

A. E. INFORMATION SERIES NO. 81 DEPARTMENT OF AGRICULTURAL ECONOMICS NORTH CAROLINA STATE COLLEGE RALEIGH, NORTH CAROLINA DECEMBER, 1960

Case Handling Costs In Fluid Milk Plants

Digitized by the Internet Archive in 2016

https://archive.org/details/casehandlingcost00simm

Case Handling Costs In Fluid Milk Plants

Richard L. Simmons Assistant Professor

A. E. Information Series No. 81 Department of Agricultural Economics North Carolina State College Raleigh, North Carolina December, 1960

PREFACE

This is the first in a series of studies designed to reduce the costs of distributing fluid milk. Publications are planned dealing with wholesale milk distribution and the costs and returns of operating branch sales plants.

This study shows that substantial reductions in the costs of case handling can be achieved by the proper selection of equipment, building design and work crew organization.

This study is a contribution to Southern Regional Project SM-10 revised, "Establishing Guides for Efficient Organization of the Dairy Industry Under Changing Conditions in the South." The project is a cooperative undertaking by the Agricultural Experiment Stations of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Texas and the Agricultural Marketing Service of the United States Department of Agriculture.

The author gratefully acknowledges the cooperation received from many fluid milk plants in North Carolina and Florida in offering their plant facilities and accounting data for analysis. Appreciation is expressed to Creamery Package Company, Cherry Burrell and the Mojonnier Company for aid in the design and costs of the conveyor systems, to Dr. Richard Knight of the Department of Mechanical Engineering for help in estimating refrigeration requirements, and to Armstrong Contracting and Supply and Recony Sales and Engineering for help in estimating building requirements and costs. Dr. William Roberts and Dr. Robert Redfearn provided helpful advice on the technical aspects of plant operation.

SUMMARY AND CONCLUSIONS

This study analyzes the costs of case handling in fluid milk plants. Four different case handling methods are analyzed for model plants comparable to actual plants in North Carolina. A complete list was made of the inputs and services necessary to accomplish the case handling operation. Building and equipment lists were compiled according to engineering specifications. Work crew requirements were estimated from time and motion studies. Electricity costs were estimated from the horsepower requirements of the power equipment. Waiting time of the truck drivers was estimated by the application of queuing theory to known frequencies of truck arrivals and loading times.

The analysis indicates that the proper design and use of an infloor conveyor system can accomplish the case handling function with a substantial cost saving over the older system of an above-floor conveyor. Still further cost savings can be realized by making up the shipping orders directly from the conveyor if the filling operation is correctly coordinated with the case handling work in the cold room. The magnitude of annual cost savings between the above-floor conveyor system and the infloor conveyor system with preformed loads ranged from \$4,300 for a model plant bottling one million pounds of fluid milk per month to \$26,000 for a model plant bottling eight million pounds per month.

TABLE OF CONTENTS

SUMMARY AND CONCLUSIONS	Page 3
INTRODUCTION Purpose of Study Scope of Study Procedure Applicability of Results	9 9 10 10 11
COST ESTIMATION PROCEDURE Building Costs Equipment Costs Labor Costs Cost of Salesman Time at Loading Docks Utilities	11 12 13 13 14 16
COST ANALYSIS FOR MODEL PLANT C Characteristics of Plant C Description of Case Handling Method No. 1 Building Costs Equipment Costs Labor Costs Cost of Salesman Time Utilities	17 17 22 26 26 26 26 36 36
Description of Method 2 for Plant C Building, Equipment and Labor Costs Cost of Salesman Time Utilities Description of Method 3, Plant C Building, Equipment and Labor Cost Cost of Salesman Time Utilities	37 38 41 45 46 46 49 49
Description of Method 4 for Plant C Building, Equipment and Labor Costs Cost of Salesman Time Utilities Summary and Conclusions for Plant C	55 55 55 55 62
SUMMARY FOR PLANT B	64
SUMMARY FOR PLANT A	65
SUMMARY FOR PLANT D	66
APPENDIX	70

LIST OF TABLES

rable	e de la constant de l	Page
1	Monthly volume, Product Mix and Retail-Wholesale- Transport Sales Breakdown of Plant C	19
2	Number of Cases of Milk per Month Sold as Retail, Wholesale, Transport	20
3	Daily Variation in Sales	21
4	Initial Building Costs for Plant C, Method 1	27
5	Annual Building Costs for Plant C	27
6	Initial Equipment Cost for Plant C, Method 1	28
7	Annual Equipment Costs for Plant C, Method 1	29
8	Labor Costs for Plant C, Method 1	31
9	Filling Schedule for Plant C for One Day and Product Assignments for Cold Room Workers, Plant C	33
10	Cost of Salesman Time	37
11	Cost of Utilities	38
12	Initial Building Costs	40
13	Annual Building Costs	40
14	Initial Cost of Equipment	41
15	Annual Cost of Equipment	42
16	Labor Costs for Plant C, Method 2	43
17	Cost of Salesman Time, Plant C, Method 2	45
18	Cost of Utilities for Plant C, Method 2	46
19	Initial Building Costs for Plant C, Method 3	48
20	Annual Building Costs for Plant C, Method 3	48
21	Initial Equipment Cost for Plant C, Method 3	50
22	Annual Cost of Equipment for Plant C, Method 3	51

LIST OF TABLES (continued)

2 4 4

rable		Page
23	Labor Costs for Plant C, Method 3	52
24	Cost of Salesman Time, Plant C, Method 3, Loadout Crew of Two and Three	54
25	Initial Building Costs for Plant C, Method 4	57
26	Annual Building Costs, Plant C, Method 4	57
27	Initial Equipment Cost for Plant C, Method 4	58
28	Annual Equipment Cost for Plant C, Method 4	59
29	Labor Requirements and Costs for Plant C, Method 4	60
30	Cost of Salesman Time, Plant C, Method 4	61
31	Electricity Cost for Plant C, Method 4	62
32	Summary of Costs for Plant C, Methods 1, 2, 3, and 4	63
33	Summary of Four Case Handling Methods for Plant B	65
34	Summary of Four Case Handling Methods for Plant A	66
35	Summary of Four Case Handling Methods for Plant D	67
Appei	ndix	
Tab	le	
A-1	An Illustration of the Method of Estimating Time Requirements	70
A-2	Sample Analysis of Work Sampling Sheets	71
A-3	Time Standard for Case Handling Jobs with Infloor Conveyor	73
A-4	Time Standards for Off-Floor Conveyor	77
B-1	A Chi-Square Test To Determine if Truck Arrivals Could Have Come from a Poisson Distribution	79

Appen Tabl		Page
B-2	A Monte Carlo Sample of a Queue of Trucks at Loading Docks A and B	85
C-1	Initial Building Costs for Plant B, Four Case Handling Methods	88
C-2	Annual Building Costs for Plant B, Four Case Handling Methods	91
C-3	Initial Equipment Costs for Plant B, Four Case Handling Methods	92
C-4	Annual Equipment Costs for Plant B, Four Case Handling Methods	95
C-5	Labor Costs for Plant B, Four Case Handling Methods	97
C-6	Cost of Salesman Time for Plant B, Four Case Handling Methods	100
C-7	Utilities Cost for Plant B, Four Case Handling Methods	101
D-1	Initial Building Costs for Plant A, Four Case Handling Methods	103
D-2	Annual Building Costs for Plant A, Four Case Handling Methods	105
D -3	Initial Equipment Costs for Plant A, Four Case Handling Methods	10 6
D-4	Annual Equipment Cost for Plant A, Four Case Handling Methods	109
D - 5	Labor Costs for Plant A, Four Case Handling Methods	110
D -6	Cost of Salesman Time for Plant A, Four Case Handling Methods	113
D -7	Utilities Cost for Plant A, Four Case Handling Methods	114
E-1	Initial Building Costs for Plant D, Four Case Handling Methods	115

Appen Tabl		Page
E-2	Annual Building Costs for Plant D, Four Case Handling Methods	117
E-3	Initial Equipment Costs for Plant D, Four Case Handling Methods	118
E-4	Annual Equipment Costs for Plant D, Four Case Handling Methods	121
E-5	Labor Costs for Plant D, Four Case Handling Methods	122
E-6	Cost of Salesman Time for Plant D, Four Case Handling Methods	125
E-7	Utilities Cost for Plant B, Four Case Handling Methods	126

LIST OF FIGURES

Figur	e	Page
1	Building Design and Conveyor Layout for Plant C, Method 1	23
2	Arrangement of Preformed Loads in Cold Room, Method 1, Plant C	25
3	Building Design and Conveyor Layout for Plant C, Method 2	39
4	Building Design and Conveyor Layout for Plant C, Method 3	47
5	Building Design and Conveyor Layout for Plant C, Method 4	56
B-1	Distribution of Truck Arrivals for Loading during an Afternoon Loading Period	83

Case Handling Costs In Fluid Milk Plants

INTRODUCTION

Substantial variation currently exists in case handling methods among milk bottling plants in North Carolina. Variations occur in the type of equipment used, the design and layout of the plant and the size and organization of work crews. Part of the variation is attributable to differences among plants in the volume of milk bottled, the number and type of trucks loaded, space limitations, age and condition of equipment and the desired degree of accounting control over products. Unfortunately, however, much of the variation results from lack of knowledge about the effects of plant design on the efficiency of case handling. Plants are frequently remodeled long before the expiration of their useful life merely because they were found to be poorly designed. Experience can be an expensive teacher. It is important for plant managers and superintendents to have specific knowledge about the effects of equipment selection and plant design on case handling costs.

Purpose of Study

It is the purpose of this study to analyze several case handling technologies 1/ currently available for milk bottling plants and to indicate those which promise the greatest reduction in monetary cost for plants of the particular types and volumes which are common in North Carolina.

1/ Technology is defined here as a composite of such factors as the type of equipment, the design and layout of the plant, work crew organization and all other phases of organization which result in a distinct and describable method of accomplishing the case handling function.

Scope of Study

Only those portions of the plant which are directly affected by case handling are considered. These portions include the case conveyors, the loading and unloading docks (including the work of all of the driver-salesmen), the milk storage room, and the empty case storage room.

The study is necessarily limited in scope to the consideration of only the most important factors affecting case handling costs. Cost factors selected for specific analysis are (1) the volume of plant, (2) type of equipment and layout, (3) work crew organization, and (4) the number and type of trucks loaded. The effects of less important factors such as number of products, proportion of glass and paper, etc. are acknowledged, but the specific measurement of all of these factors would be quite costly in terms of research inputs. It is believed that the exclusion of these less important factors will not alter the major conclusions of the study.

Another limitation of the study is that it deals only with direct monetary costs. Psychological factors such as the morale of the workers, the degree of physical exertion required in different labor activities and the general desirability of the work may affect the choice of equipment but the lack of adequate procedures for quantifying such factors preludes their direct consideration.

Procedure

From the many different case handling methods currently available, four methods were selected as representing the latest and most promising technologies. Each of the four methods was studied for model plants of four different sizes as follows:

Plant A - 1 million pounds per month of fluid sales Plant B - 2 million pounds per month of fluid sales Plant C - 4 million pounds per month of fluid sales Plant D - 8 million pounds per month of fluid sales

These four model plants represent a range in volumes which includes plants selling more than 80 per cent of the total fluid milk sales in North Carolina.

The characteristics of each of these plants in terms of number, type and volume of individual products, the wholesale-retail-transport distribution of total sales, etc. are specified in detail and held constant for each plant size as the different case handling methods are analyzed.

Applicability of Results

Since the characteristics of some of the plants in North Carolina may differ in some degree from the attributes of model plants considered in the study, the derived cost estimates and conclusions may not be immediately applicable to every existing plant. However, the cost estimation pro-cedure is outlined in sufficient detail so that the modification of the estimates to fit a special situation can be readily accomplished. Even though the cost estimates do not immediately fit the individual situations of each plant, it is believed that the study will be useful as a general comparison of the different case handling methods. To ensure broader applicability, considerable care was taken to design the model plants to conform closely to the char-acteristics of many North Carolina plants. It must be kept in mind, however, that the most efficient layout for any particular plant can best be determined by a detailed case study in which the design is engineered to fit the plant.

COST ESTIMATION PROCEDURE

For each model plant and each case handling method a complete list is made of the physical inputs and services required to move the product from the fillers through the storage room and onto the delivery trucks. Only those inputs which vary with the case handling method are considered. For example, the cost of land, the cost of case washing, water to clean the storage room, etc., are not measured since these costs will not vary significantly among case handling methods and thus will not affect the selection of the method.

The costs are divided into five categories--building costs, equipment costs, labor costs, the labor of the salesmen at the loading and unloading docks and utility costs. For ease in conceptual organization the cost components were further divided into two broad groups-fixed costs and variable costs. Fixed costs include interest payments on invested capital, taxes, insurance, depreciation and repairs. Variable costs are those incurred only on days of operation, such as electricity, hourly labor, etc. Variable costs are computed on a daily basis, multiplied by 313 days of operation per year and added to annual fixed costs to get total annual costs. Each of the five major cost components are now discussed individually.

Building Costs

The size and shape of the cold room and the loading docks vary according to the case handling method used. For each size of plant and case handling method, the size and shape of the building were designed to provide sufficient storage space for milk stacked five cases high 1/ plus sufficient additional space for unhampered product handling. No provision was made for future plant expansion. Buildings were designed to handle a given volume of milk efficiently. Alteration of the building specifications as outlined in this study can be easily accomplished by individual plant Guides for managers to fit their own expansion plans. building designs were obtained from consultation with sales engineers from equipment manufacturing companies, talks with plant superintendents, studies of floor plans of existing plants and by detailed computations involving space alloca-After the size and shape of the buildings were tion. selected, construction costs were estimated for a type of building having poured concrete floors and foundations, prefabricated wall and ceiling panels and a truss roof of tar and gravel covering. This type of construction was selected because of its ease and speed of construction, its flexibility in remodeling and its durability. Construction costs for the building were estimated by construction engineers.

The initial building costs are allocated on an annual basis over the physical life of the building.2/ Firm estimates of the life of the prefabricated wall and ceiling panels are not currently available since this type of construction material has not been in use long enough to need replacement. An expected life of 20 years was used as an estimate based primarily on the current condition of existing buildings of this type of construction. Annual

1/ Other research studies, including one by Charles E. French and Harry R. Varney, Jr., "Labor Utilization in Cold Storage and Empty Bottle Rooms," Purdue University Research Bulletin No. 677, indicate that stacking cases five high results in the most efficient labor utilization.

2/ Since there is no objective method of predicting just when obsolescence will require a change in equipment, the sole criterion for estimating depreciation is the expected physical life of the equipment.

fixed costs in addition to depreciation are repairs (maintenance), insurance, taxes and interest on the investment. Repairs were estimated at two per cent of the purchase price and insurance, taxes and interest on the invested capital were estimated at one per cent, two per cent and five per cent of the unamortized value of the building.

Equipment Costs

Selecting the conveyor equipment for each case handling method is largely a matter of fitting the equipment to the building. For each building design the equipment specifications and prices were selected by experienced engineers from major dairy plant equipment companies. The initial installed cost of each item of equipment was allocated as depreciation over its estimated life. Here again a problem arose from the lack of a concrete basis to estimate the useful life of some of the equipment. Some of the equipment has been in use only a few years so that estimates of useful life for many items were based on experience with other machines and equipment of similar complexity operating under similar conditions.

The fixed costs due to repairs, taxes, insurance and interest were added to depreciation to get total annual fixed costs. Annual repairs were estimated at four per cent of the installed purchase price. Taxes, insurance and interest were included at the same rates as for the building.

Labor Costs

Estimates of physical labor requirements were based on time and motion production studies of actual plant operations. These studies were accomplished by close observation of workers performing specific tasks. Time measurements were recorded and analyzed for each required work category. The quantity of work performed (the number of cases stacked, for example) was recorded along with the time measurement. Extraneous activities which a worker may have performed and interruptions of the normal work were subtracted from the time measurements. If the work was of a continuous nature, allowances were made for fatigue and unavoidable delay. Thus the "labor standards" which were derived indicate the amount of work which a worker can normally and continuously perform when his full attention is directed to that particular task. By timing the efforts of different workers in different plants performing the same type of work, a good indication was obtained as to the output of average workers when working at an efficient rate. A more detailed description of the derivation of labor standards is given in Appendix A.

Labor costs were estimated by applying appropriate hourly wage rates to physical time requirements. Hourly wage rates were based on wages paid by two representative North Carolina plants. The basic hourly rates were expanded by 25 per cent to allow for slack labor to cover unforeseen contingencies 1/ and other payroll costs such as Social Security taxes, paid vacations, sick leaves and other fringe benefits paid by the employer.

Cost of Salesman Time at Loading Docks

The length of time which a salesman is required to spend at the loading dock can usually be considered a direct cost. With some case handling methods a salesman may have to spend considerable time waiting in line for space at the loading dock. Other plants keep large shipping crews on hand to avoid the waiting problem. The cost of the waiting time required of salesmen must be balanced against the cost of additional loading facilities in order to arrive at decisions regarding appropriate loading facilities for the plant.

The method of estimating salesman waiting time for each of the case handling methods is given in detail in Appendix B so only a brief explanation is given here. The order of arrivals of refrigerated trucks at the loading dock after the daily deliveries is not specified or controlled by the plant itself so that the trucks can be said to arrive randomly on a "first come-first served" basis. To say that trucks arrive randomly means that they do not arrive at regularly spaced intervals but are

1/ Since work crews were estimated from "labor standards," they represent the minimum number of men required to accomplish the work. However, a prudent plant manager will not continuously operate a plant with minimum work crews, but he will keep some slack labor around to handle unforeseen contingencies, such as sickness. Rather than arbitrarily assign slack labor to each position, the hourly wage rate for each job was merely expanded approximately 20 per cent. Social Security taxes and other fringe benefits constitute the remainder of the 25 per cent expansion in wage rates. scattered or clustered in some fashion. Even though it is not possible to predict accurately the exact times of truck arrivals at a loading dock, it is possible (by appropriate sampling procedures) to estimate the probability of (say) ten trucks arriving between 3:00 and 4:00 p.m. In fact, it is possible to estimate the probabilities of any number of trucks arriving in any specified interval. The sum total of the probability characteristics of truck arrivals is called a "probability distribution of arrivals." Given the probability distribution of arrivals, the average rate of arrivals per time period, the probability distribution of loading times and the average loading time, it is possible with well established mathematical procedures to estimate the total waiting time of the trucks.1/

The probability distribution of arrivals and the average arrival rate per hour were estimated by a sample at the loading dock of a North Carolina plant. For an entire week the times of arrival of all of the trucks were recorded. Labor standards from Appendix Tables A-3 and A-4 were used for the loading times. The analysis of these data using the procedures outlined in Appendix B provided estimates of the total dock time for trucks under each case handling method.

An appropriate hourly cost rate for salesman waiting time at the loading dock is difficult to determine. Some plant managers would impute a very low cost rate to this time. A few plant managers believe that most salesmen would waste a certain amount of time at the end of the day whether or not the dock was immediately available. Others believe that waiting is costly to the plant only when salesmen are on a straight salary basis and that salesmen who are paid on a commission basis are merely wasting their own time. However, it is easily seen that waiting time is costly to the plant even when salesmen are on a straight commission basis. Salesmen who are paid on a commission basis are normally dissatisfied at having to wait long intervals before loading. Waiting lines give the salesmen an opportunity to get together in "griping sessions." This dissatisfaction could lead to a more rapid turnover of sales personnel with resultant higher training costs. The elimination of waiting time may afford an opportunity to accomodate additional customers on each route, thus spreading the fixed truck costs over a larger volume or providing an opportunity to reduce the number of trucks.

1/ See, for example, Philip M. Morse, Queues, Inventories and Maintenance, John Wiley and Sons, 1958, New York. These factors present difficulties in estimating appropriate cost rates for salesman waiting time. For lack of a more objective measure the physical waiting time as estimated in this study was costed at the full average hourly wage rate for salesmen. Individual plant managers who wish to impute a different cost rate to this activity can easily do so since the physical waiting time for each method is listed independently of the cost rate.

Since most salesmen in North Carolina are paid on a commission basis, the hourly wage rate was approximated by dividing the average monthly pay check by the average hours worked per month. Monthly income and hours worked were estimated from a sample of routes from several North Carolina plants.

Utilities

The two main items in this category are (a) electricity for the refrigeration units in the storage room and power units to drive the conveyor and (b) lubrication costs for the conveyor. These two factors can vary significantly with the case handling method used. Other utilities which may be required, such as water for cleaning, are considered insignificant and are not included in the analysis.

Refrigeration requirements vary considerably during the day and in different seasons of the year. Although the total tonnage necessary for peak loads is estimated as a part of the building requirements, the average amount of actual operating time of the compressors cannot be determined without extensive observation. Kilowatt requirements per ton of refrigeration for evaporated milk plants in the San Joaquin Valley of California have been estimated by refrigeration manufacturers to be .87 kilowatts per ton of refrigeration.1/ Since the mean temperature and temperature ranges in North Carolina are roughly similar to those in the San Joaquin Valley, these estimates were adapted for this study.

Kilowatt requirements for the conveyor drive units are estimated at one kilowatt per horsepower. The addition of these two factors gives the total kilowatt hours per hour.

1/ James N. Boles, "Economies of Scale for Evaporated Milk Plants," Hilgardia, Volume 27, No. 21, University of California, Berkeley, California.

Prices to be applied to these physical electricity requirements were derived from the following schedule which is an average of the schedules filed by three major power companies with the North Carolina Utilities Commission:

Billing demand 1/

\$1.50 per K.W.H. for the first 25 K.W.H. \$1.20 per K.W.H. for the next 25 K.W.H. \$1.10 per K.W.H. for the next 50 K.W.H. \$1.00 per K.W.H. for the rest.

Energy charge

\$.010 for the first 20,000 K.W.H. \$.008 for the next 50,000 K.W.H. \$.007 for next 100,000 K.W.H. \$.006 for next 200,000 K.W.H. \$.005 for the rest.

In computing the electricity costs for case handling, the procedure was to assume that the plant was already using enough electricity in other parts of the plant so that additional electricity for the cold room and conveyor could be obtained at one of the reduced rates. The particular reduced rate was determined for each plant on the basis of its size.

Lubrication costs for the conveyor were estimated to be \$25 per lubrication unit per month. The number of lubrication units in each model plant is listed in the equipment lists.

This completes the explanation of the procedure for estimating costs. The next step is a discussion of the characteristics of model Plant C. The analysis for Plant C is accomplished first because of the importance of this size of plant in terms of the proportion of total sales in North Carolina.

COST ANALYSIS FOR MODEL PLANT C

Characteristics of Plant C

Cost handling costs depend largely on the number and type of trucks loaded. The following discussion of volume,

1/ Billing demand is a technical term used to describe the number of kilowatts used during a fifteen minute period of peak load. product mix, the retail-wholesale-transport distribution of total sales and daily variation of sales is necessary to arrive at the appropriate number of trucks to be loaded. Also each of these factors affects case handling costs aside from affecting the number and type of trucks.

Model Plant C bottles an average volume of four million pounds of milk per month. The number of products and the quantity of each product are outlined in Table 1. This product mix was selected so that the monthly volume of each item constituted the same proportion of total volume as the average product mix of seven North Carolina plants of approximately this size. The number of products affects case handling costs by affecting the complexity of case handling in the storage room, the floor space requirements and the size of work crews. It was assumed that Plant C bottles all items in paper. This assumption departs somewhat from the characteristics of the average plant at present, but current trends toward all paper operations make the assumption more plausible for future use.

The distribution of total volume between retail, wholesale and transport sales is also shown in Table 1. This distribution also bears the same relationship as the average of seven North Carolina plants of the same size. Case handling costs are affected by the distribution of sales between retail, wholesale and transport because of the different time requirements for unloading and loading these different types of trucks. It is assumed that all trucks are refrigerated so that loading is accomplished in the afternoon. This assumption is also based on current trends in the North Carolina dairy industry toward completely refrigerated operations.

Plant volume in units is converted into total number of cases in Table 2. Since the number of products and the product mix is held constant as different case handling methods are varied, the total number of cases can be used as a standard measure of volume.

Table 3 shows the daily variation in retail and wholesale sales throughout the week. Since a plant must be designed to handle peak volumes over the week, the daily variation in volume affects costs by affecting the average utilization of floor space, filling equipment and work crews. The particular daily variation selected reflects average North Carolina conditions as determined by a sample of wholesale routes and conversations with industry representatives.

Table 1. Month Trans

Monthly Volume, Product Mix and Retail-Wholesale-Transport Sales Breakdown of Plant C

Product		Moi	thly volum	e	
product	Unit	Retail	Wholesale	Transport	Total
(1)	(2)	(3)	(4)	(5)	(6)
Grade A	2				- 1918 L
pasteur.	qts.	13,780	920	2,594	17,294
Grade A homo.	3 gal.		547	97	644
	1/2 gal.	89,570	179,280	47,443	316,293
	qts.	170,500	170,500	60,180	401,180
	pts.		93,840	16,560	110,400
	1/2 pts.	·	1,129,300	199,290	1,328,590
Grade A					
special	qts.	23,460	7,820	5,520	36,800
Heavy cream	1/2 pts.	1,122	4,500	995	6,617
Medium cream	1/2 pts.	350	1,527	330	2,207
Half and half	qts.	644	3,422	720	4,786
	pts.	1,720	5,161	1,215	8,096
Choc. milk	qts.	14,860	14,860	5,244	34,964
	pts.		51,612	9,110	60,722
	1/2 pts.		91,338	16,120	107,458
Whole lactic	qts.	3,675	3,675	1,300	8,650
	1/2 pts.		14,390	2,540	16,930
Skim milk	qts.	23,000	20,790	7,730	51,520
Plain					
buttermilk	1/2 gal.	7,270	14,550	3,850	25,670
	qts.	35,690	35,690	12,420	83,800
	1/2 pts.		15,950	2,820	18,770
Multi-vit.	qts.	20,850	10,120	5,465	36,435
Misc.	1/2 gal.	5,865	5,870	2,070	13,805
Cot. cheese	lbs.				20,000
	1		NELIST	1	

Sources:

Col. (1), (2): Selection of products was based on sales data from seven North Carolina plants of this same size. Minor items were grouped as miscellaneous.

- Col. (3), (4), (5): Total retail sales were selected to be 27 per cent of total volume, wholesale sales were 57 per cent and transport sales were 16 per cent of total. These figures are an average of seven North Carolina plants of this same size. The breakdown of product was then accomplished by averaging the figures from the sales records of three of these plants.
- Col. (6): Total volume is selected to equal an equivalent of 4 million pounds. The volume of individual products as a proportion of total sales is based on the average proportional relationships of seven North Carolina plants of the same size.

