Guidelines for Establishing and Operating Broiler Processing Plants

The broiler processing industry is changing so rapidly that a handbook of operating guidelines would be useful in helping to solve day-to-day problems and in decisionmaking.

In this handbook the physical and chemical characteristics of broilers and the related effects of processing are discussed. Important considerations that should be observed in the layout, design, construction of facilities, and installation of equipment are stressed. Operating procedures and commonly occurring problems are described. Plant sanitation and maintenance of product quality are emphasized, with detailed information on laboratory procedures to control microbes.

Although the publication is oriented to broiler processing, much of the information is also applicable to processing other classes of poultry.

This handbook has several purposes. For plant managers, it provides a checklist for the many components of an overall processing complex. Administrative personnel, especially those from nonrelated areas of specialization, will find the information useful in becoming familiar with the nature and complexities of poultry processing. Teachers can use it in preparing students for jobs in the poultry industry or related fields. Lastly, it is expected that this handbook will be a useful reference for government regulatory agencies.

KEYWORDS: Broiler processing, food processing, plant layout, plant operations, processing, processing guidelines, processing methods, processing problems, quality control.
Guidelines for Establishing and Operating Broiler Processing Plants

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Mention of commercial products and organizations in this publication is solely
to provide specific information. It does not constitute endorsement by the U.S.
Department of Agriculture over other products and organizations not mentioned.
Guidelines for Establishing and Operating Broiler Processing Plants

by A. W. Brant, J. W. Goble, J. A. Hamann, C. J. Wabeck, and R. E. Walters

The poultry processing industry is rapidly changing, with modernization having begun since World War II. Although on-line eviscerating had already been developed, it was not widely accepted until the late 1940's. With the adoption of mandatory inspection for wholesomeness by the U.S. Department of Agriculture in 1959 for interstate shipments of poultry, on-line evisceration rapidly became a general practice in the United States. After passage of the Wholesome Poultry Act of 1969, which extended federally supervised inspection to all poultry processors, only small operators who produced and processed limited numbers of birds were exempted.

Processing of poultry beyond the eviscerated whole birds began with cutting birds into parts because of bruises, discolorations, broken bones, or other imperfections that had to be trimmed. With consumer acceptance of "parts," further processing became a general practice. Not long afterward, precooked frozen meals (commonly called "TV dinners") appeared. Although canned chicken soups and poultry meat had been available for many years, they seemingly did not serve as an opening wedge for the introduction of additional processed poultry food items.

These changes in product forms have been accompanied by equally rapid changes in facilities, equipment, procedures, and supplies used by processing plants. Government regulations affecting the industry have also brought about other changes and created complexities not previously anticipated. In addition to regulations promulgated by the U.S. Department of Agriculture, there are those enforced by the U.S. Environmental Protection Agency and the Occupational Safety and Health Administration that are applicable to the poultry industry.

The various changes have caused industry to request that standards be developed for equipment and processes to alleviate uncertainties encountered by plant operators when new equipment was installed or different operating procedures were adopted. Investigations revealed, however, that processors' concerns were not limited to equipment and processing standards. Rather, a handbook of operating guidelines, which incorporated a gamut of standards, was apparently needed as a basic reference to help avoid or minimize day-to-day problems. Likewise, it would be useful for decisionmaking as changes become necessary.

Although there is much similarity in the processing procedures for the different classes of poultry (i.e., broilers, fowl, turkeys, ducks, geese), there are also distinct differences. Because of these differences and the widespread interest in broiler processing, this publication is directed primarily to the broiler industry. The physical and chemical characteristics of broilers and the related effects of processing are identified. Important considerations are emphasized that should be observed in the design, construction, layout of facilities, and arrangement and installation of equipment. Commonly occurring operating procedures and problems are also described, with emphasis on plant sanitation and product quality and maintenance.

This handbook is intended to serve several purposes. For processing plant managers, it provides a checklist for the many components of an overall operation. Administrative personnel, especially those in areas of specialization other than poultry, may find the information useful in becoming familiar with the nature and complexities of processing poultry. Students and teachers can use the information as well as processing plant personnel. Finally, it is hoped that this handbook will be a useful reference for regulatory agencies.

Composition of Broilers

The physical and chemical composition of poultry is affected by many factors, including breeding, nutrition, age, sex, size, conformation, rearing management, and state of health (23). Preceding slaughter, the length of time the birds are without feed and water, the environmental temperature, air circulation, extent of crowding, and related conditions are extremely important to the processor. With so many factors affecting composition, it is surprising that yields and chemical analyses of broilers are as uniform as they are. Yield differences from 1 to 2 percent within a class of poultry, such as 7-week-old broilers, are considered to be cause for alarm or satisfaction depending on the direction of the variation from the expected.

Physical composition and yields have become less variable because of the breeding of highly uniform stock. Primary emphasis has been on body conformation to produce a chunky, whole-body carcass with plump breast and legs. Only recently has attention been directed to evisceration and meat yields. Fortunately the conformation sought generally resulted in acceptable yields. Some attention in breeding has also been focused on genetic traits that affect yields, such as comb, head, and shank size, quantity of feathers, and back width.

Chemically, carcasses tend to be highly uniform on a fat-free basis. Muscle, skin, bone, and connective tissue without accompanying fat vary little in composition. But the relative proportion and distribution of these tissues in the various parts of the carcass can vary considerably and are important since boning poultry meat and cutting carcasses into parts have become widely practiced.

The relative quantity of fat is known to be affected by nutrition, but the effects of breeding are less clear. Selection for rapid growth and good feed conversion may have resulted in broilers that have a genetic tendency for greater fat deposition. Birds that have been affected by diseases or environmental stresses during the grow-
### Table 1.—Typical yields of broiler-fryers at various processing stages\(^1\)

<table>
<thead>
<tr>
<th>Processing stage</th>
<th>Expected loss</th>
<th>Expected yield from live weight</th>
<th>Actual yield measured in 7 plants(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood and feathers removed (slaught)</td>
<td>9.5 (%)</td>
<td>90.5 (%)</td>
<td>87.8 (%)</td>
</tr>
<tr>
<td>Head removed</td>
<td>3.9 (%)</td>
<td>86.6 (%)</td>
<td>84.6 (%)</td>
</tr>
<tr>
<td>Feet removed</td>
<td>5.1 (%)</td>
<td>81.5 (%)</td>
<td>80.5 (%)</td>
</tr>
<tr>
<td>Inedible viscera removed (dry carcass)</td>
<td>8.0 (%)</td>
<td>73.5 (%)</td>
<td>71.0 (%)</td>
</tr>
<tr>
<td>Ready to cook (chilling gain)</td>
<td>-4.0 (%)</td>
<td>77.5 (%)</td>
<td>76.4 (%)</td>
</tr>
<tr>
<td>Cooking (oven fried)</td>
<td>34.0 (%)</td>
<td>51.0 (%)</td>
<td>(\frac{2}{3}(65.8))</td>
</tr>
<tr>
<td>Cooked meat and skin (less bone)</td>
<td>31.0 (%)</td>
<td>35.0 (%)</td>
<td>(\frac{2}{3}(45.1))</td>
</tr>
</tbody>
</table>

\(^1\)Compiled from various sources.  
\(^2\)Veerkamp (30).  
\(^3\)Percent of ready-to-cook weight.

### Table 2.—Yield (with bones) and chemical composition of raw broiler-fryers (flesh and skin, minus bones)\(^1\)

<table>
<thead>
<tr>
<th>Broiler-fryer parts</th>
<th>Yield</th>
<th>Water</th>
<th>Protein</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body with neck and giblets</td>
<td>1,512 (\text{Gm})</td>
<td>100 (%)</td>
<td>66.3 (%)</td>
<td>18.3 (%)</td>
</tr>
<tr>
<td>Whole body</td>
<td>1,358 (\text{Gm})</td>
<td>90 (%)</td>
<td>66.0 (%)</td>
<td>18.6 (%)</td>
</tr>
<tr>
<td>Back</td>
<td>354 (\text{Gm})</td>
<td>23 (%)</td>
<td>58.1 (%)</td>
<td>14.1 (%)</td>
</tr>
<tr>
<td>Breast</td>
<td>362 (\text{Gm})</td>
<td>24 (%)</td>
<td>69.5 (%)</td>
<td>20.9 (%)</td>
</tr>
<tr>
<td>Drumsticks</td>
<td>220 (\text{Gm})</td>
<td>15 (%)</td>
<td>72.5 (%)</td>
<td>19.3 (%)</td>
</tr>
<tr>
<td>Neck</td>
<td>79 (\text{Gm})</td>
<td>5 (%)</td>
<td>60.0 (%)</td>
<td>14.1 (%)</td>
</tr>
<tr>
<td>Thighs</td>
<td>240 (\text{Gm})</td>
<td>16 (%)</td>
<td>67.7 (%)</td>
<td>17.3 (%)</td>
</tr>
<tr>
<td>Wings</td>
<td>180 (\text{Gm})</td>
<td>12 (%)</td>
<td>66.2 (%)</td>
<td>18.3 (%)</td>
</tr>
<tr>
<td>Giblets</td>
<td>75 (\text{Gm})</td>
<td>5 (%)</td>
<td>74.9 (%)</td>
<td>17.9 (%)</td>
</tr>
<tr>
<td>Gizzard</td>
<td>37 (\text{Gm})</td>
<td>2.4 (%)</td>
<td>76.2 (%)</td>
<td>18.2 (%)</td>
</tr>
<tr>
<td>Heart</td>
<td>6 (\text{Gm})</td>
<td>.5 (%)</td>
<td>73.6 (%)</td>
<td>15.6 (%)</td>
</tr>
<tr>
<td>Liver</td>
<td>32 (\text{Gm})</td>
<td>2.1 (%)</td>
<td>73.6 (%)</td>
<td>18.0 (%)</td>
</tr>
</tbody>
</table>

\(^1\)From Posati (17).  
\(^2\)Composition does not equal 100 percent; ash not included.

### Table 3.—Estimated average yield of broiler-fryer inedible product per 100-lb live weight\(^1\)

<table>
<thead>
<tr>
<th>Inedible product</th>
<th>Offal</th>
<th>Blood</th>
<th>Feathers</th>
<th>Mixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste from poultry</td>
<td>17.5 (\text{Lb})</td>
<td>3.5 (\text{Lb})</td>
<td>7.0 (\text{Lb})</td>
<td>28.0 (\text{Lb})</td>
</tr>
<tr>
<td>Water pickup(^2)</td>
<td>1.0 (\text{Lb})</td>
<td>(\ldots)</td>
<td>15.0 (\text{Lb})</td>
<td>16.0 (\text{Lb})</td>
</tr>
<tr>
<td>Total waste</td>
<td>18.5 (\text{Lb})</td>
<td>3.5 (\text{Lb})</td>
<td>22.0 (\text{Lb})</td>
<td>44.0 (\text{Lb})</td>
</tr>
<tr>
<td>Water evaporated</td>
<td>12.70 (\text{Lb})</td>
<td>2.72 (\text{Lb})</td>
<td>16.50 (\text{Lb})</td>
<td>31.92 (\text{Lb})</td>
</tr>
<tr>
<td>Dry product (8 percent water)</td>
<td>5.80 (\text{Lb})</td>
<td>.78 (\text{Lb})</td>
<td>5.50 (\text{Lb})</td>
<td>12.08 (\text{Lb})</td>
</tr>
<tr>
<td>Pressed product (10 percent fat)</td>
<td>5.16 (\text{Lb})</td>
<td>(\ldots)</td>
<td>(\ldots)</td>
<td>(\ldots)</td>
</tr>
<tr>
<td>Fat</td>
<td>.64 (\text{Lb})</td>
<td>(\ldots)</td>
<td>(\ldots)</td>
<td>(\ldots)</td>
</tr>
</tbody>
</table>

\(^1\)From Lortscher et al. (14).  
\(^2\)Data considered reasonable; actual data obtained in specific slaughtering plants depend on plant practice.
Table 4.—Composition of poultry byproducts for animal feed

<table>
<thead>
<tr>
<th>Composition</th>
<th>Feather meal</th>
<th>Dried blood</th>
<th>Poultry byproduct meal</th>
<th>Tankage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Protein</td>
<td>75-90 (85)</td>
<td>75-85 (80)</td>
<td>50-60 (55)</td>
<td>45-55 (50)</td>
</tr>
<tr>
<td>Moisture</td>
<td>5-15 (8)</td>
<td>5-15 (8)</td>
<td>5-15 (8)</td>
<td>5-12 (8)</td>
</tr>
<tr>
<td>Fat</td>
<td>2-4 (3)</td>
<td>.8-1.2 (1.0)</td>
<td>6-15 (10)</td>
<td>16-25 (20)</td>
</tr>
<tr>
<td>Fiber and ash</td>
<td>2-7 (4)</td>
<td>8-14 (11)</td>
<td>25-30 (27)</td>
<td>20-25 (22)</td>
</tr>
</tbody>
</table>

1From Lortscher et al. (14).
2Reported ranges, with assumed averages in parentheses.

Figure 1.—Relationship between average weight of broiler parts and eviscerated whole-body carcass weight (adapted from Walters et al. (31)).

The health of the bird is of great importance to the processor. The health of the bird is of great importance to the processor. The health of the bird is of great importance to the processor. The health of the bird is of great importance to the processor. The health of the bird is of great importance to the processor.
Processing Systems

A broiler processing plant is generally part of an overall complex comprised of breeding farms, a hatchery, a feed mill, and producing and processing facilities.

The size of the processing plant is usually related to the capacity of the hatcheries, feed mill components, or both. Most poultry complexes in recent years have been in some continuous stage of planning or implementing changes to increase capacity of the various operations while keeping them in balance with one another. Plant capacity and utility requirements are also affected by the type or groups of products prepared. Advances in automation and changing scale economies have required that alterations be made rather continuously in plant size.

Complexities in determining optimum size, configuration, and utility needs of a plant are dictated by changing live production capacity and increased market sophistication. As a result, physical plant layout and the building site should provide flexibility for later modifications or additions to the plant.

General Considerations

Top management must provide basic guidelines if the processing system is to be properly utilized as designed. In a system design approach to plant layout, the areas are considered in the order that operations are performed, including (1) live handling, (2) stunning, slaughter, bleeding, scalding, defeathering, (4) chilling, (5) grading, (6) sizing, (7) preparing product in required form for distribution, and (8) packing. The last two include product form, such as whole (ice pack or frozen, with or without giblets), cut-up bulk, special cuts (for fast-food outlets and caterers), prepackaged, prepriced, and cooked. The operations of slaughtering, scalding, defeathering, eviscerating, chilling, grading, sizing, and preparing the product for different markets are normally scaled to coincide with the line speed of the evisceration operation because of its large labor requirements.

The size of the area for final preparation of products for distribution must often provide for preparing such items as fresh cut-up and tray-packed whole birds, halves, drumsticks, thighs, legs, breasts, wings, livers, and gizzards for the retail market. It should also provide for those products needed in various sizes and particular cutting styles by fast-food establishments, caterers, and institutional users of fresh poultry. The various types of products, separately or in combination, may require special production lines that are subject to frequent changes and equipment substitutions depending on the availability of birds in the proper weight range and the market demand. Consequently, the end-product lines must be designed for easy modification to meet changing situations, different bird sizes, and shifts in product demands.

The need for special production equipment in the end-product area is often determined by economies of scale and market demand. Since some products have very limited demand but provide favorable profit margins, production lines can be designed with flexibility by using portable equipment for making changes frequently to prepare orders for different products.

Although flexibility is necessary, economy requires a mix of products with similar production requirements. Some compatible products can be grouped from the standpoint of processing plant design, utilization of the entire bird, and the most efficient marketing plan.

Product Specialization

Many processing plants have become specialized in producing certain products and have done so either because of management's desire to utilize a specialized facility or because of a special marketing situation.
Site Selection

The major factors to be considered in selecting a suitable location and site for a poultry processing plant include (1) a supply of chickens sufficient for continuous and efficient operation, (2) markets within convenient hauling distance for overnight delivery, (3) reliable transportation at reasonable cost, (4) a reliable and stable labor force, (5) adequate and dependable utilities and services (power, water, fuel, communications, and sewage systems), (6) means of disposing of processing waste (either by the plant or an outside rendering plant), and (7) ownership of sufficient land to accommodate buildings, driveways, and parking areas. Generally a site no less than five times the actual size of the plant facility is considered minimum for meeting these requirements (5).

Other important factors in selecting a site are (1) accessibility, including convenient connections with interstate highway systems, (2) size, shape, and cost of the site, including costs necessary for preparation and development, (3) potential availability of land adjoining the initial site for future expansion, (4) land topography, including drainage conditions and likelihood of flooding, (5) soil conditions, including load-bearing characteristics, (6) zoning status of the plant site and other legal considerations, (7) attitude of local residents toward a proposed plant, (8) adjacent land use, including present and future freedom from dust or other potential contaminants, (9) availability of fire and police protection, and (10) annual taxes and insurance rates for the site under consideration (22).

From the standpoint of economy, gently sloping sites with good drainage are preferable to very flat or steep slopes. A flat site may involve poor drainage and steep slopes require excessive grading. Also, foundations on filled ground are subject to unequal settling. Topography of the site should also permit future expansion of a facility without excessive grading and filling.

The total cost of a site is usually relatively small compared with the cost of the facility. This initial cost should not be a barrier until all other factors have been considered and their value to the plant site determined. Land that may be needed for possible future expansion can usually be purchased more cheaply at the time of the initial site acquisition than at a future date (5).

Plant Layout and Equipment Installation

Layout Principles

An efficient poultry processing plant layout entails the physical arrangement of the facilities relating to the space needed for operating equipment, moving products and materials, storing products and supplies, worker activities, and auxiliary functions and services, including shops, offices, and those for the personal needs of workers.

The primary objectives in developing the layout are to provide (1) a smooth direct flow of products through the plant (economy), (2) economical movement of packaging materials and supplies over distances as short as possible with minimum interference from crossflow and traffic congestion (time saving), (3) adequate space for workers to perform their tasks and to move about (comfort), (4) sufficient space for operations and services (workspace), (5) an environment conducive to orderliness and one creating good relations between workers and management (good morale), (6) a design that permits future plant expansion at minimum cost and least disruption of operations (avoids shutdown during alterations), and (7) one that uses labor efficiently (productivity).

The goal is to arrange the equipment, work areas, and nonproductive areas so they will be economical to operate but safe and satisfying for employees without compromising the layout objectives (economy for management) or product quality. Developing a satisfactory layout by chance is unlikely. Each item of processing or handling equipment included in the layout should be essential to the operations. Processing activities must be located relative to other areas to provide the most convenient, direct, and uninterrupted movement.

Types of Layouts

There are three types of layouts (16). One is by fixed location, in which the product remains at one place and the workers' tools and materials are brought to it. (It has little application to a poultry processing plant.) The second is layout-by-process, in which all operations and equipment of a process or similar ones
are grouped together by the processes or functions performed. This type of layout is used in further processing operations, where several different products are produced. By performing the complete job at one location, the machines and equipment can be more fully utilized, frequent changes can be made in the sequence of operations, and production schedules can be varied. Furthermore, the continuity of the operations is easier to maintain.

The third type is line production or layout-by-product, where a product is processed or produced in one area, but the material being worked on is moved. Typically, the slaughtering, eviscerating, and packing operations in a poultry plant utilize this type of layout. Each operation is performed following the preceding one, with the equipment generally positioned along a conveyor according to the sequences of the operations. This layout type provides the easiest and fastest way to perform a job where an operation immediately follows one and precedes another. Labor is used more efficiently because of job specialization and the opportunity offered to use both semiskilled and unskilled workers. Space is also more fully utilized since less is required for aisles and storage than in other types of layout and thus congestion is reduced.

Factors Affecting Layout Design

For an effective broiler processing plant layout, various factors and considerations must be recognized in an orderly way. They include the materials, machinery, workers, movement, waiting, services, and change. Solving a particular layout problem may require compromising these considerations depending on the objectives of a plan (14). Their relationship may be intertwined so that one may affect several others. Thus it often becomes necessary to make "trade-offs." When a feature is overlooked that should be provided for, or an important one is not recognized, an unsatisfactory layout may result. By developing a checklist in advance to determine which features and considerations are important, problems can be identified and conflicts resolved in order to develop a satisfactory layout (5).

The material to be handled is the most important factor. It includes the incoming live birds, those in various stages of processing, and the finished outgoing products. It also includes the condemned product, salvage, packaging material, and maintenance products.

The production objective is to effectively process the birds so that the desired end product results. Considerations that have a contributory effect include the quantity, size, and class of birds, their physical characteristics, component body parts and their relationships (such as necks, giblets, and cut-up parts), and the quantity and variety of finished products.

The second factor is the equipment and machinery needed for slaughtering, defeathering, eviscerating, and packing, along with those necessary for handling operations and maintenance.

Workers comprise the third factor. Too frequently less concern is shown for the workers than for the other factors that are essential in developing a layout except work-station space and access aisles. This occurs primarily because the workers can be moved about rather than having to remain in a fixed place so that they provide for flexibility in planning. Considerations for the workers can be reflected by safety and working conditions, labor needs (kind and number of workers, operating hours), utilization rate, and personal and psychological aspects.

Movement that usually involves the birds, whether live or in various stages of processing or packing, is essential to a poultry plant operation. It is made possible by using such equipment as conveyors (overhead monorail, belt, and gravity), pallet transporters, forklifts, and tanks. Layout considerations related to movement include the flow pattern, handling practices, utilization of space, handling equipment, and methods.

The waiting factor occurs when the movement of birds or products is stopped. Whenever this happens, a cost occurs that can be justified only if it contributes to savings elsewhere in the overall operation. Waiting birds or other products may be held in designated areas identified for storage or they may only be delayed in the processing area when movement is interrupted.

The service factor includes activities, facilities, and the personnel that support the processing activities. Considerations relating to the service factor are access ways, employee facilities, fire protection, lighting, heating, cooling, ventilation, and offices. They help to keep the production operation functioning. Services relating to the products consist of controls for quality, production, and waste, whereas those relating to machinery include distribution of such auxiliary service lines as electricity and gas.

Less thought and concern are generally given to the service factor than to some of the others in layout planning. Yet many operational problems result from not having given sufficient attention to service features when a particular layout was being planned (15).

The building factor must be considered as to whether the layout is for a new plant or an existing building. An existing building places limitations on the layout, whereas a new structure provides an opportunity to design the new building around the layout. If there is a choice, a general-purpose, clear, span-type building should be considered because a structure is more permanent than its layout or equipment. Less difficulty will then occur if it becomes necessary to convert to new products, change equipment, or adopt different production programs. A specialized building is advisable only when it is essential to a particular type of business that will occupy it, such as poultry processing (21).

Building features that relate to planning the layout include the number of floor levels, shape, basement, balconies, windows, doors, floors, roofs, ceilings, walls, columns, and site.

General Planning Guidelines and Requirements

In planning poultry processing plants, consideration must be given to the increasing emphasis being placed on food quality, the continuous need
for enlarged plant capacity, and the impact of government regulations. Consequently, plants need to be designed for maximum efficiency, product wholesomeness, ease of cleaning, sanitation and maintenance, and safety and comfort of workers, with minimal effect on the environment.

Compliance with Federal regulations pertaining to product wholesomeness and facility acceptability is now mandated by the Poultry Inspection Act (1967), the Williams-Steiger Occupational Safety and Health Act 1970 (26), and the Federal Water Pollution Control Act as amended in 1972 (25).

When planning new facilities or remodeling existing ones, plant management must comply with the appropriate regulations while at the same time developing an efficient plant layout. Since facility drawings must be officially approved by the Food Safety and Inspection Service of the U.S. Department of Agriculture before a plant begins operating, it is advisable to submit drawings to that agency before any construction is started. This will avoid costs of making facility changes that might result from having to alter the drawings to obtain their official approval.

Sanitation Considerations

There are three prime considerations from a sanitation standpoint in the design of a processing facility (24). Concern may be shown for each of the three principles (A–C) in the following ways:

A. Protect the product from contamination by—
   1. Bacteria and mold.
   2. Rot putrefaction, chemical contamination, or physical deterioration.
   3. Rodents, birds, insects, dirt, other foreign substances.
   4. Human contact, human error, or both.

B. Protect the process and equipment by—
   1. Selecting proper equipment for specific process or operation.
   2. Providing an equipment layout that permits smooth process flow, with ease of cleaning and maintenance.
   3. Choosing acceptable materials for—
      a. Product contact surfaces.
      b. Floors, walls, and ceilings.
      c. Structural members, equipment supports, and access structures.
      d. Process support equipment – nonproduct contact equipment.

C. Protect the plant by—
   1. Selecting a site that minimizes external and environmental hazards.
   2. Choosing a building design to—
      a. House the process so that it can be cleaned and maintained.
      b. Prevent entry by dirt, dust, insects, birds, rodents, and other foreign substances, and optimize good housekeeping.
      c. Withstand weather conditions.
      d. Separate process areas from support services and personnel areas.
      e. Avoid dead spots (voids, corners, pockets, or ledges).
   3. Eliminating unnecessary structures and equipment.
   4. Designing waste-disposal facilities to meet Federal, State, and local requirements.
   5. Landscaping and selecting facility layouts to prevent unwanted access by outsiders or employees.
   6. Designing for operator and environmental safety.
   7. Selecting proper materials for building construction.
   8. Providing proper drainage systems.
   9. Providing adequate lighting systems.
   10. Providing environmentally adequate and safe storage facilities for raw materials, packaging supplies, finished goods, equipment, and other supplies.
   11. Providing proper heating, ventilating, and air-conditioning systems.
   12. Providing proper instrumentation for warning when processing room environment exceeds product control specifications.
   13. Providing adequate, safe, and noncontaminating change rooms and support facilities for inspectors, graders, employees, contractors, and vendors.

