Review of FSIS Compliance Guidelines for Controlling *Salmonella* in Small and Very Small Plants that Produce Raw Poultry Products

Patricia A. Curtis, Professor & Director
Auburn University Poultry Products Safety & Quality Peaks of Excellence Program

Each step in the process from farm to fork plays an important role in food safety. Therefore, each operation at each step of the process must not only control hazards while the food product is in their establishment, but they must also pay close attention to materials entering their operations and to the best of their ability protect the final product leaving their operation.

The following is a collection of excerpts from the online resources listed at the end of this handout. For more information about any of the individual topics, go to the original online source.

How Plants are Evaluated Based on Sample Set Results[1]

FSIS published a *Federal Register* Notice entitled, "*Salmonella* Verification Sample Result Reporting: Agency Policy and Use in Public Health Protection (71 FR 9772) on February 27, 2006 (http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/04-026N.pdf). The document describes how FSIS will sample for *Salmonella* in poultry processing plants. The percent of broilers that test positive for *Salmonella* in "A" sets has increased steadily from 11.5% in 2002 to 16.3% in 2005. In positive sample sets, FSIS frequently identifies *Salmonella* serotypes commonly known to cause human illness. The rate of human salmonellosis from all sources of food was 14.6 cases/100,000 persons in 2005. This rate is more than twice the goal of 6.8 cases/100,000 persons set by the U.S. Department of Health and Human Services in its National Food Safety Objectives: Healthy People 2010. Therefore, FSIS is changing its *Salmonella* verification-sampling program. FSIS believes this change will help to reduce human exposure to *Salmonella* from FSIS-regulated products.

Plants are evaluated based on sample set results. Plants demonstrate "consistent process control" when they have two *Salmonella* sample sets in a row at or below 50% of the performance standard. The current performance standard for broilers is 20% of carcasses positive for *Salmonella.* The plants classified as demonstrating "consistent process control" will be tested for *Salmonella* less often than plants having less "consistent process control." Plants that exceed 50% of the performance standard, but do not exceed the performance standard are said to have demonstrated "variable process control." Plants that fail the performance standard have "poor process control." FSIS will test plants in the last two categories more often than plants with "consistent process control."

Once a plant achieves "consistent process control," FSIS places that plant into the sampling population selected for scheduled testing at the lowest frequency. However, FSIS is also concerned about the serotypes of *Salmonella* found in positive samples. Plants that produce a product with a high number of serotypes that commonly cause human illnesses are selected at a higher rate than plants that produce a low number of these serotypes. All serotypes are compared to the Centers for Disease Control and Prevention's list of top 20 most frequently isolated *Salmonella* serotypes from human sources reported to CDC. FSIS is concerned with any sample set that contains a serotype common to human illness. However, FSIS is particularly concerned with establishments whose sample set includes four or more positive samples that contain serotypes that are known to cause human illness. They do not see these

operations as demonstrating “consistent process control.” FSIS strongly recommends that plants recognize this cutoff as a trigger to take immediate action to improve their food safety systems. Plants with serotypes linked to human illness could expect FSIS to decrease the time between scheduling of sample sets or schedule a specialized Food Safety Assessment.

Bacterial Growth

There are several major factors which influence microbial growth. They include temperature, time, oxygen, nutrients, pH, water activity, and other microbial interactions. Poultry processing plants provide the majority of the components needed for microbial growth. The way you control microbial growth in your processing plant is to remove one or more of these key factors that the microorganisms need to grow.

Under optimum conditions, bacteria can multiply in as little as 15 minutes. According to some calculations that were done in the mid-1990s, a poultry carcass contaminated with *Salmonella* might initially have 40 cells. Given the right conditions, in only 15 minutes those 40 cells could grow to 80 cells. In an hour, those 40 cells could grow to 640 cells. In an hour and a half, those 40 cells could grow to 2,560 cells. Therefore, you can see why it is important to control the growth of bacteria.

The goal is to remove as many *Salmonella* from the carcasses as possible and then to keep any remaining *Salmonella* from multiplying. Reducing *Salmonella* on finished carcasses requires a comprehensive, multi-hurdle approach. No individual procedure is adequate to accomplish this task.

Selected Potential Intervention Strategies

Pre-Harvest[1,2]

There are a number of on-farm interventions that can have a great impact on reducing *Salmonella.* Feed withdrawal is recommended to reduce food and fecal contamination on carcasses. Removing feed too late may result in carcass contamination because the gut may rupture during processing. However, if feed is removed too early, the internal organs become more fragile and may break. One study has shown that feed withdrawal periods greater than 14 hours made the intestine and gall bladder more fragile.

