A MODULAR SHELL EGG GRADING AND PACKING PLANT

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PREFACE

This report describes the layout and operating methods for an 80-case-per-hour shell egg grading and packing plant and shows how it can be expanded to double the output with minimum structural changes and least interruption to the operations.

Appreciation is expressed to processing equipment companies and construction firms that furnished data on dimensions, installations, operations, and costs for the building and equipment and to the shell egg packing firm that made its facilities available for study. Appreciation is also expressed to Raymond H. Greenfield, National Supervisor for Shell Eggs, Poultry Division, Agricultural Marketing Service, U.S. Department of Agriculture, for his technical contribution in developing the layouts.

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SUMMARY

A shell egg grading and packing operation with a capacity of 80 cases per hour was studied. The operation was found to be inefficient, and the cost of improving it to provide a 100-percent anticipated growth in volume was not feasible. Furthermore, the plant site severely limited the changes that would have to be made.

Plans and operating methods were developed for a new plant to be constructed in two phases on another site. The first phase provides more adequate facilities for grading and packing eggs using existing equipment more efficiently. The plant is designed so it can be expanded with minimum changes and the least disruption to ongoing operations. In the second phase of construction, the plant is enlarged by adding space without making major structural or operational changes. Plant output is doubled by adding a second grading and packing machine.

The anticipated cost of constructing a preengineered steel building is approximately $205,000, including delivery to the site, foundation, floor, insulation, and plumbing.

Benefits that could be expected include more efficient use of labor, maintenance of product quality, and expansion with minimum structural changes and little disruption to a continuing operation. Expansion of the facility to increase space 37 percent would enable a firm to double its output.

INTRODUCTION

The increasing costs of constructing and operating shell egg grading and packing plants require careful planning of new facilities. Economies of scale should be considered when deciding about the capacity of a facility. Too small a plant will not provide the efficiencies attainable in larger ones. Future growth of a firm must also be projected so that a plant can be designed to minimize costs of later expansion with least disruption to the operation. The likelihood of relocating an established shell egg packing plant to an egg production complex and integrating it into the total operation at one location must also be considered. Under these conditions the facilities and operations should be planned so they are compatible with those of production and can

handle the volume produced. Plant layout and space requirements are also affected when more efficient grading and packing equipment is used to provide greater capacity and specialized capabilities, such as automatic packing. Sufficient product volume is also necessary to justify using improved materials-handling systems to increase efficiency. These handling systems have minimum space requirements that must be considered in designing a plant.

The purpose of this report is to develop layout plans and operating methods for a shell egg packing plant that can be constructed in two phases. The first phase provides facilities for handling a given volume. The second phase shows how the facilities can be expanded to handle a 100-percent increase in volume.

A firm that was studied had decided to build a new shell egg packing plant because its existing one no longer had sufficient capacity to handle efficiently an increasing volume. A new 80-case-per-hour grading machine had been installed in an attempt to handle the increased volume. However, it was too large for the space available and caused congestion and inefficiencies that partially offset the machine's advantages. The problems of the existing plant and anticipated growth rate caused the management to decide to relocate and construct a new plant.

PRESENT OPERATION

The firm that was studied grades and packs approximately 2,500 cases of shell eggs per week or 500 cases per day. Most of the eggs handled are from flocks owned by the firm and located on several farms in different areas of the State. A cooler on each farm provides temporary storage for the eggs until they are picked up by trucks from the central processing plant, usually twice a week. The farm coolers supplement the plant's inadequate storage capacity.

Grading and packing operations are conducted in a long, narrow masonry-type building located at the edge of a small town. The building lacks sufficient space for unloading, grading, packing, and loading operations and cannot be expanded because the site is too small. The installation of a new grading machine has further reduced the limited interior space available for other packing functions.

Shortcomings of the present operation are as follows:

- The platform is too small.

- Too small a cooler for holding incoming ungraded eggs necessitates temporarily storing eggs on the platform and in the washing area.

- Inadequate space for grading and packing operations results in congestion and inefficiency.

- A load-bearing wall between the egg washing and grading operations necessitates connecting the machines with a conveyor that extends through a wall opening.

- The cooler for graded eggs is inadequate.

- Arrangement of equipment is inconvenient for employees and supervisors.

- Modern materials-handling equipment cannot be used effectively because of the plant layout and limited space.

- An employees' welfare area is not provided.

- Major and costly modifications would be necessary to efficiently handle a greater volume of eggs because of the building design.

PROPOSED PLANT

In the first phase, the proposed plant is designed to handle an output of 80 cases per hour using one machine with automatic packers. In the second construction phase, the facility can be expanded and a second grading and packing machine installed to double the output.

Building Design and Construction

The building is a preengineered steel structure designed in units (fig. 1), although other building materials would also be satisfactory. The central section is 90 by 70 feet with 14-foot-high sidewalls. The roof is doubled pitched and slopes 4 inches per foot. One section adjoining the side is 50 by 40 feet with a single sloping roof and a 12-foot-high eave. The section adjoining the other side is of the same dimensions. Another section extending partially across the front of the building is 100 by 20 feet with a single sloping roof and an eave height of 10 feet. All these roofs have a pitch of one-half inch per foot.