Planning the Processing Plant

Preliminary steps in planning a poultry processing plant layout include (1) collecting data as to total volume to be handled, kind of products, and product rates for present and future operations, (2) determining the processes involved and sequence of operations, (3) determining the relative locations of various departments and areas, and (4) establishing the flow of products.

The basic concept of the layout is to develop initially a theoretically ideal plan without concern for existing conditions or costs. Later, as the plan is made more realistic, changes can be made that are imposed by constraints from such factors as structural design. This procedure leads to the development of a practical layout (11).

Beginning with the overall layout, one should proceed to develop the details. First, determine the space requirements in relation to the volume of poultry that is expected to be handled. Then, ascertain the approximate part of the total space required for each activity. After these determinations have been made, details of the plan can be developed that include positioning workers, machines, materials, and supporting activities.

Factors such as product form and the package type in which the products will leave the plant are important considerations to the overall plant layout. The rate of production, both for the present and future, will to a large ex-
tent determine the type and quantity of equipment needed and the size and relative location of the plant facilities. Important also are the capacity and dimensions of equipment, the number of employees required for peak production, the amount of supplies and materials to be received and stored, and the utility requirements.

With these factors in mind and the necessary determinations made, the various activities and the areas where they will be performed can be arranged in the order of their occurrence as shown in figure 2. Next, the relationship is established between different activities and areas (fig. 3). Work stations should also be positioned according to the predominant traffic flow between the areas and activities. Only the relative location of an area to the others is shown without any concern for the size of the areas.

The approximate size of each area is then established and a space-relationship-flow diagram developed to indicate the activity occurring in each and the flow direction. Following this, the approximate size is established for each area and a space-relationship-flow diagram developed to indicate the activities between areas and the estimated square footage of floorspace needed for each activity (fig. 4).

Engineering analysis of the plant design begins with a complete flow diagram of the entire operation. A space-relationship-flow diagram is even more helpful for thorough planning because it develops space relationship between plant areas, their interrelationship, and directional flow of product and materials.

A space-requirement flow chart can serve as a basic tool for an efficient engineering design, with details developed for each of the areas and activities on the chart. For dry storage, determine the number of items used, the weekly requirement for each, how products are packaged as well as their dimensions from which the space for the total inventory can be calculated, any special storage conditions required, and the estimated frequency of ordering supplies and volumes to be received. For eviscerating and chilling, determine the number of birds to be eviscerated, the type and number of chillers to be used, and estimates of square feet of floorspace required.

Figure 2.—Major activities or facilities of a poultry processing plant.

Figure 3.—Activity relationship plan for a poultry processing plant, indicating product flow or services between areas.
Close cooperation and complete understanding between top management and design engineers are essential at this phase of the design. Since many situations unique to poultry processing operations are involved, special consideration should be given to using an engineering design leader who is very familiar with the production needs and problems involved at all stages of planning. Knowledgeable production management personnel and an industry-wise engineering staff should be directly involved in establishing space requirements, flow charts, production requirements, and plant layout, all of which should be considered before structural and utility designs are prepared and actual construction begins.

Frequently overlooked in layout planning is the location of the transformer and motor control center rooms. With the rapid increase in product chilling innovations and in automation of waste-handling operations, it is estimated that up to one-third of the motor horsepower required in the plant is expended for refrigeration, one-third for defeathering and fat handling, and one-third for the remaining needs of the plant. It is essential, therefore, that the transformer and motor control center room(s) be located as close as possible to the areas of greatest use.

The space requirements for each area of the space-relationship-flow diagram are estimated from actual plant situations and then an attempt is made to fit the areas together to establish a smooth flow of product from one area to another. An appropriate method for establishing the relative location of different areas is to make templates of correctly scaled size for each and then place them on scaled line graph paper for experimentally determining the various arrangements that can be made to minimize crossflow, travel distances, and traffic congestion.

After the approximate location of each area in relationship to the others is determined, the flow of products within and between areas is identified and the location of machinery, equipment, and supporting facilities essential for carrying out the overall processing operation is planned.

Layout Considerations for Each Area

Unloading and Hanging Area. The live bird unloading and hanging area consists of a sheltered space for removing the birds from the trucks. Layout arrangement is dependent on the design of the transporting vehicles and the unloading equipment.

If individual coops are used, space should be provided for positioning two trucks at the same time to permit uninterrupted unloading and reloading. A platform of expanded metal for self-cleaning that is positioned between the trucks permits side unloading of the coops from the trucks onto a bilevel conveyor. The lowest level of the conveyor transports coops of birds from the incoming truck to the hanging area and the upper level returns the empties for reloading onto the outgoing truck. The area where birds are removed from the coops should provide adequate space for the workers. A small office to overview the receiving operations is useful to the supervisor and for his recordkeeping. Toilet facilities should be provided for live bird handlers since regulations forbid them to pass through areas where ready-to-cook products are being processed.

Desirable structural features of the truck unloading area include (1) bays at least 10 feet wide, hard surfaced (concrete preferred for ease of cleanup), and sloped to properly trapped trench drains, (2) roof cover with a minimum overhead clearance of 14 feet extending the full length and width of truck beds and conveyor, (3) platforms at truck-bed height (approximately 46 inches) and 6 to 8 feet wide to accommodate coop conveyors and unloading personnel, and (4) bumper guards of heavy steel-capped timber at truck impact height (5).

If pullman trucks are used, the drive-through area must be approximately 16 feet wide to accommodate their width, permit installation of a mobile work platform on each side, and provide space for an overhead monorail conveyor.

A slope of approximately one-fourth inch per foot for wheel-type coop conveyors and one-half inch for roller conveyors is usually adequate. Greater slopes can cause coops to move at excessive speeds that may result in bruising birds and damaging coops. Con-
veyors that return the empty coops can be of lighter construction than those that transport coops containing birds.

Several powered units are usually included in the conveyor system that moves coops to and from the live bird hanging area. They are controlled by the worker at the last hanging position since it is that person’s responsibility to remove the remaining birds from each coop. The suspended shackles should clear the top of the coops by about 18 inches to prevent the shackled birds from contacting the coop. The tops of the coops should be approximately 3 feet above floor level to provide workers with convenient access into the coops and create a short reach to the shackles.

The coop conveyor should be positioned in a straight line at the hanging stations and be of sufficient length to hold at least as many coops as there are workers hanging birds. Space for two additional coops will provide extra stations and be of sufficient length to position sufficiently long to quiet them before they reach the stunning. The platform on each side of the truck is sufficiently wide to provide a walkway that permits unloading the truck from both sides. Height of the platform should enable workers to reach the top level of birds before the truck has to be hoisted. An overhead conveyor with shackles encircles the truck and thus eliminates the need for transporting coops on conveyors and the workspace required to hang the birds.

A third system recently developed automatically handles coops of birds in the receiving and hanging area. The coops are unloaded from trucks a tier at a time with a forklift and placed on an automated coop unstacker (20). The birds are dumped automatically through side doors in the coops onto a belt conveyor, which transports them to the hanging area, where they are discharged onto a turntable. The birds are then manually removed one at a time and hung in shackles on the overhead monorail conveyor. The empty coops are reloaded onto the trucks with the forklift. The system requires a sufficient area for maneuvering the forklift when unloading the coops and placing them on the conveyor. The trucks need not be positioned at specified locations since a forklift has flexibility in moving around a load of birds. Neither is a truck-bed height platform necessary because all the operations are performed at ground level.

Whichever method is selected, adequate space should be provided for the work stations; however, the amount needed may vary depending on an individual layout design. Concern must also be directed to worker safety. Hazardous areas such as the edges of platforms should be provided with a protective railing to prevent accidents. Likewise, adjustable working platforms should be designed and properly installed to avoid fatigue that could also result in accidents.

Slaughter Area. When broilers are removed from the coops or trucks, they are suspended head down from shackles of the overhead monorail conveyor. They should remain suspended in this position sufficiently long to quiet them before they reach the stunning. Slaughtering occurs within a blood tunnel or narrow room that is no less than 6 feet wide but wide enough to accommodate the stunning and killing machines. The length of the tunnel should allow up to about 2 ½ minutes of bleeding time before the birds enter the scald tank. If the birds are killed manually, the operation is also performed within the blood tunnel.

Since blood cannot be released into the sewer system because it raises the BOD (biochemical oxygen demand) levels excessively, it must be collected and transported from the plant. The simplest procedure, but now obsolete, is to manually scoop the congealed blood into containers, which are periodically moved to the offal room by handtruck. A system now widely used includes collecting the blood in a catch basin and removing it by pump or vacuum to a collection tank in the offal room. The system must be designed for efficient blood removal and maintaining a low BOD level of the waste water from the area. The walls of the tunnel must be constructed of moisture-impervious material and be easily cleaned.

Defeathering Area. Processing activities in the defeathering area include scalding, mechanical feather removal, pinning (manual removal of remaining feathers), singeing, bird washing, and shank removal. The space required for these operations depends on the type and capacity of the equipment, the number of birds to be processed per hour, and the layout of the conveyor system that transports the birds through the various processes (5).

Arrangement of the equipment must provide adequate space for personnel movement, maintenance, and work stations. The layout of the defeath-
The scalder must allow birds to remain sufficiently long to achieve satisfactory feather release and skin color. To accomplish this, determine the required length of the scalder by the speed of the overhead conveyor line that transports the birds through the hot water. Configuration of the scalder may be either a single pass "straight through" type or a two-or-more pass design. Space is better utilized when a scalder is constructed so that the conveyor makes two or more passes through it rather than a single pass. The two-pass scalder is most commonly used where birds move along one side of a U-shaped configuration on entering and along the opposite side on the way out. Thus the birds enter and leave at the same end of the machine.

The floor of the defeathering area should have a smooth finish and be pitched to trench drains for handling the scalder overflow water, feathers, and cleanup water.

The first picking machine should be placed near the exit end of the scalder. The number of pickers used (generally three) depends on the type of machines selected, condition of the poultry, and the production rate. After the physical dimensions of the pickers have been determined, the layout of the area can then be planned. The pickers should be alined with the overhead conveyor that transports the birds through the defeathering process. At least 30 inches of space should exist between the pickers and 36 inches between each unit and the walls to permit passage of workers, adjustments, maintenance, and cleanup. Ideally, the pickers should be placed sequentially in a straight line along a floor trench drain to receive the discharged feathers, which are then transported by water to the offal room. The machines may, however, be positioned in an L- or U-shaped configuration, where space is limited or the relationship to other areas makes it preferable.

Adequate ventilation is essential to prevent heat and moisture buildup from the hot, humid conditions created by the hot water and steam. Exhaust fans capable of producing one air change per minute are usually sufficient. Screened air inlets of adequate size should be provided.

Because of the humid conditions, electrical distribution panels should be located outside the defeathering area but nearby. Major switches should be readily accessible for responding to emergencies. Safety switches should be installed on or near equipment that is hazardous to operate.

The manual pinning operation is located just beyond the last picking machine. Since each worker or pinner requires a minimum of 3 feet of space along the conveyor line, the total space allocated to pinning operations should be sufficient for the maximum number of workers that may be needed. The shackles suspended from the overhead conveyor should be approximately 54 inches above the floor as they pass through the pinning area.

After the birds are pinned, they are conveyed to a singeing machine, which momentarily envelopes them in a gas flame to remove vestigial feathers (hair). To be most effective, locate the singer about 25 to 30 feet from the last picking machine to permit as much drying of the carcass as possible before singeing occurs.

A bird washer usually 8 feet long and about 4 feet wide is next in sequence. The outside of the birds is cleaned as they are conveyed through an enclosed washer containing several spray nozzles (5, 33).

The final operation in the defeathering area is performed by the shank removal machine (hock cutter), which severs the hock joints and allows the birds to drop onto a belt conveyor. The birds are manually removed from the belt and hung on a nearby overhead eviscerating conveyor, which extends through a wall opening into the defeathering area. This work area is commonly referred to as the "transfer station." Sufficient space is necessary for positioning the hock-cutting machine at the approximate level of the overhead conveyor and in line with the belt conveyor directly beneath it. Space is also necessary for the workers who rehang the birds on the eviscerating line.

**Eviscerating and Chilling Area.** Design of the eviscerating area requires special attention to work stations, aisle space, and placement of personal facilities for workers because operations performed in this area require a relatively large number of workers compared with those in other plant operations.

The primary equipment consists of either a single or dual overhead monorail conveyor located over a water-flushed offal trough, commonly referred to as an evisceration line. Many plants now use mechanical eviscerators, which require allocations of space depending on the make and model used. Broilers suspended from individual shackles should pass by the tallest workers at approximately elbow height. Adjustable height platforms of perforated metal can be used to elevate shorter workers to a convenient height.

The length of the eviscerating line should provide at least 3 linear feet for each employee and 8 linear feet for an inspector and trimmer. Additional space is also desirable for training new employees or for increasing output without having to alter the layout of fixed equipment. The offal trough should be 40 inches or more in width to accommodate a dual line even though a single line is first contemplated; otherwise, future expansion will be costly and require an operational shutdown to make the change.

A straight eviscerating trough provides the least resistance to the flow of water and offal and is preferred to an L-shaped design. The latter also causes an inspector more difficulty in monitoring the birds as they pass through successive operations.

The final bird washer, approximately 8 feet long, is at the end of the trough just beyond the last eviscerating operation. Water from the final wash is used to assist in flushing waste material from the trough. The flow of water should be toward the forward end of the trough so that waste moves in the opposite direction to the path of the birds as they are being converted to an edible product. Inedible material is discharged from the forward end of the trough into a floor trench, which directs the waste-bearing water to the offal accumulation area.

Adequate aisle space is essential for the safety of workers and for minimizing damage to walls and fixed equipment that can be caused by material-handling equipment. Unobstructed

*For times and temperatures, see p. 25.*
aisles 6 feet wide on each side of the
evicerating trough excluding the
depth of the work station are ample.
The same amount of space should be
provided if the trough is near a wall. A
floor trench drain is usually under the
trough and extends its full length.

An alternative to removing offal by
water-flushed troughs is the negative-
pressure pneumatic waste-handling
system. Inedible material removed from
the birds as they are eviscerated is col-
clected in hoppers beneath the over-
head conveyor located convenient to
the work stations. A tube connecting
the hoppers removes the waste materi-
als periodically by an air stream, which
transports the material to a central col-
clection container in the offal room (32).

A shallow, convex, trench floor drain
beneath the overhead conveyor col-
lects the moisture that drips from the
birds and the clean up water. Workers
standing along a guardrail on each side
of the eviscerating line perform their
tasks as the birds are conveyed past
them. The parallel guardrails are 4 feet
apart. Several hand-washing facilities
along the guardrails discharge into the
trench floor drain beneath the line of
birds. If two eviscerating lines are used
with the dry offal system, the same aisle
space needed for water-flushed
troughs should be provided.

The ceiling height of an eviscerating
area is usually 15 to 20 feet to permit
overhead monorail conveyors to clear
the equipment beneath them and to
rise high enough to avoid obstructing
aisles. Sufficient height also makes it
possible to suspend eviscerating
troughs and other equipment from the
ceiling.

The principal equipment in the chill-
ing area consists of in-line mechanical
chillers operating on the continuous
flow principle. Birds are transferred di-
rectly from the eviscerating line to the
chiller, where they are slowly moved
through a cooling medium of slush ice,
icewater, or chilled water. Chillers may
consist of a tank, tables, or closed
boxes, as well as for maneuvering

shackle conveyor line, the breast of
the birds should be at eye level of the
worker. The approximate eye level
height for women is 58 inches above
the floor or platform and 64 inches for
men (7). The area should be free from
obstruction and located so that grad-
ing will not have to be performed on
overhead conveyor curves, inclines, or
declines.

If the grading personnel need to be
elevated in relation to an overhead bird
conveyor so they will be at the proper
height to perform their duties, plat-
forms should be provided that are
sturdily constructed, safe, and easily
cleaned. Platforms more than 12 inches
high should have guardrails. The plat-
forms should also be at least 2 feet
wide and as long as the grading area.

If grading belts or tables are used,
they must be large enough to handle
the maximum output that is to be
graded without delay or accumulation
of birds. Equipment and sufficient
space should be provided for tempo-
rarily holding undergraduate birds that
can be upgraded by further treatment,
such as pin feather removal. The equip-
ment might consist of a tank, tables, or
a hangback rail.

Mechanical sizing according to
weight takes place on in-line scales as
the birds are conveyed above the series
of packing bins. They are dropped into
the appropriate bin according to
weight classifications. Sections of
roller conveyor positioned between the
packing stations can be moved back
and forth in front of the bin and thus
enable workers to continuously pack
birds of various sizes. A bilevel con-
veyor is located parallel to and about 5
feet away from the packing bins. The
upper conveyor supplies empty boxes
to the packing stations and the lower
one transports filled boxes from the
packing station to the in-line scales,
which determine the total box weight,
and thence to the icing station, followed
by closing of the boxes (5). If carbon
dioxide (CO2) snow is used rather than
ice, the dispensing machine is located
in line so that the conveyor transport-
ing the filled boxes will be positioned
beneath the CO2 outlet. After the boxes
are closed, they are palletized. This
operation requires sufficient space for
the number of pallets needed for the
various grades and sizes of birds that
are packed, as well as for maneuvering
pallet-transporting equipment. If pallets are used, space must be provided for moving them and positioning them near the packing stations.

If the birds are cut up rather than packed as whole birds, they are conveyed to an area where cutting and packaging of the parts are conducted. These operations could take place within the same area where eviscerating and whole-bird packing occurs or in another area limited to cut-up operations. Regardless of where cutting and packaging occurs, adequate space must be provided for the necessary equipment.

The cutting operation can be performed in numerous ways. If it is performed manually, the birds are suspended from an overhead monorail conveyor with the parts removed sequentially from each bird and placed on a belt conveyor, which passes beneath the birds and in front of the workers. It transports the parts to the packing station at the far end of the conveyor. An alternative system uses circular knives for dismembering the birds, which are placed sequentially along a belt conveyor. Parts are placed on the conveyor as they are removed and transported to packing stations. When parts are bulk packed, workers who perform the cutting also pack the parts in bags positioned nearby. A third method still rather experimental utilizes a machine to dismember the birds in one or two complex operations, with workers feeding the birds into it one at a time. The machines are designed to cut a bird into a specific number of pieces that drop onto a conveyor transporting them past a series of packing, wrapping, and weighing stations. A trench floor drain parallel to and either beneath or near the belt conveyor for cutting operations provides for draining cleanup water.

Although many different layouts of the cutting operations are possible, they all require that adequate space be provided for work stations, stationary equipment, aisles for passage of employees and mobile equipment, and workspace for servicing equipment.

Shipping Area. Ice-packed poultry is usually moved directly into trucks immediately following processing and packing. It may, however, be held for a short time in refrigerated coolers and subsequently loaded into trucks.

The shipping platform should therefore be located near the packing area and refrigerated holding rooms to minimize travel distances. For reasons of plant appearance and because of the possibility of future expansion, loading operations should not be located at the front of the building.

The width of the shipping platform should be at least 14 feet if forklift trucks are used for handling operations (13). A platform height of 48-51 inches is usually sufficient to accommodate truck trailers. If portable gravity conveyors are used to load trucks, a 10-foot-wide platform is adequate. The platform should be long enough to provide space for the number of trucks and equipment that would be needed at peak loading times. The frontage necessary for each truck is 12 linear feet. The shipping area should be free of columns, but if necessary, they should be positioned along the outer edge and spaced on 24-foot centers.

Sufficient space is also needed beyond the apron in front of the platform for maneuvering trucks. As the width of the platform space allotted per truck is increased, the space necessary for maneuvering decreases (table 5). However, maneuvering space must be provided for trucks with the largest turning radius.

If the platform cannot be constructed at the required height, the same effect can be accomplished by excavating the ground and sloping the apron toward the platform; however, the incline should not be too steep. Dock plates can also be used to compensate for limited differences in height.

Platform surfaces should be constructed of reinforced concrete sloped at least one-fourth inch per foot for drainage and should have a nonskid surface. The necessary load capacity will depend on handling methods and the equipment used.

Height of the platform roof or canopy is dictated by the types of handling equipment used and the ceiling height of adjacent areas. A minimum height of 12 feet is necessary for forklift operations. A 3-foot roof overhang beyond the platform edge is required to shield loading operators from rainfall. At least 14 feet of clearance is needed between the truck apron surface and roof overhang. A drain with sand trap should be installed in the apron near the platform for removing surface water that might otherwise accumulate.

A glass-enclosed cubicle large enough for a shelf-type desk and a stool can serve as a shipping office. It should be located so that the shipping activities can be overseen.

Storage Areas. The type, size, and usually the location of storage areas are affected by the volume processed and the form of the final product. Three categories of basic storage include nonrefrigerated (dry), refrigerated (cooler), and freezer, although broiler processing plants may or may not have the freezer.

Dry storage used primarily for packaging materials is a relatively uncomplicated area, especially when only one type of container is needed such as in a plant where the entire output is ice-packed ready-to-cook broilers. As a plant's output increases and becomes more diversified in form, the dry storage operation comprising inventory control, materials handling, and capital investment increases in complexity.

Since packing boxes are usually formed in the storage room and then conveyed to the packing stations, the areas where the two operations are performed should be near one another.

<table>
<thead>
<tr>
<th>Length of tractor-trailer (ft)</th>
<th>Width of allotted dock space</th>
<th>Minimum apron space required</th>
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<tr>
<td>40</td>
<td>10</td>
<td>48</td>
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<td>60</td>
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<td>14</td>
<td>56</td>
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</table>

1Data from tests using standard equipment handled by experienced drivers able to back into position in one maneuver. Also from Childs et al. (5).

The space needed for the box storage area varies from plant to plant depending on box delivery schedules, procurement policies, inventory size, plant operating methods, and shipping schedules. Locating the box storage area on the floor above the packing operation has two advantages: Gravity can be utilized to convey the boxes to the packing operation below, and space above refrigerated storage or machinery rooms can often be incorporated into the dry storage area. Floors must be tight to prevent dust falling into the processing area below.

If boxing material is stored on a second floor, a portable elevator or similar system will be needed to move the materials to the storage area from the trucks, and a stairway is necessary for worker access to the area. Consideration must also be given to planning future expansion at minimum cost resulting from either increased production or packaging diversification.

Usually chilled, whole, ice-packed chickens are shipped on the same day as processed. However, if they must be held temporarily, they should be placed in a cooler at 32° to 36°F. Often the cooler is located between the packing area and the shipping platform. The product is moved into or through the cooler on forklift trucks or walk-type pallet transporters. The location and size of the coolers and the entrances into them should be planned so that they will accommodate various types of products, handling equipment, and operating methods to facilitate efficient movement.

The cooler should be designed with a minimum capacity for 1 day's processing output. This quantity usually does not justify high stacking of loaded pallets because the storage is temporary and thus a ceiling height of 10 feet is adequate.

Design and construction features of cold storage areas that must be considered are (1) construction materials used, (2) installation to provide protection from moisture and mechanical damage (vapor barriers), (3) type and quantity of insulating material, (4) adequate foundations to support maximum floor loads, (5) floor constructed to provide adequate drainage, (6) curbs 6 inches high on inside walls to facilitate air movement around product and to prevent equipment damage to walls, and (7) durable door and threshold construction to minimize physical damage by materials-handling equipment. Other factors that should be considered include (1) aisles at least 10 feet wide for operating rider-type fork-lifts, at least 8 feet wide for walk-type pallet transporters, and 4 feet wide for operating two-wheel handtrucks and worker movement, (2) at least 2 feet of clearance between ceilings and stacked product, (3) at least 6 inches of space between walls and product, (4) unpalleted products stacked 4 feet high, and (5) cooler doors no less than 12 inches wider than the widest load to pass through them.

The need for freezer storage depends on an individual plant's operation. If a freezer is provided, it should have two components—a blast-freezer room operated at -20° to -60° F to rapidly freeze the birds and a second room operated at 0° to hold the frozen product. Birds are often blast frozen first, then boxed and placed in the holding area.

The ceiling height of blast freezers is usually 8 to 10 feet since the poultry is usually frozen on racks or on pallets but not high stacked.

When pallet loads of cartoned frozen products are stored, they are frequently stacked three or four pallets high on steel pallet storage racks, which allow air to circulate between the pallets and permit "first-in, first-out" inventory control.

The use of pallet racks compared to stacking one pallet directly on top of another avoids excessive weight being placed on individual boxes or cartons. However, the strength of the floor must be greatly increased to withstand the weight at the points where the pallet racks' vertical supports contact the floor.

The entrance door to refrigerated storage is a major concern because temperature differentials between the inside and outside air cause the cold air to escape and warm air to enter when the door is opened. This results in loss of refrigeration and entry of moisture. Properly designed and maintained doors minimize the refrigeration loss and provide for smooth traffic flow. Mechanically operated doors are generally installed where power-driven transporters are used to move the product into and out of storage. Power-operated swingout doors or biarting ones are also available. For safety, at least one freezer door should have an inside manually operated safety release to prevent accidental entrapment of workers. An alarm system that can be activated from within the freezer will also provide for safety.

Double-swinging doors installed within the freezer as auxiliary to the primary doors aid in reducing the loss of refrigeration when products are being moved into or from the freezer. Auxiliary doors are usually not installed in coolers because loss of refrigeration is not so important.