Number of Cases of Milk per Month Sold as Retail, Wholesale, Transport Table 2.

Each case holds 16 quarts. Col. (6): Summation of Cols. (3)-(5). Col. (7) (8), (9): Table 1, Col. (3), (4), (5) divided by the appropriate number of items in a 24 quart wire case. Col. (10): Sum of cols. (7), (8), (9). 3,954 26,358 2,508 16,716 345 2,300 1,519), (5): Table 1, Col. (3), (4), (5) divided by appropriate num-1,459 1,266 2,148 Number of 24-quart cases 200 1,792 2,139 3,492 1,151 38 361 282 950 Total 721 111 170 313 18,599 123,139 21,390 52,643 13,130 87,163 505 3,353 ber of that item in a standard wire case measuring 13 1/8 x 13 1/8 inches. 3,322 22,144 1,533 (0I)1 230 108 17 9 26 219 190 269 55 322 321 518 228 Trans. 30 173 47 6 Whs1. 14,940 1,955 18,822 326 1,076 1,523 489 2,025 39 7,104 143 108 240 1,212 266 422 75 26 153 1,487 867 750 8 823 7,464 7,104 959 606 1,487 Retail 574 776 620 153 19 27 36 869 489 ł ł 1 1 -I 1 E 4,736 35,14425,0753,2202,8523,94430,1962,3002,186 2,1692,443542 385 1,082 300 289 5,239 427 2,277 1,5341,333151 51 Total 9 Number of 16-quart cases 716 58 483 428 777 4,530 345 328 326 367 Trans. **I62** 5,271 3,761 592 00 45 82 342 230 333 23 44 64 1 3 19,920 10,657 3,352 25,666 1,8452,076 1,299 2,842 230 73,877 Whs1. 488 102 214 929 1,616 58 35 327 1,000 2,231 363 632 652 ł (Ŧ 1,179 9,953 862 1,467 929 230 1,438 808 1,303 652 30,667 10,657 26 41 60 Retail 2,231 1 1 1 1 1 1 1 6 1/2 gal. pts. 1/2 pts. qts. 1/2 gal. qts. 1/2 gal. 1/2 pts. qts. 1/2 pts. qts. 1/2 pts. 1/2 pts. 1/2 pts. Unit qts. 3 gal. qts. 3 qts. qts. pts. pts. lbs. qts. <u></u> Plain buttermilk Grade A special Col. Grade A homog. Grade A past. falf and half Monthly total Product Medium cream Whole lactic Heavy cream Cot. cheese Avg. daily Choc. milk Multi-vit. E Skim milk Sources: total Misc.

1

Table 3. Daily Variation in Sales

Day	Wholesale, per cent of wkly. tot.	Retail, per cent of	of 16	r. no. 5-quart per load	of 24	r. no. 4-quart per load
	WELY. LOL.	wkly. tot.	Whsl.	Retail	Whsl.	Retail
	(1)	(2)	(3)	(4)	(5)	(6)
Mon. Tues. Wed. Thur. Fri. Sat.	14.0 13.5 13.1 17.6 22.5 19.5	15.8 15.8 15.8 15.8 19.1 17.7	92 90 87 117 149 129	33 33 33 33 40 38	66 63 62 83 105 92	24 24 24 24 29 27

Sources: Col. (1), (2): Samples of wholesale routes in Raleigh and Charlotte and conversation with industry members. Col. (3), (4): Based on an average of 110 cases per day for each wholesale load and 35 cases per day for each retail load. Col. (5), (6): Based on an average of 78 24-quart cases for each wholesale load and 25 cases per retail load.

Each retail truck was assumed to load an average of 35 sixteen quart cases or 25 twenty-four quart cases, and the wholesale trucks are assumed to carry an average of 110 sixteen quart cases or 78 twenty-four quart cases.1/ These load sizes conform roughly to averages in North Carolina. Under these assumptions Plant C would operate 26 wholesale routes, 34 retail routes and send two tractor-trailer loads to branch sales plants.

In order to bottle the required volume of milk in one shift per day without exceeding the normal work week, Plant C uses five Purepak "senior" fillers (four model Q's and one model C). The number and type of fillers affect the rate at which the cases enter the cold room and hence affect work crew sizes.

This completes the description of the pertinent characteristics of Plant C. Each of the four case handling technologies are now analyzed.

1/ The case size may vary with the different types of case handling equipment.

Description of Case Handling Method No. 1

The floor plan and conveyor layout for case handling method 1 are shown in Figure 1. This layout is often called the "Hollywood" or "island box" system. This system is neither widely used nor understood in the Southeast at the present time although its popularity seems to be growing somewhat. The system is more widely used in California, Florida and the Northeastern states.

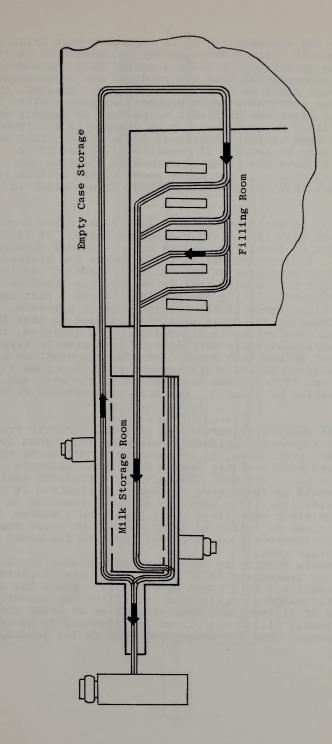
Its essential features are that the individual shipping orders for each truck are preformed 1/ and placed in prearranged areas near the individual loading doors through which the drivers load their own trucks. When the driversalesmen return from the daily deliveries, they back up to the loading dock, place the empty cases and returned milk on the conveyor, open the door to the cold room, check their order for accuracy and slide the stacks of milk into the truck. There is virtually no waiting time on the part of the driver, and he loads his truck and arranges the milk within the truck at his own speed.2/

The cases of milk are conveyed into the storage room on an infloor conveyor in five-high stacks of cases. Since milk can be easily handled in stacks, the system is readily adaptable to automatic casing and stacking equipment should the use of such equipment prove economical. The feasibility of automatic equipment is a separate problem and is not analyzed in this study.

It is often possible to preform a large portion of the shipping orders directly from the filler as the milk comes down the conveyor. This is accomplished by placing the individual shipping orders near the appropriate floor spaces allocated for each load so that the required items can be quickly read off, selected and placed as the milk

1/ Preformed loads are those that have been assembled and placed in previously assigned locations prior to the arrival of the trucks for loading.

2/ A modification to this basic plan is the enclosure of individual loads by barriers or cages which prevent the salesmen from entering any area of the storage room other than his own load. While this prevents any stealing, the cages cut down on effective floor space and hamper product movement. Since salesmen do not steal from each other as readily as from the plant itself, it is usually only necessary to erect a barrier between the inventory area and the rest of the cold room.



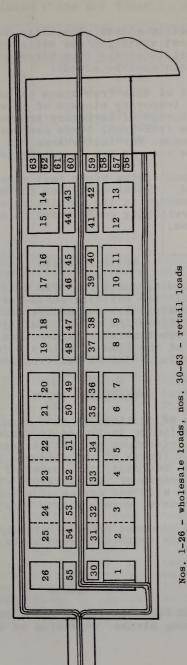
Building Design and Conveyor Layout for Plant C, Method 1 Figure 1.

comes down the conveyor.1/ It is necessary that driversalesmen submit their orders one day in advance of their needs. The preforming of loads directly from the conveyor is easily accomplished when the products are those required by individual loads in case lots or larger. However, there may be items which have to be broken down into smaller lots. Often these items are difficult to preform as rapidly as they are filled so that they may be stacked in the inventory area to be made up into individual loads later. This double handling is to be avoided if possible.2/ Since it is necessary to have the loads preformed by the time the trucks start coming in (normally about eleven o'clock in the morning), filling must start about five o'clock in the morning.

It will be noted in Figure 1 that Plant C has a cold storage room with 14 individual loading doors. It is planned that at least four trucks will be loaded through each door. The arrangement of loads inside the storage room can vary depending on the relative sizes of the loads, but for Plant C it seemed best to arrange the loads as shown in Figure 2. It is obvious from Figure 2 that considerable floor space in the storage room is unusable. The space in front of the doors must be kept open so that the drivers can have access to their loads. In addition, there must be sufficient space for the cold room crew to have "elbow room" around each load. Detailed computations of space allocation indicate the need of a storage room 115 feet long and 27 feet wide for a plant of the size and characteristics of Plant C. Based on observations of case

1/ The successful preforming of loads directly from the filler requires considerable organization. When two or more men are preforming, it is possible to divide up the products and have each man handle only those products assigned to him. However, the particular products assigned to each should be those products normally required in similar quantities. The handling of items required in vastly dissimilar quantities would result in a worker finishing loads at different rates so that he would soon be working simultaneously on different loads in different parts of the storage room.

2/ Double handing is also required for much of the milk going out of transports to branch plants. Branch plants normally require a full range of products. Since the number of products loaded directly from the filler can not exceed the number of fillers, the remaining 15 or 20 items must have been previously filled and placed in inventory to be replaced on the conveyor when the transports come in for loading.



Arrangement of Preformed Loads in Cold Room, Method 1, Plant C Figure 2. handling in existing plants of similar design, 27 feet seems to be a convenient width for the efficient handling of products. The width of the room affects the average distance which the products must be moved.

The 23 feet of door free space in one end of the cold room is for the temporary storage of inventory products. The temporary storage of inventory products in the spaces allotted for the individual loads can seriously impede the preforming of loads. For that reason, it is important to provide adequate storage for inventory products.

The Hollywood system works best when all of the trucks are refrigerated. Trucks using ice for cooling would not load out early enough in the morning to clear the storage space so that preforming could start in conjunction with the filling operation.

Building Costs

Initial building costs for this cold storage room are given in Table 4. The building costs for this particular room are approximately \$13 per square foot of floor space exclusive of refrigeration units. Refrigeration costs for this system are substantially higher than for the other systems because of the loss of cold air through the loading doors during loading. Annual building costs are given in Table 5.

Equipment Costs

Each of the major items of case handling equipment needed for the building is listed in Table 6. The building design and size determines in part the necessary equipment. For instance, the length of the conveyor is affected by the length of the building, the number of power units is affected by the length of the conveyor, etc. The equipment list was compiled with the advice of sales engineers and by studying blueprints of actual plants under construction.

The initial purchase price of the equipment as estimated in Table 6 is translated into annual fixed costs and given in Table 7.

Labor Costs

The size and organization of labor crews differ substantially among plants, depending on the efficiency Table 4. Initial Building Costs for Plant C, Method 1

	N	Dred	Dunchage	Tat	Ammeral
					Annual
Unit	of	per unit	price	ful life	deprec.
1	units	(dol.)	(dol.)	(years)	(do1.)
(1)	(2)	(3)	(4)	(5)	(6)
sq. ft.	4,033	1.50	6,050	40	151
sq. ft.	4,033	.67	2,700	40	68
sq. ft.	6,628	3.50	23,200	20	1,160
sq. ft.	3,840	.25	960	15	64
each	14	250.00	3,500	20	175
					and speak as
each	9	1,625.00	14,625	15	975
					and the
sa. ft.	4,033	.90	3,630	20	181
					and the
each	24	20.00	480	10	48
100			55.145		2,822
			,		
	sq. ft. sq. ft. sq. ft. sq. ft. each each sq. ft.	units (1) (2) sq. ft. 4,033 sq. ft. 4,033 sq. ft. 6,628 sq. ft. 3,840 each 14 each 9 sq. ft. 4,033	Unitofper unit(1)(2)(3)sq. ft.4,0331.50sq. ft.4,033.67sq. ft.6,6283.50sq. ft.3,840.25each14250.00each91,625.00sq. ft.4,033.90	Unitof unitsper unit (dol.)price (dol.)(1)(2)(3)(4)sq. ft.4,0331.506,050sq. ft.4,033.672,700sq. ft.6,6283.5023,200sq. ft.3,840.25960each14250.003,500each91,625.0014,625sq. ft.4,033.903,630	Unitof unitsper unit (dol.)price (dol.)ful life (years)(1)(2)(3)(4)(5)sq. ft.4,0331.506,05040sq. ft.4,033.672,70040sq. ft.6,6283.5023,20020sq. ft.3,840.2596015each14250.003,50020each91,625.0014,62515sq. ft.4,033.903,63020each2420.00 <u>480</u> 10

Sources: Col. (1), (2): Figure 1, p. 23. Col. (3): Estimates from two construction engineers from two different construction companies. Col. (4): Col. (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research studies. Col. (6): Col. (4) divided by Col. (5).

Table 5. Annual Building Costs for Plant C

		· · · · · · · · · · · · · · · · · · ·				· · · · · · · · · · · · · · · · · · ·
Initial	Depreci-	Repairs	Insur-	Taxes	Interest	Total
cost	ation	(2%)	ance	(1.05%)	on invest.	annual
			(.8%)		(3%)	costs
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)	(dol.)
55,145	2,822	1,103	441	579	1,654	6,599
Sources	Based of studies undepro- rate wi per cei based of plants precia but 2 rates of Col. (1	on exper- s. Col. eciated will vary at is con- on data s . Col. ted value per cent quoted b 5): Equiv	ience an (4): 1 value. with p nsidered submitte (5): Equ e. This is take y three valent value.	nd other Equivaled Based on lant and d repress ed by thu uivalent s rate w en as rep North C to appro Col. (7	entative. 1 ree North C to 2 per c ill vary wi	research er cent of rage. The but this 1.6 Rate is arolina ent on unde- th location e. Based on nts. per cent of

Table 6. Initial Equipment Cost for Plant C, Method 1

		No.	Price	Total
Item	Unit	of	per unit	cost
		units	(do1.)	(dol.)
	(1)	(2)	(3)	(4)
Infloor conveyor, straight double		181.27		
chain	ft.	536	27	14,472
Above floor conveyor, straight	C		S-SP (S.S. S	0 0000
single chain	ft.	288	18	5,184
90° turns, infloor conveyor	each	3	360	1,080
90 ⁰ turns, above floor conveyor	each	-	255	765
45° turns, infloor conveyor	each	-	180	180
45° turns, above floor conveyor	each	-	120	480
90° Y junctions, infloor conveyor	each	1	450	450
90 ⁰ double Y junction, infloor				
conveyor	each		750	750
45° Y junction, infloor conveyor		3	325	975
90° Y junction, above floor	1 1 1 1	21.10	1 1 1 2 2 1	E P ILLE
conveyor	each	3	350	1,050
5 horsepower drive units	each	-	1,500	9,000
3 horsepower drive units	each		1,250	5,000
Case pass doors, insulated	each		336	672
Case pass doors, uninsulated	each		240	480
Take up units	each		300	3,600
Lubricators	each		100	1,200
Traffic control	each		220	1,540
Unstacker	each		3,000	3,000
			e price	49,878
		on cos		9,976
To	otal p		e price	59,854
and the second s			Freight	800
To	tal co	ost ins	stalled	60,654

Sources: Col. (1), (2): Estimates by sales engineers of several major dairy plant equipment manufacturers. Col. (3): Price lists supplied by dairy plant equipment manufacturers. Col. (4): Col. (2) multiplied by Col. (3).

Item	Initial price	Est. life	Annual depre-	depre- (4%) (4%) ance		Taxes (1.05%)	Interest Total (3%)	Total annual
	(dol.) (dol.) (dol.)	(sites)	(dol.)		~	(dol.) (dol.)	(dol.)	(dol.)
	(1)	(2)	(3)	(4)	(2)	(9)	(1)	(8)
Straight conveyor chain	11,794	QI	2,359	472	94	124	354	3,403
All other conveyor equipment	45,260	12	3,772	1,810	362	475	1,358	7777
Unstacker	3,600	7	514	144	29	38	108	833
Total				0 10 10				12,013
Sources: Col. (1): Table 6, p. 28. Col. (2): Schedule F, United States Internal Revenue Service, estimates from other research studies and estimates fr major dairy plant equipment manufacturers. Col. (3): Col. (1) divided	Col. (1): Table 6, p. 28. Col. (2): Schedule F, United States Internal Revenue Service, estimates from other research studies and estimates from major dairy plant equipment manufacturers. Col. (3): Col. (1) divided by	28. Co mates fi ipment n	ol. (2): rom other nanufactu	Schedule researc	F, Uni th studi tol. (3)	ted Star es and e : Col.	tes Inter estimates (1) divid	from from
Col. (2). research s	Col. (2). Col. (4): Rates are comparable to those assumed in other research studies. Col. (5): Estimated on basis of data submitted by three	Rates a) 1. (5):	re compar Estimate	able to	those a dist of d	ssumed : ata subr	in other mitted by	three
North Caro value. Co	North Carolina plants. Equivalent to 1.6 per cent on undepreciated value Col (6): Estimated on basis of data submitted by three North	Equivimented	valent to	of data	· cent o submitt	n undepied by tl	reciated hree Nort	-
Carolina p balance. (Carolina plants. Equivalent to 2 per cent of value on undepreciated balance. Col. (7): Equivalent to 5 per cent interest on the average	ivalent quivaler	to 2 per	cent of	value interes	on under t on the	preciated e average	
unamortized value.	d value.							

Table 7. Annual Equipment Costs for Plant C, Method 1

of labor utilization and the number of different tasks and services performed in addition to the required minimum. Some plants employ a man to fill special orders, carry milk out to a salesman in case he should run out, etc. In some plants ice cream loading and milk loading overlap, with some men working part time in both areas. In order to achieve some semblance of generality it is necessary to confine the analysis to those activities necessary to accomplish the case handling for only those products normally kept in the Plants which perform services in addimilk storage room. tion to these must estimate the costs and add them to the costs as estimated in this study. Table 8 lists the work categories required to operate the Hollywood loadout system and the estimated time requirements for each job. The following discussion of each work category will explain the procedure for estimating work requirements. Supervisory work and work which does not vary with the case handling method were not considered.

First of all, the required work crew must include men to take the milk off the conveyor and preform the loads. These men will be rather steadily occupied during the entire filling operation. With the number and type of fillers used in model Plant C, it is possible for milk to enter the cold room at a rate varying from 12.3 cases per minute to 23.1 cases per minute, depending on the proportion of half-pints, pints, quarts and half gallons being filled at any particular time. Considerable care in organizing the filling schedule may be required if both the filling operation and the case handling operation are to work efficiently. The filling operation itself should be arranged to minimize stoppages for cleaning between products. The cold room work proceeds best if the rate of flow into the cold room is evenly distributed in terms of work load. It is usually possible to harmonize these two activities only by outlining in detail the daily filling schedule and checking resulting cold room work loads.

According to the labor standards outlined in Appendix Tables A-3 and A-4, a man can preform major items (those that do not have to be broken down into partial cases) at the rate of 14.1 cases per minute. For the items such as buttermilk, skim, cream, etc., which are required by loads in less than case lots, one man can preform 6.6 cases per minute. In preforming these latter items, nearly two-thirds of the total working time is spent in reading the load sheet and breaking down the cases.

A sample filling schedule designed for efficiency in both the filling and case handling is given in Table 9.

_
1-1
p
20
letho
le
~
•
0
4
lant
La
A
for
4
10
Ť,
Costs
ö
H
aboi
a
н
~
~
e
5
able
H

Job description	Time standard	Maximum rate required	Total work required per day	No. of Dail men re labor quired cost	Daily labor cost
(1)	(2)	(3)	(4)	(2)	(dol.) (6)
Receive major items off conveyor and preform loads	14.1 cases per 10.6 cases min. per man	10.6 cases per min. a/	1	Ч	14
Receive minor items off conveyor and preform loads		4.4 cases per min. a/		1	14
Make up odd items	2.25 min. per load per man	1	135 min. <u>c</u> /	1/2	12
Check loads for accuracy	3 min. per load per man	1	180 min. d/	1/2	1
Receive empty cases from conveyor and place in case storage	14.7 cases per 10.9 cases min. per man per min. \underline{b}	10.9 cases per min. <u>b</u> /	370 min. <u>e</u> /	1	12
Check in returned milk	retail52 min. per truck per man wholesale-1.27	1	18 min.	1	
	min. per uruck per man	1	33 min.	1	
Supply empty cases to fillers	30 cases per min. per man	1	190 min. f/ 1/2	1/2	9
		Ĩ	Total per day		58
Sources: Col. (1): Text, pp. 26-36. Col. (2): Appendix Tables A-3, A-4. Col. (3) a/ Table 9. b/ Average rate at which cases are returned on heaviest day during unloading hours of 11:00 a.m. and 5:30 p.m. (continued on next page)	26-36. Col. (2): s rate at which c s of 11:00 a.m. a	Appendix 7 ases are ret nd 5:30 p.m.	(2): Appendix Tables A-3, A-4. ch cases are returned on heavie m. and 5:30 p.m. (continued on p	A-4. Co aviest d on next	Col. (3): day xt page)

Table 8 (continued)

two representative plants. Actual wage rates were inflated 25 per cent to allow for fringe costs and additional labor for replacement in case Col. (4): c/ Performed between 9:00 a.m. and 11:15 a.m. d/ Performed from 11:15 \overline{a} .m. until 5:30 p.m. e/ Total number of cases Unloaded on heaviest day (5,600 cases) divided by labor standard. f/ Performed intermittently in alternate half hours from 5:00 a.m. until 1:00 p.m. during filling. Col. (5): Part time jobs involving 4 hours or less per day were lumped together into one man where the jobs dovetailed in terms of time of performance. Col. (6): Based on wage rates used by of illness.

	Tour	INOH	of	day	CI		9	-	-	00		6		10		11	11ed that
5 1	×	D RE	K	H R						В					4	۹	l
Room Workers, Plant C a/		Filler 5	-	(Model C)	Sanitize	1/2 gal.									butterm.	products are filled first s product belo	
	X	2 84	R	H R		m											fi
		Filler 4		(b Tebom)	Sanitize	Sanitize									Other fluid at items are f the following		
	3	2 24	M	ящ						В					4	9	lay. er fa lute
		Filler 3		(D Tepow)	Sanitize	Sanitize								homog.	a/ Only homogenized milk is filled every day. Other fluid products are f. every other day. On each filling day the higher fat items are filled first so any product remaining in the lines will not dilute the following product below		
	≥ 0	2 84	M	я ж		B		A					8				ag di
		Filler 2		(b Tebom)	Sanitize	1/2 pt.hom.	¢	Quarts homog.		~	<		1/2 pts.	· Somoti		->	Only homogenized milk is ther day. On each filling duct remaining in the line
	30	2 54	M	яæ		A					A	Creamed X		A	~		on On nin
		Filler 1		(b Tebom)	Sanitize	1/2 pt.cr.	*	Quarts homog.	Quarts >	buttermilk	Quarts	A LET TEN NO	11 a/ Only home every other day.				
	Howe	THOM	of	day	ß		9	-	-	80		6		10		11	every any pi

Table 9. Filling Schedule for Plant C for One Day and Product Assignments for Cold

Table 9 (continued)

Buttermilk and chocolate items are filled last so that the fillers will not have to be cleaned until the end of the day. minimum standard fat requirements.

(Another is accomplished by using two or more fillers simultaneously to fill the same item. advantage in using two or more fillers simultaneously on a single item is that an This Although this procedure may increase the number of size changes on the fillers, In order to keep cold room work requirements to a minimum the number of different items entering the cold room at any particular time is minimized. it simplifies work in the cold room. Size changes can be accomplished in 5 minutes or less so they do not seriously retard the production procedure. automatic caser can be used to displace two or more case-off men.)

that worker A works with guarts of homogenized from about 6:10 a.m. until 8:25 a.m. length of the cold room before starting another item. For instance, Table 8 shows Similarly, B finishes 1/2 pints of homogenized at 11:00 a.m. before coming in. Thus he can start back at one end of the cold room with skim and work The two men are assigned products in such a way that each starts with one or He completely finishes all the quarts of homogenized before quarts of skim start the length of the cold room again instead of, perhaps, having to start the skim more items at one end of the cold room and works completely through the entire 100 feet away at the other end of the cold room while finishing the quarts of starting with pints of homogenized and 1/2 gallons of plain buttermilk. homogenized.

This schedule applies to only one day, but schedules for other days can be designed in the same general manner. This filling schedule is designed so that stoppages to clean the machine are completely eliminated, yet it is designed so that two men can easily accomplish the preforming of all of the items. Each man (denoted by A and B in Table 9) is assigned particular products in such a way that he works only in a small area of the cold room at a time and handles not more than two different products at one time. A more detailed explanation of the method of designing the filling schedule is given as a footnote in Table 9. The work capabilities of these two men exceed maximum requirements by a comfortable margin, leaving room for unforeseen contingencies.

Handling the milk which goes to the branch plants adds to the complexity of the preforming operation but does not seriously affect the time requirements when only two transports are loaded as in Plant C. If many more transports were loaded, each coming in at uncertain times and in undetermined order, the preforming operation for wholesale and retail loads might be somewhat disrupted. Of extreme importance is an adequate storage area where the milk for branch plants may be temporarily stored. It may be necessary in some cases for the plant to keep an extra man for loading transports. Some plants require the transports to load out before filling starts.

For Plant C a third man is employed to make up odd items such as cottage cheese, butter, eggs, orange drink, etc. which do not enter the cold room through the fillers.

Plant C also requires a man to receive empty cases from returning trucks, stack cases and place them in the case storage room. Although total daily work requirements for this job never exceed one man-day (for Plant C), there are certain times of the day when peak unloads of empty cases may exceed the time standard of 14.7 cases per manminute. However, the surge capacity provided by the long conveyor extending the full length of the case storage room (with a case stop at the end) enables the empty case handler to work at a steady rate at considerably less than his full capabilities. Therefore, it is assumed that the empty case handler also performs the function of checking in the milk which the drivers return. The task of checking returns is expedited by having the driver "tag" their returns so that the empty case handler can check them at his convenience.

Another required job is that of supplying empty cases to the fillers during the filling operation. According to the time standards, a worker (aided by an automatic unstacker) can supply empty cases at the rate of about 30 per minute or about twice as fast as the fillers require. Furthermore, since it is possible to stack sufficient cases on the conveyor to supply the fillers for about half an hour, this job can be combined with another requiring intermittent attention so the allowance for supplying cases to the fillers is charged at the rate of half a man.

Appropriate wage rates were applied to these physical labor requirements and the total daily labor costs are given in Table 8.

In addition to these labor requirements, most plants would probably provide a shipping superintendent whose responsibility was divided between milk and ice cream, and a dock supervisor. Since these two jobs would not necessarily vary with the case handling system, they are not considered explicitly in the analysis.

Cost of Salesman Time

The cost of the time required by the salesmen to unload and load their trucks is given in Table 10. Since waiting time with the Hollywood system is zero, the only time charged as an expense is for loading and unloading.

