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Evaluation of a Shell Egg-Packing Plant Layout

Contents

Abstract

Increasing costs of constructing and operating shell egg-packing plants make it essential that new or remodeled facilities be carefully planned to achieve maximum efficiency. This study evaluates the layout of a new shell egg-packing plant that demonstrates U.S. Department of Agriculture (USDA) planning concepts.

The layout provides for adequate operating space and allows for future expansion at minimal cost. It also provides for the flow of products without backtracking, ease of maintaining sanitation, employee safety and welfare, maintenance of product quality, effective materials handling, and operating efficiency. Labor productivity in the new plant is 8.30 cases per worker-hour compared with 7.03 in the old plant, a gain of 18 percent.

Data suggest that the USDA planning concept that was evaluated satisfies essential criteria that should be considered in developing layouts for shell egg-packing plants.

Acknowledgments

The authors express their appreciation to the egg-packing firm that cooperated with them by making its facilities available for study and by providing essential information.

Recognition is also given to Marvin Volz, an industrial engineer, who collected some of the engineering data as a participant in the study before his death.

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Evaluation of a Shell Egg-Packing Plant Layout

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Introduction

Increasing costs of constructing and operating shell egg-packing plants make it essential that new or remodeled facilities be carefully planned to achieve maximum efficiency. Consideration also must be given to future needs for additional capacity, impacts of government regulations, the necessity for maintaining product quality, and assuring the safety and comfort of workers.

A shell egg plant layout encompasses the physical arrangement of the facility, the space necessary for operations, and the movement and storage of eggs and packaging materials. Attention also must be given to auxiliary functional needs such as shops, offices, and employee services including restrooms and dining areas.

Several factors must be considered when planning a layout for a shell egg-packing plant, but eggs and packaging material are perhaps the most important. Eggs include incoming eggs, those in various stages of being graded and packed, and eggs that have been packaged and held in storage until shipped. Packaging material comprises cartons, cases, filler-flats, and similar items. Provisions also must be made for handling inedible products, undergrade eggs, and maintenance supplies.

Movement of materials by conveyors, belts, pallet transporters, and forklift trucks is essential to the packing operation. In some situations, manual movement may be justified to a limited extent. Layout considerations related to the function of movement include the flow pattern, handling practices, utilization of space, and handling equipment. Such other factors as machinery and equipment, delay in movement, storage, services (utilities, etc.), the work force, and changing facility needs also must be considered.

The purpose of this study is to assess the adequacy of a facility planning concept developed by the U.S. Department of Agriculture (USDA). This assessment includes comparing labor costs for handling shell eggs in a new packing plant with those of the outmoded plant it replaced.

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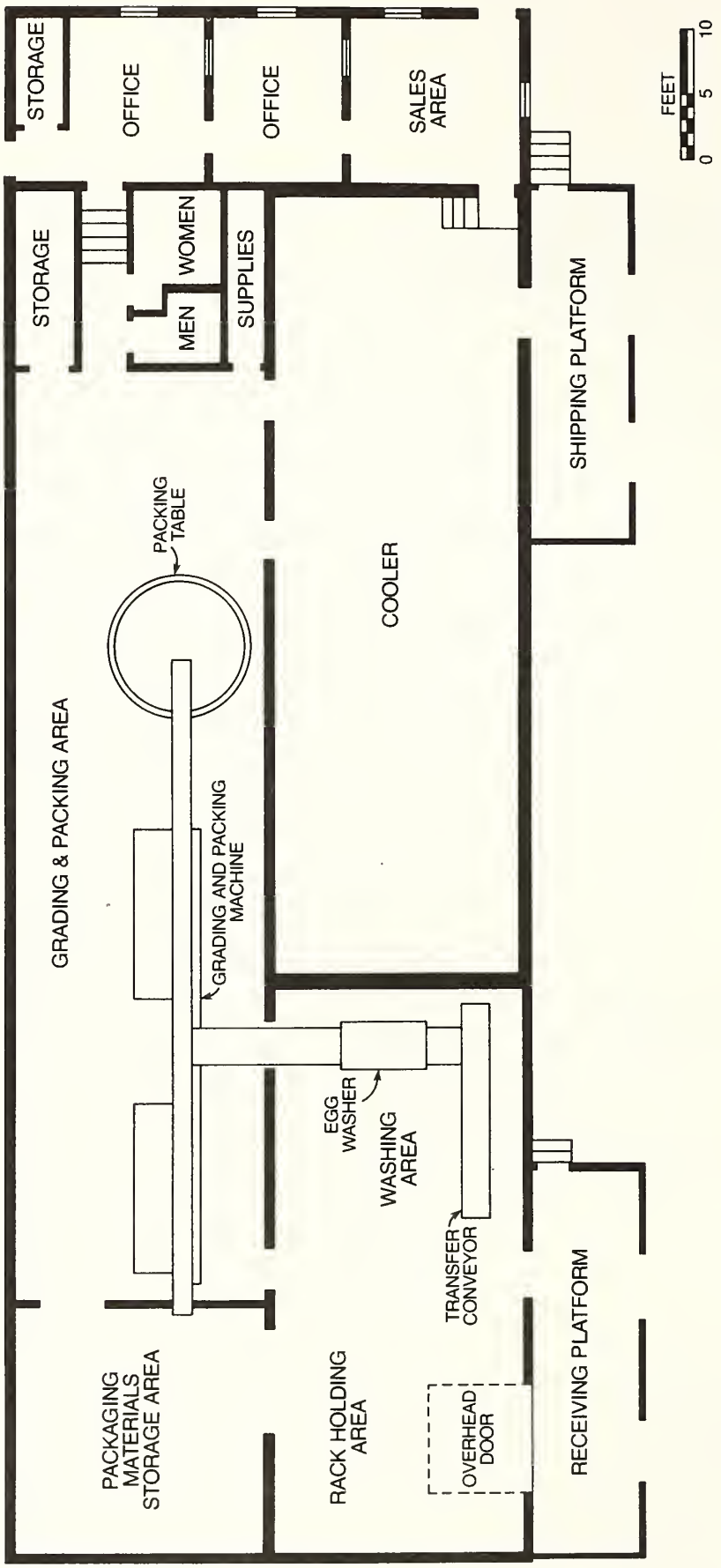

