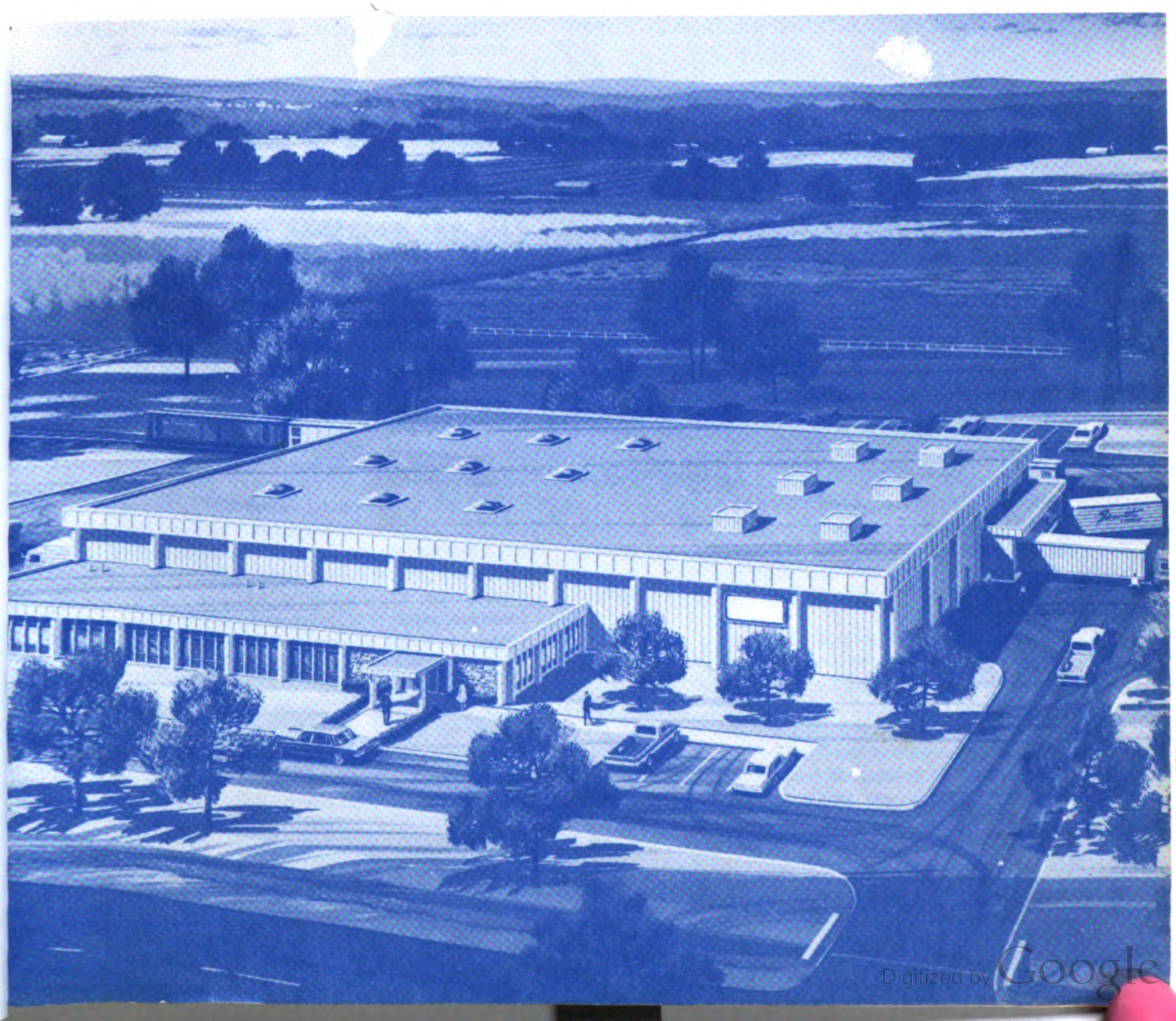
United States
Department of
Agriculture

Agricultural
Marketing
Service

Marketing
Research Report
Number 1134

Feasibility of Expanding an Egg-Grading Plant to Achieve Economies of Scale

Clarence E. Harris



Contents

Summary

Management of many firms in the egg industry are contemplating upgrading their facilities to improve efficiency. High-speed egg washers and graders are available that exceed the capacity of the most modern equipment used 10 years ago. This report presents a step-by-step example of the economic feasibility analysis that the management of a shell egg-grading and packing plant may wish to conduct before starting an expansion.

The report is based on expanding a plant with a capacity of 70 cases per hour to 135 cases per hour. Initially, the volume of product would be about the same in the expanded plant, but it would operate one shift per day rather than two.

The existing 18,400-square-foot plant has sufficient floorspace in all areas except the egg-grading and packing room. Layouts are included in the report illustrating how this room can be expanded for an estimated cost of $10,000.

The facilities and flow of product are described and illustrated. All utilities and support systems are adequate for the expanded plant. Present potable water and wastewater systems should be adequate for the expanded plant.

Cost data were collected from the study plant and compared with other plants of similar size and operations. Approximately 280,800 cases of eggs are processed each year in the study plant at a processing labor cost of $0.59 per case and a total in-plant processing cost of $1.62 per case, excluding packaging, receiving and order assembly, transportation, and cost of sales. The present production rate is 8.5 cases per worker-hour, using eight production people per shift.

A layout for expanding the plant is presented and described, along with the major items of new equipment needed. Itemized equipment prices are presented for four systems, with an average used for the feasibility analysis. An estimated 11 workers are required to process 135 cases per hour. The average production labor cost would drop to $0.41 per case at the present volume, but increased overhead and other costs would drop the average overhead and variable costs per case only to $1.54.

The expanded plant would have the capacity for higher volumes, where the economies of scale are even more favorable. Conversely, if the volume decreased, the cost per case would be higher in the expanded plant than in the existing plant.

July 1983

Feasibility of Expanding an Egg-Grading Plant to Achieve Economies of Scale

by Clarence E. Harris[1]

Introduction

Competition in the egg industry has been extensive in recent years, with many firms improving their efficiency in terms of productivity per worker-hour and costs per unit produced. The volume of product handled by many firms is so large that a saving of 1 or 2 cents per dozen enhances the competitive position of that firm. Use of recently developed high-speed egg-washing, grading, and packing equipment becomes increasingly attractive at these production levels. Before changing to the high-speed systems, however, economic feasibility and production quality should be evaluated. Most of these systems cannot be operated at or near capacity when excessive undergrades are being processed; some firms consider any volume of undergrades over 4 percent as excessive.

Typically, an egg-grading and packing plant is operated at a production level between the eggs produced by the farm unit or production units and the eggs needed to fill the market demand. The production level represents a market "equilibrium" quantity of eggs the firm can sell for a profit. How to handle this volume raises several questions. Should the firm operate a small plant two or three shifts per day or should the firm secure (or build) a plant with sufficient capacity to handle the product in 8 hours or less per day? Which approach is the least-cost alternative? Plant operators may have to decide between expanding their plant capacity or operating more hours per day. A decision on plant expansion or working more hours should be analyzed thoroughly with the most accurate data available from all sources.

This report is designed to provide the manager of a plant with a format and data for comparing expansion versus new plant construction, taking into consideration present costs and future growth. An existing plant is used as an example of ways to increase the capacity, eliminate the need to operate two shifts per day, and meet the grading and packing demands. The present egg-washing, grading, and packing equipment in the example plant has a rated capacity of 70 cases of eggs (30 dozen per case) per hour, and it operates typically at about 95 to 97 percent of rated capacity.

Ungraded and unwashed eggs are received in plastic filler flats or in cases stacked on pallets. The washed and graded eggs are shipped out in fiberboard cases or wire or plastic baskets. Approximately 90 percent of the graded eggs are packed in fiberboard or expanded polystyrene cartons, with 10 percent being packed in fiberboard filler flats. About 55 percent of the eggs are shipped directly to retail stores, restuarants, wholesalers, and institutions. Most of the eggs are graded and shipped within 3 days from day of receipt to ensure freshness of product. The firm markets ap-

[1]Agricultural Marketing Specialist (Research), Market Research and Development Division, Agricultural Marketing Service, Agricultural Research Center, Beltsville, Md. 20705