Prior to evisceration, carcasses should be evaluated to determine if the birds have undergone proper feed withdrawal. By examining the abdominal cavity to see if it is concave (small amount of feces in the intestines) or convex (large amount of feces in the intestines), it is possible to determine if the birds have been withdrawn from feed long enough. Flat intestines indicate the proper feed withdrawal time.

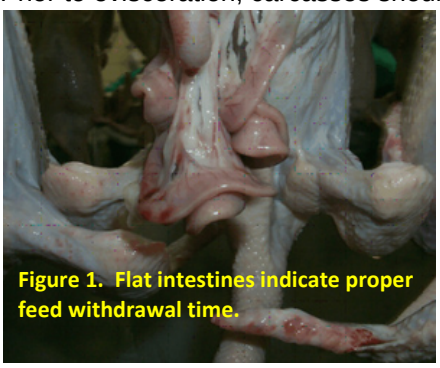


Figure 1. Flat intestines indicate proper feed withdrawal time.

Moreover, the intestines hanging from the birds after evisceration should be flat (Figure 1) and not full of ingesta or bloated with gas. In the processing plant, birds held off feed for extended periods may exhibit a higher incidence of contamination with pathogens due to loose droppings as the result of cross-contamination from bird to bird during transport. These birds may have intestines that are distended with gas which, if nicked during evisceration, may explode and disperse contents onto the carcass, other carcasses or processing machinery. Extended periods of feed withdrawal also cause the tensile strength of the intestines to become weak. Weakness increases the propensity for them to be torn during evisceration.

If birds are not held off feed long enough (<8 hours), the intestines will be full of ingesta. If full intestines are nicked during evisceration, contents likely will be spread to the inside or outside of the carcass, to

other carcasses and to processing equipment. Also, if pressure is applied to the outside of a bird with full intestines, the contents may come out of the vent and spread onto the carcass. Immediately after venting, if the colon is full of material, then the contents will leak onto the carcass, especially if any line jerking or swinging occurs (Figure 2). Insufficient feed withdrawal time is perhaps the most important factor in meeting the "zero tolerance" standard for contamination on carcasses entering the chiller. Reprocessing levels as high as 75 percent and line speeds as low as 20 birds/minute have been reported in plants due to excessive contamination as a result of insufficient feed withdrawal times.

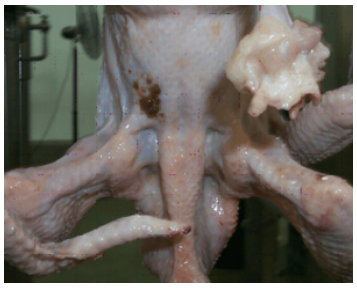


Figure 2. Fecal contamination due to feces leaking from colon. Line swinging caused feces to be spread to the back of the carcass.

Research has also shown that providing organic acid in drinking water greatly reduces post-harvest contamination with *Salmonella.*

Receiving[1]

Some research has shown that washing transport cages with water greatly lowers the levels of *Salmonella* found in the cages. Washing and then having the cages dry for 48 hours is the most effective way of cleaning the cages. Some research has shown that if the cages are not allowed to dry *Salmonella* can actually increase rather than decrease on the cages.

Cleaning and sanitation in the unloading and holding areas are important. High levels of *Salmonella* found on incoming birds can overwhelm in-plant interventions. These levels are carried forward through the next steps of the slaughter process. Studies show links between *Salmonella* found in the live receiving and *Salmonella* found later in the process.

Employee traffic patterns and air flow should be controlled to prevent cross contamination and reduce the 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 should be put into place.

Scalder[2]

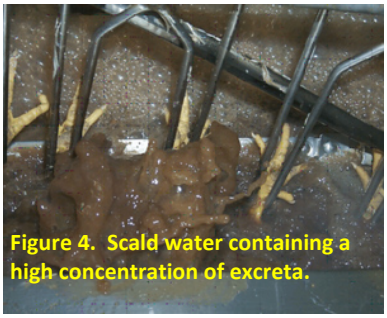


Figure 4. Scald water containing a high concentration of excreta.