**Auxiliary Areas. Employee Comfort Facilities.**—In recent years greater concern has been shown to providing workers with more comfortable personal facilities, with the expectation that worker productivity would increase, workmanship improve, morale could be maintained and acceptable levels, and lower worker turnover would result. Greater efforts to maintain plant cleanliness also further reflect management's concern for sanitary operations and employee welfare. Facilities for the personal use of employees include restrooms and dining areas. The term "restrooms" includes locker rooms or clothes-changing areas, lavatories, and toilet facilities. The areas should be nearest the eviscerating operations, where the largest percentage of employees work, but they should also be accessible to other workers who are not permitted to pass through the eviscerating area.

By locating the separate restrooms for men and women adjacent to each other, the plumbing is simplified and less costly. In large plants, especially those with further processing operations, restrooms located in more than one area of the plant save worker time by reducing walking distances. A separate restroom for the live bird handling crew is essential so that the workers will not have to walk through processing areas. Likewise, separate restrooms for office and administrative personnel are highly desirable. Important considerations for the layout and design of restroom facilities include (1) complying with Federal, State, and local regulations, (2) selecting locations to minimize walking distances and complex plumbing installations, (3) providing sufficient space for
workers to store personal belongings including coats, (4) providing for plant expansion by allowing for additional washroom space and by "roughing-in" connections in the initial building construction, (5) selecting building materials for walls, floors, and ceilings for attractiveness and ease of cleaning and maintaining, (6) providing an adequate supply and delivery of hot and cold water to foot- or arm-operated faucets, and (7) providing adequate heating, cooling, and ventilation by fans or windows opening to the outside, and lighting (5).

The dressing area must be separated from toilet rooms by ceiling height partitions. Toilet rooms must be arranged so they do not open directly into an area where ingredients or products are handled, processed, or stored. Entrance to the toilet area can be from the dressing room, a vestibule, or a directly adjoining hallway. The toilet and dressing areas should be mechanically ventilated by an exhaust fan and duct to convey the air to the outside. The amount of space allocated for the toilet facilities depends on the number of workers of each sex.

The following guideline is useful in determining the number of toilet units that must be provided (28):

<table>
<thead>
<tr>
<th>Number of persons</th>
<th>Minimum number of same sex</th>
<th>of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16-35</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>36-55</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>56-80</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Each additional 30 persons above 80</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Urinals may be substituted for toilet bowls but only to the extent of one-third of the total number of bowls stated.

The dressing room space needed is contingent on a locker being made available for each employee to store clothing and personal items. An aisle width of at least 7 feet between rows of lockers is desirable.

Adequate facilities should be provided for dining, snacking, and consuming beverages as well as smoking since these activities are not permitted in product-handling areas. The facilities and food service in plants vary widely from cafeterias serving hot meals that occupy up to 2,200 square feet to rooms as small as 450 square feet equipped with only tables and chairs where workers can consume food brought with them. Between the two extremes is a snack service with limited food selections or vending machines. The latter relieves management of some problems associated with providing a commercial-type food service. Regardless of the type of food service provided, the minimum facilities usually consist of either tables and chairs or picnic-type tables and benches and possibly food, beverage, and cigarette vending machines. The total space required depends on the maximum number of workers expected to be on a break at any given time because of staggered operations (8).

Thus the dining area need not be designed with a capacity to accommodate the total number of plant workers at the same time.

Office Facilities.—Office facility requirements include (1) adequate space for waiting visitors, (2) private offices for persons whose work requires them, (3) a general office with space for files and business machines, (4) restroom facilities, (5) adequate lighting from natural and artificial sources, and (6) provision for expansion and flexibility by using nonload-bearing walls or movable prefabricated sections. The last simplifies making changes and minimizes problems of heating, cooling, ventilating, and lighting.

Since restroom facilities must also be provided for inspectors, the facilities generally adjoin the inspector's office area.

This guideline may be useful in planning office space (16):

Private offices:
- 1 person ..................... 8–9 by 12–15
- 2 persons ..................... 12–18 minimum

General office:
- Standard-width aisle ..................... 3–5
- Desks for clerical workers with 18-inch-minimum chair space at side of desks ..................... 4 ft apart
- Aisles between desks and filing cabinet ..................... 5–7
- Conference room with 4- by 8-ft table ..................... 12 by 16

Offal Room.—Approximately 25 percent of the live weight of each broiler processed is removed as inedible material in the form of blood, feathers, viscera, feet, and head. In addition, condemned whole birds and unwhole-some parts must be disposed of with the other inedible products. Because of the large amount of inedibles, facilities must be provided for their rapid removal.

The offal room, where the inedible products are accumulated, should be located adjacent to the defathering area and near the eviscerating area to minimize the distances that feathers and offal must be transported by floor trench drains or vacuum lines. The trench drains must be large enough to handle the necessary volume of water and the waste and they must be sloped slightly for effective movement of the waste products. Feather trench drains are generally 18 to 24 inches wide and sloped 1 inch per 50 feet toward the discharge end. Trench drains from the eviscerating area are narrower than those used for feathers, usually 12 to 18 inches and sloped 1 inch per 10 feet. Drains from the feather and eviscerating areas discharge into separate mechanical separators in the offal room, where most of the solids are removed from the water (5).

The waste material is discharged from the separators or from an overhead collection hopper into a disposal truck. The truck area should have a sloping floor to the drains, which contain deep seal traps to remove seepage and cleanup water. The area should also be sheltered with walls that are impervious to moisture up to 6 feet and moisture resistant above that. All doors should be tight fitting.

Miscellaneous Facilities.—Provision must be made for maintenance and shop facilities, boiler equipment, refrigeration equipment, and utilities, including electricity, lighting, water, fuel, sewage, heating, cooling, and ventilating. However, layout needs for each are related directly to the overall layout design and the capacity of the plant as well as the variety of products.
Building Features

A building encompassing poultry processing operations requires special construction characteristics and materials that differ from those of most industries. This requirement is caused by the large volume of product produced, its extremely perishable nature, the diverse processing stages through which it passes, and the strict sanitation regulations. The special requirements for poultry processing affect construction costs. Because of high humidity, building materials such as steel and concrete are the most commonly used. Furthermore, owing to the rapidly developing industry, it is often necessary to expand facilities to handle future volumes.

Design of Facilities

The building and auxiliary structures must be of adequate size and constructed for their intended purposes to facilitate operation and maintenance. Sufficient space must be provided for orderly placement of equipment and storage of products and materials. Provision must also be made to prevent cross-contamination of food products by bacteria, molds, toxic chemicals, filth, or extraneous materials. All construction materials must be on the approved list of the Food Safety and Inspection Service of the U.S. Department of Agriculture (28). Acceptable materials must be easy to clean, impervious to moisture, and resistant to wear and corrosion. Absorbent material cannot be used in areas where poultry is processed. All outside building openings must be screened to exclude insects and rodents. However, air curtains at the entrances to areas where no moisture is present, such as packaging material storage, may be acceptable.

Floors. Various materials may be used for floor construction, such as dense waterproof concrete mortar containing an approved latex or synthetic resin base. Floors in the operational areas should have nonslip surfaces since smooth ones may be hazardous to workers. Floors where wet operations are performed must be well drained. Approximately one 4-inch drain outlet with deep seal trap vented to prevent sewer gases from entering the plant should be provided for each 400 square feet of floorspace. Where nonwet operations normally exist, one drain for approximately 1,000 square feet is usually adequate.

If trench drains are used, the bottom of each one must slope at least one-eighth inch per foot to a 4-inch drain located within it. Cover plates must be fitted over the trenches and remain in place whenever operations are being performed. A floor slope of one-fourth inch per foot to drainage outlets where wet conditions exist is generally satisfactory. In other areas where a very limited amount of water is used, a slope of one-eighth inch per foot is usually adequate. All floor surfaces must slope uniformly to the drains without any low areas that would permit liquid to collect. Drains are unnecessary in freezers or dry storage areas.

At the juncture of the floors and walls, coves with approximately a 4-inch radius should be installed to augment sanitation.

Interior Walls and Ceilings. All walls, columns, partitions, and doors in areas where exposed poultry is being processed or handled should be constructed of smooth, moisture-impervious material to a height of 6 feet above the floor to assure thorough cleaning. Surfaces above that height must be smooth and finished with resistant materials. Moisture-impervious materials such as glazed brick and tile or smooth surface Portland cement plaster are typically used, but other non-toxic, nonabsorbent materials applied to a suitable base can be equally satisfactory. Consideration should also be given to the sound-deadening qualities of the materials because of government regulations and the increasing health concerns for workers subjected to relatively high noise levels in processing areas.

Glass blocks used in lieu of windows must have smooth surfaces and be installed so as to avoid breakage by equipment. Window sills should be at least 3 feet or more above the floor to minimize glass breakage, and the ledges should be sloped 45° to promote sanitation.

In rooms where poultry is handled or processed, the ceilings must be moisture resistant, smooth finished, and sealed to prevent dust from collecting that might otherwise fall onto the equipment or exposed poultry products. Ceilings must also be free from scaling of plaster, condensate, or water leaks. Preferably they should remain unpainted. Materials used for ceilings include Portland cement plaster, cement asbestos board with joints sealed with a flexible compound, or other approved impervious materials such as fiberglass board. Exposed joists must be at least 36 inches on center and contain few ledges or crevices that would otherwise make cleaning difficult.

Guidelines for Structure Design.

Guidelines for designing a structure to house poultry processing and storage operations can be summarized as follows (24):

1. Floors, walls, and ceilings must be smooth, nonpeeling, inert to process, and easily cleaned.
2. Avoid painted walls and ceilings, particularly where there is moisture. Use prefinished, easily cleaned panels, insulated as necessary.
3. Floors, walls, and ceiling corners should be coved for easy cleaning. Suggest a 4-inch radius.
4. Structural members must be integral to the supported surface or caulked to it.
5. Building supports or equipment should not have horizontal ledges. If ledges cannot be avoided, slope at 45° and make accessible for cleaning.
6. In pipelines where walls and floors are penetrated, use sleeves to prevent dripping and damage.
7. Wall and floor penetrations must be large enough to allow inspection and cleaning or sealed to prevent contamination.
8. Avoid using windows where possible.
9. Use solid-core doors.
10. All windows and doors to the outside must have screens.
11. Air curtains should be used above or around shipping dock and personnel doors to the outside.
12. Provide controlled access to the processing area from the outside.
13. Locate lunchrooms, locker and change rooms, and sanitary facilities in separate areas away from but convenient to the process area.
14. Caulk or seal all wall, floor, and ceiling joints.
15. Plug all wall, floor, or ceiling penetrations not in use.
(16) Do not run a sanitary sewer through a process area.
(17) Provide for dry cleanup procedures where possible.
(18) Use troughs in floors to drain process areas where possible.
(19) If floor drains must be used—
(a) In wet operations, provide 4-inch-diameter floor drains for each 400 square feet. For normally nonwet operations, install floor drains approximately every 1,000 square feet.
(b) Pitch floor for draining—one-eighth inch minimum per linear foot.
(c) Drains must be trapped.
(d) Drains must have strainers and covers.
(e) Drains must not be pockets that retain water.
(20) All electrical equipment and fixtures should be watertight to permit washdown.
(21) Provide sufficient lighting for observation of processing and inspection of equipment.
(22) Design structure to minimize access by rodents, birds, and crawling pests:
(a) Locate docks and process floor above grade.
(b) Lower panels of doors should be metal.
(c) Insure tight fit of doors by proper gasketing.
(d) All solid doors should be self-closing or self-closing screened doors.
(e) Provide an open (no foliage) perimeter of 2 to 5 feet around the plant.
(f) Eliminate silts or other convenient roosts for birds and other pests.
(23) Collect exhaust dust, vapors, and fumes to prevent contaminating the plant and grounds and avoid polluting the air.
(24) Treat all recycled waters to prevent bacterial growth.
(25) Collect waste streams of water for proper disposal.
(26) Collect solid waste (rubbish) in closed containers in a designated area away from the plant and its normal access.
(27) Contain possible spill areas with curbs.
(28) Provide off-floor storage for raw materials and packaging supplies.
(29) Separate storage for finished products from that for raw materials, reject goods, and quarantined materials.

Ventilation. Adequate and properly designed ventilating facilities and equipment are closely related to sanitation maintenance. Objectionable vapors and odors must be removed promptly to avoid absorption by exposed products. This can be accomplished mechanically by air-conditioning or a fan-and-duct system. Fan intakes must be located so that incoming air is not contaminated by odors, dust, or smoke. They must also be provided with filters that effectively prevent insects, dust, and other foreign material from entering the plant. Arrangement of the fans should move air from the areas where products are in the most advanced stages of processing to the areas of incoming products where it is exhausted. A mechanical ventilating system should provide for at least six complete air changes hourly in non-refrigerated and employee comfort areas that are dependent on artificial ventilation. About 300 cubic feet of fresh air per minute should be supplied to work areas to provide favorable conditions.

Lighting. Adequate light is essential for maintaining sanitation and effective performance and safety of workers. The light can be either natural, artificial, or both, and it should be properly distributed in all plant areas. Light bulbs, fixtures, skylights, or any other glass suspended over products in various stages of preparation should be of the safety type or otherwise protected to prevent food contamination in case of breakage. One effective method is to install a shield made of nonshattering plastic material.

The glass window area in unrefrigerated workrooms should approximate one-fourth of the floorspace of a particular work area. If outside obstructions exist, such as adjacent buildings, the amount of window glass should be increased to compensate for the reduced light intensity.

Areas where poultry is slaughtered, eviscerated, and otherwise processed should have 30 foot-candles of light at all working surface levels, except at the inspection stations where 50 foot-candles must be supplied. In all other areas, at least 5 foot-candles should be provided, measured 30 inches from the floor (28). The quantity of artificial light supplied is affected by the kind (incandescent or fluorescent), number, and arrangement of the fixtures.

The intensity and quality of light are very important to grading accuracy. Overhead lighting equipment at the grading stations should provide a light intensity from 90 to 110 foot-candles to assure a minimum of 50 foot-candles of light at the grading level. Preferably the fixtures should be of the fluorescent type, at least 48 inches long, with a minimum of two lamps, although four are more desirable. Other types of fixtures may be acceptable provided they meet the criteria for light intensity and quality (12). The lighting fixtures should be installed parallel to the working surfaces and extend the full length of the grading area.

Quality of the light must approximate the color and spectral composition of natural daylight. It should be diffused enough to permit depth perception by the grading employees and sufficiently uniform over all the working area to eliminate glare or crosslighting. A criterion for artificial light quality is provided by north sky daylight with a color temperature of 7500° K.

The level of light provided should be checked approximately every 2 months with a light meter. If the illumination falls below 50 foot-candles at the working level, the lamps should be replaced. Cleanliness of the lamps is also essential to maintaining the illumination level.

The Illuminating Engineering Society (24) recommends the following general guide for plant areas:

<table>
<thead>
<tr>
<th>Foot-candles</th>
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<tbody>
<tr>
<td>Storage areas</td>
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<tr>
<td>Offices</td>
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<tr>
<td>Processing room</td>
</tr>
<tr>
<td>Inspection stations</td>
</tr>
<tr>
<td>Platforms</td>
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<tr>
<td>Restrooms</td>
</tr>
</tbody>
</table>

Sanitation. Both hot and cold potable water under pressure must be provided for convenient outlets throughout the plant. A minimum hot water temperature of 180° F at the points of use is required for cleaning floors, walls, and equipment. Adequate hose connections for cleanup purposes must be provided along with racks for storing the hose when not in use. The maximum hose length from each outlet should not exceed 50 feet.

The following sanitation checklist (24) can be useful in designing facilities:

1. Know your product and process so you understand the problems of preserving product quality during processing. Be aware of conditions or operations that will affect the acceptability of the finished goods.
2. Select or design equipment to prevent contamination by contact surfaces and foreign materials.
   a. Cover the product stream.
   b. Avoid locating mechanisms and pipes directly above the product stream.
   c. Bearings and seals should be located outside the product zone. Parts in the product zone should be sealed or self-lubricated.
   d. Provide dry clean air for conveying, dust control, instrument and valve operations, and building ventilation.
   e. Close off or screen all building openings – doors, windows, vents, etc.
   f. Minimize outside roof and wall equipment. If required, install suitable protection from weather, dust, pests.
   g. Equipment itself or its operation should not contaminate the product.
3. Minimize loose items – provide storage facilities.
   a. Hinge doors and ports.
   b. Provide storage for utensils and racks for mops, brooms, cans, scoops, knives, spatulas, etc.
4. Plant or its critical areas should be maintained under slight positive air pressure to help prevent atmospheric contaminants (dust, flying insects) from entering. If not possible, protect packing area with positive pressure.
5. Air for processing stream conveying or for blowing out lines, equipment, packaging materials, etc., should be filtered.
6. Incoming plant air, especially in the processing area, should be filtered. Air sources should be carefully selected to avoid contamination.
7. Instrument and processing air must be clean, dry, and oil free.
8. All filters must be easily replaced and cleaned.
9. Various operations should be sufficiently separated to avoid cross-contamination or mixing of product from different stages of processing.
11. Provide dust collection for areas requiring it.
12. Plant should be designed for thorough washdown with water at 180° F and detergents as required for proper cleaning.
13. Mechanical cleaning for equipment and premises should be considered, as high-pressure cleaning, in-place cleaning, and central vacuum.
14. Processing areas should be arranged so they do not open directly into outdoor areas.
15. Building contractors should be aware of necessity of keeping site clear to prevent attracting rodents and insects.
16. False walls and voids in walls should be avoided, particularly in processing areas.
17. Building construction should provide for insect, rodent, and bird control to avoid installation of extra control devices.
18. Avoid using glass in, above, or near the processing area.
19. External lighting (grounds) should minimize insect attraction, particularly near building openings.
20. Landscaping should be designed to avoid attracting and harboring pests.
21. Dock areas should be designed to prevent attracting birds and insects.
22. In nonproduct zones, equipment and piping should be laid out or designed to provide maximum balance between labor costs required for cleaning and construction costs.
23. Reclaim operations should be mechanized commensurate with product risk to avoid contamination, including that from personnel.
24. Handwashing facilities should be sufficiently abundant and convenient to reach.
25. Suitable personnel facilities should be provided for clothes changing and separate eating areas.
26. In employee locker room, lockers should be full size, ventilated, and sealed in a concrete base. The top of the lockers should be sloped to prevent accumulation of dust and dirt and for easy cleaning. A metal locker bottom should be omitted when the locker is installed in a concrete base. Fixtures and partitions should be wall hung for easy cleaning. Double doors should be provided as appropriate.
27. Lavatories should have foot- or knee-operated valves; water and soap supplies should be adequate.
28. All buildings and equipment should be designed to avoid dead spots, such as voids, pockets, or ledges, to eliminate the need for cleaning and possible pest harborage.

Safety

Providing for the safety of plant workers is essential to planning a satisfactory layout. Accidents are costly not only in lost productive time but also in benefits to be paid during the worker’s recovery and the possibility of increased insurance premiums. A nonskid surface on wet floors will aid in preventing workers from slipping and falling. When new surfaces are installed in wet areas, they can be treated with various products such as abrasive crystals toweled into the surface to provide a smooth, nonskid finish. In making the surface safe for workers, do not compromise the ease of cleaning the floor to maintain sanitation. Adequate safety guards on equipment, with clear areas at least 3 feet wide around the machines, will help prevent accidents. Proper ventilation will eliminate vapors, including steam, that otherwise reduce visibility and affect the comfort and safety of workers.

Safety railings with a strength to withstand at least a minimum of 200 pounds’ toprail pressure should be installed 42 inches above floors, ramps, or runways to protect workers from falling. Handrails should be installed with not more than 34 inches nor less than 30 inches measured from the
Equipment

Selection Factors
An increasing amount of automated equipment is being developed and made available to the industry. Much of it is first- or second-generation design. A systematic evaluation of new equipment for a particular operation can avoid selections that might lead to product damage, yield reduction, and operational interruptions from malfunctions or failure. The compatibility of various parts of the equipment can also be predetermined to enhance performance and reliability.

Selecting equipment is a process requiring patience and experience in applying rather basic evaluation techniques. They are equally applicable to individual items of equipment or entire processing lines.

The decisionmaking steps in choosing equipment include making (1) a preliminary evaluation, (2) an operational analysis under actual processing conditions, and (3) an economic analysis. A piece of equipment can be eliminated from further consideration at any point in the evaluation process.

Preliminary Evaluation
A preliminary evaluation of the equipment being considered should include an estimate of (1) the labor savings, (2) the effect on product quality, (3) the approximate installation cost, (4) the probable return on investment, and (5) the operating speeds and how they coincide with the anticipated rate of production.

Also ascertain the number of machines of the brand and the model being considered presently in use in other processing plants and whether any units have been removed from operation and why. Check with other equipment firms that manufacture competitive items, noting any special features, the number of units in operation, and where such operations can be observed. Get the user’s first-hand experience in poultry processing if the machine is not designed exclusively for poultry processing. Require a copy of the official USDA acceptance of the specific brand and model of equipment being evaluated.

Operational Analysis
The operational analysis must be made in the field under conditions that are the same as those where the equipment will be used, that is, the same sizes of birds and similar production speeds. Errors in judgment are frequently made by observing only one installation. Visits to at least three plants employing the equipment are desirable to permit confirmation of judgments that have been made and to see results under different management. During such visits, it is important to confer with operating personnel who are familiar with the capabilities of the equipment, then compare answers received to the same questions asked of several people. Observing competitors’ operations is often very helpful.

Evaluation of equipment under operating conditions should include the following:

(1) Determine the construction quality, including the precision of the machines, the smoothness of welds, material thickness used on covers, the ruggedness of the main frame, and the load-bearing capability of motor shafts, gears, and motors. Attempt to judge the likelihood of the machines lasting for 5 years or more.

(2) Check the ease of cleaning, the time required, and the difficulty of reaching some areas.

(3) Observe the effect on product grade and yield by making periodic checks or simple tests. Repeat the tests at least three times in each plant.

(4) Observe the performance on birds of different sizes, varying quality, and physical conditions.

(5) Determine other performance measures, such as the number of unsealed packages from an automated package sealer or the effect on the sanitation of an automatic eviscerating machine when birds have not been taken off feed long enough before slaughter.

(6) See how adaptable the machine would be with other equipment; for example, will it work with the overhead conveyor shackles presently being used?

(7) Check the ease of adjusting the machines. Frequently efficiency claims are based on the preciseness and frequency of adjustments rather than on the original design. Look for simplicity.

(8) Determine whether the machine can be repaired safely and quickly without interfering with production.
(9) Estimate the likelihood of machine-caused accidents.

(10) Determine to the extent possible what the utility requirements are, including the number and size of circuits, the amount of piping needed, the volumes of water and air, and the quantity of electricity used.

(11) Estimate the effect the equipment will have on plant noise levels, its impact on waste-water treatment, or both.

(12) Ask the opinion of key operating personnel regarding performance and reliability of the equipment.

(13) Check the frequency and annual costs of repairs.

Economic Analysis

An economic analysis made prior to purchase should include a detailed cost comparison of the current methods and equipment with the proposed new equipment and methods. The following example shows how a typical comparison can be made with consideration given to total capital expense, including installation cost, repairs, labor savings, and other cost factors:

Evaluation of New Plant Cleaning Equipment Compared With Equipment Now Being Used

Total capital outlay for new equipment:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit price</td>
<td>$8,000</td>
</tr>
<tr>
<td>Freight</td>
<td>300</td>
</tr>
<tr>
<td>Installation labor</td>
<td>900</td>
</tr>
<tr>
<td>Installation supplies</td>
<td>2,100</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td>$11,300</td>
</tr>
</tbody>
</table>

Annual operating cost compared with that of present system:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor savings (including fringe benefits)</td>
<td>$6,700</td>
</tr>
<tr>
<td>Other savings:</td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>6,500</td>
</tr>
<tr>
<td>Water</td>
<td>2,500</td>
</tr>
<tr>
<td>Soap</td>
<td>1,350</td>
</tr>
<tr>
<td><strong>Added cost:</strong></td>
<td></td>
</tr>
<tr>
<td>Repairs</td>
<td>(720)</td>
</tr>
<tr>
<td>Insurance and taxes</td>
<td>(240)</td>
</tr>
<tr>
<td><strong>Depreciation:</strong></td>
<td></td>
</tr>
<tr>
<td>(5-year life)</td>
<td>(2,400)</td>
</tr>
<tr>
<td><strong>Annual profit increase</strong></td>
<td>13,690</td>
</tr>
</tbody>
</table>

The first-year returns exceed the total capital outlay in this example. This conclusion is based on some further assumptions and findings, such as:

(1) The equipment is widely used in other poultry plants, it is accepted by USDA, and several operational problems have been solved since the first installation 2 years ago.

(2) The equipment provides better control over steam and soap usage than the equipment now being used.

(3) An improved working relationship will exist with USDA inspection personnel.

(4) Product yield and grade are not adversely affected.

(5) The equipment provides for more flexibility than that now being used but has a higher maintenance cost.

(6) It has basically the same features as a competing brand, but it has been in use 18 months longer and most of the operating problems have been corrected. The machine under consideration is third-generation equipment, whereas the other is first-generation equipment. This favors selection of the brand being considered because the performance risk is reduced.

Installation

The placement, arrangement, and installation of equipment should make cleaning and maintenance convenient and easy for an orderly flow process and sanitary handling of products. At the time equipment is installed or when operational changes are made, the effects on sanitation should be carefully analyzed to avoid problems that might result in product contamination.