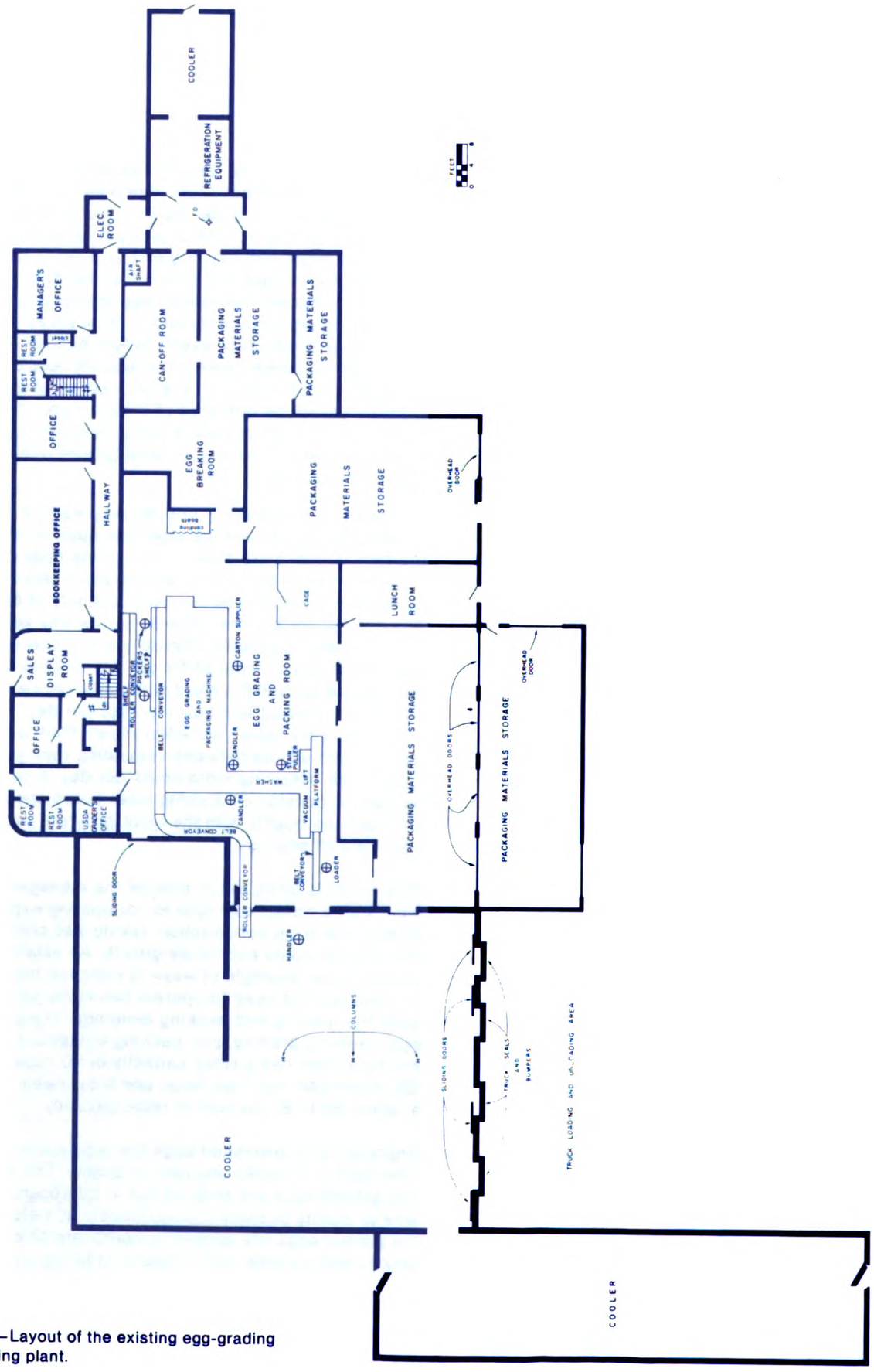


Figure 1.—Layout of the existing egg-grading and packing plant.

Description of the Existing Plant

proximately 45 percent of its product under its own brand name, with the remaining volume being customer packed.

A layout of the existing facilities with equipment and personnel stations identified is shown in figure 1. A layout of the proposed facilities, with the higher volume equipment and recommended personnel stations, is presented later in figure 9.

The proposed plant is designed so that employees may wash, grade, and pack 125 to 150 cases of eggs per hour, depending upon the level of efficiency that can be achieved. Of equipment available, two of the systems are rated by the manufacturer at 140 cases per hour, a third is rated at 150 cases per hour, and the fourth is rated at 120 cases per hour. However, the manufacturer of the fourth system indicates that it has "a top running speed of about 140 cases per hour and has proven to be able to supply a consistent net output of 135 cases per hour. Costs are calculated at an assumed level of 135 cases per hour based on the average cost of the four systems with the necessary building modifications for the example plant.

The egg-grading and packing plant contains approximately 18,400 square feet of floorspace. The original portion of the facility is over 20 years old and various portions have been added subsequently to form a multiroom plant. Even though the roof line and ceiling in the various rooms are at different heights, the floor is at the same level throughout the plant. The truck loading area at the rear of the plant is designed to facilitate a truck-bed-high floor at the cooler doors. The doors and the truck parking area are shown in figure 2. The middle door provides for passage of personnel.

As shown in figure 1, the plant is divided into numerous rooms, with various shapes and sizes. The plant design is the result of many attachments to the original building without an overall plan. As rooms were needed, they were added in the space available. Most of these additions have their own load-bearing walls which can interfere with expansion. The building is of sturdy construction and in good condition, having been well maintained. Additionally, the building and, particularly, the coolers and offices are well insulated. The original portion of the building is masonry construction, while the additions are mostly wood construction.

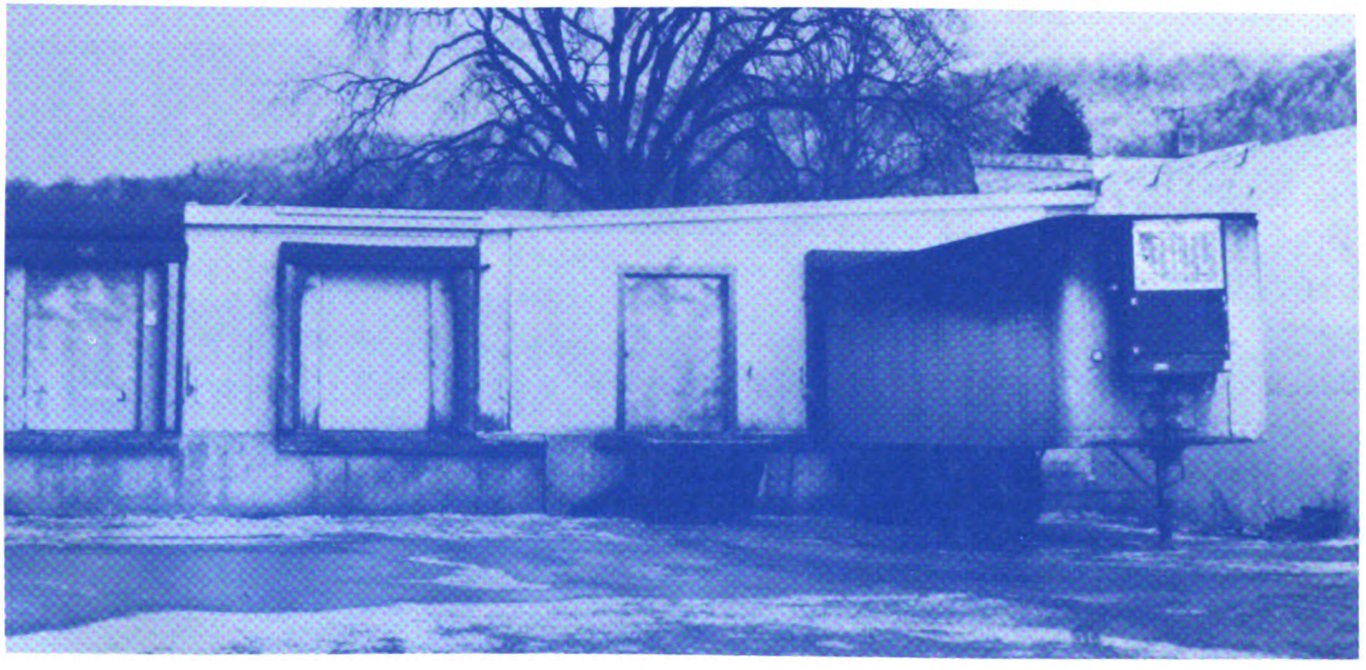


Figure 2.—The truck loading and unloading area. There are three doors with air seals, one of which is obscured by the trailer. The smaller door in the middle provides driver access to the cooler.