Figure 1.—Layout of the old plant.

The difference in handling costs provides a measure of the efficiency attainable through layout design of the new plant contrasted to the outmoded plant. Efficiency, however, is not an absolute measure of a satisfactory layout. A plant's capability to handle a required volume while at the same time maintaining quality is a criterion that must be considered.

Nor should the effects of management in operating the facilities be overlooked. A plant designed to achieve efficiency can be managed in ways that offset planned benefits.

Old Plant

Since the inadequacy of the old facility caused the firm to abandon it, identifying some of the problems and shortcomings of the facility are worthwhile. A general description of the facility, handling operations, and shortcomings follows.

The building was not constructed originally for use as a shell egg-packing facility but was converted to that use sometime later. A partition divided the operational section of the building lengthwise into two primary areas each 19 feet wide (fig. 1). The egg-washing operations occupied one section and egg-grading and packaging operations the other. Storage areas consisted of a room for packaging materials and a small cooler for packed eggs ready to be shipped.

The receiving and loading platforms were too narrow and lacked sufficient maneuvering space. Each one measured 29 by 8 feet, with two narrow doors that swung outward and had to be opened prior to positioning a truck. Since the platforms were lower than the height of most truck beds, a metal ramp had to be used to compensate for the differences (fig. 2). The narrow width of the platforms did not provide enough space for either unloading incoming eggs or loading the outgoing product.

Figure 2.—A portable ramp used for receiving and shipping eggs in the old plant.

Overall, the plant was too small and poorly arranged. The quantity of product handled exceeded the capacity of the plant, resulting in inefficiency, congestion, and poor working conditions. There was also the possibility of product quality being affected because limited space made it impossible to hold most of the eggs at optimum temperatures.

The lack of a cooler for holding incoming eggs reduced the plant's flexibility during equipment breakdowns, bad weather, and overproduction. Furthermore, it did not allow for maintaining a sufficient quantity of eggs at the plant in the event of a supply interruption.

Racks of eggs were unloaded from trucks and held in a portion of the washing area (fig. 3). When the area was full, remaining racks of eggs had to be held near the washing operation where the temperature was much higher than the prescribed 60° F maximum for holding incoming eggs. The racks of eggs created congestion in the washing area, as did empty racks that were waiting to be returned to the farms. Since no rack storage area was available, empty racks were intermingled with the full ones. Because of inadequate floorspace, the egg-packing equipment was positioned too near the walls and restricted the passageway for servicing, adjusting, and cleaning the machinery.

A wall separating the egg-washing and egg-grading and packing operations made communication and supervision difficult. A doorway between the two areas was usually obstructed by egg racks so that anyone wanting to pass from one operating area to another had to use a circuitous route through the package storage area.