Consideration must be given to the dimensions of machinery to be installed, such as the width, length, height, extensions, overhang, and swing. Weight is also important since it affects the construction requirements of floors and foundations. Construction requirements are also affected by the weight and routing of suspended conveyors, machinery, and ice storage bins. Standardized machinery and equipment are easier to replace than fixed-position types, and the layout is less difficult to alter if the plant output changes or if product lines are added. All permanently mounted equipment should be installed far enough from the floors, walls, and ceiling to facilitate cleaning, inspection, and maintenance or else it should be sealed to the adjacent structure. If not sealed, the installations should be at least 8 inches off the floor, no closer than 3 feet from the walls, and, where possible, on single pedestals. If suspended, the machines should be at least 18 inches from the ceiling. For ease of cleaning and sanitizing, equipment and platform supports should be made of pipe or structural tubing rather than angle iron.

Pipes serving equipment should be mounted 1 to 4 inches from walls, depending on the diameter of the pipes, and 12 inches above floors, other pipes, or conduits. Pipe joints or connections should be free of frictions, and internal caulking should be avoided. Product lines should not contain threaded pipes, and welds connecting them should be inspected at the time of installation to eliminate imperfections. Trapeze or clevis-type hangers should be used to support pipes and conduits, but they should not be installed above processing vessels. Where pipelines pass through walls or floors, sleeves should be used to avoid dripping. The penetration openings should be large enough to permit inspection and cleaning or else fully sealed to prevent contamination. Vent stacks from exhaust hoods should be arranged or constructed to prevent condensate from running back onto the equipment or products.

Wall-mounted cabinets, such as switchboxes and electrical connections (conduits), should be mounted at least 1 inch from the equipment and walls or else completely sealed to whatever they are attached. All electrical equipment and fixtures should be watertight to prevent damage from cleanup water and injury to workers.

When planning the installation of equipment, the following guidelines can be useful (24):

(1) Select or design equipment to be safe under processing conditions, easily cleaned, inspected, and maintained.

(2) Construction materials should be selected to resist wear and corrosion and to protect contents from external contamination.

(3) Product contact surfaces must be inert, nontoxic, nonporous, smooth (no cracks, crevices, or sharp corners), easily cleaned, nonpeeling, and inert.

Not applicable to equipment in example since cleaning equipment per se has no effect on product yield or grade.
to steam cleaning, hot water, and sanitizing solutions.

(4) All inside corners should have internal angles of sufficient radius (one-fourth inch or greater) to provide easy cleanability.

(5) All surfaces in contact with food should be visible for inspection or readily disassembled for inspection. Routine cleaning procedures should indicate that they eliminate contamination from bacteria, insects, and soil.

(6) All surfaces in contact with food should be readily accessible for manual cleaning. If not readily accessible, equipment should be easily disassembled for manual cleaning. If mechanical in-place cleaning is used, the results achieved without disassembly should be equivalent to those obtained with manual cleaning.

(7) Interior surfaces in contact with food should be self-emptying or self-drying.

(8) Exterior of equipment must be easily cleaned and not retain soil or wash water.

(9) If equipment requires adjustment during operation, it should be designed so operators do not touch the product.

(10) Arrange processing equipment to maintain smooth flow.

(11) Arrange processing equipment for ease of access, cleaning, and inspection:

(a) Floor attachments should be minimized.

(b) Equipment should be at least 8 inches off the floor, mounted on single pedestals wherever possible, and with clearance of at least 18 inches from the ceiling. Use single point contact supports.

(c) Design footpads to be integral with the floor, with coves so they do not retain water or floor drainings.

(d) Equipment should be mounted at least 36 inches away from the wall.

(12) All openings into equipment should be protected against entrance of contaminants.

(13) Agitators must be easily removed for shaft cleaning, installed from inside the vessel, or otherwise designed to eliminate possible lubricant contamination.

(14) Agitators and moving shafts should be mounted to keep bearings and seals outside the product zone. If bearings or seals must be in the product zone, they must be sealed or self-lubricating. Check with the USDA Equipment Group, Technical Services, Food Safety and Inspection Service, Washington, D.C. 20250.

(15) Covered vessels must be properly vented and, if possible, designed to be cleaned in place if run for extended periods.

(16) When equipment is to be dismantled for cleaning, provide off-the-floor racks for holding parts.

(17) All processing equipment must be self-draining with syphon breaks in the drain lines.

(18) Painting of product contact and product zones surfaces should be avoided.

(19) Do not install pipes, conduit, or lighting directly above the processing vessels.

(20) Piping or electrical conduit should be buried in or underneath floor slabs whenever practical.

(21) Pipes serving equipment should be mounted 1 to 4 inches from a wall, depending on the pipe diameter, and from other pipe or conduit to floor clearance of at least 12 inches.

(22) Pipe joints must be free of fractures.

(23) Internal pipe caulking should be avoided.

(24) Flexible piping should be nonporous, not affected by the food or cleaning compounds, and in sections not over 3 feet long. If more than 3 feet long, it should be transparent.

(25) Piping must be designed to operate “flooded” during normal operation.

(26) Avoid using screwed pipe in product lines. Welded pipe must be inspected for proper penetration of weld before installation.

(27) Sifters, detectors, and similar units should be installed to detect foreign materials as appropriate.

(28) Fluidizing should be used wherever possible to convey dry bulk materials as opposed to screw conveyors, bucket elevators, etc.

(29) Be sure fluids used in sensing devices are nontoxic and will not contaminate the product.

(30) Do not use chain or threaded rods to hang equipment, piping, or fixtures from the ceiling.

(31) Use pipe or structural tubing for equipment and platform supports.

(32) Continuously weld all support connections.

(33) Seal all ends of support members and stair handrails.

(34) Use trapeze or clevis-type hangers to support pipe or conduit – no unistructure.

(35) Do not use open grating for catwalks or stairs over areas where product is or may be exposed.

(36) Do not install vessels with openings at deck or floor level.

(37) Be sure vessel openings do not permit leakage of product into or out of the vessel.

(38) Design sample stations and instrument sensing points to eliminate dead pockets.

(39) Welded lines must be designed to be dismantled after each bend so they can be inspected for cleanliness.

(40) Eliminate all unused or unnecessary pipes.

(41) In order of preference, use self-draining plug valves, butterfly valves, or self-draining ball valves in processing lines. Do not use gate, globe, or swing check valves.

(42) Use self-draining plug valves or self-draining ball valves for control functions.

(43) Avoid using header piping with multiple inputs and discharges to prevent dead spots and accidental mixing.

(44) Do not install pressure relief recycle pipe unless there will be a constant flow to keep the pipe clean.

(45) Pitch pipes to drain completely and arrange for breaks at the high points to prevent a vacuum in the lines.

(46) Select gasket materials to provide proper seals so as not to contaminate the product.

(47) Install hose stations with hang- ers so maximum hose length is 50 feet.

(48) Locate motor control centers and panel boards to minimize conduit runs.

The following guidelines should be observed regarding the water used in the plant:

Waste-water equipment should be installed so that waste water is delivered through an uninterrupted connection into the drainage system without flowing over the floor, or it should be discharged within a properly drained and curbed area. Cooking, soaking, and chilling tanks and other large
vessels may be discharged across the floor for short distances to a drain after operations have ceased and the product has been removed from the area.

An air gap should be provided between the highest possible level of liquids in the equipment and water supply pipes. Functional vacuum breakers are needed in installations where submerged waterlines are unavoidable. They should be of a type that can be checked easily to be sure they are working.

Valves on drainage outlets should be readily cleanable and mounted flush with the bottom of the equipment. Construct overflow pipes so that all interior and exterior surfaces can be cleaned.

**Definition of Terms**

In order for these guidelines to be uniformly understood and applied, common definitions of certain terms (29) are necessary:

**Accessible** - easily exposed for regularly performed cleaning and inspecting using simple tools such as those normally carried by cleaning personnel.

**Readily accessible** - easily exposed to sight and touch for regularly performed cleaning and inspecting without using tools.

**Removable** - a component part capable of being separated from the principal part using simple tools such as a screwdriver, pliers, or open-end wrench.

**Readily cleanable** - equipment can be cleaned with hot water, cleaning agents, and scrubbing implements normally used by cleaning personnel.

**Corrosion-resistant material** - maintains its original surface characteristics under prolonged effect of the normal components of its environment, such as product, ingredients, ambient conditions, and cleaning and sanitizing materials.

**Acceptable materials** - chemically acceptable by the Chemistry Staff (FSIS, USDA) and physically suitable for the purpose intended by Technical Services (FSIS, USDA).

**Sealed** - no openings to permit entry of product, dirt, or moisture.

**Product zone** - all surfaces of equipment to which product or ingredients may normally be exposed directly or indirectly.

**Nonproduct zone** - all surfaces of equipment outside the product zone.

The poultry processing plant and its associated facilities for handling live birds, rendering inedible products, and treating waste water may affect the environment in several ways. These effects may include stream-water quality, odors, noise, concentrations of auto and truck traffic, and road littering with feathers and other coop trash from arriving and departing trucks.

By locating the processing facility within an industrial park or on a relatively large site with direct access to a major traffic artery, many environmental problems associated with poultry processing operations can be eliminated. A buffer zone is thus provided for round-the-clock traffic, feathers on roadways, unesthetic appearing construction, and so forth. Trees and other living border barriers are also useful as buffers. The additional cost to extend utility and sewage lines can be at least partially offset by the advantages of isolating the facility.

Waste-water disposal, even when the treatment is the ultimate responsibility of an organized sewer district or municipality, requires careful planning. This phase of the facility design should be handled by an engineer experienced in managing poultry processing plant waste. Engineers with broad knowledge and experience with waste treatment often do not understand the special problems of handling poultry waste. Most plants are now required by government regulations to pretreat the plant effluent. Problems associated with handling the waste water can be minimized by proper design of the system in the processing plant, on the plant site, and at the rendering facility.

The smaller the quantity of effluent, the less difficulty and costly will be the treatment problem. Therefore it is essential that the waste be handled within the plant with the least amount of water. Adequate water pressure will permit the use of low-volume, high-pressure nozzles on bird washers (33). High-pressure cleaning systems reduce water volume considerably compared with the amounts required when steam is used to generate pressure. Replacing a water flotation system for removing viscera with a dry offal collection system also reduces water usage. Continuously monitoring and recording water flow rates and usage by work shifts are also valuable in controlling water consumption.

The facility and surrounding land should be designed to insure that water runoff from roofs, parking areas, and surrounding grounds is excluded from the plant effluent system. The live bird receiving platform, live bird holding shelter area, and the ice-pack shipping platform should be designed so that waste resulting from these operations is directed to the plant effluent lines with minimum dilution from weather-related water.

If the complex includes a rendering plant, it should be designed for the quantity of offal to be handled with necessary standby equipment provided. An overloaded or poorly operated rendering plant often results in high levels of BOD (biochemical oxygen demand) and suspended solids in the effluent. Similarly, a well-run rendering plant produces a minimum of odors; however, good design now provides for scrubbing the air exhausted from the rendering operations to minimize offensive odors.

Outside noise problems at poultry processing plants are due primarily to vehicular traffic. A plant processing 100,000 birds per day may have as many as 30-50 trucks and 200-300 cars entering and leaving the premises per operating day. Selection of an isolated location for the plant practically eliminates external noise as a problem in its operations.

Inside plant noise can be minimized by providing proper ceiling heights, carefully selected equipment, and adequate floorspace for the processing operations.
Broiler processing is a system of complex steps to convert the live bird into a ready-to-cook product either as a whole bird or cut up into component parts. Each processing operation is designed to perform a particular task in an efficient, sanitary manner. Preparing poultry in a ready-to-cook form involves live bird catching, cooling and handling, holding live birds on a truck, unloading, hanging on the conveyor, stunning, slaughtering, defeathering, eviscerating, inspecting, chilling, grading, packing, and shipping. In some instances, the process may include cutting eviscerated birds into parts, boning, or further processing them into specialty items.

**Live Bird Handling**

**Pickup and Hauling.** In the live bird handling operations, broilers are transferred from the grow-out operation to the processing plant. Attention must be given to minimizing bruises, which affect product quality, mortality, and shrinkage and which all influence operating costs. The normal procedure in the broiler house is to raise the feeders and waterers above the reach of the birds at least 1 to 4 hours prior to the arrival of the live haul crew. Precise scheduling of feed and water withdrawal is important for reducing the extent of fecal contamination in processing, avoiding excessive live shrink, and preventing decreased eviscerated yield. The optimum withdrawal time for feed and water is about 10 hours. Live bird shrink can range from 0.3 to 0.5 percent per hour for the first 12 hours off feed and will average approximately 0.2 percent per hour over a 24-hour period. Furthermore, the incidence of fecal contamination can be kept to a minimum when the total feed and water withdrawal time is from 8 to 12 hours. During this period, the fecal material in the intestinal tract will be minimal and the consistency firm. After 12 hours, metabolic processes cause the feces to become less firm and a watery condition is reached by 24 hours off feed. The longer broilers are off feed and water the lower the yield at slaughter, which may vary as much as 5 percent between 4 and 24 hours of withholding feed.

Live haul involves hand catching the birds, mostly at night, in a darkened dust-laden atmosphere and trucking them long distances. Rapid loading and lifting are required. This is costly in numbers of persons required, worker discomfort, bruised or dead birds, and equipment maintenance. Live haul crews vary from eight to nine workers. A flatbed tractor-trailer is most frequently used that holds 6,000–7,000 birds in stacks of wooden or plastic coops. During the summer, fewer birds per coop are loaded than in the winter to minimize death losses from suffocation. Loading time ranges from one-half to 1 hour per load. One crew can supply about 3,000-birds-per-hour capacity of the processing plant. Thus a plant processing 15,000 birds per hour would need 5 live haul crews.

When loading live birds, one worker usually drives the birds into groups within the house while four or five others catch and carry them to the truck. One or two workers are required to position the coops and place birds in them. The bruise rate is usually 8 to 12 percent because of bird activity and handling (18). So that bruising or broken bones are reduced, the stair-step method of loading is commonly used. Empty crates are placed on the ground next to the truck in a stair-step fashion. Catchers then carry the birds up the stairs to the workers who place the birds in the coops. This method usually results in gentle handling. Care must be taken in catching to avoid smothering the birds and overfilling the coops.

During the summer, 12-inch-high coops should be filled with 12 to 14 broilers each depending on the size of the bird. In the winter, when less ventilation is needed, a 10-inch-high coop holding 14 to 16 broilers can be used depending on bird size. Climate should be considered when choosing the type of coop to be used. Plastic and wooden coops each have advantages depending on the type of operation in which they are to be used.

Broiler firms using properly trained catching crews and good live haul procedures usually experience a low DOA (dead-on-arrival) rate and few bruises. Success or failure in live bird handling, therefore, depends largely on the emphasis management places on training programs and how well employees respond (6).

Another system for transporting live birds consists of rigid wire sides on a truck bed and a series of compartments with hinged floors that can be raised during the loading operation. As each compartment is filled using a conveyor, the next floor is lowered in place until all compartments are filled. The wire sides have doors for unloading; the rear side of each compartment level is raised and the birds fall to a belt that takes them to the hanging area. However, with a conveyor system for loading, it is difficult to count the broilers as they are placed in the compartments. The system also requires a large capital expenditure because it is necessary to redesign the catching operation and the receiving area.

Another system using pallets has reduced the incidence of bruises. Empty pallets are stacked on pallets and transported on flatbed truck trailers. On arrival at the broiler farm, a fork-lift truck unloads and transports the palletized coops into the broiler house. After the coops are filled, they are returned to the truck on pallets and loaded. The design and equipment layout of the broiler house must permit the fork-lift truck to be maneuvered easily. At the processing plant, pallet loads of broilers are placed directly on a roller conveyor or on an adjustable platform that permits each coop to be placed on a roller conveyor gently and transported to the hanging area. This method has reduced bruise rates considerably.

A vacuum system has been tried in which broilers are dropped into a pipe system, which transfers them from the broiler house to a specially designed truck with fixed wire compartments. Although this system shows promise, it causes considerable bruising. Furthermore, it is difficult to obtain an accurate load count.

**Receiving and Holding.** Truckloads of live birds are held in a holding shed at the plant while awaiting unloading. A popular design for the holding shed is an A-frame structure with a high roofline and open sides and ends that can be enclosed during inclement weather. Good ventilation is necessary to prevent broilers from dying of heat prostration. Large volume, slow speed fans on the sides and in the roof maintain a desirable airflow. It is important to position the fans so that the
heat in the middle of the load is removed. A common mistake is to blow air onto one side of the load and not remove or draw air from the center, especially when broilers are held from 1 to 9 hours. Even with the precautions that provide good ventilation, losses from heat prostration increase sharply during the hottest time of the day.

Successful measures to reduce losses considerably require enclosing the side(s) of the structure with greatest exposure to the sun and then providing a continuous, fan-activated, evaporative cooling system as a part of the sidewalls. The fans are installed at truck-bed height. Under favorable low humidity conditions, an additional 10° of cooling can be achieved in this manner, minimizing shrinkage and sharply reducing heat prostration losses. It should be noted that although cooling is not so effective with high atmospheric humidity, the increased ventilation and shelter from the sun provided by the sidewalls do reduce losses over those sustained in sheds with open sides.

Location of the holding sheds and the scales for live bird truckloads and scale house should be carefully considered to avoid traffic congestion and contamination of the atmosphere with dust and feathers in close proximity to the plant, while providing protection for live birds and minimizing damage to truck, coops, and scales.

Trailer loads in the holding shed are moved into the plant unloading area as needed. A mechanized or gravity-wheel conveyor placed at an incline is used to move the full coops from the trucks to the hanging area. Two workers usually unload the coops of live birds onto the conveyor. As the coops are emptied in the bird-hanging area, they are stacked onto another truck by one or two workers. Coops should enter the hanging area positioned with the lids open in the opposite direction to the movement of the line so that the birds can be removed easily without dragging the wings over the coop lids. Trailer loads of birds should be scheduled into the receiving area so that slaughtering will occur approximately 8 to 12 hours after the last feeding to minimize yield loss and fecal contamination.

As broilers are removed from the coops, they are hung by shanks in shackles attached to an overhead monorail conveyor, the starting point of the killing or dressing line. Broilers should be removed from the coops carefully by gripping the shanks firmly and placing them securely in the shackles. Hangers should be trained to place birds in shackles without exciting or injuring them. Grasping the drumstick may cause hock bruising, as well reaching up to place the bird in shackles positioned at or above the worker’s head or shoulder level.

Generally one hanger is needed for each increment of 15 to 18 broilers slaughtered per minute. In order to minimize exciting the broilers prior to their entering the stunning and killing area, keep illumination levels relatively low. Blue or red lighting is best. The time a bird should hang in a shackle prior to slaughter depends on the line speed, but a minimum of 40 to 60 seconds is advisable for calming them and avoiding improper entry into the stunning machine or stunning. The live hanging area is important with respect to the effect on quality as it is related to bleed-out and loss of parts caused by improper procedures. The slaughter lines must be synchronized with the evisceration line. Since one kill line normally serves two eviscerating lines, its speed is usually twice that of the latter.

**Slaughtering and Defeathering**

**Stunning, Killing, and Bleeding.**

Stunning is essential to satisfactory bleeding and feather release. The major concern in the killing and bleeding operation is to minimize the number of birds improperly bled.

Sufficient bleeding time is necessary to maximize blood loss prior to the bird entering the scalder and thus reduces the BOD load in the scalder and prevents possible adverse effects on product quality. Also, if birds are not well bled before scalding, the blood adds to the BOD load of the scald water. Incomplete bleeding causes red discoloration of the body extremities and feather tracts, causing the carcass to be downgraded or even condemned as a cadaver if excessive.

The killing operation can be performed either manually or mechanically. In the manual operation, a kosher cut is generally used. A skilled worker with a sharp knife cuts the jugular veins with little or no contact with the neck bones. One worker should be capable of killing approximately 4,000 birds per hour with periodic rest breaks. In an operation handling 8,000 birds per hour, 2 killers and a relief worker are needed.

Two types of mechanical killers are being used presently. Each consists of a guide bar with grooved rollers that hold the heads rigid and extend the necks in preparation for making the cuts. It is essential that the birds be stunned sufficiently so that the necks can be guided into contact with the grooved rollers. One type of killing machine uses a high speed revolving circular blade positioned to cut in a prescribed area without contacting the vertebrae of the neck. Another type utilizes the same type of rollers but has three or four sharp knife blades that perform the cutting.

The position of the bird’s head and throat can result in different types of cuts that have both advantages and disadvantages. Cutting under the lower mandible severs the carotid arteries and both jugular veins to maximize bleeding. If the machine is adjusted properly, the trachea or spinal cord will not be cut nor will the neck bones be crushed. Cutting the trachea should be avoided so the bird can continue to breathe and facilitate proper bleeding. By cutting only one side of the neck, both the carotid arteries and jugular veins can be severed without affecting the trachea and spinal cord. However, generally the vertebrae are crushed or partially cut. If both sides of the neck are cut, the trachea will be severed as well as the spinal cord and vertebrae. If the cut is made at the junction of the head and the neck, the carotid arteries will be cut but with varying effectiveness in severing the jugular veins. Although the trachea is normally not cut by this method, severing the spinal cord and crushing the neck do occur.

The USDA requires that bleeding of carcasses must be complete enough to assure that birds are no longer breathing when they enter the scalder.
This prevents scald water from entering the air sacs or the lungs and causing product contamination. Bleeding time from the killer to the scalder ranges from 55 to 100 seconds depending on the effects of the stunner, the time between stunning and killing, the type of cut made, and the season of the year. A worker is assigned to monitor killing machines to insure that cuts are made properly.

Improper bleeding is indicated by an orange-red skin. A bird that has been missed in the killing process will have a distinct red skin indicating a cadaver. Cadavers, if they occur, should not exceed more than 1 or 2 birds per 1,000 slaughtered. Recommended bleeding time ranges from 55 seconds to 2 minutes and 13 seconds. During the cold season, bleeding time should be extended 5 to 10 seconds. Over 80 percent of the bird’s blood is released within the first 40 seconds, and it is essential to allow at least 60 seconds of bleeding time before entering the scalder to minimize contaminating the scald water with blood. A general rule for determining whether proper bleeding is occurring is to watch the birds as they enter the scalder and observe whether wing flapping and struggling have ceased.

Use of a blood tunnel as previously described under plant layout serves two important purposes: It collects the blood in a small confined area for easy removal to minimize the amount entering into the waste-treatment system, and it reduces cleanup time and the quantity of cleaning chemicals needed.

Scalding and Defeathering. Scalding completes the feather-release process and increases the feather-density and friction area for the feather-removal operation. A surge-agitation-type tank is generally used, with the carcasses conveyed through hot water. The USDA recommends that a minimum overflow of 1 quart per bird scalded be maintained to reduce buildup of contamination.

Agitation of the scald water is necessary to assure good penetration to the bird’s skin and reduce the pulling force required to remove feathers as well as to avoid cold spots in the scald tanks. In addition to the scalder for body feathers, some operations employ separate neck and wing scalders that operate at higher temperatures to denature the protein of the feather follicles and further reduce the pulling force required to remove the feathers in these areas.

Time and temperature are important considerations in scalding broilers. Several markets in the United States prefer yellow-skinned birds. In other markets and for further processing, yellow is not important or necessarily desirable. As the scald time is increased, the yellow color of the skin decreases significantly.

Generally a scald temperature of 125° to 130° F is used with a median of approximately 126°. Scald time usually varies from 1 1/2 to 2 1/2 minutes depending on the scald temperature and the desired results. Neck scalders are usually operated at between 140° and 150°. If separate wing scalders are used, they are generally operated at between 130° and 140°.

After the carcasses leave the scalder, they enter a series of defeathering machines referred to as “roughers” or “pickers,” each with a specialized purpose. Time for the entire operation requires about 30 seconds. The machines are designed to pluck the wing, hock, neck, and body feathers with a series of drums having short, firm rubber fingers with rippled surfaces.

Some roughers are called “counter-rotators” because the drums are sectionalized to permit them to rotate alternately in opposite directions. Roughers for finishing the defeathering job have long, more flexible fingers that provide a gentle slapping action. Generally three or four inclined roughers are used in sequence followed by a picker-scalder for removing the hock, neck, and wing feathers.

Scalding and defeathering are confined to a room separate from other operations because of high noise levels (usually about 100 decibels) and hot, moisture-laden air. One worker is usually assigned to adjusting equipment and keeping the area clean.

An alternative to immersion scalding with separate defeathering machines is the combined spray-scalding and defeathering system, in which the scalding and defeathering operations are combined in a long cabinet that uses supersaturated air (steam and hot water) at 128° F. Water at 100-pound-per-square-inch pressure is sprayed on the birds at 3 gallons per bird within an 8-foot cabinet. A second 8-foot humidity cabinet utilizing steam comprises the remainder of the unit. The total scalding and defeathering time is approximately 90 seconds.

After defeathering is completed, the carcasses pass through the pinning, singeing, and bird-washing area. Generally 2 to 4 workers (pinners) are used for multiples of 3,000 birds processed depending on the extent of pinfeathers remaining after mechanical picking is completed.

Head Removal. The head-removal operation may take place in the defeathering area between the scalder and the outside bird washer, or it can be performed in the eviscerating room to facilitate crop removal. Wherever the operation is performed, the bird’s neck passes through a shaped device to restrain the head as the body is pulled forward by the overhead conveyor and thus separates the neck vertebrae at the base of the skull, or the process may be assisted by a set of rollers to separate the neck bones and by a rotating knife to sever the neck skin instead of tearing it. The latter procedure salvages some neck skin and improves the processing yield.