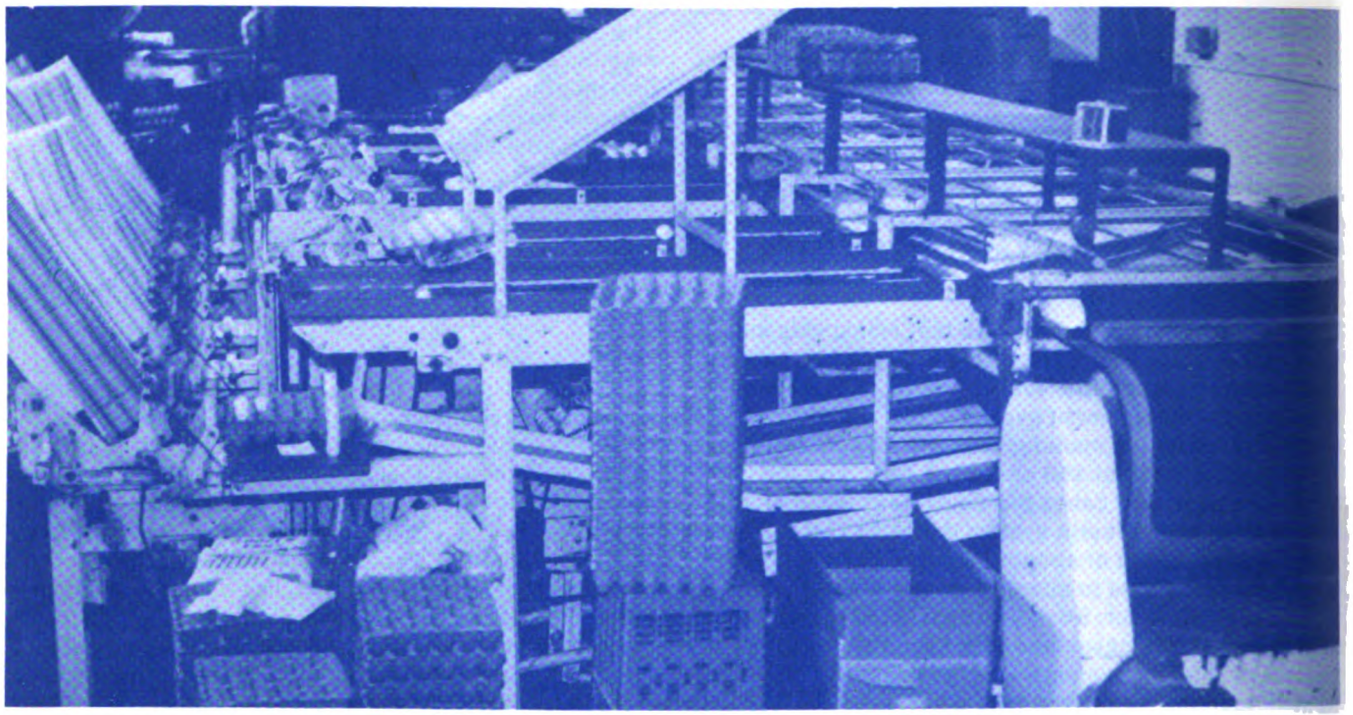


Figure 3.—One side of the egg-grading and packing equipment.

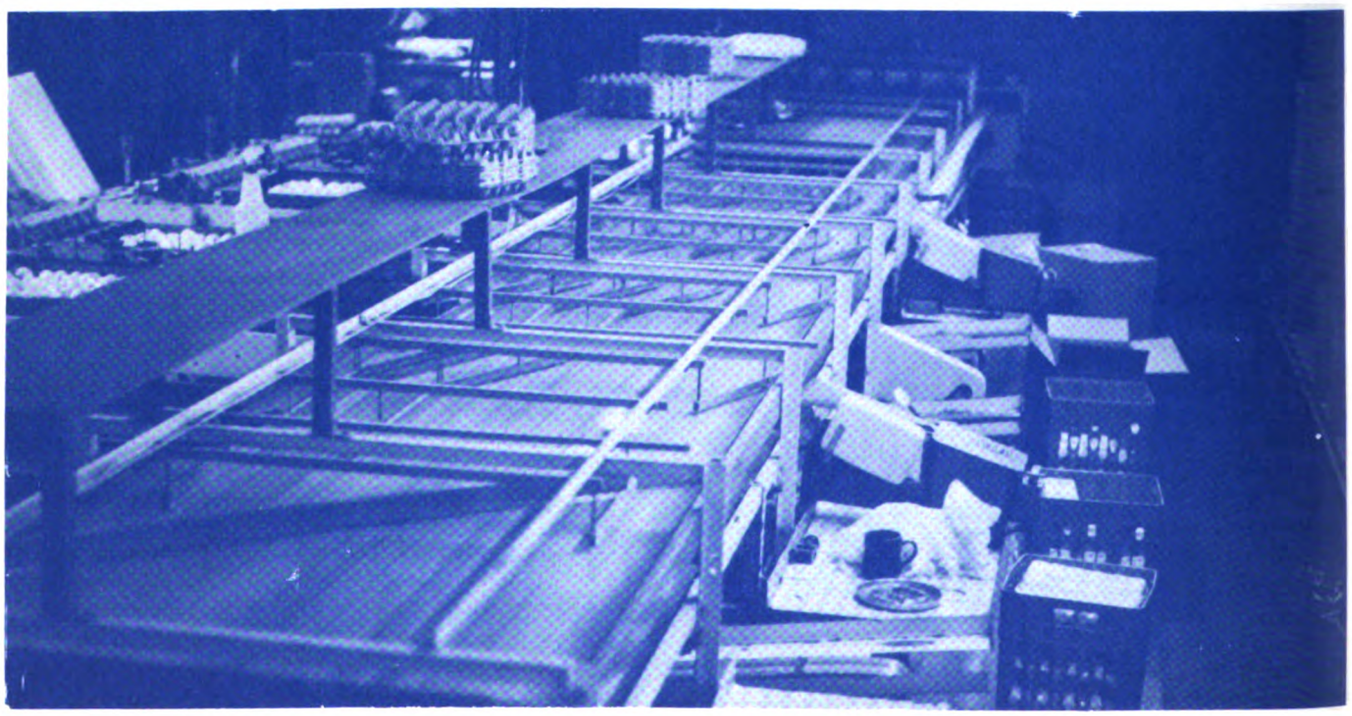


Figure 4.—The belt that brings the eggs from the scales to the packing heads. The case-packing stations are on the right.

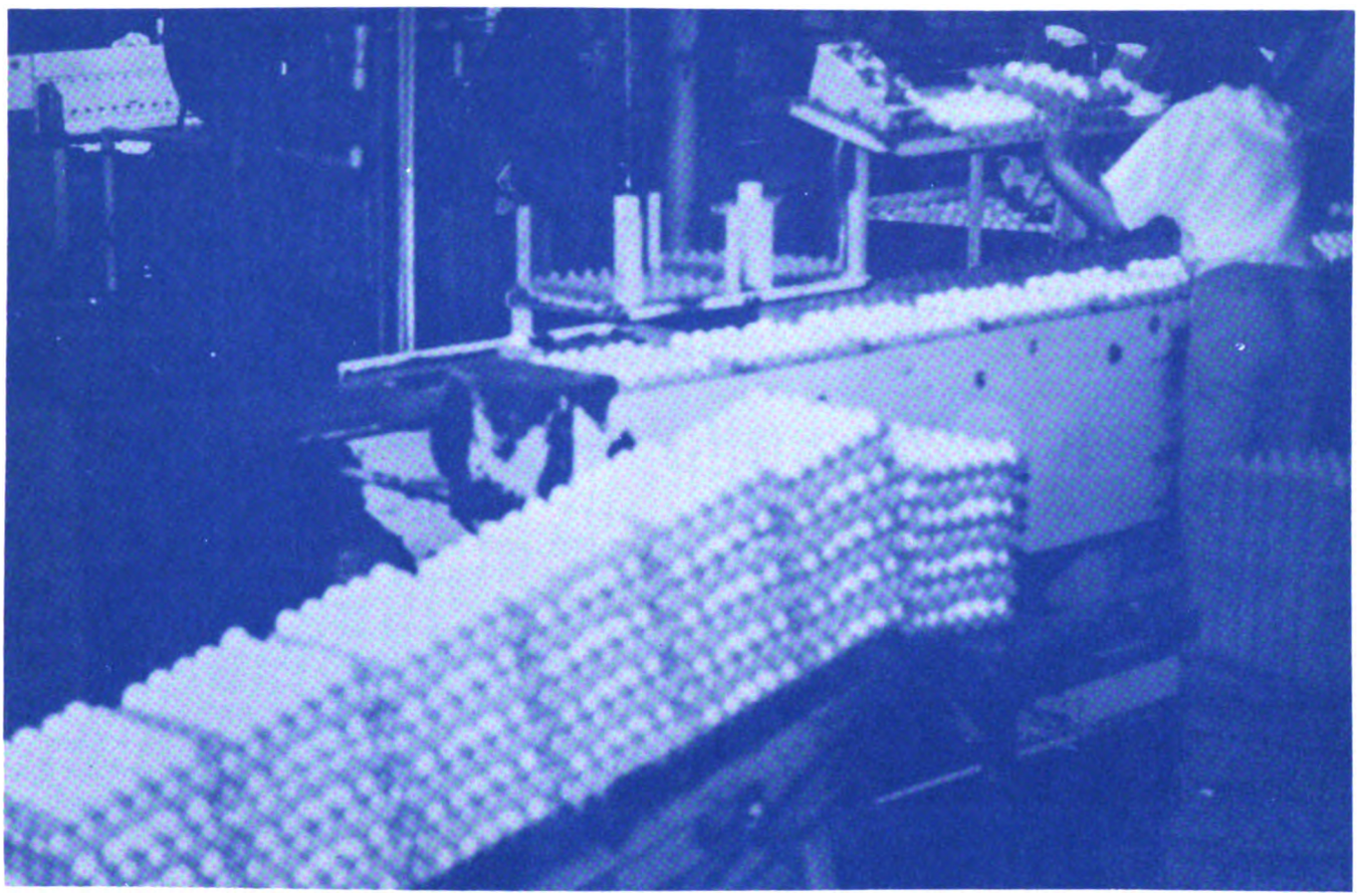


Figure 5.—Stacks of eggs in filler flats. The egg washer is in the background.

