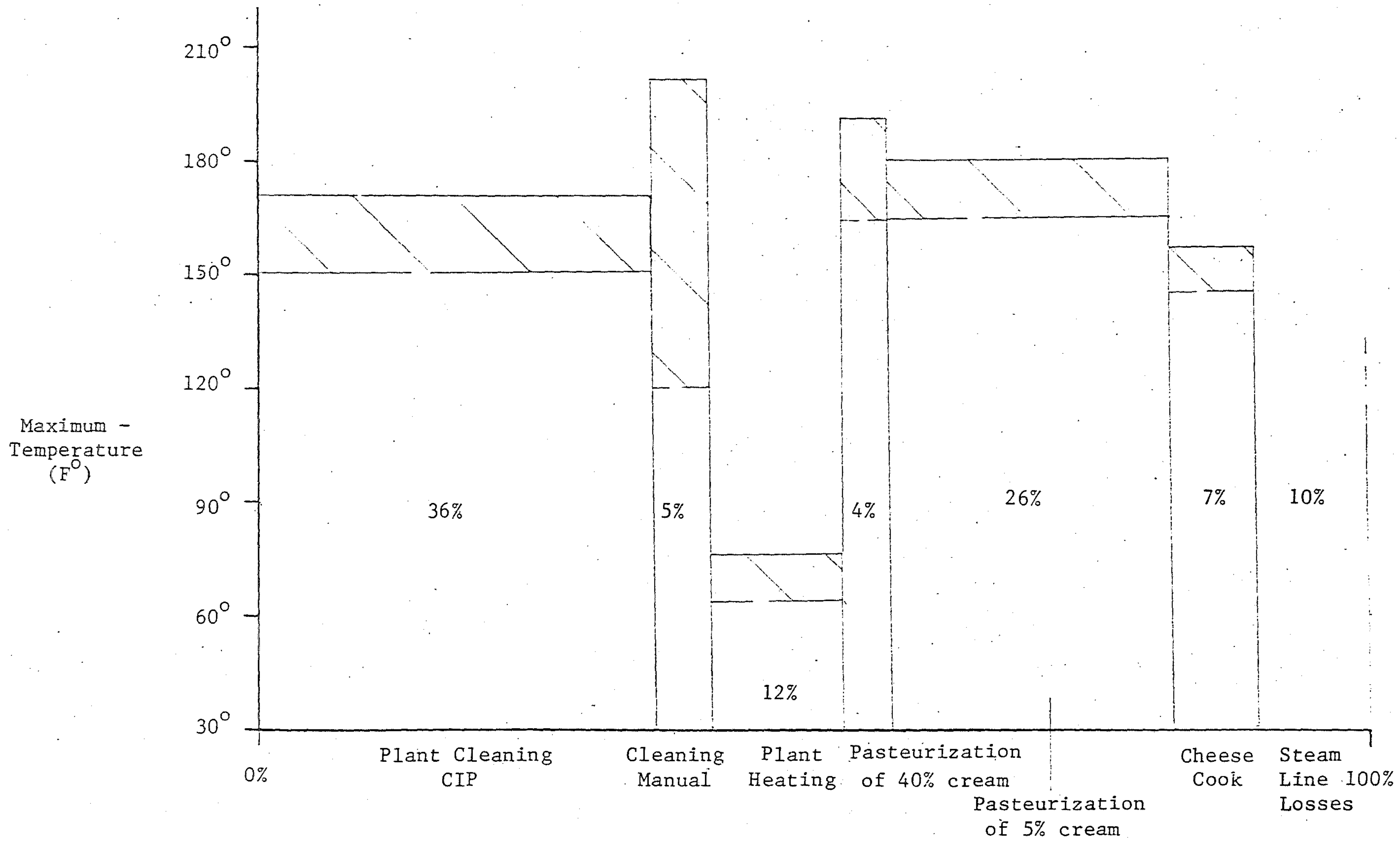


Table 5-5f. Maximum process temperature and percent of total heating energy consumption is Cream Cheese production neglecting Whey Drying. (Cross hatching represents the maximum temperature range per process.)

Section 5-6

CULTURED MILK PRODUCTION

Description

Cultured milk, commonly known as buttermilk, is made from a whole and skim milk blend with a fat content between 1 and 2 percent.

Incoming milk, for cultured milk production, is weighed, cooled and stored until further processing. The processing begins with clarification and separation of the whole milk into skim milk and 40% fat cream. The raw skim milk is belnded with raw whole milk in the proper proportions to give a 1 to 2 percent fat mixture. The cream from the separator is used in the production of other products.

The skim and whole milk mixture is heated in a vat to 190°F and held there for 30 minutes to pasteurize the mixture. After the holding time is over the mixture is cooled to 70°F with culinary and sweet-water which is circulated in the jacket surrounding the vat. Starter is added until it represents about 1% of the total mass in the vat. The mixture is allowed to incubate for 16 hours at 70°F or until an acidity of 0.88% is reached. It is then agitated to break up the coagulum and cooled to 40°F by circulating sweet water around the vat. The cultured milk is then packaged and put into the cold storage room until shipment. The energy intensive procedures of starter making are described in the cheddar cheese section.

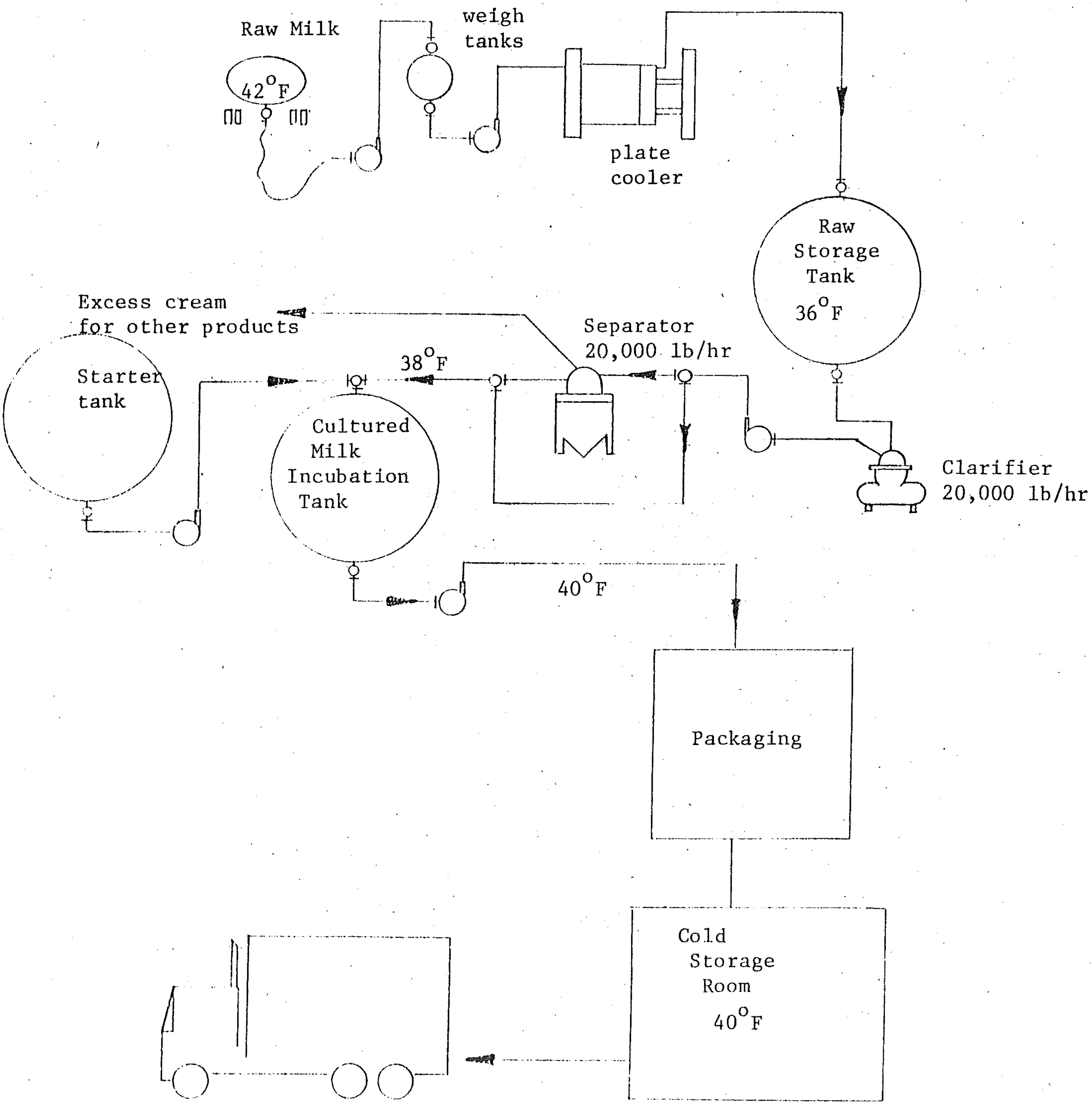


Figure 5-6a. Flow chart showing cultured milk production.

Energy Inputs into Cultured Milk Production

The energy inputs for cultured milk production will be based on a plant processing 1,200,000 pounds of milk per week.[13] The plant will operate 5 days a week making 132,000 pounds of cultured milk every week. The following assumptions will be made about the plant.

1. The plant will also produce cottage cheese, cream cheese, and sour cream.
2. The 132,000 pounds of cultured milk produced weekly will be expressed as 61,395 quarts of cultured milk. Thus there is 2.15 pounds of cultured milk per quart.
3. To make 132,000 lbs. of cultured milk containing 1% fat requires the consumption of 99,000 lbs. of skim milk and 33,000 lbs. of whole milk at 4.0% fat.
4. The air circulation rate for the entire plant is 73,500 CFM.
5. The climate of the area the plant is located in is similar to that of the Salt Lake City, Utah area.
6. Two CIP cleaning cycles are needed each day with one being an acid wash. The two cycles will clean most of the pipelines and tanks used for cultured milk production.
7. The milk separator and the packaging equipment are the only equipment to be cleaned manually every day and it all can be done in one batch.
8. Six - 1/2 horsepower fans circulate air in the cold storage room.

9. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	Volume (ft.^{3})
Offices, lunch, locker and restrooms	3544	49,616
Dry Storage	2400	33,600
Processing Rooms	8229	91,990
Cold Storage Room	2800	36,400
Boiler and Refrigeration Rooms	2909	40,726
Culture rooms	3857	43,370
Packaging Rooms	2306	27,672
Receiving Shelter	2400	33,600
TOTALS	28,445	256,974

The The following tables represent estimates of most of the energy requirements for producing cultured milk. The estimating prcedure for each energy use is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A layout of a plant producing cottage cheese, cream cheese, sour cream, and cultured milk is shown in the section describing cottage cheese production.

Table 5-6a. Typical electrical energy costs per quart of cultured milk.

Process	Calculation Number	Energy Use (BTU/qt)	%
Pumping Milk	1.06	0.9	2.0
Clarification	2.06	2.2	4.8
Separation	3.06	1.6	3.5
CIP Pumps	5.06	1.9	4.2
Air Compressor	8.06	0.6	1.3
Cold Storage Room Fans	9.06	4.3	9.4
Heating and Air Condition Fans	10.06	16.0	35.1
Boiler Fan	11.06	4.0	8.8
Cooling Tower Fans	12.06	2.6	5.7
Lights and Misc. Motors	13.06	11.5	25.2
TOTAL		45.6	100.0

Table 5-6b. Typical steam energy costs per quart of cultured milk.

Process	Calculation Number	Amount (BTU/qt)	%
Cleaning - CIP	15.06	122	22.7
Cleaning - Manual	16.06	16	3.0
Heating the Plant	18.06	40	7.4
Product Heating	19.06	326	60.6
Steam Line Losses	20.06	34	6.3
TOTAL		538	100.0

Table 5-6c. Uses of refrigeration.

Uses of Refirgeration	Calculation Number	Cooling Needed (BTU/qt)	%
Cold Storage Room	22.06	24	11.8
Air Conditioning	23.06	6	3.0
Product Cooling	24.06	143	70.4
Cooling Line Losses	25.06	30	14.8
Total		203	100.0

With a coefficient of performance of 2.86 for the refrigeraiton system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(203 \frac{\text{BTU}}{\text{qt. cult. milk}}\right)}{2.86} = 71 \frac{\text{BTU}}{\text{qt. cult. milk}}$$

Table 5-6d. Total energy cost per quart of cultured milk

Type of Energy	Energy Used (BTU/qt.)	Unit Price* $\frac{\$}{10^6 \text{ BTU}}$	Dollar Cost $\frac{\$}{\text{qt.}}$	Fossil Fuel Equivalent* (BTU/qt.)
Electrical				
1. Lights and motors	46	7.32	0.00034	138
2. Refrigeration	71	7.32	0.00052	213
Steam	538	1.33	0.00072	646
Total			0.00158	997

[*] Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

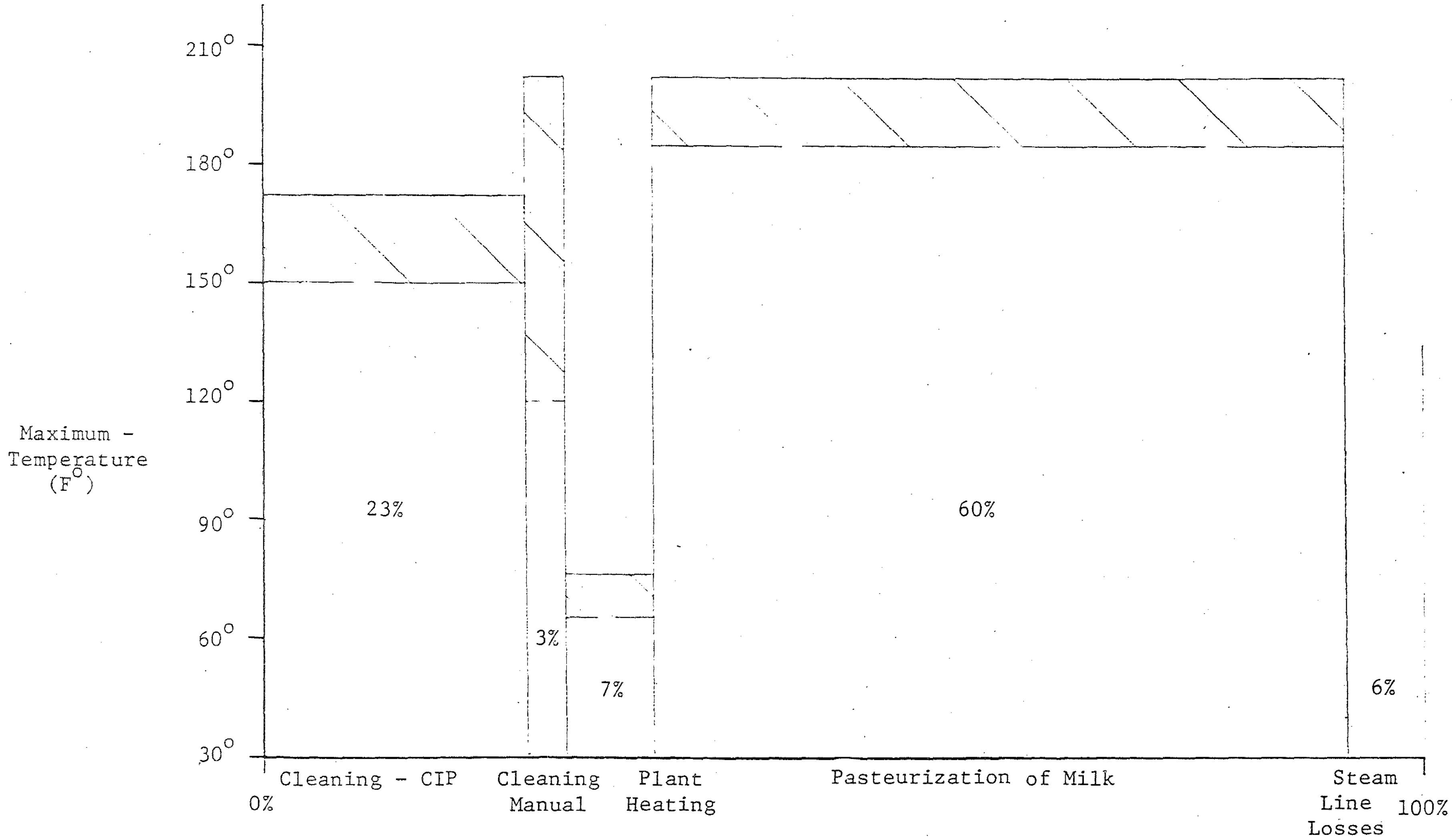


Table 5-6e. Maximum process temperature and percent of total heating energy consumption in Cultured Milk production. (Cross hatching represents the maximum temperature range per process.)

Section 5-7

DRIED WHEY PRODUCTION

Description

The first step of whey drying is clarification of the whey to remove curd particles. If the whey is removed from cheese made from whole milk, the whey is separated to remove any remaining fat. The whey is then cooled in a plate cooler to 40°F so that it can be stored until enough is present for further processing.

The next step is concentrating the whey in the double effect evaporator. On its way into the evaporator the whey is heated via vapor preheaters and a steam fed preheater to eventually raise the temperature to 165°F. The 6% solids whey flows through both evaporator effects and comes out as a 40% solids concentrate. It is then cooled to 40°F by a plate cooler and stored overnight to allow for crystalization of lactose. The whey concentrate, heated to 165°F, is fed into a high pressure pump, and spray dried to approximately 3 or 3½ percent moisture. As the dried whey powder collects, it is bagged and stored to await shipment.

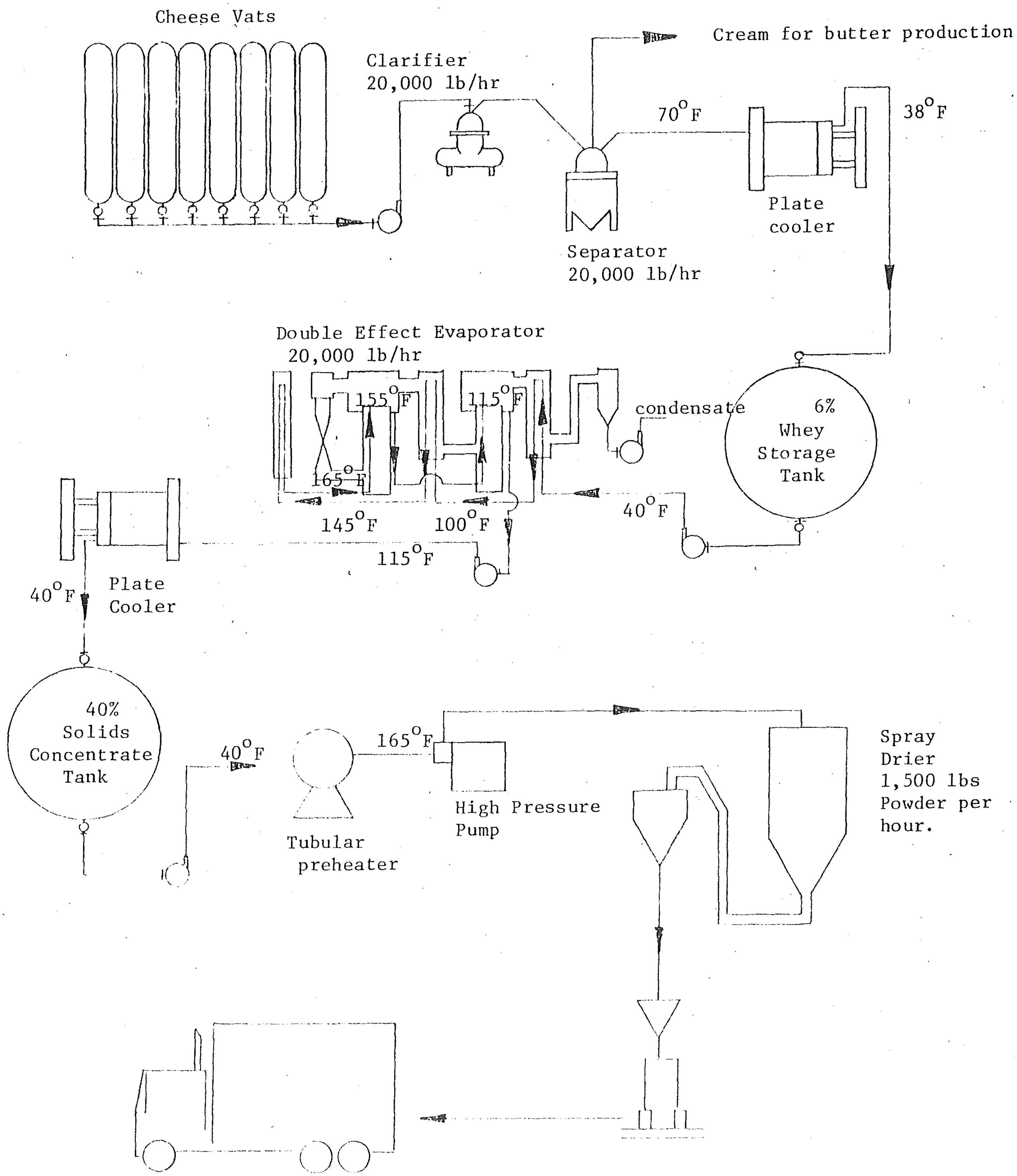


Figure 5-7a. Flow chart showing dried whey production.

Energy Inputs into Dried Whey Production

The energy inputs to dried whey production will contain only those costs directly associated with drying whey. This is because a dairy plant may use some other means to dispose of its whey. Thus, the costs given here are to be combined with cheese production costs in each cheese section to show the total energy costs with a whey drying option. The whey drying costs are based on an equipment set-up capable of producing 43,000 pounds of dried whey poweder per week. The following assumptions will be made about the operation.

1. The additional equipment and space needed for whey drying will not significantly increase the energy costs of heating, lighting, air conditioning, or other indirect energy costs.
2. The whey for drying will contain 6% solids and the finished product will contain 3.5% moisture.
3. There will be six CIP cleaning cycles needed each day to clean the pipelines, tanks, plate coolers, the double effect evaporator, and the spray dryer. Two of the cycles will be acid wash cycles.

The following table represent estimates of most of the energy requirements for producing dried whey. The estimating procedure of each energy use is found in the Energy Calculation Section under the Energy Calculation Number given with each energy cost.

Table 5-7a. Typical electrical energy costs per pound of whey powder.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Pumping Whey	1.07	3.2	1.5
Clarification of Whey	2.07	16.1	7.8
Double Effect Evaporator	6.07	30.0	14.6
Spray Drier	7.07	117.5	57.2
Cooling Tower Fans	12.07	38.8	18.9
Total		205.6	100.0

Table 5-7b. Typical steam energy costs per pound of whey powder.

Process	Calculation Number	Energy Use (BTU/lb.)	%
Cleaning - CIP	15.07	585	10.5
Double Effect Evaporator	17.07	4708	84.5
Product Heating	19.07	281	5.0
Total		5574	100.0

Table 5-7c. Typical uses of refrigeration per pound of whey powder.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Product Cooling	24.07	603	100.0
Total		603	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(603 \frac{\text{BTU}}{\text{lb. whey powder}}\right)}{2.86} = 211 \frac{\text{BTU}}{\text{lb. whey powder}}$$

Table 5-7d. Direct uses of natural gas energy per pound of whey powder.

Direct Uses of Natural Gas Energy	Calculation Number	Energy Use (BTU/lb.)	%
Spray Drying	27.07	3102	100.0
	Total	3102	100.0

Table 5-7e. Total energy cost per pound of whey powder.

Type of Energy	Energy Used (BTU/lb)	Unit Price* $/$10^6$ BTU	Dollar Cost ($/lb.)	Fossil Fuel Equivalent* (BTU/lb.)
Electrical				
1. Lights and motors	206	7.32	0.0015	618
2. Refrigeration	211	7.32	0.0015	633
Steam	5574	1.33	0.0074	6689
Natural Gas	3102	1.06	0.0033	3102
Total			0.0137	11,042

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

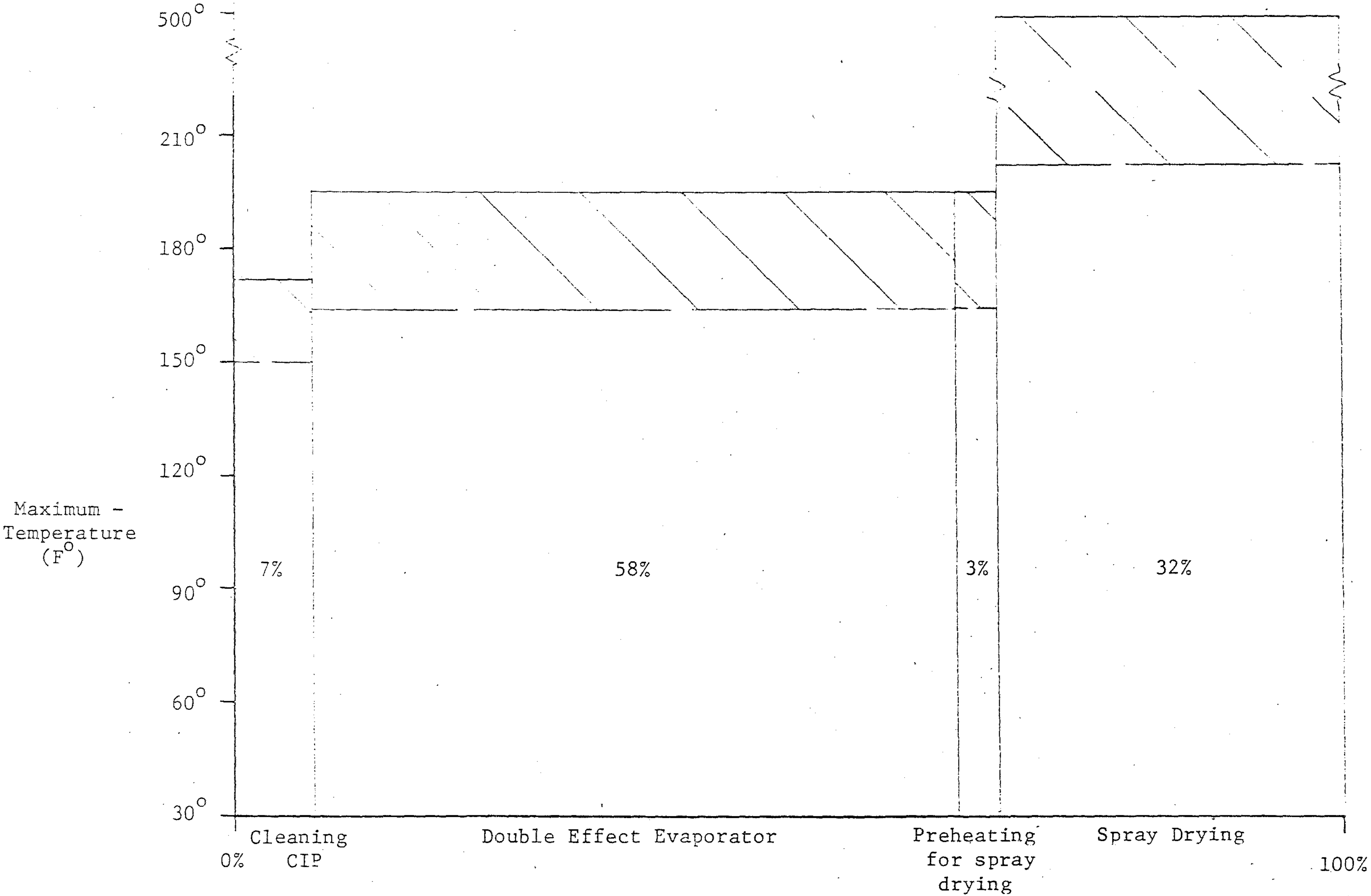


Table 5-7f. Maximum process temperature and percent of total heating energy consumption in Whey Powder production. (Cross hatching represents the maximum temperature range per process.)

Section 5-8

BUTTER PRODUCTION

Description

Large butter producing plants are very often combined with the production of dried skim milk. This description of butter production is for a butter and dried skim milk processing operation.

As raw milk is received, it is weighed and pumped to a storage tank. Soon afterwards the milk is pumped through a plate heater on its way to the separator. The plate heater increases the milk temperature to 85°F, which increases the separator efficiency. The heated skim milk coming from the separator is directed back into the plate heat exchanger to warm incoming milk in the regeneration section. The 40% fat cream from the separator is forwarded on to a HTST pasteurizer. In the pasteurizer, the cream is warmed to 142°F in the regenerator and to 180°F in the heating unit. After the proper holding time the cream is cooled to 123°F and to 42°F in the regeneration and cooling sections of the pasteurizer respectively. The cream is stored in a refrigerated vat which removes the latent heat caused by a small amount of fat which may slowly solidified.

Churning cream into butter is usually done in batches, although continuous butter makers are available. The cream for churning is first warmed from 40°F to about 50°F in a tubular preheater. The churn is filled with the warmed 40% fat cream. The cream is churned for about 30 minutes until butter granules are formed. The buttermilk is drained off and salt is added and worked into the butter for about 20 minutes. At this time a fat test is run and water is added to the butter to standardize the fat content to 80%. After the water has been worked into the butter, the butter is removed from the churn and is packaged. After packaging, the butter is placed in the cold storage room until shipment. It should be noted that some cooling is required during the churning process to remove the latent heat of the solidifying fat.

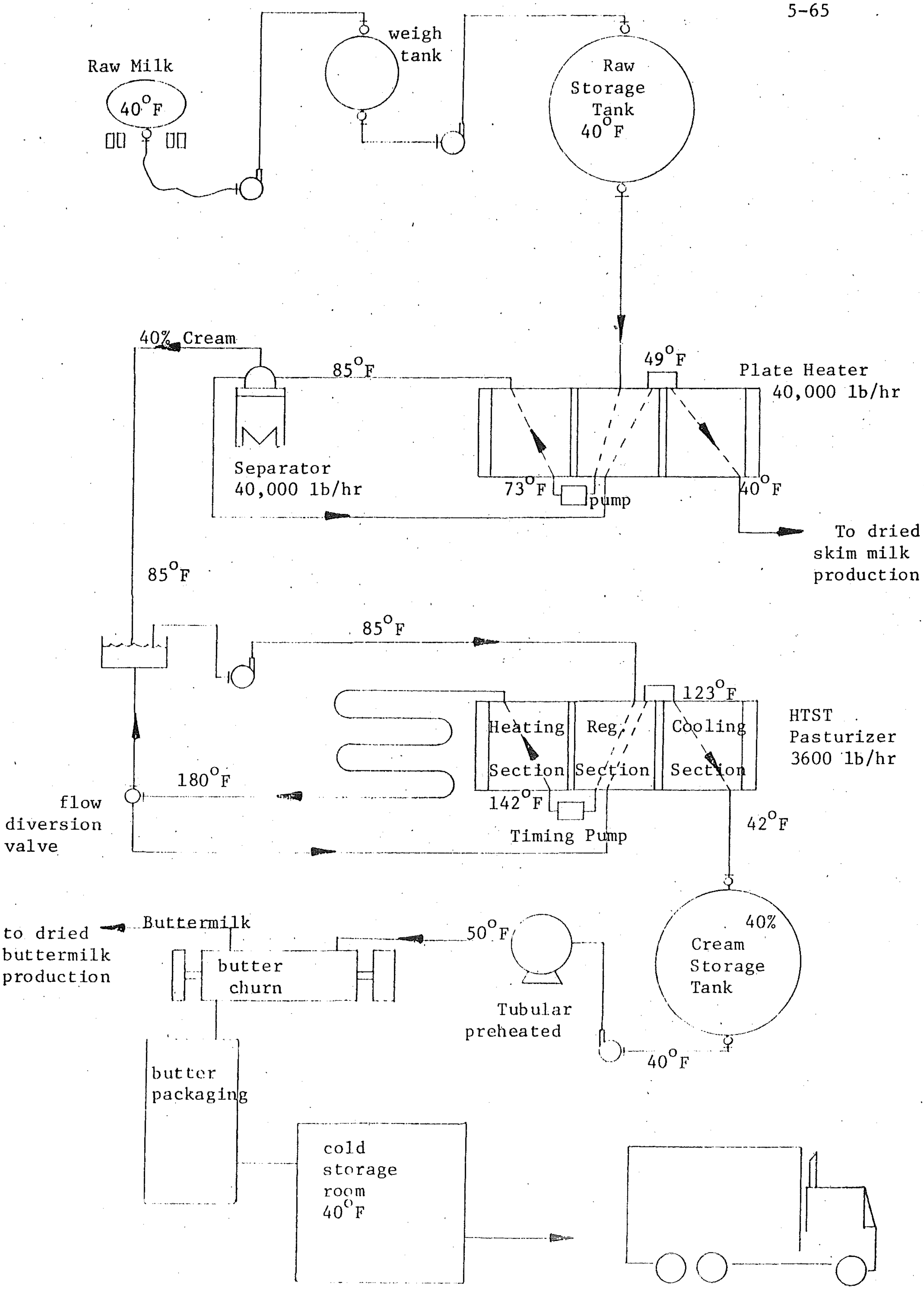


Figure 5-8a. Flow chart showing butter production.

Energy Inputs into Butter Production

The energy inputs into butter production will be based on a plant processing 1,750,000 pounds of milk per week.[14] The plant will operate seven days a week making 11,222 pounds of butter each day. The following assumptions will be made about the plant.

1. The plant will also produce dried skim milk, instantized dried skim milk, and dried buttermilk.
2. To make 11,222 pounes of butter each day requires the consumption of 22,444 pounds of 40% cream.
3. Each butter batch will contain 11,250 pounds of cream.
4. The air circulation rate for the entire plant is 62,000 CFM.
5. The climate of the area surrounding the plant is similar to that of the Salt Lake City, Utah area.
6. The following CIP cleaning cycles are needed each day:

    1 - Cream HTST Pasteurizer (Acid Wash)
    1 - Plate heat exchanger (Acid Wash)
    1 - Tanker Truck
    4 - Cream tanks and pipeline systems
    7 cycles/day

7. The following batches of items must be cleaned manually each day:

    1 - Churn
    1 - Separator, butter packaging equipment
    1 - Positive displacement pumps and butter handling tools
    1 - Balance tanks, buttermilk strainer
    4 batches/day

8. There are two- 1/2 horsepower fans which circulate air in the cold room.

9. The sizes of the rooms in the plant are:

ROOM	Floor space (ft.^{2})	volume (ft.^{3})
Offices, lunch, locker, and restrooms	2715	27,150
Processing rooms	3889	54,446
Evaporating and Drying Rooms	3531	60,027
Cold Storage Room	1560	21,840
Powder Storage Room	3022	51,374
Boiler and Refrigeration Rooms	2980	50,660
Receiving Shelter	1440	24,480
Hallways	1016	10,160
TOTALS	20,153	300,137

The following tables represent most of the energy requirements for producing butter. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given. A layout of a plant producing butter and dried milk products follow the tables.

Table 5-8a. Typical electrical energy uses per pound of butter.

Process	Calculation Number	Energy Use (BTU/lb)	%
Pumping Milk	1.08	1.2	4.0
Separation	3.08	2.0	6.6
CIP Pumps	5.08	7.4	24.6
Air Compressor	8.08	0.2	0.7
Cold Storage Room Fans	9.08	3.6	12.0
Heating and Air Cond. Fans	10.08	5.3	17.6
Boiler Fan	11.08	1.5	5.0
Cooling Tower Fans	12.08	3.3	10.9
Lights and Misc. Motors	13.08	3.2	10.6
Churning	14.08	2.4	8.0
Total		30.1	100.0

Table 5-8b. Typical steam energy uses per pound of butter.

Process	Calculation Number	Energy Use (BTU/lb)	%
Cleaning - CIP	15.08	429	69.4
Cleaning - Manual	16.08	68	11.0
Heating the Plant	19.08	9	1.5
Product Heating	19.08	102	16.5
Steam Line Losses	20.08	10	1.6
Total		618	100.0

Table 5-8c. Typical refrigeration requirements per pound of butter.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Cold Storage Room	22.08	65	25.9
Air Conditioning	23.08	1	0.4
Product Cooling	24.08	154	61.4
Cooling Line Losses	25.08	31	12.3
Total		251	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{(251 \frac{\text{BTU}}{\text{lb butter}})}{2.86} = 88 \frac{\text{BTU}}{\text{lb butter}}$$

Table 5-8d. Total energy cost per pound of butter.