Utilities

Table 6 indicates that a total of 40 horsepower is necessary to drive the conveyor. This is immediately translated into kilowatts per hour on the basis of one kilowatt per horsepower. It is assumed that the conveyors will operate continuously for 12 hours per day, 6 days per week. This would require a monthly total power consumption of 12,480 kilowatt hours. The contribution to billing demand, or the highest rate of consumption for any 15 minute period, would be 10 kilowatt hours.

Average annual electricity consumption rates for the refrigeration units are computed on the basis of one ton equals .87 K.W.H. For the 36 tons operating 24 hours per day the monthly consumption would be 22,864 K.W.H. The contribution to billing demand is computed on the basis of maximum consumption, which would be in the hottest part of the day and also when several loading doors are open. It can be assumed that all nine units will be operating continuously during this period. Assuming that one horsepower is required for each ton, the maximum consumption in a 15 minute period is 9 K.W.H. Table 10. Cost of Salesman Time

Type truck	Un- load (min.)	Load (min.)	Wait (min.)	Time for each driver (min.)	No. of trucks	Total time (min.)	Cost per min. (dol.)	Total daily cost (dol.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Retail	5.12	10.10	0	15.22	34	517.48	.035	18.11
Whole- sale Total	11.49	12.98	0	24.47	26	636.22	.04	25.45 43.56
Source	and	d 110 ca	ase load	ed 35 case d for who	lesale.	Labor	standa:	rds of

and 110 case load for wholesale. Labor standards of .1463 minutes per case for retail trucks and .1045 for wholesale trucks. Col. (2): Labor standard of .2887 minutes per case for retail trucks and .1180 minutes per case for wholesale trucks. Col. (3): Truck driver loads from his own door. Col. (4): Summation of Cols. (1)-(3). Col. (5): Page 21 of text. Col. (6): Col. (4) multiplied by Col. (5). Col. (7): Assumed to be representative of wage rates in North Carolina. Col. (8): Col. (6) multiplied by Col. (7).

Total billing demand is thus estimated as 19 K.W.H. and the monthly energy usage is 37,549 K.W.H. It is assumed that other activities of the plant (such as homogenizing and pumping milk through the plant) consume at least 20,000 K.W.H. per month with a billing demand of 25 K.W.H. The appropriate cost for the electricity attributable to case handling according to the rate schedule in a preceding section would be .7 cents per K.W.H. for energy usage and \$1.10 per K.W.H. for billing demand, for a total monthly cost of \$283. These cost figures are shown in Table 11. Lubrication costs for the 12 lubrication units at \$25 per month per lubrication unit amounts to \$300 per month.

Description of Method 2 for Plant C

The plant layout for method 2 is illustrated in Figure 3. This method is similar to method 1 in that loads for individual routes are preformed prior to the arrival of the trucks for loading. However, in method 2 there are no individual loading doors. The loads are pulled onto the conveyor by a cold room crew, and the milk is conveyed out onto the loading dock where the driver pulls the milk into the truck and arranges the milk within the truck. Often the cases arrive so rapidly that the driver pulls the cases onto the dock along side the conveyor and loads the milk at a more leisurely rate. A wide loading dock is desirable for this method. Cases are handled on an infloor conveyor in five high stacks as in the previous method.

Item	Total horse- power	Average kilowatt hours per hour	Hours of operation per day		energy
	(1)	(2)	(3)	(4)	(5)
Conveyor	40	40	12	10	14,600
Refrigeration units	36	31.3	24	9	22,949
	1	Total bi	lling deman	nd 19	37,449
		Drice ner	N W U	\$ 1 10	\$ 007

Table 11. Cost of Utilities

Price per K.W.H. 1.10 \$20,90 \$262,14 Total billing cost

energy charge

Total

Col. (1): Table 4, p. 27, gives the refrigeration Sources: horsepower and Table 6, p. 28, gives the horsepower of the conveyor or drive units. Col. (2): Based on one K.W.H. per H.P. for conveyor and .87 K.W.H. per H.P. for refrigeration. Col. (3): Based on plant observations. Col. (4): Col. (1) divided by 4. Col. (5): Based on 12 hours per day, 313 days per year for conveyor and 24 hours per day, 365 days per year for refrigeration.

Building, Equipment and Labor Costs

Nearly as much storage space is required for this method as for the Hollywood system. Computations indicate the need for a storage room 108 feet long and 27 feet wide. Initial building costs and annual fixed costs are given in Tables 12 and 13. It will be noted in comparing building requirements with the Hollywood system that considerably less refrigeration is required, the cost of doors is avoided, and hence building costs are somewhat lower.

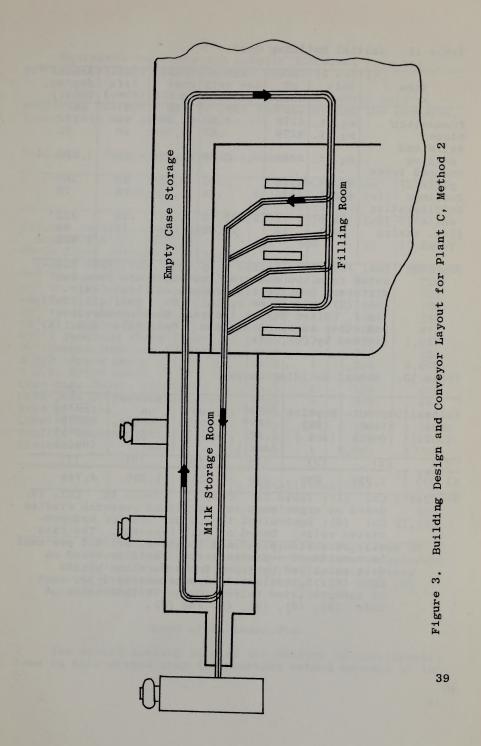


Table 12. Initial Building Costs

		No.	Price	Total	Est.	Annual
Item	Unit	of	per unit	cost	life	deprec.
		units	(dol.)	(dol.)	(yrs.)	(dol.)
	(1)	(2)	(3)	(4)	(5)	(6)
Foundation	sq.ft.	4176	1.50	6,264	40	157
Floor	sq.ft.	4176	.67	2,798	40	70
Walls and	-					
ceiling	sq.ft.	6264	3.50	21,924	20	1,096
Diamond tread	1					
plate	sq.ft.	4176	.90	3,758	20	188
Roofing	sa.ft.		.25	1,142	15	76
Refrigeration						
units (3 ton)	each	3	1,625.00	4,875	15	325
Elec. wiring	each	12	20.00	240	10	24
	each	14	20.00		10	and the second se
Total	Los ()			41,000		1,936

Sources: Col. (1), (2): Figure 3, p. 39. Col. (3): Estimates from two construction engineers from two different construction companies. Col. (4): Col. (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research studies. Col. (6): Col. (4) divided by Col. (5).

Table	13.	Annual	Building	Costs
-------	-----	--------	----------	-------

Initial cost (dol.)	Depreci- ation (dol.)	(2%) (dol.)	Insur- ance (.8%) (dol.)	(1.05%) (dol.)	Interest on invest. (3%) (dol.)	Total annual costs (dol.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
41,000	1,936	820	328	431	1,230	4,745
Sources	Based Col. (4	on exper: 4): Equi	ience an valent	nd publis to 1.6 p	shed resea er cent of	2. Col. (3): arch studies. undepre- The rate

ciated value. Based on full coverage. The rate will vary with plant and location, but 1.6 per cent is considered representative. Rate is based on data submitted by three North Carolina plants. Col. (6): Equivalent to approximately 5 per cent of undepreciated value. Col. (7): Summation of Cols. (2), (3), (4), (5) and (6).

Equipment costs are not greatly different from the previous method and are given in Tables 14 and 15.

Labor costs differ from the previous method only in requiring one extra man to pull the loads onto the conveyor. Labor costs are given in Table 16.

		No.	Price	Total
Item	Unit	of	per unit	cost
		units	(dol.)	(dol.)
	(1)	(2)	(3)	(4)
Infloor conveyor, straight				
double chain	ft.	400	27	10,800
Above floor conveyor, straight	12			
single chain	ft.	288	18	5,184
90° turn, infloor conveyor	each		360	720
90 ⁰ turn, above floor	each	3	255	765
45 [°] turn, infloor	each	1	180	180
45 ⁰ turn, above floor	each	4	120	480
45° Y junction infloor	each	3	325	975
90 ⁰ Y junction above floor	each	3	350	1,050
90° double junction infloor	each	1	750	750
5 H.P. drive units	each		1,500	6,000
3 H.P. drive units	each	5	1,250	6,250
Case pass doors, insulated	each	2	336	672
Case pass doors, uninsulated	each	2	240	480
Take up units	each	10	300	3,000
Lubricators	each	10	100	1,000
Traffic controls	each	6	220	1,320
Unstacker	each	1	3,000	3,000
	1	L	I	42,626
	Inst	allatio	on cost	8,525

Table 14. Initial Cost of Equipment

> 800 51,951

Col. (1), (2): Estimates by sales engineers of Sources: several major dairy plant equipment manufacturers. Col. (3): Price lists supplied by dairy plant equipment manufacturers. Col. (4): Col. (2) multiplied by Col. (3).

Cost of Salesman Time

The actual loading time of the drivers is considerably less in this method than the previous method because of the

Total annual costs (dol.)	(8)	2,825	6,629	833	10,287	cernal s from ded by tiated th
Inter- Total est annua (3%) costs (dol.) (dol.	(2)	294	1,157	108		lates Ind stimates timates a other itted by indeprec ree Nort reclatec average
Taxes (1.05%) (dol.)	(9)	103	405	38		ilted Sti ss and e: Col. (csumed in ta submu ta submu ent on u undep: on the
epairs Insur- (4%) (.8%) (.8%) (.01.)	(2)	78	309	29		$\begin{bmatrix} I & I \\ I $
Repairs (4%) (dol.)	(4)	392	1,543	144		Schedu research rers. Co tble to tble to tble to tble to tble tble tble tble tble tble tble tble
Annual depreci-Repairs (4%)Insuation (dol.)(4%)(.8%)	(3)	1,958	3,215 1,543	514		Col. (2): om other iandactur e compara Estimated Equivale to 2 per it to 5 pe
Estimated life (years)	(2)	ũ	12	7		Col. (1): Table 14, p. 41. Col. (2): Schedule F, United States Internal Revenue Service, estimates from other research studies and estimates from major dairy plant equipment manufacturers. Col. (3): Col. (1) divided by Col. (2). Col. (4): Rates are comparable to those assumed in other research studies. Col. (5): Estimated on basis of data submitted by three North Carolina plants. Equivalent to 1.6 per cent on undepreciated value. Col. (6): Estimated on basis of data submitted by three North Carolina plants. Equivalent to 1.6 per cent on undepreciated value. Col. (7): Equivalent to 2 per cent of value on undepreciated balance. Col. (7): Equivalent to 5 per cent interest on the average unamortized value.
Initial price installed (dol.)	(1)	9,791	38,560	3,600		Col. (1): Table 14, Revenue Service, es major dairy plant es Col. (2). Col. (4) research studies. three North Carolir value. Col. (6): H Carolina plants. balance. Col. (7): unamortized value.
Item		Infloor conveyor straight double chain	All other conveyor equipment	Unstacker	Total	Sources: Col. (1): Revenue S major dai Col. (2). research three Nor value. (Carolina balance. unamortiz

. ...

Table 15. Annual Cost of Equipment

Job description	Time standard	Maximum rate required	work red y	No. of men re- quired	Daily labor cost (dol.)
(1) Receive major items off con- veyor and preform loads	(2) 14.1 cases per min. per man	(2) (3) cases per 10.6 cases per man per min. <u>a</u> /	(4)	(5) 1	(6) 14
Receive minor items off con- veyor and preform loads	6.6 cases per min. per man	4.4 cases per min. <u>a</u> /	ł	1	14
Make up odd items	2.25 min. per load per man	1	135 min. <u>c</u> /	1/2	12
Check loads for accuracy	3 min. per load per man	1	180 min. <u>d</u> /	1/2	1
Receive empty cases from con- veyor and place in case storage	14.7 cases per 10.9 cases min. per man per min. \underline{b}	10.9 cases per min. <u>b</u> / 370 min. <u>e</u> /	370 min. <u>e</u> /	1	12
Check in returned milk	rtl52 min. per truck per manwhs1 -	1	18 min.	1	
A ST LOLAN AND A ST A	1.27 min. per truck per man		33 min.	1	
Supply empty cases to fillers	30 cases per min. per man	1	190 min. <u>f</u> /	1/2	9

Table 16. Labor Costs for Plant C, Method 2

					-
Job description	Time standard	Maximum rate required	Total work No. of Daily required men re- per day quired (dol.)	No. of men re- quired	Daily labor cost (dol.)
(1)	(2)	(3)	(4)	(2)	(9)
Pull preformed loads onto conveyor	23.4 cases per min. per man	I	240 min.	1	12
			Total per day	lay	70

during unloading hours of 11:00 a.m. and 5:30 p.m. Col. (4): c/ Performed between 9:00 a.m. and 11:15 a.m. d/ Performed from 11:15 a.m. until 5:30 p.m. e/ Total number of cases unloaded on heaviest day (5,600 cases) divided by Tabor standard. f/ Performed intermittently in alternate half 6 hours from 5:00 a.m. until 1:00 p.m. during filling. Col. (5); Part time Col. (1): Text, pp. 26-36. Col. (2): Appendix Tables A-3, A-4. Col. (3) a/ Table 9. b/ Average rate at which cases are returned on heaviest day jobs involving 4 hours or less per day were lumped together into one man where the jobs dovetailed in terms of time of performing. Col. (6): Sources:

3ased on wage rates used by two representative plants. Actual wage rates

were inflated 25 per cent to allow for fringe costs and additional labor

for replacement in case of illness.

Table 16 (continued)

lesser distance which they must move the milk. However, since only one load at a time can be placed on the conveyor, there is a possibility of one driver having to wait on another to load. Using the analytical method outlined in Appendix B with the standard loading times given in Appendix Tables A-3 and 4 the total waiting time is estimated to be 120 minutes per day. Total costs incurred by the driversalesmen are given in Table 17.

Type truck	Unload time (min.) (1)	Load (min.) (2)	Wait per truck (min.) (3)	Time for each driver (min.) (4)	No. of trucks (5)	Total time (min.) (6)	Cost per min. (dol.) (7)	Total daily cost (dol.) (8)
Retail	5.12	4.94	2.00	12.06	34	410.04	.035	14.35
Whsl.	11.49	8,28	2.00	19.77	26	514.02	.04	20.56
Total								34.91

Table 17. Cost of Salesman Time, Plant C, Method 2

Sources: Col. (1): Assumed 35 case load for retail trucks and 110 case load for wholesale. Labor standards of .1463 minutes per case for retail trucks and .1045 for wholesale trucks. Col. (2): Labor standards of .1411 minutes per case for retail trucks and .0753 minutes per case for wholesale trucks. Col. (3): Estimated with the procedure outlined in Appendix B. Col. (4): Summation of Cols. (1)-(3). Col. (5): Page 21 of text. Col. (6): Col. (4) multiplied by Col. (5). Col. (7): Assumed to be representative of wage rates in North Carolina. Col. (8): Col. (6) multiplied by Col. (7).

Utilities

Using the same estimation procedure as was utilized in method 1, the total electricity costs attributable to case handling with method 2 are outlined in Table 18. Lubrication costs for the 9 lubrication units at \$25 per month per lubrication unit amount to \$225 per month. Table 18. Cost of Utilities for Plant C, Method 2

Item	Total horse- power	Average kilowatt hours per hour	Hours of operation per day	Maximum usage in a 15 minute period (K.W.H.)	Total monthly energy usage (K.W.H.)
	(1)	(2)	(3)	(4)	(5)
Conveyor	35	35	12	8.75	10,955
Refrigeration units	9	7.83	24	2.25	5.716
1	11.00 \$ 1.10 \$12.10	16,671 \$.007 \$116.70			

Sources: Col. (1): Table 4, p. 27, gives the refrigeration horsepower and Table 6, p. 28, gives the horsepower of the conveyor or drive units. Col. (2): Based on one K.W.H. per H.P. for conveyor and .87 K.W.H. per H.P. for refrigeration. Col. (3): Based on plant observations. Col. (4): Total H.P. divided by 4. Col. (5): Based on 12 hours per day, 313 days per year for conveyor and 24 hours per day, 365 days per year for refrigeration.

Description of Method 3, Plant C

In this method the individual loads are not preformed. The milk is merely stacked in the cold room with all of the half-gallons in one area, half-pints of buttermilk in another place, etc. When a driver arrives at the loading dock, he hands his shipping order to the load out crew. The load out crew takes the shipping order into the cold room, selects the appropriate items in the desired number and sends them out on the conveyor. When the products reach the truck, the driver pulls the milk into the truck. The layout for this method is illustrated in Figure 4.

Building, Equipment and Labor Cost

Initial building costs and annual fixed building cost are given in Tables 19 and 20. It will be noted that annual building costs are lower than for the other two methods because of a higher utilization of floor space.

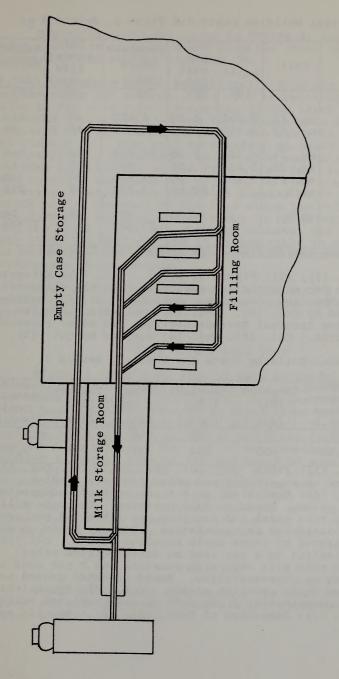




Table 19. Initial Building Costs for Plant C, Method 3 a/

Item	Unit	No. of units	Price per unit (dol.)	price (dol.)	Est. useful life (years)	Annual deprec. (dol.)
	(1)	(2)	(3)	(4)	(5)	(6)
Foundation Floor Ceiling and walls Roofing Diamond tread Refrigeration Electric wiring Total	sq. ft. sq. ft. sq. ft. sq. ft. sq. ft. each each	2,952 4,264 3,280 2,952	.67 3.50 .25 .90 1625.00	4,428 1,978 14,924 820 2,657 4,875 240 31,547	40 40 20 15 20 15 15	111 49 746 55 133 325 <u>24</u> 1,443

a/ Building inside dimensions are 82 feet long and 27 feet \overline{w} ide.

Sources: Col. (1), (2): Figure 4, p. 47. Col. (3): Estimates from two construction engineers from two different construction companies. Col. (4): Col. (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research studies. Col. (6): Col. (4) divided by Col. (5).

Table 20. Annual Building Costs for Plant C, Method 3

Initial cost (dol.)	Annual depreci- ation (dol.)	Repairs (2%) (dol.)	Insurance (.8%) (dol.)	Taxes (1.05%) (dol.)	Interest (3%) (dol.)	Total annual costs (dol.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
31,547	1,443	631	252	331	946	3,603

Sources: Col. (1): Table 19. Col. (2): Table 19. Col. (3): Based on experience and other research studies. Col. (4): Equivalent to 1.6 per cent of undepreciated value. Based on full coverage. The rate will vary with plant and location, but this 1.6 per cent is considered representative. Rate is based on data submitted by three North Carolina plants. Col. (5): Equivalent to 2 per cent on undepreciated value. This rate will vary with location but 2 per cent is taken as representative. Based on rates quoted to three North Carolina plants. Col. (6): Equivalent to approximately 5 per cent of undepreciated value. Col. (7): Summation of Cols. (2), (3), (4), (5) and (6).

Equipment costs are given in Tables 21 and 22. Equipment costs are slightly lower than the other two methods because of the shorter conveyor.

Labor crews differ significantly from the requirements of the other two methods. Men will be required to stack the milk in the cold room. According to the labor standards in Appendix Tables A-3, A-4 and the maximum rate of work required by the filling schedule, two men will be required to stack milk. They will be steadily occupied during the entire filling operation. Two or more men will be required to make up the loads as the trucks come in. Another man has to check the loads for accuracy as they come down the conveyor. The drivers cannot be counted on to make a reliable check on the accuracy of the load since the milk comes down the conveyor too fast and they are fully occupied with loading the truck. A double check on accuracy was provided in the other two methods, and it is desirable to keep the degree of product control constant so that the costs will be more comparable among methods.

The remainder of the work is accomplished in the same manner as in the other two methods. Labor costs are summarized in Table 23.

Cost of Salesman Time

Since it takes some time to make up loads, the rate of loadout for this method is slower than method 2 unless loadout crews are sufficiently large. A larger loadout crew would mean increased expense in plant labor but would decrease the cost of waiting time of the salesman. It is clear that one man could not make up all of the loads fast enough to avoid a long waiting line. It is not immediately clear whether a loadout crew of two men would be more economic than a crew of three men. Waiting time of salesmen was therefore analyzed under both situations and the total salesman cost is indicated in Table 24. Since the loadout crew of three saves \$41.27 of salesman time per day, and the additional loadout man costs only \$14 per day, it appears that it would pay to use three men to loadout trucks.

Utilities

Since this method uses exactly the same number of power units and refrigeration costs, the utilities cost is the same--\$353.80 per month. Table 21. Initial Equipment Cost for Plant C, Method 3

		No.	Price	Total
Item	Unit		per unit	cost
-hear he he here a here and the		units	(dol.)	(dol.)
a he accesses as bracked an	(1)	(2)	(3)	(4)
Infloor conveyor, straight	1.2.2.2.	1429/3	27 . C # 3 . 5 .	
double chain	ft.	336	27	9,072
Above floor conveyor, straight				
single chain	ft.	288	18	5,184
90° turn, infloor conveyor	each		360	720
90 ⁰ turn, above floor conveyor	each		255	765
45 ⁰ turn, infloor	each	1	180	180
45 ⁰ turn, above floor	each	4	120	480
45° Y junction infloor	each	4 3 3 1	325	975
90° Y junction above floor	each	3	350	1,050
90° Y double junction	each	1	750	750
5 H.P. drive units	each	4 5	1,500	6,000
3 H.P. drive units	each	- 5	1,250	6,250
Case pass doors, insulated	each		336	672
Case pass doors, uninsulated	each	2	240	480
Take up units	each		300	3,000
Lubricators	each		100	1,000
Traffic controls	each		220	1,320
Unstacker	each	1	3,000	3,000
		L		40,898
	Inst	allatio	on (20%)	8,180
	Tota	l price	9	49,078
	Freig	ght		800
				49,878

Sources: Col. (1), (2): Estimated by sales engineers of several major dairy plant equipment manufacturers. Col. (3): Price lists supplied by dairy plant equipment manufacturers. Col. (4): Col. (2) multiplied by Col. (3).

	~		m	~	Le
Total nnual cost (dol.)	2,467	6,503	833	9,803	cernic ss led lb- on on on con
t ar					Int Int (1) (1) ssur ssur ssur stent on rest
nteres (3%) (dol.) (7)	257	5	108		ites se av dation ilue ilue
InterestTotalInterestannual(3%)cost(dol.)(dol.)(7)(8)	25	1,132	10		Star (1): (1): (1): (1) (1): (1): (1): (1): (1): (1): (1): (1):
	06	9	38		ited es a to to to 1. da f da r ce
Taxes (1.05%) (dol.) (6)	G	396	ŝ		 d1. (2): Schedule F, United States Interniom other research studies and estimates ent manufacturers. Col. (3): Col. (1)): Rates are comparable to those assumed ol. (5): Estimated on basis of data subaplants. Equivalent to 1.6 per cent on): Estimated on basis of data submitted by Equivalent to 2 per cent of value on (7): Equivalent to 5 per cent interest on
			-	1	to t
nsuran (.8%) (dol.) (5)	68	302	29		edul earc com com com con guiv on to 2 to 2
Annual Repairs Insurance depreci- (4%) (.8%) ation (4%) (.8%) (dol.) (dol.) (dol.) (3) (4) (5)					Sch res fact Est Est ent ent ival
epairs (4%) (dol.) (4)	342	609	144		(2): (2): (2): (5): (5): (5): (7): (7): (7): (7): (7): (7): (7): (7
Repai: (4%) (dol (4)		1,509	-		1. (1. 1. (1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1
	10	44	514		$\begin{bmatrix} Co \\ Co \\ Ipme \\ (4) \\ Co \\ Co \\ Co \\ (6) \\ (6) \\ (6) \\ e. \end{bmatrix}$
Annual epreci ation (dol.) (3)	1,710	3,144	ß		50. 50. col. col. col. col. col. col. col.
		_			p. p. p. p. p. p. p. p. p. p. p. p. p. p
Est. life (yrs.) (2)	Ω	12	2		21, ses, ess y pl (2) (2) (2) Nor Nor Nor alue alue alan
+					vice lair sear car car amo:
Initial price nstalled (dol.) (1)	8,551	37,727	3,600		: Ta Service by 0 res res res res res res res res res res
Initial price installed (dol.) (1)	ŵ	37,	з,		(1) nue maj ded ther ed b prec prec prec
	ain	ip.			Col. (1): Table 21, p. 50. Col. (2): Schedule F, United States Internal Revenue Service, estimates from other research studies and estimates from major dairy plant equipment manufacturers. Col. (3): Col. (1) divided by Col. (2). Col. (4): Rates are comparable to those assumed in other research studies. Col. (5): Estimated on basis of data sub- mitted by three North Carolina plants. Equivalent to 1.6 per cent on undepreciated value. Col. (6): Estimated on basis of data sub- three North Carolina plants. Equivalent to 2 per cent on undepreciated balance. Col. (7): Equivalent to 2 per cent of the undepreciated balance. Col. (7): Equivalent to 5 per cent interest on the average amortized value.
Item	nfloor conveyor, straight double chain	ther con- veyor equip.	er	100	
It	Infloor conveyor, straight double ch	Other con- veyor equ	Unstacker	Total	Sources:
	Inf co st do:	Oth ve	Uns	T	Sou

Annual Cost of Equipment for Plant C, Method 3 Table 22.

Job description	Time standard	Maximum rate required	Total work required per day	No. of men required	Daily labor cost (dol.)
(1)	(2)	(3)	(4)	(2)	(9)
Receive milk from con- veyor and stack in cold room	14.1 cases per min, per man	20 cases per min. <u>a</u> /	1	N	24
Make up loads when trucks come in	1	1	ł	3 6/	42
Check loads for accu- racy as loads come from conveyor	I	1	1	1	14
Receive empty cases from conveyor and place in storage	14.7 cases per min per man	10.9 cases per min. $\underline{b}/$	370 min.c/	1	12
Check in returned milk	rtl52 min. per truck whsll.27 min. per truck		18 min. 33 min.		
Supply empty cases to fillers	30 cases/min.	1	190 min. <u>d</u> /	1/2	9
		Ľ	Total per day	IJ	98

. ..

