Compliance Guideline for Controlling *Salmonella* and *Campylobacter* in Poultry

Third Edition

May 2010

This is the **third** edition of the Compliance Guideline for Controlling *Salmonella* and *Campylobacter* in Poultry. This update includes additional pre-harvest recommendations for controlling *Salmonella* and *Campylobacter.* Future editions will continue to reflect feedback received from all stakeholders.
This Compliance Guideline follows the procedures for guidance documents in the Office of Management and Budget's (OMB) "Final Bulletin for Agency Good Guidance Practices" (GGP). More information can be found on the FSIS Web page:
www.fsis.usda.gov/Significant_Guidance/index.asp

This Compliance Guideline represents current FSIS thinking on this topic and should be considered usable as of this issuance. This guideline for poultry articulates how industry can meet FSIS expectations regarding control of food safety hazards. The guidelines summarize known control points for *Salmonella* and *Campylobacter* in the pre- and post-harvest production process, and include summaries of scientific studies that can be used to support specific control parameters. The guidelines will be updated as needed to reflect the most current information available to FSIS and stakeholders.

This document includes recommendations rather than regulatory requirements. FSIS requests that all interested persons submit comments regarding any aspect of this document, including but not limited to: content, readability, applicability, and accessibility. The comment period will be 60 days. The document will be updated in response to comments.

Comments may be submitted by either of the following methods:

Federal eRulemaking Portal: This Web site provides the ability to type short comments directly into the comment field on this Web page or attach a file for lengthier comments. Go to http://www.regulations.gov.
Follow the online instructions at that site for submitting comments.

Mail, including floppy disks or CD-ROMs, and hand- or courier-delivered items: Send to Docket Clerk, U.S. Department of Agriculture (USDA), FSIS, Room 2-2127, George Washington Carver Center, 5601 Sunnyside Avenue, Mailstop 5474, Beltsville, MD 20705-5474.

Instructions: All items submitted by mail or electronic mail must include the Agency name and docket number FSIS-2009-0034. Comments received in response to this docket will be made available for public inspection and posted without change, including any personal information, to http://www.regulations.gov

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I. Summary of Guidance Material

This is the third edition of the Compliance Guideline for Controlling *Salmonella* and *Campylobacter* in Poultry and includes the following changes:

1. Additional pre-harvest guidance for the control of *Salmonella* and *Campylobacter*;

2. Addition of current research in applicable sections of the document. Guidance on air chilling and further processed products, i.e., parts; and

3. Updated information regarding FSIS initiatives on implementation of the *Salmonella* verification program.

II. Purpose

This compliance guideline describes concerns and validated controls for each step in the poultry slaughter process. It targets small and very small poultry plants to help them better comply with regulatory requirements (9 CFR 381.65, 381.76, 381.92, 381.93, and 381.94, 416, and 417).

FSIS encourages plants to reduce levels of *Salmonella* and *Campylobacter* on carcasses during poultry slaughter operations using best management practices outlined in this guideline. The interventions suggested cannot overcome poor pre-harvest production practices, poor sanitary practices in slaughter and dressing, or poor slaughter facility sanitation. Plants should use this guideline to improve management practices. When a plant makes changes at the appropriate locations, process control should improve. As a result, plants should produce raw poultry products that have less contamination with pathogens, including *Salmonella* and *Campylobacter*. Generally, those interventions to reduce or prevent *Salmonella* will likewise reduce or prevent *Campylobacter*. The Agency strongly recommends that plants consider both pathogens when designing food safety systems.

For easy use, some sections of this guideline begin with best practice recommendations. The paragraphs that follow the recommendations further explain concerns and controls specific to that step. Again, this information is provided as guidance to assist poultry slaughter establishments, and is not legally binding from a regulatory perspective.

III. Background

Food Safety Systems

A. Unlike the production of ready-to-eat (RTE) product in which a lethality treatment destroys pathogens of public health concern, slaughter and dressing operations do not have a treatment capable of destroying all pathogens. FSIS expects plants to have food safety systems designed to ensure birds are processed in a manner that reduces possible contamination during slaughter and dressing. FSIS expects plants to have treatments in place to reduce the level of incoming contamination on the exterior of the birds throughout the operation. The procedures and treatments the plants use to reduce contamination should be documented as part of their food safety systems.

HACCP Plan

A. If the plant decides through its hazard analysis that *Salmonella* or *Campylobacter* is a food safety hazard likely to occur, 9 CFR 417.2 requires that the plant's Hazard Analysis and Critical Control Point (HACCP) plan address these food safety hazards. The HACCP plan must meet all parts of 9 CFR 417.2(c). In this case, the HACCP plan must have a Critical Control Point (CCP) to address *Salmonella* or *Campylobacter*. A plant should be able to support any decision that it makes during the hazard analysis. The HACCP plan must contain verification procedures that the plant will do to ensure the HACCP system is working as designed. If a critical limit is not met in the HACCP plan, the corrective actions listed in 417.3 must be met.

Sanitation Standard Operating Procedure (Sanitation SOP) or Other Prerequisite Programs

B. Plants may address *Salmonella* and *Campylobacter* in their Sanitation SOP or other prerequisite programs. The plants should have records associated with their Sanitation SOP or other prerequisite programs that show these programs are preventing a food safety hazard from being reasonably likely to occur.

C. If the process results in a high number of *Salmonella* or *Campylobacter* subtypes associated with common human illness, the plant is expected to take appropriate action. If the process is addressed in the Sanitation SOP but is not met, then 9 CFR and the corrective actions listed in 416.15 must be met. If the process is addressed in another prerequisite program, the actions listed in the program are expected to be followed. The plant should determine specifically why its food safety system is not appropriately and consistently minimizing the level and type of contamination on poultry arriving at the plant, as well as during slaughter and dressing processes.

D. If a plant is not maintaining consistent process control (Category 2 or 3), or cannot control *Salmonella* or *Campylobacter* subtypes associated with common human illness,

the plant should re-evaluate its food safety system. The plant should determine if its Sanitation SOP or prerequisite program is adequate to control *Salmonella* and *Campylobacter*. If not, the plant should consider addressing *Salmonella* and *Campylobacter* control in a HACCP plan.

Food Safety Assessments: Common Findings

A. An FSIS Food Safety Assessment (FSA) considers all food safety aspects that relate to a plant and its environment, the nature and source of all materials received, and the plant's processes and products.

B. An Enforcement, Investigations, and Analysis Officer (EIAO) is an FSIS employee specially trained to conduct FSAs. EIAOs are required to assess the design and validity of the hazard analysis, HACCP plan, Sanitation SOPs, prerequisite programs, testing programs, and any other programs that constitute the plant's food safety system. An FSA may be conducted for the following reasons:

1. Positive laboratory findings including subtypes linked to human illness;

2. To determine if a plant has reassessed its HACCP plan or evaluated its Sanitation SOP;

3. Foodborne illness outbreaks, recalls, or consumer complaints; or

4. Four year cycle if a plant has not been assessed for other reasons.

C. Designing and implementing an effective food safety system can be challenging. The Food Safety Assessments conducted through 2006 indicated that some plants struggle to put in place an effective food safety system. General findings included inconsistencies between the hazard analysis and the selection of the CCP and critical limits. Hazards were identified in the hazard analysis, but there was no indication why they were not reasonably likely to occur. Supporting documentation was lacking for decisions that a hazard was not reasonably likely to occur. Prerequisite programs lacked records showing how the prerequisite program was effective in preventing certain potential hazards from being reasonably likely to occur in the process.

D. In addition, there was often no support for decisions on selection of CCP and critical limits. There were minimal decision-making documents for monitoring and verification frequencies. When corrective actions were taken, they were often ineffective. Deviations would occur and reoccur. Documentation would reflect the deviation, but the same corrective actions were carried out repeatedly without any regard to whether or not they were successful. Many plants did not address *Salmonella* specifically as a pathogen likely to be present. To ensure the highest food safety production, plants should have a clear understanding of their HACCP plans, Sanitation SOPs, and any other prerequisite programs. It is difficult for a plant to put in place interventions that work if it has not

considered which pathogens should be targeted in the plant's food safety system. Plants must have an effective food safety system design and then execute their programs as designed. If not, FSIS expects that plants will reassess, re-evaluate, modify, or make appropriate improvements in how their programs are operating to ensure they produce safe and wholesome product for the consumer.

IV. Pre-Harvest

Recommended Best Practices

1. Implement biosecurity measures.
2. Use good sanitation practices.
3. Control litter moisture.
4. Use well-timed feed withdrawal.
5. Use acids in drinking water during feed withdrawal.
6. Use vaccination programs.
7. Use boot swabs to test poultry farm for pathogens.

A. Producers should obtain their poultry from hatcheries that follow the Animal and Plant Health Inspection Service (APHIS) National Poultry Improvement Plan specific procedures described in 9 CFR 145.6. Producers may consider using an approved competitive exclusion product or probiotic on the day of hatch to establish normal gut flora. Producers may choose to obtain eggs from multipliers that are part of an approved *Salmonella* reduction program that includes the use of vaccines or autogenous bacterins.

B. Research has shown that on-farm interventions can reduce levels of *Salmonella* in poultry (Campbell, et al., 1982). Biosecurity and sanitation, including pest control, are important at grow-out houses. According to the Association of American Feed Control Officials (AAFCO), feed should come from a source that follows best management practices for plant sanitation, equipment maintenance, employee training and supervision, material purchases, and a receipt to confirm the previous information. Feed should be transported in accordance with the Sanitary Food Transportation Act of 1990 along with a third party certification, such as the Certified Transport Program (Facility Certification Institute; American Feed Industry Association). Attention should be paid to protect feed during transportation from storage facilities to feeders. Feeders need to be protected as well from contamination by poultry and other animals. Feed processed in pellet form, rather than in meal form, lowers the flock's risk of *Salmonella* contamination.

