

Guidance for Minimizing the Risk of *Escherichia coli* O157:H7 and *Salmonella* in Beef Slaughter Operations

The guidance provided in this document is predicated on the belief that *Escherichia coli* (*E. coli*) O157:H7 and *Salmonella* are likely to be food safety hazards reasonably likely to occur in beef production. The Food Safety and Inspection Service (FSIS) expects that establishments engaged in beef production will reassess their current Hazard Analysis and Critical Control Point (HACCP) plans, and that many will modify plans to include CCPs that address *E. coli* O157:H7 and *Salmonella*.

The guidance provided in this document is based on the following considerations:

- *E. coli* O157:H7 and *Salmonella* are hazards reasonably likely to occur in beef production.
- Slaughter plants need to consider appropriate controls to minimize the risk of *E. coli* O157:H7 and *Salmonella* in their operations.
- Slaughter and processing establishments should share responsibility for minimizing the risk that *E. coli* O157:H7 and *Salmonella* will reach the ultimate consumer.

I. Introduction

Cattle have been implicated as an important reservoir for the pathogen *E. coli* O157:H7 from studies that have demonstrated recovery of the organism from foods of bovine origin, prevalence studies in cattle, and epidemiological associations with foodborne outbreaks caused by this organism (Hancock et al., 1997). Farm to table control measures for *E. coli* O157:H7 and *Salmonella* include: managing farms to reduce fecal shedding in cattle; implementing HACCP procedures in slaughter operations and beef processing, proper handling during transport and by retail outlets, and proper cooking and handling by consumers.

At present, control of entry and of contamination from these pathogens in slaughter establishments is based to a large extent on sanitation procedures, control of cross contamination, and treatment of carcasses for visible fecal contamination. The U.S. Department of Agriculture (USDA) maintains a zero tolerance for fecal material on beef carcasses. Sanitation procedures and intervention methods are used during slaughter processing to prevent and remove fecal contamination, to prevent cross contamination, and to reduce the microbial load.

A. Pre-slaughter

The control measures mentioned above are not enough to prevent entry and reduce contamination by the pathogen in the food chain. Based on a review of large outbreaks

attributed to *E. coli* O157:H7 in the United States and Scotland, it became clear that greater emphasis needs to be placed on prevention during the pre-slaughter phase of meat production (Jordan et al., 1999). A vertically integrated approach to food safety (farm-to-table) where control is exerted at all stages of beef production is recommended. This approach would include control in farm/herd management, transport and handling controls between farm and slaughter, pre-slaughter and slaughter controls, product processing controls, controls in handling and transport of products, and proper cooking and handling by consumers.

Two important risk factors in the carriage of *E. coli* O157:H7 in incoming cattle are season of the year, and whether cattle come from the farm or the feedlot. Studies have shown that the following may also affect the level of *E. coli* O157:H7: age of cattle; fasting and temporary change of ration; mud, feces, bedding attached to hides of cattle; and transport and handling between farm and slaughter or between feedlot and slaughter.

Cattle presented for slaughter come from dairy farms, beef cattle farms, or the feedlot. They include heifers, steers, yearling cattle, bulls, or cull dairy cows. When cattle arrive at the slaughterhouse, they carry mud, manure, bedding, and other materials that contain a load of microorganisms on their hides and hooves. The bacterial load depends on herd or farm management practices, transport and holding practices, and feedlot conditions and controls. Aside from these, the season of the year, the age and the type of cattle are other factors that will influence the microbial load.

Feedlot cattle have a very good chance to be contaminated with *E. coli* O157:H7 because most cattle are obtained from a large number of herds (Jordan et al. 1999), and it is known that in virtually every herd some animals are shedding at all times. In addition, they are housed under crowded conditions, with or without efficient manure removal systems, which provide this organism ample opportunity to persist in the herd.

Research shows a difference in the prevalence of *E. coli* O157:H7 in heifers, cull cows, yearling cattle, cattle of certain weight, season of the year, and herd management and feedlot practices. Slaughter plant management should look at farms that incorporate practices that reduce carriage of the pathogen and consider relying on those farms as the source of animals for slaughter.

B. Slaughter

During slaughter, breaking, and boning, the following operations can increase the level of *E. coli* O157:H7, as well as *Salmonella* and other bacteria: incoming cattle as affected by season of the year and source of cattle, dehiding, evisceration, and fabrication. On the other hand, the following operations can decrease the levels: antimicrobial decontamination methods used as intervention after dehiding, before chilling and after chilling; temperature of chilling; and handling, and time and temperature during fabrication. The sanitation program of the slaughter plant plays a major role in preventing the carry-over of bacterial contamination from the farm or feedlot to the slaughter floor and meat processing areas. Microbial interventions are aimed at decontaminating the

carcass at crucial steps in the slaughter operations to remove or reduce any adhering bacterial contaminants carried over from the previous slaughter steps. Any of these may be used as CCPs to prevent, eliminate, or reduce *E. coli* O157:H7, as well as *Salmonella* and other pathogens, and must be validated.

Recordkeeping is an essential element in slaughter operations. Slaughter establishments should maintain records of the farm sources of their cattle and whatever farm/herd management controls and practices they have. Records of control and intervention methods used during the slaughter operations should also be maintained. In addition, establishments should keep records regarding the disposition of their products to enable tracing their products to intermediate handlers, suppliers and consumers. The system of records will facilitate trace-back and trace-forward in the event of a public health risk associated with their product.

C. Summary

This guidance material is designed to help slaughterers reduce carcass contamination of *E. coli* O157:H7, *Salmonella* and other pathogens through the use of sanitation procedures, intervention methods, and establishment of CCP(s) where necessary. The purpose of this guide is to help slaughter establishments accomplish the following:

- 1) Reduce entry of *E. coli* O157:H7 and *Salmonella* from cattle presented at slaughter.
- 2) Reduce transfer of *E. coli* O157:H7 and *Salmonella* from unskinned cattle to carcasses.
- 3) Reduce *E. coli* O157:H7 and *Salmonella* contamination of carcasses by establishing CCP(s) at appropriate points in the slaughter process.
- 4) Reduce *E. coli* O157:H7 and *Salmonella* contamination of carcasses by applying intervention methods at appropriate steps in the slaughter process.
- 5) Maintain reduced levels of *E. coli* O157:H7 and *Salmonella* after final carcass wash or after microbial intervention methods by control of temperature and preventing cross contamination.

The guide consists of seven sections: Section I., Introduction; Section II., Guiding Principles; Section III., Guidance for Beef Slaughter; Section IV., Flow Diagram; Section V., Interventions; Section VI., Critical Control Points; Section VII., The Use of Indicator Organisms to Assess the Presence of *E. coli* O157:H7; and Section VIII., References. This material will be continually updated and made available through the FSIS Internet web page located at <http://www.fsis.usda.gov>. Copies of this Guidance for Minimizing the Risk of *Escherichia coli* O157:H7 in Beef Slaughter Operations will also be available at the Docket Room, Room 102, Cotton Annex, 300 12th Street, SW,

Washington, D.C. 20250-3700. Comments regarding this guide should be directed to Philip Derfler at 202-720-2709 and fax at 202-720-2025.

II. Guiding Principles

- A. Preventive steps taken before slaughter operations commence can reduce the risk of *E. coli* O157:H7 and *Salmonella*. Slaughter operations should carefully consider and take steps to minimize the risk of *E. coli* O157:H7 and *Salmonella* before animals are slaughtered and throughout slaughter operations.
- B. Slaughter plants should keep abreast of new technologies and interventions that could be introduced in their processes in order to ensure that they produce safe consumer products. Slaughter plants should consider implementing procedures that incorporate at least one intervention specifically targeted to reduce the risk of *E. coli* O157:H7 and *Salmonella*. This procedure could be a CCP in the HACCP plan.
- C. Slaughter plants should develop and maintain a system of records that will facilitate trace-back and trace-forward in the event that a public health risk associated with their product is identified.
- D. Transportation and handling practices to minimize the risk of *E. coli* O157:H7 and *Salmonella* after product leaves the slaughter plant should be incorporated into operating procedures.
- E. Slaughter and processing plants share responsibility for minimizing the risk that beef products with *E. coli* O157:H7 and *Salmonella* will reach the ultimate consumer. Slaughter plants should work with their customers to develop realistic specifications to ensure the delivery of safe and wholesome raw materials that take the end use of the product into consideration.