Type of Energy	Energy Use (BTU/lb)	Unit Price* $\frac{\$}{10^6 \text{ BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb.)
Electrical				
1. Lights and motors	30	7.32	0.00022	90
2. Refrigeration	88	7.32	0.00064	264
Steam	618	1.33	0.00082	742
Total			0.00168	1096

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

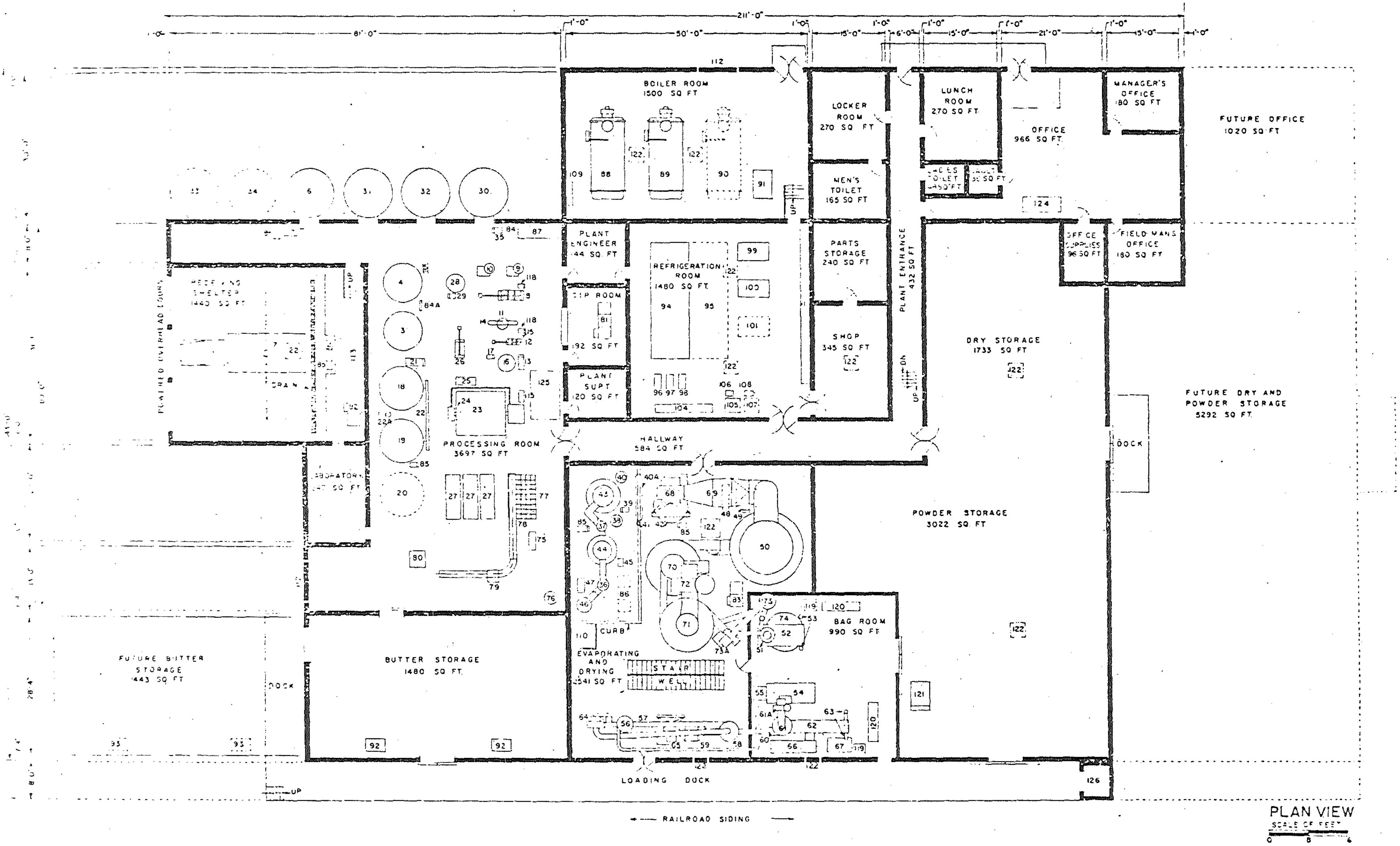


Figure 5-8b. Butter and dried milk plant layout as given by Tracy[14]

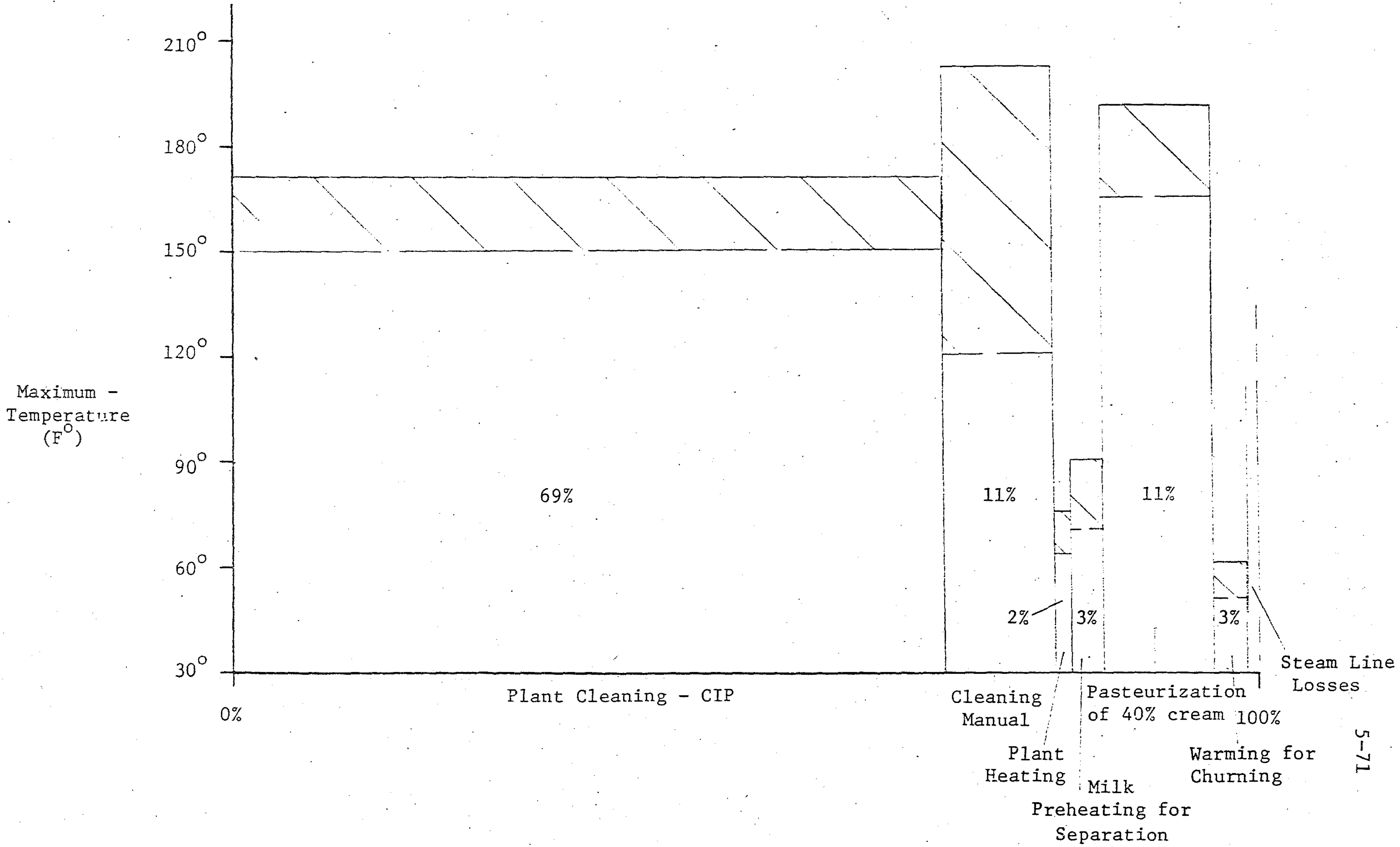


Table 5-8e. Maximum process temperature and percent of total heating energy consumption in Butter production. (Cross hatching represents the maximum temperature range per process.)

Section 5-9

DRIED MILK PRODUCTION

Description

As raw milk is received, it is weighed and pumped to a storage tank. The raw milk is then warmed by a plate heat exchanger to 85°F and pumped to a separator. Warming the milk increases the separator efficiency. The warm skim milk, after returning to the separator, is cooled in the regeneration and cooling sections to 40°F. The cool skim milk is stored until the drying operation is ready to begin. The cream from the separator continues on to a butter making operation.

The milk drying operation can be viewed as a continuous operation once it is put into motion. The first step is pumping the skim milk to a double effect evaporator. The skim milk is fed into two preheaters which uses vapor removed from the skim milk in the evaporator to heat the incoming skim milk. In the final stream-fed heater the temperature of the skim milk is raised to either 165°F or 195°F depending on whether high or low heat powder is desired. The 9% solid skim milk flows through the evaporator and exits as a 40% solids concentrate at 115°F. The concentrate is rewarmed to 165°F and pumped by a high pressure pump to the spray drier.

The high pressure concentrate is sprayed into a hot air stream in the spray drier which removes all but about 3.0% of the moisture. The dried skim milk then enters a cyclone to separate the air and milk particles after which the skim milk powder is collected and bagged.

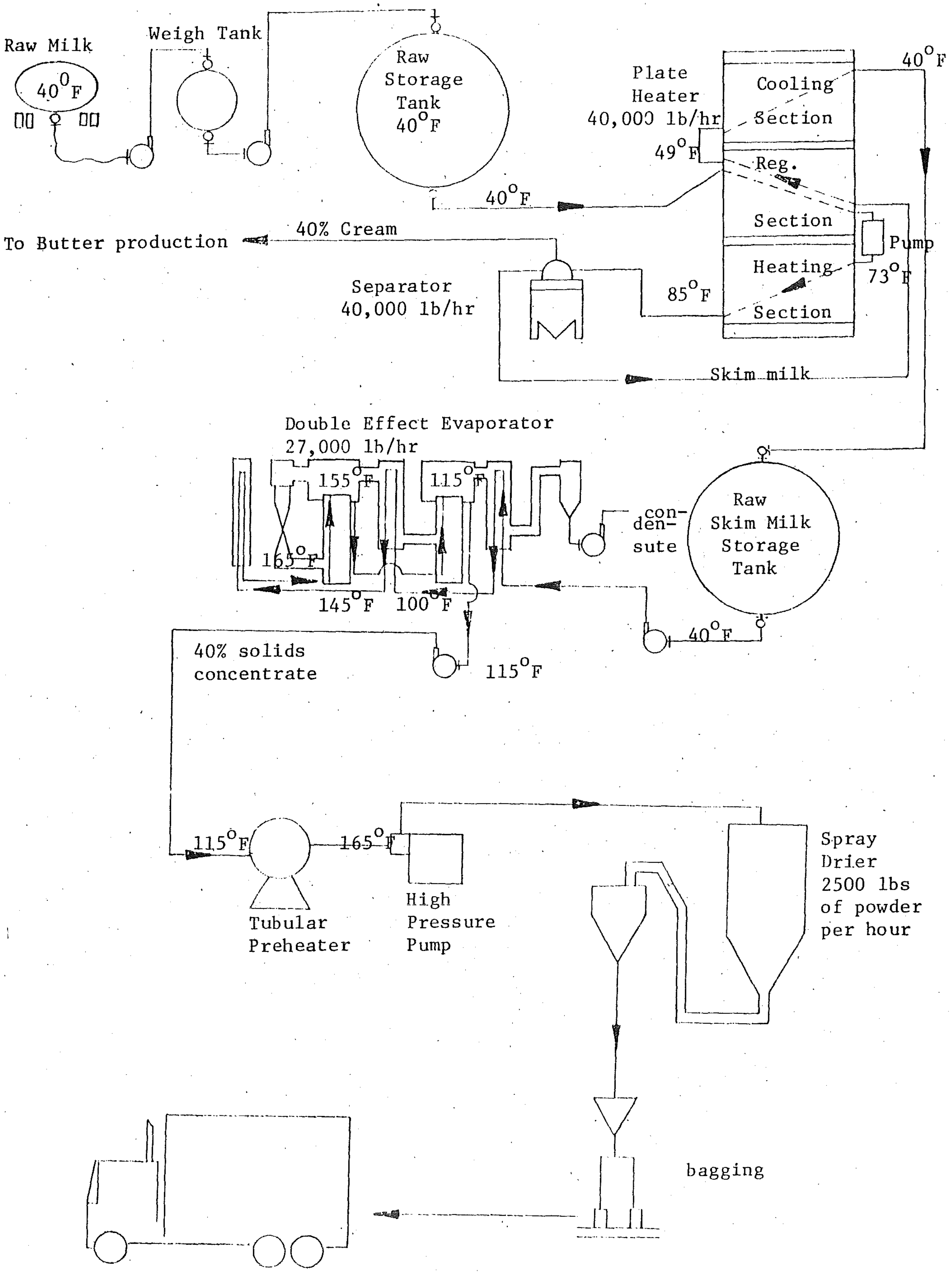


Figure 5-9a. Flow chart showing low-heat dried milk production.

Energy Inputs into Dried Milk Production

The energy inputs into dried milk production will be based on a plant processing 1,750,000 pounds of milk per week.[14] The plant will operate seven days a week making 21,150 pounds of dried milk powder per day. The following assumptions will be made about the plant.

1. The plant will also produce instantized dried skim milk, butter, and dried buttermilk.
2. To make 21,150 pounds of dried skim milk powder requires the consumption of 227,500 pounds of skim milk.
3. The steam required to concentrate high heat powder is assumed approximately equal to that for low heat.
4. The air circulation rate for the entire plant is 32,000 CFM.
5. The climate of the area surrounding the plant is similar to that of the Salt Lake City, Utah area.
6. The following CIP cleaning cycles are needed each day:

   5 - Milk tanks, and pipeline systems
   8 - Tanker trucks
   2 - Double effect evaporator (Acid Wash)
   1 - Spray dryer
   16 cycles/day

7. The positive displacement pumps and powder packaging parts must be cleaned manually each day in one batch.

8. The sizes of the rooms in the plant are:

Room	Floor space ($ft.^2$)	volume ($ft.^3$)
Offices, lunch, locker, and restrooms	2715	27,150
Processing rooms	3889	54,446
Evaporating and drying rooms	3531	60,027
Cold Storage Room	1560	21,840
Powder Storage Room	3022	51,374
Boiler and Refrigeration Rooms	2980	50,660
Receiving Shelter	1440	24,480
Hallways	1016	10,160
TOTALS	20,153	300,137

The following tables represent most of the energy requirements for producing dried milk. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given with the energy cost. A layout of a plant producing butter and dried milk products is given in the section describing butter production.

Table 5-9a. Typical electrical energy uses per pound of dry milk.

Process	Calculation Number	Energy Use (BTU/lb)	%
Pumping Milk	1.09	5.4	1.9
Separation	3.09	10.8	3.9
CIP Pumps	5.09	9.0	3.2
Double Effect Evaporator	6.09	17.3	6.2
Spray Drying	7.09	117.5	42.2
Air Compressor	8.09	2.2	0.8
Heating and Air Cond. Fans	10.09	50.5	18.1
Boiler Fan	11.09	14.7	5.3
Cooling Tower Fan	12.09	20.6	7.4
Lights and Misc. Motors	13.09	30.3	10.9
Total		278.3	100.0

Table 5-9b. Typical steam energy uses per pound of dry milk.

Steam Energy Use	Calculation Number	Energy Use (BTU/lb)	%
Cleaning - CIP	15.09	485	12.8
Cleaning - Manual	16.09	9	0.2
Double Effect Evaporator	17.09	2879	75.8
Heating the Plant	18.09	88	2.3
Product Heating	19.09	243	6.4
Steam Line Losses	20.09	92	2.4
Total		3796	100.0

Table 5-9c. Typical uses of refrigeration per pound of dry milk.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Air Conditioning	23.09	11	8.5
Product Cooling	24.09	97	74.6
Cooling Line Losses	25.09	22	16.9
Total		130	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(130 \frac{\text{BTU}}{\text{lb powder}}\right)}{2.86} = 45 \frac{\text{BTU}}{\text{lb powder}}$$

Table 5-9d. Typical natural gas energy requirement per pound of dry milk powder.

Direct Uses of Natural Gas Energy	Calculation Number	Amount (BTU/lb)	%
Spray Drying	27.09	3102	100.0
Total		3102	100.0

Table 5-9e. Total energy cost per pound of dry milk.

Type of Energy	Energy Used (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	278	7.32	0.0020	834
2. Refrigeration	45	7.32	0.0003	135
Steam	3796	1.33	0.0050	4555
Natural Gas (for spray drying)	3102	1.06	0.0033	3102
Total			0.0106	8626

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

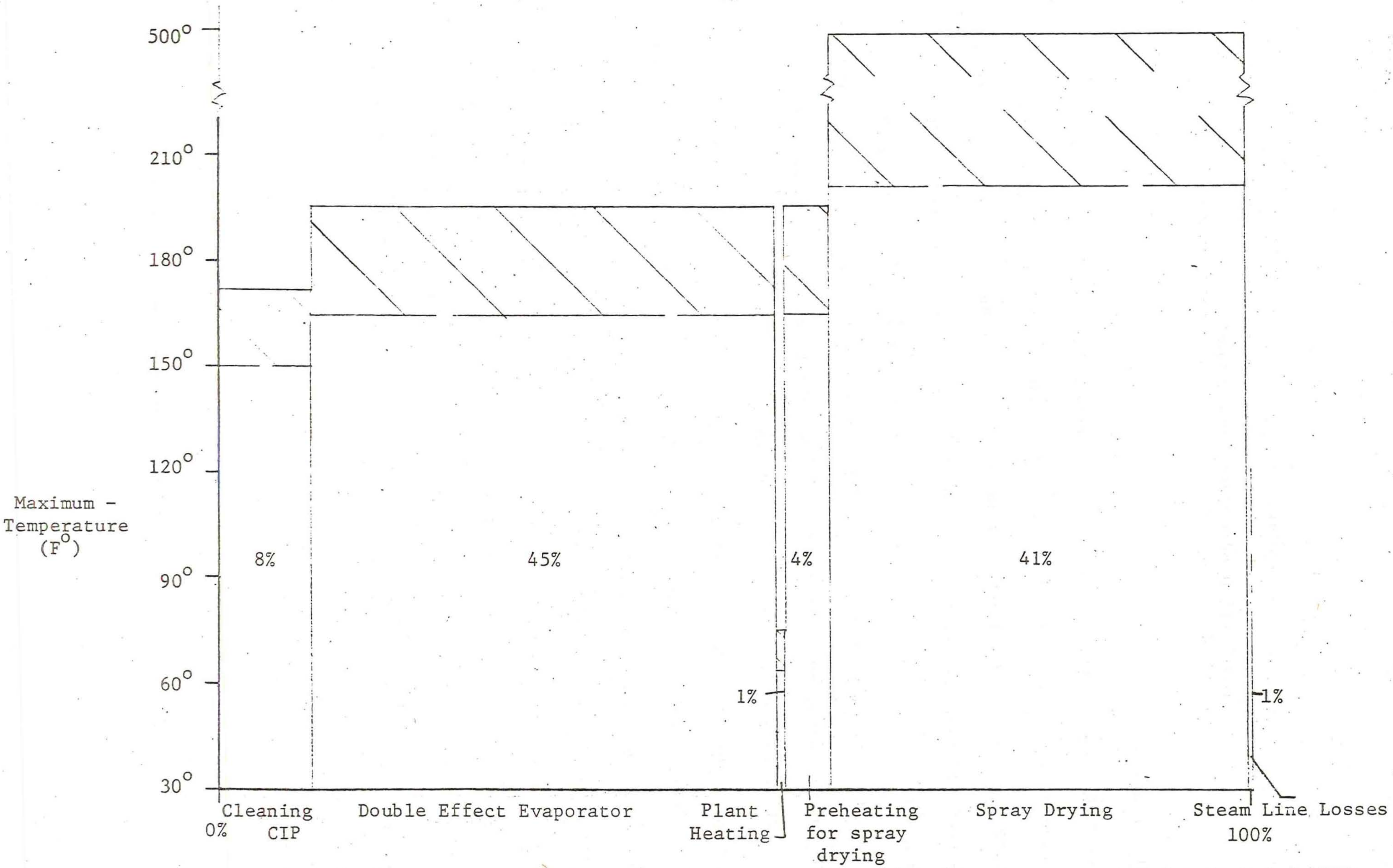


Table 5-9f. Maximum process temperature and percent of total heating energy consumption in Dried Milk production. (Cross hatching represents the maximum temperature range per process.)

Section 5-10

INSTANTIZED DRIED MILK PRODUCTION

Description

Low-heat dried milk which is sold for household consumption can be "instantized" for increased solubility. The instantizing process consists of adding moisture to the dried milk powder and redrying. The moisture content of the powdered milk is increased to about 10% by steam injection and/or a high pressure water spray. The wet particles are subjected to some form of turbulance where they collide and form clusters. The clusters are redried with hot air, cooled, and then sized to eliminate large agglomerates. After the product is bagged it is ready for shipment.

Energy Inputs into Instantized Milk Production

The energy inputs into instantized milk production will contain only those costs directly associated with the instantizing process. This is because the instantization of dried milk is optional. Thus the total energy cost of obtaining instantized dried milk is derived by adding the dried milk energy costs to the energy costs estimated here. The energy costs will be based on a plant processing 1,750,000 pounds of milk per week and producing 10,575 pounds of instantized milk per week.[14] The following assumptions will be made about the plant.

1. The plant will also produce dried skim milk, dried buttermilk, and butter.
2. No losses will occur in the instantization process. Thus one pound of dried skim milk will be converted to one pound of instantized skim milk.

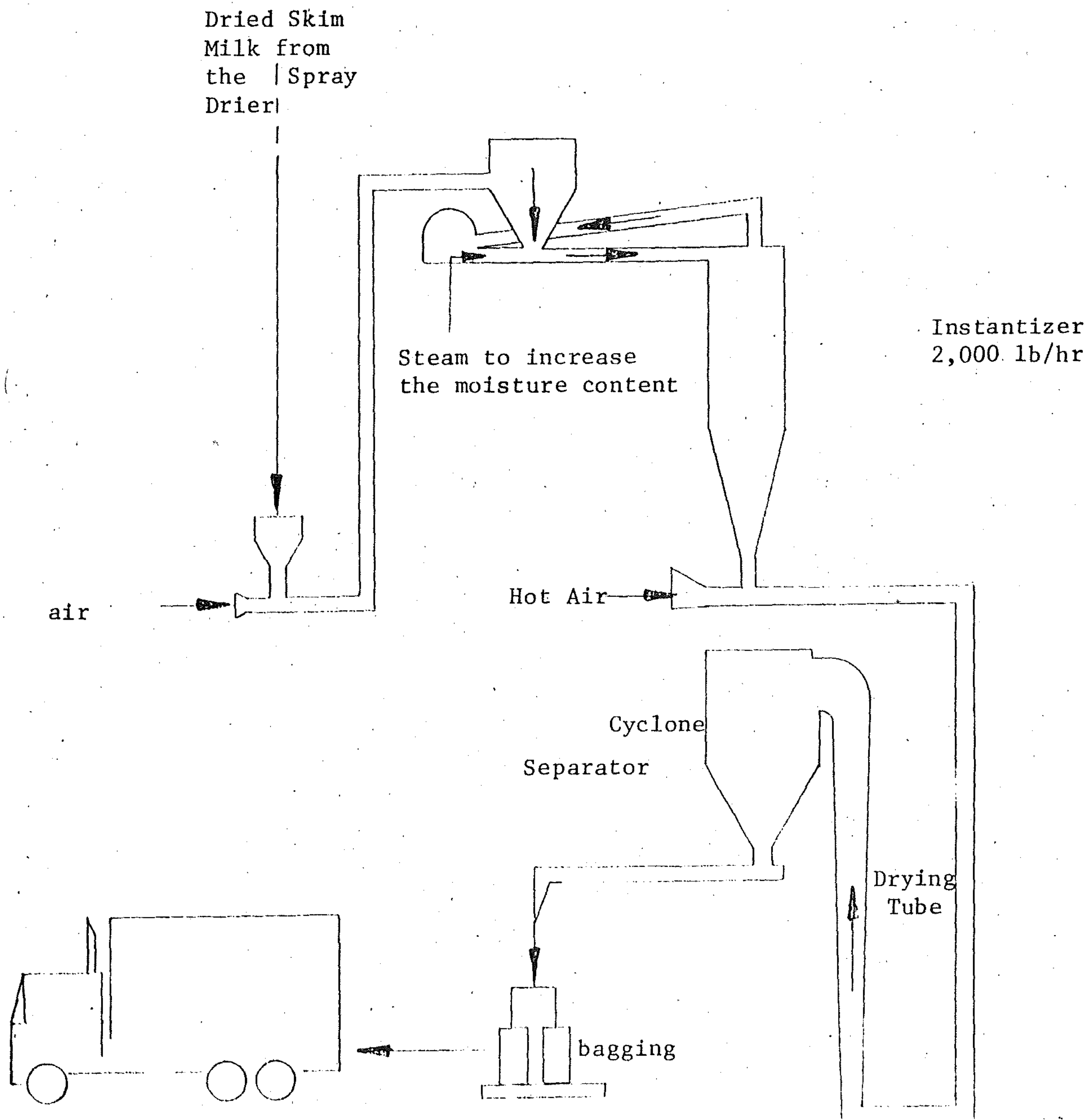


Figure 5-10a. Flow chart showing instantized milk production.

3. The additional equipment and space needed for the instantizing process will not significantly increase the energy costs of heating, lighting, air conditioning, or other indirect energy costs.
4. One CIP cleaning cycle will be needed each day to clean the instantizer equipment.

The following tables represent most of the energy requirements for producing the instantizing process. The estimating procedure for each energy requirement is found in the Energy Calculation Section under the Energy Calculation Number given with the energy cost. A layout of a plant producing butter, instantized dried milk, and dried milk products is given in the section describing butter production.

Table 5-10a. Typical electrical energy uses per pound of instantized milk powder.

Process	Calculation Number	Energy Use (BTU/lb)	%
Instantizer	14.10	44.9	100.0
Total		44.9	100.0

Table 5-10b. Typical steam energy uses per pound of instantized milk powder.

Process	Calculation Number	Energy Use (BTU/lb)	%
Instantizer	21.10	595	91.3
Cleaning - CIP	15.10	57	8.7
Total		652	100.0

Table 5-10c. Uses of refrigeration per pound of instantized milk powder.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Instantizer air cooling	26.10	36	100.0
Total		36	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(36 \frac{\text{BTU}}{\text{lb powder}}\right)}{2.86} = 13 \frac{\text{BTU}}{\text{lb powder}}$$

Table 5-10d. Total Energy cost per pound of instantized milk powder.

Type of Energy	Energy Use (BTU/lb)	Unit Price* $/$10^6$ BTU	Dollar Cost $/(lb)	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and Motors	45	7.32	0.00033	135
2. Refrigeration	13	7.32	0.00010	39
Steam	652	1.33	0.00087	782
Total			0.00130	956

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

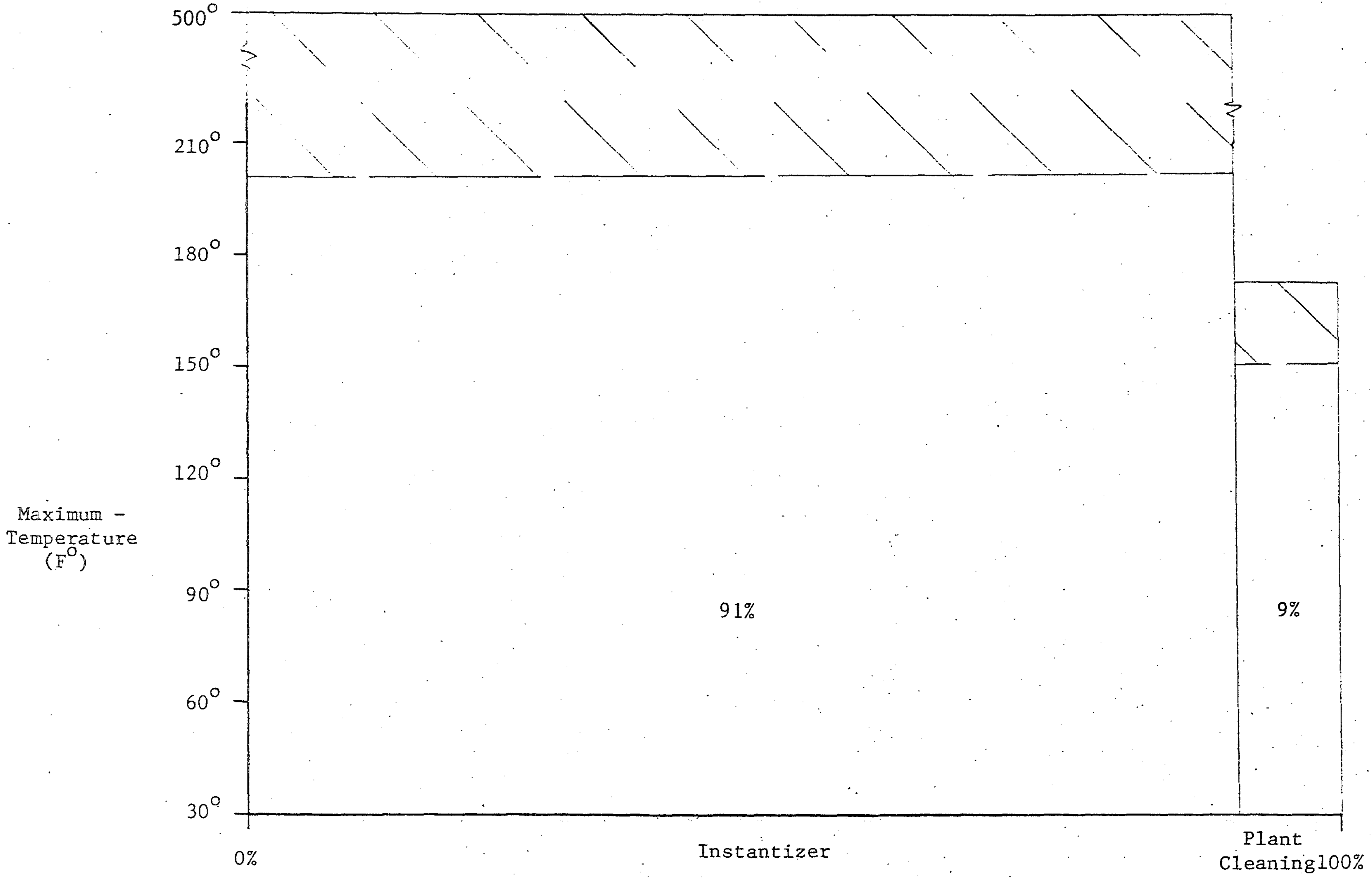


Table 5-10e. Maximum process temperature and percent of total heating energy consumption in Instantized Milk production. (Cross hatching represents the maximum temperature range per process.)

Section 5-11

DRIED BUTTERMILK PRODUCTION

Description

The buttermilk referred to in this description is the fluid expelled during butter making. The buttermilk is filtered as it is drained from the butter. It is then pumped through a plate cooler which lowers the temperature from 50°F to 35°F. The cooled buttermilk is stored until sufficient quantity is gathered to justify further processing. At this point the buttermilk contains about 9.0% solids.

The next step in processing is concentration in a double effect evaporator. The buttermilk is warmed before entering the evaporator by two vapor heaters using vapor removed from buttermilk already in the evaporator as a heat source, and a final heater using steam as a heat source. The buttermilk enters the evaporator at about 165°F and leaves at 115°F as a 40% solids concentrate. As the concentrate is removed from the evaporator it is reheated again to 165°F and compressed by a high pressure pump. The concentrate is spray dried to about 3.0% moisture. The buttermilk powder is collected, bagged and stored until shipment.

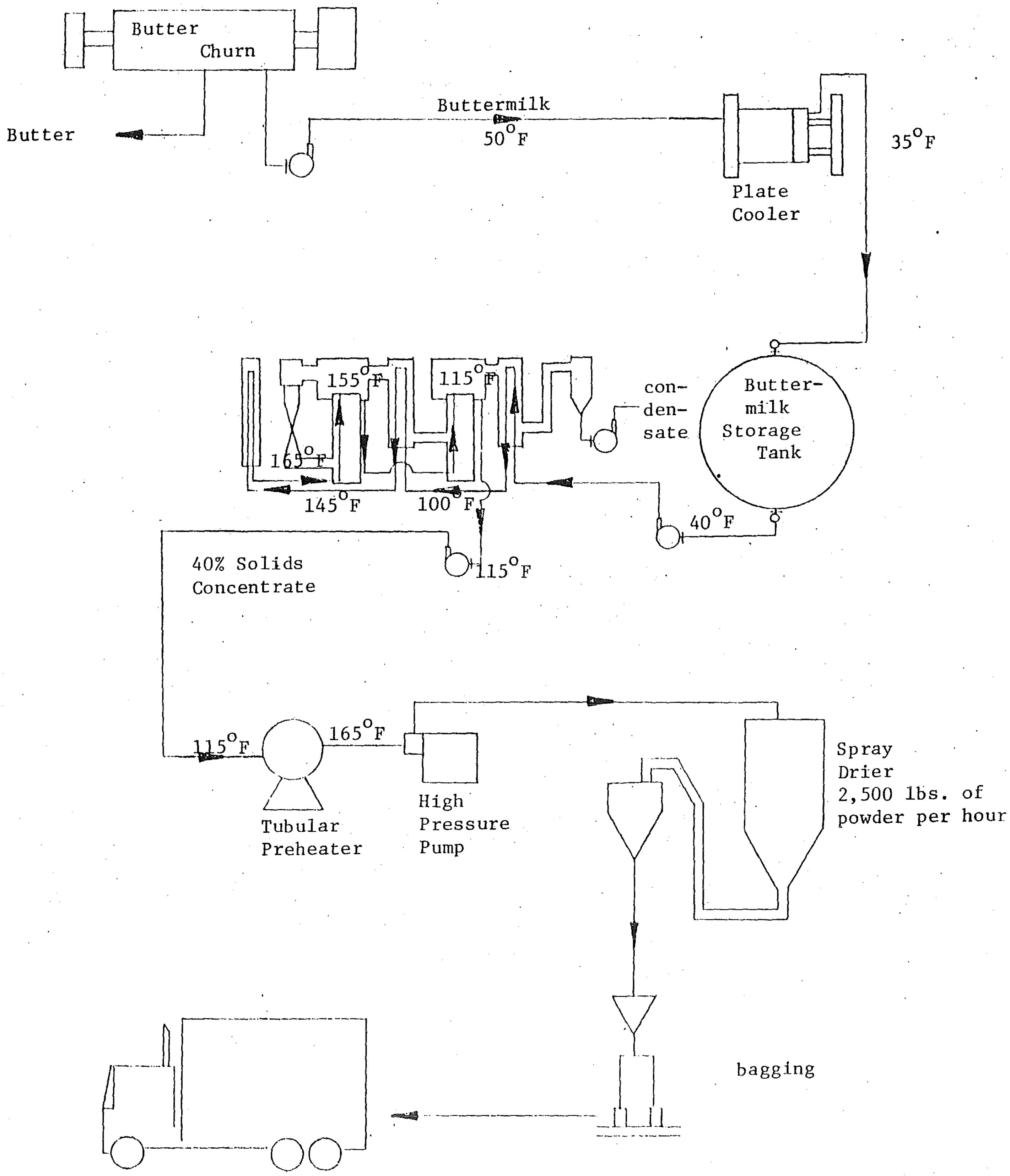


Figure 5-11a. Flow chart showing dried buttermilk production.

Energy Inputs into Dried Buttermilk Production

The energy inputs into dried buttermilk production will be based on a plant processing 1,750,000 pounds of milk every week.[14] The plant will operate seven days a week making 1,046 pounds of dried buttermilk per day. The following assumptions will be made about the plant.

1. The plant will also produce instantized dried milk, dried milk, and butter.
2. To make 1,046 pounds of dried buttermilk at 3.0% moisture requires the consumption of 11,250 pounds of 9.0% solids buttermilk.
3. The air circulation rate for the entire plant is 62,000 CFM.
4. The climate of the area surrounding the plant is similar to that of the Salt Lake City, Utah area.
5. The following CIP cleaning cycles are needed each week:

4	- Buttermilk tanks and pipeline systems
1	- Spray Drier
2	- Double Effect Evaporator (Acid Wash)
7	cycles/week

This would translate to about one CIP cleaning cycle per day.

6. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	volume (ft.^{3})
Offices, lunch, locker, and restrooms	2715	27,150
Processing rooms	3889	54,446
Evaporating and drying rooms	3531	60,027
Cold storage room	1560	21,840
Powder storage room	3022	51,374
Boiler and refrigeration rooms	2980	50,660
Receiving Shelter	1440	24,450
Hallways	1016	10,160
TOTALS	20,153	300,137

The following tables represent most of the energy requirements for producing dried buttermilk powder. The estimating procedure for each energy requirement is given in the Energy Calculation section under the Energy Calculation Number given with the energy cost. A layout of a plant producing butter, dried buttermilk, and dried milk products is given in the section describing butter production.

Table 5-11a. Typical electrical energy uses per pound of dried buttermilk powder.

Process	Calculation Number	Energy Use (BTU/1b)	%
Pumping Buttermilk	1.11	3.2	1.1
CIP Pumps	5.11	16.0	5.6
Double Effect Evaporator	6.11	17.3	6.1
Spray Drying	7.11	117.5	41.4
Air Compressor	8.11	0.4	0.1
Heating and Air Cond. Fans	10.11	56.7	20.0
Boiler Fan	11.11	16.6	5.9
Cooling Tower Fan	12.11	21.7	7.7
Lights and Misc. Motors	13.11	34.1	12.0
Total		283.5	100.0

Table 5-11b. Typical steam energy uses per pound of buttermilk powder.

Process	Calculation Number	Energy Use (BTU/1b)	%
Cleaning - CIP	15.11	578	15.3
Doulbe Effect Evaporator	17.11	2879	76.3
Heating the Plant	18.11	99	2.6
Product Heating	19.11	113	3.0
Steam Line Losses	20.11	103	2.7
Total		3772	100.0

Table 5-11c. Uses of refrigeration per pound of dried buttermilk powder.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Air Conditioning	23.11	13	6.2
Product Cooling	24.11	162	77.1
Cooling Line Losses	25.11	35	16.7
Total		210	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{(210 \frac{\text{BTU}}{\text{lb powder}})}{2.86} = 73 \frac{\text{BTU}}{\text{lb powder}}$$

Table 5-11d. Natural gas energy costs per pound of dried buttermilk powder.

Direct Uses of Natural Gas Energy	Calculation Number	Amount (BTU/lb)	%
Spray Drying	27.11	3102	100.0
Total		3102	100.0

Table 5-11c. Uses of refrigeration per pound of dried buttermilk powder.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Air Conditioning	23.11	13	6.2
Product Cooling	24.11	162	77.1
Cooling Line Losses	25.11	35	16.7
Total		210	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(210 \frac{\text{BTU}}{\text{lb powder}}\right)}{2.86} = 73 \frac{\text{BTU}}{\text{lb powder}}$$

Table 5-11d. Natural gas energy costs per pound of dried buttermilk powder.

Direct Uses of Natural Gas Energy	Calculation Number	Amount (BTU/lb)	%
Spray Drying	27.11	3102	100.0
Total		3102	100.0

Table 5-11e. Total energy cost per pound of dried buttermilk powder.

Type of Energy	Energy Use (BTU/lb)	Unit Price* $/10^6 BTU	Dollar Cost $/(lb)	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	284	7.32	0.0021	852
2. Refrigeration	73	7.32	0.0005	219
Steam	3772	1.33	0.0050	4526
Natural Gas (for spray drying)	3102	1.06	0.0033	3102
Total			0.0109	8699

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

Section 5-12

EVAPORATED MILK PRODUCTION

Description

Evaporated milk is whole milk whose solids concentration has been doubled by evaporation. The production is outlined below.

First, incoming milk is weighed, cooled and stored to await further processing. The raw milk is withdrawn from the storage tank and pumped through a clarifier and on to standardizing tanks. Some of the milk going to the standardizing tanks is separated so as to standardize the milk which is to be evaporated, to 4.0% fat and 13% total solids.

