9.5.1 Meat Packing Plants

9.5.1.1 General[1-2]

The meat packing industry is made up of establishments primarily engaged in the slaughtering, for their own account or on a contract basis for the trade, of cattle, hogs, sheep, lambs, calves, and vealers for meat to be sold or to be used on the same premises in canning, cooking, curing, and freezing, and in making sausage, lard, and other products. Also included in this industry are establishments primarily engaged in slaughtering horses for human consumption.

9.5.1.2 Process Description[3-7]

The following sections describe the operations involved in beef processing, pork processing, and other meat processing. Figure 9.5.1-1 provides a generic process flow diagram for meat packing operations.

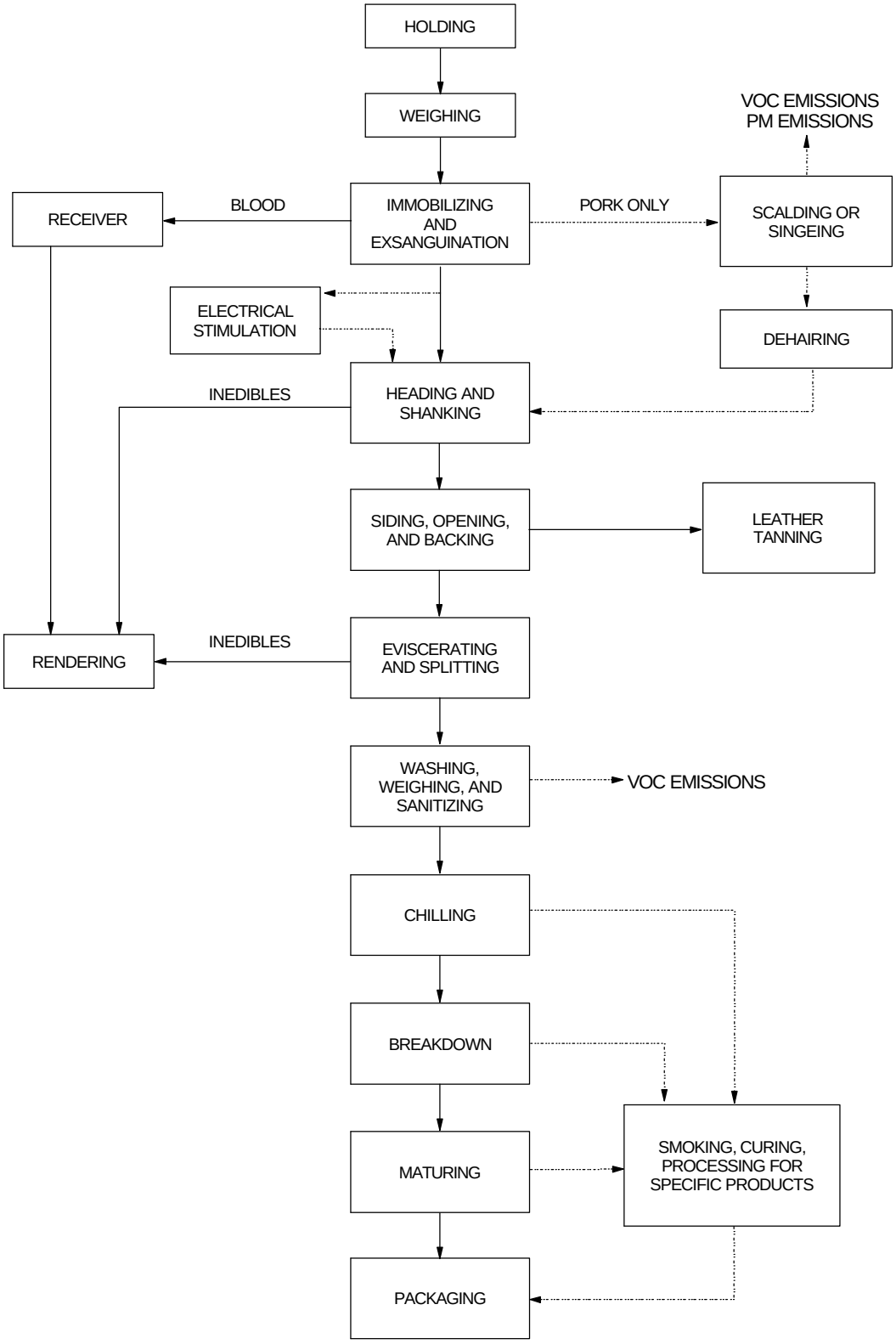
9.5.1.2.1 Beef Processing[3-7] -

Animals are delivered from the market or farm to the meat plant and are placed in holding areas. These holding areas should have adequate facilities for the inspection of livestock, including walkways over pens, crushes, and other facilities. Sick animals and those unfit for human consumption are identified and removed from the normal processing flow. Plants should have separate isolation and holding pens for these animals, and may have separate processing facilities. The live beef animals are weighed prior to processing so that yield can be accurately determined.

The animals are led from the holding area to the immobilization, or stunning, area where they are rendered unconscious. Stunning of cattle in the U.S. is usually carried out by means of a penetrating or nonpenetrating captive bolt pistol. Livestock for Kosher markets are not immobilized prior to exsanguination.

The anesthetized animals are then shackled and hoisted, hind quarters up, for exsanguination (sticking), which should be carried out as soon as possible after stunning. In cattle, exsanguination is effected by severing the carotid artery and the jugular vein. Blood is collected through a special floor drain or collected in large funneled vats or barrels and sent to a rendering facility for further processing. More information on rendering operations can be found in AP-42 Section 9.5.3, Meat Rendering Plants. Blood can be used in human food only if it is kept completely sterile by removal from the animals through tubes or syringes.