The scalder is one of the most important areas in the processing plant in which cross-contamination with *Salmonella* occurs. The water in most scalders in the U.S. does not move against the carcasses, going from the exit of the scalder toward the entrance (counter-current) and contains high levels of excreta (Figures 3 and 4). This opposing water flow is essential to wash the birds and remove contamination from the birds as they travel through the scalder. Counter-current flow may be accomplished by adding a steel barrier between the lines of chickens going in either direction. By separating these chickens, bacteria that are washed off of the external surface of the chickens entering the scalder are not transferred to chickens that are exiting the scalder. The rate of water flow should be high, so as to dilute the concentration of foreign material and bacteria in the scalder. There is a common adage that goes "A dilution is the solution to pollution," and it applies in this case. Plants that are not equipped with multi-stage scalders should attempt to make their scalders multi-stage.

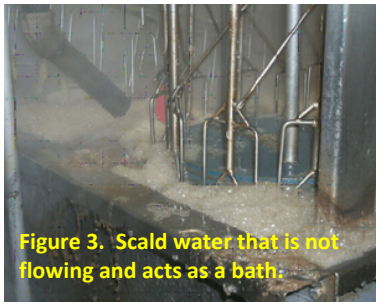


Figure 3. Scald water that is not flowing and acts as a bath.

Some companies have found that their scalders are not long enough to thoroughly rinse caked material from the outside of the birds. These companies have added sections to their scalders to increase length. In addition, the temperature of the scalder should be maintained as high as possible without causing

visible defects to finished carcasses, such as breast striping. The water where the birds exit the scalder should be fairly clean. One company installed a water recycling system that takes all rinse water from equipment and carcass rinsers in the plant and recycles the water using diatomaceous earth filters. The water is then ozonated, heated and returned to the scalder. This system has had an enormous impact on *Salmonella* prevalence on finished product.

Suggestions to ensure that scalders are operating optimally with regard to decreasing cross-contamination include:

1. Make sure scald water flows in the opposite direction as the birds (counter-current).
2. Put as much fresh water into the scalder as possible to dilute *Salmonella* concentrations.
3. Keep scalder water temperature as high as possible without causing breast striping.

Picker[1]


Figure 5. Broiler picking system.

The feather removal process is designed to remove feathers and the uppermost layer of 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.

Good process controls at picking is critical and can improve a plant's performance on an FSIS *Salmonella* sample set. Cross contamination of the carcasses occurs because of contact with contaminated rubber picking fingers and contaminated recycled water. Regular equipment sanitation and maintenance is recommended to minimize cross contamination. The National Chicken Council recommends preventing feather buildup during the defeathering process by continuously rinsing the defeathering equipment and carcasses. An 18-30 ppm available chlorine rinse can help reduce *Salmonella* counts on carcasses exiting the picker. Post feather removal rinses should be maintained at 160°F. Chlorine, acetic acid, and hydrogen peroxide are types of chemicals that can be added to the rinse during picking/defeathering.

Inside/outside Bird Washer[2]

The water from these sprayers or rinses should be checked frequently to determine chlorine levels, pH, pressure and distribution. In one processing facility, the IOBWs had very little water pressure. When confronted, the maintenance manager said, "Oh, do you want this turned up? I had it turned down so that it wouldn't spray people as they walked by." This is a case of someone changing the process without under-standing the microbiological effect on the carcass.

In another instance, a company's *E. coli* results became unacceptable within one day and continued that way. The maintenance manager had swapped the nozzles in the IOBW for a different type of low flow nozzle. This had a dramatic influence on bacterial levels.

If bleach is added to spray rinses or the IOBW, the pH will rise to unacceptable levels. The pH should be monitored to ensure that it is not too high. If so, the pH of the water should be reduced using a food-grade organic acid or carbon dioxide gas. General suggestions for all washers and rinsers include:

1. Maintain proper nozzle pressure.
2. Maintain proper water pH (as close to pH 7 as possible).
3. Maintain proper chlorine level.
4. Maintain proper water distribution on the carcass or equipment.

Automated Reprocessing Systems[1]

Simple water rinses, without the addition of chemicals, reduce *Salmonella.* Heated water, agitation, application under pressure, and calibrating pH can enhance the effect. Chlorine, chlorine dioxide, and acidified sodium chlorite are the most common chlorine-based interventions found in poultry processing plants. These compounds are water soluble and applied as a spray or dip. Chlorine is primarily used to treat poultry processing water and chiller water. Heat and a pH of about 7 decrease its effect.