The plant is equipped with an egg-washing, grading, and packing system shown in figures 3 and 4. The system is rated at 70 cases per hour by the manufacturers. Approximately 280,800 cases of eggs are processed each year by two production crews of eight people each, at an average production rate of 8.5 cases per worker-hour for a labor cost of $166,400 per year, excluding management, sales, quality control, transportation, maintenance, and sanitation personnel. The average processing labor cost is $0.59 per case.

The egg-grading and packing equipment is 15 years old, while the egg washer and the loader are less than 5 years old. The loader is shown in figure 5 with stacks of eggs in filler flats. All of the equipment does an effective job with only limited downtime, reflecting near rated-capacity output.,

The plant is located in a rural area with adequate space for expansion, yet the facility is accessible by paved road and is within a 50-mile radius of at least 1 million people and within a 100-mile radius of 3 million or more people. The plant is located in a deficit egg production region, requiring that some nest-run eggs be imported to fill the market demand. Two feed mills serve producers in the area. Both the egg-grading and packing plant and the producers are served by adequate utilities. Wastewater is handled through a screening-aeration system and discharged into an extensive seepage field. The wastewater system was designed to handle more wastewater than is being discharged at present.

Usable floorspace dimensions, descriptions and evaluations of the various areas of the plant and the major functions that are performed in each area follow.

Room	Usable Floorspace by Individual Area				
	Width[1]		Length	Area (ft^2)	Total (ft^2)
Egg-grading and packaging	11'10"	×	26'10"	316	
	40'0"	×	52'0"	2,080	
	22'5"	×	9'0"	201	
	8'2"	×	5'10"	48	2,645
Cooler	22'7"	×	90'4"		2,041
Cooler	27'0"	×	71'7"	1,933	
	46'10"	×	58'7"	2,742	4,675
Packaging materials storage	52'2"	×	19'0"		992
Packaging materials storage	18'5"	×	52'2"	960	
	7'0"	×	39'7"	277	1,237
Lunchroom	11'2"	×	25'2"		282
Packaging materials storage	26'7"	×	42'10"		1,138
Packaging materials storage	7'10"	×	29'7"		231
Packaging materials storage	29'7"	×	17'0"		503
Egg-breaking room	10'10"	×	8'10"	95	
	13'5"	×	17'7"	236	331
Can-off room	13'7"	×	29'0"	394	
	6'0"	×	5'0"	30	364
Vestibule	17'2"	×	10'0"		172
Refrigeration equipment	13'7"	×	14'7"		199
Cooler	19'0"	×	14'7"		277
Electricity room	9'0"	×	10'7"		95
Hallways	11'10"	×	8'0"	94	
	12'7"	×	10'5"	131	
	4'5"	×	70'2"	309	
	5'5"	×	15'2"	82	616
Manager's office	14'0"	×	14'5"		202
Restrooms	5'5"	×	6'0"	32	
	5'0"	×	5'2"	26	
	6'0"	×	5'0"	30	
	6'0"	×	5'9"	30	118
Office	11'0"	×	14'0"		154
Bookkeeping office	14'0"	×	31'5"		440
Display room	11'5"	×	15'2"	173	
	6'0"	×	4'0"	24	197
Grader's office	6'0"	×	7'4"		44
Total inside area					16,953 ft^2
Total outside area including thickness of walls					18,438 ft^2
Difference: 18,438 - 16,953 = 1,485 ft^2					

[1]All measurements are wall to wall.

Egg-Grading and Packing Room—The egg-grading and packing room contains approximately 2,645 square feet of floorspace and has a ceiling height of 8 feet. Its location adjacent to the cooler facilitates the movement of eggs between the two rooms via belt and roller conveyors. The floor is concrete; however, it is not sloped to floor drains. A catch basin with drain has been installed under the egg washer. The size of the room is adequate for the present processing operations but will not accomodate the storage of quantities of packaging materials exceeding a 2-day supply. Normally all packaging materials are removed from the room by the cleanup crew. During work hours, about 25 percent of the floorspace in the room is utilized for temporary storage of packaging materials. This area can accomodate 26 or more 3- by 4-foot pallets of materials with single stacking. The ceiling height is too low to allow double stacking of pallet loads. Packaging materials can be moved to and from the area from the several rooms where they are stored. Filler flats and empty cases that accumulate at the vacuum-lift egg loader are moved in bundles to the adjacent packaging material storage room for storage. From storage they pass through the cooler to trucks that go out to the production farms.

A mesh wire cage—11 feet 6 inches by 11 feet 6 inches—located in a corner of the egg-grading and packing room provides lockable storage for small and valuable items, such as test weights, stamps, and hand tools.

The candling booth shown in figure 1 is utilized for spot checking the quality of eggs that have been through the washing, grading, and packing process. The booth is 4 by 8 feet.

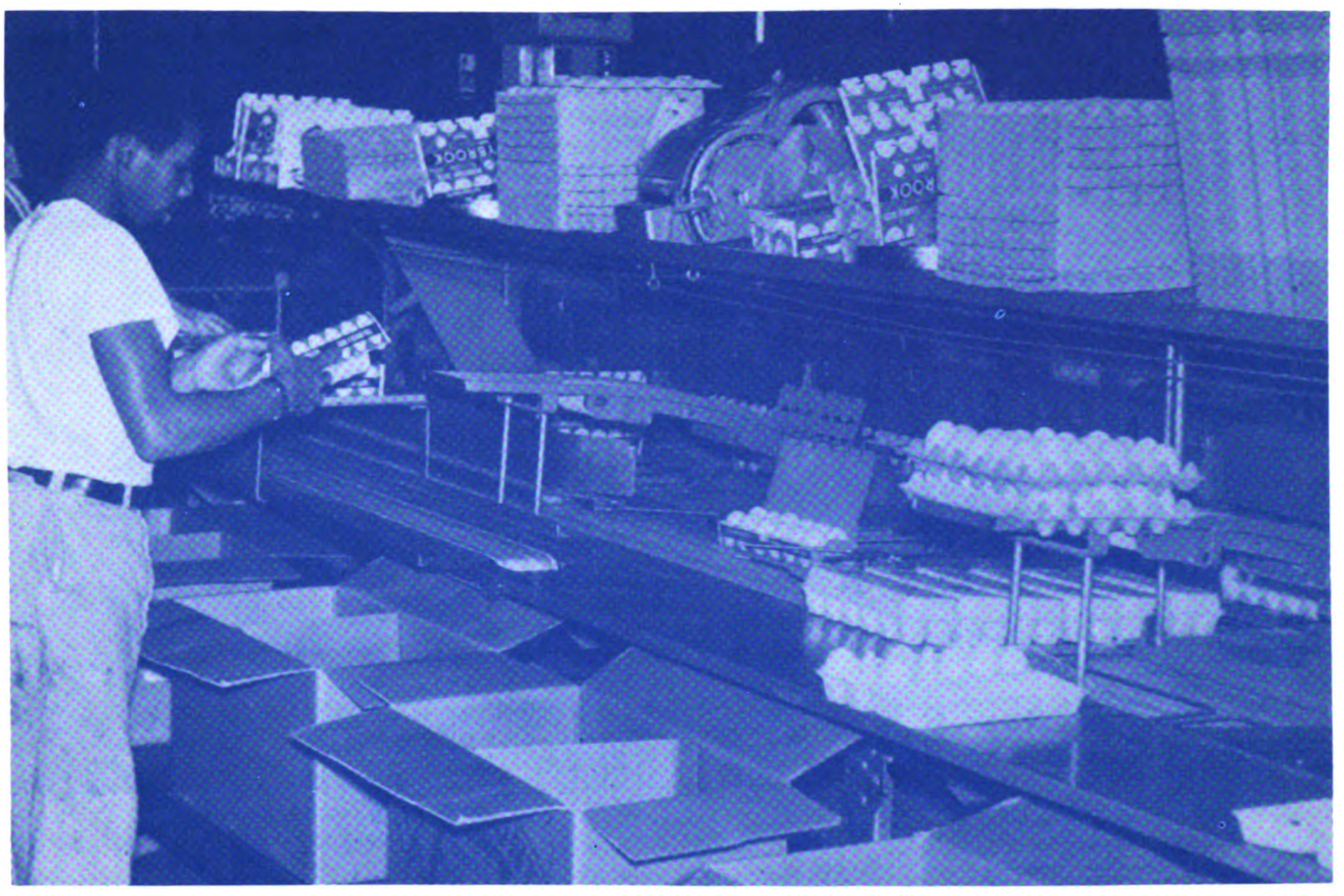


Figure 6.—Cartons of eggs being placed in cases.