In some plants, electrical stimulation (ES) is applied to the carcasses to improve lean color, firmness, texture, and marbling score; to improve bleeding of carcasses; and to make removal of the hides easier. Electrical stimulation also permits rapid chilling by hastening the onset of rigor before temperatures drop to the cold shortening range. If muscles reach temperatures below 15° to 16°C (59° to 61°F) before they have attained rigor, a contraction known as cold shortening occurs, which results in much less tender meat. In some cases ES is applied to control the fall of pH value. Meat with a low pH value will be pale, soft, and exudative (PSE meat). Meat with a high pH value may be dark, firm, and dry (DFD meat). It has been claimed that ES enhances tenderness, primarily through the hastening of the onset of rigor and prevention of cold shortening. Both high-voltage (>500 volts) and low-voltage (30 to 90 volts) ES systems can be used.


HOLDING
WEIGHING
VOC EMISSIONS
PM EMISSIONS
RECEIVER
BLOOD
IMMOBILIZING AND EXSANGUINATION
PORK ONLY
SCALDING OR SINGEING
ELECTRICAL STIMULATION
DEHAIRING
INEDIBLES
HEADING AND SHANKING
SIDING, OPENING, AND BACKING
LEATHER TANNING
RENDERING
INEDIBLES
EVISCERATING AND SPLITTING
WASHING, WEIGHING, AND SANITIZING
VOC EMISSIONS
CHILLING
BREAKDOWN
MATURING
SMOKING, CURING, PROCESSING FOR SPECIFIC PRODUCTS
PACKAGING

After exsanguination, the actual "dressing", or cleaning, of the carcasses begins. The first step is to separate the esophagus from the trachea, called "rodding the weasand". Alternatively, this can be done after the chest cavity has been opened. This separation aids in evisceration. After separation, a knot is made in the esophagus, or a band is put around it to prevent the contents of the rumen (first stomach) from spilling and contaminating the carcass.

Next, the skin is removed from the head, and the head is removed from the carcass by cutting through the Adam's apple and the atlas joint (heading). The fore and hind feet are then removed to prevent contamination of the carcass with manure and dirt dropped from the hooves (shanking or legging). Each of the legs is then skinned.

The hide is then opened down the middle of the ventral side over the entire length of the carcass. The hide is removed from the middle down over the sides (siding). Air or electrically powered rotary skinning knives are often used to make skinning easier. Care is taken to avoid cutting or scoring the hide, as this decreases its value for leather.

After siding, the carcass is opened (opening). First, a cut is made through the fat and muscle at the center of the brisket with a knife. Then a saw is used to cut through the sternum. The hind quarters are separated with a saw or knife. The tail is skinned and then removed two joints from the body. After removing the tail, the hide is completely removed (backing). Hides are collected, intermediate preserving operations performed, and the preserved hides sent to tanners for processing into leather. More information on leather tanning processes can be found in AP-42 Section 9.15, Leather Tanning.