C. To ensure water is potable, it should be obtained from an approved source and tested to verify that water is free of pathogens. Automatic water stations should be free of leaks to avoid water dripping onto the litter.

D. Controlling subsurface moisture in grow-out houses is a significant best management practice. It reduces levels of *Salmonella* in the environment and reduces cross contamination within flocks. Preventing litter from becoming too wet is recommended as a good strategy to lower *Salmonella* on the farms. Litter should be kept at an available water activity (a_W) less than .84 or moisture content between 20-25%.

E. *Campylobacter* is difficult to control through on-farm practices. However, best management practices should still be used. One study demonstrated effectiveness of keeping buildings in good repair, installing boot dips, and having strict cleaning practices to decrease *Campylobacter* in flocks (Evans and Sayers, 2000). More specific guidelines suggest using a chlorinated water supply (e.g., municipal source) and thoroughly cleaning the drinking system between flocks. In addition, strict hygiene practices for workers and visitors should be enforced. Finally, access to the houses and hatchery by rodents, wild birds, and flies should be prevented (Corry and Atabay, 2001). Reducing the level of *Campylobacter* in the guts of birds through good on-farm practices has been shown to reduce the level of *Campylobacter* on carcasses (Rosenquist, 2006).

F. Feed withdrawal is recommended to reduce food and fecal contamination on the carcasses (NCC, 1992, NTF, 2004). Removing feed too late may result in carcass contamination because the gut may rupture during processing. Economically, non-digested food does not contribute to the final weight of the carcass. However, if feed is removed too early, the internal organs become more fragile. The crop and cloaca can easily tear during processing. One study reported that feed withdrawal periods greater than 14 hours made the intestine and gall bladder more fragile (Bilgili and Hess, 1997).

G. Research has shown that providing mineral and organic acids in the drinking water greatly reduces post-harvest crop contamination with *Salmonella* and *Campylobacter* (Byrd, et al., 2001; Byrd, et al., 2003). Providing treated water does two things. First, as with providing any drinking source, it distracts the birds from pecking at their droppings. Second, acids protect the crop from an overgrowth of *Salmonella*. However, the amount and type of acid used should be carefully monitored. The acid should be of a type and strength that birds are willing to drink.

H. Plants may want to consider purchasing from growers that use acids in drinking water during feed withdrawal, or if they own the birds, adding acids to the drinking water themselves. If plants use or purchase birds fed mineral or organic acids during feed withdrawal, they should consider this in their hazard analysis (9 CFR 417.2). Currently, lactic acid, acetic acid, and sodium bisulfate are considered "general purpose food additives" by the Food and Drug Administration per 21 CFR 582.1.

I. Vaccinations are another means of reducing the shedding of *Salmonella*. Vaccines protect against pathogens like *Salmonella Enteritidis* (SE) by reducing SE in the gut as well as in the reproductive organs. This should reduce the number of eggs (and later chicks) infected with SE (Davison, et al., 1999). Live-attenuated vaccines prevent *Salmonella spp.* from developing inside the guts of chicks (Barber, et al., 1999).

J. Knowing the level or prevalence of *Salmonella* and *Campylobacter* in the flocks prior to transporting to slaughter may help the plant manage incoming loads more effectively. For example, if the plant knows that a particular flock has a high level of *Salmonella* or *Campylobacter*, the plant may want to slaughter and process that flock at the end of the day after all other flocks and before cleanup. Sampling litter, drag swabs, and foot covers are some of the methods used for testing on the farm (Hiett, et al., 2007; Bailey, et al 2001). Some research indicates that using foot covers is a low cost and effective way to determine *Salmonella* presence (McCrea, et al., 2005).

K. Research conducted by FSIS and Agricultural Research Service (ARS) researchers, S. Bailey and M.Berrang, showed that the house a flock was grown in on the farm affects the pathogen load of processed carcasses. The data indicate that on-farm testing of each house for *Salmonella* prevalence or indicator organisms (generic *E. coli*, coliforms, Enterobacteriaceae) could be used to prioritize slaughter scheduling. Plants could schedule flocks with low *Salmonella* prevalence or low indicator load early in the production day followed by flocks that had higher levels. This could have dramatic effects on pathogen loads of carcasses. These data could be used by plants to determine which farms to obtain birds from for slaughtering.

L. Many of these pre-harvest interventions were discussed in greater detail during the meeting, "Advances in Pre-Harvest Reduction of *Salmonella* in Poultry" held August 25-26, 2005. The written transcripts for this meeting can be found at: http://www.fsis.usda.gov/PDF/Salmonella_Transcripts_082505.pdf and http://www.fsis.usda.gov/PDF/Salmonella_Transcripts_082605.pdf

V. Live Receiving and Live Hanging

Recommended Best Practices

1. Sanitize and dry cages thoroughly.
2. Maintain positive air flow from inside to outside the plant.
3. Provide SOP and employee training.
4. Schedule flocks for slaughter based on pathogen loads.

A. The feathers, skin, crop, and cloaca of birds brought to slaughter are often highly contaminated with *Salmonella* (Kotula and Pandya, 1995) and *Campylobacter* (Berrang et al., 2000). Cross contamination of both birds and cages is frequently made worse when the birds are moved to the plants. There can be a 20-40% increase in *Salmonella* both inside and outside the birds during movement. Moving the birds causes them to pass more fecal material. If the birds have *Salmonella*, the cages have *Salmonella* as well. Transport cages are important sources of cross contamination (Berrang, et al., 2003, Slader, et al., 2002). A recent study found that 5% of the cages sampled were positive for *Salmonella* before use and 10% after use. Additional research showed that

the presence of *Salmonella* and *Campylobacter* on birds at receiving was linked to dirty cages (Cory, et al., 2002, and Slader, et al., 2002).

B. Research indicates that washing the transport cages with water and leaving them to completely dry for 48 hours greatly lowers the levels of *Salmonella* found in the cages. However, this approach adds to the costs. Water use, employee time, storage space, and unused equipment are all costs to be considered. One researcher suggested using removable cage floors that could be stored or dried thoroughly.

C. More recent research suggests that a two-step process that first cleans and disinfects the cages is effective at reducing *Salmonella*. Pre-cleaning the cages prior to immersing in hot water for 30 seconds at 60 ºC or higher or immersing for 30 seconds in a solution of sodium hypochlorite at 750 ppm or higher appears to reduce *Salmonella* on transport cages (Ramesh, et al., 2004).

D. Cleaning followed by sanitation of the unloading and holding area is important. High levels of *Salmonella* and *Campylobacter* found on incoming birds can overwhelm in-plant interventions. These levels are carried forward to the next steps of the slaughter process. Studies show links between *Salmonella* and *Campylobacter* at live receiving and later in the process (Fluckey, et al., 2003, Newell, et al., 2001). In addition, one study attributed the conversion of *Campylobacter*-negative birds to *Campylobacter*-positive after exposure to feces in a commercial dump cage (Berrang, et al., 2003).

E. Employee traffic patterns and air flow should be controlled to prevent cross contamination and reduce levels of *Salmonella*. There should be positive airflow moving from inside to outside of the plant. Standard operating procedures and training, including changing clothes and boots upon arrival, separate facilities for “dirty” versus “clean” employees, and restricting employee movement can be put in place. One study found employee clothing to be a source of contamination for *Campylobacter* (Herman, et al., 2003).

F. Most plants keep detailed records of suppliers and slaughter schedules by lots to monitor output or yields. A plant could use these records to correlate its own in-house testing programs to determine if there are suppliers that routinely deliver birds carrying a high microbial load. Addressing these issues with suppliers could lower the microbial level of incoming birds at receiving and thereby reduce microbial loads, particularly pathogens, in chilled carcasses.

VI. Stunning and Bleeding

Recommended Best Practices

1. Consider electrical stunning: cheapest and most effective method.
2. Use well-timed feed withdrawal practices to reduce feces release.

A. Stunning makes the birds unconscious. Bleeding ensures death by slaughter. It also ensures that poultry have stopped breathing before going into the scalder per 9 CFR 381.65(b).

B. There are three types of stunning: electrical, mechanical, and chemical. Electrical stunning is the cheapest and most effective method for plants that slaughter broilers. This method reduces struggling and convulsions. However, wing flapping and quivering that happens because of the electrical stunning can transfer bacterial pathogens from the inside to the outside of the bird and to nearby birds and equipment. Plants slaughtering turkeys or heavy fowl may find chemical stunning a better method because of the size of the birds. There is research to suggest Controlled Atmospheric Stunning, a varying mixture of carbon dioxide, argon, and nitrogen, may reduce damage to carcasses. Studies have shown that birds chemically stunned struggle less during the slaughter process and there are fewer broken bones and less muscle bruising (Kang and Sams, 1999, and Hoen and Lankhaar, 1999). Other research finds no difference between electrical and chemical methods regarding quality of the carcasses (Kang and Sams, 1999).

C. Birds release fecal material during stunning. A study by Musgrove, et al., (1997) showed that *Campylobacter* increased in carcass rinses after stunning. As described earlier, good feed withdrawal practices can greatly reduce this problem. By decreasing the amount of feces expressed, plants can reduce fecal cross-contamination on the surface of the carcasses, in the scald tank, and on the feather removal equipment. This decreases the level of *Salmonella* and *Campylobacter* carried forward into the next steps.

VII. Scalding

Recommended Best Practices

To improve process control in the scald tank:

1. Have water moving counter current to carcasses;
2. Have high flow rates of water with adequate agitation to dilute dry matter and bacteria;
3. Use multi-staged tanks; and
4. Maintain water pH at either above or below the optimum pH for *Salmonella* growth (6.5-7.5).

Additional recommendations:

1. Use pre-scald brush systems to clean birds prior to scald tank.
2. Use post-scald rinse.

A. Scalding prepares carcasses for defeathering by

breaking down the proteins that hold the feathers in place and opening up the feather follicles.