Table 23. Labor Costs for Plant C, Method 3

52

Table 23 (continued)

Col. (1): pp. 26-36. Col. (2): Appendix Tables A-3, A-4. Col. (3): a/ Table 9. b/ Average rate at which cases are returned on heaviest day during unloading hours of 11:00 a.m. and 5:50 p.m. Col. (4): c/ Total number of cases unloaded on heaviest day (5,600 cases) divided by labor standard. d/ Performed intermittently in alternate half hours from 5:00 a.m. until 1:00 p.m. during filling. Col. (5): e/ Determined in Table 24. Col. (6): Based on wage rates used by two representative fringe costs and additional labor for replacement in case of illness. plants. Actual wage rates were inflated 25 per cent to allow for Sources:

d Three	Total daily cost	(dol.) (8)	32,80	38.76	14.59	22.85	d for trucks 11 01. (4): : ntative y
f Two an	Cost per min.	(dol.)	.035	.040	.035	.040	case loa retail s of .14 e trucks th B. C. Col. (6) represe
it Crew o	Total time	(min.) (dol.) (6) (7)	937.0	969.0	416.8	571.2	<pre>i1 trucks and 110 case load for nutes per case for retail trucks 2): Labor standards of .1411 .0753 for wholesale trucks. outlined in Appendix B. Col. (4) Page 21 of text. Col. (6): (7): Assumed to be representative (8): Col. (6) multiplied by</pre>
l, Loadou	No. of	trucks (5)	34	26	34	26	<pre>L trucks ites per 753 for itlind age 21 of age 21 of 7): Assun 7): Col.</pre>
Table 24. Cost of Salesman Time, Plant C, Method 3, Loudout Crew of Two and Three	Total time per truck	(min.) (4)	27.56	37.27	12.26	21.97	or reta 1463 mi Col. (ks and cedure . (5): Col. Col.
, Plant	Wait	(min.) (3)	17.5	17.5	2.2	2.2	ase load dards of e trucks etail tr th the p -(3). (5 -(3). (5 c Col. (5
man Time	Load	(min.) (2)	4.94	8.28	4.94	8.28	imed 35 c imed 35 c whor stan the for r mated wi Cols. (1) cols. (1) in North
of Sales	Unload Load	(min.) (1)	5.12	11.49	5.12	11.49	Col. (1): Assumed 35 case load f wholesale. Labor standards of . and .1045 for wholesale trucks. minutes per case for retail truc Col. (3): Estimated with the pro Summation of Cols. (1)-(3). Col Col. (4) multiplied by Col. (5).
. Cost	Type		rtl.	whsl.	rtl.	whsl.	
Table 24	Size		5	1	ო	I	Sources:

2 2 3

54

Description of Method 4 for Plant C

Method 4 is probably the most common in North Carolina at the present time. The primary reason for the selection of this method was to compare it with the others.

The primary difference between this method and the previous ones is that this method uses an above-floor conveyor. Normally the cases are handled singly instead of in stacks of five. Although case sizes are larger with an above floor conveyor (resulting in a smaller number of cases), labor costs are increased substantially when cases are handled one at a time.

The layout is indicated in Figure 5. In this system the drivers back the truck up to the unloading dock to unload, then move the truck to the loading dock, hand the shipping clerk the shipping order and pull the cases onto the truck one at a time as they come down the conveyor. It is possible to expand the plant by adding additional loading stalls. The analysis is carried through only for a cold room having three loading stalls.1/

Building, Equipment and Labor Costs

Initial building costs and annual fixed building costs are given in Tables 25 and 26.

Since above floor conveyor equipment is priced somewhat lower than in the other methods, the initial equipment costs and annual fixed equipment costs are somewhat less as in seen in Tables 27 and 28.

Labor costs are given in Table 29.

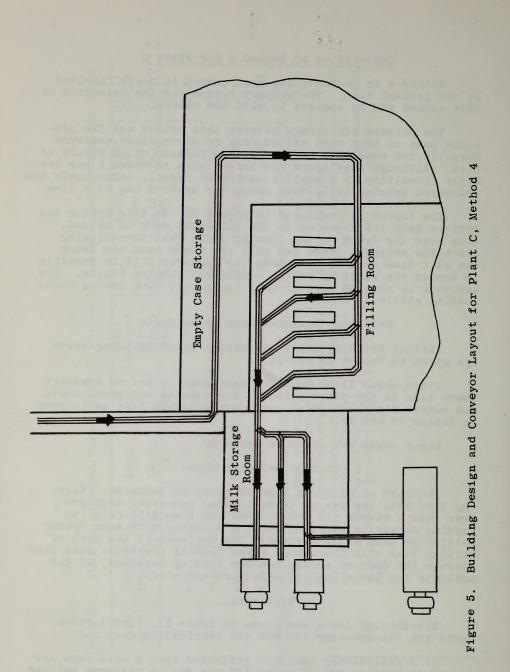
Cost of Salesman Time

The cost of salesman time is given in Table 30. Waiting time with the use of three loading conveyors averaged less than a minute per truck. Waiting time with only two loading conveyors averaged about 8 minutes, with some trucks waiting as much as 35 minutes. The decrease in the cost of waiting time with the use of three loading conveyors more than offsets the cost of adding another loading conveyor, so the analysis for three loading conveyors was used.

Utilities

Electricity costs are given in Table 31. Lubrication costs for the conveyor are \$25 per lubrication unit for

1/ A preliminary analysis indicated that a cold room having three loading stalls saved \$19 per day in salesman waiting time. This saving more than offsets the cost of an additional load out man at \$14 per day plus negligible annual building and equipment costs. 55



the stand and

Table 25. Initial Building Costs for Plant C, Method 4 a/

Building with three loading stalls	Unit	No. of units	Price per unit (dol.)	Total cost (dol.)	Est. life (yrs.)	Annual depreciation (dol.)
	(1)	(2)	(3)	(4)	(5)	(6)
Foundation Floor Diamond plate Walls and ceiling Roof Refrigeration Wiring Total	sq. f sq. f	t. 3,740 t. 3,300 t. 6,060	.90 3.50 .25 1625.00	5,610 2,506 2,970 21,210 825 4,875 240 38,236	40 40 20 20 15 15 10	$ \begin{array}{r} 140\\ 63\\ 149\\ 1,060\\ 55\\ 325\\ 24\\ 1,816\\ \end{array} $

a/ Building 55 feet wide, 60 feet long, dock 8 feet wide across front.

Sources: Col. (1), (2): Figure 5, p. 56. Col. (3): Estimates from two construction engineers from two different construction companies. Col. (4): Col (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research studies. Col. (6): Col. (4) divided by Col. (5).

Table 26. Annual Building Costs, Plant C, Method 4

Purchase cost (dol.) (1)	Annual depreci- ation (dol.) (2)	Repairs (2%) (dol.) (3)	Insur- ance (.8%) (dol.) (4)	Taxes (1.05%) (dol.) (5)	Interest (3%) (dol.) (6)	Total (dol.) (7)
38,236	1,816	1,765	306	401	1147	4,435
Sources:	Based or Col. (4) ted value vary with is const data suf Col. (5) value. cent is quoted the Equivale ciated to	experient : Equival : Equival : Based : by plant a dered rep mitted by : Equival This rate taken as to three lent to app	ace and o lent to 1 d on full and locat: presentat: y three No lent to 2 e will van represen North Care proximate ol. (7): S	ther resea 6 per cen coverage ion, but ive. Rate orth Caro per cent ry with lo tative. I olina plan ly 5 per c	le 25. Co arch studi at of unde . The rat this 1.6 p e is basec lina plant on undep ocation bu Based on p ats. Col. cent of un of Cols.	ies. eprecia- te will per cent d on ts. reciated nt 2 per rates (6): ndepre-

Item	Unit	No. of units	Price per unit (dol.)	Total cost (dol.)
56.00 1.371 IS 320	(1)	(2)	(3)	(4)
Above floor conveyor, straight				
single chain	ft.	700	18	12,600
90 [°] turns	each		255	1,275
90° Y junction	each		350	1,750
45° turns	each		120	600
45° Y junction	each	3	250	750
3 H. P. drive units	each	11	1,250	13,750
Take up units	each	12	300	3,600
Lubricators	each	12	100	1,200
Case pass doors, insulated	each	4	187	748
Case pass doors, uninsulated	each	1 1	146	146
Case pass frame	each	1	87	87
To	tal purc	hase pr	ice	36,506
	stallatio			7,301
				43,807
Fre	eight			800
CARTER CARE CARE CONTRACT	0			44,607

Table 27. Initial Equipment Cost for Plant C, Method 4

Sources: Col. (1), (2): Estimates by sales engineers of several major dairy plant equipment manufacturers. Col. (3): Price lists supplied by dairy plant equipment manufacturers. Col. (4): Col. (2) multiplied by Col. (3).

Total annual costs	(dol.)	2,180	6,362	8,542	tternal ()) ()) ()) ()) ()) ()) ()) ()) ()) ()
Interest (3%)	(dol.)	227	1,111		States Ir Id estimation : Col. (1 : hose assu- those assu- those assumate a submitter to futures it interes
Taxes (1.05%)	(dol.)	19	389		United United Col. (3) (ble to 1 th basis of dat s of dat per cent
RepairsInsuranceTaxes(4%)(.8%)(1.05%)	(dol.)	60	296		chedule F, cesearch st esearch st cturers. re compara stimated c squivalen Equivalen ed on basi lent to 2 alent to 5
Repairs (4%)	(dol.)	302	1,481		(2): S (2): S (2): S (2): S (5): E plants. Estimat Equiva
Annual depreci- ation	(dol.)	1,512	3,085		58. Col attes from col. (4): lies. Col carolina Col. (6): col. (7. value: value:
Est. life	(yrs.)	Ω I	12		27, p. 27, p. 2, estim vy plant (2). (2). (2). (2). entue. carolin carolin alance.
Initial price installed	(dol.)	7,560	37,047		Col. (1): Table 27, p. 58. Col. (2): Schedule F, United States Internal Revenue Service, estimates from other research studies and estimates from major dairy plant equipment manufacturers. Col. (3): Col. (1) divided by Col. (2). Col. (4): Rates are comparable to those assumed in other research studies. Col. (5): Estimated on basis of data submitted by three North Carolina plants. Equivalent to 1.6 per cent on undepreciated value. Col. (7): Equivalent to 2 per cent of value on undepreciated value. Col. (7): Equivalent to 5 per cent interest on the average amortized value.
Item		Conveyor	All other con- veyor equip.	Total	Sources: Col. From from divid in ot in ot in ot by the by the a

Table 28. Annual Equipment Cost for Plant C, Method 4

4
Method
υÛ
Plant
for
Costs
and
Requirements
Labor
Table 29.

Job description	Time standard	Maximum rate required	Total work required per day	No. Dally of labor men cost required (dol.)	Daily labor cost (dol.)
(1) Receive cases from above floor conveyor and place in storage	(2) 5.9 cases per min. per man	(3) 16.7 cases per min.	(4)	3 (2)	(6) 36
Make up loads when trucks come in	1	1	1	n	42
Receive empty cases from conveyor and place in case storage	9 cases per min, per man	1	1	2	24
Supply filler with empty cases	10 cases per min. per man	16.7 cases per min.	1	2	24
		Total	Total per day		126
Sources: Col. (1): Text, pp. 26-36. Col. (2): Appendix Tables A-3, A-4. Col. (3): Table 9. Col. (5): Part time jobs involving 4 hours or less per day were lumped together into one man where the jobs dovetailed in terms of time of performance. Col. (6): Based on wage rates used by two representative plants. Actual wage rates were inflated 25 per cent to allow for fringe costs and additional labor for replacement in case of illness.	3-36. Col. (2) art time jobs i one man where 1): Based on wag rates were inf labor for repla	: Appendix Ta Involving 4 hc the jobs dovet fe rates used lated 25 per c tement in cas	bles A-3, burs or le alled in by two re tent to all e of illr	A-4. Co ss per da terms of presentat low for f	Col. (3): day were if time of ative fringe

4
Method
ů,
Plant
Time,
Salesman
of
Cost
30.
ble

Tak

					Total time No. Total Cost Total	No.	Total	Cost	Total
Type	Unload	Change	Unload Change Load Wait		per	of	waiting	per	daily
truck		docks			truck	twee alon	time	min.	
	(min.)	(min.)	(min.) ((min.) ((min.)) ((min.)	(min.)	(min.)		(min.)	(dol.)	
	(1)	(2)	(3)	(4)	(2)	(9)	(1)	(8)	(6)
Retail	3.80	3.80 2.00 6.44	6.44	.67	12.91	34	34 438.94	.035	15.36
Wholesale	8.15	2.00	8.15 2.00 11.90 1.00	1.00	23.05	26	599,30	.04	23.97 39.33
Sources: Col. (1): Assumed 25 cases per retail load and 78 cases per wholesale load. Labor standards of .1463 minutes per case for retail loads and	(I): A	ssumed r r stand	25 cases ards of	s per re .1463 n	etail load a ninutes per	und 78 c case fo	cases per	wholes loads	and
104	5 minute	es ner (rase for	who les	1045 minutes ner case for wholesale trucks were used Col (2) Assumed	were us	Log Det	. (3)	Assumed

(3): Labor standards dock, dismount from truck and walk to conveyor. Col. (3): Labor standar of .2576 minutes per case for retail trucks and .1525 minutes per case for wholesale trucks were used. Col. (4): Estimated with the procedure 9 time required to walk from dock to truck, enter truck, drive to loading Col. (9) NOON . (3) . 100 outlined in Appendix B. Col. (5): Summation of Cols. (1)-(4). Col. Col. (Page 21 of text. Col. (7): Col. (5) multiplied by Col. (6). Assumed to be representative of wage rates in North Carolina. 200 Col. (7) multiplied by Col. (8). 2 PHONE T

Table 31. Electricity Cost for Plant C, Method 4

Item	Total H.P.	Average K.W.H. per hour	Hours of operation per day		Total monthly usage
	(1)	(2)	(3)	(4)	(5)
Conveyor	33	3333	12	8.25	10,329
Refrigeration units	9	7.83	24	2.50	5,716
		Mont	Price \$		16,045 .007 112.32

Sources: Col. (1): Table 4, p. 27, gives the refrigeration horsepower and Table 6, p. 28, gives the horsepower of the conveyor or drive units. Col. (2): Based on one K.W.H. per H.P. for conveyor and .87 K.W.H. per H.P. for refrigeration. Col. (3): Based on plant observations. Col. (4): Total H.P. divided by 4. Col. (5): Based on 12 hours per day, 313 days per year for conveyor and 24 hours per day, 365 days per year for refrigeration.

12 lubricators for a total monthly cost of \$300 for a system having three loading stalls. The monthly cost is \$25 less for a system of two loading stalls.

Summary and Conclusions for Plant C

The summary of costs under the four methods is given in Table 32. Method 2 is the least cost method followed by method 1, method 3 and method 4 in that order. Method 2 costs \$17,700 less per year than method 4. Method 4 is quite commonly used in North Carolina and is one of the older technologies. The prevalence of method 4 indicates that the adoption of new technologies has lagged somewhat. The causes for this lag may include lack of adequate cost information, lack of investment capital or many other reasons. A reason frequently extended for not changing over to the more modern method is that the old equipment has been completely depreciated out in terms of book value with the equipment still in good repair so that it is profitable to use the equipment since it is nearly "free" to the plant. However, this position is shown in Table 32 to be very tenuous. The savings to be realized with method 2 over method 4 exceed the total annual fixed costs of the buildings and equipment of method 4. This means that even if the users of method 4 imputed a cost

Method	Annual building costs (dol.)	Annual equipment costs (dol.)	Annual labor costs (dol.)	Annual cost of salesman time (dol.)	Annual utility costs (dol.)	Totals (dol.)
	(1)	(2)	(3)	(4)	(5)	(6)
1	6,599	12,013	18,154	13,634	6,996	57,396
2	4,745	10,287	21,910	10,926	4,246	52,115
3	3,603	9,803	30 ,6 74	11,719	4,246	60,045
4	4,435	8,542	39,438	12,310	5,090	69,815

Table 32. Summary of Costs for Plant C, Methods 1, 2, 3 and 4

Sources: Col. (1): Tables 5, 13, 20, 25. Col. (2): Tables 7, 15, 22, 27. Col. (3): Tables 9, 16, 23, 28. Col. (4): Tables 10, 19, 27, 29. Col. (5): Tables 11, 18, 24, 30. Col. (6): Summation of Cols. (1), (2), (3), (4) and (5).

of zero for their building and equipment, it would still pay to change to method 2. This would be true even if the plant had just been constructed 1/ and the equipment was new. The high cost of method 4 is due primarily to the high labor cost of handling single cases.

The analysis probably underestimates the cost savings obtainable by adopting method 2 over method 4. Under method 4 the trucks must move from the unloading dock to the loading dock. This additional driving within the restricted area of the loading docks increases the probability of minor truck accidents. Also, method 2 (as well as the other methods using the infloor conveyor) involves less strenuous work. Cases are slid along the floor instead of being lifted. Also, a plant with an infloor conveyor system is in a more flexible position to adopt innovations such as automatic casers and stackers.

The high cost of method 1 relative to method 2 is due to two factors. First, the loss of cold air through the loading doors requires expensive refrigeration. Refrigeration requirements are estimated on the basis of peak usage. In estimating peak usage it was assumed that as many as five doors would be open at a given time. Actually, refrigeration

1/ Assuming that the cost of tearing out the old equipment did not exceed the salvage value. costs can be cut considerably by requiring drivers to keep the doors closed as much as possible. The second factor causing a high cost is the high loading time required of drivers. The drivers must drag the milk a considerably further distance in method 1 than the other methods.

Method 3 has the disadvantage of loading only one truck at a time plus the disadvantage of assembling the loads after the drivers arrive for loading. When many trucks arrive at close intervals a long waiting line may develop. Loading time per truck can be decreased by larger loading crews up to a certain maximum sized crew. However, increasing the loadout crew beyond this limit will merely result in the workers' getting in each other's way.

SUMMARY FOR PLANT B

Since the procedure for estimating costs for Plant B is similar to that just described for Plant C, only the summary for Plant B is given here. The detailed tables from which the costs are estimated are given in Appendix Tables C-1 to C-7.

Model Plant B bottles an average of two million pounds of fluid milk per month, operates 17 retail routes, 14 wholesale routes and sends one transport load to a branch sales plant.1/ The cost summary for Plant B is given in Table 33. Method 2 is the lowest cost case handling method with method 3, method 1 and method 4 following in that order. Labor costs constitute the largest single cost category. This factor alone accounts for much of the cost advantage of method 2 over method 4. This savings in labor costs is partially offset by higher building and equipment costs, but the cost advantage is still substantial. The high labor costs of handling cases one at a time makes method 4 particularly disadvantageous even though the number of cases can be reduced by using a larger sized case.

Although method 1 uses a relatively small amount of labor, the high building and refrigeration costs incurred by the use of individual loading doors increases the cost of this method as compared to method 2. The high refrigeration requirement is reflected in the utilities costs as well as the building costs.

1/ The product mix and retail-wholesale-transport proportion of total sales is estimated from sales data from several North Carolina plants of this approximate size.

1 3,717 9,584 14,398 7,121 5,152 39 2 2,642 8,543 14,398 5,584 3,895 35 3 2,006 8,148 18,154 7,136 3,300 38	Method	Annual building costs (dol.) (1)	Annual equipment costs (dol.) (2)	Annual labor costs (dol.) (3)	Annual salesman costs (dol.) (4)	Annual utilities costs (dol.) (5)	Total costs (dol.) (6)
3 2,006 8,148 18,154 7,136 3,300 38	1						39,972
	2	2,642	8,543	14,398	5,584	3,895	35,062
4 1,641 6,609 23,788 7,302 4,167 43	3	2,006	8,148	18,154	7,136	3,300	38,744
	4	1,641	6,609	23,788	7,302	4,167	43,507

Table 33. Summary of Four Case Handling Methods for Plant B

Sources: Col. (1): Appendix Table C-2. Col. (2): Appendix Table C-4. Col. (3): Appendix Table C-5. Col. (4): Appendix Table C-6. Col. (5): Appendix Table C-7. Col. (6): Summation of Cols. (1)-(5).

As far as methods 1 and 2 are concerned, the cold room labor is inefficiently utilized. Plant B is slightly too large to accomplish preforming of loads with one man and considerably too small to use two men efficiently. It might be possible for some plants to lower labor costs in methods 1 and 2 still further by using only one man full time to preform loads with part time supplementary labor from some other jobs used in times of peak work requirements. This possibility was not analyzed.

SUMMARY FOR PLANT A

Table 34 gives the summary of the cost analysis for Plant A. The costs are developed in detail in Appendix Tables D-1 to D-7.

Plant A bottles an average of one million pounds of fluid milk per month, operates nine retail routes, seven wholesale routes and sends a small transport load to a branch sales plant.1/

The cost summary indicates that case handling method 2 is still the least cost method. However, the differences

1/ The product mix and retail-wholesale-transport distrIbution of total sales is estimated from sales data of several North Carolina plants of this approximate size.

Method	Annual building costs (dol.)	Annual equipment costs (dol.)	Annual labor costs (dol.)	Annual salesman time (dol.)	Annual utilities costs (dol.)	Total costs (dol.)
	(1)	(2)	(3)	(4)	(5)	(6)
1	2,291	6,608	10,016	3,687	3,388	25,990
2	1,840	5,787	10,016	2,720	2,662	23,025
3	1,375	5,325	13,772	3,660	1,995	26,127
4	1,321	4,079	15,650	4,069	2,263	27,382

Table 34. Summary of Four Case Handling Methods for Plant A

Sources: Col. (1): Appendix Table D-2. Col'(2): Appendix Table D-4. Col. (3): Appendix Table D-5. Col. (4): Appendix Table D-6. Col. (5): Appendix Table D-7. Col. (6): Summation of Cols. (1)-(5).

between the four methods for a plant of this size are small. Method 2 offers an annual saving of \$4,357 over method 4. Reduction of the labor payroll for plants as small as Plant A is difficult because there are few jobs requiring more than one man each, yet these jobs must be performed simultaneously and require the full time attention of one man. This fact accounts for the small differences between the four methods. However, this cost savings of over \$4,000 per year must not be de-emphasized. This represents the annual saving which could be realized each year over the full life of the equipment.

SUMMARY FOR PLANT D

Plant D bottles an average of eight million pounds of fluid milk per month, operates 44 retail routes, 26 wholesale routes and sends 9 transport loads to branch sales plants.1/'The cost summary for Plant D is given in Table 35. Table 35 is developed from Appendix Tables E-1 to E-7.

Cost estimates for Plant D were developed in the same manner as with other plants. One factor which required special

1/ These plant characteristics correspond roughly to plants of similar size in the Southeast.

consideration was the organization of work crews to allow for the large proportion of total volume going out in transports. Much of this milk must be handled twice. Since the transports can not load all of the milk directly off the fillers, much of the milk must be previously filled and placed in storage. When the transports come in for loading, the milk will have to be replaced on the conveyor to be conveyed to the loading dock. However, the four men allotted to the cold room case handling can accomplish the preforming of retail and wholesale loads with enough spare time to handle transport loading as well.

Table 35. Summary of Four Case Handling Methods for Plant D

Method	Annual building	Annual equipment	Annual labor	Annual salesman	Annual utilities	Total costs
	costs (dol.)	costs (dol.)	costs (dol.)	costs (dol.)	costs (dol.)	(dol.)
-	(1)	(2)	(3)	(4)	(5)	(6)
1	8,245	16,715	36,308	14,079	9,486	84,833
2	6,371	14,653	40,064	12,601	6,932	80,621
3	5,275	14,436	43,820	13,227	6,932	83,690
4	6,002	15,610	60,096	16,611	8,681	107,000

Sources: Col. (1): Appendix Table E-2. Col. (2): Appendix Table E-4. Col. (3): Appendix Table E-5. Col. (4): Appendix Table E-6. Col. (5): Appendix Table E-7. Col. (6): Summation of Cols. (1)-(5).

Method 2 is still the least cost method, costing nearly \$26,000 less than method 4. Differences between method 2 and methods 3 and 4 are less significant. Labor costs in the cold room account for much of the cost differential between methods 2 and 4. Largely the same conclusions regarding the case handling methods can be drawn for Plant D as for the other plants. However, the magnitude of the cost savings seems to increase as the size of the plant increases.

SUMMARY AND GENERAL CONCLUSIONS

The objective of this study was to analyze four case handling methods currently available for use in North Carolina milk plants and indicate which method seemed most economical in terms of monetary cost. The four methods analyzed were:

- Method 1 Infloor conveyor, preformed loads, loadout through multiple loading doors.
- Method 2 Infloor conveyor, preformed loads, loadout by a common conveyor and loading dock.
- Method 3 Infloor conveyor, loads made up on arrival of trucks, loadout on a common conveyor and loading dock.
- Method 4 Above-floor conveyor, loads made up on arrival of trucks, loadout on multiple conveyor spurs.

The analysis was carried through for plants of four different sizes in order to determine the effects of volume on the selection of the case handling method. In each case a complete list of the inputs and services necessary to accomplish the case handling function was made. Physical inputs and input prices were listed separately to allow adaptation of the results to different price situations. Costs were divided into building costs, equipment costs, labor costs, cost of salesman time at the loading docks, and utilities costs.

The analysis indicated that substantial cost savings can be realized with the use of infloor conveyor as opposed to the older method of above-floor conveyor. Much of the savings is attributable to decreased labor costs in the cold room. Cases can be easily handled in stacks of five with an infloor conveyor instead of one at a time with the above-floor conveyor. The stacking of cases for use on an infloor conveyor can be accomplished in the filling room in several ways. The case-off men can manually stack the cases while casing-off. The stacking can be expedited by the use of an inexpensive stacking aid at each filler.

Labor costs can be further reduced with an infloor conveyor by preforming loads directly from the filler-conveyor. With this procedure the cases are handled a lesser number of times than with the procedure of first stacking the cases in storage and then making up the loads. The successful preforming of loads depends largely on the effective coordination of the filling operation with the cold room case handling. Cold room work requirements vary considerably with the number and type of products being filled at any given time. Thus cold room work can be lightened by using two or more fillers on one product. Although this procedure increased the number of product and size changes on the fillers, it does not greatly affect the efficiency of the filling operation and has the advantage of lightening cold room work in preforming loads. Once the loads are preformed, the trucks may be loaded out through individual loading doors, as in method 1, or on a common conveyor and dock as in method 2. Method 1 has the advantage of giving the driver more freedom to load at will and eliminates the annoying problem of waiting in line for space at the dock. However, method 1 has the disadvantages of higher building, equipment and electricity costs. Also it takes the drivers more time to load since the milk must be dragged a longer distance. These disadvantages cause method 1 to be slightly more expensive than method 2 for all sizes of plants considered.

