

6.8 Soap And Detergents

6.8.1 General

6.8.1.1 Soap Manufacturing^{1,3,6} -

The term "soap" refers to a particular type of detergent in which the water-solubilized group is carboxylate and the positive ion is usually sodium or potassium. The largest soap market is bar soap used for personal bathing. Synthetic detergents replaced soap powders for home laundering in the late 1940s, because the carboxylate ions of the soap react with the calcium and magnesium ions in the natural hard water to form insoluble materials called lime soap. Some commercial laundries that have soft water continue to use soap powders. Metallic soaps are alkali-earth or heavy-metal long-chain carboxylates that are insoluble in water but soluble in nonaqueous solvents. They are used as additives in lubricating oils, greases, rust inhibitors, and jellied fuels.

6.8.1.2 Detergent Manufacturing^{1,3,6,8} -

The term "synthetic detergent products" applies broadly to cleaning and laundering compounds containing surface-active (surfactant) compounds along with other ingredients. Heavy-duty powders and liquids for home and commercial laundry detergent comprise 60 to 65 percent of the U. S. soap and detergent market and were estimated at 2.6 megagrams (Mg) (2.86 million tons) in 1990.

Until the early 1970s, almost all laundry detergents sold in the U. S. were heavy-duty powders. Liquid detergents were introduced that utilized sodium citrate and sodium silicate. The liquids offered superior performance and solubility at a slightly increased cost. Heavy-duty liquids now account for 40 percent of the laundry detergents sold in the U. S., up from 15 percent in 1978. As a result, 50 percent of the spray drying facilities for laundry granule production have closed since 1970. Some current trends, including the introduction of superconcentrated powder detergents, will probably lead to an increase in spray drying operations at some facilities. Manufacturers are also developing more biodegradable surfactants from natural oils.

6.8.2 Process Descriptions

6.8.2.1 Soap^{1,3,6} -

From American colonial days to the early 1940s, soap was manufactured by an alkaline hydrolysis reaction called saponification. Soap was made in huge kettles into which fats, oils, and caustic soda were piped and heated to a brisk boil. After cooling for several days, salt was added, causing the mixture to separate into two layers with the "neat" soap on top and spent lye and water on the bottom. The soap was pumped to a closed mixing tank called a crutcher where builders, perfumes, and other ingredients were added. Builders are alkaline compounds that improve the cleaning performance of the soap. Finally, the soap was rolled into flakes, cast or milled into bars, or spray-dried into soap powder.

An important modern process (post 1940s) for making soap is the direct hydrolysis of fats by water at high temperatures. This permits fractionation of the fatty acids, which are neutralized to soap in a continuous process as shown in Figure 6.8-1. Advantages for this process include close control of the soap concentration, the preparation of soaps of certain chain lengths for specific purposes, and easy recovery of glycerin, a byproduct. After the soap is recovered, it is pumped to the crutcher and treated the same as the product from the kettle process.