The floor of the plant and the platforms are constructed at ground level with truck ramps next to the platforms (fig. 2).

The main part of the building contains the processing and packaging material storage areas. The sections on opposite sides of this main part provide refrigerated storage.

Auxiliary areas consisting of offices, employee facilities, and a shop extend across the front of the building.

Layout and Operating Procedures

Receiving Area

The receiving platform is 50 by 14 feet. Since the building is constructed at ground level, the ramp in front of the platform allows unloading at truckbed height. A storm drain at the lower end of the ramp removes surface water that would otherwise accumulate. The enclosed platform with door seals

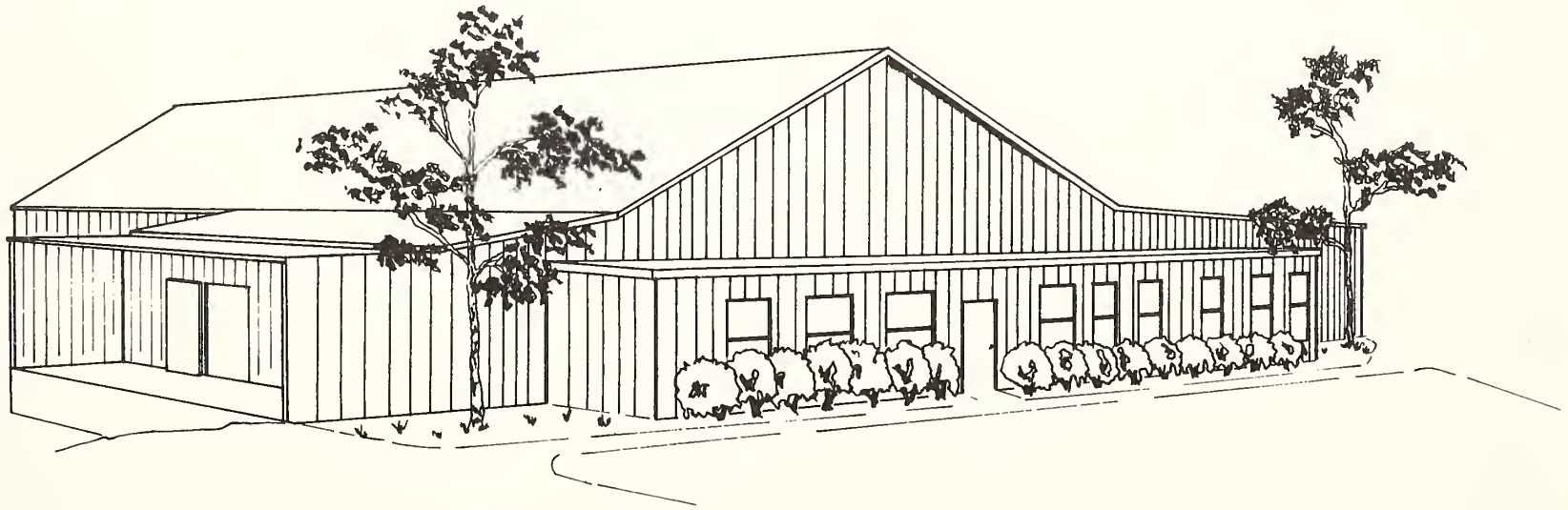


Figure 1.--Perspective of a shell egg grading and packing plant.

