9.13.1 Fish Processing

9.13.1.1 General

Fish canning and byproduct manufacturing are conducted in 136 plants in 12 states. The majority of these plants are in Washington, Alaska, Maine, Louisiana, and California. Some processing occurs in Delaware, Florida, Illinois, Maryland, New York, and Virginia. The industry experienced an 18 percent increase in the quantity of fish processed in 1990, and additional increases were expected in 1992 as well. Exports of canned fish and fish meal also are increasing because of diminishing supply in other countries.

9.13.1.2 Process Description

Fish processing includes both the canning of fish for human consumption and the production of fish byproducts such as meal and oil. Either a precooking method or a raw pack method can be used in canning. In the precooking method, the raw fish are cleaned and cooked before the canning step. In the raw pack method, the raw fish are cleaned and placed in cans before cooking. The precooking method is used typically for larger fish such as tuna, while the raw pack method is used for smaller fish such as sardines.

The byproduct manufacture segment of the fish industry uses canning or filleting wastes and fish that are not suitable for human consumption to produce fish meal and fish oil.

Canning -

The precooking method of canning (Figure 9.13.1-1) begins with thawing the fish, if necessary. The fish are eviscerated and washed, then cooked. Cooking is accomplished using steam, oil, hot air, or smoke for 1.5 to 10 hours, depending on fish size. Precooking removes the fish oils and coagulates the protein in the fish to loosen the meat. The fish are then cooled, which may take several hours. Refrigeration may be used to reduce the cooling time. After cooling, the head, fins, bones, and undesirable meat are removed, and the remainder is cut or chopped to be put in cans. Oil, brine, and/or water are added to the cans, which are sealed and pressure cooked before shipment.

The raw pack method of canning (Figure 9.13.1-2) also begins with thawing and weighing the fish. They are then washed and possibly brined, or "nobbed", which is removing the heads, viscera, and tails. The fish are placed in cans and then cooked, drained, and dried. After drying, liquid, which may be oil, brine, water, sauce, or other liquids, is added to the cans. Finally, the cans are sealed, washed, and sterilized with steam or hot water.

Byproduct Manufacture -

The only process used in the U. S. to extract oil from the fish is the wet steam process. Fish byproduct manufacturing (Figure 9.13.1-3) begins with cooking the fish at 100°C (lower for some species) in a continuous cooker. This process coagulates the protein and ruptures the cell walls to release the water and oil. The mixture may be strained with an auger in a perforated casing before pressing with a screw press. As the fish are moved along the screw press, the pressure is increased and the volume is decreased. The liquid from the mixture, known as pressing liquor, is squeezed out through a perforated casing.