Hock Cutting and Bird Transfer. After passing through the outside bird washer, the carcasses are moved through a hock cutter that severs the shanks at the hock joint and causes the carcass to drop onto a conveyor for subsequent transfer to the evisceration area. There are two types of hock cutters: One has a long cutter bar that cuts through the legs at the hock joint and the other severs the hock joint with a circular blade. By removing the heads and shanks in the defeathering area, they can be transferred from the area by flotation using the relatively large volume of rapidly moving waste water exhausting from the scalders and pickers.

Eviscerating. Birds are eviscerated and prepared in ready-to-cook form by removing the shanks, head, gizzard, gizzard, crop, and lungs from the defeathered carcass (7). This operation also includes harvesting the giblets, which normally includes trimming the gizzards, hearts, and livers and removing necks. In this eviscerating area, the birds are examined for wholesome-
ness and completeness of feather removal by USDA inspector(s) (28). Here also the trimming of bruises, blisters, and broken bones takes place. Final plant inspection and thorough washing of the carcasses are generally included as part of the eviscerating operation. Since this operation requires over 50 percent of the workers and considerable equipment, the area must have adequate space, ventilation, and lighting and must be arranged to avoid hazards that might contaminate the edible product.6

The following list (adapted from Childs (3)) includes the rates per worker for manually performing eviscerating operations and can be used to determine approximate employee requirements at various line speeds.

<table>
<thead>
<tr>
<th>Operation</th>
<th>Birds per worker-minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer birds from defeathering to eviscerating line</td>
<td>34.4</td>
</tr>
<tr>
<td>Remove preen or oil gland</td>
<td>36.8</td>
</tr>
<tr>
<td>Open body cavity</td>
<td>38.8</td>
</tr>
<tr>
<td>Remove vent</td>
<td>15.6</td>
</tr>
<tr>
<td>Draw viscera</td>
<td>13.7</td>
</tr>
<tr>
<td>Federal inspection</td>
<td>7</td>
</tr>
<tr>
<td>Remove heart and liver</td>
<td>14.2</td>
</tr>
<tr>
<td>Remove and clean gizzard</td>
<td>31.7</td>
</tr>
<tr>
<td>Snip neck vertebrae</td>
<td>37.0</td>
</tr>
<tr>
<td>Remove lungs</td>
<td>24.9</td>
</tr>
<tr>
<td>Remove crop and windpipe</td>
<td>21.1</td>
</tr>
<tr>
<td>Plant inspection</td>
<td>20.0</td>
</tr>
<tr>
<td>Peel gizzard</td>
<td>38.2</td>
</tr>
</tbody>
</table>

6Developed from a representative group of time studies. Experienced workers can exceed these rates by 15 to 20 percent. 
7Data not included because of modifications in inspection procedure under consideration. 
8With use of mechanical splitter-washer, this rate is being more than doubled.

Because evisceration and related functions require such a large percentage of the plant work force, a chief supervisor and two or three line supervisors are generally used to assure a constant flow of product at a maximum line speed. The line speed is dependent on such factors as staffing, worker training, health of the birds, and daily production requirements.

The following tasks are performed sequentially in the evisceration operation. For the number of birds processed per worker-minute for each operation, refer to the preceding tabular data.

(1) Defeathered birds are hung on the evisceration line from a belt conveyor called the "rehang belt." Each bird is suspended by the hocks from a shackle on an overhead conveyor, which moves the carcasses through the eviscerating area. Two to three persons are needed for a 25-bird-per-minute line.

(2) The first cutting operation involves removing the preen or oil gland either manually or by machine. A sharp, short-bladed knife is used to manually remove the gland, located on the top side of the tail next to its base. A cut is made from the base outward to the end of the tail so as to remove all the yellowish gland. In machine removal, the tail of each bird must be positioned so that the cutting element will function properly. Proper adjustment of the machine is important to avoid removing excessive tissue.

(3) The opening cut into the body cavity is made by inserting a short-blade knife between the vent and the tail followed by a cut across the abdomen toward the posterior end of the breast. The worker must be skilled and attentive because carelessness can result in serious errors. If the knife is inserted at an angle, the intestines near the cloaca may be cut causing fecal contamination. An opening cut that is too long will allow chill water to seep into the area between the thigh and rib cage resulting in excessive moisture pickup.

(4) Making an incision in the abdomen and removing the vent can be done manually or by machine to complete the opening process. In the manual method, the operator grasps the cloaca between the index finger and thumb and makes two transverse cuts next to the cloaca so that it and the intestine can be carefully pulled out to approximately one-third the length of the back. Failure to remove the vent and intestines without damaging them may also cause fecal contamination. Mechanized vent-removal machines cut around the cloaca with a high-speed rotary blade. In some models a vacuum simultaneously evacuates the large intestine. Such a machine, usually synchronized ahead of a mechanical eviscerating machine, can increase yields up to 0.1 percent as well as reduce fecal contamination.7

(5) Removing or drawing the viscera from the bird can be performed manually or mechanically. If done manually, the hand is inserted into the body cavity carefully so that the abdominal fat is not torn loose. The index and middle fingers pass on either side of the proventriculus (glandular stomach) to grasp the gizzard firmly. The hand is twisted, then withdrawn while gripping the gizzard securely. The viscera, still attached to the bird, are draped uniformly to one side of the tail as required for USDA inspection. Dislodging abdominal fat during this operation can result in important yield loss. If the viscera are accidentally detached from the body, they are hung on the shackle above the bird to maintain identity for inspection. Mechanized removal of the viscera is performed by any one of several makes of machines synchronized with the speed of the conveyor. Each bird is securely positioned, then a spoon- or finger-type mechanism enters the body cavity and withdraws the viscera. Usually the lungs and crop (approx. 95 percent) are also removed; however, careful adjustment is essential to reduce the loss of abdominal fat and damage to the liver. Two or three backup workers may be necessary to remove the viscera missed by the machine and occasionally to position the viscera prior to inspection. Other workers are required at the plant inspection station to remove lungs or crops missed by the machine.

(6) USDA inspection for wholesomeness is generally performed by a government-trained inspector, who detects any evidence of unwholesomeness requiring that a carcass or a part of it be condemned. The inspector examines both the outside and inside of the carcass and the viscera. A worker referred to as a trimmer refers to "Layout Considerations for Each Area."
moves parts with broken bones, bruised tissue, breast blisters, improperly trimmed shanks, or other parts that have been determined to be unwholesome by the inspector. Each inspector usually examines every third bird on a 60-bird-per-minute line for an average of 15 to 22 birds per minute depending on the health of the flock and the way the carcasses are presented for inspection. Colored tabs on each shackles identify the birds each inspector is to examine. The trimmer marks on a poultry inspection list tally sheet the appropriate reason for condemning any parts or whole birds.

Primary reasons for condemnation are tuberculosis, leukosis, septicemia and toxemia, synovitis, tumors, airsacculitis, bruises, cadavers, contamination, and overscald.

Breasts from birds with only a mild infection of airsacculitis can be salvaged.

Any organ, part of the carcass, or whole carcass that is accidently mutilated during processing is condemned.

If a poultry carcass is accidently contaminated during slaughter with digestive contents, it need not be condemned if it is promptly reprocessed under the supervision of an inspector and found to be no longer adulterated. Contaminated surfaces that are cut can only be removed by trimming. Inner surfaces that are contaminated but not cut may be cleaned in the automated operation. Generally two other workers per line inspect and manually remove any remaining parts of the lining, after which they are also flumed to the giblet chiller. Gizzards can also be handled automatically by machines that consist of a combination splitter, washer, and peeler, with a capacity of processing approximately 3,000 gizzards per hour. The machines also include supplementary manually operated peelers, which serve as backup for handling any gizzards not fully processed in the automated operation.

Finally, the viscera, after the giblets have been removed, are dropped into the eviscerating trough and carried away by water to the offal holding area. In a dry offal handling operation, the viscera and other inedible materials are removed continuously by a belt or intermittently by a vacuum.

Chilling
Modern chilling operations utilize several methods. The most common is immersion of the carcasses in long flow-through tanks containing agitated slush ice. This requires no more space for cooling 6,000 birds than was needed in the past to chill 1,200 broilers using stationary tanks. One worker monitors and serves the operation for a 12,000-bird-per-hour-capacity chill operation. USDA regulations require that the chiller overflow rate be maintained at one-half gallon of water per bird chilled in order to minimize the microbial buildup in the chill water. Research has demonstrated that with the processing methods used today, continuous immersion chilling significantly reduces microbial counts on the carcasses.

No relationship exists between moisture uptake and live bird weight, dressed weight, or sex of the broiler. Moisture uptake is more dependent on the time the bird is held in the chiller, the type of opening cut employed, and the amount of agitation in the chill media. The yield of chilled broilers is
slush consists of a two-stage operation, holding will result in a net moisture of approximately 32° to 34° F. Carcass during transportation and subsequent market are allowed a maximum temperature on exit from the chiller is 60 minutes.

Maximum moisture pickup allowed for broilers going directly to consumers is 8 percent, whereas broilers to be shipped and rehandled in a distant market are allowed a maximum moisture pickup of 12 percent. It is assumed that the loss of moisture during transportation and subsequent holding will result in a net moisture pickup of 8 percent or less before reaching the consumer.

Chilling of broilers by agitated ice slush consists of a two-stage operation, including a prechiller and final chiller. The prechiller is used to begin lowering the carcass temperature slowly to prevent rapid shortening of the muscle fibers that causes toughness in the cooked meat. In addition, prechilling removes any traces of extraneous materials that may remain after the final washing. The prechill solution at 50° to 65° F generally consists of potable water along with overflow water from the final chiller. The time required for precolling ranges from one-third to one-half of the total chill time.

The second stage or final chilling is usually performed by a machine of the same design as the prechiller (rocker or reel type), which generally uses potable tapwater in combination with ice equal to about one-third the volume. Newer chillers have insulated walls to maintain colder temperatures of approximately 32° to 34° F. Carcass temperature on exit from the chiller is 36° to 40° F.

Chilling broiler carcasses within 4 hours of slaughter and giblets within 2 hours after harvesting to 40°F or lower is in compliance with USDA regulations. Generally the time required in modern broiler plants is 40 to 60 minutes.

The procedure intended to be used by a plant for chilling poultry must be filed with the USDA inspector in charge and must include type of coolant and chilling methods to be used. Any subsequent change in the procedure must also be approved by USDA.

A sample of 50 carcasses is checked by inspection personnel when any change in procedure occurs to insure that the maximum allowable limits of water absorption are not exceeded. The test carcasses are identified by a numbered tag on the wing prior to entering the final washer, then they are weighed, and the weights are recorded. The birds are weighed again at the end of the drip line and the average moisture uptake is computed. The plant is responsible for supplying the scales, weights, tags, and other materials needed for the test. If the sample exceeds the allowable limits, all the birds cooled in a like manner are held in the cooler for 24 hours or until the moisture is reduced to allowable levels. Ten birds are routinely checked daily to assure compliance with USDA requirements.

Giblets are moved from the eviscerating line by a cold water flume or pumped to the giblet chiller, which is similar to but smaller than the second-stage carcass chiller. It also uses ice and potable water at 36° to 40° F. Total chilling time is usually 15 to 20 minutes.

After chilling, the carcasses are hung on the drip line and conveyed to the packing area. The drip line is designed to allow excess moisture to drain from the chilled carcasses prior to packing. The operational procedure varies from plant to plant. As the carcasses are moved from the chiller, they are hung by one leg in the shackles of an overhead conveyor called a drip line. The shackles are usually also weighing devices and thus this line is also a sizing line. It carries the carcasses over a receiving area and releases them according to size into bins. The length of the drip line is related directly to the estimated time necessary for adequate draining of chill water from each carcass, usually 2½ to 4 minutes.

Grading

In some plants, carcass grading is done next to the exit point of the chiller. In others it may be performed at various points before the birds reach the giblet stuffing station or sizing bins. Three to six workers especially trained to grade birds place them in the shackles of the drip line while removing under grade birds or birds with parts missing. Grading identification is based on either plant or USDA grade (10). Training and supervision of graders are under the direction of a Federal-State grader. Factors affecting product grade include body conformation, fleshing, fat cover, deformities, flesh and skin bruises, and such dressing defects as pinfeathers, disjointed or broken bones, missing parts, discolorations, evidence of misbleeding, tears, cuts, and abrasions.

Birds with missing parts are usually sent to a cut-up operation. Although such birds are considered undergrades, the parts when removed from the carcass can be grade A. In some plants, swivel shackles are used to separate carcasses of plant grade from those in USDA grade categories by turning the shackles. When the carcasses reach the sizing bins, those in USDA grades are tripped into bins on one side and those meeting plant grades into the others. In plants that pack whole-bodied birds and cut-up chicken for fast-food outlets, sizing takes place on the line ahead of where giblets are inserted into whole carcasses so that carcasses of specified weight can be tripped into special bins for the cut-up operations.

Packaging

Giblets are moved from the chiller onto a conveyerized belt or revolving table where a set of each consisting of a heart, gizzard, liver, and neck is wrapped manually and inserted into the body cavity. The wrapping material must meet USDA specifications. Wrapping giblets can be performed mechanically, but manual stuffing is required. An average of 8 persons is generally needed to wrap and stuff birds for each 8,000-bird-per-hour operation.

Several different-type packs are used, including ice, deep chill, snow, dry, and frozen. Ice-pack shipments still comprise over 50 percent of the whole-carcass market. The carcasses with giblets, including a range of weights,

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*Difference between a plant's grade and the USDA's grade for the same quality is generally a matter of degree, with the latter being more strict.*
are placed in wirebound wooden or corrugated wax-impregnated fiberboard boxes for shipment. The number of birds per box depends on the weight range (table 6).

<table>
<thead>
<tr>
<th>Birds per box (number)</th>
<th>Individual bird weights</th>
<th>Net weight per box</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lb</td>
<td>Lb</td>
</tr>
<tr>
<td>28</td>
<td>2.4-2.6</td>
<td>67-73</td>
</tr>
<tr>
<td>24</td>
<td>3.0-3.2</td>
<td>72-77</td>
</tr>
<tr>
<td>20</td>
<td>3.5-3.8</td>
<td>70-76</td>
</tr>
<tr>
<td>18</td>
<td>3.9-4.2</td>
<td>70-76</td>
</tr>
</tbody>
</table>

After boxing, ice is spread over the birds. For wirebound wooden boxes, the lid is secured with wire loops; for corrugated fiberboard boxes, the lid telescopes or is stapled to secure the contents. After packing, the boxes of birds are generally held in a cooler at 32° to 36° F prior to shipment on the same or next day. With ice keeping the skin moist and with conventional refrigeration, the chickens are pliable when unpacked. Some disadvantages include the melting ice, loss in the transporting payload, and a shorter shelf life than for birds held at colder temperatures.

The chill-pack system makes up approximately 25 percent of the whole-carcass market. It consists of several variations. In one, whole birds averaging 5 percent added moisture are placed four at a time on a bar-type trip shackles and conveyed slowly through a room with a 20° F air blast for approximately 1½ hours, causing a lowering of their body temperature 28°-29°. The birds are then released from the shackles to a conveyor belt, where they are graded and transported to the packing operation or cut-up line. Chilled parts are becoming increasingly popular and have made the largest increase in sales compared with other forms. In another variation, carcasses averaging 5 percent added moisture are cut up, packed in trays, wrapped in clear or embossed film, and placed in racks. The loaded trucks are passed through a blast freezer ranging from -20° to -40° and requiring 1 to 1½ hours.

Chill-pack whole carcasses or parts have many advantages. In most instances, they are prepackaged and prepriced before delivery to the retail outlet, shelf life is much longer than those ice packed, there is less weepage, skin color is more uniform, and they are easier to handle. One of the major disadvantages of chill pack is that special refrigeration is required to maintain sufficiently low temperatures throughout the distribution channels, retail storage cooler, and retail display cooler.

Carbon dioxide (CO2) in pellet or gas form is used to a limited extent. After carcasses are packed in a corrugated box, pellets of CO2 are placed on top of them. Otherwise boxes are handled in storage and shipping the same as for ice pack. Although the temperature is kept relatively low and the truck payload is greater, the condition of the birds tends to vary within a box from being cold and pliable to frozen.

Gaseous CO2 has also been used on a limited scale. It retards microbial growth. Boxes of chicken are wrapped with an impermeable film, and the air is evacuated and replaced by gaseous CO2. However, a problem arises when other organisms, whose growth is retarded by those growing in the presence of air, tend to grow rapidly in its absence. Nevertheless, the CO2 gas method has been used with some success because it permits larger payloads. More important than the effect of the gaseous atmosphere on retarding spoilage are the temperatures that have been used with it. Some spoilage problems associated with this method have resulted from failure to maintain a sufficiently low temperature.

Another packing method is the dry pack. Carcasses are cut up as they come from the final washer, packaged, and placed in a blast freezer at approximately -30° F for 1 to 1½ hours. Conflicting evidence exists regarding microbial quality; however, the method provides convenience for retailing.

Whichever packing method is used, workers are needed for packaging, weighing, placing the coolant in boxes, supervising, and shipping. Staffing for weighing and applying weight and size labels on boxes is also part of the package operation. Labor requirements generally average about 30 workers for each 8,000 birds per hour of processing capacity.

Further Processing

Further processing is a term originally used to identify the cutting up of broilers with missing parts, caused by trimming away defects, which necessitates removing a part or parts from the whole carcass. Although the term is still used to describe this type of salvage operation, it has also come to include the cutting up of whole-bodied birds with no defects to meet demands for broiler parts from a rapidly expanding market. This includes fast-food outlets, institutional users, and manufacturers of convenience food items who require parts cut from whole carcasses of a specific and frequently narrow weight range. Thus, further processing now also includes many other operations, such as boning and fabrication of poultry meat into specialty items.

Where further processing involves only a cut-up operation, it is generally conducted in the same facility where the other operations occur, such as killing, defeathering, eviscerating, chilling, sizing, and packing. Cutting up usually follows chilling, since to do it sooner results in a less tender product. The cutting operation can become complex, especially in plants where 50 to 60 different items are handled. They may include such variations as breast with back and wing attached, breast with ribs, boneless breasts, legs or drumsticks, and thighs. However, high labor costs and the varied experience required for operations of this complexity have brought about a trend toward deemphasizing custom preparation unless a large volume is involved. Usually basic cut-up operations are performed in processing plants rather than farther along the marketing channel because of economies of scale that are possible. Most cutting, including boning, continues to be performed manually.

Mechanized cutting uses motor-driven equipment with shielded circular blades to split the carcass into halves or into five, eight, or nine pieces. Machines are now also available for making such multiple cuts in one operation (4). The ready-to-cook whole carcass is moved
against several positioned blades by a spike-toothed chain. In the five-piece cut, the machine removes the legs, splits the breast into two pieces, and removes the backbone. The breasts and legs packed without backs have become a popular retail item. The eight-piece cut consists of the wings, thighs, drumsticks, and two pieces of breast. For the nine-piece cut, a part containing the clavicle or wishbone is removed by making a horizontal cut between the clavicle and sternum before splitting the breast. This cut is popular with fast-food firms because each piece weighs approximately the same. The parts can be conveyed to an assembly point for packing into plastic bags or they can be packed at the cut-up work station.

Generally 4 machines and 4 workers can equal the output of a comparable manual operation requiring 14 or more workers. A typical manual cut-up line using hand knives requires 14 to 18 workers to cut up 4,000 birds per hour. The five-piece cut includes cutting through the flank skin and cutting off the legs, cutting out the back, and leaving the breast to be split either manually or with a bandsaw. If an eight- or nine-piece cut is desired, the wings are removed before the breast and the drumsticks are separated from the thighs.

**Offal and Waste Treatment**

The offal consisting of heads, feet, viscera, inedible parts, condemned whole birds, feathers, and blood can be handled in two different ways. Usually all except the blood is floated from the processing areas to an accumulation area for removal by trucks. The offal is generally handled so that feathers and blood are separated from the other offal components for subsequent transporting. Rotating or vibrating screens of 50 to 100 mesh remove most of the water, leaving the solids to be taken to a rendering plant. Rotating drums are normally used for everything other than feathers and blood. Blood is pumped directly from the kill room to a storage tank, from which it is generally pumped onto the drained feathers in an awaiting truck. Since blood can contribute as much as 40 percent of the BOD load in the plant effluent, it is important to remove as much of it as possible before it enters the effluent-treatment system. An alternative method to using water for transporting offal is a dry offal system, which utilizes belts or vacuum.

Disposal of the liquid waste or effluent generally utilizes a primary and secondary lagoon-treatment system. Before the effluent reaches the lagoon, the fat is skimmed off in an open tank, then the effluent enters a primary lagoon, which uses large aerator pumps to spray the liquid waste into the air. Treatment time is dependent on the BOD load in the system. After aeration, the effluent enters a secondary treatment lagoon, where it remains until the BOD level is reduced sufficiently to meet Federal and State requirements. Afterward, the effluent is released into a stream or other body of water.

Some plants near large population areas discharge the effluent into a municipal water system after the fat and as many of the solids as possible are first removed.

A third method of waste treatment utilizes spray irrigation. The effluent passes through a fat and solids removal system and is then sprayed on sloping land with growing vegetation. The system depends on the available land, soil type, quantity and characteristics of the effluent, and the climate. Care must be taken not to create an anaerobic condition on the land caused by excessive amounts of fats and solids. A land slope of 2 to 6 percent is best to prevent pooling. Normally provision is made at the lower edge of the land plot to prevent runoff and contamination of streams.

Problems in the various handling and processing steps are related to the temperament and physical makeup of the broiler chicken and to the equipment, facilities, work methods, and workers employed in processing broilers into ready-to-cook food items. Explanations and suggestions for coping with them are presented here.

**Problems Related to Product**

Problems related to the product often begin during the growing period. Confinement rearing in large numbers with limited floorspace per bird encourages the natural nervousness and "flightiness" of commercial broiler flocks. Effective management requires gentle handling and slow nonstartling movements by workers in the broiler growing houses. Sudden movements or loud noises may cause birds to fly against feeders, water fountains, and roof support columns, resulting in bruise damage. If it occurs shortly before the birds are to be processed (within 2 to 15 minutes of slaughter and up to as much as 2 or 3 days before slaughter), yields can be affected by trimming losses. Also severe flightiness often causes birds to pile up in corners of the structure, resulting in death by suffocation. Caretakers should announce their arrival by gently knocking on the door or whistling before entering the broiler house. The use of red or blue artificial light during especially excitable periods also helps to quiet the birds.

A problem related to a product and sometimes to equipment that may show up during processing is the "oily bird syndrome." It pertains to moisture and subcutaneous fat released over the skin during processing. The integrity of the connective tissue, primarily in the hip and back areas, also breaks down to create pockets. Then during the chilling process, water enters and causes a problem due to the excess moisture. Identifying flocks and the percentage of affected birds involved serves to focus attention on the magnitude of the problem as well as probable causes. Possible field causes can be hot weather, nutritional imbalance regarding the type of fat contained in the feed, and its relationship to protein. At the plant level, high scald temperatures and pickers or roughers placed
too close to the birds may trigger the problem.

Another product-related problem that is also affected by grow-out equipment is the "scabby hip syndrome." This is a feathering problem related to nutrition, breeding, and medicating in combination with improper debeaking. A penalty factor that has been showing up in recent years, especially with the increase in cut-up broilers, is the bloody thigh and wing joint. It occurs most frequently when nights are cool and the days warm. There is speculation that grain stored in metal bins may build up enough mold toxin to cause fragile capillaries if such grain is used in broiler feed. This condition then contributes to mechanical injury from rough handling when live birds are picked up.

Many processing problems are indirectly related to the age of the bird and its fragility at 7 to 8 weeks when slaughtered. Often birds are injured from rough handling or damaged by machines and equipment that are operated at high speed processing rates and that may not be properly adjusted or maintained.

Equipment and Operational Problems

In handling live birds, problems may arise from bruising, death from heat, or suffocation because of improper broiler houses, equipment, live handling facilities, and work methods. At one time the major part of the bruise damage was assumed to be principally the fault of the live handling crews. However, research has found that a considerable amount of bruising takes place before the crews arrive (18), and even then they should not be blamed for all that occurs during the catching operations.

Building support columns, especially those on cement block bases, invite bruise damage, as do stationary feeders, water troughs, and other equipment or fixtures that cannot be moved. But even with close supervision, it is difficult to minimize bruise damage.

Besides the broiler house and its fixtures and the work habits of the employees, the coops can be a source of problems in live handling. It is difficult to provide adequate ventilation in plastic coops, which cause a greater number of DOA (dead on arrival) losses in hot weather. Coops constructed of hard wood with unpadded coop door openings and floors contribute to increased bruise rates. The dimensions and the weight of loaded coops make handling difficult for one person and often result in rough handling practices, i.e., dropping or tossing them during unloading at the plant.

Other coop-related problems can be caused by not thoroughly washing the coops before reloading. This is due to the growers' refusal to accept the shrink from the broiler house to the plant that is attributable to feces from the birds that would of course be removed by proper washing. Furthermore, washing of wooden coops would add considerable yet inconsistent weight so that it would be impossible to determine an accurate tare weight. Failure to wash coops after each use not only increases the hazards of spreading avianborne disease from farm to farm but also contributes to littering highways and increasing bacteria buildup in the scalders from filth and dust on the feet and feathers of the birds as well as dust accumulate in coops.

When the birds reach the coop unloading area at the plant, problems tend to be related mainly to the facilities, equipment, and work methods used in processing, although occasionally problems may be associated with the broiler itself.

Stunning Machine. In modern processing operations, the first processing equipment is the stunner. The one most commonly used today has a liquid medium, usually brine, to transmit an electric current to the heads of the birds on the line. The stunning time is approximately 7 seconds per bird.