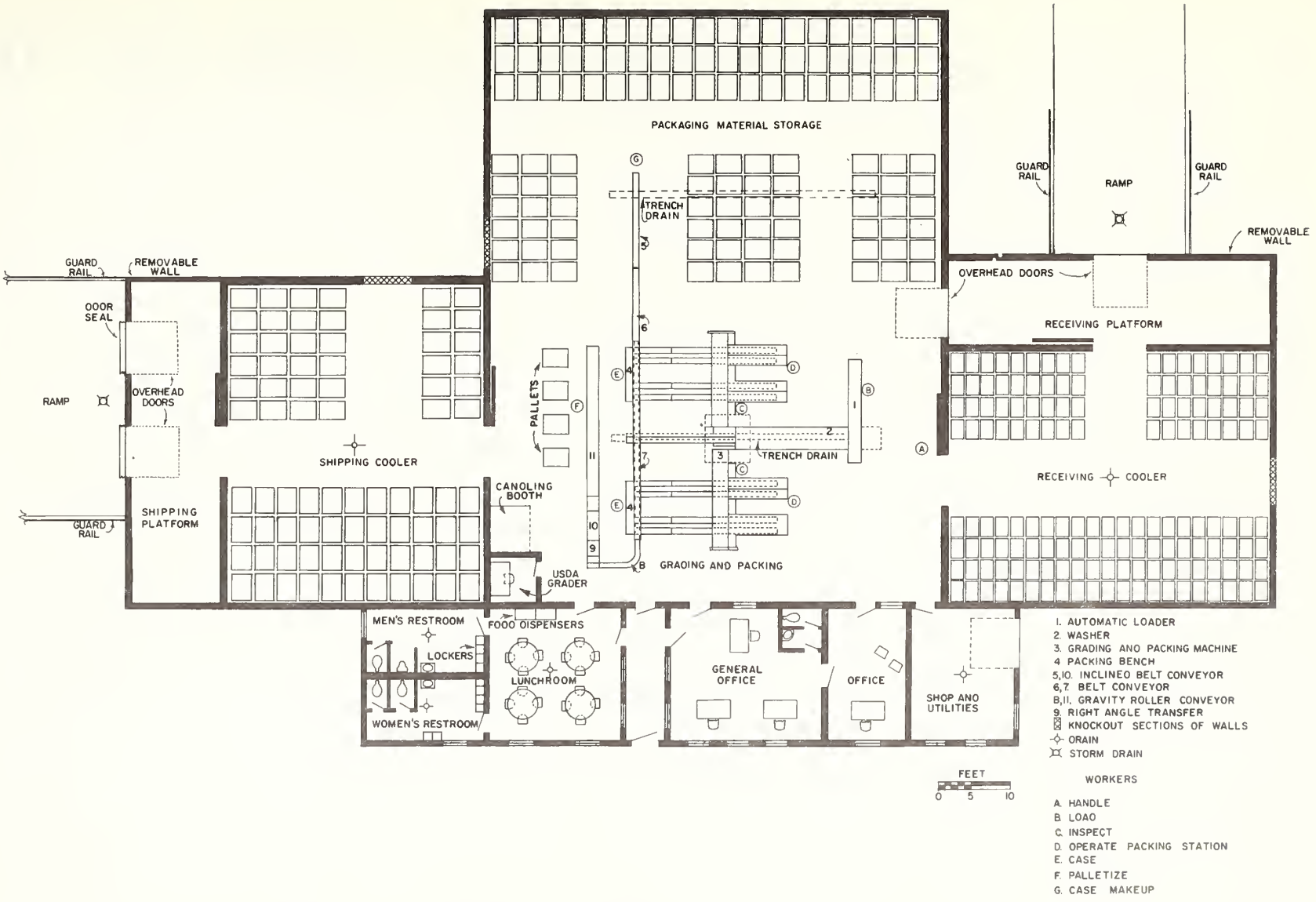


Figure 2.--Layout of a shell egg grading and packing plant.

protects unloading operations from inclement weather and aids in controlling temperatures to maintain product quality.

Ungraded eggs are received on movable metal racks with castors. The racks, which are 3 by 2 feet with 5 shelves, hold 450 dozen eggs on filler flats. The racks of eggs are moved manually from the trucks onto the platform and then to the receiving cooler. The platform is also used for receiving packaging material unloaded from trucks onto pallets and moved to dry storage with a pallet transporter.

Storage Area

The storage area consists of refrigerated (coolers) and nonrefrigerated space. The space requirements for storing eggs and packaging material are shown in table 1.

Refrigerated Storage.--A receiving cooler is provided for holding eggs that are to be graded and packed and a shipping cooler for holding eggs after they have been graded and packed.

Separate coolers enable a firm to maintain the optimum temperatures for each product. Thermal checking caused by excessive temperature differential between the eggs and the wash water can be minimized, since the ungraded eggs can be held at a higher temperature than is essential to maintain the quality of graded eggs. Potential bacteriological problems that may otherwise occur can be avoided when washed and unwashed eggs are stored in the same cooler. Providing separate coolers also improves product flow in the plant operation.

The receiving cooler is 49 by 38 feet with a 10-foot-high ceiling. It provides space for 150 movable racks positioned to form a T-shaped aisle 8 feet wide. The insulation on the walls and ceiling is covered with a material resistant to moisture and impact damage. A floor curb 4 inches thick and 8 inches high with a sloping top protects the walls from damage by transport equipment and provides for air circulation.

Although the cooler is larger than necessary for an 80-case-per-hour packing operation, it will be adequate when the output is doubled. Constructing the cooler large enough to handle future volume avoids the need to remove a wall later to enlarge the cooler or else to build a second cooler when additional capacity is needed. However, if a firm anticipated that its volume would never exceed the capacity of an 80-case-per-hour plant, the dimensions of the cooler could be reduced.

The shipping cooler is 48 by 39 feet. It provides storage space for 2,400 cases of eggs placed on 80 pallets, each of which is 4 by 3 feet. The effective capacity is less, however, since some pallets are likely to be only partially loaded because of different brands and sizes of eggs that are packed. The aisle as in the receiving cooler is T-shaped.

Nonrefrigerated Storage.--Storage for packaging material uses approximately one-half of an area 88 by 68 feet, and grading and packing operations occupy

Table 1.--Storage space requirements for output of 80 and 160 cases per hour

Output per hour and container	Quantity	Handling equipment	Containers per handling unit	Handling units	Space occupied per handling unit	Total space needed [1]
	Number		Number	Number	Sq ft	Sq ft
80 cases						
Cases of ungraded eggs--	[2] 600	Racks---------	15	40.0	8.3	332.0
Cases of graded eggs----	[3] 1,500	Pallets-------	30	50.0	15.2	760.0
Cartons-----------------	500,000	--do----------	3,750	133.0	17.1	2,274.3
Fiber cases (30 doz)----	7,500	--do----------	350	21.4	15.2	325.2
160 cases						
Cases of ungraded eggs--	1,200	Racks---------	15	80.0	8.3	664.0
Cases of graded eggs----	3,000	Pallets-------	30	100.0	15.2	1,520.0
Cartons-----------------	500,000	--do----------	3,750	133.0	17.1	2,274.3
Fiber cases (30 doz)----	7,500	--do----------	350	21.4	15.2	325.2

1/ Does not include aisle space requirements. For derivations, see figs. 5-8 (appendix).