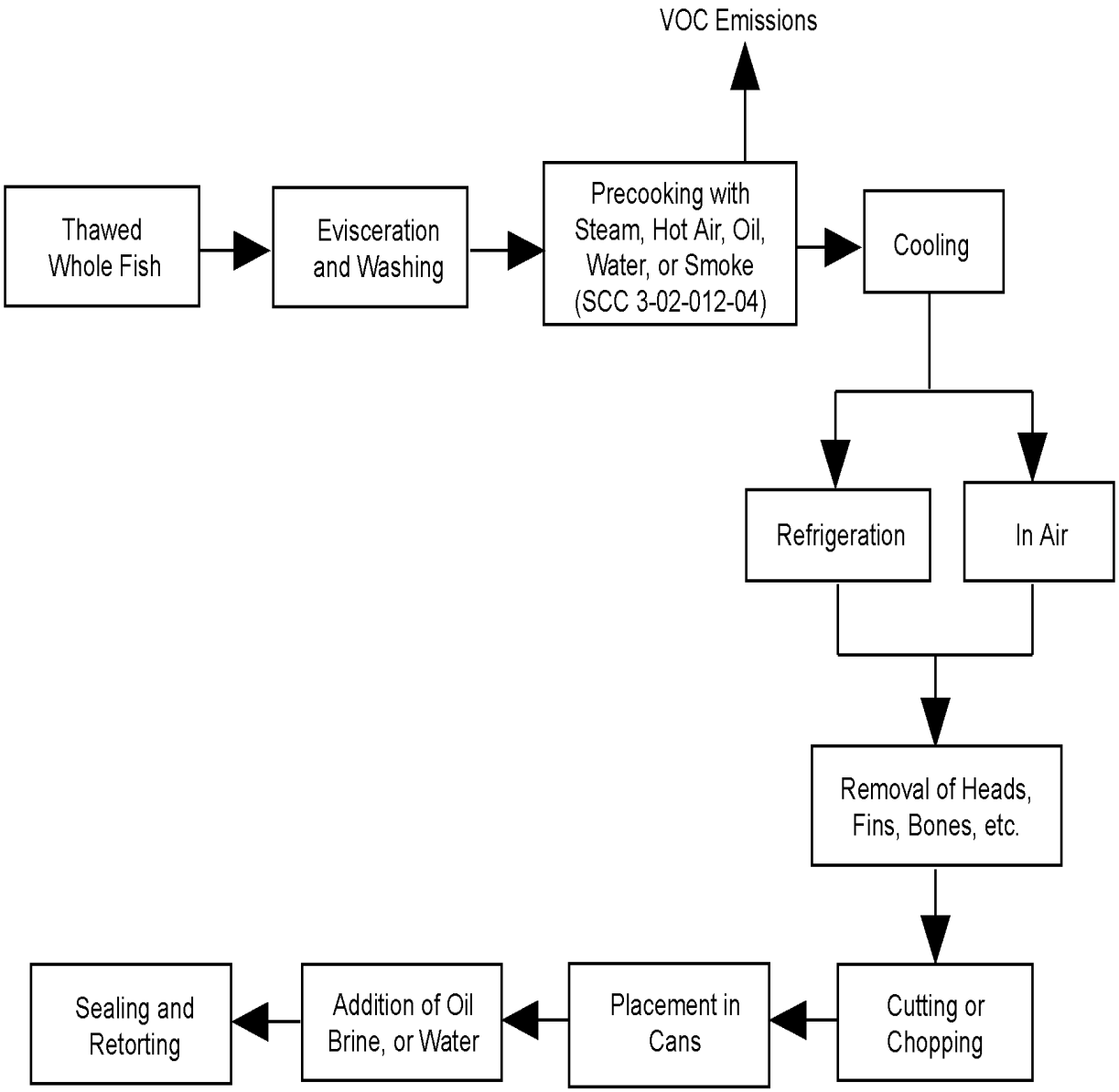


Figure 9.13.1-1. Flow diagram of precooking method.
(Source Classification Codes in parentheses.)

