9.10.2.1 Almond Processing

9.10.2.1.1 General[1-2]

Almonds are edible tree nuts, grown principally in California. The nuts are harvested from orchards and transported to almond processing facilities, where the almonds are hulled and shelled. The function of an almond huller/sheller is to remove the hull and shell of the almond from the nut, or meat. Orchard debris, soil, and pebbles represent 10 to 25 percent of the field weight of material brought to the almond processing facility. Clean almond meats are obtained as about 20 percent of the field weight. Processes for removing the debris and almond hulls and shells are potential sources of air emissions.

9.10.2.1.2 Process Description[1-7]

After almonds are collected from the field, they undergo two processing phases, post-harvest processing and finish processing. These phases are typically conducted at two different facilities. There are two basic types of almond post-harvest processing facilities: those that produce hulled, in-shell almonds as a final product (known as hullers), and those that produce hulled, shelled, almond meats as a final product (known as huller/shellers). Almond precleaning, hulling, and separating operations are common to both types of facilities. The huller/sheller includes additional steps to remove the almond meats from their shells. A typical almond hulling operation is shown in Figure 9.10.2.1-1. A typical almond huller/sheller is depicted in Figure 9.10.2.1-2. The hulled, shelled almond meats are shipped to large production facilities where the almonds may undergo further processing into various end products. Almond harvesting, along with precleaning, hulling, shelling, separating, and final processing operations, is discussed in more detail below.

Almond harvesting and processing are a seasonal industry, typically beginning in August and running from two to four months. However, the beginning and duration of the season vary with the weather and with the size of the crop. The almonds are harvested either manually, by knocking the nuts from the tree limbs with a long pole, or mechanically, by shaking them from the tree. Typically the almonds remain on the ground for 7 to 10 days to dry. The fallen almonds are then swept into rows. Mechanical pickers gather the rows for transport to the almond huller or huller/sheller. Some portion of the material in the gathered rows includes orchard debris, such as leaves, grass, twigs, pebbles, and soil. The fraction of debris is a function of farming practices (tilled versus untilled), field soil characteristics, and age of the orchard, and it can range from less than 5 to 60 percent of the material collected. On average, field weight yields 13 percent debris, 50 percent hulls, 14 percent shells, and 23 percent clean almond meats and pieces, but these ratios can vary substantially from farm to farm.

The almonds are delivered to the processing facility and are dumped into a receiving pit. The almonds are transported by screw conveyors and bucket elevators to a series of vibrating screens. The screens selectively remove orchard debris, including leaves, soil, and pebbles. A destoner removes stones, dirt clods, and other larger debris. A detwigger removes twigs and small sticks. The air streams from the various screens, destoners, and detwiggers are ducted to cyclones or fabric filters for particulate matter removal. The recovered soil and fine debris, such as leaves and grass, are disposed of by spreading on surrounding farmland. The recovered twigs may be chipped and used as fuel for co-generation plants. The precleaned almonds are transferred from the precleaner area by another series of conveyors and elevators to storage bins to await further processing. (In