The next step is evaporation. The standardized milk is warmed to 205°F before entering the evaporator to improve the heat stability and viscosity of the finished product. The milk then enters the evaporator and soon afterwards exits as a 26% total solids concentrate at 115°F. The warm evaporated milk is homogenized at a total pressure of 3000 psig and is pumped through a plate cooler to lower the temperature to 40°F.

The cooled evaporated milk is checked for total solids and fat content and restandardized if necessary. The finished product should contain at least 26.0% total solids and 8% fat. The evaporated milk is then placed in cans and sealed. The cans are placed in a retort which raises the temperature of the evaporated milk to 245°F. The cans are considered sterilized after this temperature is held for 15 minutes. The evaporated milk cans are cooled, dried, labeled, and packaged and are ready for shipment.

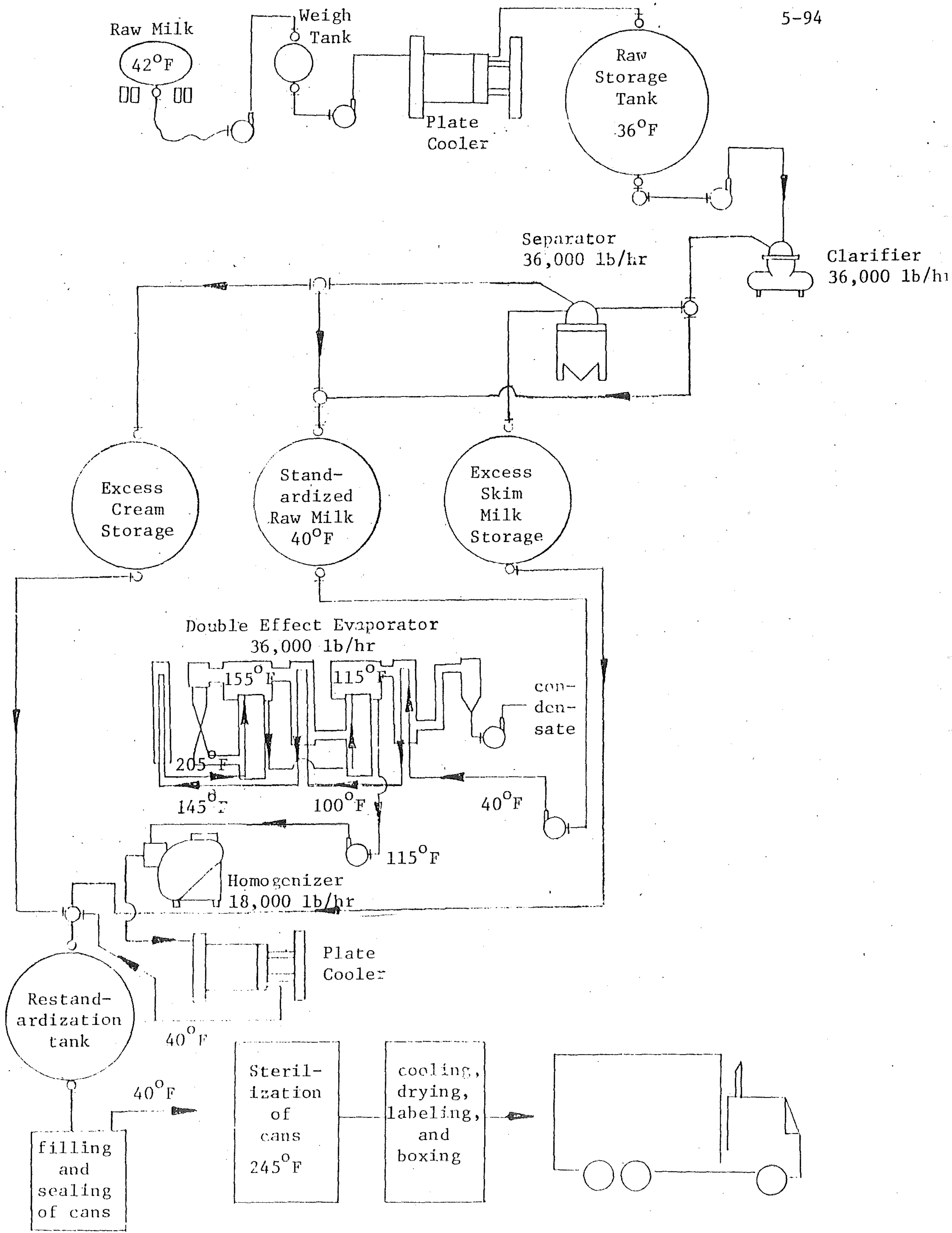


Figure 5-12a. Flow chart showing evaporated milk production.

Energy Inputs into Evaporated Milk Production

The energy inputs to evaporated milk production will be based on a plant processing 2,000,000 pounds of milk every week. Evaporated milk will be the only product produced by the plant. The size and components of the plant will be based on several evaporated milk plant descriptions. The following assumptions will be made about the plant.

1. Two pounds of whole milk will be consumed in making one pound of evaporated milk.
2. The air circulation rate for the entire plant will be 76,000 CFM.
3. The plant will operate seven days a week.
4. About one third of the incoming raw milk must be separated for standardization purposes.
5. The climate of the plant area is similar to that of the Salt Lake City, Utah area.
6. The following CIP cleaning cycles are needed each day:

    10 - Tanker trucks
    5 - Milk tanks and pipeline systems
    2 - double effect evaporator (Acid Wash)
    17 cycles/day

7. The clarifier, three positive displacement pumps, and the canning equipment parts are cleaned manually in two batches.

8. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	volume (Ft.^{3})
Processing and Evaporating Rooms	8,000	112,000
Offices, lunch, locker, and restrooms	2,700	24,300
Boiler and refrigeration rooms	3,300	46,200
Cold storage room	100	1,000
Dry storage room	2,000	28,000
Canned product storage	3,000	42,000
Receiving shelter	1,400	19,600
Labs, shop and misc.	1,300	18,000
TOTALS	21,800	291,100

The following tables represent most of the energy inputs into evaporated milk production. The estimating procedures for each energy requirement is given in the Energy Calculation Section under the Energy Calculation Number given with each energy cost.

Table 5-12a. Typical electrical energy uses per pound of evaporated milk.

Process	Calculation Number	Energy Use (BTU/lb)	%
Pumping Milk	1.12	3.0	6.8
Clarification	2.12	2.0	4.5
Separation	3.12	0.7	1.6
Homogenization	4.12	10.8	24.3
CIP Pumps	5.12	1.4	3.2
Double Effect Evaporator	6.12	2.1	4.7
Air Compressor	8.12	0.4	0.9
Cold Storage Room Fans	9.12	0.1	0.2
Heating and Air Cond. Fans	10.12	12.1	27.3
Boiler Fan	11.12	2.4	5.4
Evaporative Cooling Tower Fans	12.12	4.0	9.0
Lights and Misc. Motors	13.12	5.4	12.2
Total		44.4	100.0

Table 5-12b. Typical steam energy uses per pound of evaporated milk.

Process	Calculation Number	Energy Use (BTU/lb)	%
Cleaning - CIP	15.12	76	9.0
Cleaning - Manual	16.12	13	1.5
Double Effect Evaporator	17.12	344	40.7
Heating the Plant	18.12	21	2.5
Product Heating	19.12	80	9.5
Steam Line Losses	20.12	18	2.1
Sterilization of canned milk	21.12	293	34.7
Total		845	100.0

Table 5-12c. Uses of refrigeration per pound of evaporated milk.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Cold Storage Room	22.12	1	1.0
Air Conditioning	23.12	2	1.9
Product Cooling	24.12	83	80.6
Cooling Line Losses	25.12	17	16.5
Total		103	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(103\ \frac{\text{BTU}}{\text{lb evap. milk}}\right)}{2.86} = 36\ \frac{\text{BTU}}{\text{lb evap. milk}}$$

Table 5-12d. Total energy cost per pound of evaporated milk.

Type of Energy	Energy Use (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and Motors	44	7.32	0.00032	132
2. Refrigeration	36	7.32	0.00026	108
Steam	845	1.33	0.00112	1014
Total			0.00170	1254

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

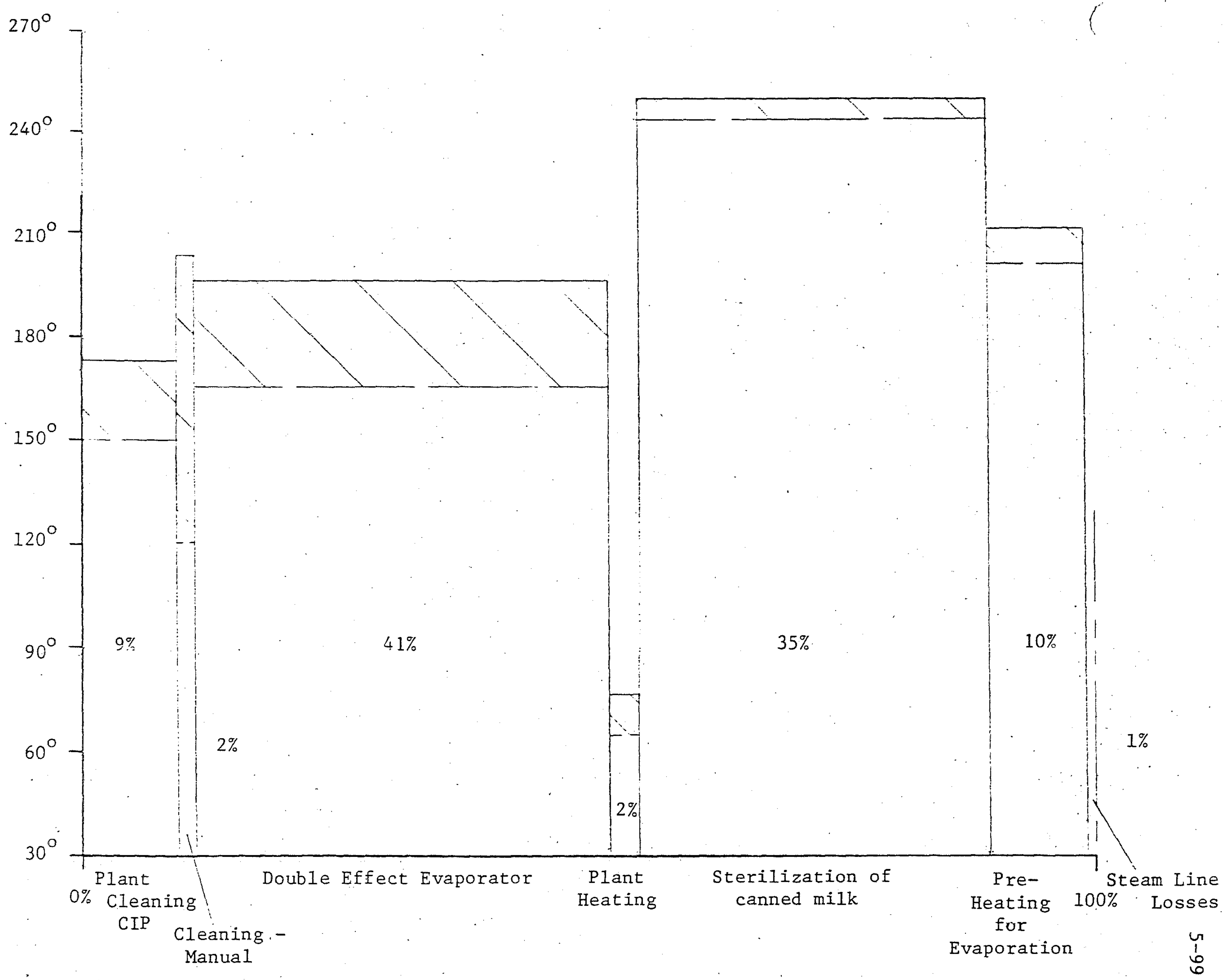


Table 5-12e. Maximum process temperature and percent of total heating energy consumption in Evaporated Milk production. (Cross hatching represents the maximum temperature range per process.)

Section 5-13

ICE CREAM PRODUCTION

Description

Ice Cream can be made with a variety of ingredients and may or may not use fresh milk in the mix. Many plants use 40% fat cream, condensed milk, and non-fat dry milk in making their mix. Liquid sugar, corn syrup, corn syrup solids, and dry sugar are used in different combinations as sweetners. No matter what ingredients are used, the mix composition is about the same. Arbuckle[1] states that a good average ice cream has the following composition:

Fat	-	12%
Milk solids, not fat	-	11%
Sugar	-	15%
Stabilizer and Emulsifier	-	0.3%
TOTAL SOLIDS		38.3%

Ice Cream is defined by federal standards to contain not less than 10% milkfat and 20% total milk solids, except in the case of bulky flavors.

The first step in making ice cream is assembling and mixing the ingredients to make the desired composition mix. Next the mix is pasteurized. Pasteurization can be done in the vat by heating the mix to 160°F for 30 minutes. An alternate method is using a HTST pasteurizer and heating the mix to 180°F for 15 seconds. After pasteurization and while the mix is still hot, it is run through a homogenizer set at 2000 psig on the first stage and 500 psig on the second. The mix, which has gained 5°F during homogenization, is cooled

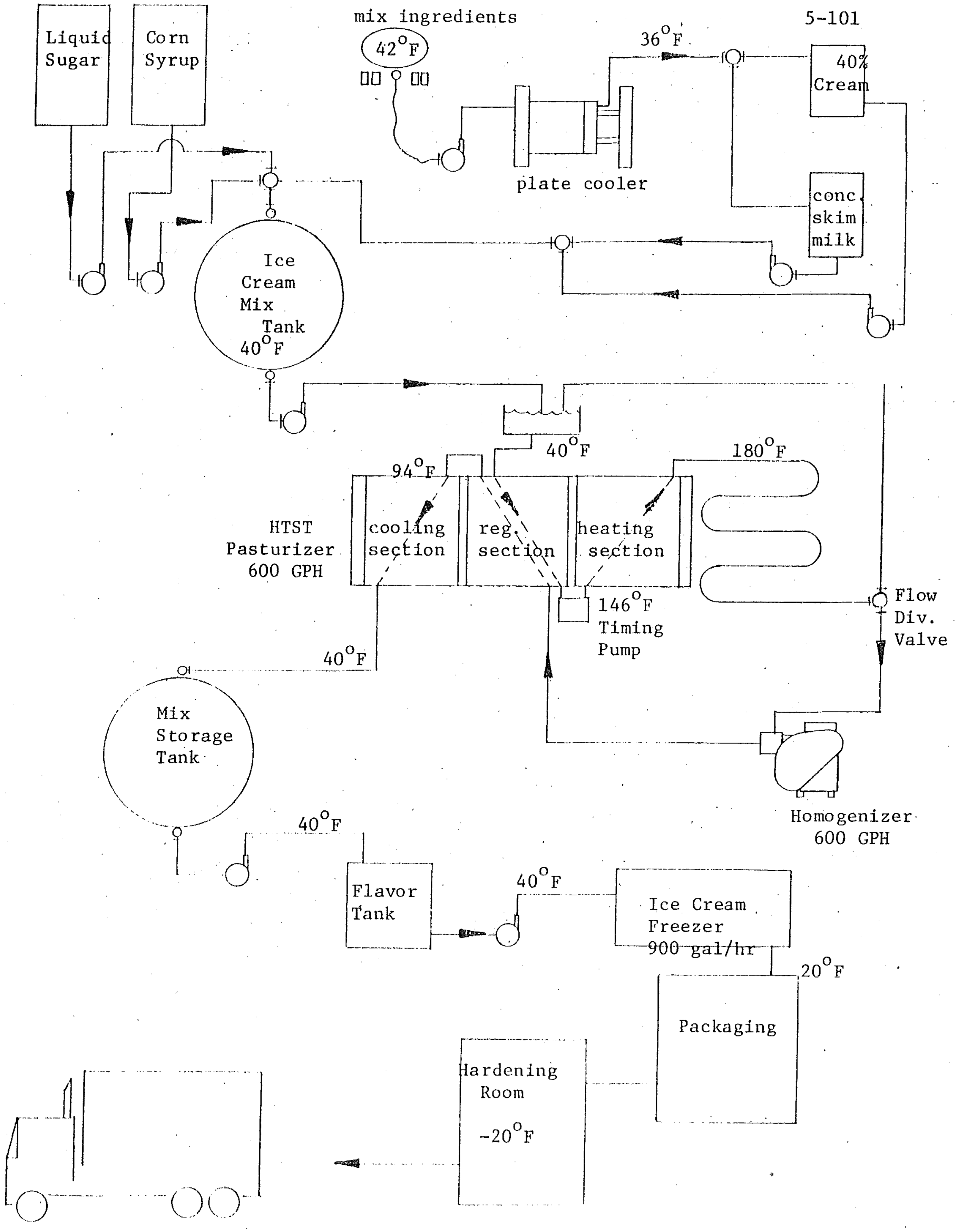


Figure 5-13a. Flow chart showing ice cream production.

from 185°F to 40°F. Flavoring can be either added and mixed in the storage tank or it can be added as the mix is pumped to the freezer. The mix can also pass through a fruit feeder which adds fruit prior to freezing.

The mix is fed into a continuous freezer which lowers the temperature to about 21°F and freezes about 65% of the water. Another function of the freezer is to entrain air into the ice cream. The volume of air entrained during the freezing process divided by the original volume of the mix and multiplied by 100 is defined as the "percent overrun". Ice cream overrun varies from 70% to 100%.

The semi-fluid ice cream is packaged and placed in the hardening room to cool to -20°F. The hardened ice cream is then ready to be shipped.

Energy Inputs into Ice Cream Production

The energy inputs into ice cream production is based on a plant producing 1,000,000 gallons of ice cream per year.[16] The plant will operate five days per week making 19,231 gallons of ice cream per week. The following assumptions are made about the plant.

1. Ice cream is the only product made by the plant.
2. The finished ice cream will have 85% overrun and one gallon will weigh 4.95 pounds.
3. To make 19,231 gallons of ice cream requires 10,395 gallons of ice cream mix made from:

40% cream	23,784 lbs.
30% concentrated skim milk	32,183 lbs.
Liquid sugar	18,184 lbs.
Corn syrup	3,992 lbs.

Emulsifer	52 lbs.
Stabilizer	288 lbs.
Water	16,632 lbs.
Total	95,115 lbs.

Thus one gallon of ice cream mix weighs 9.15 pounds.

4. The air circulation rate for the entire plant is 63,000 CFM.
5. The climate the plant is located in is similar to that of the Salt Lake City, Utah area.
6. The following CIP cleaning cycles are needed each day.

1	- HTST (acid wash)
1	- Tanker truck
5	- Storage tanks and pipeline systems
7 cycles/day	

7. The ice cream freezer, the packaging equipment, positive displacement pumps, and the fruit feeder are cleaned manually each day in three batches.
8. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	volume (ft.^{3})
Offices, labs, locker lunch and Restrooms	4,400	39,600
Processing and freezing rooms	4,863	68,082
Dry storage room	5,784	80,976
Hardening Room	3,550	49,700
Cold storage room	388	5,432
Boiler and Refrigeration room	2,336	32,704
Receiving area	1,282	17,948
Kitchen	378	5,292
TOTALS	22,981	299,734

9. There are 4 - 3/4 horsepower fans in the hardening room and 1 - 1/2 horsepower fan in the cold room to circulate air.

The following tables relate most of the energy requirement of producing ice cream. The estimating procedures for each energy requirement is given in the Energy Calculation Section under the Energy Calculation Number given with each energy cost. A plant layout showing an ice cream plant dimensions and components is given after the tables.

Table 5-13a. Typical electrical energy costs per gallon of ice cream.

Process	Calculation Number	Amount (BTU/gal)	%
Pumping Ingrediants	1.13	3.0	0.2
Homogenization	4.13	52.0	4.2
CIP Pumps	5.13	21.7	1.8
Air Compressor	8.13	18.9	1.5
Cold Storage Room Fans	9.13	51.9	4.2
Heating and Air Cond. Fans	10.13	369.3	30.1
Boiler Fan	11.13	126.3	10.3
Cooling Tower Fans	12.13	25.0	2.0
Lights and Misc. Motors	13.13	366.1	29.8
Agitation of Ice Cream Mix	14.13	5.5	0.4
Ice Cream Freezer	14.13	187.1	15.3
Total		1226.8	100.0

Table 5-13b. Typical steam energy costs per gallon of ice cream.

Process	Calculation Number	Amount (BTU/gal)	%
Cleaning - CIP	15.13	1176	36.5
Cleaning - Manual	16.13	150	4.7
Heating the Plant	18.13	954	29.6
Product Heating	19.13	138	4.3
Steam Line Losses	20.13	804	25.0
Total		3222	100.0

Table 5-13c. Uses of refrigeration.

Uses of Refrigeration	Calculation Needed	Cooling Needed (BTU/gal)	%
Hardening Room	22.13	1643	58.3
Cold Storage Room	22.13	95	3.4
Air Conditioning	23.13	133	4.7
Product Cooling	24.13	243	8.6
Cooling Line Losses	25.13	75	2.7
Ice Cream Freezer	26.13	630	22.3
Total		2819	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling load is:

$$\frac{\left(2819 \dfrac{\text{BTU}}{\text{gal. Ice Cream}}\right)}{2.86} = 986 \frac{\text{BTU}}{\text{gal. Ice Cream}}$$

Table 5-13d. Total energy cost per gallon of ice cream.

Type of Energy	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6\ \text{BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossel Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and Motors	1227	7.32	0.0090	3681
2. Refrigeration	986	7.32	0.0072	2958
Steam	3222	1.33	0.0043	3866
Total			0.0205	10,505

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

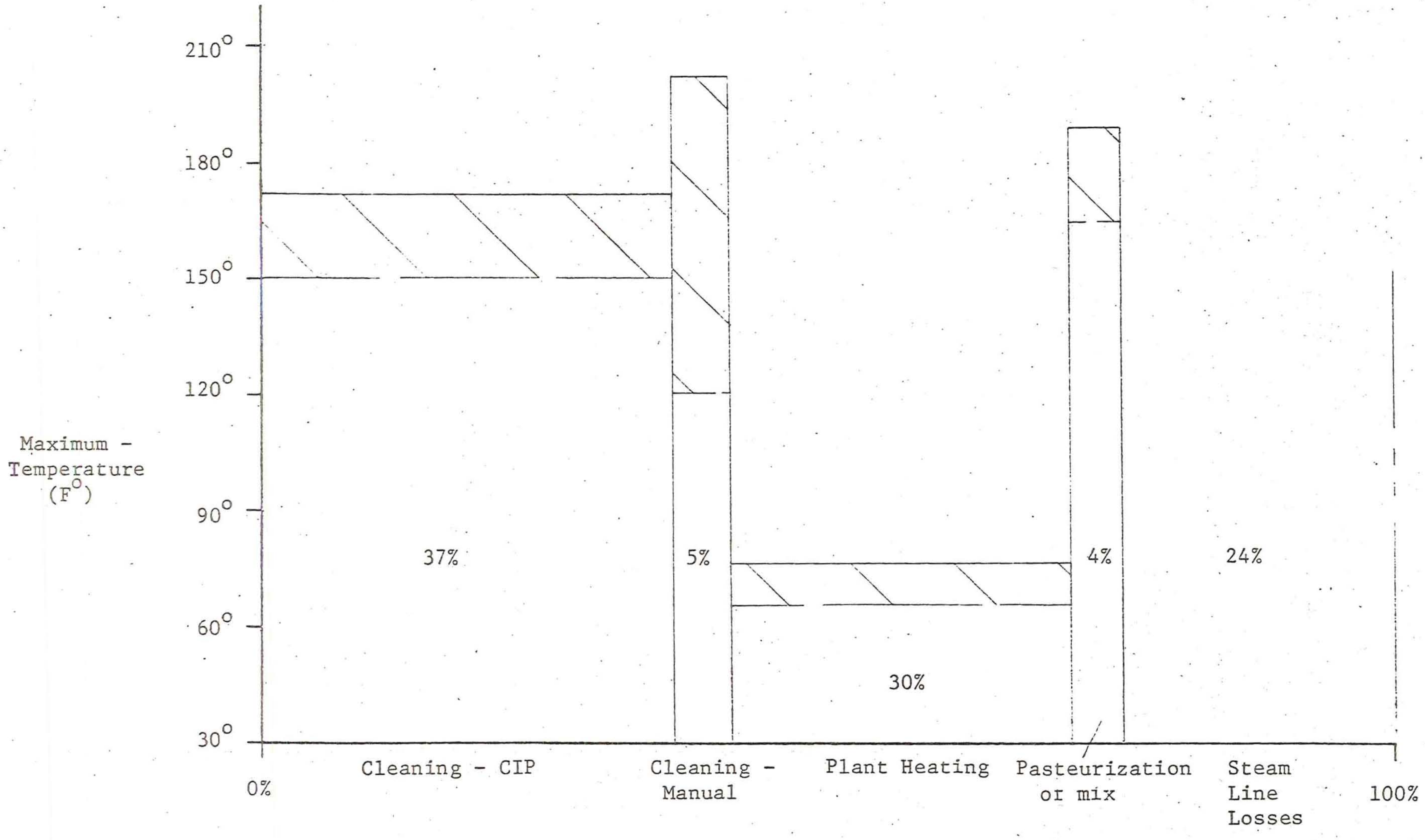


Table 5-13e. Maximum process temperature and percent of total heating energy consumption in Ice Cream production. (Cross hatching represents the maximum temperature range per process.)

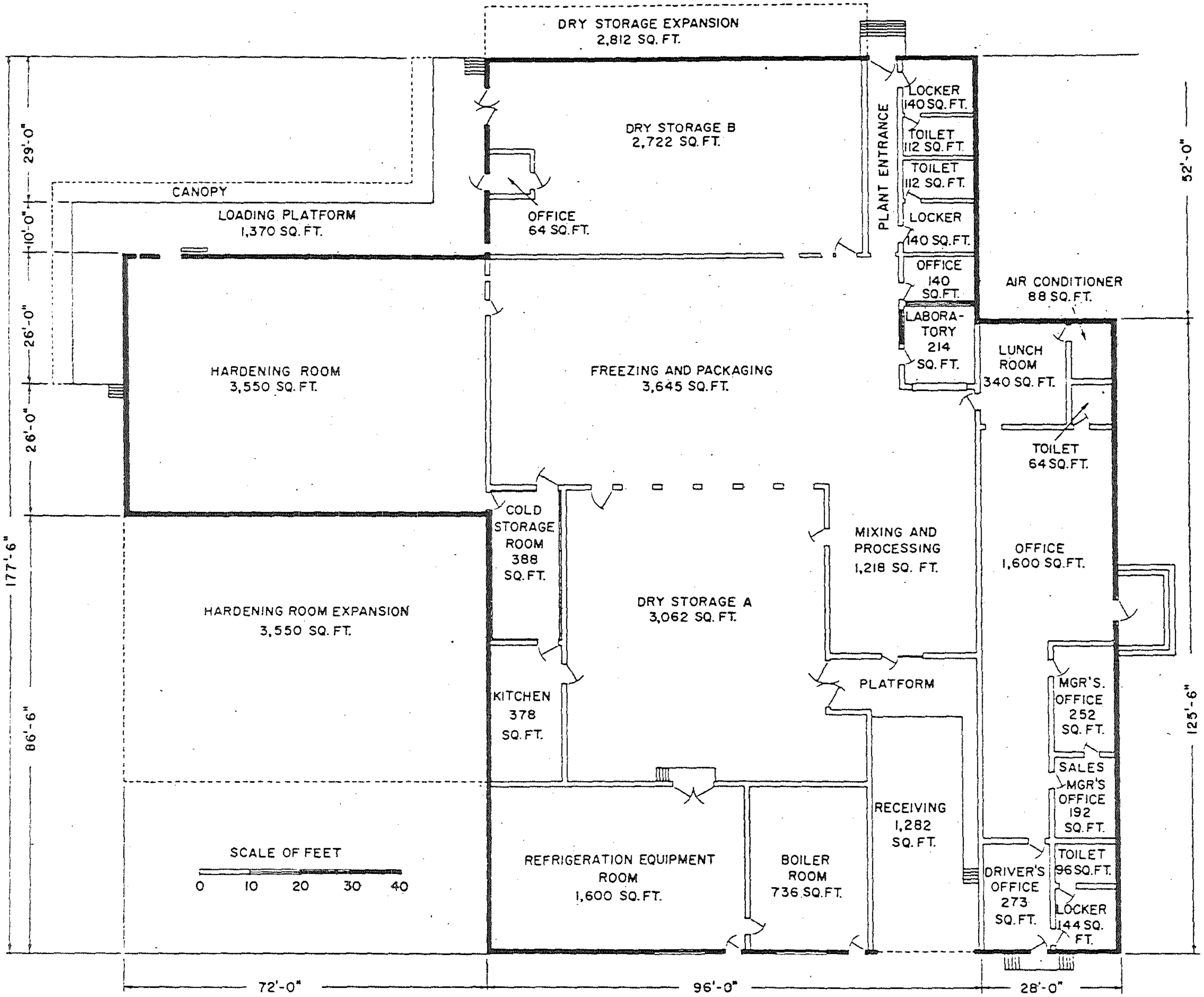


Figure 5-13b. Ice cream plant layout as given by Tracy[16]

Section 5-14

PROCESSED CHEESE PRODUCTION

Description

Processed cheese is made from natural cheese and emulsifying salts. The function of the emulsifying salts is to form a more stable emulsion which prevents oiling-off of fat in the cheese at room temperatures. Also the heat treatment given to the processed cheese is equivalent to a pasteurization process. Hence, a large portion of the microbial load is destroyed and body and flavor changes during storage are brought to a minimum. Consequently, the maximum permissible storage temperature for processed cheese is considerably higher than natural types of cheese.

A processed cheese factory would have natural cheese being delivered to it. A common method of delivering the cheese is in 55 gallon drums. The cheese is put into cold storage at 40°F as it is delivered. Samples of each batch are analyzed for fat and water content.

The processing begins by selecting, from the cheese stock, the lots of cheese which would give the desired flavor, fat, and water content. The legal definition for processed cheese requires it contain no more than 3% emulsifying salts and its fat and moisture content be equal to the fat and moisture content of the cheese from which it is derived. The calculated amount needed from each lot of cheese is brought to the grinder. The surfaces of the cheese blocks are scraped before entering the grinder to remove any mold and wax present. After the cheese has been pulverized by the grinder, it is fed into the cheese kettles or cookers. The emulsifying salts and any water or flavoring and coloring ingredients desired are added at this time.

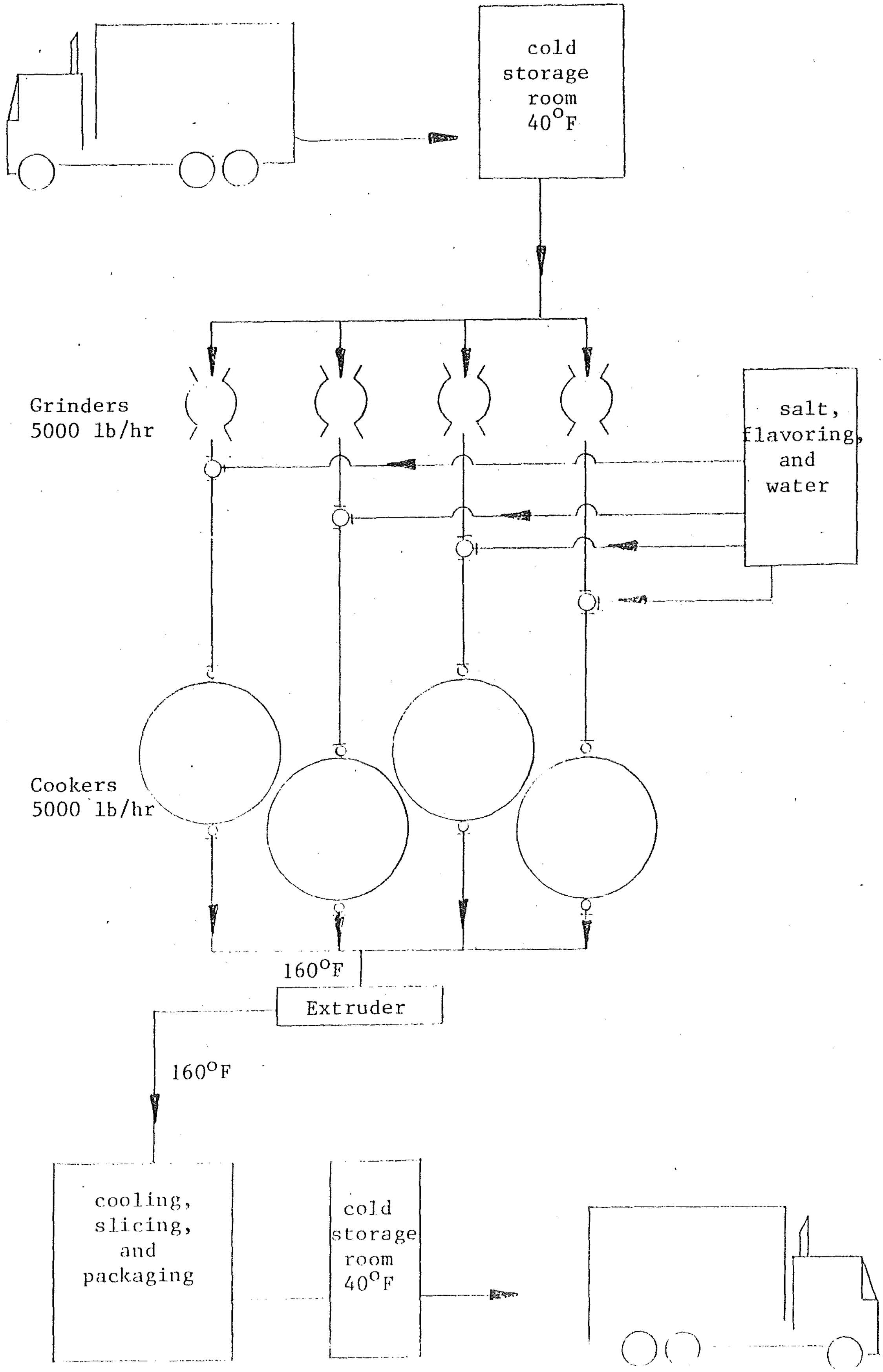


Figure 5-14a. Flow chart showing processed cheese Production.

The cook begins by heating the cheese in the cooker until its temperature reaches about 160°F. The heating can be done by a jacketed steam vat or by direct steam injection. The cheese is agitated while being heated and after being at 160°F for three minutes, the cooker is emptied. The hot plastic mass can be poured into foil-lined or plastic coated boxes or it can be pumped to a cooling belt to be extruded out in a thin layer. On the cooling belt the cheese is cooled to 50°F with a glycol-water solution circulated on the other side. With the cheese cooled it is firm enough for slicing and packaging.

After packaging the processed cheese is placed in a 40°F cold room to lower the temperature to 40°F before shipment.

Energy Inputs into Processed Cheese Production

The energy input to processed cheese production is based on a plant producing 280,000 pounds of processed cheese every day. The size and components of the plant are derived from several processed cheese plant descriptions. The following assumptions will be made about the plant.

1. Only processed cheese will be made in the plant.
2. There are 0.97 pounds of natural cheese consumed for every pound of processed cheese produced.
3. The plant will operate 6 days a week with two 8 hour shifts each day.
4. The total air circulation rate for the entire plant is 90,000 CFM.
5. The climate of the area of the plant location will be similar to that of the Salt Lake City, Utah area.

6. Four- three horsepower fans circulate air in the cold room.

7. There will be 8 CIP cleaning cycles each day to clean the cookers. These are acid washes.

8. The sizes of the rooms in the plant are:

Room	Floor space (ft.^{2})	volume (ft.^{3})
Offices, lunch, locker, and restrooms	4,875	48,750
Processing rooms	13,000	208,000
Cold storage room	12,000	240,000
Boiler and refrigeration rooms	2,500	40,000
Dry storage areas	13,000	156,000
Shop and hallways	4,875	58,500
TOTALS	50,250	751,250

The following tables represent estimatres of most of the energy requirement in producing processed cheese. The estimating procedures are found in the Energy Calculation Section under the Energy Calculation Number given with the energy cost.

Table 5-14a. Typical electrical energy costs per pound of processed cheese.

Process	Calculation Number	Amount (BTU/lb)	%
Air Compressor	8.14	0.2	0.3
Cold Storage Room Fans	9.14	2.0	2.8
Heating and Air Cond. Fans	10.14	7.2	10.2
Boiler Fan	11.14	1.4	2.0
Cooling Tower Fans	12.14	1.4	2.0
Lights and Misc. Motors	13.14	7.4	10.4
Grinding	14.14	44.9	63.3
Agitation During Cooking	14.14	4.5	6.3
Packaging Machines	14.14	1.9	2.7
Total		70.9	100.0

Table 5-14b. Typical steam energy costs per pound of processed cheese.

Process	Calculation Number	Amount (BTU/lb)	%
Cleaning - CIP	15.14	26	8.8
Heating the Plant	18.14	24	8.1
Product Heating	19.14	72	24.4
Steam Line Losses	20.14	18	6.1
Processed Cheese Plant Cleaning	21.14	155	52.5
Total		295	100.0

Table 5-14c. Uses of refrigeration.

Uses of Refrigeration	Calculation Number	Cooling Needed (BTU/lb)	%
Cold Storage Rooms	22.14	22	21.2
Air Conditioning	23.14	2	1.9
Product Cooling	24.14	66	63.5
Cooling Line Losses	25.14	14	13.4
Total		104	100.0

With a coefficient of performance of 2.86 for the refrigeration system as defined in Energy Calculation No. 28.02, the electrical energy needed to deliver the above cooling laod is:

$$\frac{\left(104 \frac{\text{BTU}}{\text{lb cheese}}\right)}{2.86} = 36 \frac{\text{BTU}}{\text{lb cheese}}$$

Table 5-14d. Total energy cost per pound of processed cheese.

Type of Energy	Amount Used (BTU/lb)	Unit Price* $\frac{\$}{10^6 \text{ BTU}}$	Dollar Cost $\frac{\$}{(\text{lb})}$	Fossil Fuel Equivalent* (BTU/lb)
Electrical				
1. Lights and motors	72	7.32	0.00053	216
2. Refrigeration	36	7.32	0.00026	108
Steam	295	1.33	0.00039	354
Total			0.00118	678

*Unit prices and fossil fuel equivalent factors are defined in Energy Calculations Nos. 28.01-28.06.