The packing area was long and too narrow, which prevented employees from moving freely about the grading and packing machine because of limited space. Bundles of cartons stored along the wall in back of the packing station severely restricted the aisle space next to the carton-packing operations. Bundles of cartons had to be hand-carried to the egg-packing stations because the narrow passageway did not permit use of a handtruck when the operators were packing cartons.

The packaging materials storage area lacked sufficient capacity to accomodate the packing operation. Additionally, some space was utilized to provide a main

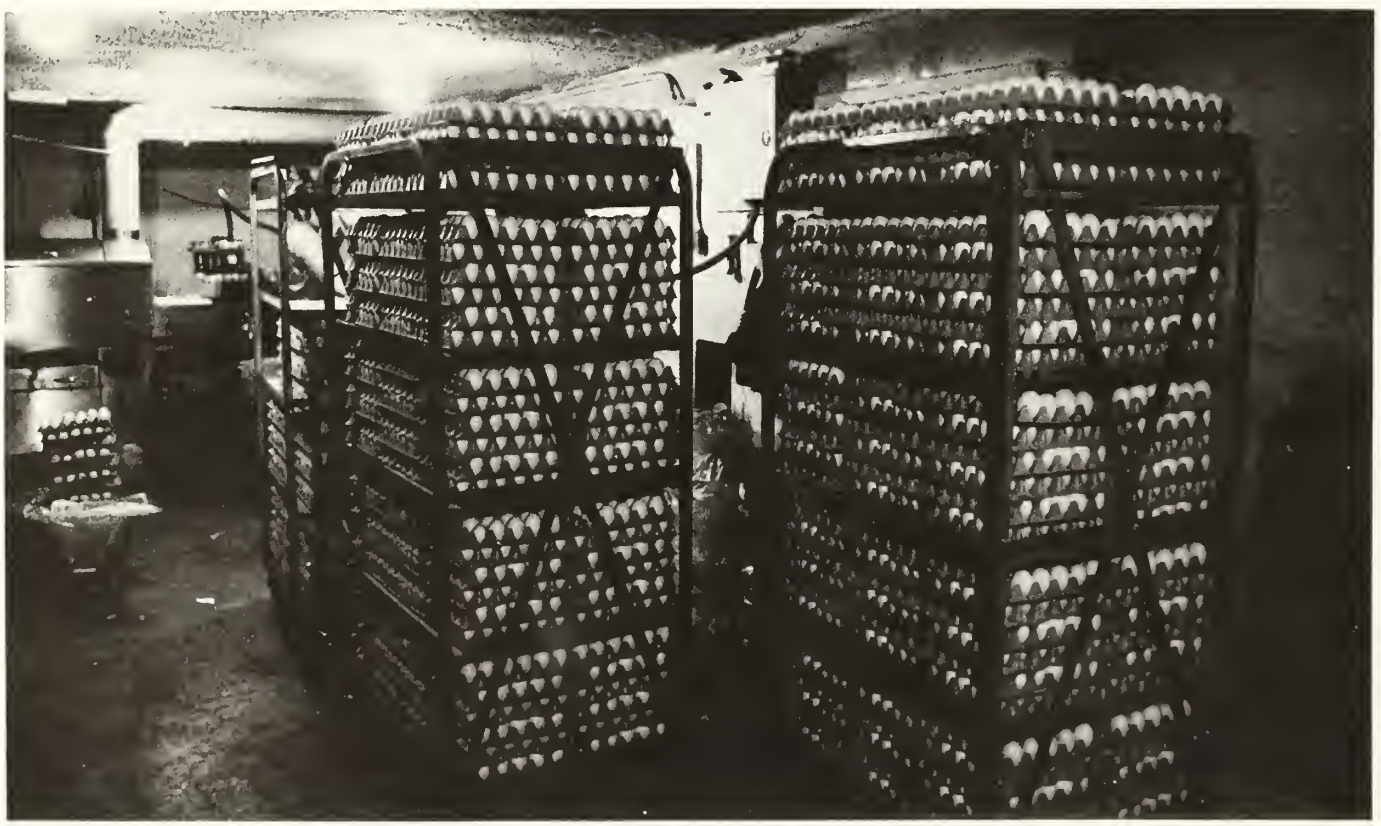

Figure 3.—Racks for receiving incoming eggs.

passageway from the truck-unloading and egg-washing operations to the packing area.

Egg cases had to be formed and stored temporarily in the carton-casing area. Although the cases were convenient to the casing operation, they added to the congestion of the area (fig. 4). At times the passageway was completely obstructed by empty cases.