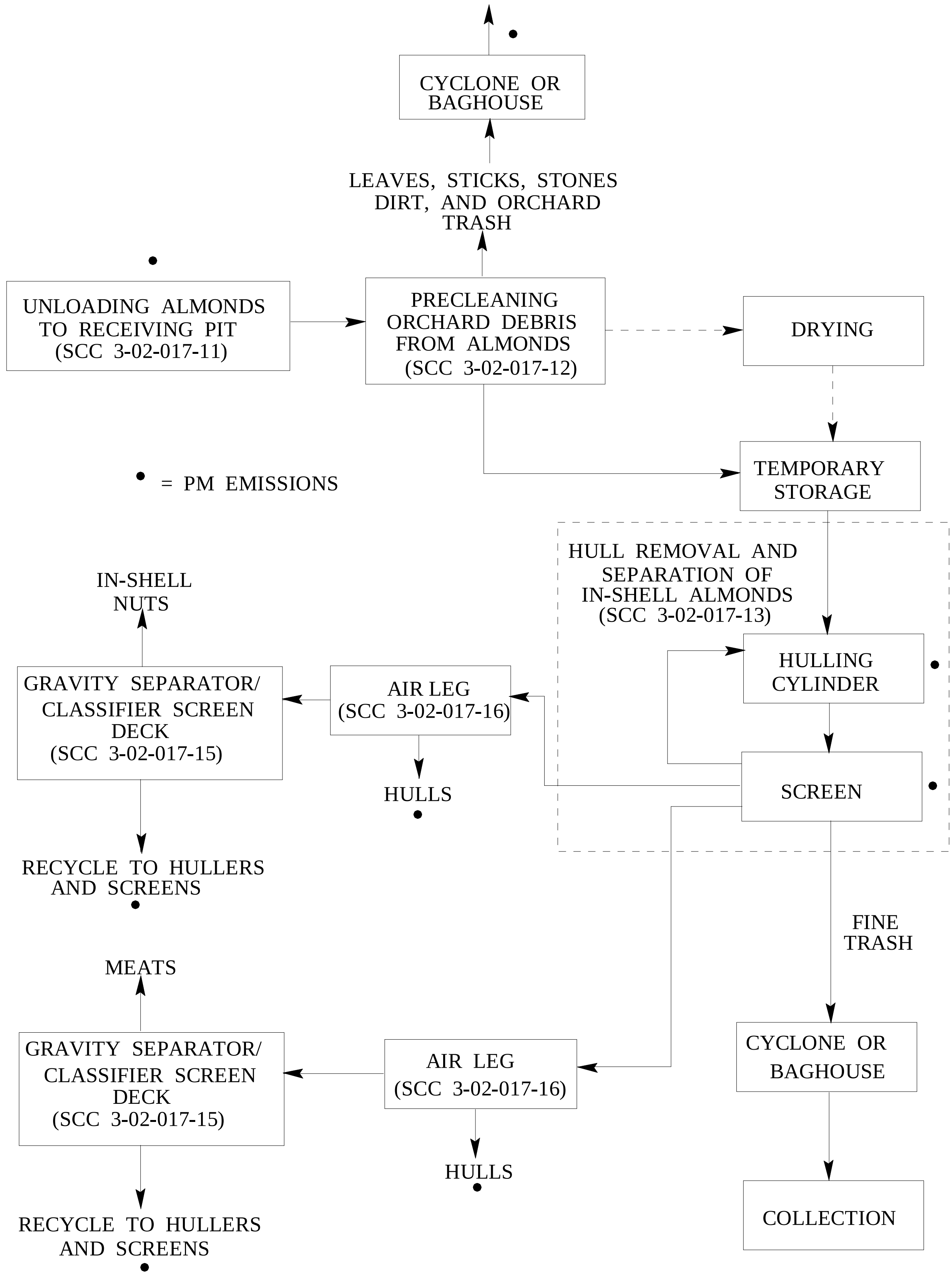

Figure 9.10.2.1-1. Representative almond hulling process flow diagram.
(Source Classification Codes in parentheses.)