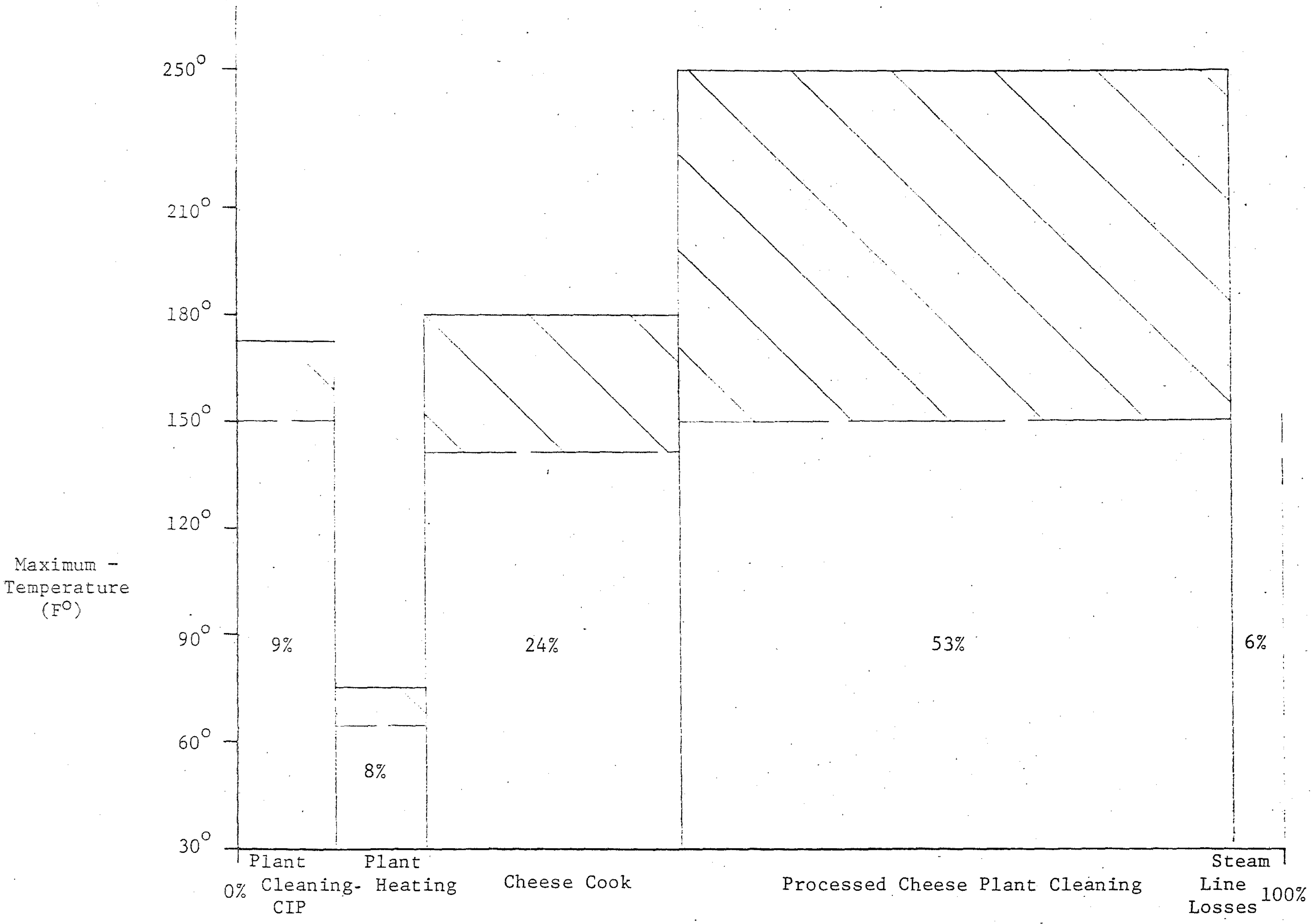


Table 5-14e. Maximum process temperature and percent of total heating energy consumption in Processed Cheese production. (Cross hatching represents the maximum temperature range per process.)

Section 5-15

COMPARISON OF CALCULATED ENERGY INPUTS WITH SURVEY DATA

Over 400 questionnaires were mailed to dairy processors in the five state region of California, Oregon, Idaho, Utah, and Nevada. Factors such as the highly competitive nature of the dairy industry perhaps contributed to the result that only 36 responses were received.

The 36 responding plants covered a wide spectrum of products and provided valuable information. However, the variation in energy inputs reported together with a sufficiently insignificant number did not provide a firm basis for determining realistic energy inputs. We, therefore, put greater reliance on the calculated values than on the survey results. Table 5-15a provides a comparison between average values of the survey data and our calculated values. This comparison indicates that the calculated values are almost certainly conservative. Also, the survey showed that our calculated values would be typical of a large energy efficient plant. Survey values which double our calculated values are not surprising since there exists wide variation in the efficiency of dairy processing equipment and procedures.

Table 5-15 Comparison of energy requirements for dairy products from survey information and from calculated values.

Product	Fossil Fuel Energy Consumed		Fossil Fuel Energy Cost		Electrical Energy Consumed		Electrical Energy Cost		No. of Plants Used to calculate the averages
	survey average	predicted	survey average	predicted	survey average	predicted	survey average	predicted	
Fluid Milk	2702 BTU/gal	1508 BTU/gal	$0.0054/gal	$0.0017/gal	1575 BTU/gal	1508 BTU/gal	$0.0067/gal	$0.0035/gal	4
Cheddar Cheese (Neglecting Whey Drying)	2545 BTU/lb	2783 BTU/lb	$0.0060/lb	$0.0031/lb	366 BTU/lb	533 BTU/lb	$0.0019/lb	$0.0039/lb	5
Cheddar Cheese (Including Whey Drying)	10,822 BTU/lb	8265 BTU/lb	$0.0080/lb	$0.0090/lb	852 BTU/lb	766 BTU/lb	$0.0042/lb	$0.0056/lb	1
Cottage Cheese	1542 BTU/lb	1034 BTU/lb	$0.0015/lb	$0.0012/lb	591 BTU/lb	153 BTU/lb	$0.0036/lb	$0.0011 lb	5
Butter	3328 BTU/lb	742 BTU/lb	$0.0043/lb	$0.0008/lb	584 BTU/lb	118 BTU/lb	$0.0057/lb	$0.0009 lb	3
Dried Milk	14,225 BTU/lb	7657 BTU/lb	$0.0017/lb	$0.0080/lb	605 BTU/lb	323 BTU/lb	$0.0040/lb	$0.0020 lb	3
Instantized Dried Milk	2958 BTU/lb	782 BTU/lb	$0.0034/lb	$0.0009/lb	475 BTU/lb	58 BTU/lb	$0.0034/lb	$0.0004/lb	1
Evaporated Milk	1627 BTU/lb	1014 BTU/lb	$0.0022/lb	$0.0011/lb	90 BTU/lb	80 BTU/lb	$0.0005/lb	$0.0006/lb	2
Ice Cream	4406 BTU/gal	3866 BTU/gal	$0.0041/gal	$0.0043/gal	3299 BTU/gal	2213 BTU/gal	$0.0148/gal	$0.0162/gal	4

Section 6

ENERGY CALCULATIONS

This section illustrates the methods used to derive each of the energy costs given in the preceeding sections. Each energy cost has an energy calculation number given with it. To locate the derivation of an energy cost, find the energy calculation numbers given in the left hand margin on the following pages and match it with the energy calculation number given with the energy cost in question.

Because the same energy consuming process may be used in the production of several dairy products, this section is divided into 28 subsections, each devoted to a particular energy consuming process. The first of each subsection gives the general procedures used to determine the energy consumption by a particular energy consuming process, such as pumping milk. The remainder of the subsection is divided up by energy calculation numbers. The data to the right of each energy calculation number includes the energy consumption for a particular product, such as cheddar cheese, and the figures which are necessary for the calculation of that particular energy consumption.

The energy calculation numbers are organized to refer to both the location of the subsection containing the energy calculation and to the product whose energy consumption we are interested in. The number to the left of the decimal point in each energy calculation number, refers to the subsection where the energy consumption derivation is found. The number to the right of the decimal point, which we shall call the product code number, refers to a specific product. The product code numbers are as follows:

.00	General derivation
.01	Fluid milk
.02	Cheddar cheese
.03	Cottage cheese
.04	Sour cream
.05	Cream cheese
.06	Cultured milk
.07	Dried whey
.08	Butter
.09	Dried milk
.10	Instantized dried milk
.11	Dried buttermilk
.12	Evaporated milk
.13	Ice cream
.14	Processed cheese

An index showing the subsections in this section follows. As an example of the definition of energy calculation numbers, the energy calculation number 1.02 refers to both subsection one where the energy consumption in pumping milk is derived and to the specific product of cheddar cheese.

Section 6 Subsections Index

Electrical Energy Calculations

Steam Energy Calculations

Refrigeration Energy Calculations

6-22 Cold Storage Rooms

6-23 Air Conditioning

6-24 Product Cooling

6-25 Cooling Line Losses

6-26 Miscellaneous Refrigeration Energy Costs

Natural Gas Energy Costs

6-27 Spray Drying

General Energy Costs

6-28 Miscellaneous Energy Calculations

Section 6-1

ENERGY CALCULATION NO. 1.00

Pumping Dairy Products During Processing

It is assumed that the average pump used in pumping dairy products has a capacity of 50 G.P.M. and is powered by a one horsepower motor. It is also assumed that the motor is under a load which is 75% of its rated capacity and has an electrical efficiency of 75%. If an average density for dairy products was assumed to be 8.6 lbs/gal, the electrical energy cost is given by:

$$\frac{(1\ \text{hp/pump})\quad (2545\ \frac{\text{BTU}}{\text{hr-hp}})\quad (0.75\ \text{load})}{(50\ \text{gal/min})\quad (60\ \text{min/hr})\quad (0.75\ \text{efficiency})\quad (8.6\ \frac{\text{lbs}}{\text{gal}})}$$

$$= 0.1\ \frac{\text{BTU}}{\text{pump - lbs. of dairy product}}$$

For simplicity the above cost is assumed to apply to pumping milk, skim milk, cream, whey, buttermilk, cultured milk, ice cream mix, evaporated milk, corn syrup, and liquid sugar.

The energy cost calculation process begins by estimating the average number of pumps the ingredients of the finished product passes through. Next, the number of pumps is multiplied by the above cost per pump and by a conversion factor. The conversion factor is defined as the ratio of the mass of material pumped to the amount of product produced. This gives the cost of pumping for various products. The following table illustrates the results.

Table 6 -1a Energy Requirements for Pumping

Energy Cal. No.	Energy Req'd for	Material Pumped	Average Number Pumps Used	BTU/Pump-lb. Pumped	Conversion Factor	Electrical Energy Req'd
1.01	Fluid Milk	Milk and Skim milk	5	0.1	8.6 lb. milk/gal. milk	4.3 BTU/Gal. Milk
1.02	Cheddar Cheese	Milk	5	0.1	10 lb. milk/lb. cheese	5.0 BTU/lb. cheese
1.03	Cottage Cheese	Milk and Skim milk	6	0.1	4.1 lb. milk/lb. cheese	2.5 BTU/lb. cheese
1.04	Sour Cream	Milk and 40% cream	6	0.1	1.0 lbs milk & cream/lb. sour cream	0.6 BTU/lb. sour cream
1.05	Cream Cheese	Milk and 40% cream	6	0.1	3.2 lbs milk & cheese/lb. cheese	1.9 BTU/lb. cheese
1.06	Cultured Milk	Milk and Skim milk	4	0.1	2.15 lbs. milk/qt. cult. milk	0.9 BTU/qt. cult. milk
1.07	Dried Whey	Whey	2	0.1	16.1 lbs 6% whey/lb. powder	3.2 BTU/lb. whey powder
1.08	Butter	40% Cream	6	0.1	2.0 lbs. cream/lb. butter	1.2 BTU/lb. butter
1.09	Dried Milk	Skim milk	5	0.1	10.8 lbs. milk/lb. powder	5.4 BTU/lb. powder
1.11	Dried Buttermilk	buttermilk	3	0.1	10.8 lbs. buttermilk/lb. powder	3.2 BTU/lb. powder
1.12	Evaporated Milk	Milk	5	0.1	2.0 lbs. milk/lb. evap. milk	1.0 BTU/lb. evap. milk
1.13	Ice Cream	ice cream mix	6	0.1	4.95 lbs. mix/gal. ice cream	3.0 BTU/gal. ice cream

Section 6-2

ENERGY CALCULATION NO. 2.00

Clarification of Milk

Manufacturer's specifications show that a 20,000 lb/hr clarifier requires a 10 horsepower motor. Assuming the motor is 88% efficient while under a load which is 75% of the rated capacity, then the electrical energy cost can be calculated as:

$$\frac{(10\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (0.75\text{ load})}{(20{,}000\ \frac{\text{lb milk}}{\text{hr}})\ (0.88\text{ efficiency})} = 1.0\ \frac{\text{BTU}}{\text{lb milk}}$$

Since, in some cases, cream is separated from milk and since both the cream and the skim milk are clarified, the cost of clarification will be distributed equally between cream and skim milk. Thus, the cost to clarify cream is

$$1.0\ \frac{\text{BTU}}{\text{lb cream}}$$

It is assumed that the energy cost to clarify 6% solids whey is the same as it is for milk.

The energy cost which clarification adds to various products is summarized in the following table. The total electrical energy cost is derived by multiplying the energy cost to clarify a material times the ratio of the mass of the material which is clarified to the mass of the product which is produced. This may be multiplied by a gravimetric to volumetric conversion factor when it is desired to express the energy cost per gallon instead of per pound.

Table 6-2a Energy Requirements for Clarification

Energy Cal. No.	Energy Req'd For	Material Clarified	$\frac{\text{BTU}}{\text{lb.}}$ clarified	Ratio of Product Clarified	Conversion Factor	Electrical Energy Req'd
2.01	Fluid Milk	Milk	1.0	1.0 $\frac{\text{lbs. milk}}{\text{lb milk}}$	8.6 $\frac{\text{lbs. milk}}{\text{gal. milk}}$	8.6 $\frac{\text{BTU}}{\text{gal. milk}}$
2.02	Cheddar Cheese	Milk	1.0	10 $\frac{\text{lbs. milk}}{\text{lb. cheese}}$	--	10.0 $\frac{\text{BTU}}{\text{lb. cheese}}$
2.03	Cottage Cheese	Skim milk	1.0	4.1 $\frac{\text{lbs. milk}}{\text{lb. cheese}}$	--	4.1 $\frac{\text{BTU}}{\text{lb. cheese}}$
2.04	Sour Cream	Milk and 40% cream	1.0	1.0 $\frac{\text{lbs. milk}}{\text{lb. sour cream}}$	--	1.0 $\frac{\text{BTU}}{\text{lb. sour cream}}$
2.05	Cream Cheese	Milk and 40% cream	1.0	3.2 $\frac{\text{lbs milk \& cream}}{\text{lb. cheese}}$	--	3.2 $\frac{\text{BTU}}{\text{lb. cheese}}$
2.06	Cultured Milk	Milk	1.0	1.0 $\frac{\text{lbs. milk}}{\text{lb. cult. milk}}$	2.15 $\frac{\text{lbs. milk}}{\text{qt. milk}}$	2.2 $\frac{\text{BTU}}{\text{qt. cult. milk}}$
2.07	Dried Whey	6% Whey	1.0	16.1 $\frac{\text{lbs. 6\% whey}}{\text{lb. powder}}$	--	16.1 $\frac{\text{BTU}}{\text{lb. powder}}$
2.12	Evaporated Milk	Milk	1.0	2.0 $\frac{\text{lbs. milk}}{\text{lb. evap. milk}}$	--	2.0 $\frac{\text{BTU}}{\text{lb. evap. milk}}$

Section 6-3

ENERGY CALCULATION NO. 3.00

Separation of Milk

Manufacturer's specifications show a 20,000 lb per-hour separator requires a 10 horsepower motor. Assuming the motor is 88% efficient while under a load which is 75% of the rated capacity, then the electrical energy cost can be calculated as:

$$\frac{(10\ \text{hp})\ \left(2545\ \frac{\text{BTU}}{\text{hr-hp}}\right)\ (0.75\ \text{load})}{\left(20{,}000\ \frac{\text{lb milk}}{\text{hr}}\right)\ (0.88\ \text{efficiency})} = 1.0\ \frac{\text{BTU}}{\text{lb milk}}$$

Since both cream and skim milk are derived from the separator, the cost per pound will be assumed to be equal. Thus, the cost to separate cream is:

$$1.0\ \frac{\text{BTU}}{\text{lb cream}}$$

and the cost to separate skim milk is:

$$1.0\ \frac{\text{BTU}}{\text{lb skim milk}}$$

Also, it is assumed that the energy cost to separate whey is equal to milk separating costs.

The energy cost of separation is summarized in the following table. The total electrical energy cost is derived by multiplying the energy cost to separate a particular material times the ratio of the mass of the material separated to the mass of the product produced. This may be multiplied by a gravimetric to volumetric conversion factor when it is desired to express the energy cost, per gallon instead of per pound.

Table 6-3a. Energy requirements for separation.

Energy Cal. No.	Energy Req'd for	Products of Separation Needed	$\frac{\text{BTU}}{\text{lb.}}$ Separated	Ratio of Product Separated	Conversion Factor	Electrical Energy Req'd
3.01	Fluid Milk	Skim Milk	1.0	0.33 $\frac{\text{lbs skim}}{\text{lb whole}}$	8.6 $\frac{\text{lbs milk}}{\text{gal milk}}$	2.9 $\frac{\text{BTU}}{\text{gal milk}}$
3.02	Cheddar Cheese	6% Whey	1.0	9.0 $\frac{\text{lbs whey}}{\text{lb cheese}}$	-------	9.0 $\frac{\text{BTU}}{\text{lb cheese}}$
3.03	Cottage Cheese	Skim Milk	1.0	4.0 $\frac{\text{lbs skim milk}}{\text{lb cheese}}$	-------	4.0 $\frac{\text{BTU}}{\text{lb cheese}}$
3.04	Sour Cream	40% Cream	1.0	0.39 $\frac{\text{lbs cream}}{\text{lb sour cream}}$	-------	0.4 $\frac{\text{BTU}}{\text{lb sour cream}}$
3.05	Cream Cheese	40% Cream	1.0	0.76 $\frac{\text{lbs cream}}{\text{lb cheese}}$	-------	0.8 $\frac{\text{BTU}}{\text{lb cheese}}$
3.06	Cultured Milk	Skim Milk	1.0	0.75 $\frac{\text{lbs skim}}{\text{lb whole}}$	2.15 $\frac{\text{lbs milk}}{\text{qt milk}}$	1.6 $\frac{\text{BTU}}{\text{qt cult milk}}$
3.08	Butter	40% Cream	1.0	2.0 $\frac{\text{lbs cream}}{\text{lb butter}}$	-------	2.0 $\frac{\text{BTU}}{\text{lb butter}}$
3.09	Dried Milk	Skim Milk	1.0	10.8 $\frac{\text{lbs skim milk}}{\text{lb powder}}$	-------	10.8 $\frac{\text{BTU}}{\text{lb powder}}$
3.12	Evaporated Milk	Skim Milk	1.0	0.7 $\frac{\text{lbs skim milk}}{\text{lb evap milk}}$	-------	0.7 $\frac{\text{BTU}}{\text{lb evap milk}}$

Section 6-4

ENERGY CALCULATION NO. 4.00

Homogenization

All homogenizers used will be assumed to be 3 cylinder, 2 stage machines with 2500 psig on the first stage and 500 psig on the second stage for a total pressure drop of 3000 psig. The theoretical work needed for this process can be calculated using the isentropic work equation for an incompressible fluid, or:

$$-w = \int \frac{dp}{D} = \frac{1}{D} (P_2 - P_1)$$

where

w = work
D = density of the fluid
P = pressure

When efficiencies of 88% for the pump and 91% for the motor are assumed and appropriate pressures and conversion factors are inserted the above equation becomes:

$$-w = \frac{(3000 \text{ psig})\ (144\ 12^2/\text{ft}^2)}{(D\ \frac{\text{lbs}}{\text{ft}^3})\ (778\ \frac{\text{ft-lb}}{\text{BTU}})\ (0.85)(0.91)} = \frac{718}{D}\ \frac{\text{BTU}}{\text{lb homogenized}}$$

The following tables gives the energy cost which homogenization adds. It is calculated by dividing the homogenization energy cost calculated above by the density of the material homogenized and multiplying by the ratio of the mass of material homogenized to the mass of product produced. This may be again multiplied by a gravimetric to volumetric conversion factor when it is desired to express the energy cost per gallon instead of per pound.

Tabe 6-4a Energy Requirements for Homogenization

Energy Cal. No.	Energy Req'd For	Material Homogenized	BTU/lb. homogenized	D= density (lb / ft^3)	Ratio of Product Homogenized	Conversion factor	Electrical Energy Req'd
4.01	Fluid Milk	Milk	718/D	64.3	1.0 lbs. milk/lb. milk	8.6 lbs. milk	96.0 BTU/gal.milk
4.03	Cottage Cheese	Cheese Dressing	718/D	63.5	0.33 lbs. dressing/lb. cheese	---	3.7 BTU/lb. cheese
4.04	Sour Cream	18% fat cream	718/D	63.5	1.0 lbs. 18% cream/lb. sour cream	---	11.3 BTU/lb. sr. cr.
4.05	Cream Cheese	Cream cheese	718/D	62.4	1.0 lbs. cream cheese/lb. cream cheese	---	11.5 BTU/lb. cr. cheese
4.12	Evaporated Milk	Evaporated Milk	718/D	66.2	1.0 lbs. evap. milk/lb. evap. milk		10.8 BTU/lb. evap. milk
4.13	Ice Cream	Ice Cream mix	718/D	68.4	1.0 lbs. ice cream/lb. ice cream	4.95 lbs. ice cr./gal. ice	52.0 BTU/gal. ice cream

Section 6-5

ENERGY CALCULATION NO. 5.00

CIP Pumps

A clean-in-place system uses pumps to circulate cleaning solution through a few pipelines or tanks. A CIP cycle is described in Energy Calculation Number 15.00. During each CIP cycle it is assumed there are two pumps running. One will be a 5 horsepower feed pump and the other a 1 horsepower return pump for a total of 6 horsepower. It is further assumed that each cycle is 50 minutes long, the motors have an electrical efficiency of 80%, and the average load on the motor is 75% of the rated capacity. The electrical energy cost per cycle is:

$$\frac{(6\ \text{hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (5/6\ \frac{\text{hr}}{\text{cycle}})\ (0.75\ \text{load})}{(0.80\ \text{efficiency})} = 11{,}930\ \frac{\text{BTU}}{\text{cycle}}$$

The following table will show the electrical energy costs which are attributed to CIP pumping. The electrical energy cost is derived by multiplying the above cost per cycle by the number of cycles per day and dividing by the average production per operating day. These factors are all shown in the table.

Table 6-5a Energy Requirements for CIP pumps

Energy Cal. No.	Energy Req'd for	Cost per cycle	Cycles Per day	Production per day	Electrical Energy Req'd
5.01	Fluid Milk	11,930 $\frac{\text{BTU}}{\text{cycle}}$	19 $\frac{\text{cycles}}{\text{day}}$	21,000 $\frac{\text{gal}}{\text{day}}$	10.8 $\frac{\text{BTU}}{\text{gal. milk}}$
5.02	Cheddar Cheese	11,930 $\frac{\text{BTU}}{\text{cycle}}$	13 $\frac{\text{cycles}}{\text{day}}$	13,333 $\frac{\text{lb}}{\text{day}}$	11.6 $\frac{\text{BTU}}{\text{lb. cheese}}$
5.03	Cottage Cheese	11,930 $\frac{\text{BTU}}{\text{cycle}}$	13 $\frac{\text{Cycles}}{\text{day}}$	43,950 $\frac{\text{lb}}{\text{day}}$	3.5 $\frac{\text{BTU}}{\text{lb. cheese}}$
5.04	Sour Cream	11,930 $\frac{\text{BTU}}{\text{cycle}}$	1 $\frac{\text{cycle}}{\text{day}}$	12,000 $\frac{\text{lb}}{\text{day}}$	1.0 $\frac{\text{BTU}}{\text{lb. sour cream}}$
5.05	Cream Cheese	11,930 $\frac{\text{BTU}}{\text{cycle}}$	2 $\frac{\text{cycles}}{\text{day}}$	3,600 $\frac{\text{lbs.}}{\text{day}}$	6.6 $\frac{\text{BTU}}{\text{lb. cheese}}$
5.06	Cultured Milk	11,930 $\frac{\text{BTU}}{\text{cycle}}$	2 $\frac{\text{cycles}}{\text{day}}$	12,279 $\frac{\text{qts.}}{\text{day}}$	1.9 $\frac{\text{BTU}}{\text{qt. cult. milk}}$
5.08	Butter	11,930 $\frac{\text{BTU}}{\text{cycle}}$	7 $\frac{\text{cycles}}{\text{day}}$	11,222 $\frac{\text{lbs}}{\text{day}}$	7.4 $\frac{\text{BTU}}{\text{lb. butter}}$
5.09	Dried Milk	11,930 $\frac{\text{BTU}}{\text{cycle}}$	16 $\frac{\text{cycles}}{\text{day}}$	21,150 $\frac{\text{lbs}}{\text{day}}$	9.0 $\frac{\text{BTU}}{\text{lb. powder}}$
5.11	Dried Buttermilk	11,930 $\frac{\text{BTU}}{\text{cycle}}$	1.4 $\frac{\text{cycles}}{\text{day}}$	1,046 $\frac{\text{lbs}}{\text{day}}$	16.0 $\frac{\text{BTU}}{\text{lb. powder}}$
5.12	Evaporated Milk	11,930 $\frac{\text{BTU}}{\text{cycle}}$	17 $\frac{\text{cycles}}{\text{day}}$	142,857 $\frac{\text{lbs}}{\text{day}}$	1.4 $\frac{\text{BTU}}{\text{lb. evap. milk}}$
5.13	Ice Cream	11,930 $\frac{\text{BTU}}{\text{cycle}}$	7 $\frac{\text{cycles}}{\text{day}}$	3,846 $\frac{\text{gals}}{\text{day}}$	21.7 $\frac{\text{BTU}}{\text{gal. ice cream}}$

Section 6-6

ENERGY CALCULATION NO. 6.00

Double Effect Evaporator (Electrical Costs)

It is assumed there are seven electric motors with a total rating of 20 horsepower running condensate and product pumps which are required to operate a double effect evaporator that has a capacity of 22,500 lbs of evaporation per hour. If the motors are 80% efficient and are under a load which is 75% of their rated capacity, the electrical cost of evaporation is:

$$\frac{(20\text{ hp})\left(2545\ \frac{\text{BTU}}{\text{hp-hr}}\right)(0.75\text{ load})}{\left(22{,}500\ \frac{\text{lbs } H_2O\text{ removed}}{\text{hr}}\right)(0.80\text{ efficiency})} = 2.1\ \frac{\text{BTU}}{\text{lb } H_2O\text{ removed}}$$

The electrical energy cost of a double effect evaporator are listed in the following table. The energy cost for a particular product is derived by multiplying the mass of the water removed in concentrating one pound of material by the above cost of evaporation and by the ratio of the mass of the material evaporated to the mass of the desired concentrated product.

able 6-6a Electrical Energy Requirements for a Double Effect Evaporator

Energy Cal. No.	Energy Req'd For	Material Concentrated	Change in % solids Concentration	Lbs. of water Removed per lb. original material	$\frac{BTU}{lb.\ H_2O}$ removed	Lbs. of original material per lb. concentrated product	Electrical Energy Req'd
6.07	Dried Whey	whey 6% solids	6% → 40%	0.85 $\frac{lbs\ H_2O}{lb\ 6\%\ whey}$	2.1	16.1 $\frac{lbs\ 6\%\ whey}{lb\ whey\ powder}$	30 $\frac{BTU}{lb\ whey\ pow}$
6.09	Dried Milk	skim milk	9% → 40%	0.775 $\frac{lbs\ H_2O}{lb\ skim\ milk}$	2.1	10.8 $\frac{lbs\ skim\ milk}{lb\ whey\ powder}$	17.3 $\frac{BTU}{lb\ milk\ pc}$
6.11	Dried Buttermilk	buttermilk	9% → 40%	0.775 $\frac{lbs\ H_2O}{lb\ buttermilk}$	2.1	10.8 $\frac{lbs\ buttermilk}{lb\ buttermilk\ powder}$	17.3 $\frac{BTU}{lb\ buttermi\ powder}$
6.12	Evaporated Milk	whole milk milk	12.5% → 25%	0.5 $\frac{lbs\ H_2O}{lb\ milk}$	2.1	2 $\frac{lbs\ milk}{lb\ evap.\ milk}$	2.1 $\frac{BTU}{lb\ evap.\ mi}$

Section 6-7

ENERGY CALCULATION NO. 7.00

Spray Drying (Electrical Costs)

Manufacturer's specifications show about 325 horsepower for a 6000 lb/hr drier that produces 3.5% moisture powder from a 40% solids concentrate. Assuming that the motors are 85% efficient and under a load which is 75% of their rated capacity, the electrical cost can be given by:

$$\frac{(325\ \text{hp})\quad (2545\ \frac{\text{BTU}}{\text{hp-hr}})\quad (0.75\ \text{load})}{(6000\ \frac{\text{lbs powder}}{\text{hr}})\quad (0.88\ \text{efficient})} = 117.5\ \frac{\text{BTU}}{\text{powder}}$$

The electrical energy cost of spray drying is the same for Dried Whey, Dried Milk, or Dried Buttermilk.

Table 6-7a. Electrical energy requirements of spray drying.

Energy Cal. No.	Energy Required For	Electric Energy Required
7.07	Dried Whey	$117.5\ \frac{\text{BTU}}{\text{lb powder}}$
7.09	Dried Milk	$117.5\ \frac{\text{BTU}}{\text{lb powder}}$
7.11	Dried Buttermilk	$117.5\ \frac{\text{BTU}}{\text{lb powder}}$

Section 6-8

ENERGY CALCULATION NO. 8.00

Air Compressor

Assuming a 20 horsepower air compressor is used in each plant and runs 5% of the time with an 88% efficient electrical motor which is under a load of 75% the energy consumption per week is:

$$\frac{(20\ \text{hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (0.75\ \text{load})\ (1.2\ \frac{\text{hr}}{\text{day}})\ (7\ \frac{\text{days}}{\text{week}})}{(0.88\ \text{efficiency})} = 364,398\ \frac{\text{BTU}}{\text{week}}$$

The following table relates the electrical energy cost of an air compressor for various products. The energy cost is derived by dividing the above electrical cost per week by the weekly production and multiplying by an apportioning factor. The apportioning factor is needed for plants producing more than one product. For these plants, it is assumed that the fraction of the cost of compressing air that should be attributed to a particular product be equal to the fraction of the total amount of raw milk coming into a plant which goes into the particular product. If a plant produces only one product the apportioning factor is equal to 1.0.

Table 6-8a Electrical Energy Requirements for Air Compressors

Energy Cal. No.	Energy Req'd For	Energy Cost Per Week	Production Per Week	Apportioning Factor	Electrical Energy Req'd
8.01	Fluid Milk	364,398 $\frac{\text{BTU}}{\text{week}}$	105,000 $\frac{\text{gal.}}{\text{week}}$	1.0	3.5 $\frac{\text{BTU}}{\text{gal. milk}}$
8.02	Cheddar Cheese	364,398 $\frac{\text{BTU}}{\text{week}}$	80,000 $\frac{\text{lbs.}}{\text{week}}$	1.0	4.6 $\frac{\text{BTU}}{\text{lb. cheese}}$
8.03	Cottage Cheese	364,398 $\frac{\text{BTU}}{\text{week}}$	219,750 $\frac{\text{lbs.}}{\text{week}}$	0.75	1.2 $\frac{\text{BTU}}{\text{lb. cheese}}$
8.04	Sour Cream	364,398 $\frac{\text{BTU}}{\text{week}}$	60,000 $\frac{\text{lbs.}}{\text{week}}$	0.05	0.3 $\frac{\text{BTU}}{\text{lb. sour cream}}$
8.05	Cream Cheese	364,398 $\frac{\text{BTU}}{\text{week}}$	18,000 $\frac{\text{lbs.}}{\text{week}}$	0.10	2.0 $\frac{\text{BTU}}{\text{lb. cheese}}$
8.06	Cultured Milk	364,398 $\frac{\text{BTU}}{\text{Week}}$	61,395 $\frac{\text{qts.}}{\text{week}}$	0.10	0.6 $\frac{\text{BTU}}{\text{qt. cult. milk}}$
8.08	Butter	364,398 $\frac{\text{BTU}}{\text{week}}$	78,554 $\frac{\text{lbs.}}{\text{week}}$	0.05	0.2 $\frac{\text{BTU}}{\text{lb. butter}}$
8.09	Dried Milk	364,398 $\frac{\text{BTU}}{\text{week}}$	148,050 $\frac{\text{lbs.}}{\text{week}}$	0.90	2.2 $\frac{\text{BTU}}{\text{lb. powder}}$
8.12	Evaporated Milk	364,398 $\frac{\text{BTU}}{\text{week}}$	1,000,000 $\frac{\text{lbs.}}{\text{week}}$	1.0	0.4 $\frac{\text{BTU}}{\text{lb. powder}}$
8.13	Ice Cream	364,398 $\frac{\text{BTU}}{\text{week}}$	19,231 $\frac{\text{gals.}}{\text{week}}$	1.0	18.9 $\frac{\text{BTU}}{\text{gal. ice cream}}$
8.14	Processed Cheese	364,398 $\frac{\text{BTU}}{\text{week}}$	$1.68\text{x}10^{6}$ $\frac{\text{lbs.}}{\text{week}}$	1.0	0.2 $\frac{\text{BTU}}{\text{lb. cheese}}$

Section 6-9

ENERGY CALCULATION NO. 9.00

Cold Storage Room Fans

The electrical energy cost to run the cold storage room fans will be estimated by assuming the fans run two-thirds of the time. The motor efficiency will be assumed to be 75% while it is under a load of 75% of its rated capacity. The electrical energy cost per total horsepower needed per week is:

$$\frac{(2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (0.75\ \text{load})\ (16\ \frac{\text{hr}}{\text{day}})\ (7\ \frac{\text{days}}{\text{week}})}{(0.75\ \text{efficiency})} = 285{,}040\ \frac{\text{BTU}}{\text{hp-week}}$$

The following table relates the electrical energy cost for cold storage room fans for various products. The energy cost is derived by multiplying the above cost by the total horsepower used to run the fans in a room, dividing by the weekly production, and multiplying by an apportioning factor. The apportioning factor is needed for cold rooms storing more than one product. For the cold storage rooms, the fraction of the cost of running the cold room fans that should be attributed to a particular product, is called the apportioning factor and is equal to that fraction of the total mass stored in the room that the mass of a particular product is equal to. The apportioning factors used were derived by Step 5 in Energy Calculations Nos. 22.03-22.06. If only one product is stored in the room, the apportioning factor is equal to 1.0.

Table 6-9a Electrical Energy Requirements for Cold Room Fans

Energy Cal. No.	Energy Req'd For	BTU/hp-week	Total Fan hp	Production per week	Apportioning Factor	Electrical Energy Req'd
9.01	Fluid Milk	285,040	2	105,000 gal./week	1.0	5.4 BTU/gal. milk
9.02	Cheddar Cheese	285.040	8	80,000 lbs./week	1.0	28.5 BTU/lb. cheese
9.03	Cottage Cheese	285.040	3	219,750 lbs./week	0.51	2.0 BTU/lb. cheese
9.04	Sour Cream	285,040	3	60,000 lbs./week	0.14	2.0 BTU/lb. sour cream
9.05	Cream Cheese	285,040	3	18,000 lbs./week	0.042	2.0 BTU/lb. cheese
9.06	Cultured Milk	285,040	3	61,395 qts./week	0.307	4.3 BTU/qt. cult. milk
9.08	Butter	285,040	1	78,554 lbs./week	1.0	3.6 BTU/lb. butter
9.12	Evaporated Milk	285,040	1/2	1,000,000 lbs./week	1.0	0.1 BTU/lb. evap. milk
9.13	Ice Cream*	285,040	3 1/2	19,229 gals./week	1.0	51.9 BTU/gal. ice cream
9.14	Processed Cheese	285,040	12	$1.68x10^6$ lbs./week	1.0	2.0 BTU/lb. cheese

* For both the 40°F cold room and the −20°F hardening room

Section 6-10

ENERGY CALCULATION NO. 10.00

Fans for Heating and Air Conditioning

The electrical energy cost to run the heating and air conditioning fans will be estimated here. Manufacturer's ratings estimate 1 horsepower per 2000 CFM on air handling units. Assuming they run 16 hours a day with a motor efficiency of 80% and under a 75% of capacity load, the electrical energy consumption per CFM of air circulation in the plant, per week is:

$$\frac{(1\ \text{hp})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})\ \ (0.75\ \text{load})\ (16\ \frac{\text{hr}}{\text{day}})\ (7\ \frac{\text{days}}{\text{week}})}{(2000\ \text{CFM})\ (0.80\ \text{efficient})} = 134\ \frac{\text{BTU}}{\text{CFM-week}}$$

The following table relates the electrical energy cost for air circulation fans for various products. The energy cost is derived by multipying the above cost by the estimated air circulation rate for the plant, dividing by the weekly production rate, and multiplying by an apportioning factor. The apportioning factor is needed for plants manufacturing more than one product. The fraction of the cost of running the air circulation units which can be attributed to a particular product is called the apportioning factor and is equal to the fraction of the mass of the incoming raw milk which goes into that particular product. For plants producing only one product, the apportioning factor is equal to one.