B. The National Chicken Council (NCC) recommends that best management practices include using counter current systems with adequate water replacement (NCC, 1992). Water in the tank should move through the system flowing against incoming carcasses. This flow creates a dirty-to-clean gradient. Carcasses moving through the tank are washed by ever-cleaner water. Multiple stage tanks are better than single stage tanks because they create more opportunities to clean the carcasses (Cason, et al., 2000).

C. High flow rates of water and adequate agitation dilute the dry matter and bacterial load in the tank (Cason, et al., 2001). The NCC recommends at least one quart of clean water entered into the scald tank for each carcass processed. A carcass rinse (bird washer) is frequently used as the carcasses leave the scald tank. This type of rinse can improve the effectiveness of the scalding process. The NCC recommends using a post-scald wash after the carcasses leave the scald tank but before they enter the picker. This wash reduces the *Salmonella* load for the next steps.

D. The water pH should be monitored carefully. A higher, more alkaline pH (9.0 ± .2) is best for reducing *Salmonella* and *Campylobacter* in the water (Humphrey and Lanning, 1987). Making the pH more acidic (3-4) is also effective at decreasing levels of *Salmonella* (Okrend, et al., 1986). Plants should monitor the pH in scald tanks as frequently as necessary to determine the pH highs and lows occurring during operation. Once plants are able to maintain a desirable pH, less monitoring is needed.

E. Uric acid from poultry feces can reduce the pH from 8.4 to 6.0 in less than 2 hours (Humphrey, 1981). Organic matter in the tank acts as a buffer to maintain a more neutral pH (6-7). *Salmonella* is heat resistant at a neutral pH **(**Okrend, et al., 1986). *Campylobacter* is most heat resistant at a pH of 7.0 (Humphrey and Lanning, 1987).

Scalding can be used as an intervention if pH is properly maintained in the scald tank.

F. Understanding water characteristics is important. The source (well or treated surface water or municipal water), hardness, mineral content, and pH influence the killing action of chemicals that are added to the water. Plants using more than one water source should carefully monitor the effect of the water on the chemicals used.

G. There are two methods for scalding: steam-spraying and immersion. Steam spray systems work by applying a mixture of steam and air at a temperature and pressure designed to scald the surface of carcasses. Immersion scalding is carried out by placing the carcasses into a tank of hot water. Tanks are either single- or multi-staged. Immersion is more common than steam-spraying. However under the right conditions, both methods can reduce *Salmonella* on carcasses (Dickens, 1989).

H. Most U.S. poultry processors prefer a hard scald to a soft scald. A hard scald is a shorter scald time at higher temperatures compared to a soft scald. This allows better removal of the outer layer of skin (epidermis). The correct water temperature for the appropriate amount of time is important to prepare the carcasses for feather removal. This also reduces dressing defects. When the water temperature is too high, the carcasses become oily. This oiliness makes it easier for *Salmonella* to stick to the surface of the skin. If the carcasses are over-scalded, the meat may start to cook and the carcasses may be marked unacceptable and rejected by inspectors. If the temperature is too low, the tank becomes a breeding ground for bacteria. *Salmonella* organisms cannot grow at temperature greater than 116.6 ºF (47ºC). Therefore, scalding temperatures higher than 116.6°F (47ºC) should be sufficient to control *Salmonella* growth.

Common Scalding Times and Temperature for Various Classes of Poultry

Broiler (hard scald)	30-75 seconds	138.2-147.2°F (59-64°C)
Broiler (soft scald)	90-120 seconds	123.8-129.2°F (51-54°C)
Turkeys	50-125 seconds	138.2-145.4°F (59-63°C)
Quail	30 seconds	127.4°F (53°C)
Waterfowl	30-60 seconds	154.4-179.6°F (68-82°C)

I. Two concerns at scalding are cross-contamination because of organic material carried forward from previous steps and *Salmonella* and *Campylobacter* in the scald water. There has been significant research on the presence of *Salmonella* and *Campylobacter* at scalding *(*Berrang, et al., 2000, Cason, et al., 2000, and Wempe, et al., 1983). *Salmonella* has been recovered from 100% of the skin and feather samples entering the scald tank (Georgnaras, et al., 1997) and has been shown to survive in the scald tank. Marker organisms introduced prior to carcasses entering the scald tank were recovered from the 230th carcass leaving the tank (Mulder, et al., 1978). Scalding cannot overcome high numbers of pathogens carried forward from previous steps. Pre-scalder brushes can be used to clean the birds prior to putting them into the tanks.

J. Scalding is an important step that can reduce levels of *Salmonella* on the carcass. Much of the dirt, litter, and feces on carcasses are removed here. One researcher reported a 38% decrease in the number of *Salmonella* positive poultry carcasses post scalding (Georgnaras, et al., 1997). Other research reported a decrease in *Campylobacter* in carcass rinses post scalding (Berrang and Dickens, 2000).

K. Some religious traditions forbid scalding. Under Kosher slaughter, carcasses are soaked in cold water to make feather removal easier. This method, as well as the steam spray method, may produce carcasses with skin more susceptible to *Salmonella* (Clouser, et al., 1995). Plants should consider this potential effect in deciding what sanitary practices they employ downstream.

VIII. Picking

Recommended Best Practices

1. Prevent feather buildup on equipment.
2. Rinse equipment and carcasses continuously.
3. Use 18-30 ppm chlorine rinse post picking.
4. Scientifically support any water reuse plan.

A. The feather removal process is designed to remove feathers and the uppermost layer of the skin before evisceration. Carcasses typically pass through rubber picking fingers that mechanically remove feathers from the carcass. Most plants use a continuous process. However, batch and manual processes are sometimes used in low-volume plants.

B. Good process controls at picking is critical and can improve a plant's performance regarding FSIS *Salmonella* sample sets. Cross-contamination of the carcasses occurs because of contact with contaminated rubber picking fingers and contaminated reuse water (Georgnaras, et al., 1997, Wempe, et al., 1983). Fecal material is released when picking fingers agitate and rub the carcasses and can lead to cross-contamination between the carcasses (Allen, et al., 2003). Several researchers have determined that levels of *Salmonella* and *Campylobacter* increase during this step (Acuff, et al., 1986, Izat, et al., 1988, Berrang and Dickens, 2000).

C. Regular equipment sanitation and maintenance are recommended to minimize cross-contamination when using either batch or continuous picking. The NCC recommends preventing feather buildup during the defeathering process by continuously rinsing the defeathering equipment and carcasses (NCC, 1992). An 18-30 ppm available chlorine rinse can help reduce *Salmonella* counts on carcasses exiting the feather removal step (Mead, et al., 1994). Post-feather removal rinses should be maintained at 160° F. Chlorine, acetic acid, and hydrogen peroxide are types of chemical rinses used during defeathering. If birds are plucked manually, the plant should take care not to cross contaminate by keeping the area as clean as possible and preventing feather buildup.

D. Water reuse is addressed in 9 CFR 416.2(g)(3). This regulation states that water, ice, and solutions may be reused for the same purpose provided that measures are taken to reduce physical, chemical, and microbiological contamination so as to prevent contamination or adulteration of product. A plant should have data to support all decisions regarding reuse, including a decision that reuse will or will not cause adulteration. Plants are expected to take measures necessary to ensure that their products do not become contaminated or adulterated.

IX. Eviscerating

Recommended Best Practices

1. Adjust and maintain equipment regularly and as needed.
2. Use 20 ppm chlorine for whole carcass rinses.
3. Enforce employee hygiene standards.

NOTE: Feed withdrawal practices affect process control at this step.

A. Evisceration begins at the transfer point (re-hang) and ends when the carcass enters the chiller. Evisceration processes remove the internal organs and any trim or processing defects from the poultry carcasses in preparation for chilling. If the head is not saved for human food, it is usually removed after scalding. If the head is saved for human food, it is presented with the carcass for post-mortem inspection.

B. Technology and methods vary widely across the poultry industry. Basic steps of evisceration include:

1. Removing the leg from the knee to foot;
2. Removing the oil gland;
3. Severing the attachments to the vent;
4. Opening the body cavity;
5. Extracting the viscera;
6. Harvesting giblets;
7. Removing and discarding the intestinal tract and air sacs;
8. Removing and discarding the trachea, esophagus, and crop; and
9. Removing and discarding the lungs.

C. For the evisceration process to work well, carcasses need to be placed on the shackles correctly and monitored as they move through the system. The machines need to be maintained in good working order and have proper alignment. Blades should be kept sharpened, and attention given to routine and thorough cleaning. Keeping the equipment

in a sanitary condition, that is free from intestinal contents and segments, is important for maintaining good process control. Automated transfer (re-hang), rather then manual transfer, of carcasses between the defeathering and evisceration lines reduces external surface cross-contamination.

D. The NCC recommends whole-carcass water rinses using 20 ppm free available chlorine (NCC, 1992). Carcass rinses are effective interventions for removing loose material from the carcass surface during evisceration. A 20 ppm free available chlorine rinse post-evisceration can decrease microbial contamination and improve food safety (Waldroup, et al., 1992). The incidence of *Salmonella*-positive carcasses can decrease by one third when carcass rinses are incorporated into the evisceration process (Notermans, et al., 1980). Rinses can reduce *Campylobacter* as well (Acuff, et al., 1986 and Izat, et al., 1988). Rinsing of carcasses is allowed after FSIS inspection.

E. Multiple *Salmonella* controls throughout the evisceration process are recommended. *Salmonella* is not effectively removed by using one carcass rinse. The multiple hurdle approach works best. In a recent study by FSIS and ARS, high levels of *E. coli* (on carcasses sampled immediately after defeathering) were often found to be linked to high levels of *Salmonella* on carcasses removed from the chiller. Reductions in *Campylobacter* levels between defeathering and removal of carcasses from the chiller were greater than reductions in *E. coli* levels between these two locations. In addition, high levels of *E. coli* post chill were correlated with high levels of *Campylobacter* on carcasses at the same location. Taken together, the results suggest that monitoring *E. coli* levels throughout processing is a cost-effective approach to monitor microbial processes for pathogen control during poultry slaughter and processing (Berrang, et al., 2007)**.** Plants already test poultry for generic *E. coli* (9 CFR 381.94).

