Sanitary/hygienic equipment design

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Keywords: poultry; processing; cleaning; sanitation; hygiene

Summary

Proper cleaning and effective sanitation is an essential component of processing poultry, as it contributes significantly to the prevention of product contamination with microorganisms that cause food-borne disease and spoilage. Rapid expansion of production volume, increased further-processing and introduction of diverse ready-to-cook and ready-to-eat products, sophistication of the processing equipment, implementation of HACCP and microbial finished-product standards, and, more importantly, expensive product recalls have necessitated greater control over the cleaning and sanitation process.

A sanitary process should effectively protect raw and/or cooked products from physical (i.e., metal, plastic, bone, packaging materials etc.), chemical (residues of cleaning and disinfection chemicals, lubricants, coolants etc.), and biological (food-borne pathogens and/or their toxins) hazards. In spite of this, many hazards continue to find their way into the processing environment and ultimately into the finished products. Microorganisms are naturally introduced into the poultry processing environments in high numbers with the live birds and, when the conditions are suitable, from growth niches by actively multiplying within the system.

It is generally accepted that processing equipment should not be a direct or indirect source of microbial contamination. Many regulatory and advisory bodies have introduced hygienic design and processing guidelines. This presentation will review the recently introduced sanitary processing equipment design principles and equipment checklist by the American Meat Institute.

A plant designed, equipped, operated and maintained with internationally accepted hygienic and sanitary standards will produce safe and wholesome poultry products for the consumer.

Introduction

Every stage of production and processing has a role in the safety of poultry products. Preventative and proactive food safety programs, such as HACCP, are globally recognized and implemented to prevent, reduce and/or eliminate the physical, chemical and biological (i.e., microbiological) hazards in finished products (Mulder, 2000). Processing phase of the poultry meat and egg production system has a special role in this process, as this is the critical point of transformation of raw materials (live birds or eggs) into diverse ready-to-cook or ready-to-eat products.

Live birds represent the single largest source of biological hazards during processing (Barbut, 2002). The role of processing plant is to reduce pathogenic microorganisms while preventing chemical and physical hazards in finished products. With the exception of few systemic conditions, the muscle tissue (i.e., meat) of healthy animals is free of pathogenic organisms until processing. During first-processing (i.e., hanging through chilling) the microbial load on the skin and internal surfaces of the carcass are progressively reduced. From a microbiological quality standpoint, the second-processing (i.e., sizing through cut-up, further processing and packaging) represents a major challenge, as carcasses are portioned into various bone-in and boneless products and further processed, exposing increasingly more product surface area for contamination from the processing surfaces, equipment and environment.

Cleaning and sanitation

Poultry processing plants have evolved significantly during the last decade from basic slaughter houses to complex food manufacturing plants (Bolder, 1998). Increasingly sophisticated processing and portioning equipment are being utilized with high-speed processing lines often operating two
continuous production shifts. Further-processing of poultry have expanded to include minimally processed products and aseptic packaging. Effective cleaning and sanitation programs are essential in these highly mechanized and complex processing facilities to minimize risks of contamination with spoilage and pathogenic microorganisms. HACCP plans, when properly designed and implemented should incorporate specific cleaning and sanitation tasks, be pre-operational or operational, on a daily basis. Facility-wide cleaning and sanitation pre-requisite programs and sanitation standard operating procedures (sSOP’s) help customize and document these procedures.

During processing, raw materials, environment (air, water), employees, facility and equipment, can serve as sources of biological hazards for poultry (Thomas et al., 1987). It is widely recognized that, in a food plant, the manufacturing process itself should not act as a source of microbial contamination (Comar, 1988). Microbial contamination of the product via the processing equipment could occur either through cross-contamination by transfer points (i.e., product contact surfaces) or by microbial growth niches (Butts, 2004). Cross-contamination by transfer points is usually controlled by the Good Manufacturing Practices (GMP’s) and sSOP’s, as contaminants, for the most part, are eliminated during cleaning and sanitation. On the other hand, growth niches harbour microorganisms from the cleaning and sanitation steps, creating undesirable and hidden sources of contamination. The top priority in a poultry processing plant should be the elimination and control of these growth niches for pathogenic microorganisms, such as Salmonella spp., Campylobacter spp., Staphylococcus aureus and Listeria monocytogenes. This can only be accomplished by sanitary/hygienic facility and equipment design and by implementation of production and sanitation process controls.