Different types of stunners are now in use. A standard alternating current (a.c.) type operates on a 60 HZ frequency, whereas the high frequency a.c. one uses approximately 400 HZ. Stunners using direct current (d.c.) are of the high voltage or pulsed type using 100 volts. If a plant has an a.c. circuit, 50 volts is recommended, whereas a 90-volt setting is recommended for d.c. circuits. The voltage should not be so high as to cause wing breakage, flutter, and other gross body movements prior to the bird entering the killing machine. Movement reduces the loss of blood and prevents accurate head alignment at the killing machine. During the summer, from 12 to 15 seconds between the stunner and killing machine should be sufficient to insure proper bleeding. In the winter, the time should be increased to 18 seconds because of the slower pulse and respiration rates. Stable and complete contact between the bird and stunner is necessary for satisfactory stunning. Assuring that the feet of the birds are wet to provide a positive contact will result in a more complete stun. This can be accomplished by directing a fine water spray on the shackles prior to their entering the stunner.

Killing Machine. The killing machine is positioned so that a sufficient time lag occurs between stunning and bleeding. If stunning has been conducted properly, the bird reaches the killing unit in a quiet state and thus assures an accurate cut. Improperly spaced rollers of the killing machine, which move the bird's neck past the cutting blades, are frequently set too close together and crush the vertebrae. This causes death before bleeding is completed and can result in downgrading due to misbleeding. Crushed vertebrae also cause bone fragments to become embedded in the neck skin and muscle tissue. This affects product condition and can result in a penalty under wholesomeness regulations.

The cutting blades of the killing machine should be checked every 8 hours and cleaned twice daily followed by spraying with light mineral oil.

Scalder. The scalder loosens the feathers necessary for mechanized de-feathering. It is important that the water temperature (approximately 126° F depending on flock conditions) be

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1In most European countries, all coops are washed to minimize interfarm contamination coop waste materials.

For the most part, plastic coops are used.

1Hertz = Hertz / cycles per second
maintained uniformly throughout the length of the unit. A simple but effective method of monitoring the tank for undesirable cold spots includes drilling ¼-inch holes in the sides of the scalder at critical points and inserting regular picking fingers, with a little hole in the closed end to accommodate a steel-shafted thermometer. The location and extent of cold spots can thus be accurately determined. Increased line speed or additional impellers to provide greater circulation of water in the scalder will usually correct the problem.

Too high a scalder temperature will allow removal of the outer epidermal layer and cause a “barked” or uneven skin color. This is due to the loss of moisture and results in a shiny area with a brown perimeter. Up to 30 percent of the skin color can be removed by increasing the scalding temperature from 121° to 129° F.

At 128° to 130° F, redness increases in the feather tracts, affecting the appearance of the birds significantly. Thus a careful control must be maintained of the scalder water temperature to bring about feather release while not adversely affecting the appearance of the carcass. Also, too high a scalder temperature tends to heat the surface muscles, especially in the breast area, and causes a shortening of the muscle fibers and irreversibly toughens them. A high scalder temperature can also accentuate the “oily bird syndrome” (see p. 30) by softening the connective tissue of the skin and making it more susceptible to loosening during the picking operation.

Several products containing wetting agents are available to add to the scalder water to aid penetration of the feathers and to raise the pH level of the scalder water. By increasing the pH to 8.5–10.5, more of the epidermis or outer skin layer can be retained even at higher scalding temperatures. For markets that prefer a highly pigmented broiler, addition of a scalding aid may be economically feasible when broiler growers are paying premium prices for feed to produce yellow-pigmented skin. The addition of a wetting agent permits the use of a lower scalder temperature.

Roughers. The roughers present few problems if basic requirements are observed. Picking machines should be positioned in close sequence so that the skin temperature of the bird remains about the same from the scalder to the rougher. Banks of picking fingers should clear their opposite numbers readily, yet be sufficiently close to remove feathers without skin abrasion or bone breakage (wings). This requires carefully checking the fingers and making adjustments from one flock to the next when birds vary in size. Worn or broken picking fingers should be replaced daily.

Conveyor Lines. Conveyor line wear and losses due to line shutdowns can be minimized and maintenance costs reduced by avoiding horizontal and vertical curves wherever possible. Automatic conveyor line lifters should be installed over the scalder and the roughers to prevent overscalding or overpicking when an emergency stops the line movement. If a line lifter is not provided for the roughers, cutoff switches should be installed.

Hock Cutters. Hock cutters that are not adjusted to the size of the birds will cut through the legs at a point above or below the hock joint. If the latter occurs, an additional worker will be needed to trim away a part of the remaining shank. If the former happens, some of the drumstick will be removed, and the part may become a loss item. The adjustment of the hock cutter must be carefully checked for the bird size of each flock processed.

Evisceration. Eviscerating requires the largest number of employees and machines in the entire processing operation. Here the broiler carcass is opened, manipulated by machine, and handled frequently, all of which increases greatly the opportunities for contamination and costly reductions in yields. Consequently, the greatest number of problems both complex and simple are associated with evisceration. Solving or avoiding them includes proper machine performance, employee training, close supervision, and a continuous check on product condition.

The importance of hand knives, the sharpening of the required cut(s) but also on how to care for the knives including use of the sharpening steel. Special instructions and training should also be given to the individual assigned to knife sharpening. Cutlery companies generally can provide printed and pictorial instructions on proper sharpening procedures. For encouragement of worker cooperation, it is helpful for each worker’s knives to be properly identified and turned in after each work shift. The practice of some plants to require workers to buy their knives when starting on the job nearly eliminates their disappearance.

Supervision. For monitoring the performance and accuracy of the operations preceding USDA inspection, supervisors can make several relatively simple checks. Removal of edible tissue with excision of the preen or oil gland sac (either manually or by machine) can be checked by examining for fragments of edible tissue attached to the gland in the effluent. Adequate training of the worker and the way the birds are presented can overcome potential problems in manual operations, whereas proper machine adjustment can eliminate problems in mechanized operations. Incomplete removal of the preen gland can be observed by examining birds on the hangback rack at the inspector’s work station or before they reach the official inspection station.

Carelessness in making the opening cut and removing the vent and dull equipment or improper procedures can be detected by observing the number of birds affected, the location on the carcass, and the reasons for the need to trim by examining the lot tally sheet at the inspection station. Improper removal of viscera manually can be detected by noting unusual amounts of abdominal fat in the offal or in the flow-away trough. Inaccurate or careless adjustment of an automatic eviscerating machine is reflected by the frequency that viscera are incompletely removed from the birds and livers are damaged.

Provided for the inspector to temporarily hold birds that need reprocessing to be acceptable for wholesomeness.

Removal of shank fragments, breast blisters, bruises, and broken wings at the trim station also confirms improper machine adjustment, live handling, and rearing practices.
When trimming losses are unusually high or increase suddenly, the training of the worker assisting the USDA inspector may be responsible. This individual trims unwholesome tissue and parts from the carcass. Frequently an overenthusiastic, improperly trained, or careless trimmer removes an excessive amount of tissue surrounding an unwholesome area or part. This practice can be determined by examining the trimmed birds and the discarded parts and tissue. Excessive trimming can reduce yields considerably if the problem is not controlled promptly. Cooperation of the USDA inspector is essential for correcting the situation.

**Sequential and Hands-Off Inspection.** Sequential and hands-off inspections are recent modifications being considered to improve the official inspection operation. They have created interest in developing equipment that will make the methods more readily workable in commercial plants. This will result in operational and equipment-related considerations for this activity (see footnote 8, p. 26).

**Giblet Removal.** Removing the heart, liver, and gizzard from the viscera, referred to as giblet harvesting, often causes loss of parts of the liver when the gall sac is separated from it. A hurried, careless, or untrained worker may pinch off a part of the liver to avoid rupturing the gall sac. Examining the livers carefully as they arrive at the giblet wrapping station or closely examining them while in the giblet chill medium or in the discarded viscera will reveal losses from improper techniques. Corrective measures may include retraining the workers.

When the gizzard is removed from the viscera and subsequently trimmed, edible parts are often discarded. Also, excess fat is frequently lost when the linings are being removed by allowing gizzards to accumulate against the peeler rollers. Alert and adequate staffing of the gizzard peelers can minimize the problem.

**Lung Removal.** Tying down the activating trigger on manually operated vacuum units used to remove the lungs often causes loss of edible tissue. Properly trained and supervised workers will eliminate such losses. Another more recent problem relates to noise levels created by both manually operated vacuum units and automatic machines that generally exceed 95 decibels. OSHA regulations (29 CFR, 1910.95) state that levels above 95 decibels cannot be exceeded for more than 4 hours. Employees exposed to the higher levels for more than 4 hours may have to be rotated. It is advisable that workers' hearing be protected by noise muffing devices such as specially fitted earplugs.

**Final Bird Wash and Other Water Usage.** Proper washing of the eviscerated carcass not only removes loose tissue fragments and bacteria to increase product shelf life but helps reduce body temperature because of the large quantity of water used. Much of this water is often wasted because of malfunctioning spray nozzles or misdirected spray patterns with improper size droplets. Research has shown that a low volume of water with appropriate droplet size, properly directed, and with high velocity greatly minimizes the water needed for final bird washing to reduce the bacteria load and tissue fragments remaining on the ready-to-cook bird.

In monitoring water usage, the installation of flow valve meters is effective for spotting operations or areas where too much water is used. Periodic checks will reveal the times of day that water usage may be excessive. Strive for a goal of 5 gallons of water per bird. Excessive water usage can be caused by continuously running spigots, toilets, and unrestricted spray nozzles. Other losses result from water not reclaimed from unenclosed vacuum pumps, lack of an enclosed condenser system, leaky steam fittings, and too great a flow into scalders and chillers. Heat and cold exchangers used to augment fuel and refrigerant needs can reduce energy requirements.

**Chilling.** Immersion chilling in a mixture of ice and water after the final bird wash greatly reduces the spoilage hazards of ready-to-cook chicken, but it creates problems of excessive moisture uptake and retention.

Under USDA inspection regulations (28), the percent tolerances of moisture uptake permitted prior to packing are specified. Moisture losses (weepage) of ice-packed birds en route to the retail store, wholesale dealer, or institutional buyer necessitate that the net weight of shipping containers should exceed the marked weight by the amount of the anticipated weight loss in transit. If underestimated, short weight claims and customer dissatisfaction at destination can result. Economic losses can accrue to the processor when an excessive overweight allowance is made to avoid destination shortage claims. For overcoming this problem, yet retaining the advantages of immersion chilling, various methods of chilling the product to a temperature slightly below freezing have become increasingly popular (sometimes referred to as "crusting" of the product). Although this has alleviated weepage, added to shelf life, and increased payloads, problems still exist in maintaining consistently low chill temperatures in retail holding rooms and display counters.

**Equipment Maintenance.** Finally, one of the most costly oversights of plant management is failure to set up an adequate preventive maintenance program for equipment. Maintenance programs are too often the assigned responsibility of a shop and service crew that only repairs or replaces equipment that has failed. This procedure overlooks the costs that result when production workers are idle while repairs are being made during operating time, the hazards to product quality, and the loss of customer goodwill that results if a shutdown causes late deliveries of the finished products.

An effective preventive maintenance program can also reduce the incidence of serious accidents and resulting sick pay compensation that can lead to increased insurance rates. Equipment maintenance programs should be viewed as a method for maximizing performance for each piece of equipment.

An ideal starting point is to schedule electric motor servicing. This includes removing motors from service at regular intervals to avoid predictable breakdowns based on past experience. At the time a motor is removed from the line, a standby motor can be installed temporarily while the one removed is being restored to good working order. Servicing might include examining, repairing, and rewinding the starter (three-phase motors). Waterproofing should be examined to

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*Occupational Safety and Health Administration, U.S. Department of Labor.*

33
Quality Assurance

determine if it is still effective. A servicing maintenance log should be maintained in the motor control room to record the unit number, date of service, type of service performed, and location on the line. Similar servicing should be scheduled for gear boxes, compressors, and pumps. Service schedules can be initiated at any time. Manufacturers’ recommendations should be followed in selecting lubricants, packing materials, and so forth.

Conveyor bearings and wheels should be checked for wear as should drive belts and chains. Belts should be replaced at regular intervals before checking or fraying begins. All replacements should be recorded in the maintenance log, which is kept current. The tension of overhead conveyors and the condition of shackles and other similar equipment should be checked daily. Broken or worn fingers of the picking equipment should be replaced during daily inspections. Incandescent light bulbs and fluorescent light tubes should be replaced prior to the expiration of the life expectancy based on the hours of usage recorded in the maintenance log.

Types of Programs

Quality assurance programs are designed to aid in producing products that conform consistently to a firm’s objectives. The market segment to which a company directs its sales will dictate, in part, those factors that should be incorporated into the program. For example, a precooked chicken operation, including battering, breading, or both, does not require a yellow-skinned carcass, whereas uncooked, chilled, ready-to-cook broilers displayed at retail in transparent plastic wrap with yellow skin may be a requisite in some markets. Each firm must design a quality assurance program to meet its particular needs.

In most firms having more than one processing plant, a director of quality assurance reports directly to top management, usually to the president or chief operating office. Each of the plants usually has two or more quality assurance supervisors with one of them in charge. The basis for this arrangement is to centralize all processes. The processes of hiring and discharging quality-control supervisors, their salary, merit raises, and the methodology to assure product consistency are all the function of the director of quality assurance. This system is thought to promote responsiveness and loyalty. The quality assurance supervisor in the plant must communicate daily with the plant manager if the program is to minimize quality problems. Complete records must be maintained to predict potential problems and should be prepared for top management, including the quality assurance director, production manager, and (bird) grow-out supervisors.

Quality assurance programs may also be structured so that the responsibility for quality assurance is that of the plant.

Checklist and Discussion

The following checklist may be useful in determining the effectiveness of the quality assurance program:

- **Checkpoint**
  - Receiving dock
- **Items to be checked**
  - Average live weight
  - DOA (dead on arrival)
  - Feathering
  - Weather

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**Processing Lines**

- Fleshing
- Color
- Breast blister incidence
- Bruising - leg, wing, breast
- Rough backs, barebacks, dry hip areas
- Bloody thigh and wing joints
- Red wing tips
- Barking
- Broken wings
- Backs partially removed
- Condemnations
  - "Oily" birds
  - Leaf fat, giblets, and whole birds in waste troughs
  - Moisture pickup
  - Trim losses
  - Finish line speed
  - and empty shackles

**Packing**

- Grade count
- Assured quality level (AQL)

**Receiving Dock.** Average live weight should be determined by management of the grow-out operation for each load of live birds received. Wet weather can cause live birds to pick up moisture, affect the accuracy of the live weight determinations, and cause a plant to erroneously show a yield loss. Average live weight will also reflect bird shrinkage from catching time to weighing and processing. Feathering conditions should also be determined and recorded for each load, with the information given immediately to the picking room foreman so that machines can be properly adjusted. The condition of the feathering is affected by breed, nutrition, and age. Since weather can also have an effect, temperature and precipitation information should be recorded (see p. 30).

**Processing Lines.** Fleshing is one of the most important quality assurance factors since it provides a check on the adequacy of the diet and whether good management practices have been followed. The width of the breast near the end of the keel (breastbone) pro-
vides the best index since fleshing at the front of the breast is generally ade-
quate. Fleshing can be measured in two ways. One method uses a breast angle meter, which is placed about half inch from the front of the keel. This provides an objective measurement, which ranges from a value of 50 to 100. Conformation, or the shape of the body, will affect the reading. A subjective method for quality measurements uses a number from one to four or five, with values agreed upon by the various management divisions of the company.

A numbering system can be used also for measuring skin color, e.g., 1 = white, 2 = creamy, 3 = golden, and 4 = orange. Measuring the color of a sample of breast skin on a color difference meter can provide an objective method of evaluation. Serum xanthophyll de-
terminations from blood drawn prior to slaughter can also be used where adequate laboratory facilities exist. The skin color of birds during the grow-out period can be affected by coccidiosis, other diseases, emaciation, or a subnormal level of xanthophyll in the ration. At the plant, scald temperatures above 126°F can result in "barking" during picking that removes some of the outer or epidermal layer of the skin and causes an uneven color.

Breast blisters are a major factor that contribute to downgrading and yield loss. Their incidence can be measured as a percentage of a flock or by esti-
mating the number of blisters that would have to be trimmed on a sample of the flock. The data can be helpful to grow-out management since the blisters usually occur during the growing period. They may result from leg weakness or moist litter (above 26 percent moisture). Caked, damp, manure-
laden litter in the grow-out houses can cause blisters that appear as raw, red, or brown areas on the breast. Bruising of the legs, wings, and breast can be indicative of problems at the field, live haul, or plant levels (see p. 30). As a general rule in identifying the source of bruises, determine the approximate time when the bruise was inflicted. Research has shown that the color and its intensity can be directly related to the lapse of time between where the bruise was inflicted and when it was observed (9). For example, yellow, green, or purple bruises proba-
bly are inflicted during grow-out be-
fore the plant handling crew arrives (24 or more hours before pickup); deep-red or purple bruises probably occur during catching, cooping, and hauling (4 to 6 hours before slaughter); and pink or bright-red bruises are proba-
bly inflicted during unloading and hanging (2 to 15 minutes before slaugh-
ter).

A flock sample should provide clues as to the approximate time and probable causes of bruises as well as the rate at which they occur. In processing, the bruised areas must be trimmed, or if serious, the part must be removed.

Checking for rough-feathered or bareback birds on the line can substit-
tute for making a feather check at the receiving dock and is a more objective and reliable indicator of feathering problems.

A common problem is characterized by a rough, dry hip area. In extreme cases, a condition termed "scabby hip syndrome" may show evidence of scratches in the same area (see p. 31).

Checks for bloody thigh and wing joints can be made periodically. The best location for conducting this check is at the cut-up operation, where the opened wing and thigh joints can be examined. The percentage of a flock affected, based on a sample, can pro-
vide historical documentation of the presence or absence of this problem (see p. 31).

Red wing tips are caused by impro-
per bleeding at the time of slaughter. An assurance check for this condition will determine the adequacy of the stunning and killing procedure in a plant as well as the need for seasonal adjustments.

Quality assurance checks of the per-
centage of the birds "barked" (removal of patches of outer skin) are necessary to determine whether the scald time and temperature are correct (see p. 32).

Broken wings are a problem usually caused by improper plant procedures (see p. 32).

The number of birds with a part of the back removed because of fecal contamination around the tail area is recorded on the USDA inspection tally sheets. Fecal contamination, whether field or plant caused, can be mini-
mized or avoided. A high salt level in the feed, excessive water intake in hot weather, and hauling stresses all con-
tribute to loose feces and potential contamination problems. Birds off feed for more than 12 hours start to develop loose feces, and after 24 hours a wetery condition develops. A nicked intestine near the cloaca during evisceration releases feces causing contamination (see p. 26). Intestines drawn free of the bird by accident are hung on the shackle above the birds, but if not posi-
tioned properly, they can fall on the bird and contaminate it.

The number of condemned birds is recorded by the worker assisting the USDA inspector and provides valuable information to the field staff about dis-
ases and abnormalities that exist in the growing operations. Parts missing (trim loss) and condemnations caused by contamination each tells a story in an aggressive quality assurance pro-
gram (see p. 27).

High yield losses can be avoided by a quality assurance check on the birds and giblets that appear in the waste troughs or in the offal collection area (see p. 30).

Moisture pickup data are required by the USDA Inspection Service on a daily basis. Checks made at the begin-
inning of a labor shift indicate what chilling operation adjustments are neces-
sary for regulatory compliance. In addition, live haul procedures may also have to be adjusted when excess or in-
consistent moisture losses occur.

Trim loss data indicate to a plant manager whether yield variability is attrib-
utable to field or plant conditions. Data on bruises, breast blisters, broken bones, or barebacks help to identify causes and also provide useful informa-
tion when the output of a USDA grade A product is low.

Finish refers to the amount of fat deposited under the skin, and it is es-
pecially noticeable in the areas be-
tween the feather tracts. A blue or fleshy color indicates lack of finish and can be attributed to nutritional or disease problems (10). A subjective scoring system can provide useful data.

Periodic checks of processing line speeds and the number of empty shackles can reveal either actual or potential plant problems that can con-
tribute to lost revenue, reduced prod-
uct yield, or fewer birds processed per hour. Plant losses can be calculated from the number of empty shackles or
the reduction in the number of birds per minute due to line speed slowdown.

Not only are sanitation checks required by the USDA but they should be a part of the plant’s quality assurance program. Unsanitary conditions affect the shelf life of the product. Daily microbial counts and visual examination will indicate whether plant cleanup is adequate. Determine whether sufficient quantities of detergent are used and that overusage is not occurring. This one check can save thousands of dollars a year in lost customers or in wasted detergent.

The Assured Quality Level (AQL) program, guided by a joint government-industry committee, is voluntary and national in scope for broilers, fowl, turkeys, and ducks. Its purpose is to assure good processing workmanship on poultry leaving the plant. Workmanship standards were developed and the responsibility for meeting them became an industry objective. Line speed, except when associated with excessive contamination of carcasses and high incidence of disease, is the responsibility of each plant operation. Bird defects were divided into major and minor categories, as illustrated in the AQL guidelines (exhibit 1). Ten birds as a sample are examined after chilling at hourly intervals during each shift and all defects are recorded. If the limits established for major and total defects are exceeded at any time, a more rigorous sampling procedure is required and all birds not meeting the criteria are reprocessed. The AQL program is a useful tool for identifying problems of workmanship or equipment operation and is considered an integral part of a sound quality assurance program.

**Packing.** An indication of how the entire operation from hatchery to plant has performed according to accepted operating procedures is the pack-out data by grades. The percentages of each grade reflect those areas of the operation that might need attention. In addition, weights should be checked daily for the percentage of boxes or crates of the total production that are being held in the cooler at a given time. The number of birds packed per box and the individual weight of each should be checked to ensure that proper sizes have been included with the proper minimum weight average per box.

**Cut-Up Weight.** In a cut-up operation, two quality assurance checks should be instituted. The quality of cut-up parts leaving the plant should be checked to insure that only top quality and uniformly cut products are being packed. Product yields of the cut-up operation should also be checked to monitor for possible losses. Approximate percentages of live and dressed parts to the whole bird are shown in table 7.

### Table 7.—Live and dressed weights of various broiler parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Live weight</th>
<th>Dressed weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td>Wing joint:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First</td>
<td>0.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Second</td>
<td>2.6</td>
<td>5.6</td>
</tr>
<tr>
<td>Shoulder</td>
<td>4.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Whole wing</td>
<td>8.3</td>
<td>14.4</td>
</tr>
<tr>
<td>Whole leg</td>
<td>9.9</td>
<td>34.5</td>
</tr>
<tr>
<td>Drumstick</td>
<td></td>
<td>17.0</td>
</tr>
<tr>
<td>Thigh</td>
<td></td>
<td>17.5</td>
</tr>
<tr>
<td>Back</td>
<td></td>
<td>24.7</td>
</tr>
<tr>
<td>Trimmed because of</td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td>contamination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breast</td>
<td></td>
<td>26.4</td>
</tr>
<tr>
<td>Liver</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>.9</td>
<td></td>
</tr>
<tr>
<td>Gizzard</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>5.0</td>
<td>7.6</td>
</tr>
<tr>
<td>Kidney</td>
<td>.6</td>
<td>.9</td>
</tr>
<tr>
<td>Testes</td>
<td></td>
<td>.15</td>
</tr>
<tr>
<td>Oil gland (excessive trim)</td>
<td>.2</td>
<td></td>
</tr>
<tr>
<td>Abdominal and gizzard fat</td>
<td>2.7</td>
<td>3.5</td>
</tr>
</tbody>
</table>

*In addition to loss in yield that can be expected from removal of various parts, live haul accounts for 0.25 percent shrink per hour after pickup. A breast blister will average 0.53 percent of a bird’s breast weight.*
### ON LINE INSPECTION OF READY-TO-COOK POULTRY

### PRODUCT & CODE (Check one):
- Young Chickens 1121 □
- Light Fowl 1122 □
- Heavy Fowl 2122 □
- Ducks 1124 □
- Light Stags 3122 □
- Heavy Stags 4122 □
- Young Turkeys 1123 □
- Mature Turkeys 2123 □
- Fryer Roaster Turkeys 3123 □

### CODE
- 1121
- 1122
- 1124
- 3122
- 4122
- 1123
- 2123
- 3123

### DEFECTS PER BIRD

<table>
<thead>
<tr>
<th>DEFECT</th>
<th>SUBGROUP</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 1/32&quot; or less = 1; 6 to 10 = 2; 11 to 15 = 3; etc.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Crop = 1.</td>
<td>Minor</td>
<td></td>
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<tr>
<td>4. Intestine = 1.</td>
<td>Minor</td>
<td></td>
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</tr>
<tr>
<td>6. Close = 1.</td>
<td>Minor</td>
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<td></td>
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<tr>
<td>7. Feathers 1&quot; or longer.</td>
<td>Minor</td>
<td></td>
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</tr>
<tr>
<td>8. Stains Each incidence more than 1/32&quot; to &amp; including 1/2&quot; = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>9. Stains Each incidence greater than 1/2&quot; = 1.</td>
<td>Minor</td>
<td></td>
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<tr>
<td>10. Grease - Wax Specks, 1/32&quot; or less = 1.</td>
<td>Minor</td>
<td></td>
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<tr>
<td>11. Grease - Wax Each incidence more than 1/32&quot; to &amp; including 1/2&quot; = 1.</td>
<td>Minor</td>
<td></td>
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<tr>
<td>12. Grease - Wax Each incidence greater than 1/2&quot; = 1.</td>
<td>Minor</td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>13. Unidentifiable Foreign Material Specks, 1/32&quot; or less = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>14. UFM Each incidence more than 1/32&quot; to &amp; including 1/2&quot; = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>15. UFM Each incidence greater than 1/2&quot; = 1.</td>
<td>Major</td>
<td></td>
<td></td>
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<tr>
<td>16. Burs of Fabricius (Rosebud) = 1.</td>
<td>Major</td>
<td></td>
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<tr>
<td>17. Windpipe = 1.</td>
<td>Major</td>
<td></td>
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</tr>
<tr>
<td>18. Oesophagus = 1.</td>
<td>Major</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Reproductive Organs = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Reproductive Organs = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Lung 1/4&quot; or less: Each 2 or less = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Lung Each incidence greater than 1/4&quot; &amp; less than whole organ = 1.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Oil Glands Each 2 or less fragments = 1. Maximum of 2.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Shanks Each incidence of both condyles covered = 1. Maximum 2.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Feathers or Protruding Pinfeathers 5-10 = 1, 11-15 = 2, 16 or more = 3.</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number Defects in sample - Cumulative Number Defects - and Limits of defects allowed.
The main purposes of poultry processing are (1) to remove soil, dust, and unwanted components of the bird, such as blood, feathers, viscera, feet, and heads; (2) to keep contamination by microbes minimal, especially those that can cause food poisoning and spoilage; (3) to retard their future growth by chilling or freezing; and (4) to change the form (e.g., further processing) and conditions (e.g., packaging) of the product. Processing has other functions, but these are primary considerations. Removal of the unwanted parts has the general effect of reducing the microbial levels, except when removing the viscera. Fecal material and crop contents can be prime sources of bacteria that may cause food poisoning. The soil and dirt on feathers, feet, skin, and other parts of live birds also harbor large numbers of microbes. Although most of them are innocuous and of little concern in either food poisoning or spoilage, some are harmful and should not be overlooked.

