9.13.3 Snack Chip Deep Fat Frying

9.13.3.1 General[1-3]

The production of potato chips, tortilla chips, and other related snack foods is a growing, competitive industry. Sales of such snack chips in the United States are projected to grow 5.7 percent between 1991 and 1995. Between 1987 and 1991, potato chip sales increased from 649×10^6 kilograms (kg) to 712×10^6 kg ($1,430 \times 10^6$ pounds [lb] to $1,570 \times 10^6$ lb), an increase of 63×10^6 kg (140×10^6 lb) (10 percent). Snack chip plants are widely dispersed across the country, with the highest concentrations in California and Texas.

New products and processes are being developed to create a more health-conscious image for snack chips. Examples include the recent introduction of multigrain chips and the use of vegetable oils (noncholesterol) in frying. Health concerns are also encouraging the promotion and introduction of nonfried snack products like pretzels, popcorn, and crackers.

9.13.3.2 Process Description[1]

Vegetables and other raw foods are cooked by industrial deep fat frying and are packaged for later use by consumers. The batch frying process consists of immersing the food in the cooking oil until it is cooked and then removing it from the oil. When the raw food is immersed in hot cooking oil, the oil replaces the naturally occurring moisture in the food as it cooks. Batch and continuous processes may be used for deep fat frying. In the continuous frying method, the food is moved through the cooking oil on a conveyor. Potato chips are one example of a food prepared by deep fat frying. Other examples include corn chips, tortilla corn chips, and multigrain chips.

Figure 9.13.3-1 provides general diagrams for the deep fat frying process for potato chips and other snack chips. The differences between the potato chip process and other snack chip processing operations are also shown. Some snack food processes (e. g., tortilla chips) include a toasting step. Because the potato chip processes represent the largest industry segment, they are discussed here as a representative example.

In the initial potato preparation, dirt, decayed potatoes, and other debris are first removed in cleaning hoppers. The potatoes go next to washers, then to abrasion, steam, or lye peelers. Abrasion is the most popular method. Preparation is either batch or continuous, depending on the number of potatoes to be peeled.

The next step is slicing, which is performed by a rotary slicer. Potato slice widths will vary with the condition of the potatoes and with the type of chips being made. The potato slices move through rotating reels where high-pressure water separates the slices and removes starch from the cut surfaces. The slices are then transferred to the rinse tank for final rinsing.

Next, the surface moisture is removed by 1 or more of the following methods: perforated revolving drum, sponge rubber-covered squeeze roller, compressed air systems, vibrating mesh belt, heated air, or centrifugal extraction.

The partially dried chips are then fried. Most producers use a continuous process, in which the slices are automatically moved through the fryer on a mesh belt. Batch frying, which is used for a