After the hide is removed, the carcass is eviscerated. With a knife, the abdomen of the carcass is opened from top to bottom. The fat and membranes that hold the intestines and bladder in place are loosened, and the ureters connecting the bladder and the kidneys are cut. The liver is removed for inspection. The previously loosened esophagus is pulled up through the diaphragm to allow the abdominal organs to fall freely into an inspection cart. The diaphragm membrane is cut and the thoracic organs are removed.

A handsaw or electric saw is used to cut through the exact center of the backbone to split the beef carcass into sides (halving or splitting). Inedible material is collected and sent to a rendering plant for further processing. More information on meat rendering processes can be found in AP-42 Section 9.5.3, Meat Rendering Plants.

After dressing, the carcasses are washed to remove any remaining blood or bone dust. The carcasses may also be physically or chemically decontaminated. The simplest physical decontamination method involves spraying the carcass with high pressure hot water or steam. A variety of chemical decontaminants may be used as well; acetic and lactic acids are the most widely used and appear to be the most effective. In addition, the following may be used: the organic acids, adipic, ascorbic, citric, fumaric, malic, propionic, and sorbic; aqueous solutions of chlorine, hydrogen peroxide, beta-propiolactone, and glutaraldehyde; and inorganic acids, including hydrochloric and phosphoric.

After the carcasses are dressed and washed, they are weighed and chilled. A thorough chilling during the first 24 hours is essential, otherwise the carcasses may sour. Air chillers are most common for beef sides. A desirable temperature for chilling warm beef carcasses is 0°C (32°F). Because a group of warm carcasses will raise the temperature of a chill room considerably, it is good practice to lower the temperature of the room to 5° below freezing (-3°C [27°F]) before the carcasses are moved in. Temperatures more severe than this can cause cold shortening, an intense shortening of muscle fibers, which brings about toughening.

Beef undergoes maturation and should be held for at least a week (preferably longer) at 0°C (32°F) before butchery into retail joints. In the past, sides remained intact up to the point of butchery, but it is now common practice to break down the carcasses into primal joints (wholesale cuts), which are then vacuum packed. Preparation of primal joints in packing plants reduces refrigeration and transport costs, and is a convenient pre-packing operation for retailers.

Some meat products are smoked or cured prior to market. More information on smoking and curing processes can be found in AP-42 Section 9.5.2, Meat Smokehouses.

In the manufacture of frankfurters (hot dogs) and other beef sausages, a mix of ground lean meat and ground fat are blended together; then spices, preservatives, extenders, and other ingredients are blended with the mixture. The mix is transferred to the hopper of the filling machine and fed to a nozzle by a piston pump. The casing, either natural or artificial, is filled from the nozzle on a continuous basis and linked, either manually or mechanically, to form a string of individual frankfurters or sausages.

9.5.1.2.2 Pork Processing[3-7] -

Animals are delivered from the market or farm to the meat plant and are placed in holding areas. These holding areas should have adequate facilities for the inspection of livestock, including walkways over pens, crushes, and other facilities. Sick animals and those unfit for human consumption are identified and removed from the normal processing flow. Plants should have separate isolation and holding pens for these animals, and may have separate processing facilities. The live animals are weighed prior to processing so that yield can be accurately determined.

Hogs must be rendered completely unconscious, in a state of surgical anesthesia, prior to being shackled and hoisted for exsanguination. In large commercial operations, a series of chutes and restrainer conveyers move the hogs into position for stunning. The V restrainer/conveyer, or similar system, is used in most large hog processing operations. Hogs must be stunned with a federally acceptable device (mechanical, chemical, or electrical). Mechanical stunning involves the use of a compression bolt with either a mushroom head or a penetrating head. The force may be provided with compressed air or with a cartridge. Mechanical stunning is largely confined to smaller operations. Chemical stunning involves the use of CO_2, which reduces blood oxygen levels, causing the animals to become anesthetized. Electrical stunning involves the use of an electric current and two electrodes placed on the head.