The cooler for eggs that had been sized, graded, and packed was inadequate (fig. 5). When the cooler was full, all remaining eggs had to be held temporarily in the packing area, which added to the congestion. More importantly, eggs not placed in the cooler were subject to loss of quality after the grade had been established and the product labeled. Lack of cooler capacity also made it difficult to rotate inventory, which could adversely affect quality.

No space was available to assemble orders for delivery to various store customers. The shipping platform designed similarly to the receiving platform was entirely too small and served primarily as a passageway for access to the trucks when they were being loaded. Sorting and selection of cased eggs had to be done within the cooler and the packing area, which interfered with the other ongoing operations.

The layout of the plant made it necessary for employees to pass through the offices to reach their work stations. No designated areas were available for lunching or relaxing which forced employees to use offices and the salesroom. Although restrooms were convenient to the packing operations, they were too small. Lockers were not provided for employees' personal belongings, nor was there adequate space for changing to and from work clothing.

Safety of the workers was also compromised by lack of a direct exit from the packing area where most of the workers were assigned. A small gas-fired boiler located in the packaging material room next to highly flammable packaging material made escape hazardous by way of that area. Alternative exits were through the of-

Figure 4.—The congested casing area.

fices and salesroom at the front of the plant and the refrigerated cooler to the truck-loading platform. The latter route was often partially obstructed with cases of eggs.

Another hazard was the receiving operation that necessitated using a narrow ramp for unloading trucks. Racks of eggs moving down the ramp endangered a person attempting to control the speed of descent by standing in front of the rack.

The design and construction of the building made it impossible to add a second floor above the operating area to store packaging material. Moreover, the plant site was too small to permit the building to be enlarged to provide more space and improve the layout design, or to enlarge the area for maneuvering trucks and parking employees' automobiles.

The ceiling height of the building restricted the volume of packaging material that could be stored, placed restraints on the effectiveness of heating and cooling processes, and limited the effectiveness and use of some of the equipment or the introduction of more efficient types. The low ceiling height in the cooler restricted the circulation of air among the cases of eggs and made it necessary to stack many eggs by hand to fully utilize the limited space.

Overall, the building was not designed for the volume of eggs being handled nor for the kinds of equipment being used. Although an effort was made to conduct a modern operation in the outdated facility, management could no longer tolerate built-in inefficiencies and product quality sacrifices in a highly competitive business. The decision was therefore made to abandon the plant and construct a new one.

New Plant

Shell egg-packing operations formerly conducted in the old plant were relocated to a new building at another site. The new building provides space for handling a much greater volume of eggs than was formerly possible.

Figure 5.—Cased eggs being moved into cooler.