III. Guidance for Beef Slaughter

Control *E. coli* O157:H7 and *Salmonella* in Beef Slaughter Operations

The sanitation programs of slaughter plants play a major role in preventing the carry-over of bacterial contamination from the farm/feedlot cattle to the slaughter floor and carcasses. FSIS published the final rule on Sanitation Requirements for Official Meat and Poultry Establishments in the Federal Register on October 20, 1999. This rule became effective on January 25, 2000, and requires all meat and poultry establishments meet sanitation performance standards applicable to their processing procedures. A compliance guide has been provided to assist establishments in meeting the sanitation performance standards. Other documents that provide sanitation guidance are the Food and Drug Administration (FDA) Model Food Code, the 1999 National Building Code, and other federal, state, and local codes and standards (Instructions for ordering these materials can be found at the end of this document). The sanitation procedures recommended in this guidance mainly parallel those in the compliance guide for the sanitation final rule.

General Information

- Facilities and equipment should be designed to prevent congestion and product contact with fixed or other objects.
- Facilities and equipment involved in the slaughter operations should be thoroughly cleaned before the startup of the operations and maintained in a sanitary manner during operations.
- Airflow in the facilities should go from the cleanest areas to less clean areas.
- Traffic/people flow should be designed to prevent cross contamination, e.g., people that work in the processing operations should not work or travel through slaughter operations and vice-versa.
- Slaughter establishments should be aware that there is an increasing evidence of prevalence of *E. coli* O157:H7 in cattle during the months of April to September, a higher prevalence detected in raw beef in these months, and a higher number of cases of foodborne illness due to *E. coli* O157:H7 in ground beef in these months, which include other exposures aside from ground beef. Establishments should account for this in their HACCP systems in terms of stricter purchase specifications of cattle, more rigorous intervention methods, or higher frequency of verification.
- During the entire slaughter operation, animals should be adequately spaced to avoid cross contamination.
- Establishments should consider innovative intervention approaches such as trimming, hot water and acid washes, steam vacuuming and steam pasteurization, to ensure

there is no fecal contamination of carcasses in beef slaughter operations. Fecal material contains enteric microorganisms such as *E.coli* O157:H7 and *Salmonella*. These intervention methods must be validated for the plant operation and verified.

- Establishments should develop a lotting or sub-lotting system for coding and tracking purposes. Lot numbers should enable tracking the raw material source up to the finished products. Lotting can be based on a full day's production or production from clean-up to clean-up. All lots produced between clean-ups would be implicated in any public health-based action (e.g., recall) unless based on the specific circumstances, the problem can be restricted to a subset of the plant's production between cleanups.

Records of farm source, farm herd/management practices, pre-slaughter and post slaughter intervention methods and other control methods should be maintained by slaughter establishments.

Cattle Receiving and Holding

- Receiving
 - 1) Slaughter establishments should identify and obtain cattle from farms or feedlots that employ one or more production systems or feedlot controls shown to reduce the carriage of *E. coli* O157:H7 and *Salmonella*. Effective farm and feedlot management and control can help to reduce fecal shedding of the organism and reduce the microbial load on the animals and in the intestinal tract.
 - 2) Animals should arrive with minimum mud and fecal contamination.
 - 3) Pre-slaughter practices and intervention methods should be investigated and incorporated in the cattle-receiving step to reduce contamination of incoming animals. These are intervention methods that remove mud and other contaminants from hides and hooves of the cattle.
- Holding pens
 - 1) The pens, ramps, unloading chutes, curbs, and runways should be of such construction, materials, and finish that they can be readily and thoroughly cleaned since these can be a source of *E. coli* O157:H7 and *Salmonella* contamination. They should be in good repair, resistant to wear, properly curbed, and well drained, with liquid wastes delivered into the plant waste system. Holding pens should be of adequate size and equipped to allow performance of proper ante-mortem inspection. Water troughs or devices with suitable overflows should be located over or adjacent to pen floor drains. A separate pen should be provided to isolate suspects and sick or injured animals. Livestock pen capacity should be sufficient to hold a single day's kill. Overcrowding should be avoided to reduce the possibility of injury or unsanitary conditions.

- 2) Holding pens should be located outside of or effectively separated from the slaughtering department by full-height partitions of impervious material to avoid dust, odor, and contamination of the slaughtering area.

Stunning

- After stunning, hides can be contaminated if stunned animals fall on the floor or come in contact with sides of chutes previously contaminated with *E. coli* O157:H7 or *Salmonella*. There is also an additional danger of cross contamination if cattle emit feces or rumen contents.
- Hides and hooves can be decontaminated by washing and dehairing before dehidng in order to reduce carriage of microorganisms from hides and hooves to the carcass during dehidng. Some establishments wet or mist the hides to reduce aerosol contamination during hide pulling.

Sticking-Bleeding

- The "dry landing" area where the stunned animals exit from the knocking box should be kept clean and dry of all blood between each animal.
- Edible blood collection devices and blood containers must be clean. The collection funnel and knife should be rinsed clean after each carcass and sanitized after each identifiable lot of blood is drawn. No blood should be saved from condemned animals.

Head Removal

- Esophagus Rodding and Tying
 - 1) When cattle are slaughtered by the "on-the-rail" method, the "rodding" of the esophagus (weasand) should take place before the head is removed from the carcass. This frees the esophagus from its attachments to the trachea and lungs so that during evisceration it may be pulled through the chest without tearing. The esophagus should be effectively closed to prevent the escape of rumen contents.
 - 2) When cattle are slaughtered by the "bed" method, the rodding of the esophagus may be deferred until the animal is positioned on the bed. "Rodding" is required in all situations in which evisceration involves removal of the abdominal viscera independent of the thoracic viscera.
 - 3) In all cases, the esophagus should be effectively closed. This should be done near the bleeding area to minimize contamination of the carcass and the dressing area.

- When head skinning begins, carcasses should be separated or positioned to avoid contamination of heads or other skinned areas of the neck. The skinned heads should not be permitted to come in contact with other heads and carcasses, the floor, or fixed objects. They should be removed as soon as possible after skinning to further reduce contamination exposure.
- The heads should be removed in such a manner to avoid soiling them with rumen contents. This can usually be accomplished by tying the esophagus and then pulling the head sharply to the side as the gullet is cut. Removal of rumen content contamination is extremely difficult because of its finely comminuted character. The head skinner should clean and disinfect his knife as frequently as necessary, especially if contaminated, but at least once at the beginning of the process for each animal.
- The horns, all pieces of hide, and eardrums should be removed from each head prior to washing. The equipment used for holding heads for trimming and dehorning should be cleaned between each head. Disinfection is required after use on each suspect, retained, or other obviously diseased animal.
- The washing of heads should be done in compartments or areas that will control the splash of wastewater to prevent contamination of other heads or adjacent carcasses. The oral and both nasal cavities should be thoroughly flushed before washing the outer surfaces of each head. Each head should also be free of all hair and other contamination prior to inspection.
- Lighting in the head wash cabinet or compartment should be no less than 50-foot candles at the level of the head.
- Head hooks in washing cabinets should be removable, or effective means for in-place sterilization (including a thermometer) should be provided. Such hooks are to be cleaned between each use and sterilized after heads from each suspect, retained or obviously diseased animal is handled.
- Head inspection racks are to be cleaned and sterilized following each use involving a retained head. Since this is impractical to accomplish with hooks installed on a continuous chain, all such installations should be provided with a suitable cabinet or other device that will clean and sterilize each hook prior to its subsequent use.
- The minimum hot water sterilization temperature is 180 °F and a thermometer should be provided to determine continual compliance throughout the operation.

Dehiding: Opening, Skinning and Hide Removal

- After the head is removed from the carcass, and is being cleaned and inspected, establishment employees place the carcass on the skinning bed (except in installations

where this procedure is not used). Care should be taken to see that the area is clean before the carcass is lowered.