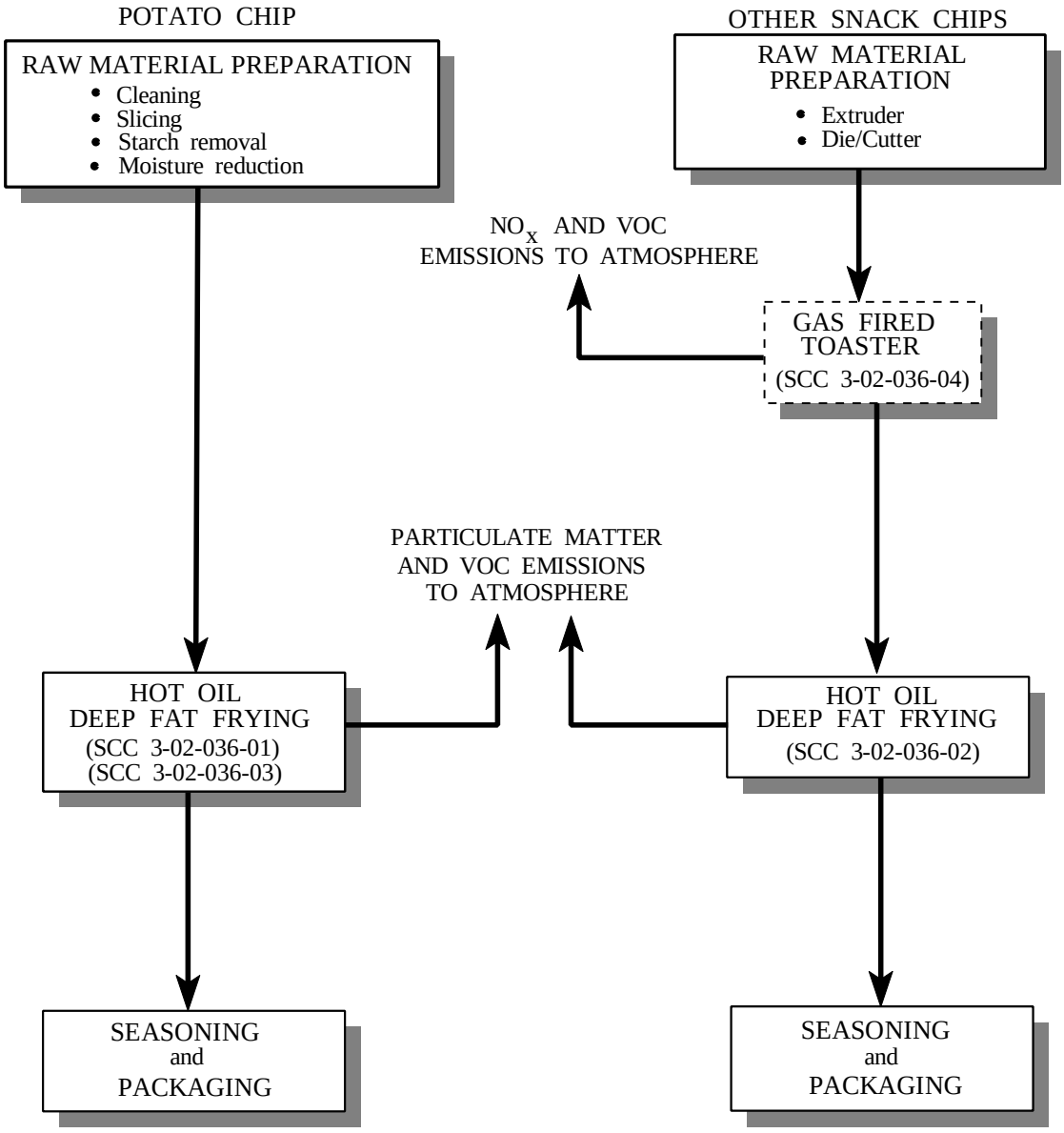

Figure 9.13.3-1. Generalized deep fat frying process for snack foods.
(Source Classification Codes in parentheses.)

smaller quantity of chips, involves placing the chips in a frying kettle for a period of time and then removing them. A variety of oils may be used for frying chips, with cottonseed, corn, and peanut oils being the most popular. Canola and soybean oils also are used. Animal fats are rarely used in this industry.

As indicated in Figure 9.13.3-1, the process for other snack chips is similar to that for potato chip frying. Typically, the raw material is extruded and cut before entering the fryer. In some cases, the chips may be toasted before frying.

9.13.3.2 Emissions And Controls[2-3]

Emissions -

Particulate matter is the major air pollutant emitted from the deep fat frying process. Emissions are released when moist foodstuff, such as potatoes, is introduced into hot oil. The rapid vaporization of the moisture in the foodstuff results in violent bubbling, and cooking oil droplets, and possibly vapors, become entrained in the water vapor stream. The emissions are exhausted from the cooking vat and into the ventilation system. Where emission controls are employed, condensed water and oil droplets in the exhaust stream are collected by control devices before the exhaust is routed to the atmosphere. The amount of particulate matter emitted depends on process throughput, oil temperature, moisture content of the feed material, equipment design, and stack emission controls.

Volatile organic compounds (VOC) are also produced in deep fat frying, but they are not a significant percentage of total frying emissions because of the low vapor pressure of the vegetable oils used. However, when the oil is entrained into the water vapor produced during frying, the oil may break down into volatile products. Small amounts of VOC and combustion products may also be emitted from toasters, but quantities are expected to be negligible.

Tables 9.13.3-1 and 9.13.3-2 provide uncontrolled and controlled particulate matter emission factors, in metric and English units, for snack chip frying. Table 9.13.3-3 provides VOC emission factors, in metric and English units, for snack chip frying without controls. Emission factors are calculated as the weight of particulate matter or VOC per ton of finished product, including salt and seasonings.

Controls -

Particulate matter emission control equipment is typically installed on potato chip fryer exhaust streams because of the elevated particulate loadings caused by the high volume of water contained in potatoes. Examples of control devices are mist eliminators, impingement devices, and wet scrubbers. One manufacturer has indicated that catalytic and thermal incinerators are not practical because of the high moisture content of the exhaust stream.

Table 9.13.3-1 (Metric Units). PARTICULATE MATTER EMISSION FACTORS FOR SNACK CHIP DEEP FAT FRYING[a]

EMISSION FACTOR RATING: E (except as noted)

Process	Filterable PM		Condensable PM			Total PM-10
	PM	PM-10	Inorganic	Organic	Total	
Continuous deep fat fryer--potato chips[b] (SCC 3-02-036-01)	0.83	ND	ND	ND	0.19	ND
Continuous deep fat fryer--other snack chips[b] (SCC 3-02-036-02)	0.28	ND	ND	ND	0.12	ND
Continuous deep fat fryer with standard mesh pad mist eliminator--potato chips[c] (SCC 3-02-036-01)	0.35[d]	0.30	0.0040[d]	0.19[d]	0.19	0.49
Continuous deep fat fryer with high-efficiency mesh pad mist eliminator--potato chips[e] (SCC 3-02-036-01)	0.12	ND	0.12	0.064	0.18	ND
Continuous deep fat fryer with standard mesh pad mist eliminator--other snack chips[f] (SCC 3-02-036-02)	0.11[d]	0.088	0.017	0.022	0.039	0.13
Batch deep fat fryer with hood scrubber--potato chips[g] (SCC 3-02-036-03)	0.89[d]	ND	0.66[d]	0.17	0.83	ND

[a] Factors are for uncontrolled emissions, except as noted. All emission factors in kg/Mg of chips produced. SCC = Source Classification Code. ND = no data.