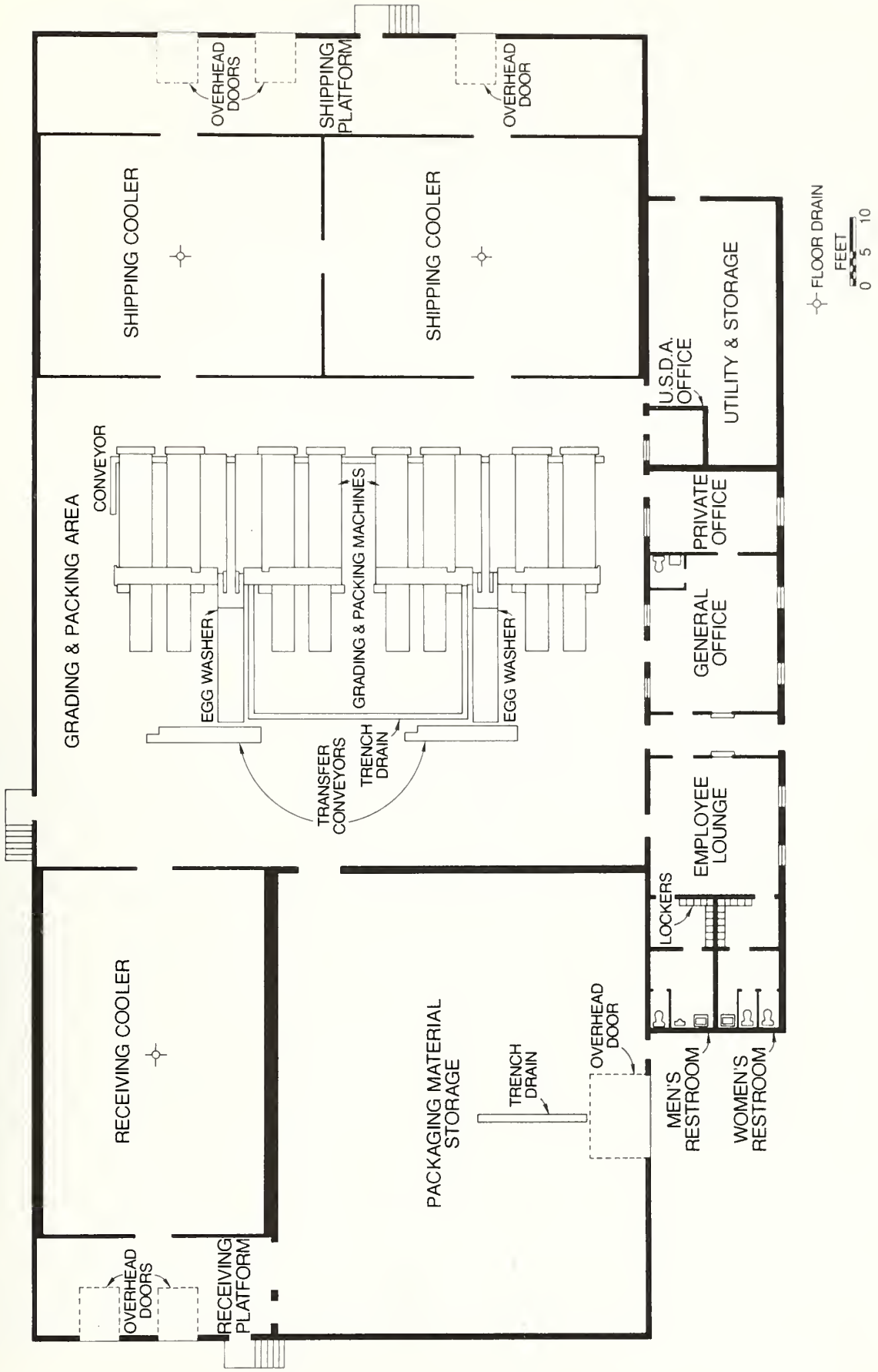

Figure 6.—Layout of the new plant.

The building is a preengineered steel structure with an attached section for auxiliary functions faced with stone. Side walls of the main structure are 14 feet high, and the roof is designed with a two-way slope of 1 inch in 12 inches. The floor at the front of the building is at ground level, and on the other three sides it is designed at truckbed height by excavating and using natural land contours. (For facility cost information, see appendix.)

The plant layout utilizes a modular concept[4] to permit expanding later at minimal cost and with least interruption to ongoing operations. It also allows for a straight-through flow of products and materials.

Essentially, the building is divided into three operational sections (fig. 6). One is for storage of incoming eggs, comprised of a cooler for receiving eggs and dry storage for packaging material. The center section is used for grading and packing activities. The third one contains two shipping coolers for eggs that have been packed.

The enclosed receiving platform for incoming eggs is 35 feet by 14 feet with two overhead doors where trucks are positioned for unloading. This platform serves both the cooler and the adjoining packaging material storage area.

The receiving cooler has a floor curb to prevent wall damage by pallets or racks. A drain in the center of the area permits washing the floor periodically to maintain sanitation.

The firm modified the packaging material storage area of the USDA-developed layout by including an overhead door. This feature was added to permit garaging overnight a delivery truck loaded with eggs to protect the product from freezing weather. Installation of a trench floor drain was necessary to prevent moisture that drips from a truck from accumulating on the floor. The availability of sufficient space for entry of a truck depends upon the inventory of packaging material. Realistically, the garaging feature will seldom be used.

[4]Goble, J. W., "A Modular Shell Egg Grading and Packing Plant," U.S. Department of Agriculture, Marketing Research Report 1050, March 1976.