The differences between microbes that cause food poisoning and those that cause spoilage are worth noting. The former consists of two kinds: Those that can form toxins by growing in or on a food and produce illness in the consumer and the other types, which, if ingested, multiply in the intestinal tract and produce toxins that cause illness. Virtually without exception the food-poisoning microbes do not produce the usual signs of spoilage or an “off” condition in the food. However, certain clostridia may cause off-odors in canned foods. Spoilage microbes, on the other hand, cause the development of off-odors and off-flavors, slimy surfaces, color changes, and related defects (2). There is no evidence that they cause illness in humans.

In general, procedures for preventing or minimizing contamination from food-poisoning microbes are also effective against the spoilage types. There is, however, one major exception. None of the major true food-poisoning organisms will produce toxins below 40°F. Thus refrigeration of food at 40°F or lower will effectively control food-poisoning microbes, but it will only slow the growth of those that cause spoilage. However, some pseudomonads, being psychrophiles, grow rapidly at refrigeration temperatures.

**Important Microbes**

**Human health hazards of microbial origin from poultry can be of two kinds:** Poultry diseases transmissible to humans and food-poisoning microbes. Theoretically as many as 26 diseases of poultry can cause disease in man, but experience has shown that such occurrences are either nonexistent or of very minor significance with one exception. Ornithosis caused by a virus has on several occasions been transmitted from infected poultry to processing plant workers, but no transmission to consumers has been reported.

Other viruses, fungi (yeasts and molds), parasites, and bacteria that cause poultry diseases are not known to be hazardous to humans, again with one exception. Salmonellae cause diseases in poultry and can also cause serious infections in man. A major human health concern in poultry processing is to control and minimize the numbers of bacteria on poultry meat that can cause food poisoning. The more harmful bacteria and the symptoms they produce in humans are shown in table 8.

**Clostridium botulinum.** Botulism is the most serious and highly fatal type of food poisoning affecting man. Fortunately it is also among the most rare and has no known significance for fresh or frozen raw poultry. Poultry meat canned or vacuum packaged in oxygen-impermeable flexible containers, however, is a potential source of botulism toxin unless proper precautions are taken. For canned products, minimum processing times and temperatures must be strictly observed. Metal can seams and closures must be carefully monitored to avoid defects that might permit contaminates transfer during immersion cooling of filled containers. Samples of each pack are usually tested in a hot room to check for adequate processing. Cooked products packed in gas-impermeable packages should be kept frozen since there is always the possibility that such products, unless frozen, might at some time exceed a temperature of 40°F and allow bacteria to grow and produce toxins. Cured products in gas-tight packages may be kept refrigerated at less than 40°F after the nitrite used in curing inhibits C. botulinum. This bacterium is anaerobic, i.e., it grows only in the absence of oxygen and is widely distributed in nature. Since it forms spores that can survive adverse conditions for long periods of time, the spores can be assumed to be present frequently on processed poultry. The conditions under which these spores germinate to produce growing cells and toxin are unique (warmth over 40°F and absence of oxygen). The botulinal toxin is destroyed by thorough cooking. This is another reason why fresh or frozen raw poultry has never been implicated in poisoning humans.

**Staphylococcus aureus.** The most prevalent and familiar kind of food poisoning is caused by this bacterium. As with botulism, illness is caused not by the organism itself but by toxins elaborated by some strains during growth in foods before they are eaten. S. aureus frequently causes a variety of infections in man and animals. They range from localized pus-containing lesions, such as infected scratches, cuts, pimples, and boils, to more generalized and systematic lesions. Apparently healthy persons frequently carry S. aureus in the nose and throat and on the skin. Workers in poultry processing plants are a major source of this bacterium, but it is also present in many areas of the environment. Present knowledge and technology are unable to eliminate all Staphylococci from raw poultry meat, but gross contamination can be prevented. Refrigeration is highly important in controlling this bacterium since it will not grow below 40°F. Toxins may be formed when poultry meat is undercooked or is held in a warm place (40°F - 140°F) for several hours after cooking and recontamination occurs.

**Salmonella.** The frequent occurrence of salmonellae in raw poultry meat has created considerable concern because it can cause an extremely serious disease in humans, especially in the very young, the old, and the infirm, occasionally resulting in death. Processing plant workers can be carriers and thus contaminate carcasses, but the most important source is from infected live poultry. Estimates vary as to the percentage of carcasses in which salmonellae are present. When an infected flock is processed, a high per-
Table 8.—Characteristics of important bacterial food intoxications and foodborne infections

<table>
<thead>
<tr>
<th>Disease</th>
<th>Causal agent</th>
<th>Time of onset</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botulism</td>
<td><em>Clostridium botulinum</em> A. B. E. F. toxin.</td>
<td>Usually 1 to 2 days; range 12 h to more than 1 wk.</td>
<td>Difficulty in swallowing, double vision, and difficulty in speech. Occasionally nausea, vomiting, and diarrhea in early stages. Constipation and subnormal temperature. Respiration becomes difficult, often followed by death from paralysis of respiratory muscles.</td>
</tr>
<tr>
<td>Staphylococcal food poisoning.</td>
<td>Staphylococcal enterotoxin.</td>
<td>1 to 6 h; average 3 h.</td>
<td>Nausea, vomiting, abdominal cramps, diarrhea, and acute prostration. Temperature subnormal during acute attack may be elevated later. Rapid recovery - usually within 1 day.</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td><em>Salmonella</em> spp. (specific infection).</td>
<td>Average about 18 h; range 7 to 72 h.</td>
<td>Abdominal pain, diarrhea, chills, fever, frequent vomiting, and prostration. Duration of illness - 1 day to 1 wk.</td>
</tr>
<tr>
<td>Shigellosis (bacillary dysentery).</td>
<td><em>Shigella sonnei</em>, <em>S. flexneri</em>, <em>S. dysenteriae</em>, <em>S. boydii</em>.</td>
<td>Usually 24 to 48 h; range 7 to 48 h.</td>
<td>Abdominal cramps, fever, chills, diarrhea, watery stools (frequently containing blood, mucus, or pus), spasm, headache, dehydration, and prostration. Duration - a few days.</td>
</tr>
<tr>
<td>Enteropathogenic <em>Escherichia coli</em> food poisoning.</td>
<td><em>Escherichia coli</em> serotypes associated with infant and adult infection.</td>
<td>Usually 10 to 12 h; range 5 to 58 h.</td>
<td>Headache, malaise, fever, chills, diarrhea, vomiting, and abdominal pain. Duration - a few days.</td>
</tr>
<tr>
<td><em>Clostridium perfringens</em> food poisoning.</td>
<td><em>Clostridium perfringens</em>.</td>
<td>Usually 10 to 12 h; range 8 to 22 h.</td>
<td>Abdominal cramps, diarrhea, nausea, and malaise; vomiting very rare. Rapid recovery.</td>
</tr>
<tr>
<td><em>Bacillus cereus</em> food poisoning.</td>
<td><em>Bacillus cereus</em>.</td>
<td>Usually about 12 h; range 8 to 16 h.</td>
<td>Similar to <em>Clostridium perfringens</em> food poisoning.</td>
</tr>
<tr>
<td><em>Vibrio parahaemolyticus</em> food poisoning.</td>
<td><em>Vibrio parahaemolyticus</em>.</td>
<td>Usually 12 to 14 h; range 2 to 48 h.</td>
<td>Abdominal pain, severe watery diarrhea, usually nausea and vomiting, milk fever, chills, and headache. Duration - 2 to 5 days.</td>
</tr>
</tbody>
</table>

pigment that can be seen under ultraviolet light (fluorescence). Other strains of *Pseudomonas* that do not produce pigment are also important, but they are not well classified. Another group of bacteria is the *Acinetobacter/Moraxella* films, spoilage is usually delayed - other things being equal - and the types of bacteria may be somewhat different. *Alteromonas putrefaciens* (formerly *Pseudomonas putrefaciens*) is a major cause of spoilage under these conditions. In cooked and cured vacuum-packaged poultry products, the major cause of spoilage will usually be lactic acid-producing bacteria and sometimes yeast.

It is impossible to specify the exact species responsible for spoilage because psychrotrophic bacteria have not been thoroughly studied and classified. As research continues, many former classifications are being changed and this complicates the situation. It is possible to conclude, however, that relatively few types of bacteria are responsible for spoilage, but those that cause spoilage do so mainly because they can break down fats and proteins and cause other biochemical changes that produce undesirable odors and flavors in poultry meats.

**Sources of Microbes in Processing**

Microbes in poultry processing plants are ultimately found on the product and come from three main sources. The birds themselves carry more microbes into the plant than any other single source. The numbers of microbes can vary widely, however, depending on the relative cleanliness of the birds. Damp or wet litter in the poultry houses frequently results in very dirty feathers and feet. Extremely dry and dusty litter can cause the skin to be dirty. Coops on live haul trucks provide another opportunity for the feathers, feet, and skin to be soiled by fecal material. Dirty coops and trucks, along with excessive excitement and agitation as well as extra long hauls or long holding times, can greatly increase the number of soiled birds. These factors all contribute to the microbial load carried by live poultry when they enter the processing plant.

It is well known that the higher the contamination of a product entering a process, the higher will be the contamination after processing. Any efforts to reduce the initial numbers of microbes on live poultry will help reduce contamination in later stages of processing.

The second most important source of microbes brought into the processing plant is the workers themselves. However, plant personnel are not as significantly responsible for spoilage bacteria as they are for bringing in the food-poisoning types. Since many workers are specifically assigned to handling poultry, the cleanliness of their hands is of paramount importance. Rubber or plastic gloves are frequently used to prevent their hands from coming in direct contact with the poultry, but they are of no value unless they are kept clean. Far too often the gloves give a false sense of security and become a detriment rather than a sanitation benefit.

The workers’ clothing can be an unknown factor unless it is completely changed and covering garments are supplied before the worker enters the processing area. Human hair usually carries large numbers of microbes, which unfortunately most people shed rather continuously from their heads, faces, and arms. The number of shed hairs usually is not large, but the microbes present can be extremely numerous. Most workers are required to wear some kind of head and arm coverage and men with facial hair may be required to wear nets. Such measures are beneficial, but as generally carried out they may fail short of fully protecting the product. One need only look at the head gear and face coverings worn by hospital operating personnel to realize what precautions are essential for maximum protection.

Worker habits also are extremely important, such as coughing, sneezing, care of scratches and cuts on the hands, and especially thorough hand washing and sanitizing when returning after an absence from their work stations. It is not important whether the absence is for a trip to the restroom, a coffee break, lunch, or only to adjust some piece of equipment because the likelihood exists for soiling the hands.

The third major source of microbes entering the plant is the water, air, and the many different kinds of supplies, especially dusty packing materials. In general, these sources mainly contribute spoilage bacteria, although food-poisoning types may also be involved from time to time. The incoming water and ice should be continuously monitored since they are frequently a major source of pseudomonads that cause spoilage. The freezing of water to form ice will kill some bacteria but not enough to materially reduce spoilage.

Outside air brought into the plant is frequently the source of harmful microbes. If the outside air vents are located so that dust or other sources of contamination can be drawn into the plant, additional microbes will enter. Air inlets should be located as far as possible from the live hanging area and screened to prevent birds and rodents from entering. The airflow should be from the finished product area to the incoming bird areas. Air filters should be installed in the incoming air ducts and they should be serviced or replaced at frequent intervals.

Necessary supplies, such as packaging materials (dust free), wing tags, record forms, and lubricants, are not likely to be a source of problems. The equipment and utensils are not themselves originators of microbial contamination, but they can be a contributing factor if microbes from other sources are allowed to grow and multiply on or in them and subsequently find their way to the product. Proper cleanup procedures and plant sanitation methods are a means for controlling this source of microbial infection. Certain types of equipment, such as forklift trucks, and the operating personnel continuously move in and out of the processing area so that extra precautions need to be taken to make sure they are not contributing unnecessarily to the microbial population in the plant.

A major concern is the transferring of microbes from one bird to another during processing. Numerous opportunities exist for this to occur although some appear to be more critical than others. In the drag-through electrical stunners, the head of the bird is in contact with a trough of water, which is of course contaminated. If a bird inhales the water, its interior will be contaminated through the lungs and air sacs.
The scald tank has always been considered as a reservoir for microbes and general filth from the birds passing through it. Intervening factors, however, tend to reduce the potential of the scald tank as a contaminator. The water is heated and thus kills some bacteria, damages others, and probably inhibits most of them. The semi-scald temperature of 124°-126° F is less effective in this regard than the subscald of 140°, although both sets of temperatures are well above the optimum for either spoilage or food-poisoning types of bacteria. A constant overflow of the scald water and that carried out by the birds which must be replaced with fresh water aid in reducing microbial numbers. Even so, the scald water does carry heavy loads of microbes and is a source for transferring them from one carcass to another. Also, the birds may inhale scald water if they are not completely dead when entering the scalding room.

The pickers are probably responsible for the greatest spread of contamination from one bird to another. The vigorous action of the rubber fingers assures that they will be well contaminated, and it is virtually impossible to clean them before the next bird arrives even though heavy sprays of water are used.

Spray washing usually follows the picking or feather removal operation. Surface contamination of the carcasses is usually reduced substantially at this point. Although singeing includes the use of flames, it is not likely to kill any significant number of bacteria. Manual pinning, when necessary, usually involves several workers handling the carcasses. Transfer of microbes from one carcass to another likely occurs frequently. Hand- or tool-rinsing facilities are seldom if ever made available to these workers.

Hock cutting brings the legs of the birds in contact with other common surfaces, but it is not likely to be a serious source of contamination. The collection or “surge” arrangement between hock cutting and the rehanging provides additional major opportunities for contamination and its transfer from carcass to carcass. The surge area frequently consists of a table or belt conveyor on which each bird comes into direct contact with many others. The rehang area involves handling by workers with a further opportunity for transfer of bacteria.

The evisceration process whether manual, mechanical, or a combination of the two is extremely critical to contamination of the carcass with fecal material and crop contents. Since these are major sources of food-poisoning bacteria, extreme precautions are required. Those parts of mechanical evisceration equipment that come in contact with the carcasses should be thoroughly flushed with water after each use. Hand and tool washing sprays are necessary for all workers in the evisceration operation section, including the trimming and giblet harvest sections that follow. Any fecal contaminated area must be trimmed; nevertheless, considerable transfer of contamination is known to occur, including that caused by the hands of inspectors, who are required to touch every carcass.

The two most important steps in reducing microbial numbers on poultry carcasses following evisceration are the final spray wash and immersion chilling. The final washer should be designed to insure that all surfaces of the carcass both inside and out will be contacted by water sprays with considerable force. Insufficient pressure will not remove the maximum number of bacteria. Too much force can drive bacteria into the skin where they cannot be removed. Immersion chilling usually reduces further the number of bacteria present on the carcasses. Exceptions have been noted when highly contaminated birds enter the chiller or when inadequate sanitation is practiced. Chillers with a counter flow of water and birds, i.e., water flowing from where the carcasses exit the chiller toward where they enter, are considered to be more effective in reducing bacterial numbers on carcasses than noncounter flow equipment. However, the noncounter flow chillers have performed rather satisfactorily in this regard.

The operations following chilling are highly critical to the final bacterial levels of the carcasses since no further cleaning processes will take place. Rehanging of the birds, dropping them into sizing bins, boxing operations, handling by workers, contact with equipment surfaces, malfunctioning check valves on vacuum lines, bagging, and bird-to-bird contact all offer opportunities for contamination. Carcasses packed in ice may receive some additional rinsing as the ice melts, but this can be self-defeating if the ice water then drips onto other boxes in a stack. Dry-packed and carbon dioxide-packed carcasses provide no opportunity for additional rinsing. The importance of the many processing steps to the final microbial quality of the carcasses is summarized in table 9.

The relative time-temperature conditions under which the carcasses are held following packing determine the merchandising shelf life and whether hazards of food poisoning are minimized. Temperatures no higher than 40° F are mandatory, but this easily met temperature requirement has been frequently violated. Shelf life of the product under such conditions is usually short (3-5 days). Temperatures near 28° are considered ideal for fresh poultry, and if carefully maintained, processed birds can usually have a shelf life of 2 to 3 weeks.

**Bacterial Count Techniques**

**Equipment.** Check equipment after cleaning and sanitizing by using spot plates filled with total count agar (see appendix B). Make a floor plan of all the equipment, floors, walls, and ceilings throughout the plant, giving each area to be tested a number. Spot plates can be numbered in the laboratory to avoid delay during the plant survey. Do not test the same spot each time, unless you are correcting a problem.

Properly cleaned and sanitized surfaces will show no more than five bacterial colonies per 2½ square inches. Check tables, belts (top and underneath surfaces of the belt, as well as the belt roller), saws, saw housings, knives, knife handles, mesh gloves, chutes, vacuum nozzles, shackles, and all areas of equipment near or contacting the product, as well as walls, ceilings, floors, tools, electric switches, overhanging apparatus, and other equipment.

**Raw Poultry.** A scheme for measuring counts on the surface of poultry can be developed by allowing one drop of fluid to fall on the spot plate from the bird while it is hanging during processing. This drop should be allowed to spread over the surface of the plate and the plate incubated at
### Table 9.—Sources of microbial contamination according to relative importance in broiler processing

<table>
<thead>
<tr>
<th>Operation</th>
<th>Workers' hands</th>
<th>Equipment and tool surfaces</th>
<th>Bird to bird</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grow out</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>**</td>
</tr>
<tr>
<td>Catching</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Live haul</td>
<td>0</td>
<td>0</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Hanging</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stunning</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>*</td>
</tr>
<tr>
<td>Killing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Scalding</td>
<td>0</td>
<td>0</td>
<td>**</td>
<td>****</td>
</tr>
<tr>
<td>Picking</td>
<td>0</td>
<td>*</td>
<td>*</td>
<td>***</td>
</tr>
<tr>
<td>Washing</td>
<td>0</td>
<td>*</td>
<td>0</td>
<td>****</td>
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<tr>
<td>Singeing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pinning</td>
<td>***</td>
<td>**</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hock cutting</td>
<td>0</td>
<td>*</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Surging</td>
<td>0</td>
<td>**</td>
<td>***</td>
<td>0</td>
</tr>
<tr>
<td>Rehanging</td>
<td>***</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evisceration (manual)</td>
<td>****</td>
<td>****</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Evisceration (mechanical)</td>
<td>*</td>
<td>****</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inspection</td>
<td>****</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trimming</td>
<td>****</td>
<td>****</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vacuum lunger</td>
<td>***</td>
<td>***</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Washing</td>
<td>0</td>
<td>*</td>
<td>0</td>
<td>****</td>
</tr>
<tr>
<td>Chilling</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>****</td>
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<tr>
<td>Surging</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>Rehanging</td>
<td>****</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sizing</td>
<td>0</td>
<td>***</td>
<td>***</td>
<td>0</td>
</tr>
<tr>
<td>Boxing</td>
<td>****</td>
<td>*</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Further processing</td>
<td>****</td>
<td>0</td>
<td>0</td>
<td>*</td>
</tr>
</tbody>
</table>

1. **** = critical, *** = significant, ** = important, * = potentially important, 0 = unimportant or not involved.
2. Refers to water, ice, air, litter, and all aspects of the environment not in the 3 other categories.

Staph found in the processing area where chicken is cooked may indicate cross-contamination from the raw area via equipment, product, or personnel. Areas showing a positive test for coliform or staph should be thoroughly investigated to determine the source.

Ingredients and raw and finished products should be checked for total count, coliform, and staph per gram on a lot-by-lot basis. Products should be coded and analyses related to code.

Spot plates taken for total counts in the cooked area can also be checked at another laboratory for presence of salmonellae as a monitoring device.

95° F for 24 hours. Counts made in this manner can be used to compare various areas of the processing line and also to evaluate any changes in the system. Spot plates made by using a drop of fluid from the bird can be taken simultaneously for total count, coliform, and staph to indicate the sanitary condition of the product.

Duplicate total count plates incubated at room temperature for 4-5 days will indicate the numbers of psychrophilic (cold-loving bacteria). These organisms grow below 40° F and produce off-flavors and off-odors in a raw product. Raw products can be checked in this manner in cold storage and at retail store level to determine whether the product has been mishandled or if the shelf life has been exceeded.

**Cooked Poultry.** The same tests should be taken on the clean and sanitized equipment before use as would be taken for raw processing.

It is wise to take spot plates during the processing of cooked chicken for coliform and staph as well as total count. Hands of the operators, gloves, aprons, belts, knives, all equipment, and problem areas can be checked in this manner during use. Coliform or
Literature Cited


Appendix A
Accepted Poultry Processing Equipment

The Federal Meat Inspection Act and the Poultry Products Inspection Act require the Secretary of Agriculture to see that meat and poultry are processed under sanitary conditions. These laws authorize the Secretary to make regulations necessary to bring about this objective. Such regulations are published in the Code of Federal Regulations. They provide the rules that apply to sanitation of facilities and equipment in federally inspected plants.

The Equipment Group, Technical Services, MPITS, Food Safety and Inspection Service, U.S. Department of Agriculture, has been assigned responsibility for the review of plant equipment, including materials, and the provisions for its sanitary maintenance. The basic concern is sanitary design, construction, installation, and maintenance. The Equipment Group will, however, not accept equipment unless its operation and output meet certain Equipment Acceptance Program requirements, even though it may be of sanitary design and construction.

Freedom of Information
The Freedom of Information Act, 5 U.S.C. 552, provides that information in the possession of the Federal Government must be made public upon request unless certain specified exemptions apply. One of these exemptions covers "trade secrets and commercial or financial information obtained from a person and privileged and confidential" (5 U.S.C. 552(b)(4)).

In order to protect the legitimate commercial interest of those submitting information to the Equipment Group, the submitting party should carefully identify all material considered to be a trade secret, or confidential commercial or financial information. The submitter should also supply a statement giving the reasons the information is so considered. Although this procedure will not guarantee that information so identified will be exempt from disclosure, it does insure that the wishes of the submitting party will be given consideration in the decision reached.

When third party requests for material identified as a trade secret, or confidential commercial or financial information, are received by the Food Safety and Inspection Service, the material will not be disclosed without first consulting the submitting party.

If there are any questions concerning the Freedom of Information Act and its effect on the procedures of the Equipment Group, they should be addressed to Freedom of Information Act Coordinator, Food Safety and Inspection Service, U.S. Department of Agriculture, Washington, D.C. 20250.

Equipment Acceptance Program
Purpose. The purpose of this program is to assure that sanitary, properly designed, and constructed equipment is used in federally inspected meat and poultry plants. The program is aimed at seeing that equipment is built right in the first place rather than at correcting problems after they become apparent. This approach has definite advantages for the consumer, the equipment manufacturer, the processor, and the inspection service.

Scope. Equipment introduced into official establishments must be formally evaluated and accepted by the Equipment Group before it is used to produce edible products on a regular basis. This applies to used as well as new equipment.

Presently installed equipment that can produce unadulterated products and be kept clean need not be presented to the Equipment Group for formal acceptance. It must, however, be acceptable to the inspector in charge at the point of use.

The following categories of equipment need not be submitted for formal acceptance if constructed, installed, and maintained in a manner acceptable to the inspector in charge:

1. Simple hand tools.
2. Equipment used for preparing packaging materials.
3. Equipment for handling or transporting packaged goods.
4. Equipment used in inedible departments.
5. Central cleaning systems.
6. Utensils and equipment cleaning machinery.
7. Pails, buckets, tote boxes, trays, etc. (chemical acceptance for plastics, if used).