Bacterial growth requirements are well characterized to include: time, temperature, water, pH and availability of nutrients. However, often many other factors contribute to the development of pathogen growth niches during processing, such as product flow and pile-ups, debris accumulation, mid-shift cleanups, use of high pressure during cleaning, temperature control, unique product characteristics (i.e, stickiness), and more importantly, problems with equipment design and/or maintenance (Butts, 2004).

Equipment design

Poultry processing equipment has traditionally been designed based on efficiency, safety, product quality, and sanitation considerations. In many countries processing equipment is evaluated and certified by the regulatory agencies for use in inspected plants. Guidelines for the hygienic construction of commercial or custom-built equipment are based on various international standards:

4. 3-A sanitary Standards
5. National Sanitation Foundation International Standards (NSF International)
6. European Norms for Food Processing Machinery
7. International Organization for Standardization (ISO)

The sanitary design criteria and guidelines developed by these regulatory and advisory bodies provide benchmarks to reduce hazards from the use of equipment in food processing. Since 1997, with the introduction of HACCP, the mandatory evaluation and certification of processing equipment prior to its use has been abandoned in the US. Absence of standards and oversight by a regulatory agency removed the assurance that the processing equipment would not cause microbial contamination problems. Most processors purchased equipment based on set of agreed-upon specifications, with little or no sanitary design standards to follow. The American Meat Institute (AMI) Equipment Design Task Force has created a list of 10 Principles of Sanitary Equipment Design (AMI, 2003) to guide the equipment manufacturers in modifying their equipment designs. To aid in equipment evaluations, a checklist is also added to each of the 10 principles listed (Table 1). These checklists allow processors to conduct a sanitary design audit of the equipment based on assigned points. To be effective, the equipment must be used in the processing line for 90-day period, disassembled to its normal daily level, and evaluated both visually and microbiologically. In the audit form, full points are assigned to satisfactory, one-half points assigned to marginal, and no points are
given to unsatisfactory items. A score of >1000 is acceptable, whereas any equipment with a score <1000 needs improvement.

**AMI Sanitary Design Principles**

Basically, these principles require all parts of the machinery easily accessible for cleaning and sanitation, and elimination of places on the machine that could trap product debris and other material that could result in the development of pathogen growth niches:

1. **Cleanable to a microbiological level:** Food equipment must be constructed to ensure effective and efficient cleaning of the equipment over its life span (100 points total). As measured post-installation:
   a. The equipment should be designed as to prevent bacterial ingress, survival, growth and reproduction on both product and non-product contact surfaces (20 points).
   b. All surfaces are cleanable as measured by less than one colony-forming unit (CFU) per 25 square cm, less than one CFU per 10 ml when the item is rinsed, acceptable RLU (device specific) when measured by residual adenosine triphosphate, and/or negative for residual protein or carbohydrate when using swabs (20 points).
   c. All surfaces are accessible for mechanical cleaning and treatment to prevent biofilms (20 points).
   d. When requested, data is available to demonstrate that soiled equipment is cleanable as indicated above, by an individual using the cleaning protocol provided by the supplier (20 points).
   e. Surfaces are clean visually and to the touch, and pass operational inspections using sight, touch, and smell (20 points).