Washing, Grading, and Packing System—Some of the components of the system are a belt conveyor for moving filler flats of eggs to the loader; a platform to facilitate the operator working at an elevated level; a vacuum-lift egg loader for moving eggs from filler flats onto the roller conveyor, which transports them through the washing machine and the candling machines; a washing machine that cleans and drys the eggs; and a candling machine that spins the eggs over lights for candling. Some other components are scales that separate the eggs according to weight; packing machines that place the appropriate number of eggs in either cartons or filler flats; carton closers that stamp the pull date on the carton while closing it; a case-packing bench where cartons or filler flats are placed in cases or baskets; a belt conveyor for transporting filled cases or baskets to the cooler; a roller conveyor and shelf for packaging materials; and a roller conveyor where filled egg cases or baskets are accumulated and stacked on pallets for storage or distribution to markets. Figure 6 shows the case or basket packing area while figure 7 shows palletized containers in the cooler.

Figure 7.—Cases and baskets of eggs stacked on pallets in the cooler.

The amount of space in the egg-grading and packing room is adequate. However, a little more space would contribute to less congestion. Frequently, a pallet or stack of packaging material must be moved to accomodate another type of packaging material, and then moved again before use. There is insufficient space on the other side of the grading machine for holding partially filled cases when only small quantities of a size are coming through the machine. Also, congestion by obstructive conveyors, shelves, the cage, the candling booth, and the narrow aisles, especially adjacent to the egg loader, limits the flow of personnel and materials around the machinery. Even with these handicaps, the plant operates at approximately 97 percent of the rated capacity of the system.

Flow of Product

Eggs are transported from the cooler to the egg-grading and packing room on pallets, either in cases or stacked in filler flats on the pallets, using a hydraulic pallet transporter. Filler flats of eggs are removed from the pallet and placed on a belt conveyor which moves them to the vacuum-lift egg loader. From the loader eggs are transferred to the conveyor of the washing and candling machines where they are washed, dried, and candled. Then the eggs are transferred to the scales where they are sized and conveyed to packing heads. The eggs are packed in cartons or filler flats, which in turn are packed in cases or baskets. The packaged eggs are then conveyed to the cooler, where they are palletized.

Labor Requirements

Although the plant is operating at 95 to 97 percent of the manufacturer's rated capacity of the egg-handling system, the level of efficiency is lower than that of some other firms in the industry whose modern, high-speed egg-handling systems have the capacity to facilitate higher production levels. Table 1 presents the in-plant production labor requirements per shift at the volume of approximately 280,800 cases per year. Doubling the production labor requirements reflects the

Table 1.—In-plant production labor requirements and costs per shift at the present 60- to 70-case-per-hour egg-grading and packing plant

Workers	Job description	Wage rate plus fringe benefits per hour	Hours per year	Cost per year	Cost per case[1]
Number		*Dollars*	*Hours*	*Dollars*	*Dollars*
1	Load eggs, replace leakers, salvage eggs left in filler flats, and stack filler flats.	5	2,080	10,400	0.074
2	Candle eggs, replace restricted eggs, and place restricted eggs in filler flats.	5	4,160	20,800	.147
2	Pack eggs in cases or baskets and load on conveyor.	5	4,160	20,800	.147
1	Supply cartons and filler flats to packing heads, correct problems with packing heads, and pack pee wee, small, and jumbo eggs.	5	2,080	10,400	.074
1	Remove stained eggs, tape cases, record lot counts, and other duties as required.	5	2,080	10,400	.074
1	Move eggs from cooler to grading room, palletize cases and baskets of eggs, move packaging material, receive, and ship eggs.	5	2,080	10,400	.074
Total 8		---	16,640	83,200	.590
In-plant labor and cost for two shifts		---	33,280	166,400	.590

[1]Based on a production rate of approximately 68 cases per hour.

present two-shift-per-day operation of 33,280 worker-hours per year, or an annual production rate of 8.5 cases per worker-hour.

A total of eight production personnel are required, including a loader; two candlers; two packers; one packing head attendant; one stained-egg remover who also tapes cases, keeps records, and performs other duties; and one product handler in the cooler (table 1). Nonprocessing labor such as order selectors and receiving and shipping personnel are not included. Processing labor costs amount to less than a dollar per case at present wage rates. However, it is anticipated that these costs would escalate in future years for the same labor requirements.

Because the plant is operated two shifts per day, an additional supervisor, who also performs quality control and maintenance, is needed. In the study plant, the day shift supervisor monitors quality of products and the night shift supervisor handles most maintenance of equipment. These functions require 4,160 worker-hours per year. These positions are classified as management functions and therefore are not shown in the production labor comparisons.

Fixed Costs

Overhead costs include interest on investment and operating capital, rent, depreciation, repair and maintenance, taxes, and insurance. In all businesses there is a time lag between the purchase of raw materials, processing the raw materials into finished products, sales and delivery of final products, and receiving payment from these sales. Because of this lag, operating capital is essential to operating any business. Since both the equipment and the building of the study plant are relatively old, the original investment has been depreciated out, and the economic conditions of the area enable the firm to rent the facility for a relatively low amount. The annual overhead costs of $153,300, of which $40,000 is operating capital, are relatively low for the industry. In the short run, most of these costs will be incurred whether any product is processed or not, so the cost per unit decreases as the volume increases. At 280,800 cases per year, the overhead cost is 55 cents per case.

Other fixed costs in the short run are most of the cost of the USDA Grading Service and the salary of the processing supervisor(s) or foreman; however, since these costs are not fixed in the long run, they are listed as a separate item in table 2. The fixed costs are approximately $41,944 for one shift and $56,504 per year for two shifts, excluding overtime. Grading service and supervisory costs are estimated at $77,252 for 416,000 cases per year, or 19 cents per case. At 280,800 per year, these costs are 20 cents per case.

Nonproduction types of fixed costs such as cost of management, transportation, and clerical and sales personnel; utility costs when the plant is not in operation; memberships in trade associations; and subscriptions to trade publications were not analyzed since they would be incurred whether the plant operates one or two shifts.

Variable Costs

Production Labor Costs

Variable costs are divided into two groups in this study, with in-plant production labor costs listed separately in table 2. Average production labor requirements for the existing plant, operating at 280,800 cases per year with two shifts, are 16 people or 33,280 worker-hours per year. Based on the present wage rate and fringe benefits of $5 per hour, the annual cost is $166,400 or 59 cents per case at the present volume. As the volume of product increases or decreases, the per-case production labor cost would be expected to increase or decrease as shown in table 2.

Other Variable Costs

Other variable costs analyzed in this study include utility expenses while the plant is operating, cleaning agents, supplies, materials, handling equipment repairs, wastewater treatment, trash removal, and incentive programs. These variable costs amount to $78,624 per year, or 28 cents per case at the present volume. As shown in table 2, these costs would range from 39 to 28 cents per case at the selected volume levels.

Total Costs

Total in-plant production fixed and variable costs for the existing facility and equipment are estimated to range from $1.53 per case to $8.28 per case for the volumes selected in table 2. The plant is operating near the lowest cost level achievable in this facility with this equipment. The cost of washing, grading, and packing eggs in the existing plant at selected levels is illustrated in figure 8.

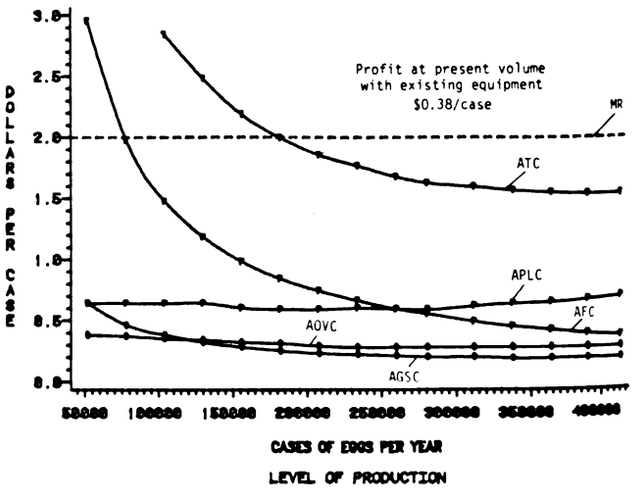


Figure 8.—Revenue and cost for selected levels of production with existing equipment.