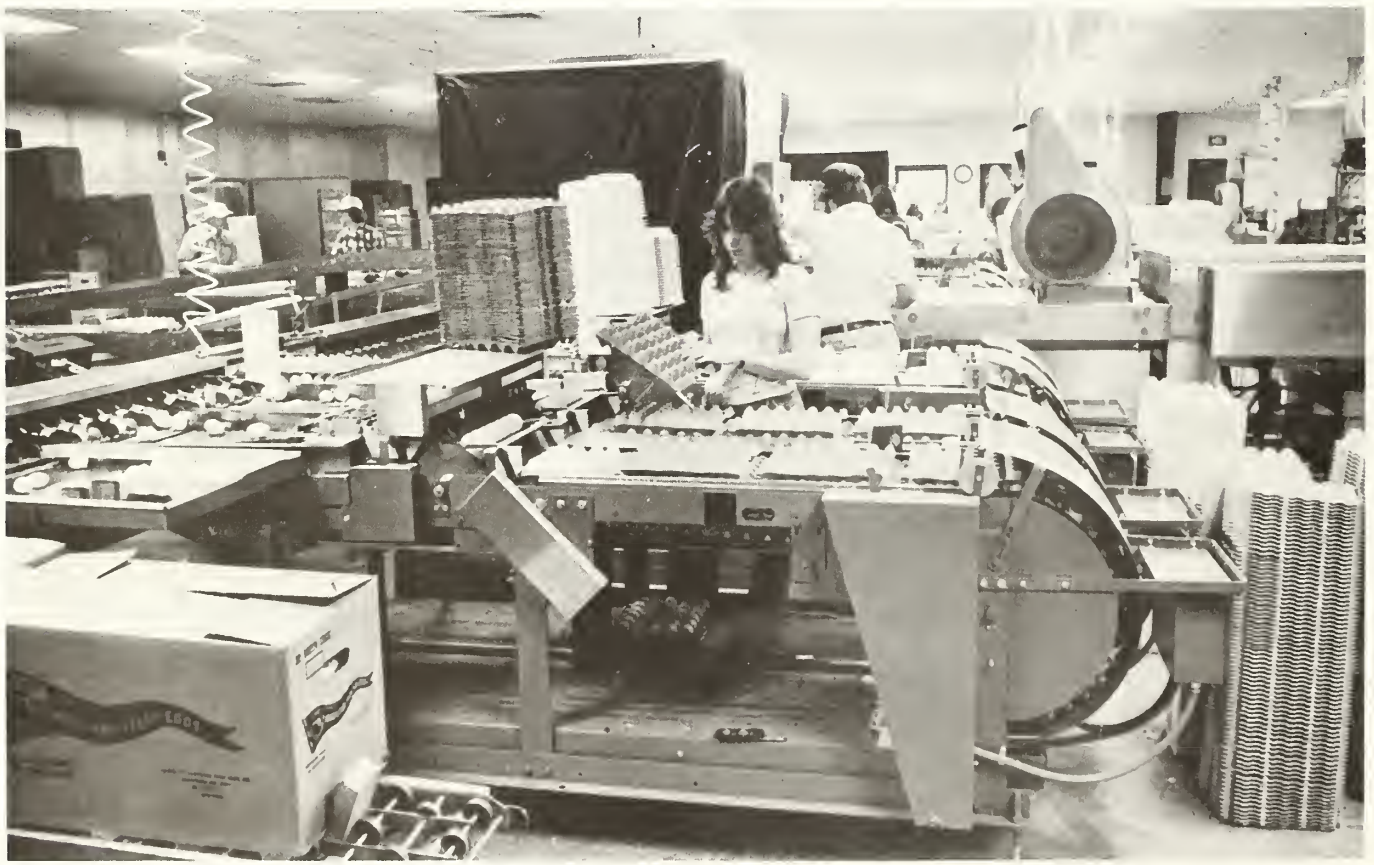

Figure 7.—Egg-packing machines.

Ideally, a separate building should be used for garaging trucks during weather emergencies and for performing routine maintenance and cleaning of vehicles.

The shell egg-packing area is adequate for operating two egg-packing machines (fig. 7). A "U"-shaped trench floor drain permits waste water from the egg washers to be discharged directly into it. A doorway in the outside wall of the packing area serves as an emergency exit for employees and a passageway for removing trash.

The two shipping coolers are constructed with walls of preengineered insulated panels. Floor curbs prevent the walls from being damaged by handling equipment. Biparting doors allow passage between the two coolers, and another door in each cooler provides access to the adjoining shipping platform.

The shipping platform extending the full width of the building is 46 inches high to accomodate most trucks. Dock levelers compensate for any difference that may exist between the platform height and the trucks. Three 8-foot-wide overhead doorways, two of which are equipped with seals, make it possible to load three trucks simultaneously (fig. 8). Since the platform is cooled somewhat by refrigerated air escaping from the coolers when pallets of eggs are being moved out, the platform door seals prevent the air from escaping while eggs are being loaded on the trucks.

The auxiliary plant areas are grouped in a section adjoining the primary structure. These include offices, employee facilities, a utility and storage area for shop tools, supplies, the boiler, and electrical panels. A central hallway provides employee access from outside the plant to the various auxiliary and production areas.

Incoming truckloads of eggs and packaging materials are unloaded on the enclosed receiving platform (fig. 9). Most of the eggs are received on racks, as in the old plant, and moved manually into the adjoining receiving cooler. Eggs received in 30-dozen cases are manually unloaded from the trucks, placed on pallets, and moved with a pallet transporter into the same cooler where racks of eggs are held. Likewise, truckloads of packaging materials are received and palletized on the same platform where eggs are unloaded and then transported to the adjoining packaging material storage area.