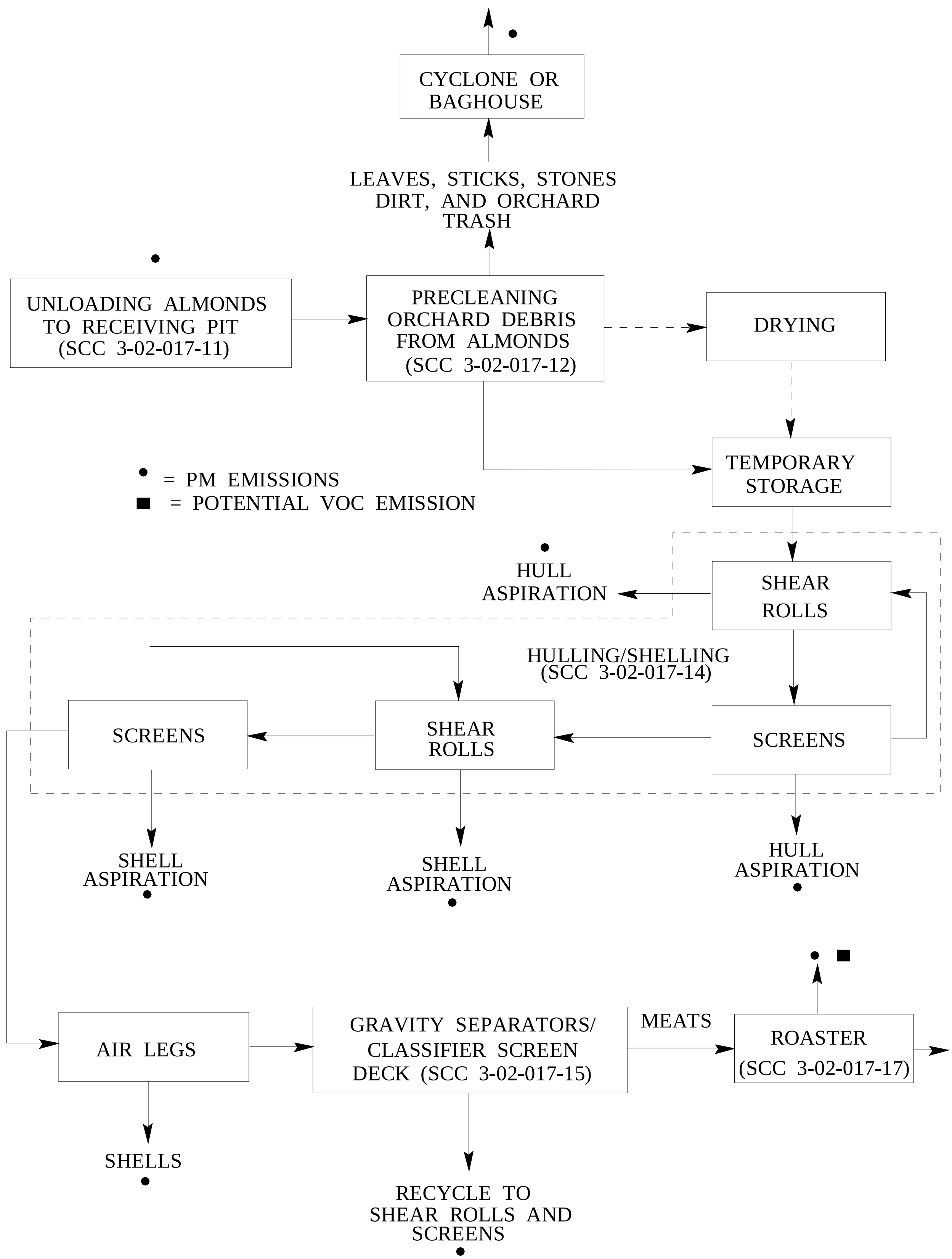

Figure 9.10.2.1-2. Representative almond huller/sheller process flow diagram.
(Source Classification Codes in parentheses.)

some instances, the precleaned almonds may be conveyed to a dryer before storage. However, field drying is used in most operations.)

Almonds are conveyed on belt and bucket conveyors to a series of hulling cylinders or shear rolls, which crack the almond hulls. Hulling cylinders are typically used in almond huller facilities. Series of shear rolls are generally used in huller/shellers. The hulling cylinders have no integral provision for aspiration of shell pieces. Shear rolls, on the other hand, do have integral aspiration to remove shell fragments from loose hulls and almond meats. The cracked almonds are then discharged to a series of vibrating screens or a gravity table, which separates hulls and unhulled almonds from the in-shell almonds, almond meats, and fine trash. The remaining unhulled almonds pass through additional hulling cylinders or shear rolls and screen separators. The number of passes and the combinations of equipment vary among facilities. The hulls are conveyed to storage and sold as an ingredient in the manufacture of cattle feed. The fine trash is ducted to a cyclone or fabric filter for collection and disposal.

In a hulling facility, the hulled, in-shell almonds are separated from any remaining hull pieces in a series of air legs (counter-flow forced air gravity separators) and are then graded, collected, and sold as finished product, along with an inevitable small percentage of almond meats. In huller/shellers, the in-shell almonds continue through more shear rolls and screen separators.

As the in-shell almonds make additional passes through sets of shear rolls, the almond shells are cracked or sheared away from the meat. More sets of vibrating screens separate the shells from the meats and small shell pieces. The separated shells are aspirated and collected in a fabric filter or cyclone, and then conveyed to storage for sale as fuel for co-generation plants. The almond meats and small shell pieces are conveyed on vibrating conveyor belts and bucket elevators to air classifiers or air legs that separate the small shell pieces from the meats. The number of these air separators varies among facilities. The shell pieces removed by these air classifiers are also collected and stored for sale as fuel for co-generation plants. The revenues generated from the sale of hulls and shells are generally sufficient to offset the costs of operating the almond processing facility.

The almond meats are then conveyed to a series of gravity tables or separators (classifier screen decks), which sort the meats by lights, middlings, goods, and heavies. Lights, middlings, and heavies, which still contain hulls and shells, are returned to various points in the process. Goods are conveyed to the finished meats box for storage. Any remaining shell pieces are aspirated and sent to shell storage.

The almond meats are now ready either for sales as raw product or for further processing, typically at a separate facility. The meats may be blanched, sliced, diced, roasted, salted, or smoked. Small meat pieces may be ground into meal or pastes for bakery products. Almonds are roasted by gradual heating in a rotating drum. They are heated slowly to prevent the skins and outer layers from burning. Roasting time develops the flavor and affects the color of the meats. To obtain almonds with a light brown color and a medium roast requires a 500-pound roaster fueled with natural gas about 1.25 hours at 118°C (245°F).