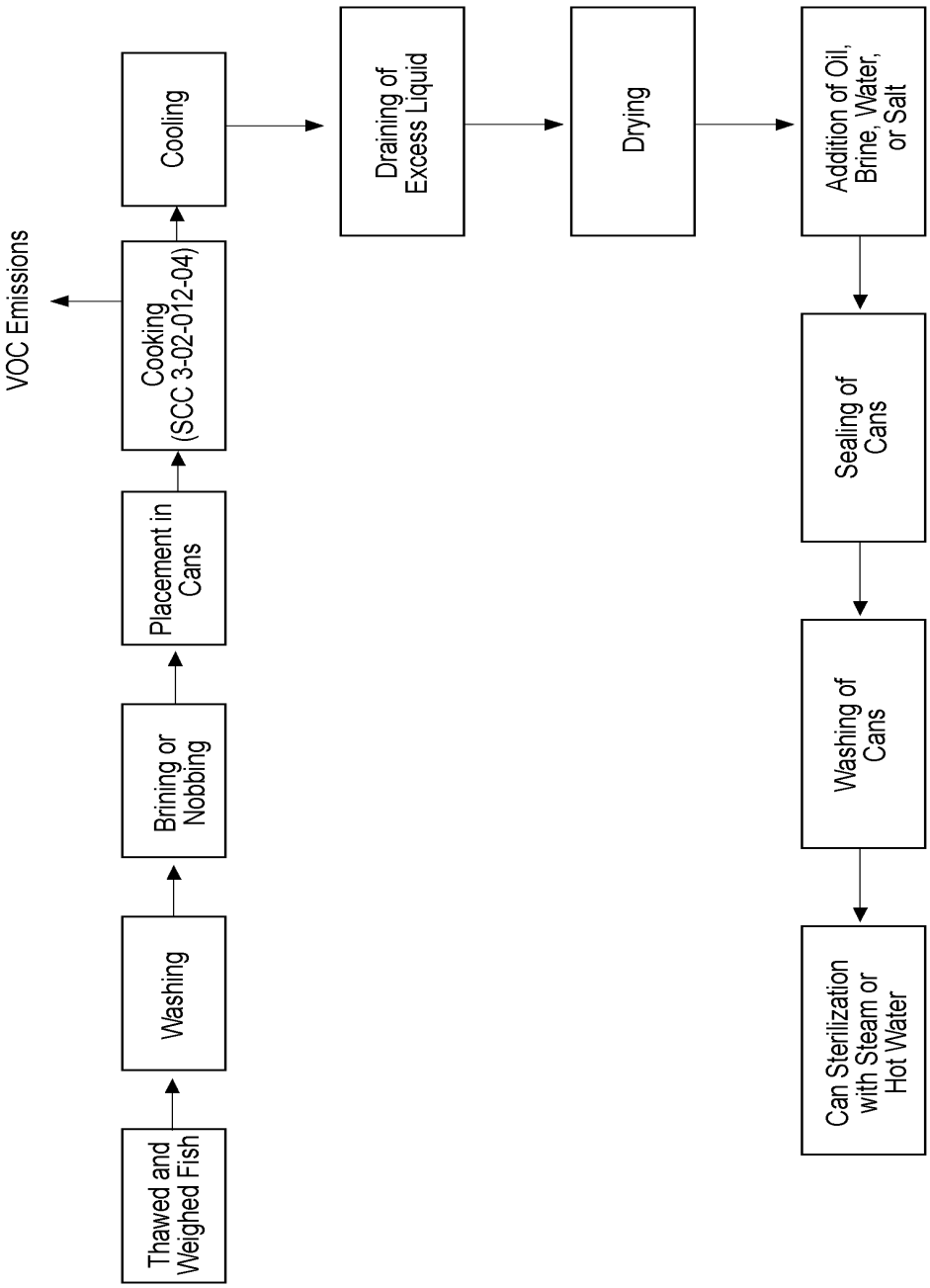
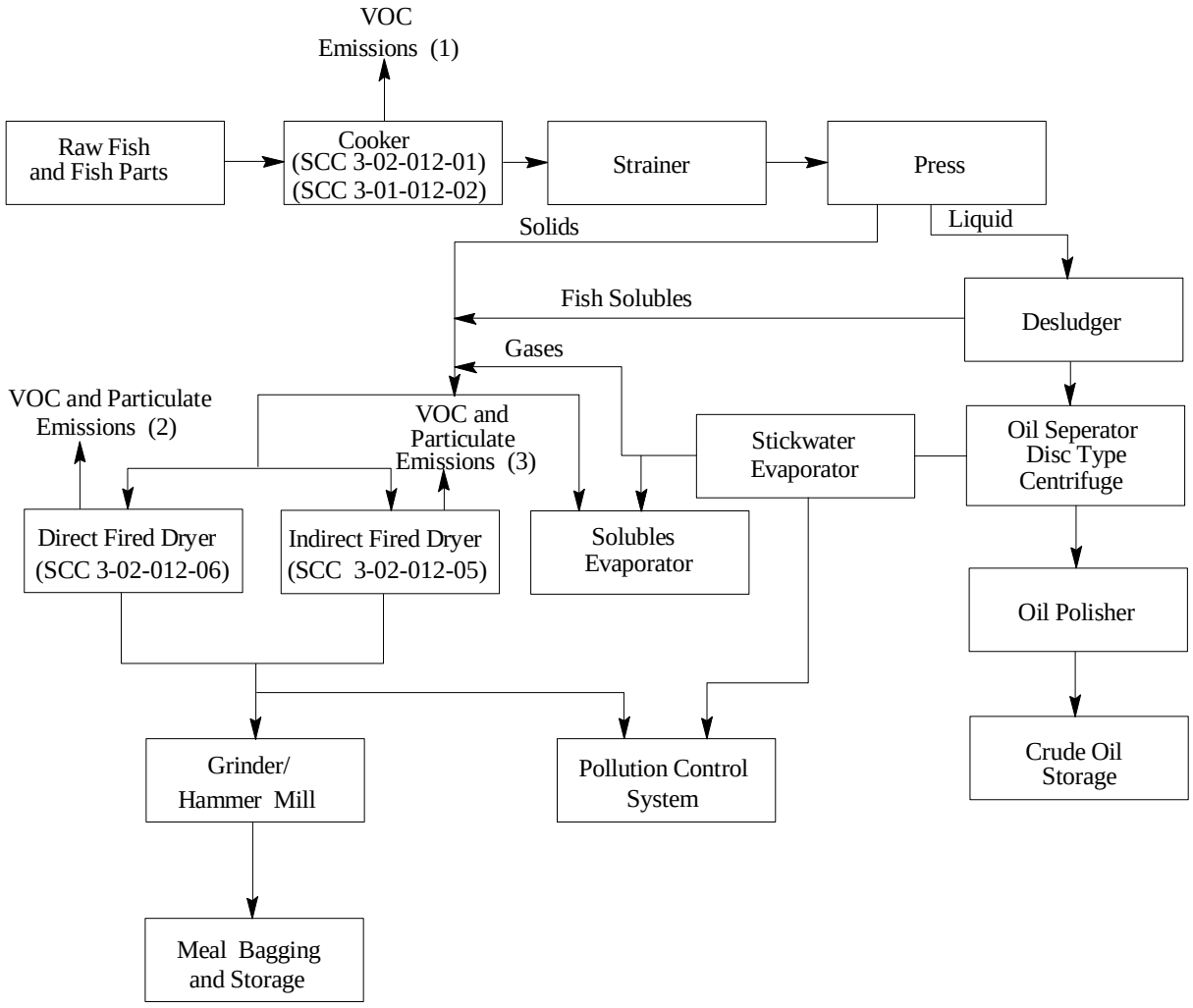