2/ Daily.

3/ 3-day turnover.

the other half. The floor is of concrete and slopes to two trench drains, each containing a 4-inch outlet with a deep seal trap. One drain is in the storage area and the other in the grading and packing area.

Space is provided for storing 120 pallets of packaging material 1 pallet high. To store the quantity of materials shown in table 1, some pallets might have to be placed temporarily in the aisle when a new shipment is received. However, the average inventory of packaging material maintained by a firm is an arbitrary management decision. Cases are made up in the area and transported on an inclined belt conveyor to the egg packing operation in the adjoining area.

Grading and Packing Area

The construction of the grading and packing area is similar to that of the packaging material storage area. The egg washing machine is positioned over the trench drain so that water is discharged directly into the drain rather than onto the floor.

Racks of eggs are moved manually from the receiving cooler by worker (A) and positioned next to the automatic loader (1) in the grading and packing area (fig. 2). A worker (B) removes the flats of eggs from the racks and places them on the automatic loader conveyor, from which they are transferred to the conveyor of the washer (2). The eggs pass through the washer to the grading machine (3), where two workers (C) visually inspect the eggs and remove those that do not meet U.S. standards for quality. The eggs are then automatically sized and placed in cartons. Two workers (D) operate the carton packing station. Undergrade eggs are placed manually on flats. Two workers (E) place the cartoned eggs in cases positioned on packing benches (4). Filled cases are pushed back onto a belt conveyor (7) and transported to a gravity roller conveyor (8), which directs the cases onto a right angle power transfer unit (9). This unit orients the cases to move forward sideways up an inclined belt conveyor (10) and onto a controlled pressure gravity roller conveyor (11),[1/] which accumulates the cases at a convenient working height. Cases of eggs are removed manually from the conveyor by a worker (F), who palletizes and transports them to the shipping cooler using a pallet transporter.

Pallets of cartons are transported from the package material storage area and positioned near the grading machine, where the cartons are used by worker (D). Worker (G) makes up cases. They are conveyed from the packaging material storage area on an inclined belt conveyor (5), which elevates the cases to a controlled pressure belt conveyor (6) positioned at the upper level of the bilevel conveyor and passes above the packing stations. This conveyor keeps a supply of cases convenient to each packing station. A photoelectric cell or similar sensing device near the forward end of the conveyor activates it as cases are needed.

1/ A wheel conveyor designed to reduce accumulation line pressure to that of the first case on the line. A power belt exerts only the amount of forward drive force necessary to move the load.

Worker (A) may also serve as a "floater" to assist at the various work stations when needed. Supervisory duties may also be included. Conceivably, employees (A) and (F) could also perform the duties of (G) and thus reduce from 10 to 9 the total number of employees needed.

A small office is provided for the use of a U.S. Department of Agriculture employee if the plant is operating under the voluntary USDA shell egg grading program. If not, the office can be used by the plant supervisor or else eliminated from the plans. A candling booth next to the office is used to spot check the quality of eggs as they come from the packing line. Later the quality is rechecked after the eggs have been held in refrigerated storage for a sufficient time to cool.

Containers of trash from the grading and packing operation are emptied into large portable storage receptacles located near the receiving platform and serviced periodically by a trash removal service.

Shipping Area

The shipping platform, which is 50 by 14 feet, adjoins the graded egg cooler. Since the platform is at ground level, a ramp in front of it permits loading at truckbed height as at the receiving platform. A storm drain is installed similar to the one at the lower end of the receiving platform ramp. The platform is enclosed. Seals are installed at the doors to protect loading operations during inclement weather and to control temperature so that product quality can be maintained. Empty pallets are stored at one end of the platform.

Auxiliary Areas

The auxiliary areas are in a section of the plant that is 100 by 20 feet with ceilings 10 feet high. Included are offices, employee facilities, and a maintenance shop. A central hallway provides access from outside the plant to the auxiliary and production areas.

Offices.--The general office is 23 by 20 feet. A private office, 20 by 12 feet, adjoins it. A restroom for office employees is located within the general office.

Employee Lunchroom.--The employee lunchroom is 20 feet square. The floor is of concrete covered with tile. A drain facilitates cleaning. Facilities include tables, chairs, and food and beverage dispensers.

Restrooms.--The women's and men's restrooms are 18 by 9-1/2 feet. Each room is mechanically ventilated to the outside and has self-closing doors. The number of lavatories, toilets, and other sanitary facilities required is based on guidelines prescribed by the U.S. Department of Agriculture regulations governing the inspection of eggs and egg products.2/

2/ Regulations governing the inspection of eggs and egg products. (7CFR Part 59). Agricultural Marketing Service, U.S. Dept. of Agriculture, June 30, 1975.

Plant Expansion

Provisions have been made to expand the facilities by enlarging the storage and the grading and packing areas to handle a 100-percent increase in volume (fig. 3).