[b] Reference 3.

[c] References 6, 10-11. The standard mesh pad mist eliminator, upon which these emission factors are based, includes a single, 6-inch, 2-layer mist pad that operates with a pressure drop of about 0.5-inch water column (when clean).

[d] EMISSION FACTOR RATING: D

[e] References 4-5. The high-efficiency mesh pad eliminator, upon which these emission factors are based, includes a coarse-weave 4-inch mist pad and a 6-inch fine weave pad, and operates with a 2.5- to 3-inch water column pressure drop (when clean).

[f] References 6-7.

[g] References 8-9.

Table 9.13.3-2 (English Units). PARTICULATE MATTER EMISSION FACTORS FOR SNACK CHIP DEEP FAT FRYING[a]

EMISSION FACTOR RATING: E (except as noted)

Process	Filterable PM		Condensable PM			Total PM-10
	PM	PM-10	Inorganic	Organic	Total	
Continuous deep fat fryer--potato chips[b] (SCC 3-02-036-01)	1.6	ND	ND	ND	0.39	ND
Continuous deep fat fryer--other snack chips[b] (SCC 3-02-036-02)	0.56	ND	ND	ND	0.24	ND
Continuous deep fat fryer with standard mesh pad mist eliminator--potato chips[c] (SCC 3-02-036-01)	0.70[d]	0.60	0.0080[d]	0.37[d]	0.38	0.98
Continuous deep fat fryer with high-efficiency mesh pad mist eliminator--potato chips[e] (SCC 3-02-036-01)	0.24	ND	0.23	0.13	0.36	ND
Continuous deep fat fryer with standard mesh pad mist eliminator--other snack chips[f] (SCC 3-02-036-02)	0.22[d]	0.18	0.034	0.044	0.078	0.26
Batch deep fat fryer with hood scrubber--potato chips[g] (SCC 3-02-036-03)	1.8[d]	ND	1.3[d]	0.33	1.6	ND

[a] Factors are for uncontrolled emissions, except as noted. All emission factors in lb/ton of chips produced. SCC = Source Classification Code. ND = no data.

[b] Reference 3.

[c] References 6, 10-11. The standard mesh pad mist eliminator, upon which these emission factors are based, includes a single, 6-inch, 2-layer mist pad that operates with a pressure drop of about 0.5 inch water column (when clean).

[d] EMISSION FACTOR RATING: D

[e] References 4-5. The high-efficiency mesh pad eliminator, upon which these emission factors are based, includes a coarse-weave 4-inch mist pad and a 6-inch fine weave pad and operates with a 2.5- to 3-inch water column pressure drop (when clean).

[f] References 6-7.

[g] References 8-9.

Table 9.13.3-3 (Metric Units). UNCONTROLLED VOC EMISSION FACTORS FOR SNACK CHIP DEEP FAT FRYING[a,b]

EMISSION FACTOR RATING: E

Process	VOC	
	kg/Mg	lb/ton
Deep fat fryer—potato chips (SCC 3-02-036-01)	0.0099	0.020
Deep fat fryer—other snack chips (SCC 3-02-036-02)	0.043	0.085

[a] Reference 3. SCC = Source Classification Code.
[b] Expressed as equivalent weight of methane (CH_4)/unit weight of product.

References For Section 9.13.3

1. O. Smith, *Potatoes: Production, Storing, Processing*, Avi Publishing, Westport, CT, 1977.

2. *Background Document For AP-42 Section 9.13.3, Snack Chip Deep Fat Frying*, Midwest Research Institute, Kansas City, MO, August 1994.

3. *Characterization Of Industrial Deep Fat Fryer Air Emissions*, Frito-Lay Inc., Plano, TX, 1991.

4. *Emission Performance Testing For Two Fryer Lines*, Western Environmental Services, Redondo Beach, CA, November 19, 20, and 21, 1991.

5. *Emission Performance Testing On One Continuous Fryer*, Western Environmental Services, Redondo Beach, CA, January 26, 1993.

6. *Emission Performance Testing Of Two Fryer Lines*, Western Environmental Services, Redondo Beach, CA, November 1990.

7. *Emission Performance Testing Of One Tortilla Continuous Frying Line*, Western Environmental Services, Redondo Beach, CA, October 20-21, 1992.

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9. *Emission Performance Testing Of Fryer No. 8*, Western Environmental Services, Redondo Beach, CA, February 3-4, 1992.

10. *Emission Performance Testing Of Two Fryer Lines*, Western Environmental Services, Redondo Beach, CA, November 1989.

11. *Emission Performance Testing Of Two Fryer Lines*, Western Environmental Services, Redondo Beach, CA, June 1989.