F. Equipment setup, adjustment, and machine performance depend on the size, shape, gender, feed digestion capability, and live average weights of the birds. Processing flocks that greatly vary within a weight range can result in machinery performing poorly. If machines are set for the median weight of the flock, carcasses that are heavier or lighter may not be properly eviscerated. They are more likely to have their gastrointestinal (GI) tracts split open, contaminating carcasses and equipment. Carcasses not properly eviscerated mechanically may need to be finished manually. This results in increased processing costs as well as the likelihood of increased potential for cross-contamination. Ideally, flocks are relatively uniform in size.

G. In flocks with high *Salmonella* counts, a high percentage of crops and ceca contain *Salmonella.* Equipment such as crop removal devices can easily become contaminated with *Salmonella*, causing later carcasses to become contaminated (Mead et al., 1994). In some operations, at least half of carcass surfaces are contaminated with crop and upper GI contents immediately before evisceration (Byrd et al., 2002). Retracting the viscera from the body cavity can transfer crop and upper GI contents to the interior body cavity (Byrd et al., 2002). All of these factors can lead to cross contamination of carcasses.

H. Some processors consistently produce *Salmonella*- or *Campylobacter*-positive carcasses while others produce carcasses that upon testing typically do not have detectable levels of *Salmonella* or *Campylobacter*. These variable test results may be due to differences in sanitary dressing practices. For example, rates of visible contamination on the carcasses after crop removal vary greatly depending on crop removal practices. In some plants, fewer crops rupture because the crops are extracted toward the head (and downward) rather than toward the thoracic inlet (and upward) (Buhr et al., 2000). This is an important consideration for *Salmonella* control, because crop tissue often contains *Salmonella*.

I. Some carcasses may become contaminated with feces and ingesta even with strict sanitary slaughter practices. However, with proper sanitary practices, fecal contamination should be minimal. Reprocessing systems are used to control *Salmonella* on visibly contaminated carcasses. Both on-line and off-line reprocessing systems are used to remove contamination. Washing equipment is used around the evisceration process to control contamination.

J. Off-line Reprocessing addresses disease conditions and contamination that cannot be removed by other means. When properly performed, off-line reprocessing should eliminate visible conditions and produce carcasses microbiologically equivalent to routinely eviscerated and inspected and passed carcasses (Blankenship et al., 1975); however, it may increase cross contamination because there is additional manual handling by employees.

K. On-line Reprocessing (OLR) addresses incidental fecal or ingesta contamination during evisceration. OLR is automated and relies on washing systems in combination with antimicrobial agents to achieve desired results. In addition to the level of carcass contamination, water temperature, pressure, nozzle type and arrangement, flow rate, and line speed all influence the effectiveness of the washing system. Multiple washers in a series are more effective at reducing *Campylobacter* than a single large washer (Bashor et al., 2004). OLR that uses effective inside and outside bird washers can reduce the need for off-line reprocessing by 73-84% (Fletcher and Craig, 1997). If properly performed, OLR can yield better results than off-line reprocessing and improve food safety and the microbiological quality of raw poultry (Kemp, et al., 2001).

NOTE: Carcasses must be free of visible fecal material prior to entering the chilling systems per (9 CFR 381.65(e)).

L. The addition of antimicrobial agents generally increases the effectiveness of an OLR system. Washes with 23 ppm free available chlorine can reduce *Salmonella* and *Campylobacter* on carcasses (Fletcher and Craig, 1997). 10% percent Trisodium Phosphate (TSP), 5% cetylpyridinium chloride, 2% lactic acid, or 5% sodium bisulfate decreases *Salmonella* on carcasses (Yang and Slavik, 1998). Research has shown TSP to be effective in reducing *Campylobacter* (Bashor, et al., 2004). One study showed that using either 10% TSP or 25 ppm free chlorine lowered levels of both *Salmonella* and *Campylobacter* (Whyte, et al., 2001). Plants should know how the pH of residual OLR

agents on carcasses will affect chemicals used in the chilling step (e.g., active and available chlorine).

X. Chilling

Recommended Best Practices

Immersion Chilling

1. If using chlorine, maintain chill water pH between 6.0 – 6.5, at a temperature of less than 40°F.
2. Use high water flow rate and counter-current flow.
3. Use 20-50 ppm free available chlorine in the potable water measured at intake to reduce bacteria in the water and reduce carcass cross contamination.
4. Use Oxidation Reduction Potential pH meters with pH monitors.

Air Chilling

1. Meet regulatory requirements for chilling.
2. Clean and oil chains regularly.
3. Inspect and replace shackles as needed.
4. Maintain tension on chain to prevent carcass to carcass contact.

A. The chilling process reduces poultry carcass temperatures as required in 9 CFR 381.66. Immersion chilling and air chilling are the two technologies used today. Both methods decrease carcass temperature and inhibit microbial growth.

B. Research studies have shown that reductions in *Campylobacter* on poultry carcasses can be similar (Rosenquist, et al., 2006) or lower in air chilling systems compared to immersion chill systems (Allen, et al., 2000 and Sanchez et al., 2002). The cooling efficiency of air and water chillers is also similar. However, there is less physical contact between carcasses in air chillers, reducing the potential for cross-contamination. When antimicrobials are used, immersion chilling can reduce biological hazards further.

C. Sanitary practices are very important in plants using an air chilling system because this step does not use a chemical intervention. Environmental sanitation, sanitary upkeep of equipment and utensils, good personal hygiene, and proper handling practices may all have an impact on a plant's ability to meet the *Salmonella* performance standards or guidance. Following both Sanitation Performance Standards (SPS) and the Sanitation SOP is necessary to prevent the creation of insanitary conditions or adulteration of product.

Immersion Chilling

A. When using chlorine in immersion chilling, optimal chill water conditions would be a pH between 6-6.5, with a temperature of less than 40°F. Chlorine reacts with water to form hypochlorous acid and hypochlorite ions, both forms of free available chlorine. However, hypochlorous acid is the chemical form that best kills pathogens. When the water pH is higher than optimal, hypochlorous acid breaks down forming hypochlorite ions, which do not kill pathogens as well. Therefore, to get the most benefit from using chlorine during immersion chilling, pH should be carefully and continuously monitored.

B. Chlorine is a common and effective water treatment used to prevent bacterial carcass cross-contamination in immersion systems in the United States. In a study comparing chill water treated with chlorine compared to chill water not treated, the researchers found that the incidence of *Salmonella* was significantly lower in chlorine-treated chill water versus non-chlorinated chill water (Lillard, 1980). The effect is directly proportional to the free available chlorine concentration. For example, 10 ppm free available chlorine can eliminate *Salmonella* in 120 minutes and *Campylobacter* in 113 minutes (Yang, et al., 2001). Thirty ppm produces the same result in 6 minutes for *Salmonella* and 15 minutes for *Campylobacter*. *Salmonella* was eliminated from the water in 3 minutes at 50 ppm and *Campylobacter* in 6 minutes (Yang, et al., 2001). Water chemistry management involves balancing pH (to maintain a free available chlorine concentration in the form of mostly hypochlorous acid) and reducing organic matter.

C. A study by Stopforth, et al., (2007) reported that chill tanks using both chlorine and chlorine dioxide (ClCo2) showed a significant decrease in pathogen numbers.

D. Three factors determine the amount of organic matter in the immersion chiller: flow rate, flow direction, and cleanliness of the chiller water. When the chiller is more like a pond than a river and the water is still, organic matter increases in the tank. When fresh water in-flow drops to less than ½ gallon per bird, organic matter accumulates in the chiller water, on the paddles, and on the sides of the chiller (Thomas et al., 1979). Organic matter in the chiller binds the free chlorine and causes less chlorine to be available to kill *Salmonella*. The concentration of organic matter often increases near the chill tank exit (Allen et al., 2000). Filtering recycled water reduces the level of organic matter and that means less chlorine is bound up.

E. High flow rate (at least 1 gallon per bird) and counter-current flow are recommended (Russell, 2005). Additionally, 20-50 ppm free available chlorine as measured at the intake water should reduce the total microbiological load in the chiller water (Waldroup, et al., 1992). The chiller reuse water in the red (used) water system may contain up to 5 ppm free available chlorine measured at influent back into the chiller. Water temperature should be maintained to ensure that product temperatures meet 9 CFR 381.66.

F. An Oxidation Reduction Potential (ORP) pH meter is a scientific instrument that measures the sanitizing effect of water. It gives an indication of the effectiveness of the

free available chlorine in the water. Two advantages for using ORP meters are monitoring in "real time" and affordability. ORP used with a pH monitor at the point of chemical addition can help to regulate the amount of active chlorine (hypochlorous acid, HOCL) added to the water. This meter is not meant to replace pH and chlorine monitoring. These meters can be purchased from any reputable laboratory supply company. For additional information, go to the Agriculture and Natural Resources, University of California Web site: http://anrcatalog.ucdavis.edu. Publication 8149 explains ORP and is a free download. Articles on chlorination (Publication 8003) and water disinfection (Publication 7256) may be downloaded for free also.

G. If water chemistry management does not occur, water chilling can cause cross-contamination between *Salmonella*- or *Campylobacter*-positive and *Salmonella*- or *Campylobacter*-negative production lots or flocks. Broilers from *Salmonella*-negative flocks generally remain negative after chilling as long as broilers from *Salmonella*-positive flocks were not chilled in the tank first (Sarlin et al, 1998). Researchers have isolated *Campylobacter* from chill water (Wempe**,** et al., 1983). Managing flock deliveries by pathogen status of flocks may help maximize cost-effective process control at a plant. Stopforth, et al. (2007) collected a total of 300 water samples from the chill tanks in three plants and did not find *Salmonella* in any of the samples.