Trisodium phosphate (TSP) is an approved antimicrobial agent used in online reprocessing of raw poultry carcasses. Residual TSP on carcasses carries over in the chiller and can increase the pH of the chiller water which decreases the effectiveness of chlorine that may also be used in the chiller. Rinsing the carcasses prior to their entry into the chiller can reduce the effect of TSP on chiller water pH.

Cetylpyridinium chloride is a quaternary ammonium compound which is approved for use as an antimicrobial agent in poultry processing for ready-to-cook products. Its pH is near neutral, and it is stable, non-volatile, and soluble in water.

For more information about these and other antimicrobials for use in automated reprocessing systems, read "Compliance Guideline for Controlling *Salmonella* in Poultry," First Edition, August 2006 (http://www.fsis.usda.gov/PDF/Compliance_Guideline_Controlling_Salmonella_Poultry.pdf).

Chiller[2]

A larger increase in bacterial reduction (both numbers and prevalence) can be accomplished in a properly balanced chiller than anywhere else in the processing plant. Most studies demonstrate that the chiller can significantly reduce *Salmonella* prevalence if operating properly. As with the scalder, the pH, temperature, flow rate, flow direction, chlorine concentration, and concentration of organic material (ingesta, fat, and blood) are crucial in order for the chlorine in the chiller to do its job. The pH should be 6.5 to 7.5, the temperature should be below 40 degrees F, the flow rate should be high (at least 1 gallon per bird), and the flow direction should be counter-current (Figure 6).

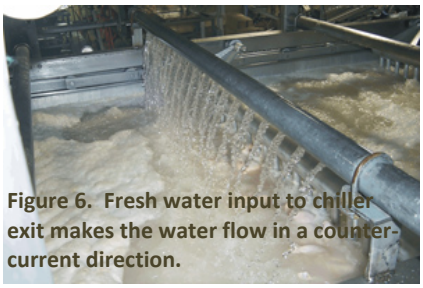


Figure 6. Fresh water input to chiller exit makes the water flow in a counter-current direction.

The organic material in the chiller is determined by three factors: the flow rate, flow direction and the cleanliness of the scalder. More organic material (blood, ingesta, fat) in the chiller will result in less chlorine being available to kill bacteria, as it will be bound up and rendered useless by the organic material.

It is also preferable to ozonate and filter the recycled, rechilled red water to decrease organic material and to add an additional level of sanitation. Many of the chillers in the industry are more like a bath than a river. The water is stagnant and organic material builds up during the shift. Also, fat builds up on the chiller paddles and sides of the chiller. This allows for *Salmonella* to be encased in the fat, offering it protection from the sanitizers used in the chiller. Suggestions for maintaining a balanced chiller include:

1. Maintain proper water flow direction (counter-current).
2. Maintain proper water pH.
3. Maintain proper chlorine level.
4. Maintain water temperature below 40 degrees F.

Secondary Processing[2]

Figure 7. Employees wearing proper clothing.

Many secondary processing steps are done manually. This means close attention must be paid to sanitation of equipment/tools and employee hygiene. Employee hygiene is also an important part of keeping contamination down in the plant. Some poultry processing plants employ individuals that have cattle farms. These employees have cattle in their yards at home and are allowed to wear their street clothes and boots into the plant. Any *Salmonella* on their clothes or boots from the cows may be transmitted to the product. All plants should be equipped with mandatory hand-washing/sanitizing stations that are refreshed frequently. There should be no access to restrooms directly from the processing floor. Each employee should begin his or her shift with a clean, long smock, hairnet and gloves (Figure 7).

Examine employees daily for illness. Send visibly sick employees home. Briefly interview foreign employees returning from their home country to determine if they have had any food-borne illnesses. They may be asymptomatic carriers similar to Typhoid Mary, who was infected with typhoid fever in 1900. She worked as a cook and spread the disease to 22 people between 1900 and 1907, causing one death. Later, she became a cook at a hospital and 25 more people became infected and two people died. These individuals may be carrying *Salmonella* or *Shigella* and not be aware of the risk they pose to the consumer. Only 10 cells of *Shigella* are required to cause a severe, life-threatening food-borne infection.