Table 6-10a Electrical Energy Requirements for Air Circulation Fans

Energy Cal. No.	Energy Req'd For	BTU/CFM-week	Total Plant CFM	Production per week	Apportioning Factor	Electrical Energy Req'd
10.01	Fluid Milk	134	35,000	105,000 gal./week	1.0	44.7 BTU/gal. milk
10.02	Cheddar Cheese	134	86,500	80,000 lbs./week	1.0	144.9 BTU/lb. cheese
10.03	Cottage Cheese	134	73,500	219,750 lbs./week	0.75	33.6 BTU/lb. cheese
10.04	Sour Cream	134	73,500	60,000 lbs./week	0.05	8.2 BTU/lb. sour cream
10.05	Cream Cheese	134	73,500	18,000 lbs./week	0.10	54.7 BTU/lb. cheese
10.06	Cultured Milk	134	73,500	61,395 qts./week	0.10	16.0 BTU/qt. cult. milk
10.08	Butter	134	62,000	78,554 lbs./week	0.05	5.3 BTU/lb. butter
10.09	Dried Milk	134	62,000	148,050 lbs./week	0.90	50.5 BTU/lb. powder
10.11	Dried Buttermilk	134	62,000	7,322 lbs./week	0.05	56.7 BTU/lb. powder
10.12	Evaporated Milk	134	90,000	1,000,000 lbs./week	1.0	12.1 BTU/lb. evap. milk
10.13	Ice Cream	134	53,000	19,231 gal./week	1.0	369.3 BTU/gal. ice cream
10.14	Processed Cheese	134	90,000	$1.68\text{x}10^{6}$ lbs./week	1.0	7.2 BTU/lb. cheese

Section 6-11

ENERGY CALCULATION NO. 11.00

Boiler Fan

The electrical energy costs to run the boiler fan will be estimated assuming that each plant's boiler has a 10 horsepower motor running a fan to furnish combustion air. The motor runs constantly while air is throttled for the correct flow rate. If the motor is 88% efficient while under a load which is 50% of the rated capacity, then the electrical energy cost is given by:

$$\frac{(10\ \text{hp})\ \left(2545\ \frac{\text{BTU}}{\text{hp-hr}}\right)\ (0.50\ \text{load})\ \left(24\ \frac{\text{hr}}{\text{day}}\right)\ \left(7\ \frac{\text{days}}{\text{week}}\right)}{(0.88\ \text{efficient})} = 2.43 \times 10^6\ \frac{\text{BTU}}{\text{week}}$$

The following table relates the electrical energy cost to run a boiler fan for various products. The energy cost is derived by dividing the above energy cost by the weekly production and multiplying by an apportioning factor. The apportioning factor is needed for plants manufacturing more than one product. The fraction of the cost of running the boiler fan which can be attributed to a particular product is the apportioning factor and is equal to the fraction of the raw milk which goes into that particular product. For plants producing only one product, the apportioning factor equals one.

Table 6-11a Electrical Energy Requirements for the Boiler Fan

Energy Cal. No.	Energy Req'd For	BTU/Week	Production Per Week	Apportioning Factor	Electrical Energy Req'd
11.01	Fluid Milk	2.43×10^6	105,000 gals./week	1.0	23.1 BTU/gal. milk
11.02	Cheddar Cheese	2.43×10^6	80,000 lbs./week	1.0	30.4 BTU/lb. cheese
11.03	Cottage Cheese	2.43×10^6	219,750 lbs./week	0.75	8.3 BTU/lb. cheese
11.04	Sour Cream	2.43×10^6	60,000 lbs./week	0.05	2.0 BTU/lb. sour cream
11.05	Cream Cheese	2.43×10^6	18,000 lbs./week	0.10	13.5 BTU/lb. cheese
11.06	Cultured Milk	2.43×10^6	61,395 qts./week	0.10	4.0 BTU/qt. cult. milk
11.08	Butter	2.43×10^6	78,554 lbs./week	0.05	1.5 BTU/lb. butter
11.09	Dried Milk	2.43×10^6	148,050 lbs./week	0.90	14.7 BTU/lb. powder
11.11	Dried Buttermilk	2.43×10^6	7,322 lbs./week	0.05	16.6 BTU/lb. powder
11.12	Evaporated Milk	2.43×10^6	1,000,000 lbs./week	1.0	2.4 BTU/lb. evap. milk
11.13	Ice Cream	2.43×10^6	19,231 gals./week	1.0	126.3 BTU/gal. ice cream
11.14	Processed Cheese	2.43×10^6	1.68×10^6 lbs./week	1.0	1.4 BTU/lb. cheese

Section 6-12

ENERGY CALCULATION NO. 12.00

Evaporative Cooling Tower Fans

Evaporative cooling towers will be used to condense refrigerant and to cool the recirculated water used to condense steam in the double effect evaporators. Manufacturer's ratings for cooling towers indicate that approximately 0.06 horsepower is required to run the fans per ton of capacity. This can be translated into the following ratio giving the BTU's of electricity consumed per BTU of cooling load exhausted out of the cooling tower. Assuming the electric motors are 88% efficient and under a load which is 75% of their rated capacity, the ratio is:

$$\frac{\left(0.06\ \frac{\text{hp}}{\text{ton}}\right)\left(2545\ \frac{\text{BTU}}{\text{hp-h4}}\right)(0.75\ \text{load})}{\left(12{,}000\ \frac{\text{BTU}}{\text{hr-ton}}\right)(0.88\ \text{efficient})} = 0.010$$

Multiplying the above dimensionless ratio by the load which exhausts out the cooling tower gives the electrical energy consumed.

The energy cost to run the evaporative cooling tower fans is derived by multiplying the total refrigeration load needed for the unit production of a dairy product times a refrigeration factor and adding this to the water cooling load generated if a double effect evaporator is used during the processing procedure of the product in question. The sum is then multiplied by the above dimensionless ratio to yield the electrical energy cost per unit product produced.

The total refrigeration load per unit production is the sum of the cooling loads associated with the production of a certain product. It can be found in the "Uses of Refrigeration" table in the section showing the total energy costs of the product in question. The total refrigeration load is the load measured at the evaporator of the refrigeration system. Assuming the coefficient of performance of the system is 3.0, the load exhausting out the cooling towers is 1.3 times the calculated cooling load. Therefore the refrigeration factor equals 1.3.

Manufacturer's specifications for a double effect evaporator indicate that 226 BTUs must be transferred to cooling water for every pound of water evaporated from the product. By multiplying the amount of water removed during the evaporation process (this is found in the Table described in Energy Calculation No. 6.00) times the above water heating factor, times the ratio of the mass of material evaporated to the mass of the finished product, yields the water cooling load generated by the use of a double effect evaporator. For dried whey production, this is:

$$\left(226\ \frac{\text{BTU}}{\text{lb H}_2\text{O removed}}\right)\left(0.85\ \frac{\text{lbs H}_2\text{O removed}}{\text{lb 6\% whey}}\right)\left(16.1\ \frac{\text{lbs 6\% whey}}{\text{lb whey powder}}\right) = 3093\ \frac{\text{BTU}}{\text{lb whey powder}}$$

For the production of dried milk the water cooling load is:

$$\left(226\ \frac{\text{BTU}}{\text{lb H}_2\text{O removed}}\right)\left(0.775\ \frac{\text{lbs H}_2\text{O removed}}{\text{lb skim milk}}\right)\left(10.8\ \frac{\text{lbs skim milk}}{\text{lb powder}}\right) = 1892\ \frac{\text{BTU}}{\text{lb milk powder}}$$

The water cooling load for dried buttermilk is the same as dried milk. For the production of evaporated milk the water cooling load would be:

$$\left(226\ \frac{\text{BTU}}{\text{lb H}_2\text{O removed}}\right)\left(0.5\ \frac{\text{lbs H}_2\text{O removed}}{\text{lb milk}}\right)\left(2\ \frac{\text{lbs milk}}{\text{lb evap. milk}}\right) = 226\ \frac{\text{BTU}}{\text{lb evaporated milk}}$$

The following table relates the evaporative cooling tower electrical energy costs in the production of various products.

Table 6-12a Electrical Energy Requirements for Cooling Tower Fans

Energy Cal. No.	Energy Req'd For	Total Refrigeration Load	Refrigeration Factor	Water Cooling Load	BTU (elec)/BTU (cooling)	Electrical Energy Req'd
12.01	Fluid Milk	598 BTU/gal. milk	1.3	0	0.01	7.8 BTU/gal. milk
12.02	Cheddar Cheese	428 BTU/lb. cheese	1.3	0	0.01	5.6 BTU/lb. cheese
12.03	Cottage Cheese	182 BTU/lb. cheese	1.3	0	0.01	2.4 BTU/lb. cheese
12.04	Sour Cream	186 BTU/lb. sr. cream	1.3	0	0.01	2.4 BTU/lb. sour cream
12.05	Cream Cheese	314 BTU/lb. cheese	1.3	0	0.01	4.1 BTU/lb. cheese
12.06	Cultured Milk	203 BTU/qt. cul. milk	1.3	0	0.01	2.6 BTU/qt. cult. milk
12.07	Dried Whey	603 BTU/lb. powder	1.3	3093 BTU/lb. powder	0.01	38.8 BTU/lb. powder
12.08	Butter	251 BTU/lb. butter	1.3	0	0.01	3.3 BTU/lb. butter
12.09	Dried Milk	130 BTU/lb. powder	1.3	1892 BTU/lb. powder	0.01	20.6 BTU/lb. powder
12.11	Dried Buttermilk	210 BTU/lb. powder	1.3	1892 BTU/lb. powder	0.01	21.7 BTU/lb. powder
12.12	Evaporated Milk	103 BTU/lb. evap.milk	1.3	226 BTU/lb. evap. milk	0.01	4.0 BTU/lb. evap. milk
12.13	Ice Cream	1925 BTU/gal. ice cr.	1.3	0	0.01	25.0 BTU/gal. ice cream
12.14	Processed Cheese	104 BTU/lb. cheese	1.3	0	0.01	1.4 BTU/lb. cheese

Section 6-13

ENERGY CALCULATION NO. 13.00

Lights and Misc. Motors

The electrical energy cost for lighting and the use of small motors will be calculated here. It is assumed that there is on the average one 8-foot, 110 watt fluorescent light per 60 Ft^2 of floor space in operation 36 hours per week. The cost of lighting per square foot of floor space is:

$$\frac{(110 \text{ watt}) \left(3.41 \frac{\text{BTU}}{\text{hr-watt}}\right) \left(36 \frac{\text{hr}}{\text{week}}\right)}{(60 \text{ Ft}^2)} = 225 \frac{\text{BTU}}{\text{ft}^2\text{-week}}$$

For the many small motors which run intermittantly, such as conveyers or stirrers, it is assumed that their cost can be estimated by adding 10% to the lighting cost or:

$$\left(225 \frac{\text{BTU}}{\text{ft}^2\text{- week}}\right) (1.1) = 247.5 \frac{\text{BTU}}{\text{ft}^2 \text{ - week}}$$

The following table relates the electrical energy cost of lighting in the production of various products. The energy cost is derived by multiplying the above energy cost times the number of square feet of floor space in a plant, times an apportioning factor and dividing the product by the weekly production of the plant. The apportioning factor is needed in plants manufacturing more than one product.

The fraction of the cost of lighting the plant which is attributed to a specific product is the apportioning factor and is equal to the fraction of the raw milk which enters the plant and goes into that particular product. If a plant produces only one product, the apportioning factor is 1.0.

Table 6-13a Electrical Energy Requirements for Lights and Misc. Motors

Energy Cal. No.	Energy Req'd For	Plant Floor Space	$\frac{\text{BTU}}{\text{Ft}^2\text{-Week}}$	Apportioning Factor	Weekly Production		Electrical Energy Req'd	
13.01	Fluid Milk	30,200 ft.^{2}	247.5	1.0	gal 105,000	$\frac{\text{gal}}{\text{week}}$	71.2	$\frac{\text{BTU}}{\text{gal. milk}}$
13.02	Cheddar Cheese	43,155 ft.^{2}	247.5	1.0	80,000	$\frac{\text{lbs}}{\text{week}}$	133.5	$\frac{\text{BTU}}{\text{lb. cheese}}$
13.03	Cottage Cheese	28,445 ft.^{2}	247.5	0.75	219,750	$\frac{\text{lbs}}{\text{week}}$	24.0	$\frac{\text{BTU}}{\text{lb. cheese}}$
13.04	Sour Cream	28,445 ft.^{2}	247.5	0.05	60,000	$\frac{\text{lbs}}{\text{week}}$	5.8	$\frac{\text{BTU}}{\text{lb. sour cream}}$
13.05	Cream Cheese	28,445 ft.^{2}	247.5	0.10	18,000	$\frac{\text{lbs}}{\text{week}}$	39.1	$\frac{\text{BTU}}{\text{lb. cheese}}$
13.06	Cultured Milk	28,445 ft.^{2}	247.5	0.10	61,395	$\frac{\text{qts}}{\text{week}}$	11.5	$\frac{\text{BTU}}{\text{qt. cult. milk}}$
13.08	Butter	20,153 ft.^{2}	247.5	0.05	78,554	$\frac{\text{lbs}}{\text{week}}$	3.2	$\frac{\text{BTU}}{\text{lb. butter}}$
13.09	Dried Milk	20,153 ft.^{2}	247.5	0.90	148,050	$\frac{\text{lbs}}{\text{week}}$	30.3	$\frac{\text{BTU}}{\text{lb. powder}}$
13.11	Dried Buttermilk	20,153 ft.^{2}	247.5	0.05	7,372	$\frac{\text{lbs}}{\text{week}}$	34.1	$\frac{\text{BTU}}{\text{lb. powder}}$
13.12	Evaporated Milk	21,800 ft.^{2}	247.5	1.0	1,000,000	$\frac{\text{lbs}}{\text{week}}$	5.4	$\frac{\text{BTU}}{\text{lb. evap.milk}}$
13.13	Ice Cream	28,445 ft.^{2}	247.5	1.0	19,231	$\frac{\text{gals}}{\text{week}}$	366.1	$\frac{\text{BTU}}{\text{gal. ice cream}}$
13.14	Processed Cheese	50,250 ft.^{2}	247.5	1.0	1.68×10^6	$\frac{\text{lbs}}{\text{week}}$	7.4	$\frac{\text{BTU}}{\text{lb. cheese}}$

Section 6-14

ENERGY CALCULATION NO. 14.00

Miscellaneous Electrical Energy Calculations

Energy Calculation No. 14.08

Churning

It is estimated that a batch-type churn with a capacity of 11,250 lbs. requires a 10 horsepower motor. The operating time per batch is 1.2 hours. If the motor is 85% efficient and is under a 75% of capacity load, the electrical energy cost is:

$$\frac{(10\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (0.75\text{ load})\ (1.2\ \frac{\text{hours}}{\text{batch}})}{(11{,}250\ \frac{\text{lbs butter}}{\text{batch}})\ (0.85\text{ efficient})} = 2.4\ \frac{\text{BTU}}{\text{lb butter}}$$

Energy Calculation No. 14.10

Instantizing (Electrical Energy Costs)

A typical instantizer has seven fans and a conveyor belt all run by electric motors. It is assumed that the total output required by these motors on a 2000 lbs per hour instantizer is 40 hp. If the motors are 83% efficient and under a load which is 75% of their rated capacity, the electrical energy cost is given by:

$$\frac{(40\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (0.75\text{ load})}{(2000\ \frac{\text{lbs powder}}{\text{hr}})\ (0.85\text{ efficiency})} = 44.9\ \frac{\text{BTU}}{\text{lb powder}}$$

Energy Calculation No. 14.13

Agitation of Ice Cream Mix

The electrical energy cost of agitating ice cream mix is calculated by the following procedure. It is assumed that a total of 6 hours of agitation by a 1 horsepower agitator is required to make 2,775 gallons of ice cream. If the motor is 75% efficient and under a load which is 75% of the rated capacity, the electrical energy cost is:

$$\frac{(1\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (6\text{ hr})\ (0.75\text{ load})}{(2775\text{ gal ice cream})\ (0.75\text{ efficiency})} = 5.5\ \frac{\text{BTU}}{\text{gal. ice cream}}$$

Ice Cream Freezer (Electrical Energy Costs)

It is assumed that a 900 gallon per hour ice cream freezer requires a 75 horsepower motor to run it. If the motor is 85% efficient and under a load which is 75% of its rated capacity, the electrical energy cost is:

$$\frac{(75\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (0.75\text{ load})}{(900\ \frac{\text{gal ice cream}}{\text{hr}})\ (0.85\text{ efficiency})} = 187.1\ \frac{\text{BTU}}{\text{gal. ice cream}}$$

Energy Calculation No. 14.14

Processed Cheese Grinding

A 5000 lb/hr grinder requires a 100 horsepower motor. If the motor is 85% efficient while under a load which is 75% of the rated capacity, the electrical energy cost to grind cheese is:

$$\frac{(100\text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (0.75\text{ load})}{(5000\ \frac{\text{lbs cheese}}{\text{hr}})\ (0.85\text{ efficiency})} = 44.9\ \frac{\text{BTU}}{\text{lb cheese}}$$

Agitation During the Cooking of Processed Cheese

It takes about 30 minutes to complete the cooking operation for processed cheese. If a 10 horsepower motor is required to agitate a 2500 pound batch of processed cheese and if the motor is 85% efficient while under a load which is 75% of the rated capacity, the electrical energy used for agitation is:

$$\frac{(10 \text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (0.75 \text{ load})\ (0.5\ \frac{\text{hr}}{\text{batch}})}{(2500\ \frac{\text{lbs cheese}}{\text{batch}})\ (0.85 \text{ efficiency})} = 4.5\ \frac{\text{BTU}}{\text{lb cheese}}$$

Processed Cheese Packaging Machines

It is estimated that a packaging machine for processed cheese would require a 1 horsepower motor and 2 kilowatts of heating for a 5000 pound per hour machine. If the motor is 75% efficient while under a load which is 75% of its rated capacity, the electrical energy cost is given by:

$$\frac{(1 \text{ hp})\ (2545\ \frac{\text{BTU}}{\text{hp-hr}})\ (0.85 \text{ load})}{(5000\ \frac{\text{lbs cheese}}{\text{hr}})\ (0.75 \text{ efficient})} + \frac{(2 \text{ kw})\ (3413\ \frac{\text{BTU}}{\text{hr-kw}})}{(5000\ \frac{\text{lbs cheese}}{\text{hr}})} = 1.9\ \frac{\text{BTU}}{\text{lb cheese}}$$

Section 6-15

ENERGY CALCULATION NO. 15.00

Hot Water for the CIP System

A typical wash cycle for a Clean-In-Place system is:

1. A 5 minute rinse with 100°F water which goes down the drain.
2. An alkali wash for 30 minutes with a 160°F solution which is recirculated and returns at an estimated 130°F.
3. A rinse with 100°F water for 5 minutes which goes down the drain.
4. A sanitizing cycle (chlorinated cold water) circulating for ten minutes.

For equipment with milk touching heated surfaces a 20 minute acid wash precedes the sanitizing. The acid wash water is assumed to leave at 165°F and return at 130°F. If the culinary water temperature is 60°F and the flow rate through the system is 50 GPM (a minimum velocity of 5 feet per second is needed for proper cleaning) the steam energy cost of each cycle is:

$$(10\text{ min})\ (50\text{ G.P.M.})\ \left(8.3\ \frac{\text{lb } H_2O}{\text{gal}}\right)\ \left(1\ \frac{\text{BTU}}{\text{lb } H_2O\text{-}^\circ\text{F}}\right)\ (40^\circ\text{F})\ +$$

$$(30\text{ min})\ (50\text{ GPM})\ \left(8.3\ \frac{\text{lbs } H_2O}{\text{gal}}\right)\ \left(1\ \frac{\text{BTU}}{\text{lb } H_2O\text{-}^\circ\text{F}}\right)\ (35^\circ\text{F}) = 604{,}287\ \frac{\text{BTU}}{\text{cycle}}$$

If an acid wash cycle is needed, the extra cost is:

$$(20\text{ min})\ (50\text{ GPM})\ \left(8.3\ \frac{\text{lb } H_2O}{\text{gal}}\right)\ \left(1\ \frac{\text{BTU}}{\text{lb } H_2O\text{-}^\circ\text{F}}\right)\ (35^\circ\text{F}) = 291{,}725\ \frac{\text{BTU}}{\text{cycle}}$$

The following table relates the steam energy consumed by the CIP system for various products. The energy cost is calculated by multiplying the energy cost for a regular CIP cycle and for the acid wash cycle times the number of regular and acid CIP cycles per day respectively. Then summing the products and dividing by the average daily production gives the steam energy cost per unit produced.

Table 6-15a Steam Energy Requirements for CIP cleaning

Energy Cal. No.	Energy Req'd For	BTU/CIP cycle	Cycles/day	BTU/acid cycle	Acid cycles/day	Daily Production		Steam Energy Req'd	
15.01	Fluid Milk	604,287	19	291,725	1	21,000	gal/day	561	BTU/gal. milk
15.02	Cheddar Cheese	604,287	13	291,725	1	13,333	lbs/day	611	BTU/lb. cheese
15.03	Cottage Cheese	604,287	13	291,725	1	43,950	lb/day	185	BTU/lb. cheese
15.04	Sour Cream	604,287	1	291,725	1	12,000	lb/day	75	BTU/lb. sour crea
15.05	Cream Cheese	604,287	2	291,725	1	3,600	lb/day	417	BTU/lb. cheese
15.06	Cultured Milk	604,287	2	291,725	1	12,279	qts./day	122	BTU/qt. cult. mil
15.07	Dried Whey	604,287	6	291,725	2	7,200	lbs./day	585	BTU/lb. powder
15.08	Butter	604,287	7	291,725	2	11,222	lbs./day	429	BTU/lb. butter
15.09	Dried Milk	604,287	16	291,725	2	21,150	lbs./day	485	BTU/lb. powder
15.10	Instantized Milk	604,287	1	291,725	0	10,575	lbs./day	57	BTU/lb. powder
15.11	Dried Buttermilk	604,287	1	291,725	0	1,046	lbs./day	578	BTU/lb. powder
15.12	Evaporated Milk	604,287	17	291,725	2	142,857	lbs./day	76	BTU/lb. evap. mil
15.13	Ice Cream	604,287	7	291,725	1	3,846	gal/day	1176	BTU/gal. ice crea
15.14	Processed Cheese	604,287	8	291,725	8	280,000	lbs./day	26	BTU/lb. cheese

Section 6-16

ENERGY CALCULATION NO. 16.00

Hot Water for Manual Washing

Steam energy is used to heat water to wash items which must be disassembled to be cleaned. The items will be washed a batch at a time in a 100 gallon wash tank. It is assumed that each batch requires 50 gallons of 100°F rinse water, 100 gallons of 150°F wash water, and after rinsing with cool water and refilling with 100 gallons of 60°F water, the tank is heated to 180°F for sanitization. With a 60°F water source, the steam cost per batch washed is:

$$(50\ \text{gal})\ \left(8.3\ \frac{\text{lb}\ H_2O}{\text{gal}}\right)\ \left(1\ \frac{\text{BTU}}{\text{lb}\ H_2O\text{-}°\text{F}}\right)\ (40°\text{F}) + (100\ \text{gal})\ \left(8.3\ \frac{\text{lb}\ H_2O}{\text{gal}}\right)$$

$$\left(1\ \frac{\text{BTU}}{\text{lb}\ H_2O\text{-}°\text{F}}\right)\ (90°\text{F})\ +\ (100\ \text{gal})\ \left(8.3\ \frac{\text{lb}\ H_2O}{\text{gal}}\right)\ \left(1\ \frac{\text{BTU}}{\text{lb}\ H_2O\text{-}°\text{F}}\right)\ (120°\text{F})$$

$$= 191{,}820\ \frac{\text{BTU}}{\text{batch}}$$

The following table relates the steam energy cost of Manual Washing for various products. The energy cost is derived by multiplying the above energy cost per batch by the number of batches washed per day and divided by the daily production. For plants having to wash cheese vats, it is assumed that the above cost per batch could also be the cost to wash a vat producing 2000 lbs. of cheese.

Table 6-16a Steam Energy Requirements for Manual Cleaning

Energy Cal. No.	Energy Req'd For	BTU/Batch	Batches/day	Production/day	Steam Energy Req'd
16.01	Fluid Milk	191,820	3	21,000 gal./day	27 BTU/gal. milk
16.02	Cheddar Cheese	191,820	13	13,333 lbs./day	187 BTU/lb. cheese
16.03	Cottage Cheese	191,820	19	43,950 lbs./day	83 BTU/lb. cheese
16.04	Sour Cream	191,820	1	12,000 lbs./day	16 BTU/lb. sour cream
16.05	Cream Cheese	191,820	1	3,600 lb./day	53 BTU/lb. cheese
16.06	Cultured Milk	191,820	1	12,279 qts./day	16 BTU/qt. cult. milk
16.08	Butter	191,820	4	11,222 lbs./day	68 BTU/lb. butter
16.09	Dried Milk	191,820	1	21,150 lbs./day	9 BTU/lb. powder
16.12	Evaporated Milk	191,820	2	142,857 lbs./day	13 BTU/lb. evap. milk
16.13	Ice Cream	191,820	3	19,231 gals./day	150 BTU/gal. ice cream

Section 6-17

ENERGY CALCULATION NO. 17.00

Double Effect Evaporator (Steam Costs)

Steam energy is used to concentrate dairy products in a vacumn evaporator. One manufacturer specifies that his double effect evaporator with vapor preheaters and a thermocompressor will consume 0.344 lbs. of steam for every lb. of evaporation. This includes the cost of air ejectors and preheating to 165°F. This cost translates to:

$$\left(0.344 \frac{\text{lbs. steam}}{\text{lb } H_2O \text{ removed}}\right) \left(1000 \frac{\text{BTU}}{\text{lb. steam}}\right) = 344 \frac{\text{BTU}}{\text{lb } H_2O} \text{ removed}$$

The following table relates the steam energy consumed in running the evaporator during the processing of various dairy products. The energy cost is derived by multiplying the above evaporation cost times the pounds of water evaporated per pound of material entering the evaporator, times the ratio of the mass of material evaporated to the mass of product produced.

Table 6-17a Steam Energy Requirements for a Double Effect Evaporator

Energy Cal. No.	Energy Req'd For	Material Concentrated	Change in % solids Concentration	Lbs. of water Removed per lb. of original material	BTU / lb H_2O removed	Lbs. of original material per lb. of concentrated product	Steam Energy Req'd
17.07	Dried Whey	6% solids whey	6% → 40%	0.85 lbs H_2O / lb 6% whey	344	16.1 lbs 6% whey / lb whey powder	4708 BTU / lb. whey pow
17.09	Dried Milk	skim milk	9% → 40%	0.775 lbs H_2O / lb skim milk	344	10.8 lbs skim milk / lb dried milk	2979 BTU / lb dried mil
17.11	Dried Buttermilk	Buttermilk	9% → 40%	0.775 lbs H_2O / lb buttermilk	344	10.8 lbs buttermilk / lb dried buttermilk	2879 BTU / lb dried but milk
17.12	Evaporated Milk	whole milk	12.5% → 25%	0.5 lbs H_2O / lb milk	344	2 lbs milk / lb evap. milk	344 BTU / lb evap. mi

Section 6-18

ENERGY CALCULATION NO. 18.00

Heating the Plant

The steam energy consumed for heating costs for one heating season will be approximated by using values given by Jennings and Lewis.[10] They estimate that for heating manufacturing buildings the steam consumption per 1000 Ft.^{3} per degree day is 0.81 lb. The heating season is considered as October 1 through May 1 (212 days). Assuming a typical degree day center for the intermountain west is Salt Lake City, Utah with 5555 degree days, the steam consumption per cubic foot of heated space can be calculated as:

$$\frac{\left(0.81\ \frac{\text{lbs steam}}{\text{degree day -MCF}}\right)\left(5555\ \frac{\text{degree days}}{\text{year}}\right)\left(1000\ \frac{\text{BTU}}{\text{lb steam}}\right)}{\left(1000\ \frac{\text{ft.}^3}{\text{MCF}}\right)} = 4500\ \frac{\text{BTU}}{\text{ft}^3 - \text{year}}$$

The following table relates, for various dairy products, the steam energy consumed in heating the plant in which the products were made. The energy cost is derived by multiplying the above energy cost per cubic foot times the cubic feet of heated space in the building, times an apportioning factor, and divided by the yearly production of product produced in the plant. The heated space in a building will not include the boiler, refrigeration, or spray drying rooms where the equipment in these rooms will furnish most the heating needed and neither will any cold storage rooms be included. An apportioning factor is needed for plants manufacturing more than one product. The fraction of the cost of heating the plant which is attributed to a specific product is the apportioning factor and is equal to the fraction of the raw milk which enters the plant and goes into that particular product. If a plant produces only one product the apportioning factor is 1.0.

Table 6-18a Steam Energy Requirements to Heat the Plant

Energy Cal. No.	Energy Req'd For	Ft^3 of Heated Space	$\frac{\text{BTU}}{\text{ft}^3\text{-year}}$	Apportioning Factor	Yearly Production	Steam Energy Req'd
18.01	Fluid Milk	278,286	4500	1.0	$5.46\text{x}10^{6}$ $\frac{\text{gal}}{\text{year}}$	229 $\frac{\text{BTU}}{\text{gal. milk}}$
18.02	Cheddar Cheese	457,528	4500	1.0	$4.16\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	495 $\frac{\text{BTU}}{\text{lb. cheese}}$
18.03	Cottage Cheese	300,918	4500	0.75	$11.4\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	89 $\frac{\text{BTU}}{\text{lb. cheese}}$
18.04	Sour Cream	300,918	4500	0.05	$3.12\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	22 $\frac{\text{BTU}}{\text{lb. sour cream}}$
18.05	Cream Cheese	300,918	4500	0.10	$0.94\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	135 $\frac{\text{BTU}}{\text{lb. cheese}}$
18.06	Cultured Milk	300,918	4500	0.10	$3.19\text{x}10^{6}$ $\frac{\text{qts.}}{\text{year}}$	40 $\frac{\text{BTU}}{\text{qt. cult. milk}}$
18.08	Butter	167,610	4500	0.05	$4.08\text{x}10^{6}$ $\frac{\text{lbs.}}{\text{year}}$	9 $\frac{\text{BTU}}{\text{lb. butter}}$
18.09	Dried Milk	167,610	4500	0.90	$7.7\text{x}10^{6}$ $\frac{\text{lbs.}}{\text{year}}$	88 $\frac{\text{BTU}}{\text{lb. powder}}$
18.11	Dried Buttermilk	167,610	4500	0.05	$0.38\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	99 $\frac{\text{BTU}}{\text{lb. powder}}$
18.12	Evaporated Milk	243,800	4500	1.0	$5.2\text{x}10^{7}$ $\frac{\text{lbs}}{\text{year}}$	21 $\frac{\text{BTU}}{\text{lb. evap. milk}}$
18.13	Ice Cream	211,898	4500	1.0	$1.0\text{x}10^{6}$ $\frac{\text{gals.}}{\text{year}}$	954 $\frac{\text{BTU}}{\text{gal. ice cream}}$
18.14	Processed Cheese	471,250	4500	1.0	$87.4\text{x}10^{6}$ $\frac{\text{lbs}}{\text{year}}$	24 $\frac{\text{BTU}}{\text{lb. cheese}}$

Section 6-19

ENERGY CALCULATION NO. 19.00

Product Heating

Much of the steam energy used in the dairy industry goes for heating the product, to pasteurize it, or to facilitate further processing such as cheese making or spray drying. The steam energy required will be calculated by multiplying the specific heat of product times the product temperature change. If the product is heated in a high temperature-short time (HTST) pasteurizer, most of the temperature change comes in the regenerative section which uses previously heated products as a heat source. Thus on the HTST systems, only the temperature changes in the heating section are counted as energy costs. Heating by means other than a HTST plate heater will be designated as vat heating or pasteurization. Some materials will be pasteurized twice. Cream, for example, is separated and pasteurized one day and a day or two later it is recombined with raw whole milk to make cottage cheese dressing and pasteurized again.

The following table will relate the steam energy used in product heating. The energy cost of heating a material is derived by multiplying the specific heat of the material by the temperature change it goes through, times the ratio of the amount of material heated to the amount of desired product produced. Since several materials may be heated separately in the production of one product, each material heating cost will be summed to form a total product heating cost.

Table 6-19 a Steam Energy Requirements for Product Heating

Energy Cal. No.	Energy Req'd For	Material Heated	Method of Heating	Specific Heat	Temperature change in °F	Lbs. of material per unit product produced		Steam Energy Req'd	
19.01	Fluid Milk	milk	HTST	1.0	143→165	8.6	lbs milk / gal milk	189	BTU / gal. milk
19.02	Cheddar Cheese	milk	HTST	1.0	110→162	10	lbs milk / lb cheese	520	BTU / lb cheese
		milk	Vat	1.0	88→102	10	lbs milk / lb cheese	140	BTU / lb cheese
		starter	vat	1.0	70→190	0.2	lbs starter / lb cheese	24	BTU / lb cheese
								684	BTU / lb cheese
19.03	Cottage Cheese	skim milk	HTST	1.0	38→90 151→162	3.76	lbs milk / lb cheese	237	BTU / lb cheese
		40% cream	HTST	0.85	38→90 154→170	0.1	lbs cream / lb cheese	6	BTU / lb cheese
		dressing	Vat	0.90	38→170	0.33	lbs dressing / lb cheese	40	BTU / lb cheese
		skim milk	Vat	1.0	90→124	3.76	lbs milk / lb cheese	128	BTU / lb cheese
		starter	Vat	1.0	70→190	0.19	lbs starter / lb cheese	23	BTU / lb cheese
								434	BTU / lb cheese
19.04	Sour Cream	40% cream	HTST	0.85	38→90 154→170	0.39	lbs cream / lb sr. cream	23	BTU / lb sour cream
		18% cream	Vat	0.9	38→170	1.0	lbs cream / lb sr. cream	119	BTU / lb sour cream
		Starter	Vat	0.9	70→190	0.02	lbs cream / lb sr. cream	2	BTU / lb sour cream
								144	BTU / lb sour cream
19.05	Cream Cheese	40% cream	HTST	0.85	38→90 154→170	0.76	lbs 40% cream / lb cheese	44	BTU / cheese
		5% cream	Vat	0.9	38→170	2.5	lbs 5% cream / lb cheese	297	BTU / lb cheese
		cream cheese	Vat	0.9	65→150	1.0	lbs cheese / lb cheese	77	BTU / lb cheese
		Starter	Vat	1.0	70→190	0.01	lbs starter / lb cheese	1	BTU / lb cheese
								419	BTU / lb cheese

Table 6-19a (continued) Steam Energy Requirements for Product Heating

	Energy Req'd For	Material Heated	Method of Heating	Specific Heat	Temperature change in °F	Lbs. of material per unit product produced		Steam Energy Req'd	
19.06	Cultured Milk	milk	Vat	1.0	40→190	2.15	lbs milk / qt. cult. milk	323	BTU / qt. cult.
		starter	Vat	1.0	70→190	.022	lb. starter / qt. cult. milk	3	BTU / qt. cult.
								326	BTU / qt. cult. milk
19.07	Dried Whey	conc. whey	Vat	0.9	40→165	2.5	lbs. conc. whey / lb. powder	281	BTU / lb. powder
19.08	Butter	cream from separator	HTST	0.85	73→85	2	lbs cream / lb butter	20	BTU / lb butter
		40% cream	HTST	0.85	142→180	2	lbs cream / lb butter	65	BTU / lb butter
		40% cream	Vat	0.85	40→50	2	lbs cream / lb butter	17	BTU / lb butter
								102	BTU / lb butter
19.09	Dried Milk	skim milk	HTST	1.0	73→85	10.8	lbs milk / lb powder	130	BTU / lb powder
		conc. milk	Vat	0.9	115→165	2.5	lbs conc. / lb powder	113	BTU / lb powder
								243	
19.11	Dried Buttermilk	concentrate	Vat	0.9	115→165	2.5	lbs. conc. / lb powder	113	BTU / lb powder
19.12	Evaporated Milk	milk	Vat	1.0	165→205*	2.0	lbs milk / lb evap. milk	80	BTU / lb evap. milk
19.13	Ice Cream	ice cream mix	HTST	0.82	146→180	4.95	lbs mix / gal ice cream	138	BTU / gal. ice cream
19.14	Processed Cheese	cheese	Vat	0.6	40→160	1.0	lbs cheese / lb cheese	72	BTU / lb cheese

* The double effect evaporator includes the cost of heating from 40°F to 165°F

Section 6-20

ENERGY CALCULATION NO. 20.00

Steam Line Losses

It is assumed that most dairy processing plants have approximately the same amount of steam lines per square foot of floor space. Using a plant described by Tracy[12] which processes cheddar cheese, the steam line losses per square foot of heated floor space will be calculated and this factor will be applied to the other dairy plants in this study. The following floor plan shows the assumed layout of steam lines and their assumed sizes. The following assumptions are made about the layout:

1. There is a 10 foot drop at the end of each line.
2. All pipes are covered with 1 1/4 inches of magnesia insulation $(k = 0.041 \frac{\text{BTU}}{\text{hr-Ft-°F}})$
3. The temperature outside the pipe is 340°F and outside the insulation it is 120°F.
4. The following lengths of pipe are used :

Pipe Diameter	Length
6 inch	37 feet
5 inch	210 feet
4 inch	160 feet
2 inch	280 feet
1 inch	723 feet

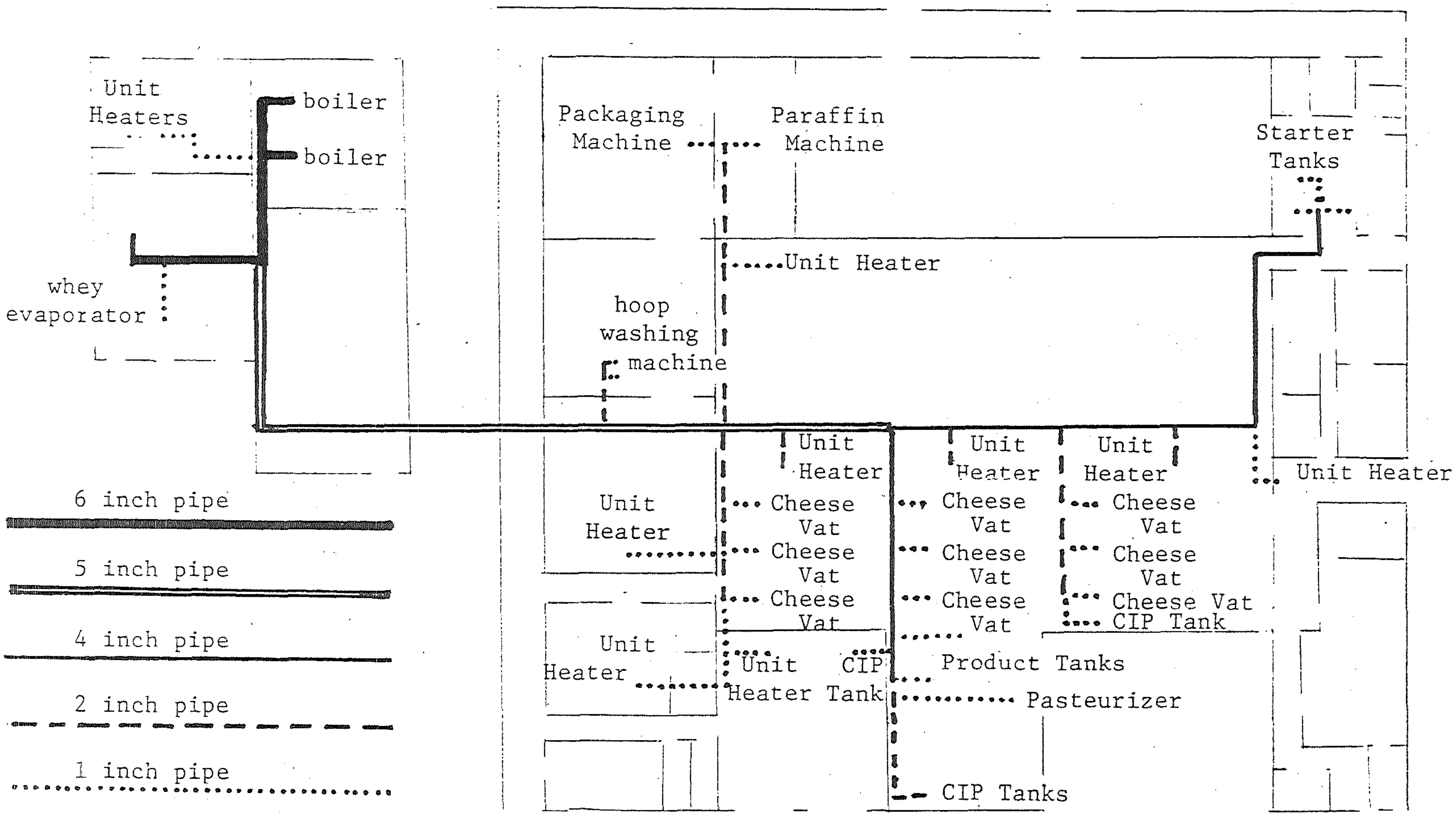


Figure 6-20a. Steam pipe layout in a cheddar cheese plant.