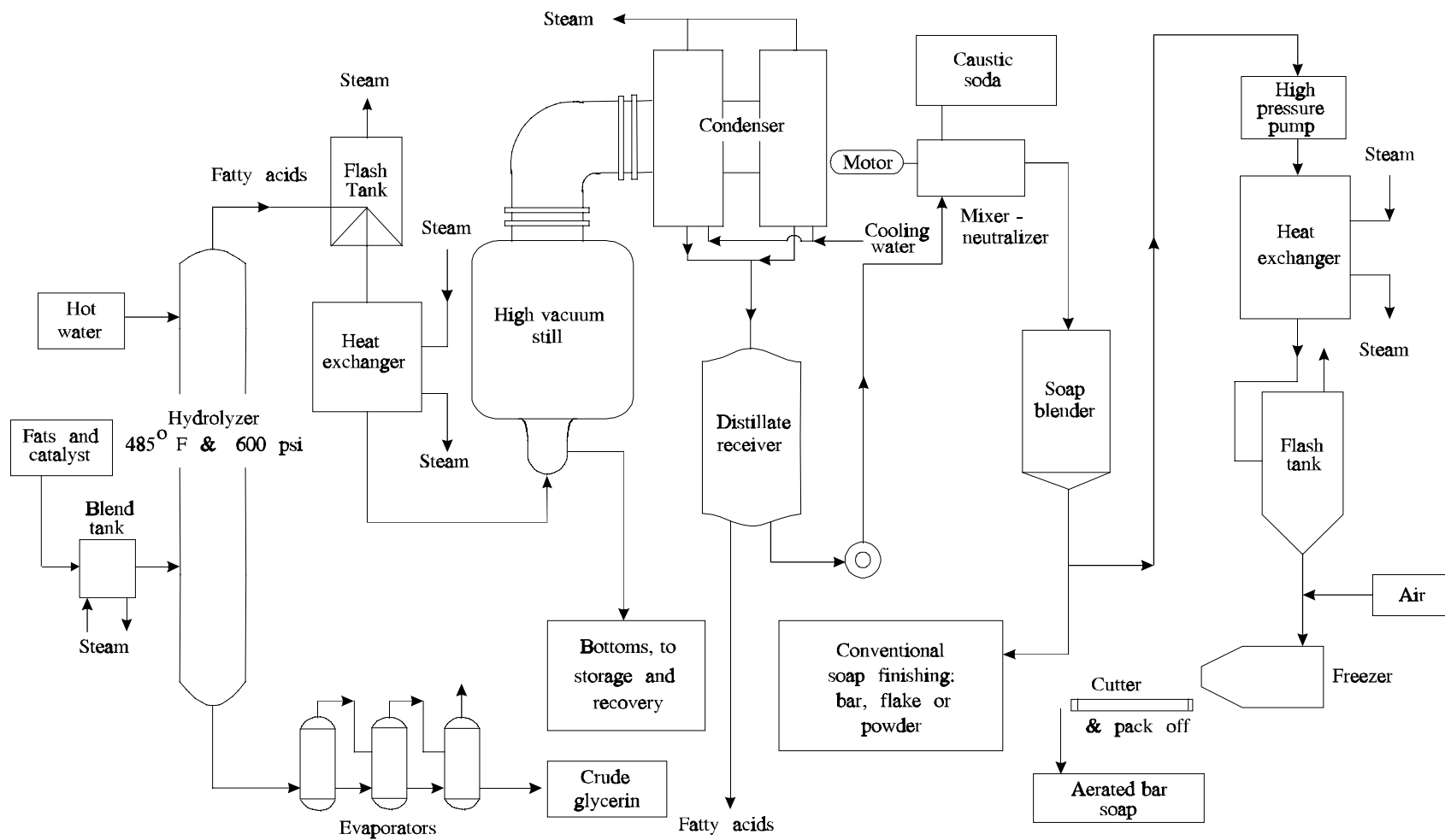


Figure 6.8-1. Continuous process for fatty acids and soaps.

6.8.2.2 Detergent^{1,3,6,8} -

The manufacture of spray-dried detergent has 3 main processing steps: (1) slurry preparation, (2) spray drying, and (3) granule handling. The 3 major components of detergent are surfactants (to remove dirt and other unwanted materials), builders (to treat the water to improve surfactant performance), and additives to improve cleaning performance. Additives may include bleaches, bleach activators, antistatic agents, fabric softeners, optical brighteners, antiredeposition agents, and fillers.

The formulation of slurry for detergent granules requires the intimate mixing of various liquid, powdered, and granulated materials. Detergent slurry is produced by blending liquid surfactant with powdered and liquid materials (builders and other additives) in a closed mixing tank called a soap crutcher. Premixing of various minor ingredients is performed in a variety of equipment prior to charging to the crutcher or final mixer. Figure 6.8-2 illustrates the various operations. Liquid surfactant used in making the detergent slurry is produced by the sulfonation of either a linear alkylate or a fatty acid, which is then neutralized with a caustic solution containing sodium hydroxide (NaOH). The blended slurry is held in a surge vessel for continuous pumping to a spray dryer. The slurry is atomized by spraying through nozzles rather than by centrifugal action. The slurry is sprayed at pressures of 4.100 to 6.900 kilopascals (kPa) (600 to 1000 pounds per square inch [psi]) in single-fluid nozzles and at pressures of 340 to 690 kPa (50 to 100 psi) in 2-fluid nozzles. Steam or air is used as the atomizing fluid in the 2-fluid nozzles. The slurry is sprayed at high pressure into a vertical drying tower having a stream of hot air of from 315 to 400°C (600 to 750°F). All spray drying equipment designed for detergent granule production incorporates the following components: spray drying tower, air heating and supply system, slurry atomizing and pumping equipment, product cooling equipment, and conveying equipment. Most towers designed for detergent production are countercurrent, with slurry introduced at the top and heated air introduced at the bottom. The towers are cylindrical with cone bottoms and range in size from 4 to 7 meters (m) (12 to 24 feet [ft]) in diameter and 12 to 38 m (40 to 125 ft) in height. The detergent granules are conveyed mechanically or by air from the tower to a mixer to incorporate additional dry or liquid ingredients, and finally to packaging and storage.