Table 2.—Fixed and variable costs per case at specified levels of production for a 60- to 70-case-per-hour egg-grading and packing plant[1]

Cases per year	Hours of operation per week	Average overhead cost[2]	Average Grading/ supervisory cost[3]	Average production labor cost[4]	Average other variable cost[5]	Average overhead and variable costs
Cases	*Hours*		*Dollars*			
26,000	10	5.90	1.19	0.80	0.39	8.28
52,000	16	2.95	.64	.64	.38	4.61
78,000	24	1.97	.46	.64	.37	3.44
104,000	32	1.47	.38	.64	.35	2.84
130,000	40	1.18	.32	.64	.34	2.48
156,000	45	.98	.28	.60	.32	2.18
182,000	52	.84	.25	.59	.31	1.99
208,000	59	.74	.23	.59	.29	1.85
234,000	67	.66	.22	.60	.28	1.76
260,000	74	.59	.21	.59	.28	1.67
280,800	80	.55	.20	.59	.28	1.62
312,000	89	.49	.20	.62	.28	1.59
338,000	96	.45	.19	.64	.28	1.56
364,000	103	.42	.19	.65	.28	1.54
390,000	111	.39	.19	.67	.28	1.53
416,000	118	.37	.19	.69	.28	1.53

[1]Based on a production rate of approximately 68 cases per hour.

[2]Based on amortization, rent repairs, and insurance.

[3]Based upon 1981 schedule of fees, and present salaries of processing supervisors(s).Two supervisors are included above 52 hours per week, and 1½ times the normal wage rate above 80 hours.

[4]Calculated at 1½ times the normal wage rate for overtime. Does not include supervisors, quality control, or maintenance personnel.

[5]Based on current costs, less denatured egg income. Does not include packaging, receiving, and order assembly, transportation, and cost of sales because these would not be expected to change whether the plant operated one or two shifts.

An assumed marginal revenue line is shown at $2 to illustrate the marginal revenue attainable at the selected volume with these costs. Each individual firm would need to estimate its own revenue and cost data to make an analogy. Based on the assumed revenue line, the firm could expect a marginal revenue of 38 cents per case at the present volume with the present equipment and facilities. The spread between marginal revenue and average total costs is almost at the maximum for the present volume of processing with the existing equipment. Packaging, administrative, sales, order assembly, and transportation costs are not included in the average total costs. Additionally, the present volume is about the maximum quantity of product that can be handled without resorting to three shifts a day or an extensive amount of overtime. It may be difficult to obtain and keep qualified personnel to operate a third shift. Other firms in other localities have experienced problems of this nature. In the event the firm had to process the additional volume of product without a third shift, or with a different crew on weekends, it would probably necessitate numerous hours of overtime and double time, causing a much larger increase in cost per case than shown in table 2.

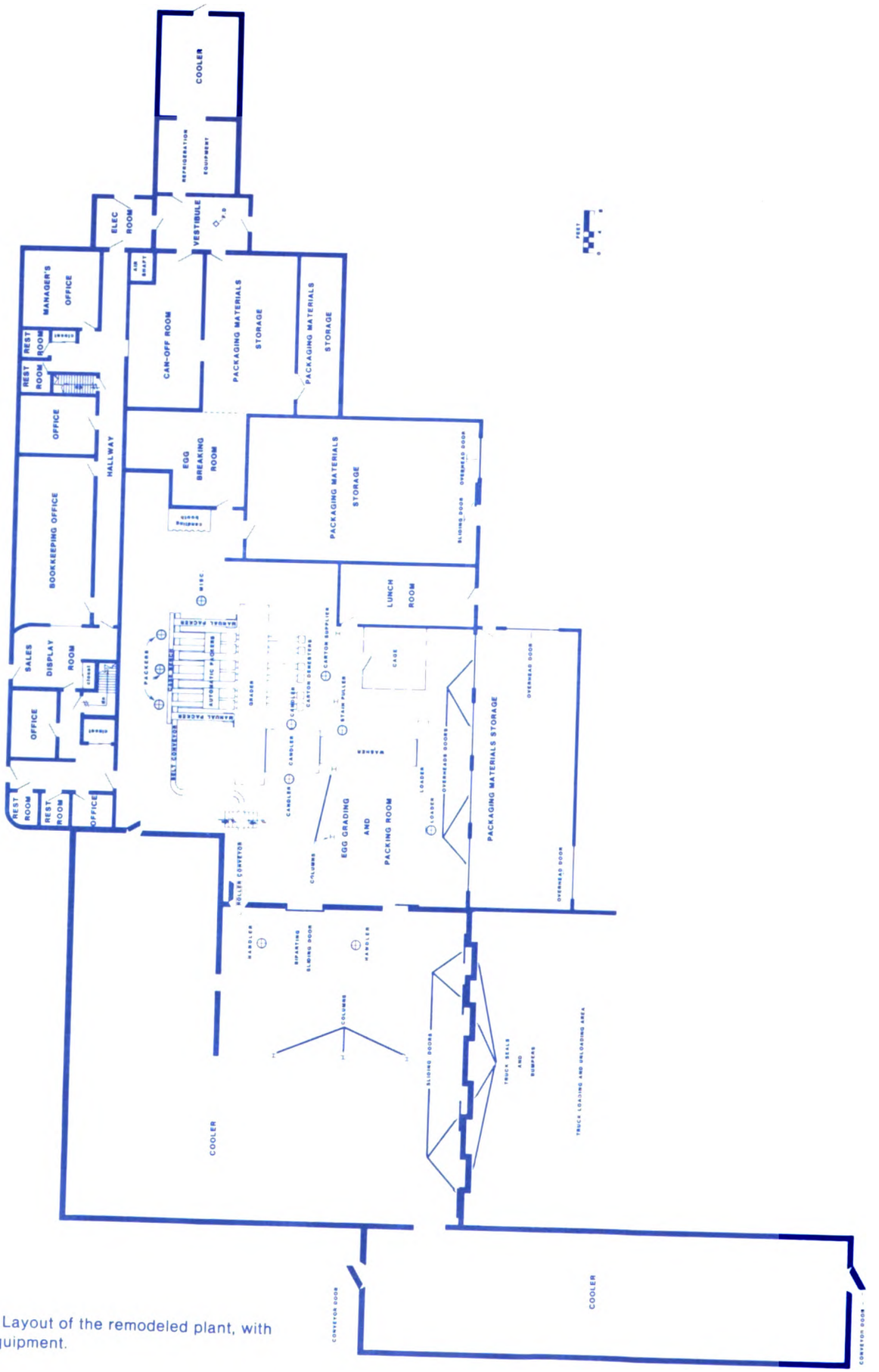


Figure 9.—Layout of the remodeled plant, with the new equipment.

Description of the Remodeled Plant

The layout of the remodeled plant is shown in figure 9. The layout is the same as figure 1, the existing plant, except that the wall separating the egg-grading and packing room and one of the adjacent packaging material storage rooms is removed to enlarge the egg-grading and packing room. Removal of this wall will add approximately 1,237 square feet of floorspace to the egg-grading and packing room. Although the wall is not load bearing, there are supporting columns as shown on the layout that must be retained and the equipment must be placed between the columns.

Another building modification that will be required is to add a ceiling to the addition in the egg-grading and packing room (formerly a packaging material storage room) and to insulate above this ceiling. The ceiling should be approximately 10 feet above the floor, or 2 feet higher than the ceiling throughout the existing egg-grading and packing room to provide for efficient hot air and humidity removal.

The remodeled plant is equipped with an egg-washing, grading, and packing system rated at 125 to 150 cases per hour. This system will enable the firm to process its present volume of approximately 280,800 cases per year in 1,872 to 2,246 hours per year. Processing productivity is estimated at 135 cases per hour or 2,080 hours per year for the present volume.

The present wastewater handling system should be adequate for the remodeled plant, since the same volume would be handled initially, and this system is designed to process a large volume. The square footage in various rooms will remain the same except one

Table 3.—Estimated initial investment and annual overhead costs for remodeling a 60- to 70-case-per-hour egg-grading and packing plant into a 125- to 150-case-per-hour plant[1]

Item	Initial investment	Expected life	Annual overhead costs				Total
			Interest[2]	Depreciation[3]	Repair and maintenance[4]	Taxes and insurance[5]	
	Dollars	*Years*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Land[6]	---	---	---	---	---	---	---
Building	10,000	20	735	500	400	300	1,935
Equipment:							
Automatic loader	23,564	8	1,856	2,946	943	707	6,452
Egg washer	31,679	8	2,495	3,960	1,267	950	8,672
Gas boiler	2,833	8	223	354	113	85	775
Oiler	965	8	76	121	39	29	265
Grader, packers, counters, and spare parts	156,855	8	12,352	19,607	6,274	4,706	42,939
Freight and installation	2,775	---	219	---	---	---	219
Estimated sale value of present equipment	(25,000)	---	---	---	---	---	---
Total	203,671	---	17,956	27,488	9,036	6,777	61,257

[1]Cost data based on March 1982 quotations.

[2]Computed by the following capital form: Principle × $\frac{\text{interest rate}}{2}$ × $\frac{\text{life of loan + 1 year}}{\text{life of loan}}$.