The heat loss through the insulation on the steam lines is calculated using the following formula for steady-state axial heat conduction in cylinders:

$$q = \frac{2 \pi K L (Ti - To)}{\ln (ro/ri)}$$

where K = conductivity
L = length
Ti = inside temperature
To - outside temperature
ro - outside radius
ri = inside radius
q = heat loss

Summing the heat losses for each pipe diameter used, the heat loss for the system is:

$$119,782 \frac{BTU}{hr}$$

To compensate for uninsulated valves and hangers, 10% is added to the above sum giving:

$$131,760 \frac{BTU}{hr}$$

Along with every steam line there is usually a condensate return line. The following assumptions will be made about the condensate lines:

1. The over-all length of pipe needed equals that of the steam line but the diameters are smaller.
2. All pipes are covered with 1 1/4 inches of magnesia insulation.
3. The temperature outside the pipe is 200°F and outside the insulation is 100°F.

4. The following lengths of pipe are used;

Pipe Diameter	Length
2 inch	37 feet
1 1/2 inch	370 feet
3/4 inch	1003 feet

The heat loss is calculated in the same way as done for steam lines giving:

34,006 BTU/hr

Adding 10% for uninsulated valves and hangers gives:

37,784 BTU/hr

The heat losses from the boiler itself will be calculated by a method similar to that of the steam pipes. The following assumptions are made about the boiler:

1. The boiler is cylindrical in shape with a 7 foot diameter and a 17 foot length.
2. The entire surface area is covered with 1 1/2 inches of magnesia insulation.
3. The temperature outside the shell of the boiler is 340°F and outside the insulation it is 170°F.

Using the same formula used for the steam pipes gives the heat transfer through the cylinder portion of the boiler. This calculation gives a value of:

21,216 BTU/hr

For the end plates which are flat, the Fourier equation gives the heat losses. The equation is;

$$q = -KA \frac{dT}{dx}$$

where K = conductivity
A = surface area
T = temperature
x = insulation thickness

This calculation gives the heat losses from the end plates as:

$$2146 \ \frac{\text{BTU}}{\text{hr}}$$

The total heat loss for the complete steam line system is:

Steam lines	131,760	BTU/hr
Condensate lines	37,784	BTU/hr
Boiler	23,362	BTU/hr
TOTAL	192,906	BTU/hr

The total square feet of floor space in this cheese plant excluding the cold storage room is 39,921 ft^2. The heat loss per square foot of floor space per week is given by:

$$\frac{\left(192{,}906 \ \frac{\text{BTU}}{\text{hr}}\right) \left(24 \ \frac{\text{hr}}{\text{day}}\right) \left(7 \ \frac{\text{day}}{\text{week}}\right)}{(39{,}921 \ \text{ft}^2)} = 812 \ \frac{\text{BTU}}{\text{ft}^2 \ \text{week}}$$

The following table relates the steam line losses in the production of various products. The energy cost is derived by multiplying the number of square feet of applicable floor space times the above energy cost factor, times an apportioning factor and then dividing the product by the weekly production of the item of interest. The applicable floor space of a plant is the total floor space less the area covered by cold storage rooms. The apportioning factor is needed in plants manufacturing more than one product. The fraction of the cost of steam line losses which is attributed to a specific product is the apportioning factor and is equal to the fraction of the raw milk which enters the plant and goes for that particular product. If a plant produces only one product, the apportioning factor is 1.0.

Table 6-20a Steam Energy Requirements from Steam Line Losses

Energy Cal. No.	Energy Req'd For	Applicable Floor Space	BTU/Ft^2-week	Apportioning Factor	Weekly Production		Steam Energy Req'd	
20.01	Fluid Milk	24,393 Ft^2	812	1.0	105,000	gal/week	189	BTU/gal. milk
20.02	Cheddar Cheese	33,715 Ft^2	812	1.0	80,000	lbs/week	342	BTU/lb. cheese
20.03	Cottage Cheese	25,632 Ft^2	812	0.75	219,750	lbs/week	71	BTU/lb. cheese
20.04	Sour Cream	25,632 Ft^2	812	0.05	60,000	lbs/week	17	BTU/lb. sour cream
20.05	Cream Cheese	25,632 Ft^2	812	0.10	18,000	lbs/week	116	BTU/lb. cheese
20.06	Cultured Milk	25,632 Ft^2	812	0.10	61,395	qts/week	34	BTU/qt. cult. milk
20.08	Butter	18,593 Ft^2	812	0.05	78,554	lbs/week	10	BTU/lb. butter
20.09	Dried Milk	18,593 Ft^2	812	0.90	148,050	lbs/week	92	BTU/lb. powder
20.11	Dried Buttermilk	18,593 Ft^2	812	0.05	7,322	lbs/week	103	BTU/lb. powder
20.12	Evaporated Milk	21,700 Ft^2	812	1.0	1x10^6	lbs/week	18	BTU/lb. evap.milk
20.13	Ice Cream	19,041 Ft^2	812	1.0	19,231	gals/week	804	BTU/gal. ice cream
20.14	Processed Cheese	38,250 Ft^2	812	1.0	1.68x10^6	lbs/week	18	BTU/lb. cheese

Section 6-21

ENERGY CALCULATION NO. 21.00

Miscellaneous Steam Energy Calculations

Energy Calculation No. 21.01

Milk Bottle Washing

A 1080 bottle per hour washing machine requires 4 boiler horsepower to operate. Assuming 25% of the product is bottled and the bottles hold 1/2 gallon, the steam energy cost is given by:

$$\frac{(4 \text{ B hp})\ (33{,}472\ \frac{\text{BTU}}{\text{B hp-hr}})\ (0.25)}{(1080\ \frac{\text{bottles}}{\text{hr}})\ (0.5\ \frac{\text{gal}}{\text{bottle}})} = 62\ \frac{\text{BTU}}{\text{gal milk}}$$

Energy Calculation No. 21.10

Instantizer (Steam Costs)

Steam is used to increase the moisture content and to heat the air to redry powder. Tracy estimates that a 2000 lb per hour instantizer requires 1.19×16^9 BTU per hour. This translates to:

$$\frac{(1.19 \times 16^6\ \frac{\text{BTU}}{\text{hr}})}{(2000\ \frac{\text{lbs}}{\text{hr}})} = 595\ \frac{\text{BTU}}{\text{lb powder}}$$

Energy Calculation No. 21.12

Sterilization of Canned Milk

It is assumed that the energy cost of running a continuous can sterilizer is approximated by the energy cost of heating the product plus 50%. The evaporated milk is heated from 40°F to 245°F and that cost is given by:

$$0.9\ \frac{\text{BTU}}{(\text{lb evap milk} - {}^\circ\text{F})\ (205^\circ\text{F})} = 195\ \frac{\text{BTU}}{\text{lb evap milk}}$$

Adding 50% gives:

$$293 \frac{\text{BTU}}{\text{lb evap milk}}$$

Energy Calculation No. 21.14

Processed Cheese Plant Manual Cleaning

Although manual cleaning in processed cheese plants consumes a portion of the total steam energy cost, it is still difficult to derive a cleaning cost that will fit most plants. This is because of the variability of the manual cleaning method. Commonly, hot water or steam spray guns are used to melt and blow cheese off the floors and equipment. It is estimated that the plant in question would draw a load of 325 boiler horsepower during the cleaning procedure, which requires 4 hours to complete. This translates to:

$$\frac{(325 \text{ boiler hp})\ (33{,}472 \frac{\text{BTU}}{\text{hr-B hp}})\ (4 \frac{\text{hr}}{\text{day}})}{(280{,}000 \text{ lbs cheese/day})} = 155 \frac{\text{BTU}}{\text{lb cheese}}$$

Section 6-22

ENERGY CALCULATION NO. 22.00

Cold Storage Rooms

Basic Assumptions

All the cold storage rooms considered will be at either 40°F or -20°F. The -20°F temperature is used only in ice cream hardening rooms. The rooms will be insulated with the equivalent of 4 inches of corkboard surrounding the 40°F room and 9 1/2 inches of corkboard surrounding the -20°F room. The average outside conditions will be estimated at 85°F and 60% relative humidity.

The estimating procedure will follow a seven step outline.

Step 1

Using the ASHRAE Handbook of Fundamentals[2], the heat transfer rate through the walls, ceiling, and floor is estimated at 81 BTU/ft^2 - 24-hr for both the 40°F and the -20°F rooms. Thus, the heat infiltration through walls, ceiling and floor is given by:

$$\frac{\text{BTU}}{(81\ \text{ft}^2\text{-day})}\ (\text{surface area of cooler}) = \text{cooling load}$$

Step 2

To account for the air infiltration due to loading and unloading, the ASHRAE Handbook[3] gives a table showing the number of air changes per day versus the volume of the cooler. The heat removed in cooling outside air to storage room conditions is also tabulated. The cooling costs per cubic foot to cool air from the assumed outside conditions is 1.56 BTU for the 40°F room and 3.24 BTU for the -20°F room. Thus, the cooling load due to air infiltration in a 40°F room is given by:

$$(\text{number air changes/day})\ (\text{volume of room})\ (1.57\ \frac{\text{BTU}}{\text{ft}^3}) = \text{cooling load}$$

For the -20°F room, the cooling load is given by:

$$(\text{number air changes/day})\ (\text{volume of room})\ (3.24\ \frac{\text{BTU}}{\text{ft}^3}) = \text{cooling load}$$

<u>Step 3</u>

The heat gain from lights will be estimated by assuming there is one 100-watt fluorescent light per 50 ft^2 of floor space running 8 hours per day. The heat gain per square foot of floor space is given by:

$$\frac{(110\ \text{watt})\ (3.41\ \frac{\text{BTU}}{\text{hr-watt}})\ (8\ \frac{\text{hr}}{\text{day}})}{(60\ \text{ft}^2)} = 50\ \frac{\text{BTU}}{\text{ft}^2\text{-day}}$$

The heat gain for the entire room is then given by:

$$(50\ \frac{\text{BTU}}{\text{ft}^2\text{-day}})\ (\text{ft}^2\ \text{of floor space}) = \text{cooling load}$$

<u>Step 4</u>

The heat gain from electric motors running the fans will be estimated by assuming the motors are 75% efficient and under a load which is 75% of the rated capacity. If the fans run two-thirds of the time, the heat gain per horsepower used is:

$$\frac{(2545\ \frac{\text{BTU}}{\text{hr-hp}})\ (16\ \frac{\text{hr}}{\text{day}})\ (0.75\ \text{load})}{(0.75\ \text{efficiency})} = 40{,}720\ \frac{\text{BTU}}{\text{hp-day}}$$

The total heat gain from motors is given by:

$$\left(40{,}720\ \frac{\text{BTU}}{\text{hp-day}}\right)\ (\text{Total hp used}) = \text{cooling load}$$

Step 5

The cooling loads from Steps 1-4 are added together and then converted to a refrigeration cost per unit production of a specific item. This is done by the following formula:

$$\frac{(\text{sum of cooling loads})}{(\text{daily input of product into cold room})} \cong \frac{\text{cooling load}}{\text{unit production}}$$

If more than one type of product enters the cold storage room, the above cooling cost is multiplied by the fraction the mass flow rate of the product being considered to the total mass flow rate of products going into the cold storage room.

Step 6

The cooling load from lowering the incoming product temperature to that of the cold storage room is estimated by:

$$(\text{specific heat of product})\ (\text{temperature change}) = \frac{\text{cooling load}}{\text{production}}$$

The above formula will function for all products with the exception of ice cream. The ASHRAE Handbook[6] estimates the load for lowering the temperature of ice cream in a hardening room as 458 BTU/gal for 85% overrun ice cream.

Step 7

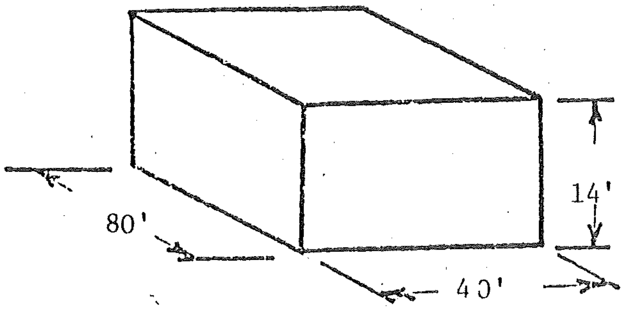
The total refrigeration load will be estimated by adding the results of Step 5 and Step 6 together. For ice cream an additional factor is needed. The energy cost to refrigerate an ice cream hardening room at -20°F is more than a 40°F cold storage room with the same cooling load. A typical ammonia refrigeration system in a dairy plant uses 25 psig suction pressure in the evaporator in a 40°F cold storage room and 0 psig suction pressure in a -20°F hardening room. The usual procedure in compressing the ammonia vapor is to first compress the vapor from 0 psig to 25 psig, then cool the vapor and compress it again to about 185 psig. Thus, the cooling load for the -20°F hardening room must run through an extra compressor and an intercooler. Tracy[17] recommends that 51.4 horsepower are required in the booster compressor to pump from 0 psig to 25 psig and handle 68.7 tons of refrigeration. He also recommends that 105.2 horsepower are required in the 25 psig to 185 psig compressor to handle 75.4 tons. If the motors are 85% efficient, this translates to 0.187 BTU of electricity for every BTU of cooling for the booster compressor and 0.349 BTU of electricity for every BTU of cooling in second stage compressor. Thus, the -20°F hardening room requires 53.6% more energy for the same cooling load than a 40°F room. Also, Tracy[17] recommends that 11.6% of the cooling load going to the hardening room is required for the intercooler. Therefore, by increasing the calculated cooling load for hardening room by 65.2% and treating it like a cooling load from a 40°F room, the correct energy cost of the ice cream hardening room is obtained.

All cooling loads for dairy plant cold storage rooms will be calculated following the above procedure.

Energy Calculation No. 22.01

Fluid Milk Cold Storage Room

The dimensions of the cooler are:



volume = 32,000 ft^3

surface area = 8,800 ft^3

floor space = 3,200 ft^3

temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. <u>Heat infiltration through walls, ceilings and floors.</u>

$$(81 \frac{\text{BTU}}{\text{ft}^2\text{-day}})\ (8800\ \text{ft}^2) = 712,800\ \frac{\text{BTU}}{\text{day}}$$

Step 2. <u>Heat gain from air changes.</u>

$$(2.6\ \frac{\text{air changes}}{\text{day}})\ (32,000\ \frac{\text{ft}^3}{\text{change}})\ (1.57\ \frac{\text{BTU}}{\text{ft}^3}) = 130,624\ \frac{\text{BTU}}{\text{day}}$$

Step 3. <u>Heat gain from lights.</u>

$$(50\ \frac{\text{BTU}}{\text{ft}^2\text{-day}})\ (3200\ \text{ft}^2) = 160,000\ \frac{\text{BTU}}{\text{day}}$$

Step 4. <u>Heat gain from motors.</u>

It is assumed there are 4 - 1/2 hp motors.

$$(40,720\ \frac{\text{BTU}}{\text{day-hp}})\ (2\ \text{hp}) = 81,440\ \frac{\text{BTU}}{\text{day}}$$

Step 5. <u>Sum of cooling loads.</u>

The sum of Steps 1-4 is 1,084,864 $\frac{\text{BTU}}{\text{day}}$

If there is an average of 15,000 gallons of milk go through the cooler per day, the cooling cost per gallon is:

$$\frac{(1,084,864\ \frac{\text{BTU}}{\text{day}})}{(15,000\ \frac{\text{gals milk}}{\text{day}})} = 72.3\ \frac{\text{BTU}}{\text{gal milk}}$$

Step 6. Cooling incoming product.

Besides the cooling of milk from 45°F to 40°F, steel cases holding the milk containers are cooled from 75°F to 40°F. The cases weigh 8 lbs and hold 2 gallons of milk. The specific heat of the case is 0.2 BTU/lb-°F.

Thus, the incoming product cooling load is given by:

$$\frac{\text{BTU}}{(1\ \text{lb milk-°F})}\ (5\text{°F})\ (8.6\ \frac{\text{lb milk}}{\text{gal milk}}) + \frac{(8\ \frac{\text{lbs steel}}{\text{case}})\ (0.2\ \frac{\text{BTU}}{\text{lb steel-°F}})\ (35\text{°F})}{(2\ \frac{\text{gal milk}}{\text{case}})}$$

$$= 71\ \frac{\text{BTU}}{\text{gal milk}}$$

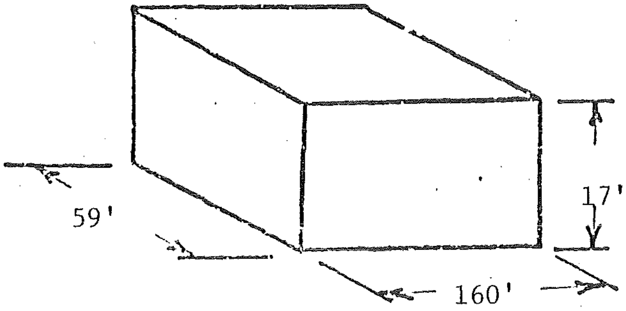
Step 7. Total cooling load.

$$(72.3\ \frac{\text{BTU}}{\text{gal milk}}) + (71\ \frac{\text{BTU}}{\text{gal milk}}) = 143.3\ \frac{\text{BTU}}{\text{gal milk}}$$

Energy Calculation No. 22.02

Cheddar Cheese Cold Storage Room

The dimensions of the cooler are:



Volume = 160,480 ft^3

Surface area = 26,326 ft^2

Floor space = 9,440 ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the coolings loads are:

Step 1. Heat infiltration through walls, ceilings, and floors.

$$(81\ \frac{\text{BTU}}{\text{ft}^2\text{-day}})\ (26,326\ \text{ft}^2) = 2,132,406\ \frac{\text{BTU}}{\text{day}}$$

Step 2. Heat gain from air changes

For this room there are 1.2 air changes/day.

$$\left(1.2\ \frac{\text{air changes}}{\text{day}}\right)\left(160{,}480\ \frac{\text{Ft}^3}{\text{change}}\right)\left(1.57\ \frac{\text{BTU}}{\text{Ft}^3}\right) = 302{,}344\ \frac{\text{BTU}}{\text{day}}$$

Step 3. Heat gain from lights

$$\left(50\ \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right)\left(9440\ \text{Ft}^2\right) = 472{,}000\ \frac{\text{BTU}}{\text{day}}$$

Step 4. Heat gain from motors.

It is assumed there are 8 - 1 hp. motors.

$$\left(40{,}720\ \frac{\text{BTU}}{\text{hp-day}}\right)\left(8\ \text{hp}\right) = 325{,}760\ \frac{\text{BTU}}{\text{day}}$$

Step 5. Sum of cooling loads.

The sum of Steps 1-4 is $3.23\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$.

There is an average of 11,429 lbs. of cheese through the cooler per day. The cooling cost per pound of cheese is:

$$\frac{\left(3.23\text{x}10^6\ \frac{\text{BTU}}{\text{day}}\right)}{\left(11{,}429\ \frac{\text{lbs. cheese}}{\text{day}}\right)} = 282.8\ \frac{\text{BTU}}{\text{lb cheese}}$$

Step 6. Cooling incoming product.

The incoming cheese is cooled from 70°F to 40°F and has a specific heat of $0.6\ \frac{\text{BTU}}{\text{lb cheese}}$ -°F.

$$\left(0.6\ \frac{\text{BTU}}{\text{lb. cheese}}\text{-°F}\right)\left(30\text{°F}\right) = 18\ \frac{\text{BTU}}{\text{lb. cheese}}$$

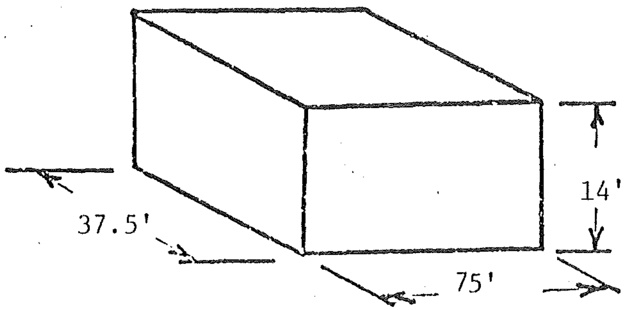
Step 7. Total Cooling load.

$$\left(282.8\ \frac{\text{BTU}}{\text{lb. cheese}}\right) + \left(18\ \frac{\text{BTU}}{\text{lb. cheese}}\right) = 300.8\ \frac{\text{BTU}}{\text{lb. cheese}}$$

Energy Calculation No. 22.03

Cottage Cheese Cold Storage Room

The dimensions of the cooler are:



Volume = 39,375 Ft^3

Surface area = 8,775 Ft^3

Floor space = 2,813 Ft^3

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling and floor.

$$\left(81\ \frac{BTU}{Ft^2\text{-day}}\right)\ (8775\ Ft^2) = 710,775\ \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 2.3 air changes/day.

$$\left(2.3\ \frac{\text{air changes}}{\text{day}}\right)\ \left(39,375\ \frac{Ft^3}{\text{change}}\right)\ \left(1.57\ \frac{BTU}{Ft^3}\right) = 142,183\ \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$\left(50\ \frac{BTU}{Ft^2\text{-day}}\right)\ (2813\ Ft^2) = 140,650\ \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is assumed there are 6 - 1/2 hp. motors.

$$\left(40,720\ \frac{BTU}{\text{hp-day}}\right)\ (3\ \text{hp}) = 122,160\ \frac{BTU}{day}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $1.116\text{x}10^{6}\ \frac{\text{BTU}}{\text{day}}$.

There is an average of 31,393 lbs. of cottage cheese through the cooler every day. But there is also 2,571 lbs. of cream cheese, 8571 lbs. of sour cream, and 18,856 lbs. of cultured milk which go through the cooler. Therefore only 51% of the load from Steps 1-4 should be attributed to cottage cheese production, or:

$$\frac{(1.116\text{x}10^{6}\ \frac{\text{BTU}}{\text{day}})\ (0.51)}{(31{,}393\ \frac{\text{lbs. cottage cheese}}{\text{day}})} = 18.1\ \frac{\text{BTU}}{\text{lb.}}\ \text{cottage cheese}$$

Step 6. Cooling incoming product.

The cottage cheese is cooled from 45°F to 40°F and has a specific heat of $0.7\ \frac{\text{BTU}}{\text{lb}}$ -°F.

$$(0.7\ \frac{\text{BTU}}{\text{lb}}\ \text{cheese -°F})\ \ (5°\text{F}) = 3.5\ \frac{\text{BTU}}{\text{lb.}}\ \text{cottage cheese}$$

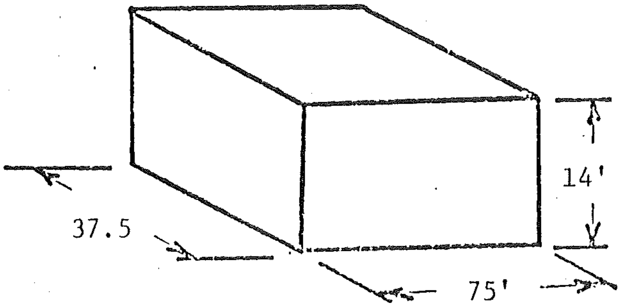
Step 7. Total Cooling Load.

$$(18.1\ \frac{\text{BTU}}{\text{lb}}\ \text{cottage cheese}) + (3.5\ \frac{\text{BTU}}{\text{lb}}\ \text{cottage cheese}) = 21.6\ \frac{\text{BTU}}{\text{lb.}}\ \text{cottage cheese}$$

Energy Calculation No. 22.04

Sour Cream Cold Storage Room

The dimensions of the cooler are:



Volume = 39,375 Ft^3

Surface area = 8,775 Ft^2

Floor Space = 2,813 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling and floors.

$$\left(81\ \frac{BTU}{Ft^2\text{-day}}\right)\ (8775\ Ft^2) = 710{,}775\ \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 2.3 air changes/day.

$$\left(2.3\ \frac{\text{air changes}}{\text{day}}\right)\ \left(39{,}375\ \frac{Ft^3}{\text{change}}\right)\ \left(1.57\ \frac{BTU}{Ft^3}\right) = 142{,}183\ \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$\left(50\ \frac{BTU}{Ft^2\text{-day}}\right)\ (2813\ Ft^2) = 140{,}650\ \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is assumed there are 6 - 1/2 hp motors.

$$\left(40{,}720\ \frac{BTU}{\text{ho-day}}\right)\ (3\ \text{hp}) = 122{,}160\ \frac{BTU}{day}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $1.116\text{x}10^6 \frac{\text{BTU}}{\text{day}}$. There is an average of 8,571 lbs. of sour cream through the cooler every day. But there is also 2,571 lbs. of cream cheese, 31,393 lbs. of cottage cheese, and 18,857 lbs. of cultured milk which go through the cooler every day. Therefore only 14.0% of the load from Steps 1-4 should be attributed to sour cream production, or:

$$\frac{(1.116\text{x}10^6 \frac{\text{BTU}}{\text{day}})\ (0.14)}{(8,571 \frac{\text{lbs. sour cream}}{\text{day}})} = 18.2 \frac{\text{BTU}}{\text{lb. sour cream}}$$

Step 6. Cooling incoming product.

The sour cream is cooled from 65°F to 40°F and has a specific heat of $0.9 \frac{\text{BTU}}{\text{lb.-°F}}$.

$$(0.9 \frac{\text{BTU}}{\text{lb sour cream -°F}})\ (25\text{°F}) = 22.5 \frac{\text{BTU}}{\text{lb sour cream}}$$

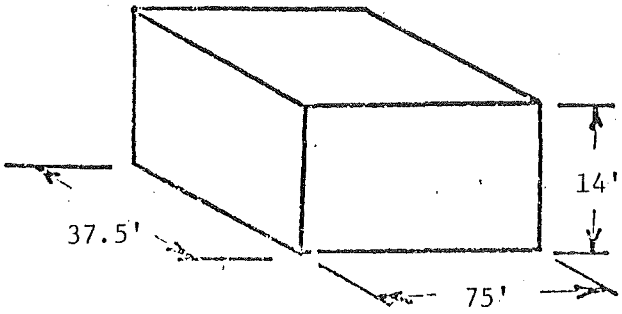
Step 7. Total Cooling Load

$$(18.2 \frac{\text{BTU}}{\text{lb sour cream}}) + (22.5 \frac{\text{BTU}}{\text{lb sour cream}}) = 40.7 \frac{\text{BTU}}{\text{lb sour cream}}$$

Energy Calculation No. 22.05

Cream Cheese Cold Storage Room

The dimensions of the cooler are:



Volume = 39,375 Ft^3

Surface area = 8,775 Ft^2

Floor space = 2,813 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floor.

$$\left(81 \frac{BTU}{Ft^2\text{-day}}\right) (8{,}775\ Ft^2) = 710{,}775 \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 2.3 air changes/day.

$$\left(2.3 \frac{\text{air changes}}{\text{day}}\right) \left(39{,}375 \frac{Ft^3}{\text{change}}\right) \left(1.57 \frac{BTU}{Ft^3}\right) = 142{,}183 \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$\left(50 \frac{BTU}{Ft^2\text{-day}}\right) (2{,}813\ Ft^2) = 140{,}650 \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is assumed there are 6 - 1/2 hp motors.

$$\left(40{,}720 \frac{BTU}{hp\text{-day}}\right) (3\ hp) = 122{,}160 \frac{BTU}{day}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $1.116\text{x}10^6 \ \frac{\text{BTU}}{\text{day}}$. There is an average of 2,571 lbs. of cream cheese through the cooler every day. But there is also 31,393 lbs. of cottage cheese, 8,571 lbs. of sour cream, and 18,857 lbs. of cultured milk which go through the cooler every day. Therefore, only 4.2% of the load from Steps 1-4 should be attributed to cream cheese production, or:

$$\frac{(1.116\text{x}10^6 \ \frac{\text{BTU}}{\text{day}}) \ (0.042)}{(2571 \ \frac{\text{lbs cream cheese}}{\text{day}})} = 18.2 \ \frac{\text{BTU}}{\text{lb cream cheese}}$$

Step 6. Cooling incoming product.

The cream cheese is cooled from 150°F to 40°F and has a specific heat of $0.9 \ \frac{\text{BTU}}{\text{lb-°F}}$.

$$(0.9 \ \frac{\text{BTU}}{\text{lb cream cheese -°F}}) \ (110\text{°F}) = 99 \ \frac{\text{BTU}}{\text{lb cream cheese}}$$

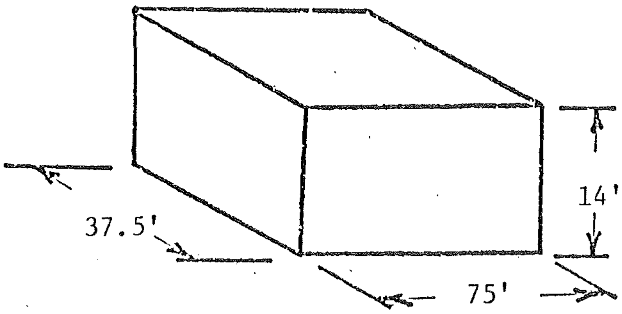
Step 7. Total Cooling Load

$$(18.2 \ \frac{\text{BTU}}{\text{lb cream cheese}}) + (99 \ \frac{\text{BTU}}{\text{lb cream cheese}}) = 117.2 \ \frac{\text{BTU}}{\text{lb cream cheese}}$$

Energy Calculation No. 22.06

Cultured Milk Cold Storage Room

The dimensions of the cooler are:



Volume = 39,375 Ft^3

Surface area = 8,775 Ft^2

Floor space = 2,813 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceilings, and floors.

$$\left(81 \frac{BTU}{Ft^2\text{-day}}\right) (8,775\ Ft^2) = 710,775 \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 2.3 air changes/day.

$$\left(2.3 \frac{\text{air changes}}{\text{day}}\right) \left(39,375 \frac{Ft^3}{\text{change}}\right) \left(1.57 \frac{BTU}{Ft^3}\right) = 142,183 \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$\left(50 \frac{BTU}{Ft^2\text{-day}}\right) (2,813\ Ft^2) = 140,650 \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is assumed there are 6 - 1/2 hp motors.

$$\left(40,720 \frac{BTU}{hp\text{-day}}\right) (3\ hp) = 122,160 \frac{BTU}{day}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $1.116\times10^{6}\ \frac{\text{BTU}}{\text{day}}$. There is an average of 18,857 lbs. of cultured milk through the cooler every day. But there is also 2,571 lbs. of cream cheese, 8,571 lbs. of sour cream, and 31,393 lbs. of cottage cheese which go through the cooler every day. Therefore, only 30.7% of the load from Steps 1-4 should be attributed to cultured milk production, or:

$$\frac{(1.116\times10^{6}\ \frac{\text{BTU}}{\text{day}})\ (0.307)\ (2.15\ \frac{\text{lbs}}{\text{qt}})}{(31{,}393\ \frac{\text{lbs cultured milk}}{\text{day}})} = 23.5\ \frac{\text{BTU}}{\text{qt. cultured milk}}$$

Step 6. Cooling incoming product.

The cultured milk enters the cooler at 40°F so no cooling load is added here.

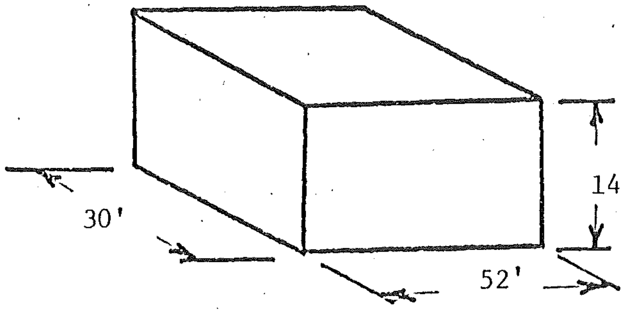
Step 7. Total Cooling Load

$$(23.5\ \frac{\text{BTU}}{\text{qt. cultured milk}}) + (0\ \frac{\text{BTU}}{\text{qt. cultured milk}}) = 23.5\ \frac{\text{BTU}}{\text{qt. cultured milk}}$$

Energy Calculation No. 22.07

Butter Cold Storage Room

The dimensions of the cooler are:



Volume = 21,840 Ft^3

Surface area = 5,416 Ft^2

Floor space = 1,560 Ft^2

Temperature = 40°F

Following the outline given in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floor.

$$\left(81 \frac{\text{BTU}}{\text{Ft}^2 - \text{day}}\right) \left(5{,}416 \text{ Ft}^2\right) = 438{,}696 \frac{\text{BTU}}{\text{day}}$$

Step 2. Heat gain from air changes.

For this room there are 3.4 air changes/day.

$$\left(3.4 \frac{\text{air changes}}{\text{day}}\right) \left(21{,}840 \frac{\text{Ft}^3}{\text{air change}}\right) \left(1.57 \frac{\text{BTU}}{\text{Ft}^3}\right) = 116{,}581 \frac{\text{BTU}}{\text{day}}$$

Step 3. Heat gain from lights.

$$\left(50 \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right) \left(1{,}560 \text{ Ft}^2\right) = 78{,}000 \frac{\text{BTU}}{\text{day}}$$

Step 4. Heat gain from motors.

It is assumed there are 2 - 1/2 hp motors.

$$\left(40{,}720 \frac{\text{BTU}}{\text{hp-day}}\right) (1 \text{ hp}) = 40{,}720 \frac{\text{BTU}}{\text{day}}$$

Step 5. Sum of cooling loads.

The sum of Steps 1-4 is 673,997 $\frac{\text{BTU}}{\text{day}}$. There is an average of 11,222 lbs of butter through the cooler every day. The cooling cost per pound is:

$$\frac{\left(673{,}997\ \frac{\text{BTU}}{\text{day}}\right)}{\left(11{,}222\ \frac{\text{lbs butter}}{\text{day}}\right)} = 60.1\ \frac{\text{BTU}}{\text{lb.}}\ \text{butter}$$

Step 6. Cooling incoming product.

The butter is cooled from 50°F to 40°F and has a specific heat of 0.5 $\frac{\text{BTU}}{\text{lb-°F}}$.

$$\left(0.5\ \frac{\text{BTU}}{\text{lb. butter-°F}}\right)\ (10\text{°F}) = 5\ \frac{\text{BTU}}{\text{lb. butter}}$$

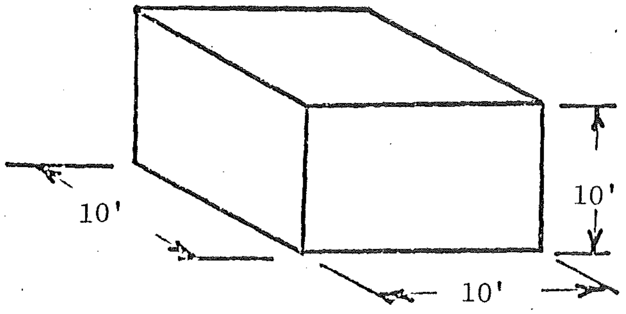
Step 7. Total Cooling Load.

$$\left(60.1\ \frac{\text{BTU}}{\text{lb butter}}\right) + \left(5.0\ \frac{\text{BTU}}{\text{lb butter}}\right) = 65.1\ \frac{\text{BTU}}{\text{lb butter}}$$

Energy Calculation No. 22.12

Evaporated Milk Storage Room

The dimensions of the room are:



Volume = 1,000 Ft^3

Surface area = 600 Ft^2

Floor space = 100 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00 the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floors.

$$\left(81\ \frac{BTU}{Ft^2\text{-day}}\right)\ \left(600\ Ft^2\right) = 48{,}600\ \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 17.5 air changes/day.

$$\left(17.5\ \frac{\text{air changes}}{\text{day}}\right)\ \left(1000\ \frac{Ft^3}{\text{change}}\right)\ \left(1.57\ \frac{BTU}{Ft^3}\right) = 27{,}475\ \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$\left(50\ \frac{BTU}{Ft^2\text{-day}}\right)\ \left(100\ Ft^2\right) = 5{,}000\ \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is estimated there is 1- 1/2 hp motor.

$$\left(40{,}720\ \frac{BTU}{hp\text{-day}}\right)\ \left(0.5\ hp\right) = 20{,}360\ \frac{BTU}{day}$$

Step 5. Sum of cooling loads.

The sum of Steps 1-4 is $101{,}435 \frac{\text{BTU}}{\text{day}}$. There is 142,857 lbs. of evaporated milk produced every day in this plant. The cost per pound is:

$$\frac{(101{,}435 \ \frac{\text{BTU}}{\text{day}})}{(142{,}857 \ \frac{\text{lbs evap. milk}}{\text{day}})} = 0.7 \ \frac{\text{BTU}}{\text{lb evap. milk}}$$

Step 6. Cooling incoming product.