- The head skin should be so manipulated that the tissues of the neck will be protected from soilage and other precautions taken to prevent contamination of any meat of the carcass. This may best be accomplished by leaving the ears on the hide and head skins tied, except in "kosher dressing." In those situations where the establishment can demonstrate the ability to consistently drop the carcass without contacting the neck to floor, the tie may be eliminated.
- The front and hind feet should be removed before any other incision is made in the carcass.
- In removing the front feet, care should be taken to expose as little as possible the tissues of the foreshank and leave a "tie" of the hide completely covering the shank as far down as possible toward the carpal articulation where the cut is made to remove the foot. The feet may also be removed by a single transverse incision through the hide and articulation.
- Except for the original incisions for sticking and starting the skinning operations at the poll and shanks, incision into the skin should be made with the knife blade directed toward the hair side of the skin to prevent contaminating the flesh with cut hair.
- Cattle should be sufficiently far apart to prevent contamination of skinned parts of adjacent carcasses by skin or hide.
- Lactating udders are to be removed in such a manner as to prevent soilage of the carcass with udder contents. Any and all such contamination from udder content must be immediately trimmed from the carcass. Also, udder contents should not be allowed to contaminate walls, floors, or equipment surfaces.
- As the skinning operation proceeds, care should be taken so that the outside surface of the hide is continually reflected away and preferably downward from the carcass. Each area should be skinned back far enough to permit the hide to stay in a rolled-back position before the skinner proceeds to another skinning location. On-the-rail dressing operations start with the hind shanks and proceed downward while in bed dressing, skinning operations begin at the midline and shanks and proceed downward with the pritch stick handled in such a way as to prevent direct contact with the exposed carcass.
- With on-the-rail layouts, the lower skinning should not begin until the carcass has passed the points of common contact, such as hindquarter skinning platforms. Also, in this type of operation the foreshanks may be left on until the brisket and foreshanks are partially skinned. This helps to avoid shank contamination.

- When establishment employees move the carcass from the skinning bed, they should use care to see that the exposed parts of the carcass are protected from contact with the floor or other fixed objects. After each carcass is handled, the floor of this area should be maintained in a clean and sanitary manner. If washing is required, it should be done in a manner that precludes splash contamination to nearby carcasses or product.
- In case of a bed kill operation, fecal matter expressed from a carcass being laid on the bed should be prevented from contacting the partially skinned carcass before it.
- When using mechanical hide pullers, the tremendous energy exerted during the final removal of the hide can generate aerosols. Air flow at this step in the slaughter operation should direct any aerosols created away from the carcasses being skinned to prevent contamination of the carcasses.
- In all types of cattle dressing procedures, the dropping of the bung should be a final part of the rumping operation. The perineal skin should be reflected laterally over the anus, leaving the external sphincter muscle intact. This procedure is known as "scalping the bung."
- The incision into the pelvic cavity to "ring" the bung should be made by a person with clean hands and a clean knife.
- Prior to evisceration, the rectum and neck of the bladder should be secured to prevent urine and fecal leakage. A plastic bag can be used for this purpose.
- The tail is to be skinned out without contamination to tail or carcass. Because the tail and switch are highly contaminated with urine and manure, attention should be given to frequent hand and tool washing at this point. This is particularly important when the same person performs other tasks involving carcass contact.
- The clamp used to suspend the tail from the overhead spreader while the skin is manually pulled should be cleaned and sterilized between each use or the tip of the tail ahead of the clamped portion should be removed and discarded. Note: the tail should be kept associated with the carcass until the final carcass disposition.
- At some point after the hide is reflected from the midline of the carcass, the brisket is opened to facilitate the easy removal of the thoracic viscera. The thoracic cavity is entered and there is no way of knowing if abscesses or other pathological conditions are present. Therefore, the saw, or other instrument used to split the brisket, should be disinfected after each use.
- In male animals, removal of the pizzle (penis) should be accomplished in a manner that precludes urine contamination of the carcass.

- A hide chute should be located where hides are removed from carcasses. The chute should have a hood of rust-resistant metal with a push-in door that is self-closing by gravity and closely fitted in an inclined metal frame. If hides are removed from the department by some means other than a chute, it must be designed and maintained to prevent sanitary problems. Spreading of hides in the slaughter room is not permitted.

Evisceration/Viscera Processing

- Prior to opening the abdominal cavity, any contaminants that may be present must be removed from the midline by trimming. Special attention should be given to prevent carcass and/or viscera contamination with uterine fluids from the uterus, and urine from the bladder.
- Knife-trimming, washing, steam vacuuming, and spot cleaning systems can be used to remove viscera contamination. Pre-evisceration carcass washing using anti-microbial sprays may also be applied at this step.
- The actual removal of the viscera from the carcass is a critical phase of the dressing operation.. Care should be taken to avoid cutting or breaking the paunch and intestines.
- If carcass tissues from visceral contents become contaminated, they should be removed by trimming with a knife or cleaver.
- At the time of evisceration, ties should be made at the point where the small intestine leaves the stomach and at the point where the esophagus attaches to the paunch. At each of these two named points, two ties should be made about 4 inches apart with the contents being stripped from the intervening portion of the intestine or esophagus, respectively, before the second tie is made so that the tissues can be severed between the ties without any spillage of contents.
- In situations where viscera is not saved as edible, the ties may be eliminated if the viscera is handled in a manner that prevents contamination.
- The animal is to be eviscerated into a clean truck or onto a clean table. Automated moving tables should be continually cleaned and disinfected.
- The viscera inspection truck requires thorough cleaning and disinfection, especially if it becomes soiled with visceral contents (e.g., feces, ingesta) or contaminated with purulent material or viscera from a condemned carcass. To prevent fat buildup on the metal pluck pan or paunch and viscera portion of the inspection truck, it should be periodically cleaned with hot water. When a viscera inspection truck is rinsed, the procedure should not result in contaminating edible product or equipment.

- When carcasses are eviscerated onto a moving top table, the eviscerator is to wear a clean apron and boots constructed of acceptable material such as rubber or plastic. These boots should be white or otherwise distinctively and exclusively identified and worn only on the table and adjacent boot cleaning compartment. The eviscerator should also have additional footwear to be worn while traveling to and from the work area.
- The boot cleaning compartment should be conveniently located and constructed so as to prevent splash of contaminants onto carcasses or viscera. Contaminated footwear, apron, or knife should be thoroughly cleaned and disinfected.

Splitting

- Prior to splitting, all contamination, bruises, grubs, and tissue damaged by grubs should be removed from the midline area of the back. This is necessary to prevent spreading of such contaminants to bone and other surfaces by the saw or cleaver.
- When splitting is done at the half-hoist position, care should be taken to avoid the neck contacting the floor. Disinfection of the carcass splitting equipment is required after each use on suspect, retained, or obviously diseased carcasses.

Trim Rail

- Washing of carcasses should be deferred until bruises have been removed, and inspection has been accomplished. This delay is necessary to assure the complete removal of excessive contamination, pus, or other pathological exudates.
- All visible fecal contamination should be removed as soon as possible after it occurs to prevent microbial attachment.
- Physical removal, decontamination methods, or both can remove visible contamination. These operations are not intended for whole carcass decontamination, but apply to specific carcass portions, especially those that show heavy contamination, like the neck area. Knife-trimming, washing, steam vacuuming, and spot cleaning systems are some of the methods that may be used to remove fecal contamination.
 - 1) Knife trimming is effective in removing visible fecal contamination. However microbial contaminants not contained in fecal matter or other visible contaminants may not be removed by this method alone.
 - 2) Washing with hot or cold water may be used for decontamination treatments. Hot water washing was one of the methods found to effectively reduce populations of *E. coli* O157:H7 and *Salmonella*.

- 3) Steam vacuuming was found to achieve greater bacterial reductions than knife trimming in commercial facilities. Use of this method was found to reduce the amount of knife trimming required to comply with the USDA zero tolerance food safety standard. Steam vacuuming was found to result in greater reduction in levels of microbial contamination than other moist heat intervention methods.
- 4) Spot cleaning systems using hot water/steam vacuum or steam vacuum only are used to remove visible spots of contamination from small localized areas on the carcass. They are also used together with commercial knife trimming procedures. Studies show that this spot cleaning system effectively reduced inoculated bacterial populations.