[3]Computed by the following formula: $\frac{\text{Initial investment}}{\text{Years of depreciation}}$ = annual depreciation

[4]Based on 4 percent per year.

[5]Based on 3 percent per year.

[6]No additional land required at the existing plant.

of the packaging material storage rooms, shown in figure 1, will be used to enlarge the egg-grading and packing room.

Washing, Grading, and Packing System—The remodeled egg-grading and packing room will encompass 3,882 square feet of floorspace. The ceiling of the existing egg-grading and packing room is 8 feet from the floor and a ceiling with insulation should be added to the expansion area, 10 feet from the floor. The cost of adding the ceiling and insulation is included in the building modification estimates in table 3. The concrete floor in the addition is not sloped to a floor drain; therefore, the existing catch basin should be moved to a position directly under the new egg-washing machine shown in figure 9. The water should be piped to the existing floor drain. Likewise, the egg-washer exhaust system should be moved to a point above the new egg washer.

Approximately 30 percent of the floorspace in the remodeled egg-grading and packing room will be available for temporary storage of packaging materials. At least 30 pallets (3 by 4 feet) of packaging material can be stored in the floorspace around the grading and packing machine. However, the quantity should be limited to a 1-day supply (except in emergencies) because excessive quantities of packaging materials in the room create potential problems with congestion, fire hazards, damaged packaging materials, rodent havens, and worker safety. Normally, all packaging materials should be removed from the room at the end of the work day to facilitate a more complete and easier cleanup. Filler flats and empty cases that accumulate at the destacker and loader are tied into bundles and moved to the cooler for shipment, or to one of the packaging material storage rooms.

The mesh wire cage for storing small items such as test weights, stamps, or hand tools has been moved to another corner of the egg-grading and packing room as shown in figure 9 to allow a wider aisle space around the equipment. The 11½ by 11½-foot cage is the same size as the previous cage, and should be sufficient in size to provide adequate lockable storage for small and valuable items. No changes were made in the candling booth.

The layout of the egg-grading and packing plant in figure 9 allows accessibility to all sides of the equipment with no obstructions except the belt and roller conveyors which move the graded and packed eggs from the case bench to the cooler. Steps are included in the layout to provide access over the conveyors. Adequate space around the equipment contributes to efficiency and neatness of the operation. In the existing facility, as well as in many egg-grading and packing plants, materials and products must be moved several times before usage because of congestion.

Equipment manufacturers use different names for some of the component machines that make up their high-speed egg-washing and grading systems and there are some differences in the design and operation of the components from one system to the other. Therefore, for nomenclature descriptive purposes, functional names were given to the major components of all systems. These names are listed in figure 9.

The first major component of the system is the automatic egg-destacker loader with filler-flat restacker, which separates stacks of five filler flats of eggs into a line of single flats. Eggs are removed from the filler flats and placed on a roller conveyor to the washing and candling machines and the empty filler flats are restacked. The next major component is the egg washer, with drier and proportioning pump, that washes the eggs, sprays them with a sanitizing rinse, and air dries them. Because a source of hot water is needed, most systems include a hot water heater. Most systems also include an oiler, a device that sprays warm oil on eggs after washing and rinsing to preserve their quality.

The third major component is the candler-grader scales with automatic packers, closers, conveyors, denesters, counters, daters, takeway belts, and spare parts. The eggs are rotated over bright lights (candled) to check the shell and interior quality, then they go to the scales to separate them by size, after which they are conveyed to packing stations where they are placed in cartons or filler flats, either manually or by mechanical packing heads. The filled cartons or filler flats are conveyed to the packing bench and placed in cases or baskets, which are conveyed to the cooler and palletized.

Flow of Product

Upon receipt from the farm, palletized cases or filler flats of eggs are transported to the cooler using either a hydraulic pallet transporter or an electric pallet truck. Filler flats of eggs are removed from the pallet and stacked five filler flats high on the destacker. The destacker places the filler flats of eggs on a conveyor belt, one filler flat high, and each filler flat is turned in the same direction. Then the loader removes the eggs from the filler flats and places them on a roller conveyor which transports the eggs through the washer and the candling machine. Meanwhile, the empty filler flats are transferred to another conveyor which takes them to a point where they are stacked or nested on top of each

other to form a manageable bundle. The loading machine automatically checks each filler flat for eggs before stacking them to salvage the eggs and to prevent the mess that would occur if the eggs become crushed between the filler flats. After the eggs are washed, dried, and candled, they are transferred to the scale where they are sized and conveyed to packing heads. There the eggs are packed in cartons or filler flats, which in turn are packed in cases or baskets. The cases or baskets of eggs are transported by the belt conveyor and roller conveyor to the cooler, as shown in figure 9, where they are palletized for storage or shipment.

Labor Requirements

Various egg-grading and packing equipment manufacturers advertise that their machine will operate at a specified production rate with a given number of personnel, while other manufacturers give different production rates and different numbers of personnel. Usually these figures are based on uninterrupted operations and top quality nest-run eggs that allow the machines and personnel to function at or near top speeds. Additionally, the personnel are usually fully trained, experienced, and capable. These conditions cannot always be met in the day-to-day operations;

Table 4.—In-plant production labor requirements and costs per shift at the proposed 125- to 150-case-per-hour egg-grading and packing plant

Workers	Job description	Wage rate plus fringe benefits per hour	Hours per year	Cost per year	Cost per case[1]
Number		*Dollars*	*Hours*	*Dollars*	*Dollars*
1	Load filler flats of eggs, replace leakers and stained eggs, salvage eggs left in filler flats, and stack filler flats.	5	2,080	10,400	0.037
2	Candle eggs, replace restricted eggs, and place restricted eggs in filler flats.	5	4,160	20,800	.074
1	Remove and replace stained and broken eggs after the washer, and carry out other functions.	5	2,080	10,400	.037
3	Pack eggs in cases or baskets and load on pallets.	5	6,240	31,200	.111
1	Supply cartons and filler flats to packing heads, and pack pee wee and jumbo eggs.	5	2,080	10,400	.037
1	Pack eggs in cases and baskets, tape cases, and other duties as required.	5	2,080	10,400	.037
2	Move eggs from cooler to grading room and move graded eggs to cooler	5	4,160	20,800	.074
Total 11		---	22,880	114,400	.410

[1]Based on a production rate of approximately 135 cases per hour.

therefore, the labor requirement, production rates, and costs used in this report are an estimated average for well-managed operations running eggs from well-managed flocks of birds.

The personnel required to operate the new equipment in this remodeled egg-grading and packing room are designated in figure 9 by a circle with a crosshatch, each of which is positioned at the primary work station for that person. The title indicates the primary function of each of the 11 production people required to operate this equipment at approximately 135 cases per hour. Personnel required include a loader, two candlers, one stain puller, three packers, one carton supplier, and one person with miscellaneous duties, such as packing eggs in cases and baskets, taping cases, and keeping records of eggs received and shipped. Two other people would be required to move eggs to and from the grading room and cooler. Nonprocessing labor such as order selection, and receiving, and shipping are not counted as production labor, and requirements should not change with the installation of new processing equipment. Equipment maintenance could be handled by either the stain puller or the miscellaneous person. These functions would be supervised by a production or working supervisor or foreman whose salary is counted as a fixed operating expense. Most of the equipment manufacturers furnish or train an equipment maintenance person as part of the package when a new system is sold.

The in-plant production labor requirements (excluding the supervisor) per shift in the proposed 135-case-per-hour egg-grading and packing plant are shown in table 4. Approximately 22,800 worker-hours would be required to process a volume of 280,800 cases per year when operating at an average speed of 135 cases per hour.

Fixed Costs

Overhead costs include amortization of the investment to remodel the egg-grading and packing room, cost of the new equipment plus freight and installation less the sales value of the present equipment, rent on the building and land, repairs, and insurance. The equipment required to expand the production of the plant to about 135 cases per hour is listed in table 5 along with the cost of each major component by three manufacturers. The costs are combined to give an average price of $218,671, reduced by an estimated salvage value or sales value of $25,000 for a total of $193,671. In table 3, the estimated initial investment, including $10,000 for building modifications, is used to estimate the additional annual overhead costs of $61,257, which when added to the $153,400 existing annual overhead cost amounts to $214,657. In the short run, most of these costs will be incurred whether any product is processed or not. The magnitude of these expenses indicate the importance of volume on average overhead cost per case of eggs. At 280,800 cases per year, the overhead cost is 76 cents per case. The cost per case at selected production levels is shown in table 6. The existing costs are estimated based on procedures outlined by Johnson and Pasour.[2]

Average USDA Grading Service cost and the salary of the production supervisor(s) are the only costs singled out as fixed operating costs since these costs must be paid in the short run regardless of the quantity of product processed. The fixed portion of the resident grading service on a per unit basis decreases as the volume of product processed increases as shown in table 6. The variable portion of grading service costs ($0.02 per case) is added to the average other variable costs shown in table 6. Since the remodeled plant eliminates the need for a second shift, the cost of a second shift supervisor is eliminated except when operating above 52 hours per week, reducing the fixed operating cost to 15 cents per case for 280,800 cases per year.