2. **Made of compatible materials:** Construction materials used for equipment must be completely compatible with the product, environment, cleaning, and sanitizing chemicals and the methods of cleaning and sanitation (100 points total).
   a. Product contact surfaces are made with materials that are corrosion resistant, non-toxic, and non-absorbent as approved in NSF/ANSI/3A 141159-1 (10 points).
   b. In general, stainless steel shall be AISI 300 series or better (10 points).
   c. Composites and plastics remain intact without changes in shape, structure, and function through cleaning and sanitation (10 points).
   d. Plated, painted, and coated surfaces are not used for food contact surfaces or for surfaces above the product zone areas (10 points).
   e. Coatings and plating must remain intact (10 points).
   f. Cloth back belts are not used (10 points).
   g. Materials such as wood, enameware, uncoated aluminium, uncoated anodized aluminium, and others per NSF/ANSI/3A 14159-1 are not used (10 points).
   h. Metals are compatible with one another (10 points).
   i. Seals and O-rings are designed to minimize product contact (10 points).
   j. Materials used in construction are compatible with the product, the environmental conditions which they will be exposed, as well as cleaning methods and chemicals (10 points).

3. **Accessible for inspection, maintenance, cleaning and sanitation:** All parts of the equipment shall be readily accessible for inspection, maintenance, cleaning and sanitation without the use of tools (150 points total).
   a. All surfaces in the product zone are readily accessible for cleaning and inspection (15 points).
   b. Product zone components with inaccessible surfaces can be disassembled without tools and easily (15 points).
   c. Where access or disassembly is not possible, the entire unit is cleaned by clean-in-place (CIP) or clean-out-of-place (COP) methods (10 points).
   d. Parts remain attached or hung on the equipment for easy cleaning and to prevent damage and loss. Separate part carts are supplied as an alternative (5 points).
   e. Machinery and chain guards drain away from product zones and are easily removed (15 points).
f. Product catch pans or drip pans are easily removable for cleanup, so they are not lost or separated from the equipment (10 points).

g. All belting is easily removable or the belt tension is removed easily without tools so the surfaces underneath can be cleaned (15 points).

h. All surfaces in non-product zones shall be readily accessible for cleaning and inspection (15 points).

i. Installation will maintain a 46-cm floor clearance for any product contact areas or conveyor travel paths. Equipment design provides 31-cm of clearance to the floor (15 points).

j. Equipment is located 77-cm from overhead structures and 92-cm from the nearest stationary object (15 points).

k. All air, vacuum, and product hoses and their assemblies on the equipment are easily removable for soaking and sanitizing (10 points).

l. All air, vacuum, and product hoses are transparent or opaque, and meet product contact surface guidelines (10 points).

4. No product or liquid collection: Equipment should be self-draining to assure that liquid, which can harbour and promote the growth of bacteria, does not accumulate, pool or condense on the equipment (total 100 points).

a. All surfaces should be designed to eliminate water pooling and to be self-draining (10 points).

b. Round framework is used for horizontal members where possible (20 points).

c. Where square or rectangular bases are used, the flat surface is turned 45 degrees to horizontal where possible (10 points).

d. All open surfaces are made of sufficient strength to prevent warping and subsequent pooling of water (15 points).

e. Moisture does not drip, drain or draw into product zones (15 points).

f. Belt tension is adequate throughout operations to prevent water from pooling on the belts (15 points).

g. Dead spaces are eliminated (15 points).

h. Materials used in the construction are non-absorbent (15 points).

5. Hollow areas should be hermetically sealed: Hollow areas of equipment, such as frames and rollers must be eliminated whenever possible or permanently sealed. Bolts, studs, mounting plates, brackets, junction boxes, nameplates, end caps, sleeves, and other such items should be continuously welded to the surface, not attached via drilled and tapped holes (150 points total).

a. All rotating members, such as drive sprockets or belt pulleys, are to be solid or filled with dye and fully sealed with continuous welds (30 points).

b. All stationary hollow tube construction, such as frame members or blade spacers, are fully sealed with continuous welds to prevent interior contamination (30 points).

c. There are no fastener penetrations into hollow tube construction (30 points).

d. Threaded leg adjustments are internal and do not penetrate the tube frame members (30 points).

e. Name plates and tags are minimized. When attached, plates and tags are continuously welded. Rivet- or screw-attached plates (often sealed with caulk) are absent (30 points).