6.8.3 Emissions And Controls

6.8.3.1 Soap^{1,3,6} -

The main atmospheric pollution problem in soap manufacturing is odor. The storage and handling of liquid ingredients (including sulfonic acids and salts) and sulfates are some of the sources of this odor. Vent lines, vacuum exhausts, raw material and product storage, and waste streams are all potential odor sources. Control of these odors may be achieved by scrubbing exhaust fumes and, if necessary, incinerating the remaining volatile organic compounds (VOC). Odors emanating from the spray dryer may be controlled by scrubbing with an acid solution. Blending, mixing, drying, packaging, and other physical operations may all involve dust emissions. The production of soap powder by spray drying is the single largest source of dust in the manufacture of synthetic detergents. Dust emissions from other finishing operations can be controlled by dry filters such as baghouses. The large sizes of the particulate from synthetic detergent drying means that high-efficiency cyclones installed in series can achieve satisfactory control. Currently, no emission factors are available for soap manufacturing. No information on hazardous air pollutants (HAP), VOCs, ozone depleters, or heavy metal emissions information were found for soap manufacturing.

6.8.3.2 Detergent^{1,3-4,6,8} -

The exhaust air from detergent spray drying towers contains 2 types of air contaminants: (1) fine detergent particles and (2) organics vaporized in the higher temperature zones of the tower. Emission factors for particulates from spray drying operations are shown in Table 6.8-1. Factors are expressed in units of kilograms per megagram (kg/Mg) and pounds per ton (lb/ton) of product.

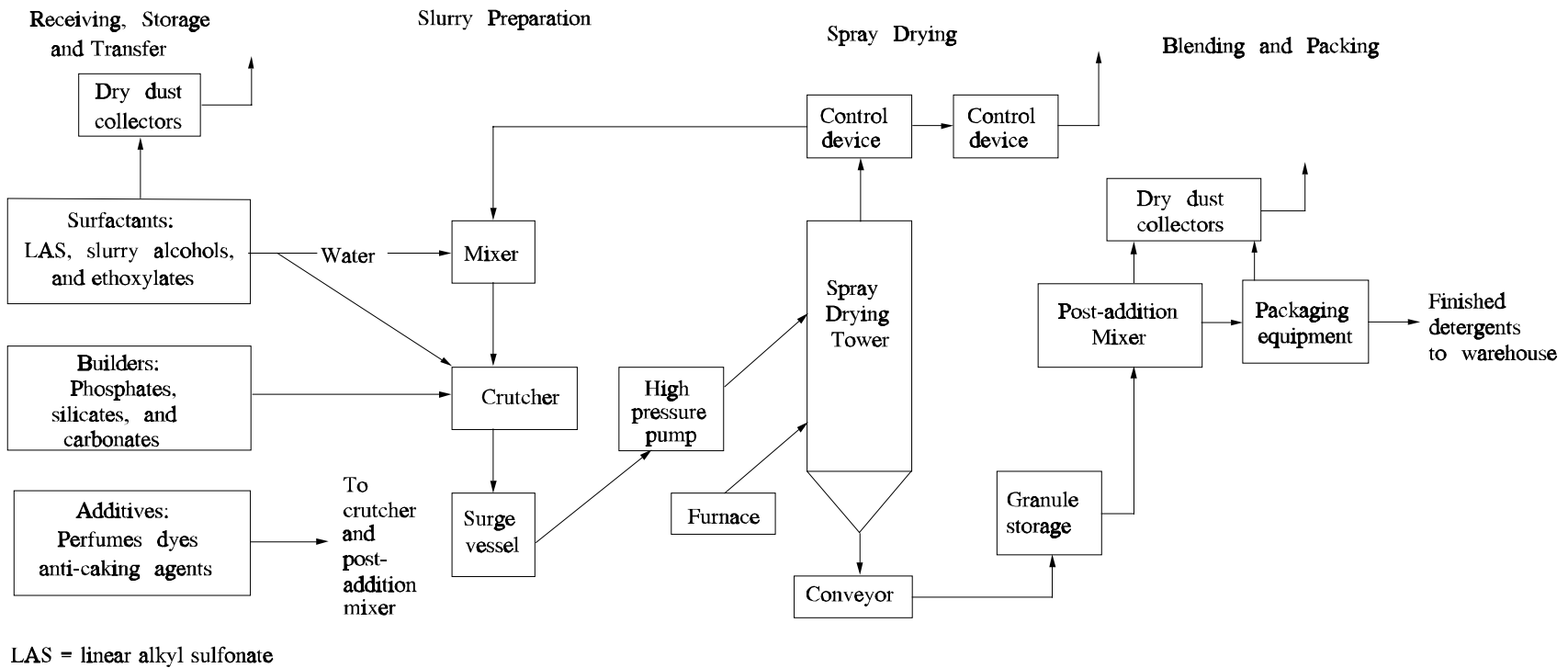


Figure 6.8-2. Manufacture of spray-dried detergents.