Final Carcass Wash

- Washing should be sufficient to ensure complete removal of hair and other foreign material. Washing is to be accomplished in a curbed and drained area and in a manner which prevents cross contamination.
- The washing should proceed from the top of the carcass in a downward direction so that contaminants gravitate away from the clean areas. Washing should be completed before shrouding.
- Shrouding (if used)
 - 1) Shrouds should be thoroughly cleaned before each use. Since drying is not required, there is a possibility that shrouds may become sour or moldy.
 - 2) Water or brine used to soak shrouds prior to use should be clean. Pins used to attach shrouds to carcasses should be cleaned and sterilized prior to each use. Wet shrouds that are not used immediately should be kept under refrigeration.
- Microbial intervention methods are best applied at this step because this is the last step before chilling. Microbial intervention methods are effective in removing bacterial contamination that may not be visible on the carcass. Establishments should tailor the intervention method to be used to the specific processing operation. Several microbial intervention methods are discussed in a subsequent section in this guidance.
- The following microbial intervention methods have been extensively studied and were found effective in reducing bacterial contamination: acid washes, water washes, steam pasteurization, steam vacuuming, and use of other antimicrobials. These methods are discussed in detail in Section V.
- Measures should be implemented to ensure that bacterial reduction effected by the intervention methods used is maintained during the rest of the operation.

Chilling

- Measures to control the holding temperature of the carcass after the final wash or after any CCP designed to reduce pathogenic organisms on carcasses should be in place. Control of the temperature will ensure that the reduction in microbial load effected by the CCP will be maintained. In addition, to retain the log reduction in microbial load as a result of the CCP and to prevent re-contamination, other sanitation control methods should be used.
- All carcasses need to begin chilling within 1 hour from bleed-out. All variety meats need to begin chilling within 1 hour after removal from carcass. Refrigeration parameters should be defined, established and recorded so that carcasses reach a temperature of 40 °F or less within 24 hours and maintained on all products.
- Refrigeration parameters should be defined, established and recorded so that carcass reach a temperature of 40 °F or less within 24 hours, and that this temperature is maintained on all products. Carcass temperature should be taken and recorded daily from 5 randomly spaced locations, usually 1 mm under fascia on the inside round.
- To prevent cross contamination and to allow efficient air circulation, cooler storage rails must be placed at least two feet from refrigeration equipment, walls, columns, and other fixed parts; traffic or header rails during transport, at least 3 feet from the walls. Sides of beef should be placed in the chiller so that there is no contact between them to allow efficient air circulation. Condensation should be prevented or minimized.
- Finished product storage areas should not exceed 40 °F.
- Aged beef should be held no longer than 7 days at a temperature not exceeding 40 °F.
- Carcasses for hot boning (deboned before chilling) should be transported to the boning areas directly from the slaughter department. The boning room environmental temperature should remain at 50 °F (10 °C) or lower, and boning should not be delayed.
 - 1) Raw materials should be placed under refrigeration until the product can enter the flow of operations.
 - 2) Within one hour after the first cut is made, product should be placed under refrigeration or cooked.
 - 3) Temperature at the center of the product placed under refrigeration should reach 40 °F (4.5 °C) or lower.

- 4) At a minimum, work areas and knives and other equipment used for boning should be cleaned and disinfected during each break or after each instance of contamination.
- 5) Temperatures maintained during the boning operation should be monitored and recorded.

Carcass Fabrication

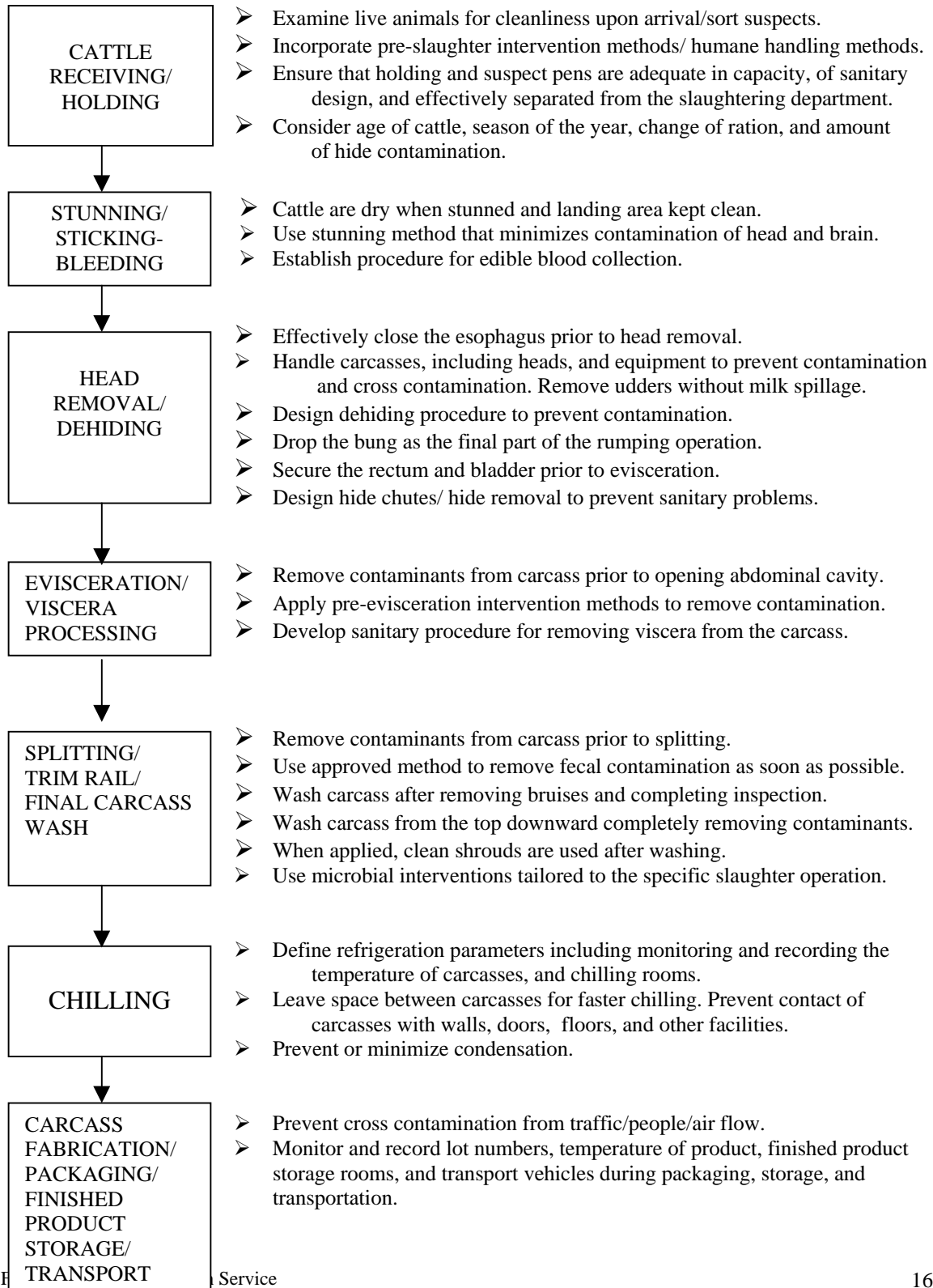
- Application of an organic acid antimicrobial treatment on chilled carcass surfaces can be used to supplement carcass decontamination intervention strategies initiated during pre-chill slaughter operations.
- Temperature of the room should be maintained at 50 °F or lower.
- The work area and equipment used for fabrication such as knives, saws, or slicers, should be cleaned and sanitized before beginning operations. This also includes scabbards and other storage devices for these implements.
- Measures should be implemented to prevent cross contamination from traffic and from people in the room.
- Cross contamination from airflow should be prevented.
- To maintain the reduction of bacterial load attained as a result of CCPs, temperature and cross contamination should be controlled and recorded.
- During the boning operation, verification activities that include testing for *E. coli* O157:H7 and *Salmonella* should be conducted to ensure control for the pathogen is maintained.

Packaging/Finished Product Storage and Transport

- Storage room and transportation vehicle temperature should be maintained at 40 °F or lower.
- The average internal meat temperature during storage should be maintained at 40 °F or lower.
- Opportunity for contamination from airflow, traffic and from people, and other environmental sources should be minimized.
- Temperature during transport and storage should be monitored and recorded.