6. No niches: Equipment parts should be free of niches such as pits, cracks, corrosion, recesses, open seams, gaps, lap seams, protruding ledges, inside threads, bolt rivets and dead ends (150 points total).

a. Surface texture of a product contact surface shall not exceed 32 microns, except as described in NSF/ANSI/3A 14159-1 (10 points).

b. Surface texture on a non-product contact surface shall not exceed 125 microns (10 points).

c. Internal corners and angles shall have a smooth and continuous radius of at least 3-mm (angles <135 degrees) (10 points).

d. No lap joints (10 points).

e. Hermetically sealed spacers are used to allow for space between two adjoining pieces to permit mechanical action during cleaning (10 points).
7. Sanitary operational performance: During normal operations, the equipment must perform so it does not contribute to unsanitary conditions or the harbourage and growth of bacteria (100 points total).
   a. Buttons on control panels are easily cleaned and sanitized during operations (15 points).
   b. All compressed air used for blowing on the product or contact surfaces is filtered to a minimum of a 0.3 micron level and dried to prevent the formation of moisture in the piping system (15 points).
   c. No bearings are present in the product contact zone areas (15 points).
   d. A separation exists between the product contact and non-product contact areas to prevent cross-contamination during operation (15 points).
   e. All surfaces near the product contact zone areas are designated as if they were product contact zone areas (15 points).
   f. Product contact surfaces are made to prevent accumulation of product residue during operation (15 points).
   g. Shafts passing through a product zone shall have an air gap to prevent product contamination (10 points).

8. Hygienic design of maintenance enclosures: Maintenance enclosures and human machine interfaces such as push buttons, valve handles, switches, and touch screens, must be designed to ensure food product, water or product liquid does not penetrate or accumulate in or on the enclosure or interface. Also, physical design of the enclosures should be sloped or pitched to avoid use as storage area (50 points total).
   a. Drives, chain guards, electrical control boxes, and bearings are not located over open product zones (10 points).
   b. Control and junction boxes are fastened to the frame in a manner consistent with the sanitary design principles (10 points).
   c. Utility supply lines and pipes are separated to prevent catch points and allow for cleaning (5 points).
   d. Utility lines are 31-cm above the floor and cleanable (5 points).
   e. Conduit and supply lines are not routed above product contact areas (10 points).
   f. Maintenance enclosures in direct wash-down areas must be able to be exposed to water and chemicals used in cleaning and sanitation (10 points).

9. Hygienic compatibility with other plant systems: Equipment design should ensure hygienic compatibility with other equipment and systems, such as electrical, hydraulics, steam, air and water (50 points total).
   a. Exhaust systems have welded seams with adequate access for cleaning and inspection (10 points).
   b. Vertical duct sections have a drain to prevent draining from flowing back into the equipment (10 points).
   c. Separate exhausts are supplied for raw and ready-to-eat product zones (10 points).
   d. CIP systems are designed, installed, and validated using a recognized third-party in sections of duct work that are not easily cleaned through access openings (10 points).
   e. Equipment is designed to meet criteria of waste water infrastructure capability to assure no backups of drainage lines result under normal operation (10 points).
Sanitary design plays an important role in controlling the biological, as well as the physical and chemical hazards in raw or ready-to-eat poultry products. The current design standards will likely be frequently modified, as other issues such as economics, ergonomics and simplification (training) are considered. Cooperation and collaboration between the manufacturers and processors is a must to achieve the desired level of hygiene/sanitation. An equipment designed, manufactured, operated, and maintained with the recognized sanitary design principles will assure the production of safe and wholesome products.

References


### Table 1 The American Meat Institute’s 10 Principles of Sanitary Design.

1. Cleanable to a microbiological level
2. Made of compatible materials
3. Accessible for inspection, maintenance, cleaning and sanitation
4. No product or liquid collection
5. Hollow areas hermetically sealed
6. No niches
7. Sanitary operational performance
8. Hygienic design of maintenance enclosures
9. Hygienic compatibility with other plant systems
10. Validated cleaning and sanitizing protocol