Methods 3 and 4 have lower building and equipment costs than methods 1 and 2 but have the disadvantage of making up the loads after the trucks arrive for loading. Loading times for each truck are therefore increased and long waiting lines may develop for plants having a large number of trucks to load. The waiting problem can be somewhat alleviated by increasing the size of shipping crews and reducing the loading time per truck. Increased shipping crews add to annual payroll costs.

The total cost advantage of method 2 over method 4 ranges from \$4,700 per year for plants bottling one million pounds of fluid milk per month to \$26,000 per year for plants bottling eight million pounds per month. Plants of intermediate size have corresponding savings. The saving in labor cost alone between methods 2 and 4 is of a greater magnitude than the total annual fixed cost of buildings and equipment for method 4. This means that the users of method 4 could save money by changing to method 2 even though they impute a value of zero to their building and equipment.1/

1/ Assuming the salvage value of the old equipment covered the cost of tearing out the old equipment.

Appendix A Estimation of Labor Requirements

There are two major methods of estimating labor standards. One is called "work sampling" and the other is the continuous stop watch method.

The work sampling method consists simply of observing the workers' activities briefly at random intervals during an extended period, noting the particular work activity being performed at each observation and inferring from these random observations the proportion of time which the workers spend on particular tasks. The output of the worker during the period of observation is also recorded. The procedure is illustrated in Table A-1.

Appendix Table A-1. An Illustration of the Method of Estimating Time Requirements

	e of job - preforming retail 10 in 8:30 End 10:20 Total time	
-	Job elements	Number of observations
1.	Read load sheet	12
2.	Drag and place milk	20
3.	Break down cases	18
4.	Miscellaneous work	5
5.	Wait, non-work	27
		Total 82

The researcher must have clearly in mind the beginning and ending points for each of the work elements so there will be no uncertainty as to which work element is being performed at the time of observation. These decisions should be worked out in advance if possible. The analysis of the sample is carried on as shown in Table A-2.

Job	No. of	Per cent of	Time	No. of	Minutes
element	obs.	total obs.	spent	cases	per case
STELLER AND AND A STATE	a territin a	Sector not care to	(min.)	TAN DEC	The second second second
Read load sheet	12	14.6	16.1	200	.0803
Drag and place milk	20	24.4	26.8	200	.1342
Break down cases	18	21.9	24.1	200	.1204
Miscellaneous work	5	6.1	6.7	200	.0336
Wait, non-work	27	33.0	36.3	200	
			Tota	al	.3685

Appendix Table A-2. Sample Analysis of Work Sampling Sheets

This process should be repeated for a number of different workers and at a number of plants if possible. Confidence in the results is increased as the sample size increases.

The other method is the "continuous stop watch" method. With this method, as the name implies, the workers are under constant observation. As the workers perform their activities, the observer keeps a running account of the worker with a stop watch. The work may be broken down into a number of job elements with separate observations for each. The total working time is divided by the output of the worker to estimate labor standards.

There are advantages and disadvantages with each of the two methods. The continuous stop watch method may be more accurate for observing a small number of workers for short periods. As the number of workers to be observed increases, the task of keeping all of the workers under constant surveillance becomes extremely difficult. The work sampling method is more appropriate where many workers are to be observed simultaneously. However, since work sampling involves the observation of each worker during only a small proportion of his working time, the sample size must be increased substantially in order to obtain confidence in the estimated labor requirements.

The labor standards in Appendix Tables A-1 and A-2 were estimated by using both methods. In each case the particular method of estimation was selected which appeared easiest to apply with satisfactory results.

With unlimited research inputs and many different plants to observe, it is possible to estimate the labor standards as accurately as may be desired. However, research inputs for this study were not unlimited so that the sample size was small. Even so, the limiting factor in extending the sample size did not arise from the limited research inputs available but from the paucity of plants using the particular labor techniques under investigation. In some cases the estimation of labor standards is based on the observation of only one plant. In such a situation, the estimates should not be interpreted as "labor standards" but more realistically should be considered as "possibilities." However, the measurements obtained do represent actual situations which may be duplicated by other plants.

2 6 2

Job description	Time standard (min./case)a/ Condition surrounding work	Condition surrounding work
Docition osces in cold	0000 ALim ton 04 Alew	Worker of the second se
room - worker walks to con-	Drag milk from con-	100 linear feet of storage
veyor, hooks onto a 5-high	veyor and position	space and was concerned with
stack and slides it to the		3 different products
appropriate place		TORNAL ALLOCAL BUG ON ON ON
Loading out milk for	Read load sheet .0049	Storage area was 200 feet
tractor-trailer - load out	Walk to get milk .0066	long
man consults load sheet,		
walks to appropriate stack	conveyor .0523	ARTICLE AND LINE OF ALL AND AL
of milk, selects required	Total .0638	
number of items and pulls		· · · · · · · · · · · · · · · · · · ·
them on the conveyor in		
5-high stacks		
Loading retail truck from		Conveyor was approximately
conveyor - truck driver	T DOG T	truck door height and about
drags milk from conveyor to		2 feet in horizontal dis-
dock beside truck and		tance from the truck door
places milk inside truck		
Loading retail truck		Milk was dragged from the
through individual loading	Drag milk to truck .1121	cold room across a 4 foot
door - truck driver opens	Arrange milk in	platform and into the truck
door, goes into storage		AND AND AND AND ADDRESS OF ADDRES
room, checks milk, pulls	Total .2887	
milk out door onto loading		
dock, puts milk in truck	(.02	State of the state of the state of
Loading wholesale truck		Milk was dragged from the
from individual loading	uck	cold room across a 4 foot
door with hand truck in	Total .1180	platform and into the truck
stacks 5-high	(.0035)	

Time Standard for Case Handling Jobs with Infloor Conveyor Appendix Table A-3.

Appendix Table A-3 (continued)

approximately 200 feet long truck door height and about Time standard (min./case) a/ |Condition surrounding work Conveyor was approximately 2 feet in horizontal distance from the truck door Storage area was approxi-Storage area was approxi-Storage area was approxi-Cold storage area approxi Storage area covered was Storage area was approxi-Storage area was approxi loaded through side door **Transport 35 feet long** mately 200 feet long mately 27 feet wide mately 75 feet long mately 75 feet long .0435d/ mately 75 feet long mately 75 feet long .0753c/ 0000<u>d</u>/ .0499 0456 1156 2680 0504 0552 1507 0731 CT1 (6100.) (.0082) .0046) .0058) .0297) Break down cases Read load sheet Drag milk conveyor, drags milk to appúll milk from conveyor and place in tractor trailer in I reads load sheet, walks to oadout man takes the load Loading out retail - three Loading out retail trucks oading out retail trucks Preforming retail loads -Load wholesale truck from trucks - 1 man crew - the sheet, goes into the cold oading tractor trailer pulls milk from conveyor conveyor - truck driver room, alternately reads the load sheet & places trucks - three man crew propriate place, breaks oading out wholesale coading out wholesale trucks - two man crew loading out wholesale Job description items on conveyor 5-high stacks one man crew two man crew into truck down cases man crew

(continued)	
A-3	
Table	
Appendix	

Condition surrounding work	Cold storage area approxi- mately 27 feet wide	Conveyor was approximately truck door height and about 2 feet in horizontal dis- tance from truck door	Conveyor was approximately truck door height and about 2 feet in horizontal dis- tance from truck door	Cold room 27 feet wide	Cases are usually received already stacked 3 or 4 high, worker increases stack to 6		52 per Less than one case per cruck truck is normally returned from refrigerated trucks
Time standard $(min./case)a/$ Condition surrounding work	Read load sheet .0071 Drag and place .0552 Break down cases .0082 .0705	.1045 (.0064)	.1463 (.0051)	.0427	.0680	.0333	Retail .52 per truck
Job description	Preforming wholesale loads - reads load sheet, drags milk to appropriate place and breaks down cases if necessary	Unload wholesale truck - place empty cases on con- veyor through rear door of truck	Unload retail truck - place empty cases on con- veyor through rear door of truck	Setting preformed loads onto conveyor - pulls stacks of milk onto conveyor	Receive empty cases from conveyor, stack to 6-high and place in storage	Pull stacks of empty cases onto conveyor for case unstacker to supply fillers	Check in returned milk from trucks

Sources on following page.

(continued)
A-3
Table
Appendix

Measured in minutes per case except as otherwise noted.

Figures in parentheses are standard errors of the estimate of the mean.

a/ Measured in minutes per case every as varies of the \overline{b}/F figures in parentheses are standard errors of the estimate of the \overline{c}/T ime requirements for this job seemed to be related to load size.

The following regression equation describes the relationship:

 $(R^2 = .74)$ (N = 38)T = -.96 X.88

These estimates d/ No observations were obtained for a crew of this size. where T = minutes required to load; X = number of cases.

were merely extrapolated from the preceding figures for one and two men crews.

Appendix Table A-4. Time Standards for Off-floor Conveyor

	La contra de
Job description	Time standard (min. per case)
Loading out wholesale trucks -	
cold room crew takes shipping	and the second distance of the second distance of the
order into cold room, selects	
the appropriate items and	1.505
sends them out on the conveyor	.1525
Loading out retail trucks -	
cold room crew takes shipping	
order into cold room, selects	
the appropriate items and sends	.2576
them out on the conveyor	(.0312) <u>a</u> /
Placing milk in cold room -	Stack case on floor .035
cold room worker receives milk	Secure stack to move .020
from conveyor, stacks the milk	Position stack and
on the floor beside the con-	turn .014
veyor, moves the stack over to	Move hand truck 15
the wall by hand truck	ft. and return .032
	Miscellaneous .070
	.171 <u>b</u> /
Loading tractor trailer - cold	
room crew takes shipping order	The survey of the start first start
into cold room, selects the	starting of the set diverse of the same start that the set
appropriate items and sends	
them out on the conveyor	. 0900
Unload wholesale truck - place	
empty cases through rear door	.1045
of truck onto case conveyor	(.0064)
Unload retail truck - place	The second s
empty cases through rear door	.1463
of truck onto case conveyor	(.0051)
Receive empty cases from con-	
veyor, stack 5-high and place	
in storage	.1111 <u>c</u> /
Take stacks of cases from con-	along and the state of the state
veyor, unstack cases and place	/
cases one at a time on conveyor	. 1000 ^c /

a/Numbers in parentheses represent the standard error of the estimated mean of the observations.

b/ Obtained from Charles E. French and Harry R. Varney, Jr., "Labor Utilization in Cold Storage and Empty Bottle Rooms," Purdue Research Bulletin No. 677, Lafayette, Indiana, April, 1959, and Fred H. H. Calhoun, Jr., "Standard Cycle Times Applied to Milk Bottle Case Handling in Dairy Plants," Unpublished thesis submitted in partial fulfillment of the degree, Master of Dairy Manufacturing, North Carolina State College, 1956, pp.28-40.

c/ Estimates taken from Calhoun, loc. cit.

Appendix B

Queuing Theory and the Determination of Waiting Time for Trucks

To use queuing theory in the determination of waiting time at a service facility such as a loading dock, the following types of information are required:

- the probability distribution of truck arrivals at the loading dock;
- (2) the mean arrival rate;
- (3) the probability distribution of loading times;
- (4) the average loading time;
- (5) the queue discipline or priority system, such as "first come-first served."

Solutions regarding the behavior of the queue differ with the type of probability distributions which characterize the truck arrivals and loading times. A particular arrival distribution which frequently occurs in practical problems is the Poisson distribution. The sample of truck arrivals obtained in the study was tested in Appendix Table B-1 by chi-square to see if it could have come from a population with a Poisson distribution. The hypothesis that the sample was obtained from a population with a Poisson distribution could not be rejected at the 95 per cent level of confidence. Consequently, the mathematical procedures developed here are applicable to queues in which the truck arrivals have a Poisson distribution.

A necessary assumption in the development that follows is that the mean arrival rate and the mean servicing rate are constant over time. The solution is given only for a loading facility which loads one truck at a time. The solution for K loading lines follows the same procedure.

mple of Truck n Distribution	$\frac{(f_c - f_o)^2}{f_c} = \chi^2$	1.156 2.227 2.337 1.539 .439 .439 .817 6.515 11.07	(x ² .95)	Col. (1): The hours from 11:00 a.m. to 5:30 p.m. were divided up into fifteen minute periods and the number of trucks arriving within these periods were counted. Col. (2): Taken from a sample in which the truck arrivals were recorded for a week at a North Carolina plant. The first number (36) means that during the week there were 36 fifteen minute periods during which there were no truck arrivals. Col. (3): Probabilities from a Poisson distribution with mean 1.5 of the number of intervals during which $0, 1, 2, 3, 4, 5, 6, 7$ trucks arrived. Col. (4): Expected value of the number of intervals during which $0, 1, \ldots 7$ trucks arrived. Obtained by multiplying the number of total arrivals by Col. (5): The square of the deviation of Col. (2) - Col. (3). Since the X ² - 6.5 is less than the tabled value of 11.07, the hypothesis that the sample came from a universe with a poisson distribution cannot be rejected at the 95 per cent level of trucks arrived was small, these intervals were combined into the trucks arrived was small, these intervals were combined into the
etermine if a Sa ne from a Poisso	$\begin{array}{c} (4) \\ Expected no. \\ of intervals \\ (f_{C}) \end{array}$	30.0 45.2 16.9 2.4 3.3 9 2.4	$(f_0 = 1.5 \text{ per } 15 \text{ minutes})$	<pre>n. to 5:30 p.m. nber of trucks a Taken from a sam a week at a Nort during the week were no truck a were no truck a ribution with me y 3, 4, 5, 6, 7 amber of interva ad by multiplyin The square of than be came from a picted at the 95 intervals during atervals were co</pre>
A Chi-Square Test to Determine if a Sample of Truck Arrivals Could Have Come from a Poisson Distribution	(3) Probabilities of occurrence $(\overline{\lambda} = 1, 5)$.223 .335 .251 .047 .018	$(\bar{f}_0 = 1.5]$	S from 11:00 a. iods and the num ed. Col. (2): 7 e recorded for 3 36) means that 6 ing which there ing which 0, 1, 2 g which 0, 1, 2 s value of the nu value of the nu vrived. (05): 7 ince the $X^2 = 6$ ince the $X^2 = 6$ sis that the sam on cannot be re- the number of small, these in or more."
	(2) Frequency of occurrence (f ₀)	36 42 255 8 8 8 7 8 8 7 8 8 7 8 7 8 8 7 8 7 8 7		Col. (1): The hours from 11:00 a.m. to 5:30 p.m. were divided up fifteen minute periods and the number of trucks arriving within the periods were counted. Col. (2): Taken from a sample in which the truck arrivals were recorded for a week at a North Carolina plant The first number (36) means that during the week there were 36 fi minute periods during which there were no truck arrivals. Col. (Probabilities from a Poisson distribution with mean 1.5 of the nu of intervals during which 0, 1, 2, 3, 4, 5, 6, 7 trucks arrived. Col. (4): Expected value of the number of intervals during which of 17 trucks arrived. Obtained by multiplying the number of arrivals by Col. (5): The square of the deviation of C (2) - Col. (3). Since the $X^2 = 6.5$ is less than the tabled value 11.07, the hypothesis that the sample came from a universe with a poisson distribution cannot be rejected at the 95 per cent level confidence. Since the number of intervals during which 5 or more trucks arrived was small, these intervals were combined into the
Appendix Table B-1.	(1) No. of arrivals in 15 min.	0 1 2 4 5 or more		Sources:

The following notation will be used:

- n = number of units in waiting line at time t
- λ = mean arrival rate
- \mathcal{M} = mean loading time
- $P_n(t)$ = probability of n units in the queue at time t
- λdt = the probability of a new truck entering the queue in the time interval dt
- pdt = the probability of a truck being loaded in the time interval dt

The solution involves the formulation of two differential equations which are to be solved simultaneously. One equation represents the probability of n trucks in the queue at time (t + dt) and the other equation represents the probability of no trucks in the queue at time (t+dt). The equations are as follows:

- (1) $P_n(t + dt) = P_n(t) \left[1 (\lambda + M)dt\right] + P_{n-1}(t) \lambda dt + P_{n+1}(t)Mdt$
- (2) $P_{0}(t+dt) = P_{n}(t) (1 \lambda dt) + P_{1}(t) \times dt$

The first equation states that the probability of n trucks in the system at time (t + dt) equals the probability of n trucks in the system at time t multiplied by the probability of no arrivals and no departures plus the probability of (n-1) trucks in the system at time t multiplied by the probability of one arrival and no departures plus the probability of (n + 1)trucks in the system at time t multiplied by the probability of one departure and no arrivals. These represent an enumeration and summation of all ways in which there might result in (n) trucks in the system at time (t + dt).

Expanding these two equations and passing to the derivative we get:

(3)
$$\frac{P_n(t + dt) - P_n(t)}{dt} = -\lambda P_n(t) - \mu P_n(t) + \mu P_{n+1}(t)$$
$$+\lambda P_{n-1}(t)$$
and (4)
$$\frac{dP_o(t + dt) - P_o(t)}{dt} = \lambda P_o(t) + \mu P_1(t)$$

In setting these derivatives to zero and transposing terms, there results:

(5)
$$(\lambda + \mu) P_n = \lambda P_{n-1} + \mu P_{n+1}$$

(6) $\lambda P_0 = \mu P_1$

Solving equation (2) for P_1

(7) $P_1 = \frac{\lambda}{H} P_0$

For n = 1 we substitute in equation (5),

(8) $(\lambda + \mathcal{H})P_1 = \lambda P_0 + \mathcal{H}P_2$

And solve for P2

(9)
$$P_2 = (\lambda)^2 P_0$$

Repetition of this process for all n gives:

(10)
$$P_n = (\lambda)^n P_o$$

Using the relationship of $\sum_{n=0}^{\infty} P_n = 1$ enables us to obtain a solution involving only the parameters λ and \mathcal{A} , as follows:

(11) $\sum_{n=0}^{\infty} P_n = 1$ but $P_n = (\lambda)^n P_0$ so $\sum_{n=0}^{\infty} (\lambda)^n P_0 = 1$ Using the formula for the sum of an infinite geometric pro-

gression, namely

(12) $\sum_{n=0}^{\infty} ar^n = a$

our equation becomes:

13)
$$\sum_{n=0}^{\infty} P_{o} \left(\frac{\lambda}{\pi}\right)^{n} = \frac{P_{o}}{1 - \frac{\lambda}{\pi}} = 1 \text{ or } P_{o} = 1 - \frac{\lambda}{\pi} \text{ hence}$$
$$P_{n} = \left(\frac{\lambda}{\pi}\right)^{n} (1 - \frac{\lambda}{\pi})$$

Now we have a formula for the estimation of the probabilities of any number of trucks in the system expressed only in terms of our parameters λ and \mathcal{A} .

An estimate of the actual number of trucks in the system at any time is given by:

(14)
$$L = \sum_{n=0}^{\infty} nP_n = (1 - \frac{\lambda}{M}) \sum_{n=0}^{\infty} n(\frac{\lambda}{M})^n = \frac{\frac{\lambda}{M}}{1 - \frac{\lambda}{M}}$$

Note that L is an expected value with variance:

$$\sum_{n=0}^{\infty} (n - L)^2 P_n = \sum_{n=0}^{\infty} n^2 P_n - \frac{\lambda}{2} \frac{1}{1 - \lambda}$$

Other formulas can be derived for estimates of the average waiting time, average idle time of the loading facility, etc.

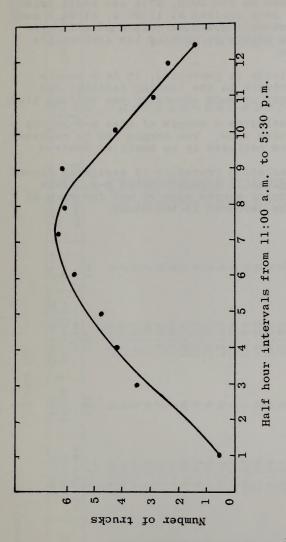
2

Direct algebraic computation of queuing characteristics for this problem is simple. However, the relaxation of the assumption that the mean arrival rate or the mean service rate are constant over time changes the method of solution. A. B. Clarkel/ has shown that when the mean arrival rate is dependent on time, the solution of queue characteristics can be found by the evaluation of a (complicated) Bessel function.

The mean arrival rate of milk delivery trucks at the loading dock is dependent on time. This fact seems obvious in Figure B-1, which shows the mean arrival rate per hour as a function of time during the entire loading period of a sample plant. Since the mean arrival rate cannot be considered independent of time, a simple algebraic solution of queue characteristics is not available. Fortunately, however, the solution can be accomplished in a simple non-mathematical manner by a Monte Carlo simulation procedure. This procedure involves (1) setting up (on paper) a series of random truck arrivals characterized by a Poisson distribution, (2) assigning the trucks to loading facilities on a first come-first serve basis and (3) keeping a running account of dock occupancy and waiting time.

Simulated truck arrival times are obtained from a table of random numbers. A group of random numbers are drawn and certain numbers are specified as being "arrivals" and some as "non-arrivals." The specification of numbers is done in such a way that the expected value of the total number of "arrivals" in the group of random numbers equals the estimated mean arrival rate and in such a way that the frequency distribution of arrivals corresponds to a Poisson distribution. In a group of two digit numbers, the occurrence of a double digit number (such as 99) has a Poisson frequency distribution. By specifying the 99 as an "arrival" and all other numbers as non-arrivals, the corresponding series of truck arrivals should be distributed in accordance with the Poisson distribution. Furthermore, since the occurrence of a 99 can be assigned a probability of .01, the appropriate

1/ A. B. Clarke, "A Waiting-Line Process of Markov Type," Annals of Mathematical Statistics, Volume 27, 1956, Waverly Press, Inc., Baltimore, Maryland.



Distribution of Truck Arrivals for Loading during an Afternoon Loading Period Figure B-1.

Source: Sample at a North Carolina plant.

mean arrival rate can be approximated by specifying the number of random numbers drawn. If the specified mean arrival rate is 3.5 trucks per half hour, it would be necessary to draw 350 random numbers. Each random number would correspond to a time interval of 30/350 = .0857 minutes. Consequently, if the sampling procedure is considered as starting at 11:00 a.m., and the number 99 occurred on the 30th, 67th and 220th trial, trucks could be said to have arrived at 11:00.2, 11:05.7 and 11:18.9 a.m. The arrival rate could be varied at will over consecutive time periods merely by drawing the appropriate number of random numbers.

Once a list of arrivals is generated, it is a simple matter to assign the arrivals to the loading facility and maintain a running account of dock occupancy and waiting time.

This procedure constitutes a sample of size n=l in the estimation of total waiting time. The sample can be repeated until the variance of the estimate is as small as desired.