IV. Flow Diagram

FLOW DIAGRAM FOR BEEF SLAUGHTER OPERATIONS AND RECOMMENDATIONS



V. Interventions

Post-slaughter interventions

Despite good slaughter practices, contamination of carcasses can occur. Thus the use of effective antimicrobial intervention strategies can prove useful during slaughter operations. Antimicrobial intervention methods are designed to reduce microbial contamination on the carcasses, and usually involve the application of organic acids, hot water, steam, physical means or a combination in sequence. The integration of established intervention methods, such as knife trimming, in combination with other antimicrobial decontamination methods such as steam vacuuming, acid or hot water spray washing systems, and steam pasteurization can help to improve the microbial safety of beef carcasses immediately post-slaughter. Establishments should determine the level of effectiveness of their antimicrobial decontamination methods with regards to reduction of specific pathogens and indicator organisms. The following section describes studies on the use of antimicrobial decontamination methods as interventions to reduce microbial load. Establishments should validate these methods according to the processes they use.

Spray-Washing Systems

Decontamination of red-meat carcasses using hot-water washes (70 to 96 °C) has shown promise as an effective bacterial intervention method. Studies indicated that hot water (>70 °C) was more effective than water at ambient temperature for reducing *E. coli* populations. The carcass appearance was not permanently affected by the hot-water washes. Another study determined that hot water washes (95 °C) reduced initial inoculation level of 5.0 log₁₀ CFU/cm² for *E. coli* O157:H7 and *S. typhimurium* to 3.7 and 3.8 log₁₀ CFU/cm², respectively.

The efficacy of trisodium phosphate (TSP) has been the subject of several studies. It was observed that TSP was capable of reducing *E. coli* O157:H7 to below detectable levels.

Steam-Vacuum Systems

The original steam vacuum was designed to take advantage of both hot water and steam, in combination with a physical removal of bacteria and contamination via vacuum. Steam only vacuums have since been designed and are used in beef-processing plants. It was reported that vacuum sanitizing equipment effectively reduced nonspecific strains of *E. coli* and *E. coli* O157:H7. Coliforms at initial levels of 5 log CFU/cm² were reduced to 1.0 CFU/cm². *E. coli* counts of 4.8 log CFU/cm² were reduced to 0.8 log CFU/cm².

Prior to the approval of the use of a steam vacuuming system, the FSIS zero-tolerance policy for the presence of fecal contamination required removal of all visible feces by knife trimming. The use of steam vacuum technology in slaughter plants has reduced the amount of knife trimming required to meet the zero-tolerance policy. Additionally, the use of steam vacuuming has resulted in an improvement of the microbial constitution of

beef carcasses, whereas they can be maintained for up to 21 days while under refrigerated storage without growth of *E. coli* O157:H7.

Studies demonstrated that an in-plant steam vacuuming system was capable of consistently reducing bacterial populations on contaminated areas that were less than one square inch on beef carcasses more effectively than knife trimming.

Steam Pasteurization

Comprehensive studies aimed at determining the ability of steam pasteurization to decontaminate beef surface tissue have been published. A reduction in *E. coli* O157:H7 of 3.5 log CFU/cm² was observed with an initial inoculation of 5.0 log CFU/cm², and a 3.7 log CFU/cm² reduction of *Salmonella typhimurium* with an initial contamination of 5.1 log CFU/cm². They concluded that steam pasteurization can be an affective intervention in an overall system of pathogen reduction on surface tissue of freshly slaughtered beef and that its greatest effectiveness is achieved when used in combination with other decontamination treatments.

The use of a commercially available steam-pasteurization chamber was studied in a processing facility. It was determined that the low initial populations (<1 log CFU/cm²) of *E. coli*, total coliforms, and other species of Enterobacteriaceae present on the carcass surfaces were immediately reduced, in many cases, to undetectable levels. The study concluded that this type of steam technology could be successfully used in a beef-slaughter environment and would likely provide a microbiologically safer carcass at the end of the slaughter process.

Table 1. Reductions of *E. coli* O157:H7 and *S. typhimurium* populations on beef by various anti-microbial treatments (Delazari, I. et al. 1998).

Treatment	Microbial Contaminant	Reduction (log CFU/cm ²)
Trimming	<i>E. coli</i> O157:H7 in feces	3.2 – 4.4
Trimming + Washing	<i>E. coli</i> O157:H7 in feces	4.71 ± 0.53
Trimming + Washing + Steam Pasteurization	<i>E. coli</i> O157:H7 in feces	4.44 ± 0.53
Trimming + Water (74 °C, 12s)	<i>E. coli</i> O157:H7 in feces	1.41
Steam-vacuum sanitizer	<i>E. coli</i> O157:H7 in feces	5.5 ± 0.25
Washing	<i>E. coli</i> O157:H7 in feces	2.0 – 3.5
Washing + Steam Pasteurization	<i>E. coli</i> O157:H7	4.22 ± 0.53
Water + 2% lactic acid (55°C, 40 lb/in ²)	<i>E. coli</i> O157:H7 in feces	2.4 – 3.7
Water + 2% lactic acid (55°C, 40 lb/in ²)	<i>E. coli</i> O157:H7 in feces	3.0 – 4.9
5% Acetic Acid	<i>E. coli</i> O157:H7	2
5% Citric Acid	<i>E. coli</i> O157:H7	1.88
5% Lactic Acid	<i>E. coli</i> O157:H7	2.6
Water + 2% lactic acid (55°C, 40 lb/in ²)	<i>S. typhimurium</i> in feces	3.4-5.0
Water + 2% lactic acid (55°C, 40 lb/in ²)	<i>S. typhimurium</i> in feces	3.2-5.1

Several studies used a combination of two or more intervention methods to reduce the number of *E. coli* O157:H7 and *Salmonella* during slaughter operations. Exact conditions of the study are reproduced and detailed here to help establishments with the procedure. However, if there are additional questions and concerns on the methodologies or equipment, establishments should get a copy of the published study or contact the investigators of the study.

Establishments can use a single treatment or a combination of treatments to fit the needs of their slaughter operations. Even though some studies were conducted on selected beef carcass muscle areas or regions, the investigators claimed that these decontamination methods can be applied to whole or half carcasses using the parameters in the study, especially where commercial spray washer or steam vacuum equipment were used. Mention of brand names and suppliers of equipment and chemicals used in the studies does not imply approval or endorsement by USDA.

A. The effects of steam vacuuming and hot water spray wash on beef carcass surface tissue inoculated with *E. coli* O157:H7 and other microorganisms (Dorsa et al., 1997a).

Beef carcass short plates were taken from 24 carcasses at a cow/bull slaughter facility and transported to the lab for the study. An area of the beef short plate was inoculated with fecal material containing *E. coli* O157:H7 by evenly spreading using a sterile 5.1 cm paint brush. The inoculated plates were left undisturbed for 15 min before the application of the intervention methods. The short plates were subjected to one of three treatments.

Hot water spray wash (W). A stainless steel insertable pod of the commercial carcass washer was used as the wash cabinet (W.J. Cary Engineering, Inc., Springfield, MO). The single spray bar contained 3 nozzles set 13 cm apart and 10 cm from the meat surface. The nozzles (Spraying Systems Co., Wheaton, IL) were designed to deliver 1 gallon (3.8 liters) of water per min as a 45 angle flat spray at 40 psi. Water temperature was maintained at 74+/-2 °C for hot water spray at 20 psi followed by a warm water spray at 30+/-1 °C at 125 psi.

Steam-vacuum (SV). The steam vacuum equipment used (Vac-San, Kentmaster Mfg., Monrovia, CA) consisted of a stainless steel vacuum head to remove bacterial and visible fecal contamination by delivering 7 to 10 psi water at 88 to 94 °C to a 1.5 by 6.5 cm area while simultaneously vacuuming the area around the stream of hot water. Static vacuum was 7 in. of Hg and when contact was made with the meat surface, the vacuum was 10 in. of Hg. To continuously sanitize the equipment while in use, steam was delivered at approximately 45 psi by a stainless steel jacket surrounding the steam nozzle.