A second grading and packing machine is installed similar to the existing one to increase output to 160 cases of eggs per hour or approximately 1,000 cases per day. The average inventory includes 1,200 cases of ungraded eggs and 3,000 of graded eggs assuming a 3-day turnover rate. The inventory of packaging material would not increase, since materials could be received more frequently. The amount of storage space required for the different items is shown in table 1.

To handle the additional volume of eggs from a second grading and packing machine, the original plant layout has to be altered to modify some areas.

Receiving Area

The receiving platform, which is 38 by 14 feet, is located at the side of instead of behind the receiving cooler (fig. 3). The former platform becomes a part of the storage area behind the receiving cooler.

A plant with the enlarged processing capability is likely to receive at least a part of its volume in 30-dozen fiber cases, and pallets thus become an efficient method for transporting the eggs to the grading and packing operations.

Grading and Packing Area

The existing packaging material storage area is converted to a processing area, and a second 80-case-per-hour grading and packing machine is installed. Storage for packaging material is relocated.

Storage Area

Refrigerated Storage.--Since the initial receiving cooler was constructed large enough to handle the output of the enlarged plant, no change in its dimensions is necessary. Only the outside entrance has to be relocated.

A second shipping cooler provides additional storage, which can be used for longer term storage. This cooler is 39 feet square and adjoins the existing shipping cooler and grading-packing area. Temperature and humidity can be controlled more uniformly in the second shipping cooler than is possible in the existing one, where eggs are moved in and out more frequently.

Biparting doors are installed in the passageway between the two coolers. The second cooler has a floor drain similar to the one in the existing shipping cooler.

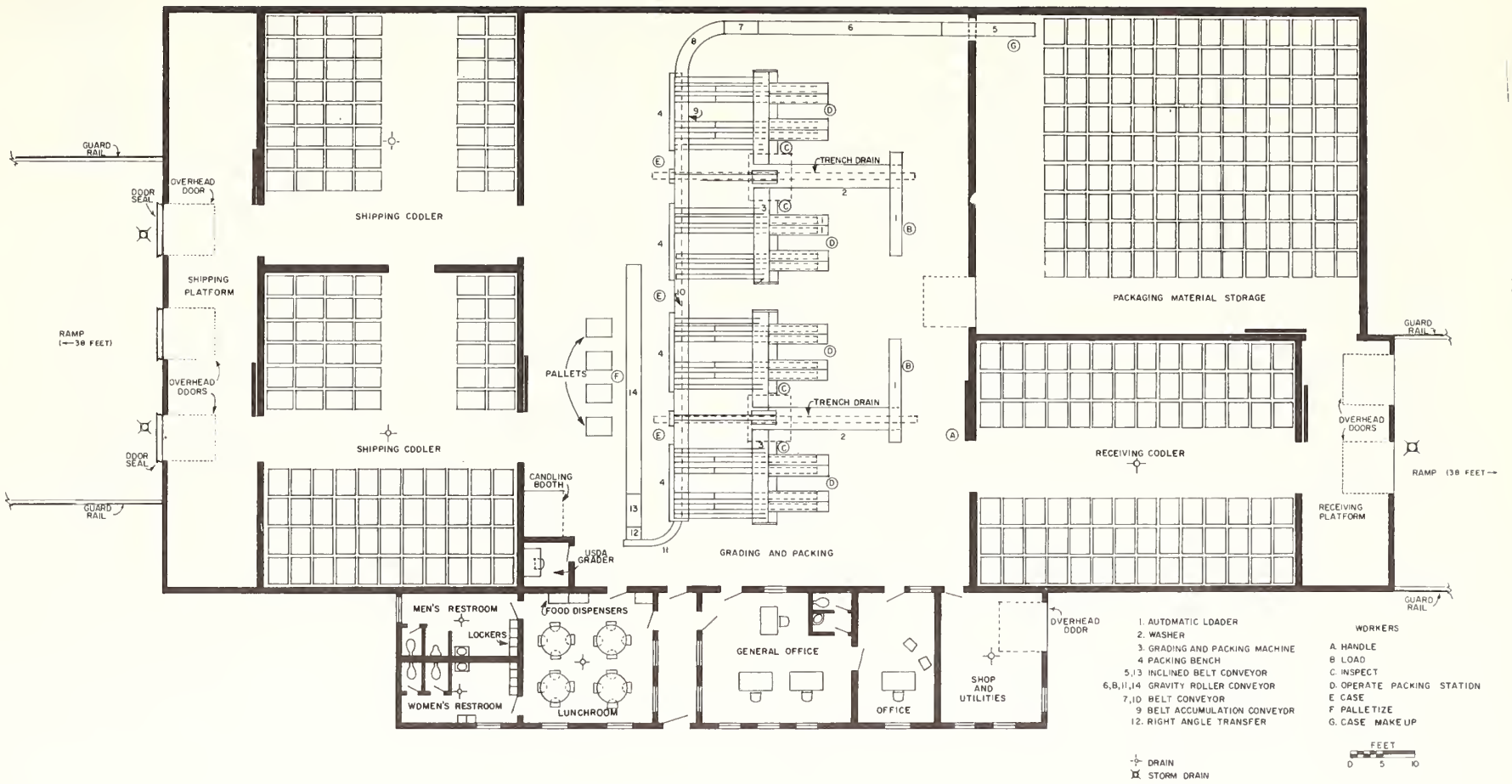


Figure 3.--Layout of an expanded shell egg grading and packing plant.