Strategies for controlling the hygiene of personnel are:

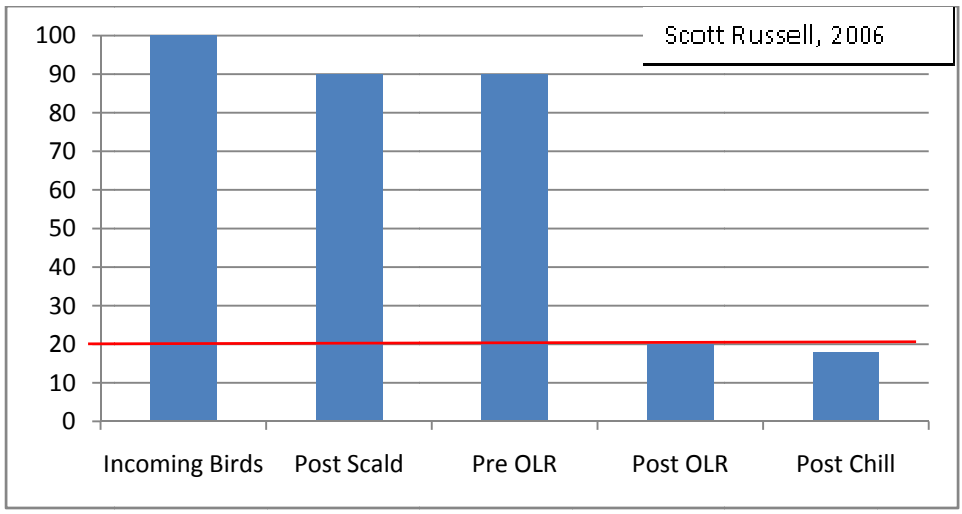
1. Control personnel flow (*i.e.,* they should not go from the kill room to the deboning area or from a cattle farm into the processing plant).
2. Control personal hygiene using written standard operating procedures that are spelled out for each area and monitored by managers daily.
3. Managers should evaluate employee health daily.
4. Managers should question employees returning from foreign countries about food-borne illness.
5. Employees must be held accountable for their failures to use hygienic practices.
6. Managers should train employees regularly concerning proper hygiene.

How to Determine *Salmonella "Hot Spots"*

Each processing plant is unique. Therefore, each operation must determine if they have *Salmonella* "hot spots." You can find your *Salmonella* "hot spots" by biomapping your operation. You can biomap your operation by taking microbial samples at various locations throughout your operation. You want to collect samples at each step of your operation. Have the samples you collect analyzed for *Salmonella*. Once you receive your results back from the lab, you should plot your results on a graph in the order of your product flow.

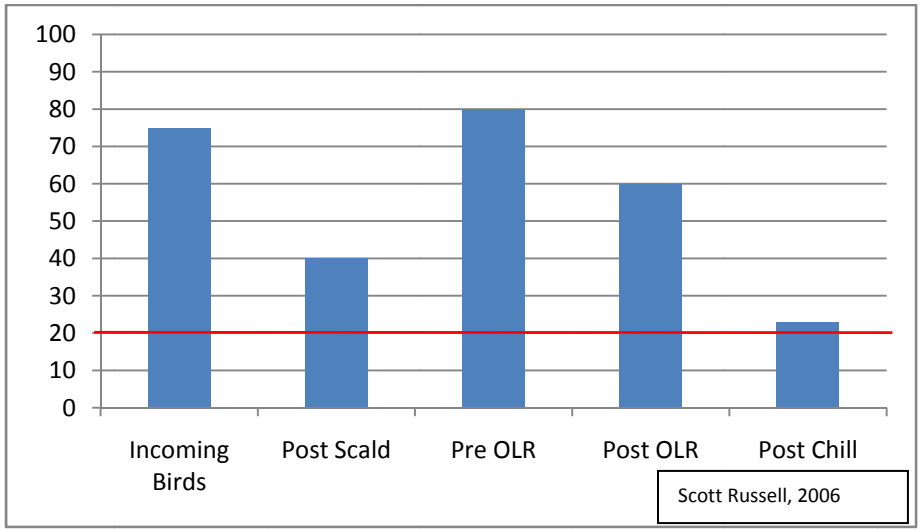
I would like to share with you some sample results from several plants. You will see that each of these scenarios is different, yet each meet the *Salmonella* performance standards.

Figure 8. Scenario 1



In scenario 1 (Figure 8), you can see that all the birds coming into the plant are contaminated with *Salmonella.* The red line in the chart show the *Salmonella* performance standard the plant must meet. The *Salmonella* "hot spots" in this plant appear to be at all steps from receiving to online reprocessing. In other words, the plant is depending totally on the online reprocessing to lower its *Salmonella* numbers.