Figure 9.13.1-2. Flow diagram of raw packing method.
(Source Classification Codes in parentheses.)



(1) VOC emissions consist of H_2S and $(CH_3)_3N$, but no particulates.

(2) Large odor source, as well as smoke.

(3) Slightly less odor than direct fired dryers, and no smoke.

Figure 9.13.1-3. Flow diagram of fish meal and crude fish oil processing.
(Source Classification Codes in parentheses.)

The pressing liquor, which consists of water, oil, and some solids, is transported to a centrifuge or desludger where the solids are removed. These solids are later returned to the press cake in the drying step. The oil and water are separated using a disc-type centrifuge in the oil separator. The oil is "polished" by using hot water washes and centrifugation and is then sent to an oil-refining operation. The water removed from the oil (stickwater) goes to an evaporator to concentrate the solids.

The press cake, stickwater, and solids are mixed and sent to either a direct-fired or an indirect-fired dryer (steam tube dryer). A direct-fired dryer consists of a slowly rotating cylinder through which air, heated to about 600°C by an open flame, passes through the meal to evaporate the liquid. An indirect-fired dryer consists of a fixed cylinder with rotating scrapers that heat the meal with steam or hot fluids flowing through discs, tubes, coils, or the dryer casing itself. Air also passes through this apparatus, but it is not heated and flows in the opposite direction to the meal to entrain the evaporated water. Indirect-fired dryers require twice as much time to dry the meal as direct-fired dryers.

The dried meal is cooled, ground to a size that passes through a U. S. No. 7 standard screen, and transferred by pneumatic conveyor to storage. The ground meal is stored in bulk or in paper, burlap, or woven plastic bags. This meal is used in animal and pet feed because of its high protein content.

The "polished oil" is further purified by a process called "hardening" (Figure 9.13.1-4). First, the polished oil is refined by mixing the oil with an alkaline solution in a large stirred vat. The alkaline solution reacts with the free fatty acids in the oil to form insoluble soaps. The mixture is allowed to settle overnight, and the cleared oil is extracted off the top. The oil is then washed with hot water to remove any remaining soaps.

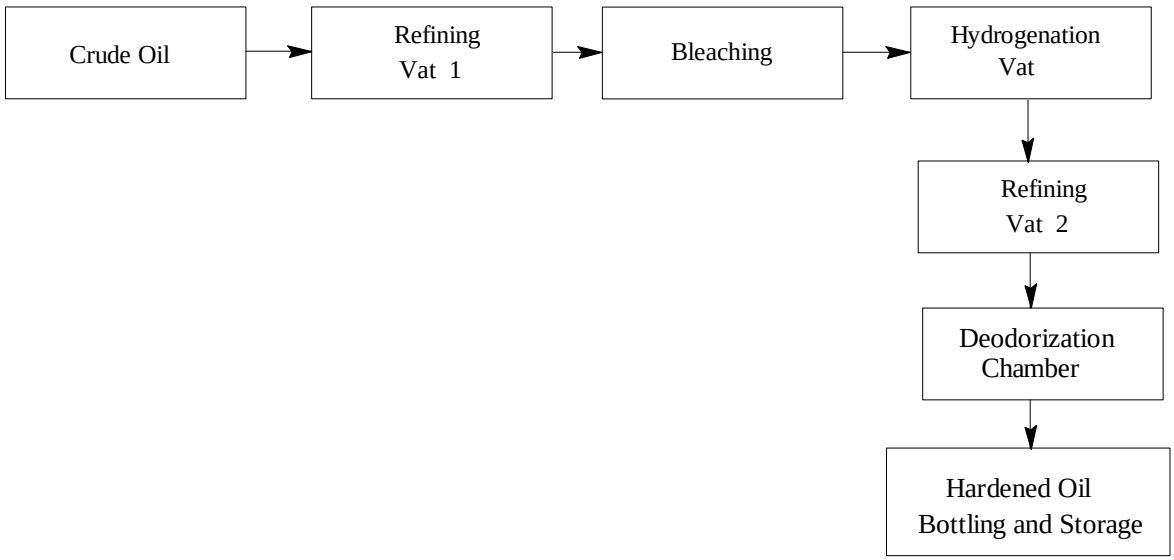


Figure 9.13.1-4. Oil hardening process.