Nonrefrigerated Storage.--A new section, 59 by 49 feet, is added to the building for storing packaging material to replace the former storage area. The new section adjoins both the grading and packing area and the receiving cooler. Space is provided for 126 pallets of packaging material stacked 1 pallet high. But to handle the volume shown in table 1, some material might have to be placed temporarily in the aisle when a new supply is received. However, since the inventory is a management decision, an amount could be stored consistent with the space provided. Access from this storage area to the grading and packing area is through a doorway made by removing a knockout section of the wall.

Shipping Area

The shipping platform is extended 88 feet along the side of the second cooler. Each end of the platform is enclosed so that pallets stored temporarily on the platform are partially protected. The projecting roof of the building (not shown) serving as a canopy protects loading operations from inclement weather.

Labor Requirements

Only one additional case packer would be needed in the expanded plant, since one employee can pack 50-60 cases per hour. Thus a 100-percent increase in plant output could be achieved with only a 60-percent increase in total plant labor.

Usable Floor Space

Table 2 shows the amount of floor space available by areas for handling 80 and 160 cases of shell eggs per hour before and after expansion, respectively.

Table 2.--Usable floor space by areas for handling egg cases before and after plant expansion

Area	Before expansion (80 cases per hour)	After expansion (160 cases per hour)
	Sq ft	Sq ft
Grading and packing	3,360	6,300
Packaging material storage	2,940	3,000
Ungraded egg cooler	2,000	2,000
Graded egg cooler	2,000	3,600
Office and employee welfare	2,000	2,000
Total	12,300	16,900

Plot Plan

The plant requires approximately 2.4 acres of land. This provides adequate space for maneuvering semitrailer trucks as well as for employee parking. The building is so located on the plot that the plant operation can be expanded later by adding a second grading machine (fig. 4). A driveway behind the plant enables trucks to move from one platform to the next and still remain on the premises rather than use a public street for that purpose. Space is provided for a landscaped lawn in front of the plant offices.

Estimated Costs and Potential Benefits

The cost of 2.4 acres of land needed for a building site is estimated at $12,000 per acre. This cost could vary widely depending on whether the plant is located on an egg production farm, in a small town, or in an urban area.

A building adequate for grading and packing 80 cases of shell eggs per hour and conforming to the recommended layout (fig. 2) is estimated to cost approximately $205,000.[3/] The expanded plant would cost approximately $295,000. These estimates, made by a commercial contracting firm, include a preengineered steel building delivered and erected on the site, concrete foundation, concrete floor 4 inches thick, insulation, plumbing, floor drains, and sewer lines extending 5 feet beyond the building.

Some advantages of the shell egg grading and packing facilities described in this report are--

- A 37-percent increase in space enables the firm to handle a 100-percent increase in volume.
- Space for each operation is planned according to needs.
- Expansion to handle a doubled volume can be made with minimum structural changes and little disruption to a continuing operation.
- Flow pattern is designed to handle eggs efficiently.
- Labor can be used efficiently.
- Product quality can be maintained.
- Sanitation is facilitated.
- Provision is made for employee needs.

3/ 1975 estimates - vary according to local costs of labor and materials and expense of transporting a preengineered building from the factory to the plant site.