H. While the chiller can remove and reduce contamination, the chiller exit is the first "common" location following chilling where carcasses come in contact with each other. Without controls in place, this step may increase cross contamination if *Salmonella*-positive carcasses touch *Salmonella*-negative carcasses (Stopforth, et al., 2007).

Air Chilling

A. Air chilling systems have shackled (or tiered) chains that move the carcasses through the chilled compartment (or rooms) until the carcasses are properly chilled (9 CFR 381.66).

B. Sanchez, et al. (2002) found that air chilling resulted in a significant ($p < 0.05$) lower incidence of *Salmonella* and *Campylobacter* compared to immersion chilling. In addition, the researchers suggested that air chilling may have a greater negative effect on *Campylobacter* because of the use of air and the dehydrating effect of this process.

C. Cross contamination may be reduced compared to immersion chilling, but not eliminated (Sanchez, et al., 2002).

D. Mead et al. (2000) showed that cross contamination does occur with air chilling, especially with the use of water sprays (even sprays that include chlorinated water). In addition, air currents and droplets from higher-hanging carcasses to lower-hanging carcassescan lead to cross contamination. However, Mead points out that cross contamination occurs to a greater degree at the dirtier stages of processing i.e., scalding, plucking, and evisceration.

E. Another concern with air chilling is complete cooling of carcasses. While the temperature of the skin drops quickly, the internal temperature of the carcass may remain warmer longer than allowed by the regulation that states: “In air chilling ready-to-cook poultry, the internal temperature of the carcasses shall be reduced to 40°F or less within 16 hours” (9 CFR 381.66(e)).

F. Effective air chilling requires effective maintenance of equipment. Plants should clean and oil the chains regularly. Shackling carcasses to balance the chain will maintain chain tension. Swinging chains may cause carcasses to touch. Plants should inspect the shackles for wear and replace as needed.

XI. Reprocessing (On-line/Off-line) and Chilling: Antimicrobial Interventions

Recommended Best Practices

1. Post-chill antimicrobial dips are used to reduce *Salmonella* loads.

A. Simple water rinses**,** of which water quality is determined by local municipality water authority, reduce *Salmonella* (Morrison and Fleet, 1985). Heated water, agitation, application under pressure, and calibrating pH can enhance the effect. Trials using hot water showed substantial reductions in *Salmonella* (Morrison and Fleet, 1985). Agitation, application under pressure, sonication (disrupting biological materials by using sound wave energy), and adjustments in pH may improve the effect.

NOTE: FSIS does not endorse the use of any of these chemicals. The following information is simply a partial listing of antimicrobial treatments approved by the FDA. FSIS encourages plants to determine the effectiveness of the chemicals used within their food safety systems through validation testing.

Safe and suitable ingredients used in production of meat and poultry products are described (listed) in FSIS Directive 7120.1 (see: http://www.fsis.usda.gov/OPPDE/rdad/FSISDirectives/7120.1Amend21.pdf).

B. Chlorine, Chlorine Dioxide, and Acidified Sodium Chlorite (ASC are the most common chlorine-based interventions found in poultry processing plants. These compounds are water soluble and applied as a spray or dip. Adding chlorine to an aqueous solution enhances its bactericidal effect. Agitation and application under pressure enhance the effect.

C. Chlorine is primarily used to treat poultry processing water and chiller water. Heat and pH above 7.5 decrease its effect. Alkaline conditions reduce ionic dissociation, reducing available chlorine. Heat increases the loss of the hypochlorite ion into the atmosphere.

D. Chlorine Dioxide can be used as an antimicrobial agent in water used in poultry processing at an amount not to exceed 3 ppm residual chlorine dioxide. Chlorine dioxide is a highly reactive compound that rapidly reduces to chlorite and chlorate in process water. Its use leaves no detectable residues of chlorine dioxide, chlorite, chlorate, or byproducts on poultry carcasses after application.

E. Acidified Sodium Chlorite (ASC) is a combination of citric acid and sodium chlorite. It is approved as a poultry spray or dip at 500 to 1,200 ppm singly or in combination with other GRAS acids to achieve a pH of 2.3 to 2.9 as an automated reprocessing method. In chiller water, acidified sodium chlorite is limited to 50 to 150 ppm singly or in combination with other GRAS acids to achieve a pH of 2.8 to 3.2. Its residues, primarily chloride and chlorate salts, are safe.

F. Field and laboratory trials indicate that the bactericidal effect of chlorine-based compounds on pathogenic and non-pathogenic bacteria vary substantially at different chlorine concentrations under comparable and diverse application conditions. It also varies depending on the location of the organisms. The bactericidal effect of chlorine on *Salmonella* suspended in chiller water is directly proportional to the concentration of hypochlorous acid. The same is not true for *Salmonella* attached to the carcass passing through the chiller. When using any form of chlorine, establishments should be mindful of any limits placed on its use by other agencies, e.g., the Occupational Safety and Health Administration and the Environmental Protection Agency**.**

G. Trisodium Phosphate (TSP) is an approved antimicrobial agent used in OLR of raw poultry carcasses. TSP acts as a surfactant and prevents bacteria from attaching to the carcass. Residual TSP on carcasses carried over into the chiller can increase the chiller water pH, which decreases the effectiveness of chlorine in the chiller. To minimize the pH effect and maintain the effectiveness of chlorine, plants should monitor the chiller water pH and adjust the level as needed. Rinsing the carcasses prior to their entry into the chiller will reduce the effect of TSP on chiller water pH.

TSP reduces the levels of pathogenic and non-pathogenic bacteria on raw poultry. However, TSP results vary based on concentration of the chemical used and the application parameters. As an antimicrobial agent for OLR, TSP typically reduces microorganisms on carcasses by less than or equal to ($\leq$) 2 $\log_{10}$ CFU (colony forming units). TSP is more effective with air chilling than with immersion chilling, probably because the pH effect is absent.

H. Cetylpyridinium Chloride is a quaternary ammonium compound. The FDA has approved its use as an antimicrobial agent in poultry processing for ready-to-cook (RTC) poultry products. Cetylpyridinium chloride is effective against a broad spectrum of pathogens, including *Salmonella*. It produces no adverse organoleptic effects to the birds when applied properly. Its pH is near neutral, and it is stable, non-volatile, and soluble in water.

I. Inspexx 100 is a peroxyacetic acid antimicrobial treatment approved by the FDA to use for OLR of poultry carcasses as a carcass spray. It can be added to the chill water. A maximum concentration is set at 220 ppm.

J. The Spectrum is a food contact substance (FCS) FMC 323 mixture containing peroxyacetic acid, hydrogen peroxide, acetic acid, 1-hydroxyethylidene-1,1-diphosphonic acid (HEDP), and water. It has been approved by FDA as an antimicrobial agent in process water applied to poultry carcasses as a spray, wash, rinse, or dip, or added to chiller water or scald water. In-plant trials have shown that Spectrum has no statistical effect on *E. coli*. The results from FMC 323 in-plant trials reduced the overall microbial load at a 95% confidence level.

K. The antimicrobial properties of organic acids are well known. Lactic acid is the most commonly used organic acid. When applied as a rinse, lactic acid decreases the levels of both pathogenic and non-pathogenic bacteria. In the scald tank, acetic acid decreases the pH and enhances the washing effect of the scald tank water. Under simulated chiller application, acetic acid, lactic acid, citric acid, malic acid, mandelic acid, propionic acid, and tartaric acid decreased *Salmonella* counts. Organic acids can have an organoleptic effect on raw product so their use is typically limited in poultry processing.

XII. Further Processing

A. Poultry carcasses processed as parts or used to make ground products may have a higher incidence of *Salmonella* because of possible cross contamination between *Salmonella*-positive and *Salmonella*-negative parts. Cross contamination may be reduced by using chlorinated washes or immersion treatments with acidified sodium chlorite or chlorinated water (Stopforth, et al., 2007).

B. FSIS recognizes the following antimicrobials listed in FSIS Directive 7120.1 (see http://www.fsis.usda.gov/OPPDE/rdad/FSISDirectives/7120.1Amend21.pdf), "Safe and Suitable Ingredients Used in the Production of Meat and Poultry Products" as chemical interventions that can be used to potentially reduce *Salmonella* in poultry products during second processing (postchill) as part of a multiple-hurdle approach without additional approval from FSIS if used as detailed in the directive:

1. Acidified sodium chlorite;

2. Calcium hypochlorite;*

3. Cetylpyridinium chloride;

4. Chlorine gas;*

5. Chlorine dioxide;

6. DBDMH (1, 3 dibromo-5,5-dimethylhydantion);

7. Electrolytically generated hypochlorous acid;*

8. An aqueous solution of citric and hydrochloric acids adjusted to a pH of 1.0 to 2.0;

9. A blend of citric, phosphoric, and hydrochloric acids;

10. Lactic acid bacteria mixture consisting of *Lactobacillus acidophilus*, *Lactobacillus lactic*, and *Pediococcus acidilactic*i;

11. Lauramide arginine ethyl ester (LAE);

12. Ozone;

13. Solution of peroxyacetic acid, octanoic acid, acetic acid, hydrogen peroxide, peroxyoctanoic acid, and hydroxethylidene-1,1-diphosphonic acid (HEDP);

14. Solution of peroxyacetic acid, hydrogen peroxide, acetic acid, and hydroxethylidene-1.1-diphosphonic acid (HEDP);

15. Sodium hypochlorite;*

16. Sodium metasilicate; and

17. TSP.

*** NOTE**: The upper limits of use for the forms of chlorine (calcium hypochlorite, chlorine gas, electrolytically generated hypochlorous acid, sodium hypochlorite) listed above to which FDA and FSIS have not objected is up to 50 ppm in water applied to poultry during post-chill processing operations (but not for product formulation), including poultry parts, salvaged parts, organs, and giblets (livers, hearts, gizzards, necks).