Combination of the two treatments (SV+W). SV was followed by W, using the same conditions as the individual treatments.

Results:

- *E. coli* O157:H7 population was reduced 2.1, 2.6 and 3.0 log CFU/cm² after application of SV,W and SV+W treatments, respectively.
- *E. coli* O157:H7 population grew by 1.2, 1.4 and 1.5 log CFU/cm² for the AV, W and SV+W treatments respectively, after 2 days of aerobic storage at 5 °C.
- After 21 days of vacuum storage at 5 °C, the levels for *E. coli* O157:H7 were 4.9, 4.6 and 4.1 log CFU/cm² for SV, W and SV+W respectively, giving a reduction of 0.5, 0.8 and 1.3 log CFU/cm² respectively, from the initial number of 5.4 +/- 1 log CFU/cm².

B. The effects of acetic acid, lactic acid, and trisodium phosphate on *E. coli* O157:H7 on refrigerated beef carcass surface tissues (Dorsa et al., 1997b).

Beef carcass short plates were taken from cows from a cow-bull slaughter facility and transported to the lab for the study. An area of the beef short plate was inoculated with fecal material containing *E. coli* O157:H7 by evenly spreading using a sterile 5.1 cm paint brush. The inoculated plates were left undisturbed for 15 min at room temperature (ca 22 °C) before the application of the intervention methods.

The study also determined the effect of the treatments on inoculated beef carcass tissues handled and stored under normal industrial conditions. The treated beef plates were stored at 5 °C aerobically for 2 days, then vacuum packaged and stored for an additional 19 days at 5 °C.

The spray wash treatments used were 1.5% (vol/vol) acetic acid (AA) (Eastman Chemical, Kingsport TN); 3.0% (vol/vol) AA; 1.5% (vol/vol) lactic acid (LA) (Sigma Chemical Co. St. Louis MO); 3.0% (vol/vol) LA; 12% (wt/vol) trisodium phosphate (TSP) (Av-Gard®, Rhone Poulenc, Washington, PA); and tap water (W). All washes were applied for 15 s at about 5.5 bar (80+/- psi) at 32 +/- 2 °C using a wash cabinet made of stainless steel insertable pod of the carcass washer (W.J. Cary Engineering, Inc. Springfield, MO).

Results of the study:

- All spray wash treatments were shown to physically remove visible fecal contamination from the inoculated areas. W treatments reduced *E. coli* O157:H7 by 1.8 log CFU/cm² while all AA, LA and TSP treatments reduced *E. coli* O157:H7 by about 2.7 log CFU/cm² from the initial 4.0 log CFU/cm².
- For the W treatment, after reducing *E. coli* O157:H7 population to 1.8 log right after the treatment, the number grew steadily during storage to reach about 4.5 log CFU/cm² from 7 to 21 days which is about 0.5 log CFU/cm² higher than the initial number, but still lower than the control.
- For the acid and TSP treatments, *E. coli* O157:H7 remained at or below 2 log CFU/cm² during the 21 day storage period.

- For both LA treated plates, *E. coli* O157:H7 remained below 0.8 log CFU/cm². The most effective treatment was 3% LA since the *E. coli* O157:H7 population was at 0.1 log CFU/cm² after 21 days of storage.

An alternate method of applying acid treatment suggested by one of the investigators is by the use of 2-3 liter sprayers operated by hand. The carcasses are washed with warm/hot water first and then the acid spray treatment is applied.

C. Comparison of water wash, trimming, and combined hot water and lactic acid treatments to reduce bacteria of fecal origin on beef carcasses (Castillo et al., 1998b).

The outside round, brisket and clod carcass surface regions of slaughtered and dressed steers and heifers were obtained after carcasses were split and before washing. A 400 square centimeter area was inoculated with dairy cow feces containing *E. coli* O157:H7 by spreading on the surface using a sterile spatula in a one-way crossing motion.

The inoculated surface area was treated within 5 min by one of the methods below.

- 1) Water wash.
- 2) Water wash followed by hot (95 °C) water spray.
- 3) Water wash followed by warm (55 °C) 2% lactic acid spray.
- 4) Water wash followed by hot water spray followed by lactic acid spray.
- 5) Water wash followed by lactic acid spray followed by hot water spray.
- 6) Trim.
- 7) Trim followed by hot water spray.
- 8) Trim followed by lactic acid spray.
- 9) Trim followed by hot water spray followed by lactic acid spray.
- 10) Trim followed by lactic acid spray followed by hot water spray.

Water wash consisted of a 1.5 liter hand wash for 90 s at 10 psi using a hand-held, noncorrosive polyethylene compressed air sprayer (10.56 liter, Universal-Gerwin, Saranac, MI) followed by a 5-liter automated cabinet wash starting at an initial pressure of 250 psi for 4 s gradually increasing to 400 psi for 2 s , and maintaining this pressure for 3 s to complete a total treatment time of 9 s.

Hot water wash consisted of spraying water at 95 °C onto the carcass regions at 24 psi for 5 s, using a flat spray nozzle (H ¼ USS5050, Spraying Systems, Wheaton, IL) from a distance of 12.5 cm. Temperature of the carcass during the treatment was raised to about 82 °C as measured by a type K thermocouple connected to a Tegam 871 digital thermometer (EIL Instruments, Inc., Sparks, MD).

Lactic acid treatment consisted of spraying 200ml of 2% warm lactic acid solution at a pressure of 40 psi for 11 s. Lactic acid solution was prepared using 88% L-lactic acid (Purac Inc., Arlington Heights, IL) mixed with enough distilled water to make a 2% solution and then tempered to 55 °C in a water bath.

Trimming of the contaminated beef carcass area (2.5 cm outside the 400 square centimeter inoculated area) was achieved by cutting the total area of visible fecal contamination with a boning knife just under the surface (0.5 to 1 cm deep) while pulling away the cut contaminated area with a sterile meat hook.

A model spray cabinet designed and constructed by Chad Company (Lenexa, KS) was used for washing, hot water spraying and lactic acid spraying of carcass surfaces.

Results of the study:

Reduction of population on inoculated carcass surface regions of outside round, brisket and clod (log CFU/cm²). Mean reductions in brackets [].

	<u><i>E. coli</i> O157:H7</u>	<u><i>S. typhimurium</i></u>
Water wash:	2.0 to 2.9 [2.4]	1.7 to 3.0 [2.3]
Water wash + hot water:	3.7 to 4.2 [4.0]	3.5 to 4.7 [4.2]
Water wash + lactic acid:	4.2 to 5.0 [4.6]	4.8 to 5.0 >[4.9]
Water wash +hot water + lactic acid:	4.5 to 5.0 [4.9]	4.3 to 4.8 >[4.5]
Water wash +lactic acid + hot water:	4.2 to >4.6 [4.4]	4.2 to 4.5[4.4]
Trim:	2.8 to 3.6 [3.1]	2.6 to 3.3 [2.9]
Trim + hot water:	>4.7 to >4.9 [>4.8]	4.5 to 4.9 >[4.7]
Trim + lactic acid:	>4.7 to >5.0 [>4.9]	4.7 to 5.0 >[4.9]
Trim + hot water + lactic acid:	>4.8 to >5.0 [>4.9]	4.4 to 4.8 >[4.6]
Trim + lactic acid + hot water:	>4.5 to >4.7 [>4.6]	4.4 to 4.8 >[4.6]

D. Comparison of steam pasteurization and other methods to reduce pathogens on the surface of carcasses (Phebus et al., 1997).

The investigators used the muscles from the cutaneous trunci (rose meat) of freshly slaughtered steers. Each piece was held suspended by a stainless steel bacon comb inserted through one edge of the sample. Each piece was spread inoculated with fecal material (collected from the overnight holding pen of the animals to be slaughtered) inoculated with *E. coli* O157:H7 and *S. typhimurium*. Several decontamination methods were used singly or in combination.

Steam pasteurization (S): A steam pasteurization chamber constructed of stainless steel cabinet where the meat is held suspended was used (Frigoscandia Food Process Systems, Bellevue, WA, and Cargill, Inc., Minneapolis, MN). The cabinet was sealed and steam was introduced into the chamber for exposure time of 15 seconds (s). The temperature was monitored during the process. The steam reservoir was maintained close to 100°C, while the temperature of the meat rose from 20 °C to about 90 °C between 15 s and 30 s, and fell to around 1°C from 30 s to 45 s.