Bleaching occurs in the next step by mixing the oil with natural clays to remove oil pigments and colored matter. This process proceeds at temperatures between 80 and 116°C, in either a batch or continuous mode. After bleaching, hydrogenation of the unsaturated fatty acid chains is the next step. A nickel catalyst, at a concentration of 0.05 to 0.1 percent by weight, is added to a vat of oil, the

mixture is heated and stirred, and hydrogen is injected into the mixture to react with the unsaturated fatty acid chains. After the hydrogenation is completed, the oil is cooled and filtered to remove the nickel.

The hydrogenated oil is refined again before the deodorization step, which removes odor and flavor-producing chemicals. Deodorization occurs in a vacuum chamber where dry, oxygen-free steam is bubbled through the oil to remove the undesirable chemicals. Volatilization of the undesirable chemicals occurs at temperatures between 170 to 230°C. The oil is then cooled to about 38°C before exposure to air to prevent formation of undesirable chemicals.

9.13.1.2 Emissions And Controls

Although smoke and particulate may be a problem, odors are the most objectionable emissions from fish processing plants. The fish byproducts segment results in more of these odorous contaminants than canning, because the fish are often in a further state of decomposition, which usually results in greater concentrations of odors.

The largest odor source in the fish byproducts segment is the fish meal driers. Usually, direct-fired driers emit more odors than steam-tube driers. Direct-fired driers also emit smoke and particulate.

Odorous gases from reduction cookers consist primarily of hydrogen sulfide (H_2S) and trimethylamine [$(CH_3)_3N$] but are emitted from this stage in appreciably smaller volumes than from fish meal driers. There are virtually no particulate emissions from reduction cookers.

Some odors are produced by the canning processes. Generally, the precooked method emits fewer odorous gases than the raw pack method. In the precooked process, the odorous exhaust gases are trapped in the cookers, whereas in the raw pack process, the steam and odorous gases typically are vented directly to the atmosphere.

Fish cannery and fish byproduct processing odors can be controlled with afterburners, chlorinator-scrubbers, or condensers. Afterburners are most effective, providing virtually 100 percent odor control, but they are costly from a fuel-use standpoint. Chlorinator scrubbers have been found to be 95 to 99 percent effective in controlling odors from cookers and driers. Condensers are the least effective control device.

Particulate emissions from the fish meal process are usually limited to the dryers, primarily the direct-fired dryers, and to the grinding and conveying of the dried fish meal. Because there is a relatively small quantity of fines in the ground fish meal, particulate emissions from the grinding, pneumatic conveyors and bagging operations are expected to be very low. Generally, cyclones have been found to be an effective means to collect particulate from the dryers, grinders and conveyors, and from the bagging of the ground fish meal.

Emission factors for fish processing are presented in Table 9.13.1-1. Factors are expressed in units of kilograms per megagram (kg/Mg) and pounds per ton (lb/ton).

Table 9.13.1-1 (Metric And English Units). UNCONTROLLED EMISSION FACTORS FOR FISH CANNING AND BYPRODUCT MANUFACTURE[a]

EMISSION FACTOR RATING: C

Process	Particulate		Trimethylamine [$(CH_3)_3N$]		Hydrogen Sulfide (H_2S)	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Cookers, canning (SCC 3-02-012-04)	Neg	Neg	—[c]	—[c]	—[c]	—[c]
Cookers, scrap						
Fresh fish (SCC 3-02-012-01)	Neg	Neg	0.15[c]	0.3[c]	0.005[c]	0.01[c]
Stale fish (SCC 3-02-012-02)	Neg	Neg	1.75[c]	3.5[c]	0.10[c]	0.2[c]
Steam tube dryer (SCC 3-02-012-05)	2.5	5	—[b]	—[b]	—[b]	—[b]
Direct-fired dryer (SCC 3-02-012-06)	4	8	—[b]	—[b]	—[b]	—[b]

[a] Reference 1. Factors are in terms of raw fish processed. SCC = Source Classification Code. Neg = negligible.
[b] Emissions suspected, but data are not available for quantification.
[c] Reference 2.

References For Section 9.13.1

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