When used in this way, the forms of chlorine are functioning as a processing aid and need not be listed in the ingredient list for the final product. For additional information refer to FSIS Directive 7120.1 and ongoing amendments to the directive.

XIII. Sanitation and Hygiene

Recommendations for Best Practices

1. Clean before sanitizing.
2. Enforce employee hygiene.

A. Cleaning followed by sanitizing is essential to control pathogens in a plant. *Salmonella* can attach to processing equipment or grow on food materials left behind on product contact surfaces. Properly cleaning an area requires removing debris prior to using a cleaning agent (detergent). Alkaline detergents are frequently used and vary in strength. Examples are sodium hydroxide, nitrous oxide, sodium silicate, and TSP. Acid detergents are also used and vary in strength. They include hydrochloric, sulfuric, phosphoric, and acetic acids. Quaternary ammonia is a type of synthetic detergent. Regardless of type, detergents should be in contact with soiled surfaces for 5-20 minutes.

B. Once a surface has been cleaned of all visible residues, sanitizers can be applied. There are several types of chemical sanitizers commonly used: quaternary ammonia, industrial strength bleach, iodine compounds, peracetic acid, steam, and ozone. There are areas within a plant where it may be better to use one type of sanitizer over another. For example, to sanitize aluminum equipment, rubber belts, and tile walls, iodophors (e.g., betadine, iodine) are recommended. Active chlorine is best for other types of walls, wooden crates, and concrete floors. A listing of various detergents and sanitizers as well as their properties can be found in Dr. Scott Russell's presentation from the Post-Harvest *Salmonella* meeting. The listing is on the FSIS Web site: http://www.fsis.usda.gov/News_&_Events/Presentations_PostHarvest_022306/index.asp.

C. The NCC recommends enforcing employee hygiene standards. The production of wholesome products is difficult when employees do not maintain clean hands and clothing. Mandatory hand washes with sanitizing stations should be available and maintained. Sanitation requirements regarding dressing rooms, lavatories, and toilets should be followed per 9 CFR 416.2 (h)(1) and 416.2 (h)(2). It is important that all employees follow standard hygienic practices in accordance with 9 CFR 416.5(a), 416.5(b), and 416.5(c). Outer garments, head coverings, aprons, gloves, and protective shields should be worn, and cleaned or changed as necessary. Furthermore, jewelry, food, and tobacco products should be restricted within the plant. Keeping track of employee foreign travel and health protects employees, product, and consumers.

XIV. New Technologies

A. FSIS recognizes that new technologies provide opportunities to improve and strengthen cost-effective process controls. The Agency strongly recommends that all plants be aware of new techniques, chemicals, and machinery that may improve their ability to produce wholesome products. FSIS has reviewed and issued waivers for submitted protocols and listed these new technologies on the FSIS Web site. For detailed information on particular technology, interested parties should contact the listed new technology provider or manufacturer's Web site. This list is at: http://www.fsis.usda.gov/Regulations_&_Policies/New_Technology_Table_Feb_06/index.asp

B. In addition, FSIS has funded Cooperative Agreement studies. From studies completed in 2003, FSIS identified technologies that may reduce levels of *Salmonella*. These technologies may be cost-effective for small and very small plants. A list of these completed studies on new technology can be found at: http://www.fsis.usda.gov/Regulations_&_Policies/Technologies_Applicable_for_Small_Very_Small_Plants_FY2003/index.asp**.**

XV. Validating

NOTE: No changes from the second edition have been made to this section. FSIS is developing updated guidance on validation which it will issue in a separate document. Consult that document for the Agency's updated guidance on validation.

Recommendations for Best Practices

1. Repeat testing for validation.
2. Consider process mapping or line profiling as a challenge study tool.
3. Use real-life validation study examples.

A. Validation activities (9 CFR 417.4) are a critical tool for plants verifying the effectiveness of process control interventions that address pathogenic microorganisms like *Salmonella* in their HACCP plans. This compliance guideline describes interventions throughout the poultry slaughter process that a plant can use to create a food safety system that demonstrates consistent process control. However, FSIS expects establishments to validate interventions for their own unique food safety system as support of decisions made in the hazard analyses.

B. Scientific research articles can be used to validate a critical limit addressing pathogens such as *Salmonella* and *Campylobacter*. This guidance document and materials from the FSIS public meeting addressing pre-harvest and post-harvest *Salmonella* interventions in poultry refer to relevant studies. When using a peer-reviewed article for validation, repeated testing is necessary to assess the adequacy of the CCP, critical limits, monitoring, recordkeeping, verification, and corrective actions associated with the food safety hazard addressed by the intervention. All the parameters used or measured in the article should be addressed in the CCP, and if not, then a justification as to why that parameter does not need to be met or measured should be documented by the plant. Initial validation demonstrates that the plant is able to meet the parameters in the peer-reviewed article. It also verifies that the pathogen contamination is prevented, eliminated, or reduced to an acceptable level. In order to determine that the intervention given in the peer-reviewed article is controlling the pathogen, the validation process must be carried out in the plant, subject to the plant's facilities, processes, and unique conditions.

C. Poultry plants are unique environments. Each plant has its own equipment, antimicrobial interventions, and management style. All parameters used in a validation study must occur in the plant's process, including following manufacturer's operation specifications for the intervention. For example, a peer-reviewed scientific article may specify four parameters to be followed for the intervention to be effective. If the plant is only capable of meeting three of the parameters defined in the article, then the plant needs additional information to validate that the fourth parameter is unnecessary. If one parameter is changed, the interaction of the other parameters may change, compromising the intervention's effectiveness. Challenge studies conducted in a laboratory or in-plant testing are other methods to validate a process control.

NOTE: Challenge studies with pathogens should be conducted in laboratories. Plants should never intentionally introduce *Salmonella* into their operations.

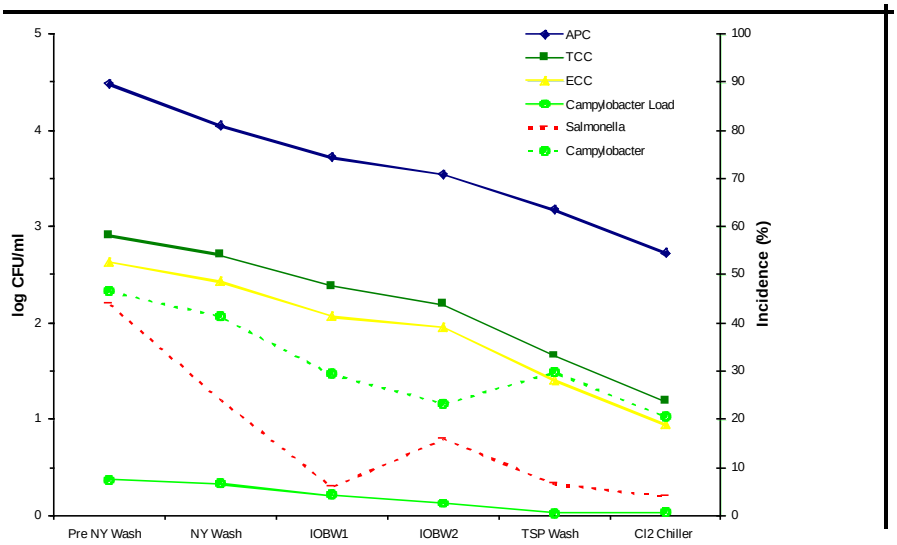
D. Process mapping (aka line profiling) is a useful challenge study tool. Process mapping is defined as conducting microbial sampling at selected points in the process where contamination levels can be assessed. The assessment measures microbiological loads on carcasses against a specific target organism or class of organisms. Process mapping provides a baseline for assessing the effectiveness of certain interventions as well as the effectiveness of the overall food safety system. Process mapping shows areas where immediate improvements can be made or where there is a need for process adjustments. A process mapping (testing) protocol could contain procedures for obtaining multiple samples from a single flock after each processing step. Plotting these test results creates a map of the microbial reduction at each intervention step in the system. The plot shows where process control is most effective, least effective, or needs modification.
FSIS strongly recommends that plants use process mapping techniques to develop their own sampling programs for *Salmonella* or indicator organisms.

Example of a Validation Study (Stopforth, et al., 2007)

A. Here is a real-life example of Company X validating its process control. Company X looked at the slaughter process with regard to pathogen control in three of its plants. One of its main objectives was to see whether the systems at each of the three plants were reducing levels of indicator organisms (e.g., aerobic plate count) and pathogens, including *Salmonella.* Company X looked at the individual intervention steps within each plant to see how well each one worked separately and collectively as part of a "hurdle" approach.

B. A third party laboratory came in to sample. A total of 2,100 samples were taken at plant A, 1,650 samples were collected at plant B, and 900 samples were collected at plant C. Carcass sampling was done by taking rinses of the carcasses. Company X looked at the level of *Salmonella* before and after the carcasses went through each step. This company saw the following reductions in *Salmonella* in the three plants monitored: 70% (plant A), 91% (plant B), and 40% (plant C). For Company X, most pathogen declines took place at steps towards the end of the process, leading company X to believe that the effects were cumulative and the reductions were statistically significant. Through its validation study, Company X felt confident that it did have process control for pathogen reduction and it did not change its process.

C. Below is a graph of the pathogen reduction for Company X's process. The dotted red line is the decline in *Salmonella*.