It is assumed that the cooling load is small since only small volumes of excess cream and milk are stored here.

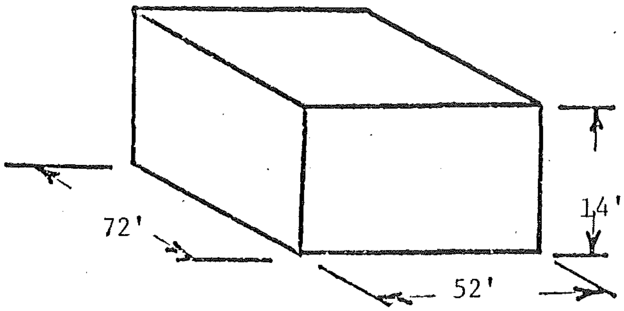
Step 7. Total Cooling Load.

$$(0.7 \ \frac{\text{BTU}}{\text{lb evap. milk}}) + (0 \ \frac{\text{BTU}}{\text{lb evap. milk}}) = 0.7 \ \frac{\text{BTU}}{\text{lb evap. milk}}$$

Energy Calculation No. 22.13

Ice Cream Hardening Room

The dimensions of the room are:



Volume = 52,416 Ft^3
Surface area = 10,960 Ft^2
Floor space = 3,550 Ft^2
Temperature = -20°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floor.

$$\left(81 \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right) \left(10{,}960 \text{ Ft}^2\right) = 887{,}760 \frac{\text{BTU}}{\text{day}}$$

Step 2. Heat gain from air changes.

For this room there are 1.97 air changes/day.

$$\left(1.97 \frac{\text{air changes}}{\text{day}}\right) \left(52{,}416 \frac{\text{Ft}^3}{\text{change}}\right) \left(3.24 \frac{\text{BTU}}{\text{Ft}^3}\right) = 334{,}561 \frac{\text{BTU}}{\text{day}}$$

Step 3. Heat gain from lights.

$$\left(50 \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right) \left(3{,}550 \text{ Ft}^2\right) = 177{,}500 \frac{\text{BTU}}{\text{day}}$$

Step 4. Heat gain from motors.

It is assumed there are 4 - 3/4 hp motors.

$$\left(40{,}720 \frac{\text{BTU}}{\text{hp-day}}\right) \left(3 \text{ hp}\right) = 122{,}160 \frac{\text{BTU}}{\text{day}}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $1.52 \times 10^6 \frac{\text{BTU}}{\text{day}}$. If there are 2,747 gallons of ice cream through the hardening room every day, the cooling cost per gallon is:

$$\frac{(1.52 \times 10^6 \frac{\text{BTU}}{\text{day}})}{(2,747 \frac{\text{gals ice cream}}{\text{day}})} = 553 \frac{\text{BTU}}{\text{gal ice cream}}$$

Step 6. Cooling incoming product.

The cooling load for hardening ice cream is estimated at $458 \frac{\text{BTU}}{\text{gal}}$.

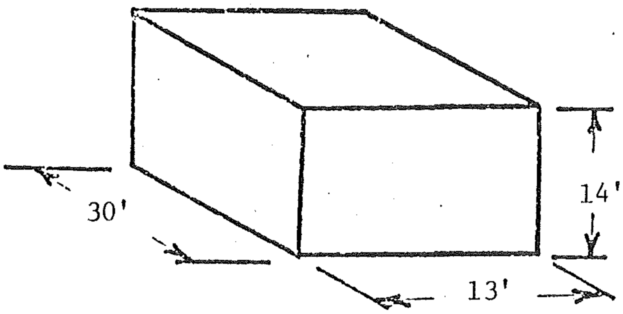
Step 7. Total Cooling Load.

Remembering the refrigeration factor needed for a Hardening Room given in Step 7 of Energy Calculation Number 22.00, the total cooling load is:

$$\left[(553 \frac{\text{BTU}}{\text{gal ice cream}}) + (458 \frac{\text{BTU}}{\text{gal ice cream}})\right](1.652) = 1643 \frac{\text{BTU}}{\text{gal ice cream}}$$

Ice Cream Cold Storage Room

The dimensions of the room are:



Volume = 5,460 Ft^3

Surface area = 1,984 Ft^2

Floor space = 390 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floor.

$$\left(81 \ \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right) \ \left(1{,}984 \ \text{Ft}^2\right) = 160{,}704 \ \frac{\text{BTU}}{\text{day}}$$

Step 2. Heat gain from air changes.

For this room there are 6.9 air changes/day.

$$\left(6.9 \ \frac{\text{air changes}}{\text{day}}\right) \ \left(5{,}460 \ \frac{\text{Ft}^3}{\text{change}}\right) \ \left(1.57 \ \frac{\text{BTU}}{\text{Ft}^3}\right) = 59{,}148 \ \frac{\text{BTU}}{\text{day}}$$

Step 3. Heat gain from lights.

$$\left(50 \ \frac{\text{BTU}}{\text{day-Ft}^2}\right) \ \left(390 \ \text{Ft}^2\right) = 19{,}500 \ \frac{\text{BTU}}{\text{day}}$$

Step 4. Heat gain from motors.

It is assumed there is 1 - 1/2 hp motor.

$$\left(40{,}720 \ \frac{\text{BTU}}{\text{hp-day}}\right) \ \left(1/2 \ \text{hp}\right) = 20{,}360 \ \frac{\text{BTU}}{\text{day}}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is 259,712 $\frac{\text{BTU}}{\text{day}}$. If an average of 2,747 gallons of ice cream are made in this plant each day, the cooling cost per gallon is:

$$\frac{\left(259{,}712\ \frac{\text{BTU}}{\text{day}}\right)}{\left(2{,}747\ \frac{\text{gal ice cream}}{\text{day}}\right)} = 94.5\ \frac{\text{BTU}}{\text{gal ice cream}}$$

Step 6. Cooling incoming products.

This room is used mainly for storage of flavoring materials and assorted goods and would have a small heat gain from incoming material.

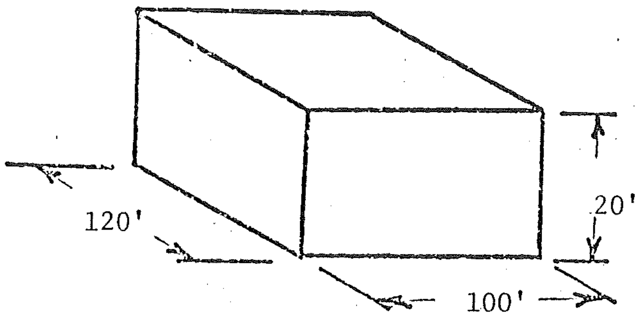
Step 7. Total Cooling Load.

$$\left(94.5\ \frac{\text{BTU}}{\text{gal ice cream}}\right) + \left(0\ \frac{\text{BTU}}{\text{gal ice cream}}\right) = 94.5\ \frac{\text{BTU}}{\text{gal ice cream}}$$

Energy Calculation No. 22.14

Processed Cheese Cold Storage Room

The dimensions of the room are:



Volume = 240,000 Ft^3

Surface area = 32,800 Ft^2

Floor space = 12,000 Ft^2

Temperature = 40°F

Following the outline in Energy Calculation No. 22.00, the cooling loads are:

Step 1. Heat infiltration through walls, ceiling, and floor.

$$(81 \frac{BTU}{Ft^2\text{-day}}) \quad (32{,}800 \frac{ft^2}{change}) = 2.66x10^6 \frac{BTU}{day}$$

Step 2. Heat gain from air changes.

For this room there are 0.8 air changes/day.

$$(0.8 \frac{\text{air changes}}{\text{day}}) \quad (240{,}000 \frac{Ft^3}{change}) \quad (1.57 \frac{BTU}{Ft^3}) = 0.30 \times 10^6 \frac{BTU}{day}$$

Step 3. Heat gain from lights.

$$(50 \frac{BTU}{day\text{-}Ft^2}) \quad (12{,}000\ Ft^2) = 0.60x10^6 \frac{BTU}{day}$$

Step 4. Heat gain from motors.

It is assumed there are 4 - 3 hp motors.

$$(40{,}720 \frac{BTU}{hp\text{-}day}) \quad (12\ hp) = 0.49x10^6 \frac{BTU}{day}$$

Step 5. Sum of the cooling loads.

The sum of Steps 1-4 is $4.55\text{x}10^6 \ \frac{\text{BTU}}{\text{day}}$. Since there are 280,000 lbs. of processed cheese made every day, the cost is:

$$\frac{(4.55\text{x}10^6 \ \frac{\text{BTU}}{\text{day}})}{(280{,}000 \ \frac{\text{lbs cheese}}{\text{day}})} = 16.25 \ \frac{\text{BTU}}{\text{lb cheese}}$$

Step 6. Cooling incoming products.

The incoming natural cheese is assumed to be at 40°F and creates no cooling load. The incoming processed cheese will enter at 50°F and is cooled to 40°F. The specific heat of processed cheese is $0.6 \ \frac{\text{BTU}}{\text{lb.-°F}}$.

$$(0.6 \ \frac{\text{BTU}}{\text{lb.-°F}}) \quad (10°\text{F}) = 6 \ \frac{\text{BTU}}{\text{lb cheese}}$$

Step 7. Total Cooling Load.

$$(16.25 \ \frac{\text{BTU}}{\text{lb cheese}}) + (6 \ \frac{\text{BTU}}{\text{lb cheese}}) = 22.25 \ \frac{\text{BTU}}{\text{lb cheese}}$$

Section 6-23

ENERGY CALCULATION NO. 23.00

Air Conditioning

Air conditioning energy costs are difficult to estimate for a "typical" dairy plant due to variation in the areas of the plant that are air conditioned and the components in these areas. In this study it is assumed that only office areas, labs, lunch rooms and restrooms should be air conditioned. In order to simplify the calculations, the following assumptions are made.

1. The air conditioning will be used from May until September (122 days).
2. The air conditioned areas of the plant shall be located together forming a square shape with one wall connected to the rest of the plant.
3. The unconditioned areas of the plant which are next to the air conditioned areas are assumed to have the same temperature as the outside air.
4. During the air conditioning season, the average daily outside temperature is 85°F while the inside temperature is at 75°F constantly. The average humidity of the outside air is 65%.
5. The roof will be flat, dark in color, and will be made of steel siding with 2 inches of insulation.
6. The walls are made of 4 inches of brick, 4 inches of concrete block, and 1 inch of insulation. The outside wall will be dark in color.

7. The air conditioning will run from 8:00 A.M. till 8:00 P.M.
8. In the air conditioned areas the ceiling is 10 feet above the floor.

Using these assumptions, an air conditioning cost per square foot of floor space will be developed.

Outside heat gains or heat transfer rates through walls and roof at any time of the day is estimated in the ASHRAE Handbook of Fundamentals[4] by using the Total Equivalent Heat Transfer Differentials. Plotting the heat transfer rates from 8:00 A.M. till 8:00 P.M. and finding the area under the curve gives the total heat transfer for the day. For the walls and roof given in the assumptions, the heat transfer is:

Roof	171.4	$\frac{BTU}{Ft^2\text{-day}}$
East Wall	59.6	$\frac{BTU}{Ft^2\text{-day}}$
South Wall	39.5	$\frac{BTU}{Ft^2\text{-day}}$
West Wall	39.5	$\frac{BTU}{Ft^2\text{-day}}$
North Wall	22.1	$\frac{BTU}{Ft^2\text{-day}}$

Since the areas which are air conditioned will always be square in shape, the wall heat transfer rates can be added together and multiplied by the area of one wall. Because the air conditioned areas form a square, variation in load due to the direction of the building faces is eliminated. Also, since the walls are 10 feet tall, the heat gain per day through the walls is given by sum of the above wall heat transfer rates multiplied by 10.0 and by the length of one wall. The length of one wall is also the square root of the air conditioned floor space. The area of the roof is approximately equal to the floor space which is air conditioned. Thus the heat transferred through the roof per day equals the above roof heat transfer rate times the area of the floor space which is air conditioned. This is summarized in the following formula:

Heat Infiltration through Walls and Ceilings =

$$\left(171.4\ \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right)\left(\text{Ft}^2 \text{ of floor space}\right) + \left(1607\ \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right)\left(\text{Ft}^2 \text{ of floor space}\right)^{1/2}$$

Heat gained from within the air conditioned areas is assumed to come from only two major sources; people and electrical devices. It is assumed there are 12 people in the air conditioned areas for 10 hours per day doing moderately active office work. Using values from the ASHRAE Handbook,[5] the following heat gain is derived.

$$(12 \text{ people})\left(450\ \frac{\text{BTU}}{\text{hr-person}}\right)(10 \text{ hr}) = 54{,}000\ \frac{\text{BTU}}{\text{day}}$$

The heat gain from electrical devices comes mainly from lights and miscellaneous motors. Using the value derived in Energy Calculation No. 13.00 the heat gain from electrical devices is given by:

$$\frac{\left(247.5\ \frac{\text{BTU}}{\text{Ft}^2\text{-week}}\right)\left(\text{Ft}^2 \text{ of floor space}\right)}{\left(7\ \frac{\text{days}}{\text{week}}\right)} = \left(35.4\ \frac{\text{BTU}}{\text{Ft}^2\text{-day}}\right)\left(\text{Ft}^2 \text{ of floor space}\right)$$

Thus the total heat given off per day by people and electrical devices is given by:

$$\text{Inside Heat Gain} = \left(54{,}000\ \frac{\text{BTU}}{\text{day}}\right) + \left(35.4\ \frac{\text{BTU}}{\text{day-Ft}^2}\right)(\text{Ft}^2 \text{ of floor space})$$

Incoming outside air which is circulated into the air conditioned areas must be cooled to room temperature. Since the average outside temperature is 85°F with 65% relative humidity, the amount of cooling required to lower one cubic foot of air to the 75°F room temperature given by:

$$\left(0.075\ \frac{\text{lb air}}{\text{Ft}^2\text{air}}\right)\left[\left(0.24\ \frac{\text{BTU}}{\text{lb air-°F}}\right) + \left(0.017\ \frac{\text{lb H}_2\text{O}}{\text{lb air}}\right)\left(0.45\ \frac{\text{BTU}}{\text{lb H}_2\text{O-°F}}\right)\right](10°\text{F})$$

$$= 0.186\ \frac{\text{BTU}}{\text{Ft}^3} \text{ of air}$$

It is assumed that the air circulation rate in the air conditioned areas is such that one complete air change occurs every 4 minutes with 10% of this circulated air coming from outside. Since the volume of the air conditioned area is given by multiplying the floor space times the ceiling height of 10 feet, the amount of outside air entering is given by:

$$\frac{(\text{Ft}^2 \text{ of floor space x10})\ \frac{\text{Ft}^3}{\text{air change}}\ \left(60\ \frac{\text{min}}{\text{hr}}\right)\left(12\ \frac{\text{hr}}{\text{day}}\right)(0.1)}{\left(4\ \frac{\text{minutes}}{\text{air change}}\right)}$$

$$= (\text{Ft}^2 \text{ of floor space})(180) = \frac{\text{Ft}^3 \text{ of air}}{\text{day}}$$

Thus the cooling load from incoming air is:

$$(\text{Ft}^2 \text{ of floor space})(180)(0.186) = 33.5\ (\text{Ft}^2 \text{ of floor space})\ \frac{\text{BTU}}{\text{day}}$$

Simplifying the outside heat gain, the inside heat gain, and the cooling of incoming air into one formula:

$$\frac{\text{BTUs of cooling}}{\text{day}} = 240.3\ (\text{ft}^2\text{ of floor space}) + 1607\ (\text{ft}^2\text{ of floor space})^{1/2}$$
$$+\ 54{,}000$$

The following table relates the air conditioning load per unit product in the production of various dairy products. The unit load is derived by inserting the square feet of air conditioned floor space into the above formula and multiplying the result times the length of the air conditioning season and the apportioning factor. The product is divided by the yearly production. The length of the air conditioning season is assumed to be 122 days per year. The apportioning factor is needed for plants producing more than one product. For these plants, the fraction of the cost of air conditioning which should be attributed to a specific product is the apportioning factor and is equal to the fraction of the incoming raw milk which goes into that particular product. If a plant produces only one product the apportioning factor equals 1.0.

Table 6-23a Air Conditioning Loads per Unit Production

Energy Cal. No.	Energy Req'd For	Air Cond. Floor Space	Air Cond. Load	Air Cond. Season	Apportioning Factor	Yearly Average Production	Refrigeration Energy Req'd
23.01	Fluid Milk	6860 Ft^2	$1.84\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	1.0	$5.46\text{x}10^6\ \frac{\text{gals}}{\text{year}}$	$41\ \frac{\text{BTU}}{\text{gal. milk}}$
23.02	Cheddar Cheese	4972 Ft^2	$1.36\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	1.0	$4.16\text{x}10^6\ \frac{\text{lbs}}{\text{year}}$	$40\ \frac{\text{BTU}}{\text{lb. cheese}}$
23.03	Cottage Cheese	5502 Ft^2	$1.50\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.75	$1.14\text{x}10^7\ \frac{\text{lbs}}{\text{year}}$	$12\ \frac{\text{BTU}}{\text{lb. cheese}}$
23.04	Sour Cream	5502 Ft^2	$1.50\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.05	$3.12\text{x}10^6\ \frac{\text{lbs}}{\text{year}}$	$3\ \frac{\text{BTU}}{\text{lb. sour crea}}$
23.05	Cream Cheese	5502 Ft^2	$1.50\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.10	$9.36\text{x}10^5\ \frac{\text{lbs}}{\text{year}}$	$20\ \frac{\text{BTU}}{\text{lb.cheese}}$
23.06	Cultured Milk	5502 Ft^2	$1.50\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.10	$3.19\text{x}10^6\ \frac{\text{qts}}{\text{year}}$	$6\ \frac{\text{BTU}}{\text{qt. cult. mil}}$
23.08	Butter	2715 Ft^2	$7.90\text{x}10^5\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.05	$4.08\text{x}10^6\ \frac{\text{lbs}}{\text{year}}$	$1\ \frac{\text{BTU}}{\text{lb. butter}}$
23.09	Dried Milk	2715 Ft^2	$7.90\text{x}10^5\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.90	$7.70\text{x}10^6\ \frac{\text{lbs}}{\text{year}}$	$11\ \frac{\text{BTU}}{\text{lb. powder}}$
23.11	Dried Buttermilk	2715 Ft^2	$7.90\text{x}10^5\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	0.05	$3.80\text{x}10^5\ \frac{\text{lbs}}{\text{year}}$	$13\ \frac{\text{BTU}}{\text{lb. powder}}$
23.12	Evaporated Milk	2700 Ft^2	$7.86\text{x}10^5\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	1.0	$5.20\text{x}10^7\ \frac{\text{lbs}}{\text{year}}$	$2\ \frac{\text{BTU}}{\text{lb. evap. mil}}$
23.13	Ice Cream	3907 Ft^2	$1.09\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	1.0	$1.00\text{x}10^6\ \frac{\text{gals}}{\text{year}}$	$133\ \frac{\text{BTU}}{\text{gal. ice crea}}$
23.14	Processed Cheese	4875 Ft^2	$1.34\text{x}10^6\ \frac{\text{BTU}}{\text{day}}$	$122\ \frac{\text{day}}{\text{year}}$	1.0	$87.4\text{x}10^6\ \frac{\text{lbs}}{\text{year}}$	$2\ \frac{\text{BTU}}{\text{lb. cheese}}$

Section 6-24

ENERGY CALCULATION NO. 24.00

Product Cooling

Most of the refrigeration costs in a dairy processing plant can be attributed to cooling dairy products after they have been heated for processing. The refrigeration energy required in each cooling of material will be estimated by multiplying the specific heat of the product times the temperature change of the product.

If the product is cooled in a high temperature-short time (HTST) pasteurizer, most of the cooling occurs in the regenerative section which uses incoming cold product for cooling.

At temperatures above 90°F to 100°F, cooling is also done with culinary water. For this study, only the cooling done with chilled brine or water solutions will be considered. Products may also be cooled in a vat by circulating chilled water or by expanding ammonia in an exterior jacket.

The following table will relate the refrigeration loads created in product cooling. The refrigeration load for cooling a material is derived by multiplying the specific heat of the material by its change in temperature. This is multiplied by the ratio of the amount of material cooled to the amount of desired product produced. Since several materials may be cooled separately in the production of one product, each material cooling cost will be summed to form a total product cooling load. Where the cooling occurred will be designated by "HTST" for a high temperature short time pasteurizer, "vat" for cooling in a jacketed vat, or "Plate" for cooling in a plate heat exchanger.

Table 6-24a Product Cooling Unit Loads

Energy Cal. No.	Energy Req'd For	Material Cooled	Where Cooling Occurred	Specific Heat	Temperature change in °F	Lbs. of Material per unit product produced	Refrigeration Unit Load
24.01	Fluid Milk	milk	Plate	1.0	42 → 36	8.6 lbs milk/gal milk	52 BTU/gal milk
		milk	HTST	1.0	64 → 36	8.6 lbs milk/gal milk	241 BTU/gal milk
							293 BTU/gal milk
24.02	Cheddar Cheese	milk	Plate	1.0	42 → 36	10 lbs milk/lb cheese	60 BTU/lb cheese
		starter	Vat	1.0	70 → 40	0.2 lbs starter/lb cheese	6 BTU/lb cheese
							66 BTU/lb cheese
24.03	Cottage Cheese	milk	Plate	1.0	42 → 36	4.1 lbs milk/lb cheese	25 BTU/lb cheese
		wash water	Vat	1.0	60 → 34	2.55 lbs water/lb cheese	66 BTU/lb cheese
		40% cream	HTST	0.85	105 → 38	0.1 lbs cream/lb cheese	6 BTU/lb cheese
		dressing	Vat	0.90	100 → 38	0.33 lb dressing/lb cheese	18 BTU/lb cheese
		starter	Vat	1.0	70 → 40	0.19 lbs starter/lb cheese	6 BTU/lb cheese
							121 BTU/lb.cheese
24.04	Sour Cream	40% cream	HTST	0.85	105 → 38	0.39 lbs cream/lb sr. cream	22 BTU/lb. sour crea
		sour cream	Vat	0.9	170 → 65	1.0 lbs sr. cream/lb sr cream	95 BTU/lb. sour crea
		starter	Vat	1.0	70 → 40	0.02 lbs starter/lbs sr. cream	1 BTU/lb. sour crea
							118 BTU/lb. sour crea
24.05	Cream Cheese	13% cream	Plate	0.9	42 → 36	3.2 lbs cream/lb cheese	17 BTU/lb cheese
		40% cream	HTST	0.85	105 → 38	0.76 lbs cream/lb cheese	43 BTU/lb cheese
		5% cream	Vat	0.95	100 → 65	2.5 lbs cream/lb cheese	83 BTU/lb cheese
		starter	Vat	1.0	70 → 40	0.03 lbs starter/lb cheese	1 BTU/lb cheese
							144 BTU/lb cheese

Table 6-24a (continued) Product Cooling Unit Loads

Energy Cal. No.	Energy Req'd For	Material Cooled	Where Cooling Occurred	Specific Heat	Temperature change in °F	Lbs of material per unit product produced	Refrigeration Unit Load
24.06	Cultured Milk	milk	Plate	1.0	42 → 36	2.15 $\frac{\text{lbs milk}}{\text{qt. cult. milk}}$	13 $\frac{\text{BTU}}{\text{qt. cult.}}$
		milk	Vat	1.0	100 → 40	2.15 $\frac{\text{lbs milk}}{\text{qt. cult. milk}}$	129 $\frac{\text{BTU}}{\text{qt. cult.}}$
		starter	Vat	1.0	70 → 40	0.02 $\frac{\text{lbs starter}}{\text{qt. cult. milk}}$	1 $\frac{\text{BTU}}{\text{qt. cult.}}$
							143 $\frac{\text{BTU}}{\text{qt. cult. milk}}$
24.07	Dried Whey	6% whey	Plate	1.0	70 → 40	16.1 $\frac{\text{lbs 6\% whey}}{\text{lb powder}}$	483 $\frac{\text{BTU}}{\text{lb. powder}}$
		40% whey	Plate	0.9	90 → 40	2.4 $\frac{\text{lbs 40\% whey}}{\text{lb powder}}$	120 $\frac{\text{BTU}}{\text{lb. powder}}$
							603 $\frac{\text{BTU}}{\text{lb. powder}}$
24.08	Butter	40% cream	HTST	0.85	123 → 42	2 $\frac{\text{lbs cream}}{\text{lb butter}}$	138 $\frac{\text{BTU}}{\text{lb. butter}}$
		40% cream	Vat	0.85	42 → 38	2 $\frac{\text{lbs cream}}{\text{lb butter}}$	7 $\frac{\text{BTU}}{\text{lb. butter}}$
		40% cream	butter churn	0.85	55 → 50	2 $\frac{\text{lbs cream}}{\text{lb butter}}$	9 $\frac{\text{BTU}}{\text{lb. butter}}$
							154 $\frac{\text{BTU}}{\text{lb. butter}}$
24.09	Dried Milk	skim milk	Plate	1.0	49 → 40	10.8 $\frac{\text{lbs milk}}{\text{lb powder}}$	97 $\frac{\text{BTU}}{\text{lb. powder}}$
24.11	Dried Buttermilk	buttermilk	Plate	1.0	50 → 35	10.8 $\frac{\text{lbs buttermilk}}{\text{lb powder}}$	162 $\frac{\text{BTU}}{\text{lb. powder}}$
24.12	Evaporated Milk	milk	Plate	1.0	42 → 36	2 $\frac{\text{lbs milk}}{\text{lb evap. milk}}$	12 $\frac{\text{BTU}}{\text{lb. evap.}}$
		evap. milk	Plate	0.95	115 → 40	1.0 $\frac{\text{lbs evap. milk}}{\text{lb evap. milk}}$	71 $\frac{\text{BTU}}{\text{lb. evap.}}$
							83 $\frac{\text{BTU}}{\text{lb. evap. milk}}$

Table 6-24a (continued) Product Cooling Unit Loads

Energy Cal. No.	Energy Req'd For	Material Cooled	Where Cooling Occurred	Specific Heat	Temperature change in°F	Lbs of material per unit product produced	Refrigeration Unit Load
24.13	Ice Cream	conc. skim	Vat	0.94	42 → 36	1.7 $\frac{\text{lbs conc. skim}}{\text{gal ice cream}}$	10 $\frac{\text{BTU}}{\text{gal. ice}}$
		40% cream	Vat	0.85	42 → 36	1.2 $\frac{\text{lbs cream}}{\text{gal ice cream}}$	6 $\frac{\text{BTU}}{\text{gal. ice}}$
		mix	Vat	0.82	42 → 40	4.95 $\frac{\text{lbs mix}}{\text{gal ice cream}}$	8 $\frac{\text{BTU}}{\text{gal. ice}}$
		mix	HTST	0.82	94 → 40	4.95 $\frac{\text{lbs mix}}{\text{gal ice cream}}$	219 $\frac{\text{BTU}}{\text{gal. ice}}$
							243 $\frac{\text{BTU}}{\text{gal.}}$ ice cream
24.14	Processed Cheese	cheese	Vat	0.60	160 → 50	1.0 $\frac{\text{lbs cheese}}{\text{lb cheese}}$	66 $\frac{\text{BTU}}{\text{lb. chees}}$

Section 6-25

ENERGY CALCULATION NO. 25.00

Cooling Line Losses

With the exceptions of the cold storage rooms, the instantizer cooling costs, and the ice cream freezer, all the cooling done in this report will be assumed to be done with a chilled brine or chilled water (sweet water). The water solutions will be chilled at a central point in the plant and pumped to the process location. These cooling lines run through the plant and are warmed by the surroundings. It was assumed that 20% of the calculated cooling load that circulates in those lines would approximate the heat gain in the lines.

The following table relates the cooling line loss unit loads in the production of various products. The unit loads will be determined by adding the applicable cooling loads and multiplying the sum by 0.2.

Table 6-25a. Cooling line loss unit loads.

Energy Cal. No.	Energy Req'd For	Air Conditioning Load	Product Cooling Load	Total Cooling Load	Line Loss Factor	Refrigeration Unit Load
25.01	Fluid Milk	42 $\frac{\text{BTU}}{\text{gal milk}}$	293 $\frac{\text{BTU}}{\text{gal milk}}$	355 $\frac{\text{BTU}}{\text{gal milk}}$	0.2	67 $\frac{\text{BTU}}{\text{gal milk}}$
25.02	Cheddar Cheese	40 $\frac{\text{BTU}}{\text{lb cheese}}$	66 $\frac{\text{BTU}}{\text{lb cheese}}$	106 $\frac{\text{BTU}}{\text{lb cheese}}$	0.2	26 $\frac{\text{BTU}}{\text{lb cheese}}$
25.03	Cottage Cheese	12 $\frac{\text{BTU}}{\text{lb cheese}}$	121 $\frac{\text{BTU}}{\text{lb cheese}}$	133 $\frac{\text{BTU}}{\text{lb cheese}}$	0.2	27 $\frac{\text{BTU}}{\text{lb cheese}}$
25.04	Sour Cream	3 $\frac{\text{BTU}}{\text{lb sour cr}}$	118 $\frac{\text{BTU}}{\text{lb sour cr}}$	121 $\frac{\text{BTU}}{\text{lb sour cr}}$	0.2	24 $\frac{\text{BTU}}{\text{lb sour cr}}$
25.05	Cream Cheese	20 $\frac{\text{BTU}}{\text{lb cheese}}$	144 $\frac{\text{BTU}}{\text{lb cheese}}$	164 $\frac{\text{BTU}}{\text{lb cheese}}$	0.2	33 $\frac{\text{BTU}}{\text{lb cheese}}$
25.06	Cultured Milk	6 $\frac{\text{BTU}}{\text{qt cult mk}}$	143 $\frac{\text{BTU}}{\text{qt cult mk}}$	149 $\frac{\text{BTU}}{\text{qt cult mk}}$	0.2	30 $\frac{\text{BTU}}{\text{qt cult mk}}$
25.07	Dried Whey	--------	603 $\frac{\text{BTU}}{\text{lb powder}}$	603 $\frac{\text{BTU}}{\text{lb powder}}$	0.2	121 $\frac{\text{BTU}}{\text{lb powder}}$
25.08	Butter	1 $\frac{\text{BTU}}{\text{lb butter}}$	154 $\frac{\text{BTU}}{\text{lb butter}}$	155 $\frac{\text{BTU}}{\text{lb butter}}$	0.2	31 $\frac{\text{BTU}}{\text{lb butter}}$
25.09	Dried Milk	11 $\frac{\text{BTU}}{\text{lb powder}}$	97 $\frac{\text{BTU}}{\text{lb powder}}$	108 $\frac{\text{BTU}}{\text{lb powder}}$	0.2	22 $\frac{\text{BTU}}{\text{lb powder}}$
25.11	Dried Buttermilk	13 $\frac{\text{BTU}}{\text{lb powder}}$	162 $\frac{\text{BTU}}{\text{lb powder}}$	175 $\frac{\text{BTU}}{\text{lb powder}}$	0.2	35 $\frac{\text{BTU}}{\text{lb powder}}$
25.12	Evaporated Milk	2 $\frac{\text{BTU}}{\text{lb evap mk}}$	83 $\frac{\text{BTU}}{\text{lb evap mk}}$	85 $\frac{\text{BTU}}{\text{lb evap mk}}$	0.2	17 $\frac{\text{BTU}}{\text{lb evap milk}}$
25.13	Ice Cream	133 $\frac{\text{BTU}}{\text{gal ice cr}}$	243 $\frac{\text{BTU}}{\text{gal ice cr}}$	376 $\frac{\text{BTU}}{\text{gal ice cr}}$	0.2	75 $\frac{\text{BTU}}{\text{gal ice cr}}$
25.14	Processed Cheese	2 $\frac{\text{BTU}}{\text{lb cheese}}$	66 $\frac{\text{BTU}}{\text{lb cheese}}$	68 $\frac{\text{BTU}}{\text{lb cheese}}$	0.2	14 $\frac{\text{BTU}}{\text{lb cheese}}$

Section 6-26

ENERGY CALCULATION NO. 26.00

Miscellaneous Cooling Loads

Energy Calculation No. 26.10

Instantizer Cooling Loads

Tracy[15] recommends that a 1000 CFM air stream at 70°F or below is needed to cool the dried powder from the 2000 lb. per hour instantizer. It will be assumed that half of the year the average outside temperature is 85°F and 60% relative humidity. The warm air is cooled to 50°F to condense some of the moisture and then raised to 70°F. The cost of cooling air from 85°F to 50°F is tabled in the ASHRAE Handbook of Fundamentals[3] as 1.21 BTU per cubic foot. With the given flow rate needed, this translates to:

$$\frac{\left(1.21\ \frac{\text{BTU}}{\text{Ft}^3}\right)\left(1000\ \frac{\text{Ft}^3}{\text{min}}\right)\left(60\ \frac{\text{min}}{\text{hr}}\right)}{\left(2000\ \frac{\text{lbs powder}}{\text{hr}}\right)} = 36\ \frac{\text{BTU}}{\text{lb powder}}$$

Energy Calculation No. 26.13

Ice Cream Freezer (cooling load)

The manufactuer's specifications for a 900 gallon per hour freezer recommend a load of 28.6 tons of refrigeration. Because all the refrigeration costs in this study are in reference to a 25 psig suction ammonia refrigeration system discharging at 185 psig, and because the ice cream freezer requires 0 psig suction, the refrigeration cost for the ice cream freezer requires an increased cost factor. This factor is described in Energy Calculation No. 20.00 on Step 7.

Using the above information, the refrigeration load translates to:

$$\frac{(28.6 \text{ tons}) \left(12{,}000 \frac{\text{BTU}}{\text{hr-ton}}\right) (1.652)}{\left(900 \frac{\text{gals ice cream}}{\text{hr}}\right)} = 630 \frac{\text{BTU}}{\text{gal ice cream}}$$

Section 6-27

ENERGY CALCULATION NO. 27.00

Energy Calculation Nos. 27.07, 27.09, and 27.11

Spray Drying (natural gas cost)

The manufacturer's ratings of a direct fired horizontal spray dryer list a requirement of 2200 BTUs of natural gas energy for each pound of water removed. To get one pound of 3.5% moisture powder from a 50% total solids concentrate of whey, skim milk, or buttermilk, requires the removal of 1.41 pounds of moisture. Thus, the cost translates to:

$$\left(2200 \frac{\text{BTU}}{\text{lb } H_2O \text{ removed}}\right) \left(1.41 \frac{\text{lb } H_2O \text{ removed}}{\text{lb powder}}\right) = 3102 \frac{\text{BTU}}{\text{lb powder}}$$

Section 6-28

ENERGY CALCULATION NO. 28.00

Miscellaneous Energy Calculations

Energy Calculation No. 28.01

Electricity Cost in Dollars

The average cost of electricity is estimated at $0.025/kw-hr. This converts to:

$$\frac{(\$0.025/\text{kw-hr})}{(3413\ \text{BTU/kw-hr})} = \$7.32/10^6\ \text{BTU}$$

Energy Calculation No. 28.02

Refrigeration Coefficient of Performance

Most of the refrigeration for dairy plants require ammonia compressors running at 25 psig suction and 185 psig discharge. This requires a 13.3 horsepower motor for every 9.2 tons of refrigeration according to Farrall[7]. Assuming an electrical motor efficiency of 88%, the coefficient of performance of the system is:

$$\frac{(9.2\ \text{tons})\ (12{,}000\ \frac{\text{BTU}}{\text{hr-ton}})}{(13.3\ \text{hp})\ (1.14\ \text{efficiency})\ (2545\ \frac{\text{BTU}}{\text{hr-hp}})} = 2.86$$

Energy Calcuation No. 28.03

Cost of Natural Gas in Dollars

It is assumed that the average cost of natural gas is $1.15/MCF. The heating value of the natural gas is assumed to be 1082 BTU/ft^3. The cost translates to:

$$\frac{(\$1.15/\text{MCF})}{(1082\ \frac{\text{BTU}}{\text{ft}^3})\ (1000\ \frac{\text{ft}^3}{\text{MCF}})} = \$1.06/10^6\ \text{BTU}$$

Energy Calculation No. 28.04

Cost of Steam in Dollars

It is assumed that the boilers used are 80% efficient and are burning natural gas. Using the above cost of natural gas, the cost of steam becomes:

$$\frac{(\$1.06/10^6 \text{ BTU})}{(0.80 \text{ efficiency})} = \$1.33/10^6 \text{ BTU}$$

Energy Calculation No. 28.05

Fossil Fuel Equivalent or Electricity

It is assumed that electrical power needed comes from a fossil fuel power plant with a thermal efficiency of 0.33. Thus, multiplying the electrical energy used by a factor of 3.0 gives the fossil fuel energy requirement for the plant.

Energy Calculation No. 28.06

Fossil Fuel Equivalent of Steam

Since the boiler is assumed to be 80% efficient, multiplying the steam energy need by 1.2 gives the fossil fuel energy requirement in steam generation.

Section 7

COPY OF SURVEY QUESTIONNAIRE

ENERGY USE SURVEY

1. Estimate the amount of each product you produced regularly (gallons/month, pounds/year, 1/2 gallons/week, or any convenient units)

Whole Milk____________________

Skim Milk____________________

Cottage Cheese____________________

Lowfat Milk____________________

Cheddar Cheese____________________

Italian Cheese____________________

Swiss Cheese____________________

Other Cheeses____________________

Chocolate Milk____________________

Buttermilk____________________

Evaporated Milk____________________

Nonfat Dry Milk____________________

Dry Whole Milk____________________

Dried Whey____________________

Butter____________________

Sour Cream____________________

Yogurt____________________

Half and Half____________________

Ice Cream____________________

Ice Milk____________________

Other (specify)____

2. What is your average consumption of raw milk? (In gal./month, lbs./week, or other convenient units.)

3. Are you aware of any innovative approaches to energy use in the dairy industry such as solar, geothermal, wind, etc.? If so, describe briefly.

4. How much energy of each of the following types did you consume during each month given and what did it cost you?

TYPE		Apr. 1975	July 1975	Oct. 1975	Jan. 1975	Total Calendar 1975
Electricity	KWHR					
	Cost					
Natural Gas	MCF					
	Cost					
Fuel Oil	Gallons					
	Cost					
Coal	Tons					
	Cost					
Other (specify)________						
	Cost					

5. The approximate size of your plant in square feet.

6. Estimate the size and temperature of your cold storage rooms.

Size (cubic feet)	Temperature (°F)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

7.