Hot water/steam vacuum spot cleaning (V): A commercially available hot water/steam vacuum spot cleaning system was used to remove all visible fecal

contamination from the surface of the meat (Vac-San, Kentmaster Mfg., Monrovia, CA). Temperatures were recorded.

Knife trimming (T): A boning knife sterilized in a hot water knife sterilizer (82.2 °C) and a sterilized meat hook was used to trim away all visible fecal contamination. An initial cut was made about 1 cm outside the visible contamination area and the entire contaminated area was removed as a unit to 0.5 cm deep. The knife was sterilized for every sample.

Warm water wash (W): Meat samples were treated in a model carcass wash system. The meat, hanging from the bacon combs, was 20.3 cm away from the spray nozzles (0.25-in. S10 BAX nozzle brass, Bete Fog Nozzle, Inc., Sumner, WA). Warm tap water at 35 °C was sprayed onto the inoculated meat surface at a pressure of 38 to 40 pounds per square inch (psi) for 23 s. The meat was moved horizontally throughout the treatment by sliding the pipe in which it was suspended, simulating an oscillating wash action.

Lactic acid decontamination (L): A 2% vol/vol solution was prepared from an 88% lactic acid solution (Purac America, Lincolnshire, IL) with a final pH of 2.25. The acid solution maintained at 54 °C was applied to the meat surface at 25 psi pressure, using a pressurized hand-held stainless steel sprayer. The meat surface was drenched with 200 ml of the lactic acid solution for 22 s and then was allowed to drip for 30 s.

Results of the study:

- The decontamination methods used singly as described above, S, V, and T had greater than 3.0 log CFU/cm² reduction of *E. coli* O157:H7, while the 35 °C water wash (W) gave 0.75 CFU/cm² reduction.
- The combination decontamination methods VW, VWS, VWLS*5 (steam for 5 s) and VWLS*10 (steam for 10 s) had greater than 3.0 log CFU/cm² reduction of *E. coli* O157:H7.
- The combination decontamination methods TW, TWS, WS, TWLS, and VWLS had greater than 4 log CFU/cm² reduction of *E. coli* O157:H7.
- The decontamination methods used singly as described above, S and V had greater than 3.0 log CFU/cm² reduction of *Salmonella typhimurium*, while the water wash (W) and trim (T) gave 1.23 and 2.72 CFU/cm² reduction.
- The combination decontamination methods TW, TWS, WS, VWS, and VWLS*5 (steam for 5 s) had greater than 4 log CFU/cm² reduction of *S. typhimurium*, while VW and VWLS*10 (steam for 10 s) had greater than 3.0 log CFU/cm² reduction.
- The combination decontamination methods TWLS and VWLS had greater than 5.0 log CFU/cm² reduction of *S. typhimurium*.

After the decontamination step, measures to prevent recontamination of carcasses should be instituted in order to maintain the reduction of pathogens resulting from these treatments. Studies showed that depending on the intervention methods used and on handling and storage conditions after the decontamination (time, temperature and vacuum packaging), recontamination and growth of *E. coli* O157:H7 after decontamination can range from minimal to significant. Decontamination methods reduce the number of pathogens, and also other microorganisms, which compete with these pathogens. Removal of these competitors will enhance the growth of pathogens in case of recontamination. Preventive and control measures during handling and storage of decontaminated carcasses should be included in the HACCP plan.

VI. Critical Control Points

FSIS regulations, 9 CFR 417.2(c)(1) and (2), require that food safety hazards identified in a hazard analysis be listed in the HACCP plan, and that there be a critical control point (CCP) for each identified hazard. A CCP is a point, step, or procedure in a food process at which control can be applied, and, as a result, a food safety hazard can be prevented, eliminated, or reduced to acceptable levels.

Each establishment must conduct a hazard analysis to determine the food safety hazards reasonably likely to occur in the production process and identify the preventive measures the establishment can apply to control those hazards. The hazard analysis must include food safety hazards that can occur before, during, and after entry into the establishment. A food safety hazard that is reasonably likely to occur is one for which a prudent establishment would establish controls because it historically has occurred, or because there is a reasonable possibility that it will occur in the particular type of product being processed, in the absence of those controls.

There are many points in the beef slaughter process that should be considered when conducting a hazard analysis including the following:

- Sources of cattle: certain ages and classes of cattle have a higher prevalence of *E. coli* O157:H7 than others; therefore it is important to know the cattle source.
- Receiving: animals should be received as clean as possible; i.e., mud and fecal contamination should be minimized.
- Holding facilities: it is important to evaluate your facilities to minimize contamination from the facilities and cross contamination between animals.
- Stunning: the facilities could be a source of contamination.
- Sticking/Bleeding: the dry landing area could be a source of contamination.

- Esophagus Rodding/Tying: the rumen could be a source of contamination for the carcass (especially the head) if the esophagus is not closed completely.
- Head Removal: should be considered because of possible contamination from the esophagus (rumen contents) if not performed correctly.
- De-hiding, including opening, skinning, and removal: should be considered because of the potential of contamination from the hide, feet, and udders. The dropping, ringing and tying of the bung should be considered because fecal and urine contamination is very likely if not performed correctly.
- Evisceration/Viscera processing: should be considered because contamination from fecal, rumen, and urine is very likely if not performed correctly.
- Final carcass wash: should be considered to ensure complete removal of any contamination.
- Chilling: should be considered to prevent the growth of *E. coli* O157:H7 and *Salmonella* at this point in the process.
- Carcass fabrication: should be considered to prevent the growth of *E. coli* O157:H7 and *Salmonella*, as well as cross contamination at this point in the process.
- Finished product storage (40° F): should be considered to prevent the growth of *E. coli* O157:H7 and *Salmonella* at this point in the process.

Some examples of hazards that may be determined to be reasonably likely to occur in a beef slaughter operation include: pathogen contamination from the hide at skinning, pathogen contamination from the gastrointestinal tract during evisceration, final wash, pathogen proliferation at chilling, and pathogen proliferation at finished products storage (cold). The establishment may choose any number of CCPs to address these hazards. For example, an establishment may choose to have the following three CCPs to address the five hazards identified above: final wash (antimicrobial), proper chilling of product, and proper maintenance of finished product temperatures during cold storage.

In this example, the final wash is designated as the first critical control point and identified in the Hazard Analysis form and HACCP Plan as “1B,” the “B” representing biological hazards (pathogens) including *E. coli* O157:H7 and *Salmonella*. Since the final wash occurs after hide skinning and evisceration, this first critical control point would address the potential pathogen contamination from both hide skinning and evisceration. Using an acceptable antimicrobial in the final wash step of the slaughter process applied to the carcasses would be a measure that could be applied to prevent, eliminate, or reduce the hazard to an acceptable level.

The second critical control point is the chilling of product and identified as “2B.” Pathogens, including *E. coli* O157:H7 and *Salmonella*, are less likely to grow if proper chilling procedures are used.

The third critical control point is the finished product storage (cold) which is identified as “3B.” Pathogens, including *E. coli* O157:H7 and *Salmonella*, are less likely to grow if the temperature is maintained at or below a level sufficient to preclude pathogen growth.

Establishments must validate CCPs in accordance with Title 9, Code of Federal Regulations, Section 417 (9 CFR 417).

The above is just an example. There are many more possibilities. Different facilities preparing the same food can differ in the number and types of CCPs they choose to use.

VI. The Use of Indicator Organisms to Assess the Presence of *E. coli* O157:H7 or *Salmonella*

There have been questions as to the practicality of testing for *E. coli* O157:H7 as part of a HACCP verification activity during slaughter and meat processing operations. These questions arise because for these pathogens they are not uniformly distributed, and a negative test is not an assurance that the pathogens are absent, and because *E. coli* O157:H7 is known to occur sporadically, and is present at low concentrations. Testing for indicator organisms in lieu of testing for *E. coli* O157:H7 has been proposed because indicator testing costs less, is simpler, and is of shorter time/duration than testing for *E. coli* O157:H7. The indicator organisms commonly used are total aerobic plate count (APC), coliforms, thermo-tolerant coliforms, generic *E. coli*, enterococci, and *Enterobacteriaceae*.