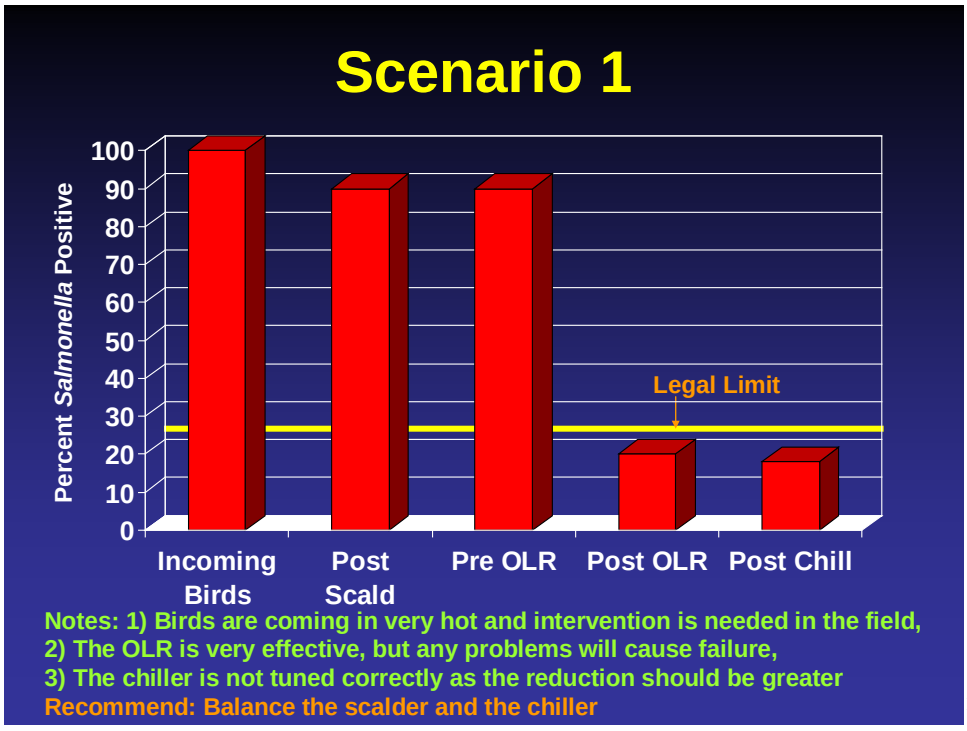
The Power Point presentation of this validation study is at:
http://www.fsis.usda.gov/PDF/Slides_022406_ROConnor.pdf.

This example shows how plants can monitor their own food safety systems' effectiveness. In this example, Company X showed that it was in fact significantly reducing levels of *Salmonella*. Company X saw how each of its intervention steps works. Finally, Company X proved that its entire process reduced pathogens. Company X continues periodic testing for on-going verification that its process is still producing safe product.

Examples of Case Studies

A. The following graphs are case studies by Dr. Scott Russell, Department of Poultry Science, University of Georgia and are being used with his permission. These graphs show information collected from different plants across the United States. The red bars show how many birds and carcasses are positive for *Salmonella* at each processing step. At the bottom of each graph is an explanation of what is going on in the plant at the time of the study and a recommendation by Dr. Russell.

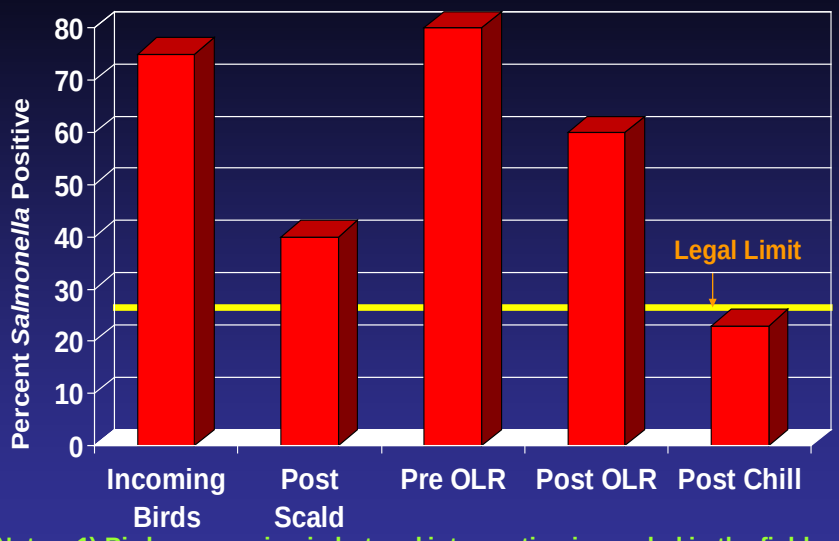
Note: The Legal Limit indicated on these graphs represents the *Salmonella* Performance Standard set at 20%



[1]

1. PreOLR and Post OLR refer to the areas before and after on-reprocessing.

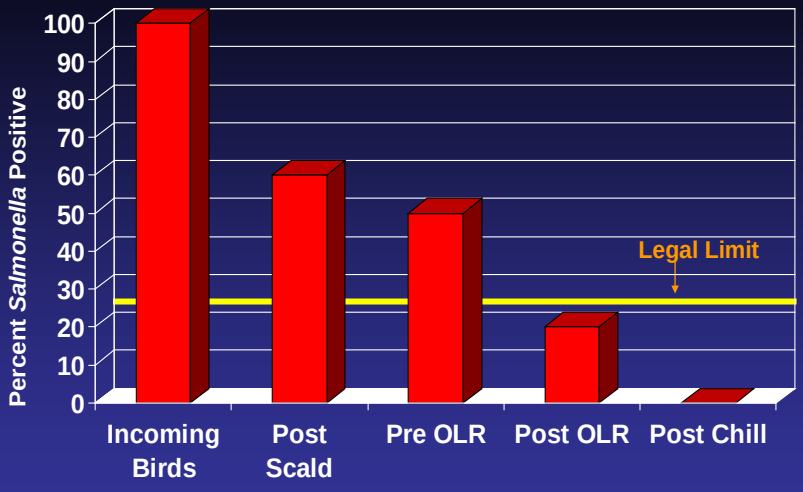
Scenario 2



Notes: 1) Birds are coming in hot and intervention is needed in the field, 2) The scalder is having a positive effect, but it is being negated by cross-contamination in the pickers, 3) The OLR is not very effective, 4) the chiller is the only reason the plant is passing

Recommend disinfecting picker and work on OLR efficacy

Scenario 6: Optimal



Notes: 1) Each intervention is effective, 2) no matter what season it is or the incoming load, this plant can control *Salmonella*

B. FSIS strongly encourages all plants to consider doing similar validation or auditing studies. These studies can be kept as supporting documentation. They are sources of verification and future references. FSIS encourages plants to know and understand their food safety systems. For example, if heavier than usual birds are being processed, plants could test to ensure they maintain process control. Testing may include plants verifying that no visible fecal contamination is present. Testing may include more microbiological testing. Plants may want to take more samples at one time or sample more often to ensure pathogen control is still in place.

XVI. Current FSIS Policies

A. FSIS published Federal Register Notice (FRN), *Salmonella Verification Sample Result Reporting: Agency Policy and Use in Public Health Protection* (71 FR 9772), on February 27, 2006, as a way to address the increasing trend of positive *Salmonella* samples seen, especially in broiler plants: http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/04-026N.pdf. This document sets out the Agency's policy on *Salmonella*, explaining how the Agency reports sample results from its *Salmonella* verification sampling program for meat and poultry plants. It discusses how the Agency uses these results to improve current public health protection and reduce human exposure to *Salmonella* from FSIS-regulated products.

B. Plants that demonstrate consistent process control by having the past two *Salmonella* sample sets at or below 50% of the performance standard or guidance are placed in the Category 1 classification. Category 1 plants are tested for *Salmonella* less often than plants having less consistent process control.

C. To encourage continued progress in plants, FSIS has introduced a fourth category, 2T. In their most recent set, 2T plants have positive sample results that are less than or equal to 50% of the current standard or guidance.

D. Plants that have sample set results above 50% of the performance standard without exceeding it have variable process control and fall in the Category 2 status.

E. Plants that fail the performance standard are considered to have highly variable process control and are classified as Category 3 plants**.** Plants in Category 2 and 3 are subject to an increased frequency of testing by FSIS compared to those plants in Category 1.

F. One of the policy initiatives discussed in the 2006 FRN states that FSIS will report aggregate results more frequently for all product classes tested under the *Salmonella* Verification program. The *Salmonella* quarterly and annual reports can be accessed at: http://origin-www.FSIS.USDA.gov/Science/Quarterly_Salmonella_Results/index.asp.

G. On January 28, 2008, FSIS published FRN *Salmonella Verification Sampling Program: Response to Comments and New Agency Policies* (73 FR 4767)

(http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/2006-0034.pdf.). In this notice, the Agency announced the *Salmonella* Initiative Program (SIP), which is a voluntary incentive program for meat and poultry slaughter and processing plants to increase process control efforts for *Salmonella* and *Campylobacter*.

H. In addition, in the January 28, 2008 FRN FSIS announced that the Agency would publish on its Web site the sample set results from both Category 2 and 3 broiler plants. FSIS believes it is important to publish results from plants in categories of greater concern because the Agency's reduced pathogen targets have not been met, in spite of increased testing in plants posing greater risk to public health. On March 28, 2008, FSIS published the names of broiler plants in Category 2 and 3 on itsWeb site. In May 2008, turkey plants were eligible for posting. However, because the turkey product class has 90% of plants in Category 1 and no plants in Category 3, turkey plants are currently not posted to the Web site.

I. The names of Category 2 broiler plants having their most recent *Salmonella* set higher than half the performance standard without exceeding it are published. Category 3 broiler plants having their most recent *Salmonella* set exceed the standard are also published. Updates occur on or about the 15th of every month.

At this time, the names of poultry plants in Category 1 and Category 2T are not published.