A sample of the simulation procedure of assigning trucks to the loading dock is given in Appendix Table B-2. This procedure was repeated for a sample size of n=7 for each of the waiting time problems involved in the study.

t Loading	
s at	
f Trucks	
of	
a Queue	
a	
6	
rlo Sample	
nte Carlo	
A Monte	A and B ^a
₹.	4
e B-2.	
Table	
Appendix	

Docks

per hour	(8)	4.6	4.6	4.6	4.6	4.6	4.6	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	0 7
λw per hr.	(1)	9.	9.	9.	9.	9.	9.	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5 4
Waiting time (min.)	(9)	0	0	0	0	0	0	0	0	0	9	e	9	0	0	0	0	1	0	2	0	10	ი	80	7	12	7
Time load- ing is completed	(2)	11:09	11:09	11:30	11:48	12:00	12:05	12:12	12:27	12:28	12:34	12:35	12:41	12:42	12:50	12:58	1:00	1:11	1:13	1:24	1:26	1:31	1:33	1:38	1:40	1:45	1.53
Dock sel.	(4)	A	В	A	A	A	B	A	A	В	A	в	A	в	A	A	В	A	В	A	В	A	B	A	В	A	æ
Time dock is avail- able	(3)	11:02	11:02	11:17	11:35	11:53	11:58	12:05	12:14	12:21	12:27	12:28	12:34	12:35	12:43	12:51	12:53	12:58	1:07	1:11	1:13	1:24	1:26	1:31	1:33	1:38	1.40
Type truck	(2)	ж	Я	M	M	Я	ж	Я	M	н	Я	Я	н	н	н	Я	Я	M	н	M	M	Я	ж	H	Я	Я	M
Time of arrival of trucks	(I)	11:02	11:02	11:17	11:35	11:53	11:59	12:05	12:14	12:21	12:21	12:25	12:28	12:35	12:43	12:51	12:53	12:57	1:07	1:09	1:13	1:14	1:23	1:23	1:26	1:26	1.33
No.		г	07	ო	4	ŋ	9	2	80	6	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

86

Appendix Table B-2 (continued)

Sources:	random r 99 and c for whol trucks a at whick Col. (5) Col. (7)	random numbers. If the number was under 99, no arrivals were made. 99 and over constituted an arrival. Col. (2): Separate drawings were for wholesale trucks and retail trucks. Col. (3): Same as Col. (1) trucks are in line. If trucks are in line, this column represents the truck are in line a dock is freed. Col. (4): Any dock that happens to be emp- col. (5): Col. (3) plus the loading time. Col. (6): Col. (3) - Col. Col. (7), (8): Arrival rates used to simulate dock occupancy.	99 and over constituted an arrival. Col. (2): Separate drawings were mad for wholesale trucks and retail trucks. Col. (3): Same as Col. (1) if no trucks are in line. If trucks are in line, this column represents the ti at which a dock is freed. Col. (4): Any dock that happens to be empty. Col. (5): Col. (3) plus the loading time. Col. (6): Col. (3) - Col. (1). Col. (7), (8): Arrival rates used to simulate dock occupancy.	ail tru ss are ol. (4) loading used t	for wholesale trucks and retail trucks. Col. (3): Same as Col. (1) if no trucks are in line. If trucks are in line, this column represents the time at which a dock is freed. Col. (4): Any dock that happens to be empty. Col. (5): Col. (3) plus the loading time. Col. (6): Col. (3) - Col. (1). (7), (8): Arrival rates used to simulate dock occupancy.	99 and over constituted an arrival. Col. (2): Separate drawings were made for wholesale trucks and retail trucks. Col. (3): Same as Col. (1) if no trucks are in line. If trucks are in line, this column represents the tim at which a dock is freed. Col. (4): Any dock that happens to be empty. Col. (5): Col. (3) plus the loading time. Col. (6): Col. (3) - Col. (1). Col. (7), (8): Arrival rates used to simulate dock occupancy.	rawings we s Col. (1) epresents s to be em (3) - Col 1CY.	Col. (1): At each time period a two digit number was drawn from a table of random numbers. If the number was under 99, no arrivals were made. Numbers 99 and over constituted an arrival. Col. (2): Separate drawings were made for wholesale trucks and retail trucks. Col. (3): Same as Col. (1) if no trucks are in line. If trucks are in line, this column represents the time at which a dock is freed. Col. (4): Any dock that happens to be empty. Col. (5): Col. (3) plus the loading time. Col. (6): Col. (3) - Col. (1).
by a \overline{P} oisso: arrival dati Unfortunate chi-square hourly comp	by a \overline{Po} is a The chi-se by a \overline{Po} is son disti- arrival data. Yet Unfortunately the chi-square tests f hourly components hourly data.	quare tes ribution t the Mon re was an for each possesse	t to determin was accomplia te Carlo simu i insufficien hour, Hence d the same di	ne whet shed by ulation t numbe the as istribu	a/ The chi-square test to determine whether the truck arrivals were characterized by a $\overline{P}oisson$ distribution was accomplished by aggregating the individual hourly arrival data. Yet the Monte Carlo simulation separated the data into individual hours. Unfortunately there was an insufficient number of observations to accomplish separate chi-square tests for each hour. Hence the assumption was made that the individual hourly components possessed the same distribution characteristics as the aggregated hourly data.	<pre>x arrivals the indiv: ne data indiv: tions to ac made that ristics as</pre>	were char idual hour to individ ccomplish the indiv s the aggr	acterized 1y ual hours. separate idual egated

Unit	No. of units	Price per unit (dol.)	Initial cost (dol.)	Est. use- ful life (years)	Annual deprec. (dol.)
(1)	(2)	(3)	(4)	(2)	(9)
sq. ft. sq. ft.	2197	1.50 .67	3,295 1,472	40 40	82 37
sq. ft. sq. ft. sq. ft.	3861 2197 2760	3.50 .90 .25	13,513 1,977 690	20 20 15	675 99 48
each each each	12 12	250.00 1625.00 20.00	$\begin{array}{c} 1,750\\ 8,125\\ 240\\ 31,012\end{array}$	20 15 10	88 542 24 <u>1,593</u>
sq. ft. sq. ft.	1952 1952	1.50 .67	2,928 1,308	40 40	73 33
sq. ft. sq. ft.	3606	3.50	12,621 1,756	200	631 88
sq. ft. each each	2480 2 6	.25 1625.00 20.00	$\begin{array}{c} 620\\ 3,250\\ 120\\ 22,603 \end{array}$	15 10	$\begin{array}{c} 41\\ 216\\ 12\\ 1,094 \end{array}$
			<pre>ft. 2197 ft. 2197 ft. 3861 3 ft. 2197 ft. 2760 ft. 2760 ft. 1952 ft. 1952 1 ft. 1952 1 ft. 1952 ft. 2480 ft. 2480 ft. 2480 ft. 2480 ft. 2480 ft. 2480</pre>	<pre>ft. 219767 ft. 219767 ft. 3861 3.50 1 ft. 219725 ft. 276025 ft. 1952 150 ft. 1952 150 ft. 1952 167 ft. 3606 350 1 ft. 2480 ft. 2480 ft. 2480 ft. 2480</pre>	ft. 2197 .67 1,472 ft. 3861 3.50 13,513 ft. 2197 .25 690 ft. 2760 .25 690 7 255.00 1,750 5 1625.00 8,125 12 20.00 1,750 5 1625.00 8,125 12 20.00 1,750 7 240 31,012 7 1952 .67 1,308 ft. 1952 .67 1,308 ft. 1952 .67 1,756 ft. 2206 3.50 12,621 ft. 22 003 3.250 ft. 22 000 22,603 ft. 20.00 22,603 2260

1 - - 2 -4

-

$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	(dol.)	cost (dol.)	Est. use- ful life (years)	Annual deprec. (dol.)
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	(3)	(4)	(2)	(9)
and ceiling sq. ft. 1435 and ceiling sq. ft. 1435 plate on floor sq. ft. 1435 g. units (2 ton) sq. ft. 1760 sq. ft. 1760 sq. ft. 1760 sq. ft. 1188 ation sq. ft. 1188 ation sq. ft. 1188 sq. ft. 1188 sq. ft. 1188 sq. ft. 1386 sq. ft. 2052 plate on floor sq. ft. 2052	1 50	2,153	40	54
and celling ls sq. ft. 2668 plate on floor sq. ft. 1435 ng sq. ft. 1760 sq. ft. 1760 sq. ft. 1760 ach 5 ach 5 ach 5 ach 5 ach 5 ach 5 sq. ft. 1188 sq. ft. 1188 sq. ft. 1188 sq. ft. 1188 sq. ft. 1386 sq. ft. 2052 plate on floor sq. ft. 2052 sq. ft. 1386 sq. ft. 2052 sq. ft. 1386 sq. ft. 2052 sq. ft. 1386 sq. ft. 2052 sq. ft. 1386 sq.	.67	961	40	24
ls sq. ft. 2668 plate on floor sq. ft. 1435 ng sq. ft. 1760 sq. ft. 1760 sq. ft. 1760 ach 5 ric outlets each 5 ation sq. ft. 1188 add celling sq. ft. 1188 and celling sq. ft. 1188 sq. ft. 1188 sq. ft. 1386 plate on floor sq. ft. 2052 plate on floor sq. ft. 20				
plate on floor sq. ft. 1435 ng sq. ft. 1760 g. units (2 ton) each 2 ric outlets each 5 ation sq. ft. 1188 and celling sq. ft. 1188 and celling sq. ft. 2052 plate on floor sq. ft. 1386 g. ft. 2052 plate on floor sq. ft. 2052	3.50	9,338	20	467
ng sq. ft. 1760 g. units (2 ton) each 2 ric outlets each 5 ation sq. ft. 1188 and celling sq. ft. 1188 and celling sq. ft. 2052 plate on floor sq. ft. 2052 plate on floor sq. ft. 272 plate on floor sq. ft. 2652 c. units (2 ton) each 2	.90	1,292	20	65
<pre>g. units (2 ton) each 2 ric outlets each 5 d 4 d/ ation sq. ft. 1188 and celling sq. ft. 1188 and celling sq. ft. 2052 plate on floor sq. ft. 2052 plate on floor sq. ft. 2386 sq. ft. 1386</pre>	.25	440	15	30
ric outlets each 5 $\frac{d}{ation}$ sq. ft. 1188 and ceiling sq. ft. 1188 and ceiling sq. ft. 2052 plate on floor sq. ft. 272 plate on floor sq. ft. 1386 sq. ft. 282 plate on floor sq. ft. 282 plate on floor sq. ft. 286	1400.00	2,800	15	186
d 4 d/ ation 4 d/ sq. ft. 1188 and ceiling sq. ft. 1188 sq. ft. 2052 plate on floor sq. ft. 2052 sq. ft. 1386 outs sq. ft. 2052 plate on floor sq. ft. 272 sq. ft. 1386 sq. ft. 222	20.00	100	10	10
d 4 d/ ation sq. ft. 1188 and ceiling sq. ft. 1188 and ceiling sq. ft. 2052 plate on floor sq. ft. 972 mg sq. ft. 1386 sq. ft. 222		17,084	The second second	836
ation sq. ft. 1188 and ceiling sq. ft. 1188 ls sq. ft. 2052 plate on floor sq. ft. 972 ng sq. ft. 1386 outs sq. ft. 2052				
and ceiling sq. ft. 1188 ls sq. ft. 2052 plate on floor sq. ft. 972 ng sq. ft. 1386 sq. ft. 22 sq. ft. 22 sq. ft. 2072	1.50	1,782	40	45
and ceiling sq. ft. 2052 plate on floor sq. ft. 972 ng sq. ft. 1386 sq. ft. 2086	.67	796	40	20
sq. ft. 2052 late on floor sq. ft. 972 sq. ft. 1386 units (2 ton) each 2				
late on floor sq. ft. 972 sq. ft. 1386 units (2 ton) each 2	3.50	7,182	20	359
sq.ft. 1386 units (2 ton) each 2	. 90	875	20	44
units (2 ton) each 2	.25	347	15	23
	1400.00	2,800	15	186
Electric outlets each 6	20.00	120 13,902	10	12 689

Appendix Table C-1 (continued)

Appendix Table C-1 (continued)

Col. (4): Col. (2) multiplied by Col. (3). from construction engineers. Col. (4): Col. (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research reports. Col. (6): Col. (4) divided by Col. (5).

a/ Inside dimensions - 65 feet long by 27 feet wide. b/ Inside dimensions - 58 feet long by 27 feet wide. $\overline{c}/$ Inside dimensions - 37 feet long by 27 feet wide. $\overline{d}/$ Inside dimensions - 27 feet long by 36 feet wide.

Methods	Total	(1) (dol.)	3,717	2,642	2,006	1,641	rectated prectated t with prectated ie. Col.
Appendix Table C-2. Annual Building Costs for Plant B, Four Case Handling Methods	Interest (3%)	(dol.) (6)	930	678	512	417	Col. (1), (2): Appendix Table C-1. Col. (3): Based on experience and research studies. Col. (4): Equivalent to 1.6 per cent of undepreciated value. Based on full coverage. The exact rate will vary somewhat with plant and location. Col. (5): Equivalent to 2 per cent on undepreciated value. Col. (6): Equivalent to 5 per cent on undepreciated value. Col. (7): Summation of Columns (2) - (6).
B, Four Cas	Taxes (1.05%)	(dol.)	326	237	179	146	3): Based o 1.6 per co rate will to 2 per co on undepre
s for Plant	Insurance (.8%)	(dol.) (4)	248	181	137	111	The exact Equivalent to The exact Equivalent 5 per cent
lding Costs	Repairs (2%)	(dol.) (3)	620	452	342	278	dix Table C 1. (4): Ec coverage. Col. (5): uivalent to lumns (2).
Annual Bui	d d	(dol.) (2)	1,593	1,094	836	689	 (2): Appendix Table C-1. (ch studies. Col. (4): Equival. Based on full coverage. The and location. Col. (5): Equiv Col. (6): Equivalent to 5 pe: Summation of Columns (2) - (6).
rable C-2.	Initial cost	(1)	31,012	22,603	17,084	13,902	Col. (1), (research st value. Bas plant and value. Co (7): Summ
Appendix 7	Case handling method		1	01 0	m	4	Sources:

(3) (3) (3) (3) (3) (3) (3) (3)	Item	Unit	No. of units	Price per unit (dol.)	Total costs (dol.)
od 1 or conveyor, straight chain e floor conveyor turn, infloor conveyor turn, above floor conveyor each 332 turn, above floor conveyor each 3 255 each 3 255 each 3 255 each 3 255 each 3 255 each 3 255 each 3 255 each 3 255 each 3 255 each 3 200 each 3 200 200 200 200 200 200 200 20		(1)	(2)	(3)	(4)
or conveyor, straight chain if feet 390 27 s floor conveyor turn, infloor conveyor each 3 255 turn, above floor conveyor each 1 180 each 3 255 each 2 3 255 each 1 1 180 each 2 3 120 each 2 1 450 each 2 1 450 each 2 1 450 each 2 1 325 each 2 1 325 each 2 1 325 each 2 2 326 each 2 2 326 each 2 3 325 each 3 3 325 each 3 3 325 each 3 3 325 each 3 3 3 325 each 3 3 3 3 a	Method 1				
\circ floor conveyor, straight chainfeet 232 18 \circ turn, infloor conveyor \circ ach 3 255 360 \circ turn, infloor conveyor \circ ach 3 120 \circ turn, above floor conveyor \circ ach 3 255 \circ turn, above floor conveyor \circ ach 3 255 \circ turn, above floor conveyor \circ ach 3 255 \circ function, infloor conveyor \circ ach 2 325 \circ junction, infloor conveyor \circ ach 2 325 \circ drive unit \circ ach 2 325 \circ drive unit \circ ach 2 326 \circ drive unit \circ ach 2 326 \circ drive unit \circ ach 2 326 \circ drive unit \circ ach 2 336 \circ drive unit \circ ach 2 240 \circ pinction, uninsulated \circ ach 2 240 \circ pinctorsunits \circ ach 2 240 \circ drive unit \circ ach 2 240 \circ pinctorsunits \circ ach 2 240 \circ pinctorsunits \circ ach 2 240 \circ pinctorsunits \circ ach 2 240 \circ doorsunits \circ ach 2 200 \circ doorsunits<	Infloor conveyor, straight chain	feet	390	27	10,530
turn, infloor conveyor turn, above floor conveyor turn, above floor conveyor turn, above floor conveyor f junction, infloor conveyor f junction, infloor conveyor each 11 450 each 2 325 each 2 326 each 2 336 each 3 1,350 each 3 1,350 each 3 3,000 each 1 3 3,000 each 3 3 36 each 3	Above floor conveyor, straight chain	feet	232	18	4,176
turn, above floor conveyor each 3 255 turn, above floor conveyor each 1 180 turn, above floor conveyor each 1 450 turn, infloor conveyor each 2 335 f junction, infloor conveyor each 2 355 each 2 1,350 each 2 1,350 each 2 2 336 each 2 2 336 each 1 1 20 pass doors, insulated each 1 300 each 1 300 each 1 300 each 2 2 200 each 1 300 each 1 300 each 2 5 1,550 each 2 2 336 each 2 5 1,550 each 2 2 200 each 1 3 300 each 1 3 300 each 2 5 1,550 each 2 5 2,500 each 2 5 2 2,50	90° turn, infloor conveyor	each	63	360	720
turn, infloor conveyor turn, above floor conveyor turn, above floor conveyor f junction, infloor conveyor f junction, infloor conveyor f junction, above floor conveyor f junction, above floor conveyor f durive unit f dores, insulated f dores, insulated f dores, uninsulated f dores, uninsulated f dores, uninsulated f dores, unitsulated f dores, f dores,	turn,	each	ი	255	765
turn, above floor conveyor each 3 120 γ junction, infloor conveyor each 1 450 γ junction, infloor conveyor each 2 325 γ junction, above floor conveyor each 2 1,350 γ drive unit 2 1,250 ρ , drive unit 2 240 ρ , drive unit 2 240 ρ drive unit 1 270 ρ drive unit ρ drive ρ 27 ρ drive drive ρ drive ρ drive ρ drive ρ 27 ρ drive ρ drive	turn,	each	1	180	180
$ \begin{array}{c cccc} \chi \ junction, \ infloor \ conveyor \ each \ junction, \ infloor \ conveyor \ each \ junction, \ infloor \ conveyor \ each \ jourdated \ jourdated \ each \ jourdated \ jourdated \ each \ jourdated \ jourda$	turn, above	each	ო	120	360
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Y junction,	each	1	450	450
<pre>% junction, above floor conveyor each 2 350 9. drive unit pass doors, insulated each 2 336 pass doors, uninsulated each 2 336 pass doors, uninsulated each 1 320 pass doors, uninsulated each 2 336 pass doors, uninsulated each 2 336 pass doors, uninsulated each 2 336 pass doors, uninsulated each 2 2 336 pass doors, uninsulated each 2 2 336 pass doors, uninsulated each 2 2 340 pass doors, uninsulated each 1 3,000 pass doors, uninsulated each 1 3,000 pass doors, uninsulated each 1 3,000 pass door conveyor, straight chain feet 232 pass door conveyor conveyor conveyor feet 232 pass door conveyor convey</pre>	Y junction,	each	63	325	650
P. drive unit51,350P. drive uniteach51,350pass doors, insulatedeach2336pass doors, uninsulatedeach11300up unitseach11100each113,000each11lcatorseach11220fic controlseach13,000unstackereach13,000unstackerfic controlsfic controls220unstackerfic controlsfic control1fic controlseach13,000fic controlsfiet20%fic controlsfiet24fic controlsfiet23fic controlsfiet23fic conveyor, straight chainfeet234filoor conveyorfiet232filoor conveyorfeet232filoor conveyorfeet232filoor conveyorfeet232filoor conveyorfeet232filoor conveyorfeet232filoor conveyorfeet232filoor conveyorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoorfeet232filoor	Y junction,	each	63	350	200
P. drive uniteach41,250pass doors, insulatedeach2336pass doors, uninsulatedeach2240up unitseach11300up unitseach11300up unitseach113,000up unitseach13,000lcatorseach13,000fic controlseach13,000fic controlseach13,000mstacker13,0001od 2rest201od 2or conveyor, straight chainfeet294of 2feet23218turn, infloor conveyoreach1360turn, infloor conveyoreach1360		each	ß	1,350	6,750
pass doors, insulated pass doors, uninsulated each 2 240 pass doors, uninsulated each 11 300 lcators fic controls each 11 300 each 11 3000 each 11 3,000 Installation cost (20%) Freight Freight each 2 5 220 each 11 3,000 each 1 3,000 each 2 7 18 Freight each 2 1 350 each 1 3,000 each 2 1 3,000 Freight each 2 1 350 each 1 3,000 each 2 1 3,000 each 2 1 3,000 each 1 3,000 each 2 1 3,000 each 1 1 3,000 each 1 1 3,000 each 1 1 3,000 each 2 1 3,000 each 1 1 3,000 each 1 1 3,000 each 2 1 3,000 each 2 1 3,000 each 2 1 3,000 each 2 1 3,000 each 3,000 each 2 1 3,000 each 2 1 3,000 each 3,0	3 H.P. drive unit	each	4	1,250	5,000
pass doors, uninsulated each 2 240 up units cach 11 300 lcators each 11 300 flc controls each 1 3,000 unstacker 3,000 Installation cost (20%) Freight Freight od 2 or conveyor, straight chain feet 234 27 each 1 360 hunn, infloor conveyor	Case pass doors, insulated	each	73	336	672
up units up units cators leach 11 300 each 11 100 each 1 3,000 unstacker 3,000 Installation cost (20%) Freight Freight od 2 of		each	73	240	480
cators fic controls unstacker unstacker outols each 1 3,000 Installation cost (20%) Freight Freight of 2 or conveyor, straight chain each 1 232 18 turn, infloor conveyor turn, infloor conveyor	Take up units	each	11	300	3,300
fic controls each 5 220 unstacker 1 3,000 Installation cost (20%) Freight 5 7 0d 2 0d 2 0d 2 0d 2 0d 2 0d 2 0d 2 0d 2	Lubricators	each	11	100	1,100
unstacker a cach 1 3,000 Installation cost (20%) Freight <u>od 2</u> <u>of 2</u> <u>or conveyor, straight chain</u> feet 294 27 e floor conveyor straight chain feet 232 18 turn, infloor conveyor cach 1 360	Traffic controls	each	Q	220	1,100
Installation cost (20%) Freight 50 50 50 50 50 50 50 50 50 50 50 50 50	Case unstacker	each	1	3,000	3,000
Freight Dot 2 Dor conveyor, straight chain effect 294 freet 232 turn, infloor conveyor freet 232 18 10 10 10 10 10 10 10 10 10 10		Installa	tion cost (2	0%)	7,987
od 22oor conveyor, straight chainfeet29427e floor conveyor, straight chainfeet23218each1a60each1a60			Frei	ght	47,920 600 48,520
Dor conveyor, straight chainfeet29427e floor conveyor, straight chainfeet23218turn, infloor conveyoreach1360turn, observe flooreach1360	Method 2	Torona and			
e floor conveyor, straight chain feet 232 18 turn, infloor conveyor each 1 360	Infloor conveyor, straight chain	feet	294	27	7,938
turn, infloor conveyor each I 360	Above floor conveyor, straight chain	feet	232	18	4,176
	900 turn, infloor conveyor	each	0	360	360

2 6 1

Item	Unit	No. of units	Price per unit (dol.)	Total costs (dol.)
	(1)	(2)	(3)	(4)
turn,	each	1	180	180
turn,	each	ო	120	360
Y junction,	each	CN 0	325	650
90 Y junction, apove iloor 90 ⁰ Y junction, infloor	each	N	750	750
P. drive uni	each	4	1,350	5,400
	each	ß	1,250	6,250
Case pass doors, insulated	each	7	336	672
Case pass doors, uninsulated	each	73	240	480
Take up units	each	80	300	2,400
Lubricators	each	80	100	800
Traffic controls	each	4	220	880
Automatic case unstacker	each	1	3,000	3,000
	Installati	Installation cost (20%)	(%	7,152
		Freight	ht	600
Stationary Party manufact			1000	43,513
Method 3				
Infloor conveyor, straight chain	feet	270	27	7,290
Above floor conveyor, straight chain	feet	232	18	4,176
90° turn, infloor conveyor	each	1	360	360
turn,	each	ო	255	765
turn,	each	1	180	180
turn, above	each	ო	120	360
Y junction,	each	2	325	650
90° Y junction, above floor	each	77 7	350	001
90 YY Junction, infloor	each	1	0C1	ne!

(continued)

Appendix Table C-3

Appendix Table C-3 (continued)				
		No. of	Price	Total
Item	Unit	units	per unit	costs
		10/	('TOD)	('TOD)
	(+)	(7)		
4 H.P. drive units	each	4	1,300	0,400
	each	4	1,250	5,000
Case pass doors, insulated	each	63	336	672
Case pass doors, uninsulated	each	63	240	480
Take up units	each	80	300	2,400
Lubricators	each	80	100	800
Traffic control	each	Ω	220	1,100
Automatic case unstacker	each	1	3,000	3,000
			Site and	34,083
	Installat	Installation cost (2)	(20%)	6,817
				40,900
		Freight	ght	009
				41,500
Method 4 Above floor conveyor, straight chain	feet	505	18	9,090
90 ⁰ turn	each	10.	255	1.275
90° Y innetion	each) er	350	1,050
45° turn	each	0	120	360
45° Y Junction	each	2	250	500
3 H.P. drive units	each	6	1,250	11,250
Take up units	each	10	300	3,000
Lubricators	each	10	100	1,000
Case pass doors, insulated	each	ი	187	561
Case pass doors, uninsulated	each	2	146	292
Case pass frame	each	1	87	87
				28,158
	Installat	Installation cost (20%)	(%)	5,693
				34,158
		Freight	ght	600
				34,758
(2): Estimates by nies. Col. (3): Col. (4): Col	salesengineersofseveraPricelistssuppliedbyda(2)multipliedby(3)	In the seven Ipplied by diversion of the seven In the seven of the seven of the seven s	sales engineers of several major plant equip Price lists supplied by dairy plant equipment (2) multiplied by Col (3)	t equip- uipment
(4): COL.	partdrirnm (7	e) . top ya		

. ...

ethods	Total annual costs (dol))	(8)	2,547 6,204 833 9,584	2,097 5,613 833 8,543	$\begin{array}{c} 1,984\\ 5,331\\ 833\\ 8,148\end{array}$	$\frac{1,574}{5,035}$	<pre>2): Schedule F, United States Internal r research studies, and estimates from Col. (3): Col. (1) divided by Col. to those used in other research studies.</pre>
M guilbi	Inte- rest (3%)	(1)	1,084 108	218 980 108	206 931 108	164 879	ted States Inte and estimates divided by Col
Case Handling Methods	Taxes (1.05%)	(9)	93 379 38	76 343 38	72 326 38	57 308	<pre>(2): Schedule F, United States er research studies, and estima Col. (3): Col. (1) divided by to those used in other research</pre>
FOUL	Insur- ance (.8%)	(2)	71 289 29	58 261 29	55 248 29	44 234	<pre>(): Schedule F, Uni' research studies, Col. (3): Col. (1) cothose used in oth</pre>
Plant B,	Re- pairs (4%)	(4)	353 1,444 144	1,307 144	275 1,241 144	218 1,172	Schedu esearch 1. (3): those u
IOL	Annual depreci- ation (dol.)	(3)	1,765 3,008 514	$1,454\\2,722\\514$	1,376 2,585 514	1,091 $2,442$	Col. (2): m other re irers. Co
sher cost	Estimated life (years)	(2)	12 12	5 12 7	122 125	5 12	Col. (1): Appendix Table C-3. Col. (2) Revenue Service, estimates from other milk plant equipment manufacturers. C (2) Col (4): Rates are comparable to
пра твиши	Initial price installed (dol.)		8,823 36,097 3,600	7,268 32,645 3,600	6,880 31,020 3,600	5,454 29,304	 Appendix Table C-3. Service, estimates fro plant equipment manufactu col (4) Rates are common
		1	equip.	equip.	equip.	equip.	(I): A ue Server plant (
Appendix Table	Item		Method 1 <u>Conveyor</u> chain Other conveyor Case unstacker	Method 2 <u>Conveyor</u> chain Other conveyor Case unstacker	Method 3 <u>Conveyor</u> chain Other conveyor Case unstacker	Method 4 Conveyor Other conveyor	Sources: Col. Reven milk (2).

Appendix Table C-4 (continued)

Estimated on the basis of data submitted by three North Carolina plants. Equivalent to 2 per cent on undepreciated value. Col. (7): Equivalent to 5 per cent interest on the average undepreciated balance. Col. (8): Sum-mation of Cols. (3) - (7). Equivalent to 1.6 per cent of undepreciated value. Col. (6) plants.