Figure 8.—Three shipping doors, two with seals, at the new plant.

Racks of shell eggs are moved manually from the receiving cooler to the packing area, where they are positioned near the transfer conveyor of the grading and packing machine. After the eggs have been manually transferred from the racks, the empty racks are returned to the cooler and held temporarily until trucked to an egg production farm for reloading.

The eggs are automatically cartoned after they have passed through the grading and sizing machines, then cased and palletized and moved with a pallet transporter to one of the two shipping coolers. One of the shipping coolers can be used for eggs having a short turnover time. The second one is useful for longer term storage during times of reduced sales or when the firm wants to accumulate a supply of eggs as part of its marketing strategy to meet anticipated peak demands or higher prices. When eggs are held beyond a plant's normal turnover time, optimum humidity and temperature levels are essential to maintaining the quality. This is difficult to achieve with only one cooler where doors are opened frequently as eggs are moved in and out.

The plant was designed to move graded eggs from the cooler on pallets to the shipping platform for loading into trucks. In actual practice, the firm used both handtrucks and pallets.

In developing a layout design for a new plant operation, the costs of the building and essential equipment are major components of total operating costs. For purposes of this study, however, the cost of labor to operate the plant was isolated as a major element of operational efficiency and used as one of several criteria to evaluate the adequacy of the layout.

Labor costs for most operations in the plants were based on time studies. An adjustment of 15 percent was added to all timed operations to allow for personal needs of the operator, fatigue, and a limited amount of unavoidable delays.

The exceptions to this were operations performed internal to the egg-packing line itself. Since those operations were controlled entirely by the speed of the machinery rather than the speed of the operator, time studies were not used. Costs of those operations were calculated by dividing total worker-hours expended by the actual output of the packing line over a given period of time. A 10-percent adjustment was added to allow for personal needs of the operators.

An average wage rate of $4 per hour was used for both the old and the new plants. This was done to offset effects of inflation and thereby allow a more meaningful comparison of the two plants.

Figure 9.—Receiving doors at the new plant.

Table 1.—Comparison of labor requirements for two plants[1]

Operation	Old plant	New plant
	Worker-min/case[2]	Worker-min/case[2]
Unload supplies at warehouse, move to storage	0.060	N.A.
Drive to warehouse, load supplies on truck, transport to plant	.078	N.A.
Unload supplies at plant, move to storage stack	.054	.069
Unload full shell egg racks from truck, move to storage, load empty racks	.172	.123
Make up egg cases, move to end of packing line	N.A.	.342
Unload returned empty cases from truck, move to end of packing line, add new cases as needed	.139	N.A.
Egg-grading and packing line	6.900[3]	5.750[4]
Label full case, stack on pallet, move full pallet to shipping cooler	N.A.	.340
Label full case, move to shipping cooler using two-wheel handtruck	.414	N.A.
Assemble orders, load full cases of eggs onto truck	.720	.604
Total	8.537	7.228

N.A. = Not applicable [1]A 15-percent allowance included for personal needs, fatigue, and unavailable delays.

[2]Based on 30-dozen-case equivalents. [3]Based on 8.6 employees. [4]Based on 7.5 employees.

Although various sizes and types of cases were packed in both plants, it was decided to base labor costs on a 30-dozen-size case of eggs. This size case made up the majority of the output in both the old and new plants. The authors determined that it would not be economically feasible to calculate costs for the various other cases and packages that were used. Furthermore, this would distort the comparison between the two plants.

Plant cleanup costs were not considered because they were minimal and also were approximately the same per unit of output for both plants. Some of the major differences between the two plant operations should be noted. First, the old plant utilized some collapsible, returnable egg cases, while the new plant used one-way cases. This causes some minor differences in labor cost (see table 1), since the one-way case must be assembled with a stapling machine, while the returnable case requires extra handling in order to get it back from the store and into the plant. This study did not consider differences in the purchase cost of the two types of cases.

At the old plant, packaging supplies were usually unloaded at a remote warehouse for temporary storage. When needed, a truck was dispatched from the plant to the warehouse to pick up essential supplies and bring them to the plant. This extra handling was unnecessary in the new plant because it has adequate storage space.

Other factors contributing to differences in labor costs were: (1) the need to use ramps for loading and unloading trucks at the old plant and the availability of loading docks at the new plant; (2) increased internal movement distances in the new plant because of its larger size; (3) the higher capacity of the new packing line; and (4) less congestion.