To access this information:
http://www.fsis.usda.gov/Science/Salmonella_Verification_Testing_Program/index.asp

Proposed New *Salmonella* and *Campylobacter* Standards for Broilers and Turkey

A. In early 2010, in the Federal Register, FSIS will issue new performance standards for *Salmonella* and *Campylobacter* for poultry carcass product classes. FSIS invites interested persons to submit comments on these new performance standards, using methods which will be described in the notice. The Agency will then evaluate comments, make necessary changes, and announce final guidelines in a subsequent FRN. The new performance standards are based on recently completed baselines for broilers (the report can be accessed at: http://origin-www.FSIS.USDA.gov/PDF/Baseline_Data_Young_Chicken_2007-2008.pdf.) and for turkeys (baselines completed in 2009, with a final report pending). As was done in 2006, categorization will be based on the performance of the two most recent sets.

B. For broilers, passing the *Salmonella* performance standard will require that no more than 5 samples test positive out of the 51 sample set. Broilers will continue to be categorized as follows:

- **Category 1**: two consecutive sets with no more than two positives in each set;

- **Category 2T**: two or fewer positive samples in last set and any result in the prior set;

- **Category 2**: the last set has 3-5 positive samples and any result in prior set; and

- **Category 3:** last set with six or more positive samples, any result in prior set

Until 90% of broiler plants are in Category 1 and no plants in Category 3, FSIS will continue to post the names of broiler plants in Category 2 and Category 3. Starting July 15, 2010, FSIS will post the names of plants in Category 2 and 3 under the new performance standards.

C. Broilers will also be tested for *Campylobacter*. The testing method for *Campylobacter* is different from the *Salmonella* method. The performance standard for *Campylobacter* is based on two percentages: one specifying the percentage of 1 ml portions that are positive, and the other specifying the percentage of total sample-specific positive results counting either the 1 ml or the 30 ml rinsate portions as positive. To meet the *Campylobacter* performance standard, a broiler plant will have no more than:

1. 8 positive samples in the 1 ml portion; and

2. 27 total positive samples out of 51 samples in either the 30 ml or 1 ml portion tests.

Because this a new sampling program, after 90% of the broiler plants have completed two sets including *Campylobacter*, FSIS will decide if the Agency will apply categories to this program.

For turkey plants, passing the *Salmonella* performance standard will require that no more than 4 samples test positive out of a 56 sample set.

Because the standard is very low for the young turkey class, the traditional category system is currently being suspended. However, unless 90% of young turkey plants are meeting the new performance standard, beginning July 15, 2010, FSIS will post information regarding plants not meeting the standard.

In addition, FSIS may consider applying the category system in the future if performance backslides in young turkey plants.

To meet the new *Campylobacter* performance standard, young turkey plants can have no more than 3 positive samples in a 56 sample set.

D. Because this is a new sampling program, after 90% of the young turkey plants have completed two sets including *Campylobacter*, FSIS may consider posting the names of

plants not meeting the standard. To be ineligible for posting, 90% of the young turkey plants must be meeting the new *Campylobacter* standard.

E. Beginning in 2010, FSIS will begin testing any broiler and young turkey plants not meeting either performance standard. Broiler and young turkey plants must meet both performance standards to indicate the plant can maintain process control. A plant that fails either performance standard will be scheduled immediately for a traditional set and tested again for both pathogens.

Revised End of Set Letters

A. FSIS has provided "End of Set" letters to plants at the completion of a *Salmonella* verification set since 2006. Beginning 2010, FSIS will send out revised letters that include additional information on subtyping (serotype *and* PFGE pattern or pulsotype). This public health-based information is provided through partnerships with the National Veterinary Services Laboratory (NVSL), the USDA Agricultural Research Service (ARS), and the Centers for Disease Control and Prevention (CDC). This information is intended to assist plants by providing specific public health-focused information on *Salmonella* isolates from positive FSIS Salmonella verification testing samples.

B. All pulsotypes are compared to the CDC PulseNet database. All serotypes are compared to the CDC list of top 20 most frequently isolated *Salmonella* serotypes from human sources reported to the CDC, which can be found at: http://www.cdc.gov/ncidod/dbmd/phlisdata/salmtab/2006/SalmonellaTable1_2006.pdf.

C. FSIS provides establishments with the serotype for each *Salmonella*-positive sample recognizing that industry may not routinely identify serotype. A prudent establishment should be tracking serotypes from producers, from food contact surfaces, and other environmental sources of contamination in the establishment. FSIS is providing the information to establishments with the expectation that establishments will use the information to evaluate the effectiveness of their food safety program, e.g., in their prerequisite program or HACCP plan. Plants with subtypes linked to human illness can expect FSIS to schedule a sample set or a Food Safety Assessment (FSA) more rapidly.

D. One serotype that remains a specific concern to the Agency is *Salmonella* Enteritidis (SE). FSIS has seen a significant increase in SE from 2000-2005. Since 2004, the CDC has reported an increase in both sporadic SE infections and SE outbreaks associated with eating chicken. Many of the guidelines developed by the egg industry to control SE could be used in the broiler industry. Appendix A provides additional guidance and strategies to control SE.

XVII. Web site References

1. Food Safety and Inspection Service (FSIS): http://www.fsis.usda.gov.

2. International HACCP Alliance: http://www.haccpalliance.org.

3. Small Business Regulatory Enforcement Fairness Act (SBREFA): http://www.dol.gov/osbp/programs/sbrefa.htm.

4. State Extension Services: http://asred.msstate.edu/links/statepartners.htm.

5. The Ohio State University Extension Services: http://extension.osu.edu.

6. Policy Development Division (PDD)
   Web site:
   http://www.fsis.usda.gov/About_FSIS/Policy_Development/index.asp
   E-mail: http://askfsis.custhelp.com
   Hotline: 1-800-233-3935.

7. Public meeting on Advances in Pre-Harvest Reduction of *Salmonella* in Poultry, August 25-26 2005.

   a. Meeting transcript, August 25, 2005: http://www.fsis.usda.gov/PDF/Salmonella_Transcripts_082505.pdf.
   b. Meeting transcript, August 26, 2005: http://www.fsis.usda.gov/PDF/Salmonella_Transcripts_082605.pdf.

8. Public meeting on Advances in Post-Harvest Reduction of *Salmonella* in Poultry
   a. Presentations from the meeting: http://www.fsis.usda.gov/News_&_Events/Presentations_PostHarvest_022306/index.asp.
   b. Meeting transcript, February 23, 2006: http://www.fsis.usda.gov/PDF/Transcript_022306_Postharvest.pdf.
   c. Meeting transcript, February 24, 2006: http://www.fsis.usda.gov/PDF/Transcript_022406_Postharvest.pdf.
   d. To order the meeting CD: http://www.fsis.usda.gov/News_&_Events/order_Postharvest_CD/index.asp

XVIII. APPENDIX A

Measures to control *Salmonella* Enteritidis (SE) in Broiler Chickens

Breeding flocks

Control of SE in the vertically integrated poultry industry begins with maintenance of "SE–clean" grandparent breeding flocks. The National Poultry Improvement Plan (NPIP), for example, specifies requirements to certify primary breeding flocks as "SE-clean" and primary and multiplier breeding flocks as "SE-monitored." All primary meat-type chicken flocks should be enrolled in this type of program. Day-old multiplier pullets and cockerels sold from breeder companies to the broiler integrators must be SE-clean. Prevention practices for SE include restricted access, sanitation, and monitoring of the poultry flock environment. New breeding stock chicks should be placed in thoroughly cleaned and disinfected poultry houses. Vaccination programs for avian pathogens and SE should be implemented under the supervision of a poultry veterinarian. Because most SE infections of poultry are asymptomatic, routine SE monitoring of the flock environment is essential to detect and control SE contamination when it occurs.

Hatchery

Hatcheries should have an effective sanitation program in accordance with national regulations (i.e., 9 CFR 147.23 and 147.24). This includes cleaning and disinfecting the hatchery environment and equipment frequently, disposing of residues such as eggshells promptly, and implementing insect and rodent control programs. The hatchery building should have separate rooms for egg receiving, incubation and hatching, chicken and poultry processing, and egg tray and hatching basket washing. Air should flow from clean to dirty areas. Eggs should be aseptically collected from nest boxes as frequently as possible and transported in crates that are cleaned and disinfected before use. Chicks should be transported to farms in new boxes on clean chick papers.

Production flocks

Restricting access of vehicles, people, and animals onto a poultry premise is a basic precaution to prevent introduction of *Salmonella* into a flock. Additional bio-security practices typically include a requirement that employees change into clean work clothing, wear boots, and use disinfectant boot dips before entering a poultry house. An integrated control program for SE should include reduction of rodent and insect populations in the production environment. The feed mill should use good management practices, including heat treatment and pelletization to kill *Salmonella* in raw ingredients. Maintaining low water activity in poultry litter (dried droppings and other floor dirt) is critical for *Salmonella* control. Management of litter moisture requires elimination of extraneous water and uniform evaporative airflow over litter. Drag swabs often are used to monitor

the poultry production environment for *Salmonella*. In the future, molecular serotyping technology may allow for the screening of more *Salmonella* colonies at a reduced cost.

SE-contaminated houses

The primary objective after depopulation of an SE-positive flock is to break the cycle of transmission to subsequent flocks. To begin, remove all food, litter, and other gross organic debris from the house. The interior of the poultry house is washed with high pressure water and floors, walls, and equipment are scrubbed with a hot, soapy water solution. Germicidal cleaning agents and sanitizers facilitate biofilm removal. Place the next flock in the house only after the poultry house is clean, dry, and in good repair.

Broiler chicken slaughter

Microbiological monitoring of the poultry environment provides data to inform risk management decisions. For example, flocks that test positive for SE should be slaughtered at the end of a shift or ideally end of the week, as a matter of practice--immediately before clean-up. In addition, poultry from these flocks could be used to prepare fully cooked product.

In summary, interventions are possible in the broiler chicken industry to limit SE contamination of raw poultry. They are needed to prevent human infections transmitted via raw poultry. The broiler chicken industry can make use of knowledge gained by the egg industry to monitor and control SE in breeding and production flocks. In addition, the industry can use *Salmonella* controls at slaughter.

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