9.10.2.1.3 Emissions And Controls[1-3,5-9]

Particulate matter (PM) is the primary air pollutant emitted from almond post-harvest processing operations. All operations in an almond processing facility involve dust generation from the movement of trash, hulls, shells, and meats. The quantity of PM emissions varies depending on the type of facility, harvest method, trash content, climate, production rate, and the type and number of controls used by the facility. Fugitive PM emissions are attributable primarily to unloading operations, but some fugitive emissions are generated from precleaning operations and subsequent screening operations.

Because farm products collected during harvest typically contain some residual dirt, which includes trace amounts of metals, it stands to reason that some amount of these metals will be emitted from the various operations along with the dust. California Air Resources Board (CARB) data indicate that metals emitted from almond processing include arsenic, beryllium, cadmium, copper, lead, manganese, mercury, and nickel in quantities on the order of 5×10^{-11} to 5×10^{-4} kilograms (kg) of metal per kg of PM emissions (5×10^{-11} to 5×10^{-4} pounds [lb] of metal per lb of PM emissions). It has been suggested that sources of these metals other than the inherent trace metal content of soil may include fertilizers, other agricultural sprays, and groundwater.

In the final processing operations, almond roasting is a potential source of volatile organic compound (VOC) emissions. However, no chemical characterization data are available to hypothesize what compounds might be emitted, and no emission source test data are available to quantify these potential emissions.

Emission control systems at almond post-harvest processing facilities include both ventilation systems to capture the dust generated during handling and processing of almonds, shells, and hulls, and an air pollution control device to collect the captured PM. Cyclones formerly served as the principal air pollution control devices for PM emissions from almond post harvest processing operations. However, fabric filters, or a combination of fabric filters and cyclones, are becoming common. Practices of combining and controlling specific exhaust streams from various operations vary considerably among facilities. The exhaust stream from a single operation may be split and ducted to two or more control devices. Conversely, exhaust streams from several operations may be combined and ducted to a single control device. According to one source within the almond processing industry, out of approximately 350 almond hullers and huller/shellers, no two are alike.

Emission factors for almond processing sources are presented in Table 9.10.2.1-1.

Table 9.10.2.1-1 (Metric And English Units). EMISSION FACTORS FOR ALMOND PROCESSING[a]

EMISSION FACTOR RATING: E

Source	Filterable PM		Condensable Inorganic PM		PM-10[b]	
	kg/Mg	lb/ton	kg/Mg	lb/ton	kg/Mg	lb/ton
Unloading[c] (SCC 3-02-017-11)	0.030	0.060	ND	ND	ND	ND
Precleaning cyclone[d] (SCC 3-02-017-12)	0.48	0.95	ND	ND	0.41	0.82
Precleaning baghouse[e] (SCC 3-02-017-12)	0.0084	0.017	ND	ND	0.0075	0.015
Hulling/separating cyclone[d] (SCC 3-02-017-13)	0.57	1.1	ND	ND	0.41	0.81
Hulling/separating baghouse[e] (SCC 3-02-017-13)	0.0078	0.016	ND	ND	0.0065	0.013
Hulling/shelling baghouse[f] (SCC 3-02-017-14)	0.026	0.051	0.0068	0.014	ND	ND
Classifier screen deck cyclone[d] (SCC 3-02-017-15)	0.20	0.40	ND	ND	0.16	0.31
Air leg[d] (SCC 3-02-017-16)	0.26	0.51	ND	ND	ND	ND
Roaster[g] (SCC 3-02-017-17)	ND	ND	ND	ND	ND	ND

[a] Process weights used to calculate emission factors include nuts and orchard debris as taken from the field, unless noted. ND = no data. SCC = Source Classification Code.
[b] PM-10 factors are based on particle size fractions found in Reference 1 applied to the filterable PM emission factor for that source. See Reference 3 for a detailed discussion of how these emission factors were developed.
[c] References 1-3,10-11.
[d] Reference 1. Emission factor is for a single air leg/classifier screen deck cyclone. Facilities may contain multiple cyclones.
[e] References 1,9.
[f] Reference 10.
[g] Factors are based on finished product throughputs.

References For Section 9.10.2.1

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5. Written communication from Darin Lundquist, Central California Almond Growers Association, Sanger, CA, to Dallas Safriet, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 9, 1993.

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