Table 1 shows that 8.537 worker-minutes of labor per case were required at the old plant compared to 7.228 worker-minutes in the new plant, representing an 18-percent increase in productivity. Output increased from 7.03 to 8.30 cases per worker-hour. Based on an average wage rate of $4 per hour, the labor costs were $.569 per case and $.482 per case or 9 cents a case less in the new plant. Savings achieved in this plant should not be interpreted as the maximum attainable with this plant layout design.

For this firm, the labor savings achieved in the new plant will approximate $32,000 annually compared with the old facility.

Conclusions

The objective of this study was to assess the adequacy of USDA planning concepts that were incorporated in the layout design of a new shell egg-packing plant that was evaluated. Data suggest that criteria essential to planning a satisfactory layout have been satisfied and operational savings are achievable. Adequate space is provided for all the operations; however, the space between the loading conveyor of the egg-grading machines and the receiving cooler wall may be somewhat generous.

Each operational area of the plant can be expanded outward without encountering obstructions or limitations imposed by the existing structure. Consequently, the layout permits future expansion of the facility at minimal cost and with least disruption to the ongoing operation.

Very importantly, the safety and welfare of employees have been considered. An attractive and functional area is provided for lunching and relaxing during work breaks. Access to the restrooms from the lunch area is convenient for employees and avoids direct entry from the plant operational areas, to assure sanitation. A door in the outside wall of the egg-packing room provides a direct escape route for workers in case of an emergency that might threaten personal safety.

A straight flow of products through the plant contributes significantly to efficiency. Backtracking that would otherwise increase the time required for moving products is eliminated.

The plant is designed for ease of maintaining sanitation. All floors are smooth with sufficient slope to floor drains. Trench drains are utilized in the packing area for maximum effectiveness.

Coolers are adequate for maintaining product quality. Two shipping coolers are provided for eggs that have been packed. One can be used for longer term storage under more controlled conditions than is possible in the other cooler, where eggs are moved in and out frequently.

At present, the firm monitors egg quality using a makeshift arrangement located in the office originally intended for a U.S. Department of Agriculture resident grader. When the plant begins operating under the USDA voluntary shell egg-grading program, other provisions will have to be made for periodically examining the quality of eggs. Preferably, the firm should install a candling booth near the entrance to the shipping cooler to facilitate examining the eggs for quality as they come from the packing line, as well as after cooling.

The plant is designed to use modern materials-handling equipment. Packaging material can be unloaded, transported, and stored on pallets, although the plant is continuing to use two-wheel handtrucks which are not labor efficient in such a large operation. However, pallets are used for transporting and storing cased eggs.

All operations are confined to one building since adequate storage space is provided. This contrasts with the old plant where a supply of packaging material had to be stored in a warehouse several miles away.

The loading and unloading platforms are enclosed to protect the products from the deleterious effects of weather. Sufficient space is provided for maneuvering racks and pallets of products and supplies. Dock levelers are available to compensate for differences between the heights of trucks and the platform, but manual dock plates could have been substituted for the mechanical levelers if a firm wanted to avoid the additional costs.

The overall design of the plant enhances ease of supervision. Since a majority of the employees are involved in the packing operations, most of the work force is highly visible from the office as they perform their individual tasks.

In evaluating a plant layout, one must keep in mind that the management of a firm plays an important part. Poor management can offset many intrinsic benefits of sound layout planning.

Building and Equipment Costs

Total cost of the new facility completed in 1979 was $410,000. This included site preparation, the building with all interior walls, plumbing and heating, electrical work, sprinkler system, overhead doors, dock levelers, refrigeration equipment, and insulation. Excluded from this cost were materials-handling equipment, egg-grading and handling equipment, and land acquisition costs. Based on approximately 20,000 square feet of floorspace, the cost per square foot was $20.50.

Included in the total cost was $86,000 for refrigeration equipment plus the prefabricated walls and ceilings of the egg storage cooler and the two shipping coolers. For other plants, refrigeration costs could vary considerably depending on plant location, cooler size, and the designed capacity of the refrigeration equipment.

As stated previously, the studied plant utilized two egg-packing lines. The installed cost of the equipment was $125,000 per line. This covered all egg-handling and grading equipment, including the egg washers, sizers, and packers. The designed capacity of this equipment is 100 cases per hour per line, but the actual output averages approximately 90 cases per hour per line. Peripheral materials-handling equipment is not included in this discussion because the type used can vary greatly depending on management preferences. A firm has many options when building and equipping a plant that will consequently affect the total cost of the facility and its operating efficiency.

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