Indirect tests as a means of detecting possible pathogens in water and foods have been in use for some time. These indirect tests use the terms, index, indicator, marker, or surrogate organisms. The terms “index”, “marker”, “simulator”, or “surrogate” were suggested to refer to organisms whose presence at certain levels indicates the possible occurrence of pathogens. The term “indicator organisms ” or “hygiene marker organisms” are those whose detection is indicative of a failure in GMP or integrated system control which results in a food product of unacceptable microbiological quality (Brodsky, M.N. 1995). Testing for index organisms serve to predict the presence of pathogens, while indicator organisms serve to assess process control.

A review by J. Johnson (1996) enumerates the characteristics of ideal index organisms (most of which are incorporated in the pointers below). The review discussed the difficulties in establishing index organisms. One issue is the impact of non-homogeneous distribution of both index and pathogenic organisms in meat and poultry. Index organisms may be concentrated in one part of the carcass or the meat, which is not necessarily the same location where the pathogens are concentrated. Another consideration is whether the effects of control, decontamination or intervention methods

on index organisms are similar to the effects on the pathogens. Organisms may react differently or have different survival rates as a result of the application of organic acid sprays depending on their acid tolerance. Some members of the coliform and *Enterobacteriaceae* groups are reported to be capable of growth at refrigeration temperatures and therefore may not be good indices for assessing adequacy of refrigeration of meat and poultry. In addition, the relationship of the number of index organisms to that of the target pathogen could change at different points in the slaughter or processing line.

Indicator organisms are especially useful for validating process implementation and verifying process control (AMSA, 1999). Pathogen testing is not useful for verification purposes because pathogens usually occur at low levels and are distributed non-randomly. However, pathogen testing as a means of HACCP verification is useful if incidence is high, distribution is random, and numbers are high enough to permit detection.

Tests for indicator organisms may be used successfully when there is sufficient data collected to establish or indicate a relationship between the occurrence or level of a pathogen or toxin and the indicator organism (AMSA, 1999). Data can be collected from studies using indicator organisms which parallel the data in a challenge study performed with inoculated pathogen in another or the same study. If a similar and consistent reduction or control can be established, then control of the indicator organism can be reliably used to indicate expected pathogen control in commercial application.

There are some studies on the use of various indicator organisms to determine the effect of intervention methods used to control pathogens in slaughter operations. Unfortunately, studies on the effects of carcass decontamination methods on *E. coli* O157:H7 and on indicator organisms were done separately, so that correlation of the effect on *E. coli* O157:H7 and indicator organisms cannot be established.

FSIS undertook an analysis of existing Agency ground beef testing program data to compare the incidence of *E. coli* O157:H7 and generic *E. coli* (unpublished) for the years 1998, 1999 and 2000 (up to July). The results show that there is no strong correlation to support the use of generic *E. coli* testing in lieu of testing for *E. coli* O157:H7. Therefore, at this time, testing for any organism other than *E. coli* O157:H7 would not be acceptable validation of a CCP to prevent, eliminate, or reduce *E. coli* O157:H7. However, if at some point in the future, establishments can demonstrate that there is an organism that can be used as an indicator organism for *E. coli* O157:H7, this organism could be used for validation of CCPs addressing *E. coli* O157:H7.

The Agency will encourage exploring the applicability and effectiveness of the use of indicator organisms in studies designed to establish a correlation in the reduction of indicator organisms with reduction of *E. coli* O157:H7. The Agency is using the term “indicator organism” because the test for the organism will assess the presence of *E. coli* O157:H7 and at the same time indicate process control. FSIS is providing its current thinking on when testing for indicator organisms can be used instead of testing for the

target pathogen, *E. coli* O157:H7. Research studies or challenge experiments should demonstrate correlation between indicator organisms and *E. coli* O157:H7 with the pointers outlined below.

1. Characteristics of indicator organisms used for the study must include:
 - a history of constant ecological association with the target pathogen in the environment where contamination originates
 - being present when the target pathogen is present and occurring in greater numbers compared to the target organism;
 - a reliable and defined quantitative relationship with the target pathogen
 - growth requirements and growth rates identical to those of the target pathogen
 - reacting in similar manner to adverse conditions/processing as the target pathogen
 - being easily differentiated from other microorganisms
 - being easily and rapidly detectable.

2. The study would need to include both the indicator organism and *E. coli* O157:H7 and be subjected to the same conditions and same decontamination methods. The level/quantity of both the indicator organism and *E. coli* O157:H7 or *Salmonella* must be determined or measured before and after the application of the decontamination methods using FSIS methods (Microbiology Laboratory Guidebook 3rd edition, 1998 at <http://www.fsis.usda.gov/OPHS/microlab/mlgbook.htm>) or equivalent.

3. Decontamination studies on carcasses will be applicable to carcasses only, while studies on trimmings or ground beef will be applicable to trimmings and ground beef, respectively.

4. Sufficient data indicating constant correlation between the level of indicator organism and that of *E. coli* O157:H7 or *Salmonella* need to be collected and analyzed. Data should establish that a statistically significant quantitative reduction of the indicator organism at the specific step in processing consistently achieved a constant reduction of *E. coli* O157:H7.

The National Advisory Committee on Microbiological Criteria for Foods (NACMCF) Subcommittee on Microbiological Performance Standards for Raw Meat and Poultry in their report included additional recommendations to assure scientific sufficiency in using an indicator organism in lieu of a specific pathogen for measurement against a performance standard. (http://www.fsis.usda.gov/OPHS/NACMCF/rep_stand.htm)

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VIII. References

How to order Generic HACCP Models and Guide

The generic HACCP models and a Guidebook for the Preparation of HACCP Plans were created to assist plant owners and operators in developing their own HACCP plan(s). To obtain free copies, please call the HACCP Hotline at 1-800-233-3935 (press “2” to connect to the HACCP Hotline) or FAX at 1-402-221-7438, or from <http://www.fsis.usda.gov>

Generic HACCP Models and Guide

- HACCP-1 Guidebook for the Preparation of HACCP Plans (September 1999)
- HACCP-3 Generic HACCP Model for Raw, Ground Meat and Poultry Products (September 1999)
- HACCP-4 Generic HACCP Model for Raw, Not Ground Meat and Poultry Products (September 1999)
- HACCP-5 Generic HACCP Model for Poultry Slaughter (September 1999)
- HACCP-6 Generic HACCP Model for Mechanically Separated (Species)/Mechanically Deboned Poultry (September 1999)
- HACCP-7 Generic HACCP Model for Thermally Processed, Commercially Sterile Meat and Poultry Products (September 1999)
- HACCP-8 Generic HACCP Model for Irradiated, Raw Meat and Poultry Products (May 1999)
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- HACCP-10 Generic HACCP Model for Heat Treated, Shelf Stable Meat and Poultry Products (September 1999)
- HACCP-11 Generic HACCP Model for Heat Treated But Not Fully Cooked, Not Shelf Stable Meat and Poultry Products (September 1999)
- HACCP-12 Generic HACCP Model for Fully Cooked, Not Shelf Stable Meat and Poultry Products (September 1999)
- HACCP-13 Generic HACCP Model for Beef Slaughter (September 1999)
- HACCP-14 Generic HACCP Model for Pork Slaughter (September 1999)
- HACCP-15 Generic HACCP Model for Not Heat Treated, Shelf Stable Meat and Poultry Products (September 1999)

How to Order the Food Code and other materials

The Food Code is a reference document for regulatory agencies responsible for overseeing food safety in retail outlets such as restaurants and grocery stores and institutions such as nursing homes and child care centers.

U.S. Department of Commerce
Technology Administration
National Technical Information Service
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Springfield, VA 22161
(703)-605-6000, refer to report number PB99-115925

From the Web site: <http://vm.cfsan.fda.gov/~dms/foodcode.html>

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The FSIS web site carries the latest information on our programs and also has links to other relevant government web sites. In addition, the Gateway to Government Information is a web site established by the President's Food Safety Initiative. It is designed to help web site users find government information on food safety.

- Food Safety and Inspection Service (FSIS) Web site: <http://www.fsis.usda.gov>
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