(8) Pallets for packaged product.
(9) Picking fingers (chemical acceptance only).
(10) Tanks for finished oils.
(11) Can openers.
(12) Chutes, flumes, poultry hangback rack, supporting stands, and brackets.
(13) Equipment used for storing, transporting, and refining rendered animal fats and vegetable oils.
(14) Vegetable cleaning equipment.
(15) Insect control units.
(16) Shipping containers (to be approved by Standards and Labeling Division, MPITS, FSIS, USDA, Cotton Annex Building, Washington, D.C. 20250).
(17) Pressure storage vessels for refrigerants.
(18) Water softeners, water heaters, water meters, and chemical dispensers.
(19) Can and jar washers.
(20) Dry spice-mixing equipment.
(21) Hot air shrink tunnels.
(22) Equipment for handling live poultry and meat animals.
(23) Air and water filters.
(24) Temperature recording equipment (chemical and sanitary acceptance of product contact components only).
(25) Casing preparation equipment.

Plants Coming Under Inspection
Equipment in existing plants at the time inspection is inaugurated need not be cleared through formal acceptance procedures if the equipment is in good repair and is installed and maintained in a manner acceptable to the inspector in charge. Equipment intended for use in newly constructed plants must be on the accepted list at the time the inspection is inaugurated or installed on an experimental basis under special permission from the Equipment Group.

Equipment Other Than That Commercially Available
Many plants make some of their own equipment or have it fabricated for them to their own specifications. Simple equipment in this category, such as racks, skinning cradles, and so forth, need not be submitted for formal acceptance. It must, however, meet the standards stated here. More complex equipment, such as conveyors, mixers, and packaging equipment, must be

This information is reproduced from "Accepted Meat and Poultry Equipment," Food Safety and Inspection Service, U.S. Department of Agriculture, MPI-2. These regulations are subject to change.
clearly evaluated and accepted. Equipment used in separate rooms for preparing bakery-type items need not appear on the accepted list. The inspector in charge will judge whether such equipment is constructed and maintained in a manner that will permit production of unadulterated products and is installed and maintained in a manner acceptable to the inspector.

**Bakery Equipment**

Equipment introduced into processing departments to prepare dough and crust for fillings or fabricating operations must be formally evaluated and accepted. Equipment used in separate rooms for preparing bakery-type items need not appear on the accepted list. The inspector in charge will judge whether such equipment is constructed and maintained in a manner that will permit production of unadulterated products in a clean environment. All the standards applying to meat or poultry processing equipment will not apply to bakery equipment used in bakery departments since such equipment may not require daily washing to be maintained in an acceptable sanitary condition.

**Procedure for Obtaining Equipment Acceptance**

The person interested in obtaining acceptance should provide the Equipment Group with drawings that clearly illustrate the main construction features of the equipment. They usually consist of side, end, and top views. More complex equipment will require section or cutaway drawings showing internal product contact parts. A list, correlated to the drawings, showing the materials of which the parts are made must accompany each submittal. Any part that is plated should be so annotated with the type of plating material specified. If paints or plastics are used, they must be cleared with the Chemistry Staff, Scientific Services. The drawings and chemical formulas should be sent to Equipment Group, Technical Services, MPITS, FSIS, USDA, Washington, D.C. 20250.

The drawings need not be drawn to a specific scale. However, they should not exceed 32 by 48 inches since the Equipment Group reduces the drawings to microfilm and this is the largest size that the microfilm equipment can handle.

The Equipment Group will review the information presented to determine (1) if acceptable materials are used, (2) if there are design, construction, or safety problems that must be corrected, and (3) if observation during use in a plant is necessary to determine acceptability.

If production trial is considered necessary for observing the equipment during plant use, the equipment manufacturer should ask the plant to request permission of the Equipment Group for use of the equipment on a trial basis. The Meat and Poultry Inspection representative at the plant will be notified if permission is granted and will evaluate the operation of the equipment and report the findings to the Equipment Group. If the report is favorable, the company will be permitted to continue use of the machine after the experimental period is completed unless notified otherwise by the Equipment Group. If sanitary or safety problems are identified during the trial period, they must be corrected before continued use is permitted.

If the equipment has performed satisfactorily, the Equipment Group will furnish the proponent a letter of acceptance and add the model to the list of accepted equipment that is published periodically. If the equipment is not accepted, the manufacturer and user will be advised of the elements needing correction. The acceptance letter, when written, is intended to clarify equipment status prior to its listing. Once the equipment is listed, the letter written to the manufacturer becomes invalid and no longer useful as an authorization for equipment installation and use in plants.

**Chemical Clearance**

Compounds such as sealants, coatings, paints, metal alloys, and plastics used as components of equipment must be cleared with the Equipment Group to assure that they are nontoxic and safe for the proposed use. The following information is needed:

1. Brand name or specific description with manufacturer's name.
2. Description of the conditions of its use.
3. List of substances of which the material is composed. The list of substances must identify all major and minor constituents by proper chemical name as they appear in the appropriate Food Additives Regulations. Dyes and pigments should be identified by Color Index number of structural formula. Components identified only by their manufacturer's brand name or code must also have the acceptance of the Food Safety and Inspection Service, U.S. Department of Agriculture. The suppliers or manufacturers should be prepared to verify acceptance of their products to buyers and inspectors.

**List of Accepted Equipment**

Periodically, Technical Services will publish an updated list of equipment that is acceptable for use in federally inspected meat and poultry plants. Inspectors use this list to determine the status of new or replacement equipment intended for use in plants.

Formal acceptance of a piece of equipment will not necessarily mean that it can be used without reservation. Poor quality workmanship, inadequate service and maintenance, substitution of materials, faulty installation, or other defects may make an otherwise acceptable machine unacceptable. When such defects can be corrected after installation, the inspector will require correction as a condition for use. Otherwise, the equipment will be rejected and the inspector will report the defects to the Equipment Group.

Experience with equipment in use may reveal objectionable defects or faults that were not apparent when acceptance was extended. If the defects are serious and the manufacturer cannot or will not make correction, the equipment in question will be removed from the accepted list.

The Food Safety and Inspection Service does not issue or sanction the use of advertisements or otherwise of any shield, emblem, legend, or insignia indicating acceptance of equipment. The only authorized reference to ac-
ceptance is in letters issued to applicants and in the list of accepted equipment published periodically by Technical Services. Publication in this list means that the equipment has been evaluated and found to comply with the Meat and Poultry Inspection Program sanitary standards. It does not imply compliance with the Department of Labor Occupational Safety and Health Standards.

Listed model numbers followed by dots indicate that a particular piece of equipment may be made in various sizes and capacities with no change in the basic design and construction.

Example:

<table>
<thead>
<tr>
<th>Equipment Model No.</th>
<th>As shown in equipment list</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conveyor</td>
<td></td>
</tr>
<tr>
<td>EC - 1218</td>
<td>EC - ...</td>
</tr>
<tr>
<td>EC - 2435</td>
<td>Basic design</td>
</tr>
<tr>
<td>EC - 2060</td>
<td>width length.</td>
</tr>
</tbody>
</table>

**Equipment Standards**

To be considered acceptable, equipment and utensils must meet certain basic criteria. They must be made of acceptable materials, must be constructed so they can be cleaned and inspected, must be designed for sanitary maintenance, and must not constitute a safety or health hazard to inspectors.

1. **Acceptable materials:** Equipment must be constructed of materials capable of preventing deterioration through normal use or deterioration by chemicals, cleaning agents, and atmospheric exposure in the normal production environment. They must be smooth surfaced, corrosion and abrasion resistant, shatterproof, nontoxic, nonabsorbent, and shall not stain or migrate to the product.

   a. **Stainless steel:** The 18-8 (300 series) is acceptable for general use. Other series have been used for construction of meat and poultry equipment, but their use is limited because they tend to rust or discolor in certain applications. The abbreviation “S/S” is used to denote stainless-steel construction.

2. **Unacceptable materials:**

   a. **Cadmium and antimony** are toxic materials and may not be used in any manner on equipment for handling the edible product.

   b. **Lead** is a toxic material and may not be used in equipment contacting the edible product except it may be employed in certain alloys in an amount not to exceed 5 percent.

   c. **Enamelware and porcelain** are not acceptable for any purpose in connection with the handling and processing of the product.

   d. **Copper, brass, and bronze** are not acceptable when used in contact with fats and oils, because their use results in objectionable greenish discoloration and decreases the keeping quality of fat. They may be used in air and water lines and for gears and bushings outside the product zone.

3. **Design and construction:**

   a. Equipment shall be designed and constructed in such a manner that it can be readily cleaned.

   b. All product contact surfaces shall be readily accessible for cleaning and inspecting and constructed of corrosion-resistant materials.

   c. All surfaces contacting the product shall be smooth, free from pits, crevices, and scale and shall be readily capable of being so maintained.

   d. All parts of the product zone shall be free of recesses, open seams, gaps, protruding ledges, inside threads, inside shoulders, bolts, rivets, and dead ends.

   e. Bearings shall be located outside the product zone and their construction shall be such that the lubricant cannot leak, drip, or be forced into the product zone.

   f. Internal corners or angles in the product zone shall have a continuous and smooth radius of one-fourth inch or greater except that lesser radii may be used where necessary for proper functioning of parts or to facilitate drainage, provided such areas can be readily cleaned.

   g. Equipment shall be self-draining or otherwise completely evacuated.

   h. Horizontal ledges or frame members should be held to a minimum outside the product zone and should be of rounded or tubular construction, where possible, to prevent accumulation of debris and to promote sanitation.

   i. Equipment shall be designed, constructed, and installed so as to guard against injury to personnel from sharp edges, moving parts, electrical shocks, excessive noise, and other hazards. Safety or gear guards shall be removable to permit inspecting and cleaning.

   j. All welding shall be continuous, smooth, even, and relatively flush with the adjacent surfaces.

   k. Painted surfaces of equipment or components in or above the product zone are not acceptable.

   l. All external surfaces that do not contact the food product shall be free of open seams, gaps, crevices, and inaccessible recesses.

   m. Where parts must be retained by nuts or bolts, fixed studs with wing nuts should be used rather than screws to a tapped hole.

   n. Electric motors and other electric gear should be sealed or otherwise protected to prevent entry of water and the product.

   o. All gasketing and packing material shall be nontoxic, nonporous, nonabsorbent, and unaffected by food products and cleaning compounds.
Appendix B

Bacterial Control of Poultry Products

Guidelines

Test

(1) Check clean equipment.

(2) Check hands of operators, equipment, walls, doors, switches, aprons, etc., especially if product will not be cooked prior to consumption.

(3) Check equipment in use.

(4) Check ingredients and final products.

(5) Survey periodically for salmonellae.

(6) Watch time and temperature of all operations. Bacteria grow best at room temperature from 50° F to above 100°. Keep hot food hot, 140° or above. Keep cold food cold, 40° or below, or don’t keep it!

(7) Take great care when handling cooked meat prior to use or packaging to assure that recontamination is held to a minimum.

(8) Prevent, at all costs, contact between raw and cooked products. Do not permit transfer of equipment or personnel from raw product line to cooked line.

Technique

Spot plate - total count agar.

Direct contact or swabs to total count, staph plates, coliform plates.

Swab to plate count. Coliform and staph agar plates.

Plate out using dilution technique (1-10 dilution and further if necessary) for total count, coliform, staph, and yeast and mold.

Swab in sterile tetraphionate broth. Send to outside laboratory for completion of test.

Prepare flowsheet of plant, indicating operation and time and temperature of product at each station.

Bacteriological Procedures

(1) Sterilize aluminum spot plates at 375° F for about 3 hours in can or glass jar. (Electric oven.) (Or sterilize in autoclave at 15-pound pressure for 15 minutes.)

(2) P.M. before day of test. Spread the needed number of sterile plastic dishes (5-10) on clean dry tabletop. Insert one sterile A1 spot plate in each dish using metal forceps sterilized by flaming with alcohol.

(3) Pour melted plate count agar into each spot plate until filled above rim but not overflowing. Allow to harden for use in test the following a.m. If desired, these plates may be covered with clean dry paper to avoid accidental contamination.

(4) Take sterile prepared spot plates to area to be tested.

(5) Remove spot plate by grasping metal tab with thumb and forefinger and touch sterile agar to surface to be tested. Press firmly, but do not slide. Hold in place for 30 seconds.

(6) Replace spot plate in sterile plastic dish and cover.

(7) Incubate at 95° F for 24 hours.

(8) Count number of colonies appearing after this time.

(9) Report total number of colonies as number of bacteria per 2½ square inches.

Suggested Schedule of Daily Tests

A.M. - Spot plates on cleaned, ready-to-use equipment - 6 to 12 tests each day: Tables, belts, knives, scissors, pans (aluminum, stainless), blades of slicer, rubber gloves, hands, and plastic tubes. Tests should be taken in further processing room each day after cleanup.

A.M. - Swab tests on equipment in use in further processing room: Belts, stainless tables, floor, light switches, pans (stainless), rubber gloves, hands, and aprons.

P.M. - Plate counts for total count, coliform, and staph on ingredients added to cooked poultry items and cooked meat before freezing and after.

P.M. - Prepare media for next day’s test. Read plates from previous day’s test and write up results.

Technique

Spot plate - total count agar.

Direct contact or swabs to total count, staph plates, coliform plates.

Swab to plate count. Coliform and staph agar plates.

Plate out using dilution technique (1-10 dilution and further if necessary) for total count, coliform, staph, and yeast and mold.

Swab in sterile tetraphionate broth. Send to outside laboratory for completion of test.

Prepare flowsheet of plant, indicating operation and time and temperature of product at each station.

Bacteriological Procedures

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(6) Replace spot plate in sterile plastic dish and cover.

(7) Incubate at 95° F for 24 hours.

(8) Count number of colonies appearing after this time.

(9) Report total number of colonies as number of bacteria per 2½ square inches.

Swab Bacteria Counts of Equipment While in Use

A. Approximate check:

1. Place cotton-tipped swabs in glass jar (6-10 in each jar) with small amount of water. (Sterile swabs may be moistened using sterile water prior to swabbing.)

2. Sterilize in autoclave for 15 minutes at 15-pound pressure.

3. Take sterile swabs and poured agar plates to area to be tested.

4. Remove one sterile swab from jar and at same time squeeze excess water from swab against side of jar. Swab a 4-square-
inch area of equipment thoroughly. It is important to keep swabbing technique uniform, e.g., 20 times across and 20 times up and down, using same amount of pressure. Swab surface of poured agar plate. Discard swab.

5. Incubate swabbed plate for 24 hours at 95° F.
6. Check for growth after this time. Heavy growth can be judged 4+ and less growth down to 1+. Less than 50 colonies can be counted and reported as count per square inch.

B. Accurate count per square inch:
1. Place cotton-tipped swabs in test tubes containing 10 ml of distilled water.
2. Sterilize in autoclave for 15 minutes at 15-pound pressure.
3. Take sterile swabs in tubes to area to be tested.
4. Remove sterile swab from tube and at same time squeeze excess water from swab against inside of tube. Replace cap. Swab area thoroughly and uniformly, e.g., 20 times one side of swab and 20 times opposite side, and replace swab in tube at same time breaking off part of wood touched by fingers. Replace cover of tube tightly. Swab area as necessary. Example: One entire glove, or 4 square inches of used equipment, or complete surface of small items such as electrical switch.
5. Shake contents of tube 50–100 times. Using sterile 2.2 ml pipette, transfer 1 ml to each of two sterile plastic petri dishes for total count and coliform. Transfer 0.1 ml to poured tellurite glycine agar plate for staph count and spread over surface of agar. Allow this plate to stand until 0.1 ml of portion is absorbed into agar, then invert and incubate for 24 hours at 95° F. If further dilutions are needed to give a plate with 30–300 colonies, transfer 1 ml to 99 ml of sterile water blank and plate 1 ml and 0.1 ml of this dilution.
6. Pour melted plate count and coliform agar into appropriate dishes, almost covering surface (15 ml) and swirl to mix.
7. Incubate plates at 95° F – plate count for 48 hours, coliform 24 hours, staph 24 hours.
8. Count colonies appearing after this time.
9. Report total number of colonies as number of bacteria per square inch or area of surface tested.
10. Factors are as follows:
   1 ml from original tube – number of colonies \( \times 10 \) = count per square inch or area.
   0.1 ml from original tube – number of colonies \( \times 100 \) = count per square inch or area.
   1 ml from 1–1,000 dilution – number of colonies \( \times 1,000 \) = count per square inch or area.
   0.1 ml from 1–1,000 dilution – number of colonies \( \times 10,000 \) = count per square inch or area.

Note: Plates to be accurate should contain 30–300 colonies per plate. If counts are low, then plate a larger portion, or if plate counts are too high, plate a smaller portion.

**Bacteria, Coliform, Staph, and Yeast and Mold Counts on Products, Ingredients, and Raw or Cooked Poultry Meat**

1. To prepare a 99 ml sterile water blank, add 103 ml of distilled water to a dilution bottle. (Excess may be lost in autoclaving. Check this by measuring after sterilization.) Sterilize these water blanks in an autoclave at 15-pound pressure for 15 minutes. Loosen screw tops before autoclaving and tighten when sterile dilution bottles are removed from autoclave. Also sterilize empty glass jars (4 oz) in autoclave to use when collecting sample.
2. Take a sample of product to be tested using a sterile spoon (wash, dry, flame in alcohol before each use).
3. Place sample in sterile jar and hold in refrigerator until plated – not longer than 1 hour.
4. Weigh 11 gm of product in 99 ml sterile water blank. (If necessary, mix, using sterile blender blade – 1 minute at high speed. Be sure to attach sterile blade assembly securely before mixing.) This is the 1–10 dilution (see fig. 5).
5. Using sterile pipette, transfer 1 ml into sterile 99 ml water blank. (This is the 1–1,000 dilution.)
6. Transfer 1 ml and 0.1 ml portions from the 1–10 and 1–1,000 dilutions into sterile properly marked plastic petri dishes. Make separate plates for each test: Bacteria, coliform, staph, and yeast and mold counts with appro-
priate dilutions to give plate with 30-300 colonies. Low count product: 1 ml and 0.1 ml from 1-10 for total count and coliform; 1 ml from 1-10 for yeast and mold; 0.5 ml or 0.1 ml from 1-10 for staph. High count product: 1 ml and 0.1 ml from 1-1,000 dilution for bacteria and coliform counts; 1 ml from 1-10 dilution for yeast and mold; 0.5 ml or 0.1 ml from 1-1,000 dilution for staph counts.

(7) Pour plates with appropriate agar. Total count – plate count agar. Coliform count – violet-red bile agar. Yeast and mold count – potato dextrose agar with 1 ml of tartaric acid solution per 100 ml of agar added before pouring agar. Staph – pour plates and allow surface to dry before adding sample; add 1 ml of 1 percent potassium tellurite solution to agar before pouring plates.

(8) Incubate plates as follows: Total count – 48 hours, 95°F; coliform – 24 hours, 95°F; staph – 24 hours, 95°F; yeast and mold – 5 days at room temperature.

(9) Count colonies on each plate. If possible, select plates with 30-300 colonies for calculating final count. Factors are as follows:
1 ml of 1-10 dilution – 10 x number of colonies = final count per gram.
0.5 ml of 1-10 dilution – 20 x number of colonies = final count per gram.
0.1 ml of 1-10 dilution – 100 x number of colonies = final count per gram.
0.5 ml of 1-1,000 dilution – 2,000 x number of colonies = final count per gram.
0.1 ml of 1-1,000 dilution – 10,000 x number of colonies = final count per gram.

Total Count, Coliform, and Staph on Cooked Poultry Part With Bone

(1) Select part, place in sterile plastic sample bag, close bag.

(2) Roll and press part to separate meat and breading from bone.

(3) Open bag and aseptically remove bone, leaving meat and breading in bag.

(4) Place meat and breading in sterile, tared (preweighed) dilution bottle, weigh sample, and add equal weight of sterile distilled water (1-1 moisture).

(5) Replace screw cap with sterile blade assembly. Mix sample using grind button and intermittently and finally using blend button for at least 1 minute. Meat, breading, and water should be a homogeneous mass.

(6) Weigh 10 gm in 90 ml of sterile water. (This is a 1-20 dilution; 1 ml contains 0.05 gm.) (See fig. 6.)

(7) Plate 1 ml and 0.1 ml amounts for total count and coliform and 0.5 ml for staph.

(8) Incubate at appropriate temperatures, multiply by appropriate dilution, and report result per gram of sample.

Bacterial Counts on Surface of Raw Poultry Parts

(1) Obtain tare weight of 8 oz sterile plastic sampling bag (about 4.5 gm).

(2) Place chicken part to be tested in sterile sample bag and weigh part to nearest 0.5 gm. Record weight of part by deducting tare of sample bag (4.5 gm).

(3) Add 100 ml sterile distilled water to bag and shake (50 times). (This is 1-100 dilution.)

(4) Remove 1 ml to 99 ml sterile water blank. (This is 1–10,000 dilution.) Make additional appropriate dilutions, if needed, to be sure plates with 30–300 colonies will be obtained.

(5) Transfer aliquots from appropriate dilutions to plates for total count, coliform, and staph. (Use total count, desoxycholate or violet-red bile, and tellurite glycate agars, respectively.)

(6) Incubate at 95°F for 2 days for total count, 95°F for 1 day for coliform and staph, and 70°F or room temperature for 4 days for shelf-life test. 5

(7) Count colonies on plates. Multiply by appropriate dilution. Divide by square centimeters of surface area. (Refer to table 10 for relation of weight of part to square centimeter surface area.)

(8) Report counts per square centimeter of surface.

Total Count, Coliform, and Staph Checks on Chill Water or Tray Drip of Packaged Raw Poultry

Prepoured sterile agar plates can be used to check water from chill tanks and other areas in the plant or tray of packaged chicken.

1 Pseudomonads are organisms that grow at 40°F and become the predominant flora on raw poultry causing off-flavor and eventually spoilage. Shelf-life tests should be made by preparing duplicate total count plates. One set should be incubated at room temperature (about 70°F) for 5 days and the second set incubated at 95°F for 2 days – comparisons of these counts on consecutive days will more accurately indicate shelf life.

Figure 6.—Total count, coliform, yeast and mold, and staph on cooked poultry parts (bone removed).

(1) Use a large individually wrapped plastic straw as follows: Immerse straw in liquid, place index finger on top of straw to hold about one-half inch of liquid in straw. Hold straw over agar plate and squeeze straw using thumb and ring finger so as to allow 1 drop to fall on contact plate. Discard straw and remaining liquid.

(2) Rotate agar plate so that drop of liquid covers surface of plate. Agar surface should be dry and free of condensation.

(3) Incubate at 95°F for 24 hours. Count colonies and report as numbers of bacteria per 0.1 ml or 0.1 gm.

Prepoured plates with plate count agar can be used for total count, violet-red bile for coliform, and tellurite glycate for staph. Incubate them for 24 hours at 95°F.

To check on development of psychrophiles (cold-loving bacteria), prepare duplicate plates using plate count agar. Incubate one at 95°F for 24 hours and the other at room temperature for 5 days.

This system can be adapted to check poultry at the chainstore or in cold storage. A drop of fluid can be taken from the bottom of the packing case using a sterile plastic straw. Two plates should be prepared from each case simultaneously. Allow the drop to spread over the surface of the agar plate. Cover and incubate one at 95°F for 24 hours and the second at room temperature for 5 days. Count the col-
Table 10.—Relationship of weight of chicken parts to equivalent surface area

<table>
<thead>
<tr>
<th>Weight of chicken part (gm)</th>
<th>Equivalent surface area^2</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Wing</td>
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<td>250</td>
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^26.5 sq cm = 1 sq inch.

<table>
<thead>
<tr>
<th>Weight of chicken part (gm)</th>
<th>Equivalent surface area^2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wing</td>
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^4Obtainable at DIFCO Laboratories, P.O. Box 1058-A, Detroit, Mich. 48232, and Baltimore Biological Laboratories, Cockysville, Md. 21030, respectively.

Preparation of Agar Media for Bacteria, Coliform, Staph, and Yeast and Mold Counts

1) Refer to instructions on media jars. (See also DIFCO and BBL manuals.) Plate count agar is used for total, violet-red bile agar for coliform, and tellurite glycine agar for staph counts. Add 1 ml of 1 percent sterile potassium tellurite solution to each 100 ml of melted tellurite glycine agar before pouring plates. Pour plates and allow to harden and dry. Then place sample on surface of agar using a sterile 2.2 ml pipette. Distribute sample over agar evenly using a sterile bent glass rod or side of the pipette. Potato dextrose agar is used for yeast and mold count. To each 100 ml of melted, sterile agar, add 1 ml of 1-10 dilution of tartaric acid according to directions on the bottle.

2) When plates are to be poured, melt agar and cool to 100°-120° F. Pour amount equivalent to 15 ml of each agar into a sterile petri dish containing the sample to be tested. Replace cover and swirl agar to mix.

3) Allow plates to harden (about 20 minutes), invert, and place in incubator for required length of time. Moisture that condenses on cover of plates is the result of bacterial growth, and if plates are upright, this moisture will drip into the plate causing colonies to merge; therefore, invert plates. Aluminum spot plates, of course, cannot be inverted.
<table>
<thead>
<tr>
<th>°F</th>
<th>°C</th>
<th>°F</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>-1.1</td>
<td>80</td>
<td>26.7</td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>85</td>
<td>29.4</td>
</tr>
<tr>
<td>35</td>
<td>1.7</td>
<td>90</td>
<td>32.2</td>
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<tr>
<td>40</td>
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<td>95</td>
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</tr>
<tr>
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<td>100</td>
<td>37.8</td>
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<tr>
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<td></td>
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</tr>
</tbody>
</table>

Conversion:

°C = °F - 32 × 5/9
°F = °C × 9/5 + 32

1 oz = 28 gm
1 lb = 0.45 kg
1 sq in = 6.5 sq cm