Figure 9. Scenario 2



In Figure 9, you can see that the incoming birds are not 100 percent contaminated with *Salmonella,* but they still have a high level of contamination. You can also see in Figure 9 that this plant has a *Salmonella* "hot spot" located between the scalding step and the online reprocessing step. Somewhere in that section of the processing, the birds are becoming contaminated with *Salmonella*.

These are just a couple of examples to show how *Salmonella* "hot spots" are not always in the same locations at each operation.

Role of Sanitation and Other Prerequisite Programs

Sanitation is an important part of any processing operation. It is the very basis of any establishment's HACCP plan. It is a must for producing the safest product possible. There are many considerations when developing, implementing and assessing the effectiveness of any sanitation program.

The type of surface to be cleaned affects the type of soil that collects and how it is removed. Soil is difficult to remove from cracks, crevices and other uneven surfaces. It is easiest to remove soil from smooth hard nonporous surfaces. Removal of soil from a surface takes three steps. First, soil must be separated from the surface. Second, the soil must be dispersed into the cleaning solution. And last, soil must not be allowed to reattach to the surface.

Soil can be separated from a surface mechanically by using high pressure water, steam, air or scrubbing. Soil can also be separated from a surface chemically. A chemical example would be using an alkaline cleaner with a fatty acid to form soap.

The soil and surface must be thoroughly wet for a cleaning compound to help separate the soil from the surface. The cleaning compound helps loosen the soil from the surface by reducing the strength of the bond between the surface and the soil. Heat or mechanical action (scrubbing, shaking, high pressure spray, etc.) can help reduce the bond. However, heat does not help loosen some protein and fat soils.

Once the soil has been separated from the surface it needs to be dispersed into the cleaning solution. Therefore, enough cleaning solution must be used to dissolve all the soil. Some soils will not dissolve in the cleaning solution. It is important to break up the undissolved soil into smaller particles so it can be carried away from the surface. Mechanical action such as scrubbing, shaking or high pressure sprays help to break the soil down into smaller particles. Cleaning solutions should be changed often enough to prevent dispersed soil from reattaching. A clean surface should be rinsed or flushed to remove all dispersed soil and cleaning residues. (Using soft water helps prevent deposits formed when hard water reacts with soap in a cleaning compound.)

The type of soil determines which cleaning compound can be used most effectively. In general, organic soils are most effectively removed by alkaline, general purpose cleaning compounds. Heavy deposits of fat and proteins require a heavy-duty alkaline cleaning compound. Mineral deposits and other soils that are not successfully removed by alkaline cleaning compounds should be cleaned with acid cleaning compounds. The most frequently used types of cleaner-sanitizers are phosphates complexed with organic chlorine. It is important to select the correct cleaning compound to remove a specific type of soil. More detailed information about the solubility of various types of soil in water, acid, or alkali; whether heat helps remove them, and how hard they are to remove can be found online in the "Cleaning and Sanitizing" publication (http://www.ag.auburn.edu/poul/virtuallibrary/curtiscleaningsanitizing.html).[4]

Cleaning and sanitizing should be done in a specific order in sure that cross contamination does not occur. The correct order is

1. Remove excess waste materials
2. Pre-rinse equipment
3. Clean and scrub equipment
4. Rinse away detergent
5. Visually inspect equipment
6. Wash and rinse floors
7. Sanitize floors and then sanitize equipment
8. Remove excess moisture

Sanitation and other prerequisite programs should have documentation available to show how the program is conducted and monitoring results showing its effectiveness. This documentation is important

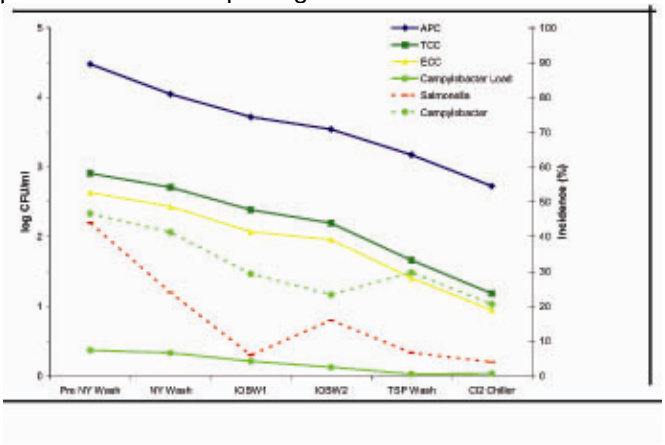
because it must be considered when conducting your hazard analysis for your HACCP plan. Any time a change is many in the HACCP plan, SSOPs or other prerequisite programs, you must determine how that change might impact ALL the other food safety programs you have in place.