Distance raw milk hauled from farm to plant	% of total milk received
Under 25 miles	
25-100 miles	
100-500 miles	
500-1000 miles	
Over 1000 miles	

8. Please give us any readily available information on what the average distance that your finished product is shipped from your plant.

PRODUCT	Plant to Wholesale distributor	Local Delivery (if applicable)
1. Cheese		
2. Fluid Milk		
3. Butter		
4. Ice Cream		
5. Condensed Milk		
6. Dried Milk		
7. Dried Whey		
8. Cultured Products		
9. Other (specify)		

Section 8

LOCATIONS AND PRODUCTION LEVELS OF DAIRY PLANTS IN CALIFORNIA, IDAHO, OREGON, NEVADA AND UTAH

Table 8-1a. Dairy processing plants in California.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
A & J Sales	1151 Foothill Upland	X		
Adolphs Milk Depot	1650 East Main St. Stockton	X		
Adohr	1717 Mission Street San Francisco		X	
Adohr Farms	720 J Street Tulare			X
Adohr Milk Farms	4002 Westminster Blvd. Santa Ana		X	
Adohr Milk Farms	9923 Atlantic Ave South Gate		X	
Albertsons	939 E Street Modesto	X		
Allura Farm Dairy	8809 Grove Ave Upland	X		
Alpha Beta Co.	777 S. Harbor Blvd. La Habra			X
Alpine Swiss Dairy	Route 1, Box 299A El Centro	X		
Alta Dena Dairy	637 S. Hambledon Ave City of Industry			X
Alves Dairy	2205 South Cabrillo Half Moon Bay	X		
Andersons Dairy	Route 4, Box 4007 Auburn	X		
Arcata Creamline Dairy	1330 Q Street Arcata	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Arden Mayfair Inc	1914 West Slauson Ave Los Angeles	X		
Arden Mayfair Inc.	2101 South Los Angeles Los Angeles	X		
Arden Mayfair Inc.	1136 K Street San Diego	X		
Arden Mayfair Inc.	2065 Oakdale Avenue San Francisco	X		
Arden Mayfair Inc.	1815 Williams Street San Leandro			X
Arden Mayfair Inc.	Tipton	X		
Ariza Cheese Co.	20320 So. Norwalk Blvd Artesia	X		
Arlington Farms Inc.	617 Sebastopol Rd Santa Rosa	X		
Arrow Dairy	1661 W Arrow Highway Upland	X		
Ashjians Cheese	7684 E Kings Canyon Rd Fresno	X		
Avoset Co.	P.O. Box A Gustine		X	
Babs	1001 Fruitvale Ave Oakland	X		
Babs Dairy Drive-In	6628 Foothill Blvd. Oakland	X		
Babs Dairy Drive-In	1006 23rd St. Richmond	X		
Babs Dairy Drive-In	10200 White Road San Jose	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Balian Ice Cream Co.	2916-30 E. Olympic Rd Los Angeles	X		
Baskin Robbins	1201 S. Victory Blvd. Burbank			X
Belmont Farms	1090 No. Armstrong Fresno	X		
Bennett's Ice Cream	6333 West Third St Los Angeles	X		
Berkeley Farms	4550 San Pablo Emeryville			X
Berkeley Farms	555 Fulton St San Francisco	X		
Betsy Ross Ice Cream Co.	969 East Hold Avenue Pomona	X		
Blewett Dairy	221 So. Sacramento St. Lodi	X		
Blue Bird Dairy	2985 Rubidoux Blvd Riverside	X		
Blue Ribbon Dairy Inc.	323 E Alisal St Salinas	X		
Brentwood Farms Milk Co.	2585 California St. Mt. View	X		
Brewster Foods	7127 Canby Ave Reseda	X		
Brookside Dairy	Route 2, Box 67 Redlands	X		
Brothers Three Dairy	11423 E Florence Ave Santa Fe Springs	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Cacique Cheese Company	3610 Monroe St. Richmond	X		
Cal Va Dairy	1190 North Glassell Orange	X		
Cal Va Dairy	4226 West 5 Santa Ana	X		
Cal Va Dairy Drive-Thru	6297 Ball Road Cypress	X		
Cal Va Dairy Drive-Thru	7931 Speer Huntington Beach	X		
California Coast Dairymen	1250 South Ave Turlock	X		
California Cheese Co.	1451 Sunny Court San Jose			X
California Cooperative Creamery	1527 N Street Newman	X		
California Cooperative Creamery	Western Ave-Baker St. Petaluma			X
California Cooperative Creamery	530 Aurora Street Stockton	X		
California Cooperative Creamery	2401 McArthur Tracy			X
California Milk Producers Assn.	11709 East Artesia Blvd Artesia	X		
Carnation Company	201 Union Ave Bakersfield		X	
Carnation Company	P.O. Box 36 Gustine			X

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Carnation Company	1639 N Main Street Los Angeles			X
Carnation Company	8015 Van Nuys Blvd. Van Nuys	X		
Carnation Company	1310 14th Street Oakland			X
Carnation Company	354 11 Avenue San Diego	X		
Carnation Company	Turlock	X		
Central Valley Dairy Co.	755 F Street Fresno	X		
Certified Grocers of California Ltd.	3626 11th Avenue Los Angeles			X
Challenge Cream & Butter Assn.	708 Addison Berkeley	X		
Challenge Cream & Butter Assn.	Fernbridge	X		
Challenge Cream & Butter Assn.	15729 E Smithway St Los Angeles	X		
Challenge Cream & Butter Assn.	2650 18 Street San Francisco	X		
Chino Dairy	13613 Central Ave Chino	X		
Clancy Muldoons	11834 Wilshire Blvd. Los Angeles	X		
Clearbrook Dairy	11230 Wright Road Lynwood	X		
Cloverdale Creamery	37085 Fremont Blvd. Fremont	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Collica Dairy	8228 Phlox Street Downey	X		
Continental Culture Specialist	1354 E Colorado Blvd Glendale	X		
Consolidated Dairy Products	1474 N Indiana Street Los Angeles		X	
Country Maid Dairy	P.O. Box 75 Smith River	X		
Covina Meadows	4030 Glendora Ave Covina	X		
Crafton Dairy	1765 E Citrus Avenue Redlands	X		
Crystal Cream & Butter Company	1013 D Street Sacramento			X
Culp Dairy	8554 Beverly Blvd. Pico Rivera	X		
D-V Marketing Ltd	939 E Street Modesto		X	
Dairy Enterprizes Co.	735 East Baseline San Bernardino	X		
Dairy Fresh	1013 D Street Sacramento	X		
Dairy King Milk Farms	11501 Exposition Blvd. Los Angeles	X		
Dairy Mart Farms, Inc.	2050 Dairy Mart Rd San Ysidro	X		
Dairy Rich Milk Co.	3071 East 14 Street Oakland	X		

Table 8-1a. California continued

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Dairy Valley Cheese Corp.	17227 Jersey Ave Artesia	X		
Dairymens Coop. Creamery Assn.	400 So. M Street Tulare			X
Daisy Farms	4876 Stevens Creek Rd Santa Clara	X		
Danish Creamery Assn.	E & Inyo Sts 755 F St Fresno			X
De Jongs Dairy	Route 2, Box 505 Elsinore	X		
Denham Company	520 Lacey Blvd Hanford	X		
Deveni's Dairy	Route 1, Box 484 Fort Bragg	X		
Dipsey Doodle Inc.	7811 South Alameda Los Angeles	X		
Dreyers Grand Ice Cream Inc.	5929 College Ave. Oakland		X	
Driftwood Dairy	10724 Lower Azusa Rd El Monte		X	
Du Mor Milk Deport Inc.	1261 E Newell Walnut Creek	X		
Dutch Maid Dairy Drive-In	2110 South Broad St San Luis Obispo	X		
Dutch Premium Dairy	4894 Tequesquite Avenue Riverside	X		
Dutch Pride Dairy	215 East 18 Street Antioch	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
EM Consumer Corp	575 1st Street Gilroy	X		
Eastside Dairy Farms Inc.	2929 North Durfee Ave El Monte	X		
Edgemar Farms	346 Rose Ave. Venice		X	
Eds Dairy	16561 Bolsa Chico Rd Huntington Beach	X		
Evergreen Dairy Ranch	2218 Quimby Road San Jose	X		
Excelsior Creamery Co. Ltd	926 E First Street Santa Ana	X		
Favorite Foods	1901 Via Burton Fullerton		X	
Fletcher Hills Farms	1055 North Cuyamaca El Cajon	X		
Foothill Dairy	8145 Canyon Road Azusa	X		
Foothill Home Dairy	5500 Auburn Sacramento	X		
Foremost Foods Co.	175 S. Redwood Hwy Fortuna		X	
Foremost Foods Co.	450 Belmont Ave. Fresno	X		
Foremost Foods Co.	P.O. Box 307 Gustine	X		
Foremost Foods Co.	2331 Tully Road Hughson			X

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Foremost Foods Inc.	P.O. Box 531 Lemoore			X
Foremost Foods Inc.	490 F Street Lemoore	X		
Foremost Foods Inc.	281 Loleta Drive Loleta		X	
Foremost Foods Inc.	P.O. Box 428 Loleta	X		
Foremost Foods Inc.	802 8th Street Los Banos	X		
Foremost Foods Inc.	1739 Albion Los Angeles			X
Foremost Foods Inc.	5829 Smithway St Los Angeles			X
Foremost Foods Inc.	214 19th Street Sacramento			X
Foremost Foods Inc.	835 K Street San Diego	X		
Foremost Foods Inc.	366 Guerreto Street San Francisco			X
Foremost Foods Inc.	1675 Howard Street San Francisco			X
Foremost Foods Inc.	Cedar & Tehema Sts Willows		X	
Fortuna Cheese Factory	858 Riverside Drive Chico	X		
Foss Bros. Dairy	6641 Riverside Drive Chino	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Fosselmans	1824 West Main St Alhambra	X		
Foster Farms Jersey Dairy	1707 McHenry Ave. Modesto		X	
Friendly Quality Dairies	14341 Newland Westminster	X		
Frozen Desserts Co.	6659 Santa Monica Blvd. Hollywood	X		
Gardena Cheese Co.	5583 E Imperial Hwy. South Gate		X	
Galaxy Products Inc.	2 Spain St Sonoma	X		
Giacopuzzi Dairy	4223 Vineyard Ave El Rio	X		
Gilbert Brockmeyer Ice Cream Co.	1527 N Street Newman	X		
Gilt Edge Creamery	685 4th Street San Francisco	X		
Glen Farms	12986 Branford Street Pacoima	X		
Glen Farms Inc.	9021 East Beverly Road Pico Rivera	X		
Glen Oaks Dairy	1095 Yulupa Ave Santa Rosa	X		
Glendora Quality Dairy	860 South Glendora Ave Glendora	X		
Glenn Milk Producers Assn.	P.O. Box 868 Willows		X	

Table 8-1a. California continued.

Name	Address	Average weekly use of milk Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Gold N Rich Corp.	2031 Second Street Berkeley	X		
Golden Arrow Co.	2750 Kurtz St San Diego			X
Golden Arrow Dairy	2014 West Vista Way Vista	X		
Golden Coast Dairy	6416 Hollister Ave Goleta	X		
Golden Jersey Dairy Inc.	11090 San Pablo Ave El Cerrito	X		
Golden State Foods	60 North Sierra Madre Pasadena	X		
Grays Ice Cream Inc.	480 E Sixth Street Beaumont	X		
Green Mill Dairy	8761 Knott Ave Buona Park	X		
Grueters Swiss Dairy	237 South Azusa Ave La Puente	X		
Hailwood Inc., Chase Bros.	E. 5th & Wolff Road Oxnard		X	
Ham & Son Ice Cream	11369 South Atlantic Blv Lynwood	X		
Harpains Dairy Farm	3949 North Barton Fresno	X		
Hendricks Milk Drive-In	605 Hickory St Red Bluff	X		
Hershey Foods Corp.	Milk Receiving Room Oakdale	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Hillsdale Dairy Farms	201 Lewis Road San Jose	X		
Hites Dairy Farm	3900 Fruitridge Rd Sacramento	X		
Holdener Dairy	985 E Stanley Blvd Livermore	X		
Holland Dairy Drive-In	140 E Travis Blvd Fairfield	X		
Hollandia Dairy	540 West Felicita Ave Escondido	X		
Hollendia Dairy	622 Mission Road San Marcos	X		
Hopson Dairy Inc.	Route 1, Box 1790 Anderson	X		
Hudson Dairy	17010 Van Ness Ave Torrance	X		
Humboldt Creamery Assn.	P.O. Box 33 Fernbridge			X
Instantwhip - Los Angeles Inc.	830 Main Street Pleasanton	X		
Instantwhip - San Francisco Inc.	136 South Second Richmond	X		
Jersey Gold Dairy	12627 South Street Cerritos	X		
Jersey Cow Dairy Drive-In	315 North Main St Manteca	X		
Jerseymaid Milk Products Co.	1040 W. Slauson Ave Los Angeles			X

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Jerseymaid Milk Products Co.	442 South Fair Oaks Pasadena	X		
Jerseymaid Milk Products Co.	2522 E. 37th Vernon			X
John Boere Dairy	6842 East Alondra Paramount	X		
John Boere Dairy	9910 Glenoaks Sun Valley	X		
Johnston Foods Inc.	550 Rodier Drive Glendale	X		
Joplin Boys Ranch	P.O. Box 307 Trabuco Canyon	X		
K-N Marketing Ltd.	3380 West Ashlan Ave Fresno		X	
K-V Marketing Ltd.	510 9th Street Modesto	X		
Knudsen Creamery of California	231 East 23rd St Los Angeles	X		
Knudsen Company	240 North Avenue Gustine	X		
Knudsen Dairy Products	2101 S. Los Angeles St. Los Angeles			X
Knudsen Dairy Products	415 Kansas Ave. Modesto			X
Knudsen Dairy Products	1049 Baseline San Bernardino	X		
Knudsen Dairy Products	1100 Goshen Avenue Visalia			X
Kraft Foods	6950 Artesia Ave Buena Park	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Langlois Flour Co.	5354 E Slauson Los Angeles	X		
Larsons Dairyland	2800 Larson Lane Bakersfield	X		
Laurel Industries Inc.	9647 Rush St South El Monte	X		
Laurelwood Acres	P.O. Box 577 Ripon	X		
Lawndale Dairy	4210 West Compton Blvd. Lawndale	X		
Liquidiet Formulas	6115 Manchester Blvd. Buena Park	X		
Little Home Dairy	11421 Ocean Ave. La Habra	X		
Lockman Drive-In Dairy	22010 South Avalon Blv Carson	X		
Lockmann Farms	24327 South Main St Wilmington	X		
Loma Linda University	4700 Pierce Place Riverside	X		
Longs Dairy	8627 E Rosecrans Blv Paramount	X		
Luckens Drive-In Dairy	1814 West Edinger Santa Ana	X		
Lucky Stores - Markets Inc.	2550 Merced St. San Leandro			X
Lukens Drive-In Dairy	425 So. State Col. Blvd Anaheim	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk: Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
M & G Yogurt Co.	900 Leavenworth Str San Francisco	X		
Maple Dairy Farm	737 So. Maple Ave. Montebello	X		
Marin Dairymen's Milk Co.	1675 Howard Street San Francisco	X		
Marin French Cheese Co.	7500 Red Hill Road Petaluma			
Markets Inc. - Lucky Stores Inc.	6565 Knott Ave. Buena Park			X
Masson Cheese Corp.	6218 Maywood Bell	X		
Mava Ice Cream Co.	1111 West Sixth St Corona	X		
Mayfair Creamery	20301 South Western Ave. Torrance	X		
McColls Dairy Products Co.	2500 Angelo Redding		X	
McConnels Fine Ice Cream	2001 State Street Santa Barbara	X		
McMullan Dairy	3259 North Frazier St. Baldwin Park	X		
Meadow Gold Dairies	120 Elm St Los Gatos		X	
Meadow Gold Dairies	519 Main St Watsonville		X	
Meadow Park Dairy	17018 South Normandie Gardena	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk: Under 500,000 lbs.	Average weekly use of milk: 500,000 to 999,999 lbs.	Average weekly use of milk: 1,000,000 or more lbs.
Meadowlark Dairy	3459 Foothill Road Pleasanton	X		
Medo Bel Creamery	345 College Ave. Gardena	X		
Meyenberg Milk Products Inc.	408 E Alondra Blvd. Compton	X		
Meyenberg Milk Products Inc.	339 Industrial St. Ripon		X	
Miersma Dairy	11446 E. Artesia St. Artesia	X		
Mr. Milk Bottle Dairy	1533 Indian Hill Blvd. Pomona	X		
Milk Pail	21150 Redwood Road Castro Valley	X		
The Milk Pail	286 Jackson Street Hayward	X		
The Milk Stop	321 South Hutchins Str. Lodi	X		
Milkaway Dairy	1051 Mangrove Chico	X		
Mr. Milkman Inc.	400 South Blosser Road Santa Maria	X		
Milky Way Dairy	2442 Elm Ave Fresno	X		
Miller Dairy	7953 Mt. Vernon St Lemon Grove	X		
Millers Dairy	9501 Mill Station Road Sebastopol	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk: Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Monte Vista Dairy	2 School Way Watsonville	X		
Montebello Sanitary Dairy	505 South Maple Ave. Montevello	X		
Montclair Drive-In Dairy	5157 San Bernardino Rd Montclair	X		
Montrose Dairy	9850 Lower Azusa Rd El Monte	X		
Moreno Cheese Co.	Route 2, Box 181 Chino	X		
Morgan Ice Cream Co.	9228 E. Valley Blvd. Rosemead	X		
Morning Glory Dairies	1900 Richmond Road Susanville	X		
Mountain View Dairies Inc.	725 W. Anaheim St. Long Beach	X		
Namar Company	7530 Jefferson Street Paramount	X		
Newark Farms Inc.	134931 Newark Blvd. Newark	X		
Nielsons Creamery	136 East Cross Tulare	X		
Norwalk Dairy Inc.	13101 E Rosecrans Ave Santa Fe Springs	X		
P & M Cheese Corp.	1155 Pacheco Blvd. Los Banos	X		
Pacoima Drive-In Dairy	13032 Van Nuys Pacoima	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Palos Verdes View Dairy Inc.	20301 South Western Ave. Torrance	X		
Par Mel Ice Cream Co.	5321 South Central Ave. Los Angeles	X		
Paramount Drive-In Dairy	400 West Rosecrans Compton	X		
Paramount Milk Depot	2721 Del Amo Blvd. Lakewood	X		
Pauls Dairy	6170 Paramount Blvd. Long Beach	X		
Peninsula Creamery	875 Alma St. Palo Alto	X		
Petaluma Cooperative Creamery	Western Ave & Baker St. Box 950 Petaluma	X		
Peter Pan Dairy	16940 Chatsworth Street Granada Hills	X		
Piers Dairy	3070 Louis Road Palo Alto	X		
Pine View Dairy	1430 South East End Ave. Pomona	X		
Pleasant Hills	1829 South White Road San Jose	X		
Pomona Valley Creamery	4835 Mission Blvd. Ontario	X		
Premier Creamery	6th and Elm Streets Coalinga	X		
Producers Dairy Delivery Co. Inc.	144 Belmont Ave Fresno	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk: Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Purity Dairy	9810 South Painter St. Whittier	X		
Quaker Maid Dairy	7026 South Comstock Ave. Whittier	X		
Quaker Ice Cream Co.	100 South Cherokee Lane Lodi	X		
Quaker Maid Farms	16823 Carmenita Road Cerritos	X		
Quality Dairy	619 New York Street Redlands	X		
Quality Dairy Farms	25642 Avenue 14 Madera	X		
Ralphs Grocery Co.	2201 S. Wilmington Compton			X
Real Fresh Milk Inc.	1221 E. Noble Visalia	X		
Reddi Whip Manufacturing Co.	2443 E 27th Street Los Angeles	X		
Redwood Drive-In Dairy	2560 Petaluma Blvd. No. Petaluma	X		
Redwood Drive-In Dairy	10855 Occidental Road Sebastopol	X		
Rex Bottling Co.	1209 N Court Visalia	X		
Rialto Home Dairy	206 South Lilac Ave. Rialto	X		
Richmaid Ice Cream Co.	100 South Cherokee Lane Lodi	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Ridgewood Ranch Dairy	P.O. Box 659 Willits	X		
Riverbank Cheese Company	6603 Second St Riverbank	X		
Riverside Dairy	6726 Doolittle Ave. Riverside	X		
Rockview Dairies Inc.	7011 Steward & Gray Sts. Downey		X	
Rocky Home Dairy Inc.	12027 Rocky Home Drive Lakeside	X		
Rombergs Drive-In Dairy	19655 Arnold Drive Sonoma	X		
Roosevelt Dairy	7216 Alondra Blvd. Paramount	X		
Rosecrest Dairy	11703 E Rose Avenue Selma	X		
Royal Jersey Inc.	3508 San Pablo Dam Blvd. El Sobrante	X		
Royal Oaks Dairy Farm	Box 176 Ojai	X		
Royal Spumoni & Ice Cream Co.	835 South Vermont Ave. Los Angeles	X		
Rubidoux Dairy Farms	3260 Rubidoux Blvd. Rubidoux	X		
Rumieno Cheese Co.	9th and E Streets Crescent City	X		
Rumiano Cheese Co.	231 West Wood Street Willows	X		
Ryns Dairy Prod.	17389 Arrow Blvd. Fontana	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
S & M Marketing	Boone & Oakley Sts. Santa Maria		X	
Safeways Stores Inc Milk Depot	P.O. Box G-1070 Hanford			X
Safeway Stores Inc	612 West 5th Hanford	X		
Safeway Stores Inc Ice Cream Inc.	3327 S. Boxford Ave. Los Angeles		X	
Safeway Stores Inc Milk Dept.	3361 S. Boxford Ave. Los Angeles			X
Safeway Stores Inc Ice Cream Inc.	2240 Filbert St. Oakland			X
Safeway Stores Inc Milk Dept.	5725 E. 14th St. Oakland			X
Safeway Stores Inc Milk Dept.	4400 Florin Perkins Rd Sacramento		X	
Sampson Milk Prod.	21422 So. Alameda Str. Long Beach	X		
San Fernando Valley Creamery	9220 E Firestone Vlvd. Downey	X		
San Joaquin Valley Milk Producers	1155 Pacheco Blvd. Los Banos			X
San Joaquin Valley Dairymens Assn.	P.O. Box 548 Newman	X		
San Juan Dairy	8845 Fair Oaks Blvd. Carmichael	X		
Sanitary Dairy	1613 West Muir Street Fillmore	X		
Santa Cruz Dairy Farms	2202 Soquel Ave. Santa Cruz	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Scott Bros. Dairy	1200 South East End Ave. Pomona	X		
Scottsman's Farms	2100 North Santa Fe Ave. Compton	X		
Select Dairies	8101 East Compton Paramount	X		
Sequoia Creamery	1254 West Tulare Road Lindsay	X		
Shady Grove Dairy Inc.	711 W. Holt Blvd. Ontario		X	
Sierra Cheese Mfg. Co.	916 South Santa Fe Compton	X		
Sonoma Mission Creamery	465 Cabot Road San Francisco		X	
Stan Co. Cheese Company	3141 Sierra Street Riverbank	X		
Standard Cheese Co., Inc.	830 Main Street Pleasanton	X		
Stauffer Chemical Co.	712 North Leslie Visalia	X		
Steelmans Creamery	1070 North Western Ave. Los Angeles	X		
Stornettas Dairy	4300 Fremont Drive Sonoma	X		
Sun Up Dairy	1500 East George St. Banning	X		
Sunny Crest Dairy	9152 Westminster Ave. Westminster	X		
Sunshine Dairy	4644 North Maxson Rd. El Monte	X		

Table 8-1a. California continued.

Name	Address	Average weekly use of milk Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Sunshine Farms Inc.	753 16th Street Merced	X		
Super Dairy	14042 South Garfield Ave. Paramount	X		
Superior Dairy Products Co.	325 North Douty St. Hanford	X		
Superior Milk Producers Assn.	10581 South Los Alamitos Los Alamitos	X		
Swensons on the Mall	1025 K Street Sacramento	X		
Swiss Dairy	4221 Buchanan Riverside	X		
Sycamore Hill Farm	Route 2, Box 2230 Newcastle	X		
Teunissen Dairy	4500 Van Buren Street Riverside	X		
Thrifty Drugstores	9200 Telstar Ave. El Monte			X
Thrifty Drugstores Inc.	915 North Mansfield Hollywood	X		
Todds Food Co.	2731 Halladay Street Santa Ana	X		
Todds Food Co.	231 East 23rd Street Los Angeles			X
Tomales Bay Creamery	561 Eccles Ave. South San Francisco	X		
Tulare Home Dairy	1401 West Inyo Ave. Tulare	X		
Tuttle Cheese Co.	2401 Union Street Oakland	X		

Table 8-1a. California continued.

Name	Address	Average weekly uses of milk: Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Valley View Farms	13907 Valley View La Mirada	X		
Van Kampens Drive-In Dairy	22441 South Norwalk Blv Hawaiian Gardens	X		
Vans Dairy Farms Inc.	5800 South Street Lakewood	X		
Vans Dairy Farms Inc.	10030 Orr & Day Rds. Santa Fe Springs	X		
Vella Cheese Co.	315 East 2nd St. Sonoma	X		
Velvet Ice Cream Co.	708 L Street Modesto	X		
Vermont Dairy Farms	22400 South Vermont Torrance	X		
Vics Ice Cream	3199 Riverside Blvd. Sacramento	X		
Vitafreeze Frozen Confection	1210 66th Street Sacramento	X		
Vons Grocery Co.	10150 Lower Azusa Road El Monte	X		
Walkers Dairy	16650 Mojave Drive Victorville	X		
Waynes Dairy	4050 North Chester Ave. Bakersfield	X		
Wesdamar Goat Dairy	23401 Yucca Lorna Road Apple Valley	X		
Western Dairy Products Inc.	405 East D Street Petaluma	X		

Table 8-1a. California continued.

Name	Address	Average weekly uses of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Western Holstein Farms Inc.	3100 So. Grand Ave. Los Angeles	X		
Whipped Butter Products Inc.	1164 E Hyde Park Blvd. Inglewood	X		
White Rose Dairy	697 North Wuterman Ave. San Bernardino	X		
Wil Wright Ice Cream	8252 Santa Monica Blvd. Los Angeles	X		
Wilsey Bennett Co.	633 So. Mission St. Los Angeles	X		
Wilsey Bennett Co.	2300 Army Street San Francisco	X		
Woodbury Ranch Dairy Inc.	2020 N. Winery Fresno		X	

Table 8-1b. Dairy processing plants in Idaho.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
A & A Dairy	Route 2, Box 96A Pocatello, Idaho	X		
Albertson's Inc.	P.O. Box 20 Boise, Idaho	X		
Ashton Dairy	Route 1, Box 36 Payette, Idaho	X		
Associated Dairies Inc.	3310 Gekeler Land Boise, Idaho			X
Bingham Dairy	Route 3, E. Addison Twin Falls, Idaho	X		
Boise Fruit and Produce Co.	501 So. 8th St. Boise, Idaho	X		
Cammack Dairy	498 So. Fisher Blackfoot, Idaho	X		
Carroll's Dairy	Route #2 Emmett, Idaho	X		
Circle K. Corp.	6703 Ustick Rd. Boise, Idaho	X		
Coeur d'Alene Creamery	304 North 4th Coeur d'Alene, Ida.	X		
Commerical Creamery Co.	Moscow Idaho Plant Moscow, Idaho	X		
Commerical Creamery Co.	Kamiah Idaho Plant So. 159 Cedar St. Spokane, Washington	X		
Cottonwood Dairy	Cottonwood, Idaho	X		
Dairyland Dairy, Inc.	260 So. State Rigby, Idaho	X		

Table 8-1b. Idaho continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Dairymen's Creamery Assn.	520 Albany Caldwell, Idaho			X
Delsa's Ice Cream	7923 Ustick Boise, Idaho	X		
Elison Dairy	655 Airport Rd. Blackfoot, Idaho	X		
Emmett Dairy	109 E. 4th St. Emmett, Idaho	X		
Farm Dairy	Star Route Mullan, Idaho	X		
Farr Candy Co., Inc.	345 D Street Idaho Falls, Ida.	X		
Flavor Freeze	P.O. Box 397 Caldwell, Idaho	X		
French's Dairy	Route 4 Buhl, Idaho		X	
Fun Farm Dairy	Route 1 St. Anthony, Ida.	X		
Gold Seal Dairy	850 Benjamine Ln Boise, Idaho	X		
Golden Grain Dairy Prod.	1830 Main Street Lewiston, Idaho		X	
High "C" Acres	Route 3 Meridian, Idaho	X		
Home Dairies Co.	424 12th Ave. Rd. Nampa, Idaho	X		
Hopperdeitzel Cheese Co.	39 East 6th South St. Anthony, Ida.		X	

Table 8-1b. Idaho continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Ida Gem Dairymen's Assn.	220 South Birch Jerome, Idaho			X
Idaho Rocky Mountain Dairy	Pocatello Creek Rd. Pocatello, Idaho	X		
Kraft Foods Co.	P.O. Box 4047 Pocatello, Idaho	X		
Kraft Foods Co.	Blackfoot, Idaho			X
Kraft Foods Co.	Carey, Idaho		X	
Kraft Foods Co.	Ririe, Idaho		X	
Kraft Foods Co.	Rupert, Idaho			X
Kraft Foods Co.	Caldwell, Idaho			X
Lost River Valley Dairy	Darlington, Idaho	X		
Manwaring Yellowstone and Teton	Box 416 Rigby, Idaho	X		
Meadow Gold Dairies	856 South 1st Ave. Pocatello, Idaho	X		
Meadow Gold Dairies	Miller Street Boise, Idaho		X	
Meadow Gold Dairies	1301 Bannock St. Boise, Idaho			X
Meadow Lawn Dairy	Route 2 Meridian, Idaho	X		
Milky Way Dairy	100 South State Rigby, Idaho	X		
Mountain Empire Dairymen's Assn.	237 West Taylor St. Meridian, Idaho	X		

Table 8-1b. Idaho continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Nelson Ricks Creamery	Rexburg, Idaho		X	
Paradise Dairy	Star Route #1 Bonners Ferry, Ida.	X		
Patten Dairy	Route 1 Boise, Idaho	X		
Pend Oreille Cheese Co., Inc.	P.O. Box 518 Sandpoint, Idaho	X		
Pet Inc.	500 Condensory Rd. Buhl, Idaho			X
Reed Bros. Dairy	Route 5, Box 3 Idaho Falls, Ida.	X		
Rowland's Inc.	Box 1151 Pocatello, Idaho		X	
Salmon Valley Cheese Co.	P.O. Box B Salmon, Idaho	X		
Sam's Dairy	Route 3 Moscow, Idaho	X		
Smith's Dairy	205 So. Broadway Buhl, Idaho	X		
Smith's Dairy Products Inc.	205 So. Broadway Buhl, Idaho	X		
Starks Family Corp.	Route 1, Box 49 Payette, Idaho	X		
Stoker's Dairy	260 East 100 South Burley, Idaho	X		
Sun Ray Dairy	6127 Franklin Road Boise, Idaho		X	

Table 8-1b. Idaho continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Swift and Co.	264-4th Ave. So. Twin Falls, Idaho			X
Swiss Village	Route 3 Nampa, Idaho		X	
Tomlinson's Dari-Mart	332 Thain Lewiston, Idaho	X		
Triangle Dairy	3310 Gekeler Lane Boise, Idaho	X		
Twenty-Four Flavors Ice Cream	322 East Main Burley, Idaho	X		
Upper Sanke River Valley Dairymen's Assn., Inc.	P.O. Box 1847 Idaho Falls, Idaho	X		
Wallace Dairy	Route 3, Box 12 Idaho Falls, Idaho	X		
Ward Cheese Co.	P.O. Box 96 Richfield, Idaho			X
Ward's Dairy	Route 2, Box 96 Pocatello, Idaho	X		
Western General Dairies	P.O. Box 1847 Idaho Falls, Idaho			X
Yellowstone and Teton Cheese	P.O. Box 416 Rigby, Idaho	X		
Young's Dairy Products Co.	143-4th Ave. West Twin Falls, Idaho		X	

Table 8-1c. Dairy processing plants in Oregon.

Name	Address	Average weekly use of milk: Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Alpenrose Dairy	6149 SW Shattuck Rd. Portland, Oregon			X
Arden-Mayfair, Inc.	617 SE Main Street Portland, Oregon		X	
Carnation Company	3342 SW Morrison St. Portland, Oregon			X
Coquille Valley Dairy Coop.	2nd Street E Brandon, Oregon		X	
Curly's Dairy Inc.	2310 Mission St. SE Salem, Oregon		X	
Cutlips Ice Cream Co.	Washington & Sheridan North Bend, Oregon	X		
DeLuxe Ice Cream Co.	1860 State Street Salem, Oregon		X	
DeLuxe Ice Cream Co.	1860 State Street Salem, Oregon	X		
Dutch Girl Ice Cream Co.	1780 West Eighth Eugene, Oregon	X		
Eberhard Creamery	Box 845 Redmond, Oregon	X		
Echo Spring Dairy	1750 West 8th Eugene, Oregon	X		
Erickson's Dairy Products, Inc.	927 SE Marion St. Portland, Oregon	X		
Eugene Farmers Creamery	568 Olive Street Eugene, Oregon		X	
Farmers Coop Creamery	P.O. Box 119 McMinnville, Oregon			X

Table 8-1c. Oregon continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Fred Meyer, Inc.	4950 Basin Road Portland, Oregon			X
Foremost Foods Co.	8440 NE Halsey Portland, Oregon	X		
Jones Boys Dairy	Route 5, Box 160 Hood River, Oregon	X		
Kilgore's Dairy	536 South 6th Redmond, Oregon		X	
Klamath Falls Creamery	P.O. Box 488 Klamath Falls, Ore.		X	
Larsen's Creamery	215 Thirteenth Oregon City, Oregon	X		
Lloyd's Dairy	3825 Gilham Road Eugene, Oregon	X		
Lochmead Dairy	4155 99-W Junction City, Ore.	X		
Madrona Diary	3425 Madrona Land Medford, Oregon	X		
Mallorie's Dairy	P.O. Box 618 Silverton, Oregon		X	
Mayflower Farms	2720 SE 6th Portland, Oregon			X
Mayflower Farms	1300 Court Street Medford, Oregon		X	
McMinnville Sunshine Dairy	P.O. Box 282 McMinnville, Oregon		X	
Meadowland Dairy	16430 SW Powell Blvd. Portland, Oregon	X		

Table 8-1c. Oregon continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Meadow Gold Creamery Co.	675 Charnelton Eugene, Oregon		X	
Medo-Bel Creamery	1500 Explanade Klamath Falls, Ore.		X	
Pope Dairy	617 LaCreole Drive Dallas, Oregon	X		
Reedsport Creamery and Cheese Fty.	250 Water Street Reedsport, Oregon	X		
Rogue River Valley Creamery	P.O. Box 606 Central Point, Ore.		X	
Safeway Stores, Inc.	P.O. Box 455 Myrtle Point, Ore.		X	
Safeway Stores, Inc.	P.O. Box 275 Clackamas, Oregon			X
Senn's Drive-In Dairies, Inc.	11206 NE Prescott Portland, Oregon		X	
Seppa Dairy Co.	Route 3, Box 270 Astoria, Oregon	X		
Springfield Creamery	145 North 3rd Springfield, Oregon		X	
Standard Dairy	2808 NE Union Ave Portland, Oregon		X	
Sunny Brook Dairy	1025 North 9th Corvallis, Oregon		X	
Sunshine Dairy	801 NE 21st Portland, Oregon		X	
Three Jay's Dairy Inc.	10815 Old Stage Road Gold Hill, Oregon	X		

Table 8-1c. Oregon continued.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Tillamook County Creamery Assn.	P.O. Box 313 Tillamook, Oregon			X
Twin Oaks Dairy	8485 River Road Hillsboro, Oregon	X		
Umpqua Diary Products Co.	333 SE Sykes Roseburg, Oregon	X		
Valley of the Rogue Dairy	P.O. 'Box 1327 Grants Pass, Ore.	X		
Walker's Dairy	Route 3, Box 138 Scio, Oregon	X		

Table 8-1d. Dairy processing plants in Nevada.

Name	Address	Average weekly use of milk		
		Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
Anderson Dairy	P.O. Box 2017 Reno, Nevada		X	
Anderson Dairy	1440 Las Vegas Blvd. Las Vegas, Nevada			X
Arden-Mayfair, Inc.	1000 North Main St. Las Vegas, Nevada		X	
Creamland Dairy	500 Harrigan Road Fallon, Nevada	X		
Meadow Gold Dairies	2600 Mill Street Reno, Nevada		X	
Model Dairy	P.O. Box 477 Reno, Nevada		X	
Nevada Dairy Distributors	2960 Westwood Las Vegas, Nevada	X		
Valley Dairy	123 McKenzie Land Yerington, Nevada	X		
Vegas Valley Farms	Logandale, Nevada		X	

Table 8-1e. Dairy processing plants in Utah.

Name	Address	Average weekly use of milk Under 500,000 lbs.	500,000 to 999,999 lbs.	1,000,000 or more lbs.
BYU Dairy Products Lab	Brigham Young Univ. Provo, Utah	X		
Blue Hill Dairy	P.O. Box 298 Helper, Utah	X		
Bluebird Ice Cream	Logan, Utah	X		
Brown's Dairy	Coalville, Utah	X		
Burton Place Dairy	2365 S.W. Temple Salt Lake City, Utah	X		
Cache Valley Dairy Assn.	Smithfield, Utah			X
Clearfield Cheese	Wellsville, Utah	X		
Cow Palace	Smithfield, Utah	X		
Deseret Dairy	751 West 7th South Salt Lake City, Utah	X		
Ekins Golden Arrow Dairy	Hinckley, Utah	X		
Erekson Brothers Dairy	701 East 5900 South Murray, Utah	X		
Farr Better Ice Cream Co.	274 21st Street Ogden, Utah	X		
Fendall Ice Cream	470 South 7th East Salt Lake City, Utah	X		
Fernwood Ice Cream	150 West Commonwealth Salt Lake City, Utah	X		
Fisher Dairy	2891 South 20th East Salt Lake City, Utah	X		

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