Daily labor cost (dol.)	(2)		14	-	14				12	1				6 46			14		14	
	(4)		1		1				-					1/2			1		1	
Maximum rate Total work re- No. of men required quired per day required	(3)		1			70 min. <u>c</u> /	90 min. d/				9 min. e/	1	18 min.	1			1			70 min. c/
Maximum rate required	(2)	6.4 [Shan	6.19 cases per min. <u>a</u> /	5.5 cases	per min. a/	1	and and and a		b.36 cases per min. b/					11.98 cases per min. $\underline{a}/$		6 19 races	per min. a/	1	5.5 cases per min. a/	
Time standard	(I)	the map had	14.1 cases per min. per man	6.6 cases per min. per man		2.25 min./load	3 min./ load		min. per man		rtl52 min.	per truck	whs11.27 min.	30 cases per min. per man		14 1 cases ner	min. per man		o.o cases per min, per man	Z.Z5 min./load
Job Description	BURGE AND ADDRESS CONTRACTOR	Method 1 Receive major items	from conveyor and preform loads	Receive minor items from conveyor and	preform loads	make up oud items and preform loads	accuracy	Receive empty cases	place in storage	Check returns from	trucks		and the second se	Supply empty cases to fillers	Method 2	Receive major items from convevor and	preform loads	Receive minor items	preform loads	make up odd items and preform loads

Appendix Table C-5. Labor Costs for Plant B, Four Case Handling Methods

Appendix Table C-5	(continued)	141. Mar. 14		-	
Job description	Time standard	Maximum rate required	Maximum rate Total work re- No. of men required quired per day required		Daily labor cost (dol.)
	(1)	(2)	(3)	(4)	(2)
Check loads for 3 min./load accuracy Pull preformed loads 23.4 cases per onto conveyor min. per man	3 min./load 23.4 cases per min. per man		90 min. <u>d</u> /		
Receive empty cases from conveyor and place in storage Check returns from truck	14.7 cases per min. per man rtl52 min. per truck whsl1.27 min.	6.36 cases per min. $\underline{b}/$	9 min. <u>e</u> / 18 min.	I	12
Supply empty cases to fillers	30 cases per min, per man	12 cases per min. $\underline{a}/$		1/2	6 46
Method 3 Receive cases from conveyor and place in storage	14.8 cases per min. per man	12 cases per min. <u>a</u> /		1	12
Make up loads when trucks come in				2	28
Receive empty cases from conveyor and place in storage Check returns from trucks	14.7 cases per min. per man rtl52 min. per truck whsl1.27 min.	6.4 cases per min. $\underline{b}/$	9 min. <u>e</u> / 18 min. <u>e</u> /	1	12

2

Daily labor cost (dol.)	(2)	6 58	24	28		12	The second	12 76	rates from rerage rate s of 11:00 until
No. of men required	(4)	1/2	Ø	5		1		1	I on output ler. \underline{b} And adding hours measure measure measure i col. (4) i cogether (5): Based arolina. u hefits and measure i colina. u
Maximum rate Total work re- No. of men required quired per day required	(3)	and the factor	the water of			9 min e/	18 min. e/		. (2): <u>a</u> / Based on output rates from id 1 Model S filler. <u>b</u> / Average rate day during unloading hours of 11:00 b performed from 9:00 a.m. until 1:40 a.m. until 5:30 p.m. <u>e</u> / This ring empty cases. Col. (4): Part day were lumped together where the ormance. Col. (5): Based on wage ants in North Carolina. Actual wage for fringe benefits and replacement
Maximum rate required	(2)	12 cases per min. <u>a</u> /	7.5 cases per min. <u>a</u> /		4.8 cases	per min. b/		7.5 cases per min. <u>a</u> /	$\frac{A-3}{A-4}$, $A-4$. Cole 1 N filler are d on heaviest 3): $C/$ This jc rformed from 1 on with received the of perfective milk placet to allow cent to allow
Time standard	(I)	30 cases per min. per man	5.85 cases per min. per man		9 cases per	min. per man rtl - 52 min.	per truck whsl1.27 min.	10 cases per min. per man	Col. (1): Appendix Tables A-3, A-4. Col. (2): <u>a</u> / Based on output rates from two Model Q fillers, 1 Model N filler and 1 Model S filler. <u>b</u> / Average rate at which cases are returned on heaviest day during unloading hours of 11:00 a.m. and 5:30 p.m. Col. (3): <u>c</u> / This job performed from 9:00 a.m. until 11:40 a.m. <u>d</u> / This job performed from 11:40 a.m. until 5:30 p.m. <u>e</u> / This job performed in conjunction with receiving empty cases. Col. (4): Part time jobs involving 4 hours or less per day were lumped together where the jobs dovetailed in terms of time of performance. Col. (5): Based on wage rates used by two representative milk plants in North Carolina. Actual wage rates were inflated 25 per cent to allow for fringe benefits and replacement labor.
Job description		Supply empty cases to fillers	Method 4 Receive cases from conveyor and place in storage	Make up loads when trucks come in	Receive empty cases from conveyor and	place in storage Check returns from	truck	Supply empty cases to fillers	Sources: Col. (1): two Model at which c a.m. and 5 11:40 a.m. job perfor time jobs jobs dovet rates usec rates were labor.

Appendix Table C-5 (continued)

Appendix Tabl	e C-6. Co	st of Sale	ssman Time	for Plant B, F	Appendix Table C-6. Cost of Salesman Time for Plant B, Four Case Handling Methods	ing Methods
Type truck	Unload (min.)	Load (min.)	Wait (min.)	Time for each truck (min.)	Total time all trucks (min.)	Total daily cost (dollars)
	(I)	(2)	(3)	(4)	(5)	(9)
Method 1 Retail Whs1.	5.1 11.5	10.1 13.0	00	15.2 24.5	258 343 Total	9.03 13.72 22.75
Method 2 Retail Whsl.	5.1 11.5	4.9 8.3	1.0 1.0	11.0 20.8	170 291 Total	6.20 11.64
Method <u>3a/</u> Retail Whsl.	5.1 11.5	4.9 8,3	4.9	14.9 24.7	253 246 Total	8.86 13.84 22.70
Method 4 <u>b/</u> Retail Whsl.	3.8 8.1	8.4 14.0	3.2	15.4 25.3	262 354 354	9.17 9.17 14.16 73.33
a/ Shipp b/ Two 1	ing clerk oading con	crew compr veyor spur	Shipping clerk crew comprised of two Two loading conveyor spurs are used.	o loadout men . l.	Shipping clerk crew comprised of two loadout men and one checker Two loading conveyor spurs are used.	

(3): Based on the application of queuing theory to known arrival rates and loading times as explained in Appendix B. Col. (4): Summation of Cols. (1) - (3). Col. (5): Col. (4) expanded to allow for 17 retail and 14 wholesale trucks. Col. (6): Based on \$.035 per minute for retail Co1. Col. (1), (2): Methods 1, 2 and 3 are assumed to involve average load sizes of 35 cases for retail trucks and 110 cases for wholesale trucks. Method 4 involves case loads of 26 cases for retail and 76 cases for wholesale. Labor standards are given in Appendix Tables A-3, A-4. drivers and \$.04 per minute for wholesale drivers. Sources:

ods	Total monthly	energy usage	(K.W.H.)	(2)	10,016	17,637	\$.008 \$141.10	9,703 3,811	13, 214 \$.008 \$108.11	8,764	2,540 11.304	\$.008 \$ 90.43	8,451	2,540	\$.008 \$.008 \$ 87.93
Appendix Table C-7. Utilities Cost for Plant B, Four Case Handling Methods	Maximum usage in	a 15 min. period	(K.W.H.)	(4)	α α	٦,	\$ 1.20 \$13.20	7.75	13.75 \$ 1.20 \$16.50	7	oq ⊢-	\$ 1.20 \$ 9.60	6.75	1.00	\$ 1.20 \$ 9.30
ant B, Four Cas	Hours of operation	per day		(3)	12 94	4 H	Price Cost	12 24	Price Cost	12	24	Price Cost	12	24	Price Cost
les Cost for Pl	Average kilowatt	hours per hour		(2)	32.00	FF.01		31.00 5.22		28.00	3.48		27.00	3.48	The second second
C-7. Utiliti	Total horse-	power		(1)	32	77		31 6		28	4		27	4	
Appendix Table (Power	item			Method 1 Conveyor	TOTI TRATTON		Method 2 Conveyor Refrigeration		Method 3 Conveyor	Refrigeration		Method 4 Conveyor	Refrigeration	

Sources on following page.

Appendix Table C-7 (continued)

Col. (1): Appendix Tables C-1, C-3. Col. (2): Based on 1 K.W.H. per H.P. for conveyor and .87 K.W.H. per H.P. for refrigeration units. Col. (3): Based on plant observation. Col. (4): Col. (1) divided by 4. Col. (5): Based on 12 hours per day, 313 days per year for conveyor, and 24 hours per day, 365 days per year for refrigeration. Sources:

Initial Building Costs for Plant A, Four Case Handling Methods	Est. use- Annual ful life deprec. (years) (dol.)				40 23			-		0 12	978		_	22				5 187		768		-		-			5 187	0 8 586
r Case	Est. us ful lif (years)	(2)		40	4.0	20		15	1	10			40	40	20	Ñ	-	15				# •	104	20	N	F	15	ī
tt A, Four	Initial cost (dol.)	(4)		2052	917	1231	1000	360	4875	10 120	ALT'AT	2001	CAAT	168	8337	1197	360	2800	80	15,660	0201	0071	000	0000	999/	245	2800	80 11.542
sts for Plan	Price per unit (dol.)	(3)		1.50	3 50	06	250.00	.25	1625.00	20.00		L RO	DC . T	1.9.	3.50	.90	.25	1400.00	20.00		L RO	100°T	01 0	00.0	06.	.25	1400.00	20.00
lding Cos	No. of units	(2)		1368	1368	1368	4	1440	ო	9		1330	OCCT	133U	2382	1330	1440	2	4		840	010	0501	0001	840	980	61	4
Initial Bui	Unit	(I)	The second second	sq. ft.	sq. It.			sq. ft.	each	each		++		sq. It.		sq. ft.	sq. ft.	each	each		4 + + +		• • • • • • • • • • • • • • • • • • •			sq. ft.	each	each
Appendix Table D-1. 1	Item		Method 1 a/	Foundation	F100r Walls ceiling	Steel plate on floor	Doors	Roofing	Refrig. units(3 ton)	Electric outlets	W-41 - 2 - 0 - 7	Metriod 2 D/	ET COLLAR LA CH		walls, celling	Steel plate on floor	Roofing	Refrig. units (2 ton)	Electric outlets		Method 3 c/	Floor	Wolle coiling	Ctool aloto a floor	DICET DIALE ON ITOOL	Roofing	Refrig. units (2 ton)	Electric outlets

103

	Annual deprec. (dol.)	(9)	76	12	292	24	16	187	œ	566	and and and and and and and and and and	dequate stimates 31. (3). 1 other
	Est. use- ful life (years)	(2)	ОЮ	40	20	20	15	15	10		202	Col. (1), (2): Estimates of floor area were designed to provide adequat space to store cases stacked five high on peak day. Col. (3): Estimate from construction engineers. Col. (4): Col. (2) multiplied by Col. (3) Col. (5): Bulletin F, United States Internal Revenue Service, and other research reports. Col. (6): Col. (4) divided by Col. (5).
	Initial cost (dol.)	(4)	1094	488	5838	486	236	2800	80	11,022	de. de. de.	e designed peak day. 1. (2) mult al Revenue ded by Col.
	Price per unit (dol.)	(3)	1 50	.67	3.50	.90	.25	1400.00	20.00		27 feet wide. 27 feet wide. 27 feet wide. 27 feet wide.	mates of floor area were designed to p as stacked five high on peak day. Col. angineers. Col. (4): Col. (2) multipli F, United States Internal Revenue Serv Col. (6): Col. (4) divided by Col. (5)
	No. of units	(2)	799	729	1668	540	945	63	4		long by long by long by long by	s of flo acked fi teers. C nited St (6): Co
(continued)	Unit	(1)	++ 5	so. ft.	sq. ft.	sq. ft.	sq. ft.	each	each		ons 36 feet ons 34 feet ons 20 feet ons 20 feet): Estimate re cases st ction engin lletin F, U orts. Col.
Appendix Table D-1 (Item		Method 4 d/	Floor	Walls, ceiling	Steel plate on floor	Roofing	Refrig. units (2 ton)	Electric outlets		a/ Inside dimensions 36 feet long by b/ Inside dimensions 34 feet long by c/ Inside dimensions 20 feet long by d/ Inside dimensions 20 feet long by	<pre>Sources: Col. (1), (2): Estimates of floor area were designed to provide adequate space to store cases stacked five high on peak day. Col. (3): Estimates from construction engineers. Col. (4): Col. (2) multiplied by Col. (3). Col. (5): Bulletin F, United States Internal Revenue Service, and other research reports. Col. (6): Col. (4) divided by Col. (5).</pre>

- 10 -

A

dist.	Total		(dol.)	(1)	2,291	1,840	1,375	1,321	and inde-	ry some-	on	reciated	
	Interest	(3%)	(dol.)	(9)	575	470	346	331	experience er cent of 1	The exact rate will vary some-	2 per cent	nt on undepi	
	Taxes	(1.05%)	(dol.)	(5)	201	164	121	116	: Based on t to 1.6 p	ne exact r	ivalent to	o 5 per ce	3).
	Insurance	(.8%)	(dol.)	(4)	153	125	92	88	Col. (1), (2): Appendix Table D-1. Col. (3): Based on experience and other research studies. Col. (4): Equivalent to 1.6 per cent of unde-	coverage. Th	what with plant and location. Col. (5): Equivalent to 2 per cent on	undepreciated value. Col. (6): Equivalent to 5 per cent on undepreciated	value. Col. (7): Summary of columns (2) - (6).
	Repairs	(2%)	(dol.)	(3)	384	313	230	220	x Table D- Col. (4	d on full	cation. C	Col. (6):	ary of col
	Annual depreci-	ation	(dol.)	(2)	978	768	586	566	(Z): Appendi urch studies	preciated value. Based on full coverage.	olant and lo	ed value.	(7): Summ
AND AND	Initial	cost	(dol.)	(1)	19,179	15,660	11,542	11,022	Col. (1), (preciated v	what with I	undepreciat	value. Col
1 THE REAL	Case handling	method			Ч	63	ო	4	Sources:				

Appendix Table D-2. Annual Building Costs for Plant A, Four Case Handling Methods

Appendix Table D-3. Initial Equipment Costs for Plant A, Four Case Handling Methods	Costs for I	lant A, Fou	r Case Handli	ng Methods
Item	Unit	No. of units	Price per unit (dol.)	Total costs (dol.)
	(1)	(2)	(3)	(4)
Method 1				
Infloor conveyor, straight chain	feet	240	27	6,480
re floor	feet	186	18	3,348
turns,	each	77	360	720
turns,	each	ო	255	765
45° turns, infloor conveyor	each	1	180	180
45° turns, above floor conveyor	each	63	12	240
	each	1	450	450
45° Y junction, infloor conveyor	each	1	325	325
Ы	each	1	350	350
5 H.P. drive unit	each	e	1,500	4,500
3 H.P. drive unit	each	73	1,250	2,500
Case pass doors, insulated	each	5	336	672
Case pass doors, uninsulated	each	63	240	480
Take up units	each	7	300	2,100
Lubricators	each	7	100	002
Traffic controls	each	63	220	440
Case unstacker	each	1	3,000	3,000
	Ins	Installation cost (20%)	ost (20%)	5.450
				32,700
	Fre	Freight		500
		1 (((((((((((((((((((1.100	33,200
Method 2 Tnfloor convevor straight chain	feet	188	27	5 076
Above floor convevor. straight chain	feet	186	18	3,348
90° turn, infloor	each	01 0	360	720
90 turn, above iloor	each	S	007	C0/

2 2 4

Item	Unit	No. of units	Price per unit	Total costs
	(I)	(2)	(3)	(F)
45° turn, infloor	each	1	180	180
45° turn, above floor	each	7	120	240
45° Y junction	each	1	325	325
~	each	1	350	350
5 H.P. drive units	each	ო	1,500	4,500
3 H.P. drive units	each	1	1,250	1,250
Case pass doors, insulated	each	7	336	672
Case pass doors, uninsulated	each	63	240	480
Take up units	each	9	300	1,800
Lubricators	each	9	100	600
Traffic controls	each	7	220	440
Case unstacker	each	1	3,000	3,000
				23,746
	II	Installation cost (20%)	cost (20%)	4,749
	FJ	Freight		500
		0		28,995
<u>Method 3</u> <u>Infloor</u> convevor. straight chain	feet	144	27	3.888
Above floor conveyor. straight chain	feet	186	18	3,348
90° turn, infloor conveyor	each	7	360	720
90 ⁰ turn, above floor conveyor	each	с Э	255	765
curn,	each	1	180	180
turn,	each	5	120	240
45° Y junction, infloor conveyor	each	1	325	325
	each	1	350	350
	each	73	1,500	3,000
3.H.P. drive unit	each	63	1,250	2,500

(continued)

Appendix Table D-3

10

Appendix Table D-3 (continued)				
		No. of	Price	Total
Item	Unit	units	per unit	costs
		(3)	(3)	(4)
Case pass doors. insulated	each	10	336	672
	each	63	240	480
Take up units	each	CI CI	300	1,500
Lubricators	each	വ	100	500
Traffic controls	each	63	220	440
Case unstacker	each	1	3,000	3,000
				21,908
	lnst	Installation cost	ST (20%)	4,382
	Freight	ght		500 26.790
Method 4				
Above floor conveyor, straight chain	feet	296	18	5,328
90° turns, above floor conveyor	each	4	255	1,420
45° turn, above floor conveyor	each	e	120	360
45° Y junction, above floor	each	I	250	250
Y Junction, above	each	I	350	350
P. drive unit	each	Q	1,250	6,250
Case pass doors, insulated	each	63	336	672
Case pass doors, uninsulated	each	21	240	480
Take up units	each	5	300	1,500
Lubricators	each	വ	100	500
Traffic controls	each	73	220	440
				17,550
	Inst	Installation cost	st (20%)	3,510 21,060
	Freight	eht		500
		D	No. of the second	21,560
Sources: Col. (1), (2): Estimates by sales engineers of several major plant equip- ment companies. Col. (3): Price lists supplied by dairy plant equipment companies. Col. (4): Col. (2) multiplied by Col. (3).	sales engineers of several Price lists supplied by dai (2) multiplied by Col. (3).	s of severa plied by da by Col. (3)	es by sales engineers of several major plant equip. (3): Price lists supplied by dairy plant equipment Col. (2) multiplied by Col. (3).	equip- ipment

2 6 2

thods	Total annual costs (dol.)	(8)	1,702	4,073	6,608	1,458	3,496	833	5,787	1,253	3,239	833 5.325		923	$\frac{3,156}{4,079}$	Internal es from Col. h ee North ee North . Col. na . Squiv- Col.
ing Met	Inte- rest (3%) (dol.)	(2)	177	117	DOT	152	610	108		130	565	108		96	551	ted States Interna and estimates from divided by Col. ther research tted by three Nort tated value. Col. forth Carolina or Col. (7): Equiv ed balance. Col.
e Handl	Taxes (1.05%) (dol.)	(9)	62	249	5	53	214	38		46	198	38		34	193	United S United S s's, and e 1) divid buitted reciated e North lue. Cc ated bal
our Cas	Insur- ance (.8%) (dol.)	(2)	47	190	0	40	163	29		35	151	29		26	147	2): Schedule F, United States Int research studies, and estimates Col. (3): Col. (1) divided by Col to those used in other research basis of data submitted by three ber cent of undepreciated value. out inted by three North Carolina undepreciated value. Col. (7): E verage undepreciated balance. Co
nt A, F	Re- pairs (4%) (dol.)	(4)	236	948	F F F	202	814	144		174	754	144	1	128	735	Schedule F search stud . (3): Col. those used is of data ited by thh epreciated age undeprec
for Pla	Annual depreci- ation (dol.)	(3)	1,180	1,975 514	H TO	1,011	1,695	514		868	1,571	514		639	1,530	Col. (2): other res ers. Col. rable to 1 1.6 per data submid the avers (7).
aent Cost	Estimated life (years)	(2)	ເດ	12	-	ß	12	7		S	12	7		Q	12	lix Table D-3. Col. (2): Schedule F, United States In , estimates from other research studies, and estimates ment manufacturers. Col. (3): Col. (1) divided by Co Rates are comparable to those used in other research (5): Estimated on the basis of data submitted by three Equivalent to 1.6 per cent of undepreciated value. In the basis of data submitted by three North Carolina. The basis of data submitted by three North Carolina. Soft interest on the average undepreciated balance. C of Columns (3) - (7).
Annual Equipment Cost for Plant A, Four Case Handling Methods	Initial Es price installed (dol.)	(1)	5,897	23,703	· · ·	5,052	20,343	3,600		4,341	18,849	3,600		3, 197	18,363	Col. (1): Appendix Table D-3. Col. (2): Schedule F, Unite Revenue Service, estimates from other research studies, an milk plant equipment manufacturers. Col. (3): Col. (1) di (2). Col. (4): Rates are comparable to those used in othe studies. Col. (5): Estimated on the basis of data submitt Carolina plants. Equivalent to 1.6 per cent of undeprecia (6): Estimated on the basis of data submitted by three Nor plants. Equivalent to 2 per cent on undepreciated value. (8): Summation of Columns (3) - (7).
	Ţ			equip.			equip.				equip.				equip.	<pre>Col. (1): Appendix Revenue Service, e milk plant equipme (2). Col. (4): Ra studies. Col. (5) carolina plants. (6): Estimated on plants. Equivalen alent to 5 per cen (8): Summation of</pre>
Appendix Table D-4.	Item	Method 1	Conveyor chain	Other conveyor	Mothod 9	Conveyor chain	Other conveyor	Case unstacker	Method 3	Conveyor chain	Other conveyor	Case unstacker	Method 4	Conveyor chain	Other conveyor equip.	Sources: Col. (1): Revenue S milk plar (2). Col studies. Carolina (6): Esti plants. alent to (8): Summ
					-	-10	-	-	-	10	0	-	Al		-	

			0		
Job description	Time standard	Maximum rate required	ork re- oer day	No. of men required	Daily labor cost (dol.)
Method 1	(1)	(2)	(3)	(4)	(2)
Receive major items from conveyor and	14.1 cases per min. per man		2.4	Laberth I	
preform loads Receive minor items	Notes and and a	6.5 cases			
from conveyor and preform loads	181,381	per min. <u>a/</u> (total major		1	14
Make up odd items	2.25 min. per	and minor)	36 minutes c/		
and preform loads	load		Ĩ		
Check loads lor accuracy	3 min./load		48 minutes d/		
Receive empty cases	14.7 cases per	6 cases)		
from conveyor and	min.	per min. <u>b</u> /		1	12
place in storage					
Supply empty cases	30 cases per	6.5 cases			LPS
to fillers	min.	per min.		1/2	396
					77
Method 2 Receive maior items	14.1 cases ner	6.5 cases			
from conveyor and	min. per man	per min. a/		L'all all	
preform loads	104 2	(total major and minor)	210 100	1	14
Receive minor items	6.6 cases per		The state of the s	A REAL PROPERTY.	
from conveyor and	min. per man	- (4b)	C. Igentif Const	0011 (. 100)	
Make up odd items	2.25 min./load	The second second	36 minutes c/	0 080 0	
and preform loads Check loads for					
accuracy	3 min./load		48 minutes <u>d</u> /		

. . .

Appendix Table D-5. Labor Costs for Plant A, Four Case Handling Methods

Daily labor cost (dol.)	(2)	12	6 32	12	14	12	6 44	12	14
No. of men required	(4)	1	1/2	1	1	1	1/2	1	1
Maximum rate Total work re- No. of men Daily required quired per day required labor cost (dol.)	(3)	64 minutes						and the second	
Maximum rate required	(2)	6 cases per min. <u>b</u> /	6.5 cases per min. $\underline{a}/$	6.5 cases per min. <u>a</u> /		6 cases per min. <u>b</u> /	6.5 cases per min. <u>a</u> /	4.84 cases per min. <u>a</u> /	
Time standard	(1)	23.4 cases per min. per man 14.7 cases per min. per man	30 cases per min. per man	14.1 cases per min. per man		14.7 cases per min.	30 cases per min. per man	5.85 cases per min. per man	
Job description		Pull preformed loads23.4 cases per min. per manonto conveyormin. per manReceive empty cases14.7 cases per from conveyor and place in storage	Supply empty cases to fillers	Method 3 Receive cases from conveyor and place in storage	Make up loads when trucks come in	Receive empty cases from conveyor and place in storage	Supply empty cases to fillers	Method 4 Receive cases from conveyor and place in storage	Make up loads when trucks come in

Appendix Table D-5 (continued)

Appendix Table D-5 (continued)	(continued)				
Job description	Time standard	Maximum rate required	Maximum rate Total work re- No. of men Daily required quired per day required labor cost (dol.)	No. of men required	Daily labor cost (dol.)
	(1)	(2)	(3)	(4)	(5)
Receive empty cases from conveyor and place in storage	9 cases per min. per man	5 cases per min. <u>b</u> /		1	12
Supply empty cases to fillers	10 cases per min. per man	4.84 cases per min. \underline{a}		1	12 50
Sources: Col. (1): Appendix Tables D-3, D-4. Col. (2): a/ Based on output rates from two Model Q fillers, one Model N filler and one Model S filler. b/ Average rate at which cases are returned on heaviest day during unloading hours of 11:00 a.m. and 5:30 p.m. Col. (3): c/ This job performed from 9:00 a.m. withil 11:40 a.m. d/ This job performed from 11:40 a.m. until 5:30 p.m. e/ This job performed in conjunction with receiving empty cases. Col. (4): Part-time jobs involving 4 hours of time of performance. Col. (5): Based on wage rates used by two representative milk plants in North Carolina. Actual wage rates were inflated 25 per cent to allow for fringe benefits and replacement labor.	Appendix Tables 0 fillers, one l ich cases are r and 5:30 p.m. 0 a.m. $\frac{d}{This}$ b performed in jobs involving ovetailed in ter used by two rej were inflated ; t labor.	D-3, D-4. Col Model N filler eturned on heav Col. $(3): c/$ J job performed conjunction wit t hours or less rms of time of presentative mi 25 per cent to	Col. (1): Appendix Tables D-3, D-4. Col. (2): $a/Based$ on output rates from two Model Q fillers, one Model N filler and one Model S filler. $b/Averagerate at which cases are returned on heaviest day during unloading hours of11:00 a.m. and 5:30 p.m. Col. (3): c/This job performed from 9:00 a.m.until 11:40 a.m. d/This job performed from 11:40 a.m. until 5:30 p.m.e/This job performed in conjunction with receiving empty cases. Col. (4):Part-time jobs involving 4 hours or less per day were lumped together wherethe jobs dovetailed in terms of time of performance. Col. (5): Based onwage rates used by two representative milk plants in North Carolina. Actua.replacement labor.$	<pre>f on output f filler. h unloading ed from 9:0 until 5:30 upt cases. upt cases. upt cases utp (5): Ba rth Carolin rth Carolin e benefits</pre>	rates from / Average hours of 0 a.m. 0 p.m. 0 p.m. 1 p.m. col. (4): frer where sed on ia. Actual and

Appendix Table D-6.

Cost of Salesman Time for Plant A, Four Case Handling Methods

1				Time for	Total time	Total
Туре	Unload	Load	Wait	each truck	all trucks	daily cost
truck	(min.)	(min.)	(min.)	(min.)	(min.)	(dollars)
	(1)	(2)	(3)	(4)	(5)	(6)
Method	1					
Retail	5.1	10.1	0	15.6	140	4.90
Whsl.	11.5	13.0	0	24.5	172	6.88
					Total	11.78
Method	2					
Retail	- 5.1	4.9	0	10.0	90	3,15
Whsl.	11.5	8.3	0	19.8	138.6	5.54
		179.00			Total	8.69
Method 3	3a/					
Retail	5.1	4.9	5	15.0	135	4.73
Whsl.	11.5	8.3	5 5	24.8	174	6.96
					Total	11.69
Method	4b/					
Retail	3.8	8.4	5	17.2	155	5.43
Whsl.	8.1	14.0	5	27.1	190	7.60
	32 11-		2 3 5 4	1000	Total	13.03

a/ One man loading out.

b/ One loading conveyor.