Deep stunning, which was approved by the U.S. Department of Agriculture, Food and Safety Inspection Service in 1985, requires more amperage and voltage and a third electrode attached to the back or a foot. Stunning causes the heart to stop beating (cardiac arrest). The stunned animals undergo exsanguination (sticking) and blood collection in the same manner as described for cattle.

Hog carcasses, unlike cattle carcasses, generally are not skinned after exsanguination. Instead, the carcasses are dropped into scalding water which loosens the hair for subsequent removal. The carcasses should be kept under water and continually moved and turned for uniform scalding. In large plants, carcasses enter the scalding tub and are carried through the tub by a conveyer moving at the proper speed to allow the proper scalding time. During the hard-hair season (September-November), the water temperature should be 59° to 60°C (139° to 140°F) and the immersion period 4 to 4-1/2 minutes, while in the easy-hair season (February-March), a temperature of 58°C (136°F) for 4 minutes is preferable. In small plants without automation, hair condition is checked periodically during the scalding period. Some plants use an alternative to scalding that involves passing the carcass through gas flames to singe the hair. The hair is then removed by rotating brushes and water sprays, and the carcass is rinsed.

Various dehairing machines, sometimes called "polishers", are manufactured to remove hair from the scalded pork carcasses. The dehairing process is begun with a dehairing machine, which uses one or more cylinders with metal tipped rubber beaters to scour the outside of the carcasses. Hot water (60°C [140°F]) is sprayed on the carcasses as they pass through the dehairer moving toward the discharge end. The carcasses are removed from this machine, hand scraped, then hoisted again, hind quarters up. The carcasses are hand-scraped again from the top (hind quarters) down. Any remaining hairs can be removed by singeing with a propane or similar torch. Once the remaining hairs have been singed, the carcasses are scraped a final time and washed thoroughly from the hind feet to the head. Some plants pass the carcasses through a singeing machine, which singes any remaining hairs from the carcasses.

At one time, it was popular to dip dehaired carcasses into a hot solution (121° to 149°C [250° to 300°F]) of rosin and cottonseed oil for a period of six to eight seconds. When the rosin coating plasticized after cooling, it was stripped by pull-rolling it down the carcass, taking with it the remaining hair, stubble, and roots. However, in recent years, many packers have discontinued its use, turning instead to mechanical brushes and torches to completely clean dehaired pork carcasses.

In some plants, hogs are skinned after exsanguination. The head and belly of the carcass are hand-skinned, and the legs are either hand-skinned or removed. Then the carcass is hoisted, hind quarters up, and placed under tension. A second hoist is connected to the loose head and leg skin and tightened to pull the remaining skin from the carcass. The removed pigskins are trimmed, salted, folded, and stored in 50-gallon drums.

After scalding and dehairing, singeing, or skinning, the head is severed from the backbone at the atlas joint, and the cut is continued through the windpipe and esophagus. The head is inspected, the tongue is dropped, and the head is removed from the carcass. The head is cleaned, washed, and an inspection stamp is applied.

Following heading, the carcass is eviscerated. The hams are separated, the sternum is split, the ventral side is opened down the entire length of the carcass, and the abdominal organs are removed. The thoracic organs are then freed. All of the internal organs are inspected, those intended for human consumption are separated, and the remainder are discarded into a barrel to be shipped to the rendering plant. As mentioned previously, more information on meat rendering can be found in AP-42 Section 9.5.3, Meat Rendering Plants.

After evisceration, the carcass is split precisely in half. Glands and blood clots in the neck region are removed, the leaf fat and kidneys are removed, and the hams are faced (a strip of skin and fat is removed to improve appearance).

The carcass is then washed from the top down to remove any bone dust, blood, or bacterial contamination. A mild salt solution (0.1 M KCl) weakens bacterial attachment to the carcass and makes the bacteria more susceptible to the sanitization procedure, especially if the sanitizing solution is applied promptly. Dilute organic acids (2 percent lactic acid and 3 percent acetic acid) are good sanitizers. In large operations, carcass washing is automated. As the carcass passes through booths on the slaughter line, the proper solutions are applied at the most effective pressure.