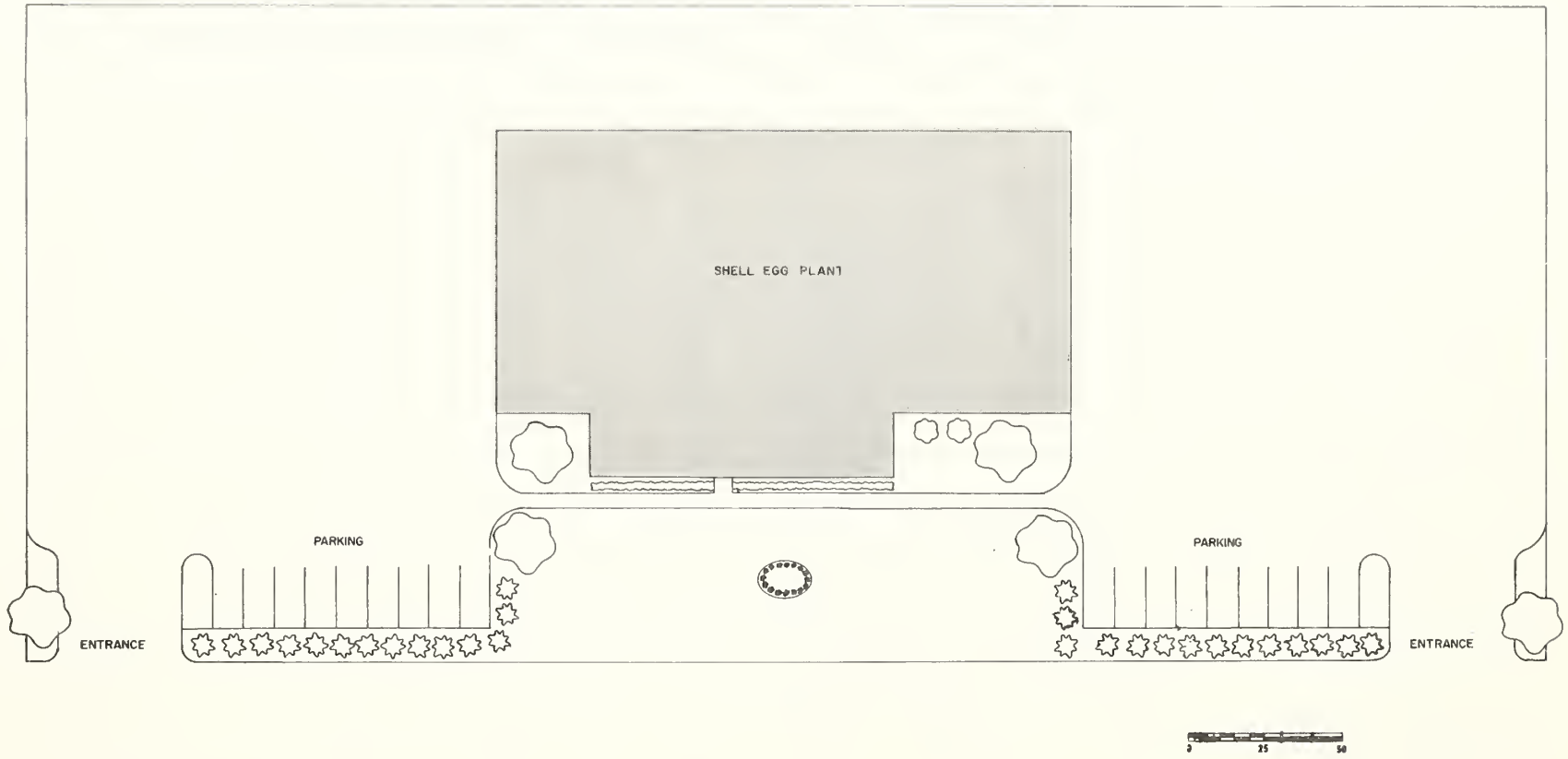
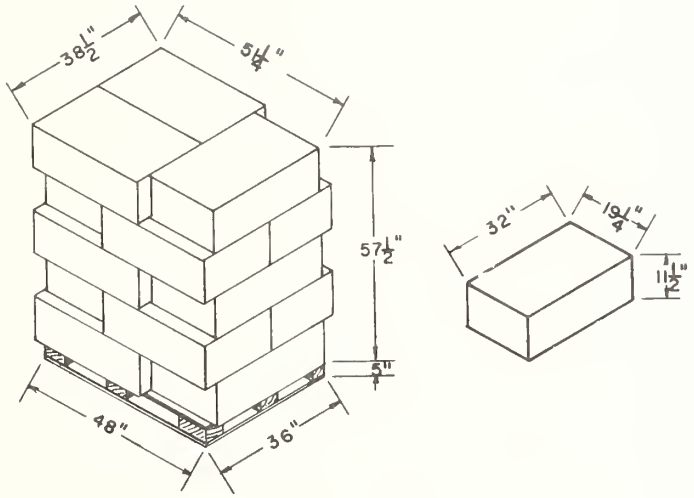


Figure 4.--Plot plan for a shell egg grading and packing plant.

APPENDIX

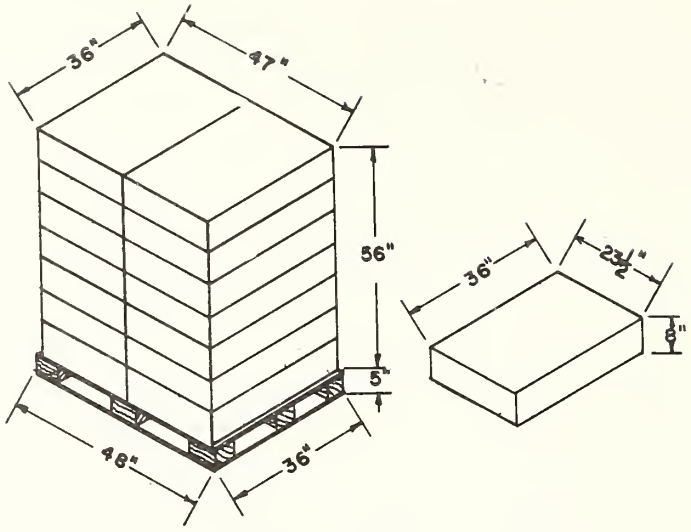


Quantity, weight, and space values:

Number cartons per bundle	250
Number bundles per tier	3
Number tiers per pallet	5
Number bundles per pallet	15
Weight cartons and pallet	488 lb
Capacity in finished goods per pallet	125 cases
Overall dimensions	51-1/4 by 38-1/2 by 62-1/2 in
Space that should be set aside for each pallet to provide clearance between lanes and irregularity in stacking includes a use factor.1/	55-1/4 by 44-1/2 in or 17.1 sq ft

1/ USE FACTOR.--The additional square feet of floorspace required to provide 6 inches of clearance between lanes of stacked materials and 2 inches of clearance at each end of the loaded pallet. This additional space allows for irregular stacking of bundles on pallets and easy in-and-out traffic for each lane with minimum hazard of collision with adjoining stacks.