Sources:

Col. (1), (2): Methods 1, 2 and 3 are assumed to involve average load sizes of 35 cases for retail trucks and 110 cases for wholesale trucks. Method 4 involves case loads of 26 cases for retail and 76 cases for wholesale. Labor standards are given in Appendix Tables D-3, D-4. Col. (3): Based on the application of queuing theory to known arrival rates and loading times as explained in Appendix B. Col. (4): Summation of Columns (1) - (3). Col. (5): Col. (4) expanded to allow for 9 retail trucks and 7 wholesale trucks. Col. (6): Based on \$.035 per minute for retail drivers and \$.04 per minute for wholesale drivers.

Utilities Cost for Plant A, Four Case Handling Methods	Total monthly energy usage (K.W.H.)	(5) 6,573 5,716 12,289 K.W.H. \$.008	5,634 2,540 8,174 K.W.H. \$ 65.39	5,008 2,540 7,548 K.W.H. \$.008 \$ 60.38	4,695 2,540 7,235 K.W.H. \$ 008 \$ 57.88	<pre>Col. (2): Based on one K.W.H. per H.P. for refrigeration units. Col. (4): Col. (1) divided by 4. 313 days per year for conveyor, ar for refrigeration.</pre>
Four Case Ha	Maximum usage in a 15 min. period (K.W.H.)	(4) 5.25 7.50 \$ 1.20		4.00 .87 4.87 \$ 1.20 \$ 5.84	3.75 1.00 \$ 1.20 \$ 5.70	Col. (2): Based (H.P. for refrige Col. (4): Col. 313 days per year ar for refrigerat
for Plant A,	Hours of operation per day	(3) 12 24 Price	Lost 12 24 Price Cost	12 24 Price Cost	12 24 Price Cost	
ilities Cost	Average kilowatt hours per hour	(2) 21,00 7,83	18.00 3.48	16.00 3.48	15.00 3.48	
	Total horse- power	(1) $^{21}_{9}$	18 4	16 4	15 4	(1): for c (3): (5): 24 hou
Appendix Table D-7.	Power item	<u>Method 1</u> <u>Conveyor</u> Refrigeration	<u>Method 2</u> Conveyor Refrigeration	Method 3 Conveyor Refrigeration	<u>Method 4</u> Conveyor Refrigeration	Sources: Col. H.P. Col. Col. and

Appendix Table E-1. I	Initial Bu	ilding Cos	Initial Building Costs for Plant D, Four	at D, Four	Case I	
Item	Unit	No. of units	Price per unit (dol.)	Initial cost (dol.)	Est. use- ful life (years)	Annual deprec. (dol.)
	(1)	(2)	(3)	(4)	(2)	(9)
Method 1 a/						
Foundation		5460	1.50	8190	40	205
Floor		5460	.67	3658	40	91
		8808	3.50	30,828	20	1,541
Steel plate on floor	sq. ft.	5460	.90	4914	20	246
Roofing		6600	.25	1650	15	110
Indiv. loading doors	each	14	250.00	3500	20	175
Refrig. units (4 ton)	each	10	1625.00	16,250	15	1,083
Electric outlets	each	20	20.00	400	10	40
				69,390		3,491
Method 2 b/						
Foundation	sq. ft.	5390	1.50	8085	40	202
Floor	sq. ft.	5390	.67	3611	40	06
Walls, ceiling	sq. ft.	8298	3.50	29,043	20	1,452
Steel plate on floor	sq. ft.	5390	.90	4851	20	242
Roofing	sq. ft.	6160	.25	1540	15	103
Refrig. units (4 ton)	each	4	1625.00	7500	15	500
Electric outlets	each	12	20,00	240	10	24
			00.0	54,870		2,613
Method 3 c/						
Foundation	sq. ft.	4515	1.50	6773	40	169
Floor	sq. ft.	4515	.67	3025	40	76
Walls, ceiling	sq. ft.	6375	3.50	22,313	20	1,116
Steel plate on floor	sq. ft.	4515	06.	4064	20	203
Roofing	sq. ft.	5200	.25	1300	15	06
Refrig. units (4 ton)	each	4	1625.00	7500	15	500
Electric outlets	each	12	20.00	240	10	24
				40,210		2,110

Appendix Table E-1 ((continued)	0				
			Price	Initial	Est. use-	Annual
Item	Unit	No. of	per unit	cost	ful life	deprec.
		units	(dol.)	(dol.)	(years)	(dol.)
	(1)	(2)	(3)	(4)	(2)	(9)
1 - 4 - 4 - M						
Method 4 d/	so ft.	5016	1.50	7524	40	188
Floor	sq. ft.	5016	.67	3361	40	84
Walls. ceiling	sq. ft.	7848	3.50	27,468	20	1,373
Steel plate on floor	sq. ft.	4560	.90	4104	20	205
Roofing	sq. ft.	5600	.25	1400	15	93
Refrig. units (4 ton)	each	4	1625.00	7500	15	500
Electric outlets	each	12	20.00	240	10	24
				51,597		2,467
a/ Inside dimensi	ons 160 f	eet long	by 27 feet v	vide.		
D/ Inside dimensions 150 feet long by 27 feet wide.	ons 150 f	eet long 1	by 27 feet v	vide.		
\overline{c} Inside dimensi	ons 125 f	eet long 1	dimensions 125 feet long by 27 feet wide,	vide.		
<u>d</u> / Inside dimensi	ons 80 fe	et long by	dimensions 80 feet long by 57 feet wide.	lde.		
Sources: Col. (1), (2 space to sto from constru	2): Estima ore cases action eng	ttes of flo stacked fi ineers. (or area wei ive high on Col. (4): Co	re designe peak day. ol. (2) mu	Col. (1), (2): Estimates of floor area were designed to provide adequate space to store cases stacked five high on peak day. Col. (3): Estimates from construction engineers. Col. (4): Col. (2) multiplied by Col. (3).	adequate Estimates Col. (3).

Col. (5): Bulletin F, United States Internal Revenue Service, and other research reports. Col. (6): Col. (4) divided by Col. (5). •

	1 1			1 4
Methods	Total (dol.)	(7) 8,245	6,371 5,275 6,002	e and 11 vary cent nde-
se Handling	Interest (3%) (dol.)	(6) 2,082	1,646 1,356 1,548	<pre>1 experienc per cent of act rate wi at to 2 per r cent on u - (6).</pre>
D, Four Cas	Taxes (1.05%) (dol.)	(c) 729	576 475 542): Based of nt to 1.6 k e. The ext : Equivaler nt to 5 per lumns (2) -
for Plant	Insurance (.8%) (dol.)	(4) 555	439 362 413	<pre>Col. (3 Col. (3 Equivale Col. (5) Col. (5) Equivale tion of Co</pre>
ding Costs	Repairs (2%) (dol.)	(3) 1,388	$1,097 \\904 \\1,032$	x Table E-1 Col. (4) Based on fu d location. Col. (6) (7): Summa
Appendix Table E-2. Annual Building Costs for Plant D, Four Case Handling Methods	Annual depreci- ation (dol.)	(2) 3,491	2,613 2,178 2,467	Col. (1), (2): Appendix Table E-1. Col. (3): Based on experience and other research studies. Col. (4): Equivalent to 1.6 per cent of undepreciated value. Based on full coverage. The exact rate will vary somewhat with plant and location. Col. (5): Equivalent to 2 per cent on undepreciated value. Col. (6): Equivalent to 5 per cent on undepreciated value. Col. (7): Summation of Columns (2) - (6).
able E-2.	Initial cost (dol.)	(T) 69,390	54,870 45,215 51,597	Col. (1), (other resea undepreciat somewhat wi on undeprec preciated v
Appendix T	Case handling method	1	ი ი 4	Sources:

Appendix Table E-3. Initial Equipment Costs for Plant D, Four Case Handling Methods	Costs for	Plant D, Fou	r Case Handli	ng Methods
Item	Unit	No. of units	Price per unit	Total costs
	(T)	(2)	(3)	(4)
Method 1 <u>Infloor</u> convevor, straight chain	feet	723	27	19,521
Above floor conveyor, straight chain	feet	470	18	8,460
90° turn, infloor conveyor	each	73	360	720
turn, a	each	en N	255	765
turns,	each		180	180
45° turns, above floor conveyor	each	2	120	840
90 Y junction, infloor conveyor	each	- - ,	450	450
g,	each	0	750	1 020
7	each	9	325	I,950
х	each	9	350	2,100
7 1/2 H.P. drive units	each	ო	1,750	5,250
5 H.P. drive units	each	e	1,500	4,500
3 H.P. drive units	each	80	1,250	10,000
Case pass doors, insulated	each	2	336	672
Case pass doors, uninsulated	each	63	240	480
Take up units	each	18	300	5,400
Lubricators	each	18	100	1,800
Traffic controls	each	13	220	2,860
Case unstacker	each	1	3,000	3,000
				69,698
	In	Installation cost (20%)	ost (20%)	13,939
				83,637
	Fr	Freight		1,000
				84,637
Method 2		i i	Ľ	202 11
Intloor conveyor, straight chain Above floor conveyor straight chain	I C C C C C C C C C C C C C C C C C C C	190 470	18	120,021 8.460
90° turn. infloor convevor	each	2	360	720
90° turn, above floor conveyor	each	ŝ	255	- 765

2

Total costs (dol.) (4)	$\begin{array}{c} 180\\ 2,700\\ 1,950\\ 3,500\\ 3,500\\ 10,000\\ 672\\ 672\\ 672\\ 672\\ 672\\ 672\\ 672\\ 672$	14,337 8,460 720 720 720 720 840 2,700 1,950 3,500
Price per unit (dol.) (3)	180 120 450 325 1,750 1,500 1,250 3,500 1,250 3,000 3,000 3,000	27 27 360 255 180 180 120 450 750 1,750
No. of units (2)	1 1 18(7 7 12(6 6 325 2 1,75(32(2 1,75(32(2 1,75(32(2 1,75(32(2 1,75(32(2 1,75(32(2 2 1,25(2 2 33(16 16 100(12 3,00(1 1 3,000(3,000(1 3,000(1 1 1 3,000(1 1 3,000(1 1 3,000(1 1 3,000(1 1 3,000(1 1 3,000(470 470 22 66 11 66 71 22 66
Unit (1)	each each each each each each each each	feet feet each each each each each each each
Item	45° turn, infloor conveyor 45° turn, above floor conveyor 90° Y junction, above floor conveyor 45° Y junction, infloor conveyor 7 1/2 H.P. drive units 5 H.P. drive units 3 H.P. drive units Case pass doors, insulated Case pass doors, uninsulated Take up units Lubricators Traffic controls Case unstacker	Method 3 Infloor conveyor, straight chain bove floor conveyor, straight chain 90° turn, infloor conveyor 90° turn, above floor conveyor 45° turn, above floor conveyor 90° Y junction, above floor 90° double Y junction 45° Y junction, infloor 7.1/2 H.P. drive units

Appendix Table E-3 (continued)

Appendix Table E-3 (continued)		No. of	Price	Total
Item	Unit	units	per unit	costs
			(dol.)	(dol.)
	(1)	(2)	(3)	(4)
5 H.P. drive units	each	61	1,500	3,000
drive unit	each	80	1,250	10,000
Case pass doors, insulated	each	63	336	672
Case pass doors, uninsulated	each	73	240	480
Take up units	each	16	300	4,800
Lubricators	each	16	100	1,600
Traffic controls	each	12	220	2,640
Unstacker	each	1	3,000	3,000
	• <u>1</u>	[] [] [] [] [] [] [] [] [] [] [] [] [] [000+ (000)	10,394
	-	TOTA BTTBA GT	(0,07) 2000	79,473
	FJ	Freight		1,000
				73,473
Method 4 Above floor conveyor, straight chain	feet	1,277	18	22,986
90° turns, above floor conveyor	each	6	255	2,295
90° junctions, above floor conveyor	each	9	350	2,100
45° junctions, above floor conveyor	each	4	250	1,000
45° turns, above floor conveyor	each	80	120	960
3 H.P. drive units	each	20	1,250	25,000
Take up units	each	20	300	6,000
Lubricators	each	20	100	2,000
Traffic controls	each	11	220	2,420
Case pass doors, insulated	each	4	336	1,344
Case pass doors, uninsulated	each	4	240	960
				67,065
	II	Installation cost	cost (20%)	13,413
				80,478
	E.	Freight		1,000
				81,478
(3) ·	les engine	sers of seve	y sales engineers of several major plant equip Price lists supplied by dairy plant equipment	: equip-
. (4): Col.	multiplie	(2) multiplied by Col. (3).	3).	

2 2 4

	P- D	1. 200			1	H . Ó
thods	Total annual costs (dol.)	$(8) \\ 4,844 \\ 11,038 \\ 833 \\ 833$	4,180 9,640 833 14.653	3,946 9,657 833 14,436	3,979 11,631 15,610	Internal tes from Col. (2) dies. Carolina (6): lent to):
ling Me	Inte- rest (3%) (dol.)	(7) 504 1,927 108	434 1,683 108	410 1,686 108	414 2,031	States I estimate ded by C th studi North Ca Col. (6 Lina pla Equivale ol. (8):
se Hand	Taxes (1.05%) (dol.)	(6) 176 675 38	152 589 38	144 590 38	145 711	nited Sta , and est) divided three Nor three Nor alue. Cc alue. Cc (7): Equ (7): Equ
for Plant D, Four Case Handling Methods	Insur- ance (.8%) (dol.)	(5) 134 514 29	116 449 29	109 450 29	110 541	le F, U studies Col. (1 other ted by iated v ee Nort . Col. d balan
ant D,	Re- pairs (4%) (dol.)	(4) 672 2,570 144	580 2,244 144	547 2,248 144	552 2,707	Schedu search . (3): used in submit ndeprec by thr d value reciate
s for Pl	Annual depreci- ation (dol.)	(3) 3,358 5,352 514	2,898 4,675 514	2,736 4,683 514	2,758 5,641	Col. (2): Schedule F, United States Internal to other research studies, and estimates from ers. Col. (3): Col. (1) divided by Col. (2) to those used in other research studies. s of data submitted by three North Carolina cent of undepreciated value. Col. (6): submitted by three North Carolina plants. lepreciated value. Col. (7): Equivalent to age undepreciated balance. Col. (8):
ent Cost	Estimated life (years)	(2) 5 12 7	5 12 7	5 12 7	5 12	Crocking (
Annual Equipment Costs	Initial Est price installed (; (dol.)	(1) 16,789 64,248 3,600	14,488 56,105 3,600	13,679 56,194 3,600	13,791 67,687	Col. (1): Appendix Table E-3. Col. (2): Schedule F, United States Interna Revenue Service, estimates from other research studies, and estimates from milk plant equipment manufacturers. Col. (3): Col. (1) divided by Col. (2 Col. (4): Rates are comparable to those used in other research studies. Col. (5): Estimated on the basis of data submitted by three North Carolina plants. Equivalent to 1.6 per cent of undepreciated value. Col. (6): Estimated on the basis of data submitted by three North Carolina plants to 2 per cent on undepreciated value. Col. (6): Equivalent to 2 per cent on undepreciated value. Col. (8): Summation of Columns (3) - (7).
		equip.	equip.	equip.	equip.	(1): Apr ue Servi plant ec (4): Rat (5): Est (5): Est is: Equi ated on alent to cent in tion of
Appendix Table E-4.	Item	Method <u>1</u> Conveyor chain Other conveyor Case unstacker	Method 2 Conveyor chain Other conveyor Case unstacker	Method 3 Conveyor chain Other conveyor Case unstacker	Method 4 <u>Conveyor</u> chain Other conveyor equip.	
Appen		Method 1 Conveyor Other cc Case uns	Method 2 Conveyor Other co Case uns	Method 3 Conveyor Other co Case uns	Method 4 Conveyor Other co	Sources:

	Daily labor cost (dol.)	(2)		28		28		12								24	10000		24	OTI		28			28		
						10													,								
	No. of men required	(4)	ATAINGA	01		01	Lange and	I		14 050						21			0		1922 292	2			73		
0	Maximum rate Total work re- No. of men required quired per day required	(3)	()	1		-	NIT CHA	158 min. c/		ZIU MIN. a/				10	23 mln. e/		23 min. <u>e</u> /		Fran 224		145 1 570 ···		(8) (8)		- Partie and		158 min. <u>c</u> /
	Maximum rate required	(2)	23.8 cases	per min. a/	g g rases				1	72		JI CASES	ber min. D/				1711 M	33.9 cases	per min. a/		23 8 rases	per min. a/		9.4 cases	per min. a/		
	Time standard	(1)	14.1 cases per	man per min.	6 6 cases ner	min. per man	10 001	2.25 min./load		3 min./load		14. / Cases per	штп. рег. шап		rtu52 min.	per truck	whs11.27 min.	30 cases per	min. per man		14 1 cases ner	min. per man		6.6 cases per	min. per man		2.25 min./load
	Job Description	Wathad 1	Receive major items	from conveyor and	Prelorm loads Receive minor items	from conveyor and	preform loads	Make up odd items	and preform loads	Check loads lor	accut acy	from converses	Troll COLVEYOF ALL	place in storage	Check returns Irom	trucks		Supply empty cases	to fillers		Method 2 Receive maior items	from convevor and	preform loads	Receive minor items	from conveyor and	preform loads	Make up odd items and preform loads

Appendix Table E-5. Labor Costs for Plant D, Four Case Handling Methods

Daily labor cost (dol.)	(2)	12	24		No. 195	24		12 128			30	40	44	14		24	A ROAD AND A DATE			24 140
No. of men required	(4)	1	2	or outlast		2		1		c	c,	c	0	L	+	5				2
Maximum rate Total work re- No. of men required quired per day required	(3)	210 min. <u>d</u> /	There and an all		23 min. <u>e/</u> 23 min. <u>e</u> /			10 . MA ES									ACTING STRATES		23 min. e/ 23 min. e/	
Maximum rate required	(2)	an test of al	31 cases per min. $\underline{b}/$			33.9 cases per min. a/	23.4 cases	per min.		33.9 cases	per min. <u>a</u> /				3 cases	per min. b/				33.9 cases per min. <u>a</u> /
Time standard	(1)	3 min./load	14.7 cases per min. per man	rtl52 min.	per truck whsl1.27 min.	30 cases per min	loads 23.4 cases per	min. per man		14.1 cases per	min. per man				14 7 cases her			rtl52 min.	per truck whsl1.27 min.	30 cases per min, per man
Job description		Check loads for accuracy	Receive empty cases from conveyor and	place in storage Check returns from	trucks	Supply empty cases to fillers	med	onto conveyor	Mathed 2	Receive cases from	conveyor and place in storage	Make up loads when	trucks come in	Check loads for	accuracy Beceive empty cases	from conveyor and	place in storage	Check returns from	trucks	Supply empty cases to fillers

(continued)

Appendix Table E-5

Laboration and	Daily labor cost (dol.)	(2)		72	64	77	42	TXG					36 192	rates from	b/ Average	DO a.m.	0 p.m.	Col. (4):	ther where	ased on na Ac-	efits and		
	No. of men required	(4)		9	c	2	3 1/2						3	d on output	5 filler. 1 * unloading	ned from 9:0	until 5:30	pty cases.	Lumped toget	orth Carolin	fringe bene		
	Maximum rate Total work re- No. of men required quired per day required	(3)							23 min. e/	I	23 min. <u>e</u> /		Nate St	I. (2): a/ Based	and one Model [This iob perform	from 11:40 a.m.	th receiving emp	s per day were	periormance. (nt to allow for		
	Maximum rate required	(2)	33.9 cases	per min. <u>a</u> /			31 cases per min. b/	1				33.9 cases	per min. <u>a</u> /	E-3, E-4. Co.	odel N filler	Col. (3): c/	job performed	onjunction wit	hours or less	ns or time or	ted 25 per cel		
(manutruno)	Time standard	(I)	5.85 cases per	min. per man			9 cases per min. per man		rtl52 min.	per truck	whs11.27 min.	10 cases per	min. per man	(1): Appendix Tables E-3, E-4. Col. (2): a/ Based on output rates from	two Model Q fillers, one Model N filler and one Model 5 filler. b/ Average	and 5:30 p.m.	0 a.m. d/ This	b performed in c	Part-time jobs involving 4 hours or less per day were lumped together where	the jobs dovetailed in terms of time of performance. Col. (5); based on wave rates used by two representative milk plants in North Carolina Ac.	tual wage rates were inflated 25 per cent to allow for fringe benefits and	t labor.	
Appendix Table E-3 (continued)	Job description		Method 4 Receive cases from	conveyor and place in storage	Make up loads when	L'ucks come III	Receive empty cases from conveyor and	place in storage	Check returns from	trucks		Supply empty cases	to fillers	Sources: Col. (1):	two Model	Iate at wir	until 11:4	e/ This jo	Part-time	une jobs d wage rates	tual wage	replacement labor.	

Appendix Table E-5 (continued)

ng Methods	Total daily cost (dol.)	(9)	23.42 21.56 44.98	18.62 21.64 40.26	20.02 22.24 42.26	26.95 26.12 53.07	ge load e trucks. es for E-4. Col. al rates al rates tion of 4 retail
ur Case Handli	Total time all trucks (min.)	(2)	669 539 Total	532 541 Total	572 556 Total	770 653 Total	re assumed to involve average load and 110 cases for wholesale trucks cases for retail and 76 cases for en in Appendix Tables E-3, E-4. Co euing theory to known arrival rates ppendix B. Col. (4): Summation of (4) expanded to allow for 44 retail 1. (6): Based on \$.035 per minute for wholesale drivers.
Cost of Salesman Time for Plant D, Four Case Handling Methods	Time for each truck (min.)	(4)	15.2 24.5	12.1 20.8	13 21.4	17.5 25.1	
esman Time 1	Wait (min.)	(3)	00	2.1	3.0 1.6	3°0 3	<pre>chods 1, 2 and 3 a for retail trucks case loads of 26 standards are giv application of qu as explained in A col. (5): col. esale trucks. co esale trucks. co</pre>
st of Sal	Load (min.)	(2)	10.10 12.98	4.9 8.3	4.9 8.3	8,4 14,0	 (2): Methods 1, 5 cases for rets nvolves case los Labor standarc on the application of times as expls i - (3). Col. 26 wholesale tr vers and \$.04 i
Appendix Table E-6. Co	Unload (min.)	(1)	5,1 11,5	5.1 11.5	5.1 11.5	3,8 8,1	Col. (1), (2): Methods 1, 2 and sizes of 35 cases for retail try Method 4 involves case loads of wholesale. Labor standards are (3): Based on the application of (3): Based on the application of and loading times as explained Columns (1) - (3). Col. (5): Co trucks and 26 wholesale trucks. retail drivers and \$.04 per mi
Appendix 7	Type truck		Method 1 Retail Whs1.	Method 2 Retail Whsl.	Method 3 Retail Whsl.	Method 4 Retail Whsl.	Sources:

SDOU	Total monthly energy usage	I (K.W.H.) (5)	19,250 25,404 44,654	\$ 312.58	15,337 7,621 22,958	\$ 160.85	15,337 7,621 77,621	\$.007 \$ 160.85	18,780 10,147 78 077	\$ 202.49 \$ 202.49
HADUIIDE MEU	Maximum usage in a 15 min. period	(4)	15.4 10.0 25.4	\$ 1.10 \$ 27.94	12.25 3.00 15.25	\$ 1.10 \$ 16.78	12.25 3.00 15.95	\$ 16.78	15.0 4.0	\$ 1.10 \$ 20.90
at b, rour case	Hours of operation per day	(3)	12 24	Price Cost	12 24	Price Cost	12 24	Price Cost	12 24	Price Cost
UTILITIES COST IOT FLADT B, FOUT CASE HADULING MELDOUS	Average kilowatt hours per hour	(2)	61.5 34.8	the state of the state	49.0 10.44	201 201 201 201 201 201 201 201 201 201	49.0 10.44		60.0 13.9	
	Total horse- power	(1)	61.5 40.0	914 - C-14	49.0 12.0		49.0 12.0		60.0 16.0	
Appendix Table E-7.	Power item		Method 1 Conveyor Refrigeration	Martin another	<u>Method 2</u> <u>Conveyor</u> Refrigeration		<u>Method 3</u> <u>Conveyor</u> Refrigeration	Tager TAD	Method 4 <u>Conveyor</u> Refrigeration	

1. 12 A

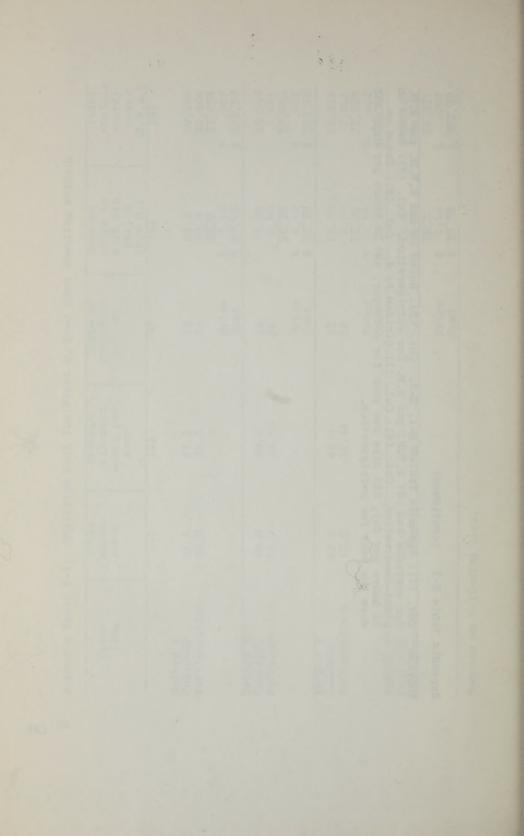
Annendix Table E-7. Utilities Cost for Plant B. Four Case Handling Methods

126

Sources on following page.

Appendix Table E-7 (continued)

Col. (1): Appendix Tables E-1, E-3. Col. (2): Based on one K.W.H. per H.P. for conveyor and .87 K.W.H. per H.P. for refrigeration. Col. (3): Based on plant observation. Col. (4): Col. (1) divided by 4. Col. (5): Based on 12 hours per day, 313 days per year for conveyor, and 24 hours per day, 365 days per year for refrigeration. Sources:





Agricultural Experiment Station

North Carolina State College Raleigh, N. C.

R. L. Louvorn, Director of Research

Bulletins of this station will be sent free to all citizens who request them