Other fixed operating costs includes salaries for management, sales, and clerical personnel plus fringe benefits; utility costs when the plant is not in operation; memberships in trade associations and subscriptions to trade publications and other miscellaneous items. These costs are not included in the analysis since it is assumed that these costs would not be affected appreciably by the conversion.

Variable Costs

Production Labor Cost

Based on the production personnel indicated in table 4, 22,880 worker-hours would be required to process the present volume of 280,800 cases per hour in the study plant at a cost of $114,400 per year or 41 cents per case. These figures are based on the present wage-benefit rate in the study plant. If the wage-benefit rate increases, the costs (annual labor and cost per case) will increase. Assuming that personnel would be paid at 1½ times normal salary for overtime, the labor cost per case would increase with more volume of product per year, unless a higher rate of productivity could be

[2]Johnson, M. A. and Pasour, E. C., Jr. "An Opportunity Cost View of Fixed Assets Theory and the Overproduction Trap." American Journal Agricultural Economics, Feb. 1981, pp 1-7.

Table 5.—Equipment required to expand a 60- to 70-case-per-hour egg-grading and packing plant into a 125- to 150-case-per-hour plant

Item	Manufacturer's suggested price				
		Brand B			
	Brand A	System No. 1	System No. 2	Brand C	Average price
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Automatic egg destacker loader with flat stacker	29,000	20,800	25,000	19,456	23,564
Egg washer with dryers and proportioning pump	33,500	29,350	46,485	17,380	31,679
Gas hot water boiler	3,190	1,620	2,600	3,920	2,833
Egg oiler	1,900	([1])	([1])	1,961	965
Candler-grader-scales Automatic packers, closers, conveyors, denesters, counter, daters, takeway belts, and spare parts[2]	165,000	139,370	142,250	180,800	156,855
Freight and installation[3]	7,500	1,200	1,200	1,200	2,775
Subtotal[4]	240,090	192,340	217,535	224,717	218,671
Estimated trade in or resale value of present equipment	-25,000	-25,000	-25,000	-25,000	-25,000
Total	215,090	167,340	192,535	199,717	193,671

[1]Included in the price of the egg washer.

[2]Spare parts furnished usually are those parts which are not generally available from other sources and which if missing will shut the entire system down—critical parts.

[3]Minimum figures as quoted. Some firms charge an additional fee for mileage in excess of a minimum.

[4]Does not include taxes which range from 0 to 7 percent with approximately 10 States charging a sales tax. The sales tax may be incurred or not incurred, depending upon whether the equipment is delivered or picked up at the factory by the processor.

achieved. Labor cost may vary from plant to plant and from locality to locality.

Other Variable Costs

Variable costs included in this analysis are limited to the cost of utilities and other variables in the existing plant, since it is assumed that the remodeled plant, operating one shift per day, would not need more utilities and other variables. At the present volume, the other variable cost would be $61,776 per year, or 22 cents per case. These costs would be expected to range from 22 to 35 cents per case, for the selected levels of production, with the higher cost being at the lower volumes. The variable costs are slightly less for the new equipment than for the old equipment since only one working grading-packing system is used whereas now two are used.

Table 6.—Fixed and variable costs per case at specified levels of production for a 125- to 150-case-per-hour egg-grading and packing plant[1]

Cases per year	Hours of operation per week	Average overhead cost[2]	Average Grading/ supervisory cost[3]	Average production labor cost[4]	Average other variable cost[5]	Average overhead and variable costs
Cases	*Hours*		*Dollars*			
52,000	8	4.13	0.61	0.44	0.35	5.53
78,000	12	2.75	.43	.44	.34	3.96
104,000	15	2.06	.33	.41	.33	3.13
130,000	19	1.65	.27	.42	.31	2.65
156,000	23	1.38	.24	.42	.30	2.34
182,000	26	1.18	.21	.41	.27	2.07
208,000	30	1.03	.19	.41	.25	1.88
234,000	34	.92	.17	.42	.23	1.75
260,000	37	.83	.16	.41	.23	1.63
280,800	40	.76	.15	.41	.22	1.54
312,000	44	.69	.14	.42	.22	1.47
338,000	48	.64	.14	.44	.22	1.44
364,000	52	.59	.13	.46	.22	1.40
390,000	56	.55	.13	.47	.22	1.37
416,000	60	.52	.13	.48	.22	1.35

[1]Based on a production rate of approximately 135 cases per hour.

[2]Based on amortization, rent, repairs, and insurance.

[3]Based on 1981 schedule of fees, and present salaries of processing supervisor(s). Two supervisors are included above 52 hours per week.

[4]Calculated at 1½ times the normal wage rate for overtime. Does not include supervisors.

[5]Based on current costs, less denatured egg income. Does not include packaging, transportation, overhead costs, and cost of sales because these would not be expected to change whether the plant operated one or two shifts.

Total Costs

The total in-plant processing costs (excluding the cost items mentioned in the previous sections) for washing, grading, and packing the present volume of 280,800 cases of eggs per year would be about $432,432 per year or $1.54 per case. This is 8 cents per case or $22,464 less than the cost of handling the same volume in the existing facility with the existing equipment. If the volume of product increases, then the savings would be even greater as shown in tables 6 and 7. Conversely, if the volume of product decreases drastically, the remodeled plant would not be feasible, assuming that none of the other variables changed. The average cost per case at the selected levels of production is illustrated in figure 10, and a comparison of the cost per case in the remodeled plant and the existing plant is shown in figure 11.

Table 7.—Total cost per case at selected production levels for the existing plant and equipment compared with costs for the remodeled plant and new equipment.

Cases per year	Cost per case with existing equipment	Cost per case with remodeled plant & new equipment	Difference in cost per case
Cases	*Dollars*	*Dollars*	*Dollars*
52,000	4.61	5.53	+0.92
78,000	3.44	3.96	+0.52
104,000	2.84	3.13	+0.29
130,000	2.48	2.65	+0.17
156,000	2.18	2.34	+0.16
182,000	1.99	2.07	+0.08
208,000	1.85	1.88	+0.03
234,000	1.76	1.75	-0.01
260,000	1.67	1.63	-0.04
280,800	1.62	1.54	-0.08
312,000	1.59	1.47	-0.12
338,000	1.56	1.44	-0.12
364,000	1.54	1.40	-0.14
390,000	1.53	1.37	-0.16
416,000	1.53	1.35	-0.18

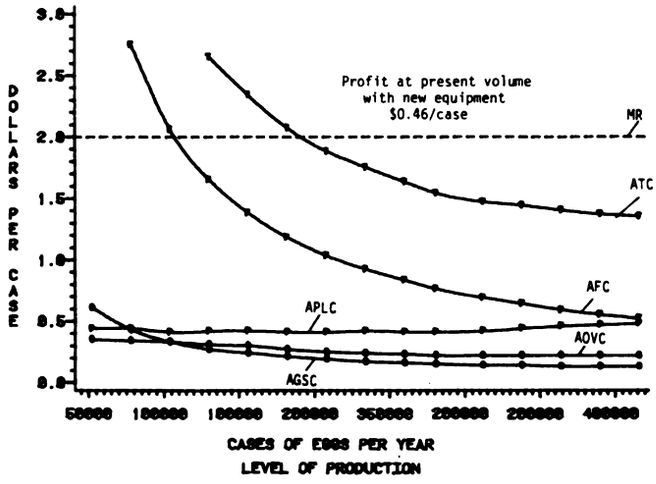


Figure 10.—Revenue and cost for selected levels of production with the new equipment.

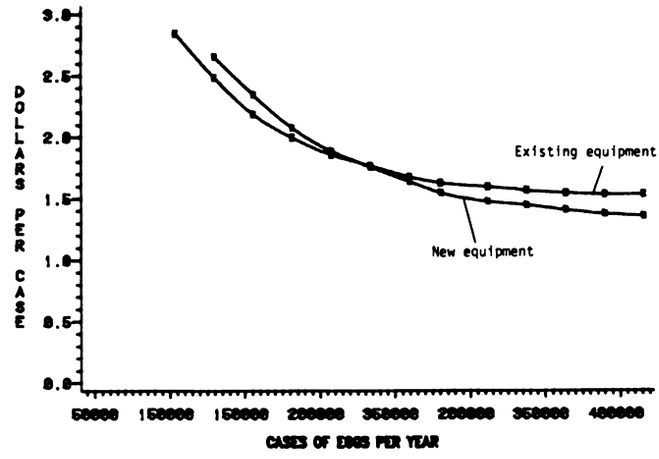


Figure 11.—Total cost per case for grading and packing eggs with the present equipment and the estimated cost per case with the proposed remodeled plant and new equipment.