After washing and sanitizing, the carcass is inspected one final time, weighed, and the inspection stamp is applied to each wholesale cut. The carcass is then placed in a cooler at 0° to 1°C (32° to 34°F) with air velocity typically 5 to 15 mph, equating to -5°C (23°F) wind chill, for a 24-hour chill period. For thorough chilling, the inside temperature of the ham should reach at least 3°C (37°F). With accelerated (hot) processing, the carcass may be held (tempered) at an intermediate temperature of 16°C (60°F) for several

hours, or be boned immediately. When large numbers of warm carcasses are handled, the chill room is normally precooled to a temperature several degrees below freezing -3°C (27°F), bringing the wind chill to -9°C (16°F) to compensate for the heat from the carcasses.

Spray chilling is permitted by the U.S.D.A. to reduce cooler shrink. Spray chilling solutions may contain up to 5 ppm available chlorine, which acts a sanitizer. At least one plant sends carcasses directly from the kill floor through a freezer, to produce a brightly colored pork with reduced carcass shrink. Following cooling, pork carcasses are often divided into deboned primal joints for distribution. The primal joints may be vacuum packed. To manufacture pork sausages, ground lean meat and ground fat are blended together and processed in the same manner as that described for beef sausages in Section 9.5.1.2.1.

9.5.1.2.3 Other Meat Processing -

Other meats undergo processes similar to those described above for beef and pork processing. These other meats include veal, lamb, mutton, goat, horse (generally for export), and farm-raised large game animals.

9.5.1.3 Emissions And Controls

No emission data quantifying VOC, HAP, or PM emissions from the meat packing industry were identified during the development of this report. However, engineering judgment and comparison of meat packing plant processes with similar processes in other industries may provide an estimation of the types of emissions that might be expected from meat packing plant operations.

Animal holding areas, feed storage, singeing operations, and other heat sources (including boilers) may be sources of PM and PM-10 emissions. Carbon dioxide stunning operations may be sources of CO_2 emissions. Animal holding areas, scalding tanks, singeing operations, rosin dipping (where still used), sanitizing operations, wastewater systems, and heat sources may be sources of VOC, HAP, and other criteria pollutant emissions.

Potential emissions from boilers are addressed in AP-42 Sections 1.1 through 1.4 (Combustion). Meat smokehouses, meat rendering operations, and leather tanning may be sources of air pollutant emissions, but these sources are included in other sections of AP-42 and are not addressed in this section.

A number of VOC and particulate emission control techniques are potentially available to the meat packing industry. These options include the traditional approaches of wet scrubbers, dry sorbants, and cyclones. Other options include condensation and chemical reaction. No information is available for the actual controls used at meat packing plants. The controls presented in this section are ones that theoretically could be used. The specific type of control device or combination of devices would vary from facility to facility depending upon the particular nature of the emissions and the pollutant loading in the gas stream. The VOC emissions from meat packing operations are likely to be very low and associated with a high moisture content.

Control of VOC from a gas stream can be accomplished using one of several techniques, but the most common methods are absorption, adsorption, and afterburners. Absorptive methods encompass all types of wet scrubbers using aqueous solutions to absorb the VOC. The most common scrubber systems are packed columns or beds, plate columns, spray towers, or other types of towers. Most scrubber systems require a mist eliminator downstream of the scrubber.

Gas adsorption is a relatively expensive technique and may not be applicable to a wide variety of pollutants. Adsorptive methods usually include one of four main adsorbents: activated carbon, activated

alumina, silica gel, or molecular sieves. Of these four, activated carbon is the most widely used for VOC control, and the remaining three are used for applications other than pollution control.

Afterburners, or thermal incinerators, are add-on combustion control devices in which VOC's are oxidized to CO_2, water, sulfur oxides, and nitrogen oxides. The destruction efficiency of an afterburner is primarily a function of the operating temperature and residence time at that temperature. A temperature above 816°C (1,500°F) will destroy most organic vapors and aerosols.

Particulate control commonly employs methods such as venturi scrubbers, dry cyclones, wet or dry electrostatic precipitators (ESPs), or dry filter systems. The most common controls are likely to be the venturi scrubbers or dry cyclones. Wet or dry ESPs are used depending upon the particulate loading of the gas stream.

Condensation methods and scrubbing by chemical reaction may be applicable techniques depending upon the type of emissions. Condensation methods may be either direct contact or indirect contact. The shell and tube indirect method is the most common technique. Chemical reactive scrubbing may be used for odor control in selective applications.

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