Table 6.8-1 (Metric And English Units). PARTICULATE EMISSION FACTORS FOR DETERGENT SPRAY DRYING^a

EMISSION FACTOR RATING: E^b

Control Device	Efficiency (%)	Particulate	
		kg/Mg of Product	lb/ton of Product
Uncontrolled (SCC 3-01-009-01)	NA	45	90
Cyclone	85	7	14
Cyclone with:			
Spray chamber	92	3.5	7
Packed scrubber	95	2.5	5
Venturi scrubber	97	1.5	3
Wet scrubber	99	0.544	1.09
Wet scrubber/ESP	99.9	0.023	0.046
Packed bed/ESP	99 ^c	0.47	0.94
Fabric filter	99	0.54	1.1

^a Some type of primary collector, such as a cyclone, is considered integral to a spray drying system. NA = not applicable. ESP = electrostatic precipitator. SCC = Source Classification Code.

^b Emission factors are estimations and are not supported by current test data.

^c Emission factor has been calculated from a single source test. An efficiency of 99% has been estimated.

Dust emissions are generated at scale hoppers, mixers, and crutchers during the batching and mixing of fine dry ingredients to form slurry. Conveying, mixing, and packaging of detergent granules can also cause dust emissions. Pneumatic conveying of fine materials causes dust emissions when conveying air is separated from bulk solids. For this process, fabric filters are generally used, not only to reduce or to eliminate dust emissions, but also to recover raw materials. The dust emissions principally consist of detergent compounds, although some of the particles are uncombined phosphates, sulfates, and other mineral compounds.

Dry cyclones and cyclonic impingement scrubbers are the primary collection equipment employed to capture the detergent dust in the spray dryer exhaust for return to processing. Dry cyclones are used in parallel or in series to collect this particulate matter (PM) and recycle it back to the crutcher. The dry cyclone separators can remove 90 percent or more by weight of the detergent product fines from the exhaust air. Cyclonic impinged scrubbers are used in parallel to collect the particulate from a scrubbing slurry and to recycle it to the crutcher.

Secondary collection equipment is used to collect fine particulates that escape from primary devices. For example, cyclonic impingement scrubbers are often followed by mist eliminators, and dry cyclones are followed by fabric filters or scrubber/electrostatic precipitator units. Several types of scrubbers can be used following the cyclone collectors. Venturi scrubbers have been used but are being replaced with packed bed scrubbers. Packed bed scrubbers are usually followed by wet-pipe-type

electrostatic precipitators built immediately above the packed bed in the same vessel. Fabric filters have been used after cyclones but have limited applicability, especially on efficient spray dryers, due to condensing water vapor and organic aerosols binding the fabric filter.

In addition to particulate emissions, volatile organics may be emitted when the slurry contains organic materials with low vapor pressures. The VOCs originate primarily from the surfactants included in the slurry. The amount vaporized depends on many variables such as tower temperature and the volatility of organics used in the slurry. These vaporized organic materials condense in the tower exhaust airstream into droplets or particles. Paraffin alcohols and amides in the exhaust stream can result in a highly visible plume that persists after the condensed water vapor plume has dissipated.

Opacity and the organic emissions are influenced by granule temperature and moisture at the end of drying, temperature profiles in the dryer, and formulation of the slurry. A method for controlling visible emissions would be to remove offending organic compounds (i. e., by substitution) from the slurry. Otherwise, tower production rate may be reduced thereby reducing air inlet temperatures and exhaust temperatures. Lowering production rate will also reduce organic emissions.

Some of the HAPs and VOCs identified from the VOC/PM Speciate Database Management System (SPECIATE) are: hexane, methyl alcohol, 1,1,1-trichloroethane, perchloroethylene, benzene, and toluene. Lead was identified from SPECIATE data as the only heavy metal constituent. No numerical data are presented for lead, HAP, or VOC emissions due to the lack of sufficient supporting documentation.

References For Section 6.8

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