Validating Your *Salmonella* Control Program

Not all interventions work equally at all establishments. Therefore, it is important to test the effectiveness of any intervention to determine its effectiveness for a particular establishment. One way to accomplish this task is to create a biomap of your operation. You can do this by taking a sample for microbial analysis just before and just after each food safety intervention in your operation. You can analyze your samples by testing for aerobic plate counts (APC) to get a general idea of how much reduction in overall microbial load you might expect by subtracting you post intervention microbial results from your pre-intervention microbial results. However, if you are trying to determine the effectiveness of a specific intervention for a specific organism such as *Salmonella* you should probably also conduct *Salmonella* tests. Since *Salmonella* test samples are generally enriched, you are not able to get quantitative results so that you can measure reductions like suggested for the APC of subtracting the post test results from the pretest results. Once you enrich a microbial sample, you can only determine if the sample was positive or negative. Therefore, if you conduct *Salmonella* measurements you will need to evaluate the percentage of positive samples prior to the intervention to the percentage of positive samples post intervention. If you have a very low percentage of positive samples coming into your operation, you may need to rely on the APC counts rather than trying to test for *Salmonella* since you would need to test a larger number of samples in order to find potentially positive *Salmonella* samples.

The following example of a validation study was taken from the "Compliance Guideline for Controlling *Salmonella* in Poultry."[1] (Pathogen Control: Validation Study; Atlanta, GA, Post Harvest Public Meeting; R. O'Connor)

> Here is a real-life example of Company X validating its process control. Company X looked at its slaughter process with regard to pathogen control. One of its main objectives was to see whether its system was reducing levels of indicator organisms (e.g., aerobic plate count) and pathogens, including *Salmonella.* Company X looked at individual intervention steps to see how well each one worked.
>
> A third party laboratory came in for five different visits. Five steps in the slaughter process were sampled at each visit. At each step, 15 carcasses were sampled before the step and 15 after the step. A total of 150 samples were taken at each step. The results showed that levels of *Salmonella* were reduced from 30% to 3%. For Company X, most pathogen declines took place at steps toward the end of the process. Through its validation study, Company X felt confident that it did have process control for pathogen reduction.



This example shows how plants can monitor their own food safety systems' effectiveness. In this example, Company X showed that it was in fact reducing levels of *Salmonella.* Company X saw how each of its intervention steps works. Finally, Company X proved that its entire process reduced pathogens

Summary and Conclusions

In summary, it is important that a plant strives to demonstrate consistent process control by controlling *Salmonella* populations and avoiding *Salmonella* serotypes that are common to human illness.

- Locate your *Salmonella* "hot spots" and implement interventions to reduce microbial levels.
- Test new interventions to make sure they are effective.
- Continually monitor the effectiveness of your food safety system.
- Remember when you make changes in your HACCP plan, SSOPs or other prerequisite programs you need to check what impact those changes have on the other programs you have in place.
- Make sure you have on file your validation information to support your HACCP plan and any other programs as necessary.

Resources

1. Compliance Guideline for Controlling *Salmonella* in Poultry, First Edition, August 2006
   - P. Bennett, USDA http://www.fsis.usda.gov/PDF/Compliance_Guideline_Controlling_Salmonella_Poultry.pdf
   - "*Salmonella* Verification Sample Result Reporting: Agency Policy and Use in Public Health Protection (71 FR 9772), February 27, 2006 (http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/04-026N.pdf).
2. Intervention Strategies for Reducing Salmonella Prevalence On Ready-to-Cook Chicken
   - Scott Russell, University of Georgia http://pubs.caes.uga.edu/caespubs/pubcd/B1222.htm
3. Sanitation Performance Standards Guide
   - http://www.fsis.usda.gov/Regulations_&_Policies/Sanitation_Performance_Standards/index.asp
4. Virtual Library
   - http://www.ag.auburn.edu/poul/virtuallibrary
     - Effective Use of Chlorine in Food Processing Environments
     - Controlling Airborne Microbial Contamination
     - Cleaning and Sanitizing
     - Auditing HACCP