Figure 5.--Stacking pattern and dimensions for palletized bundles of egg cartons (2 by 6).

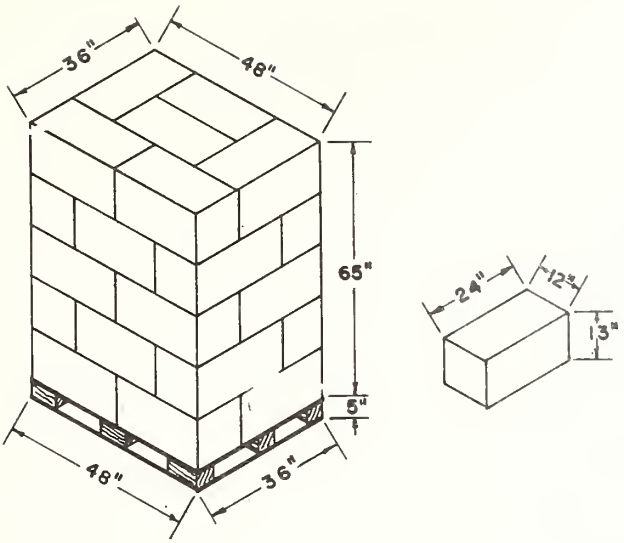


Quantity, weight, and space values:

Number cartons per bundle	25
Number bundles per tier	2
Number tiers per pallet	7
Number bundles per pallet	14
Weight full cases and pallet	580 lb
Capacity in finished goods per pallet	350 cases
Overall dimensions	48 by 36 by 61 in
Space that should be set aside for each pallet to provide clearance between lanes and irregularity in stacking includes a use factor.1/	52 by 42 in or 15.2 sq ft

1/ USE FACTOR.--The additional square feet of floorspace required to provide 6 inches of clearance between lanes of stacked materials and 2 inches of clearance at each end of the loaded pallet. This additional space allows for irregular stacking of bundles on pallets and easy in-and-out traffic for each lane with minimum hazard of collision with adjoining stacks.

Figure 6.--Stacking pattern and dimensions for palletized bundles of fiber egg cases (30 doz each).

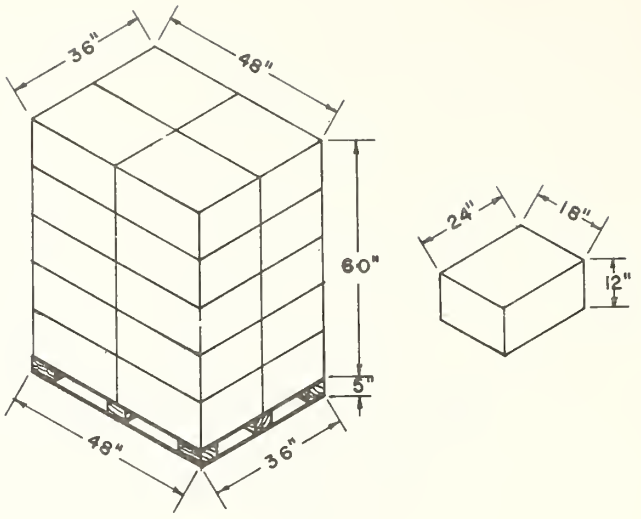


Quantity, weight, and space values:

Number cases per tier	6
Number tiers per pallet	5
Number cases per pallet	30
Weight cases and pallet	1,425 lb
Overall dimensions	48 by 36 by 70 in
Space that should be set aside for each pallet to provide clearance between lanes and irregularity in stacking includes a use factor.1/	52 by 42 in or 15.2 sq ft

1/ USE FACTOR.--The additional square feet of floorspace required to provide 6 inches of clearance between lanes of stacked materials and 2 inches of clearance at each end of the loaded pallet. This additional space allows for irregular stacking of bundles on pallets and easy in-and-out traffic for each lane with minimum hazard of collision with adjoining stacks.

Figure 7.--Stacking pattern and dimensions for palletized fiber cases full of eggs (30 doz each).



Quantity, weight, and space values:

Number filler flats per bundle	140
Number bundles per tier	4
Number tiers per pallet	5
Number bundles per pallet	20
Weight filler flats and pallet	475 lb
Capacity in finished goods per pallet	200 cases
Overall dimensions	48 by 36 by 65 in
Space that should be set aside for each pallet to provide clearance between lanes and irregularity in stacking includes a use factor.1/	52 by 42 in or 15.2 sq ft

1/ USE FACTOR.--The additional square feet of floorspace required to provide 6 inches of clearance between lanes of stacked materials and 2 inches of clearance at each end of the loaded pallet. This additional space allows for irregular stacking of bundles on pallets and easy in-and-out traffic for each lane with minimum hazard of collision with adjoining stacks.

Figure 8.--Stacking pattern and dimensions for palletized bundles of filler flats (5 by 6).

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