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Source Category Survey: Detergent Industry

Emission Standards and Engineering Division

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PREFACE

This revised Source Category Survey Report was prepared by Midwest Research Institute (MRI) under EPA Contract No. 68-02-3059, Task 7. The report was prepared by Ms. Linda E. Greer for Mr. James Eddinger, EPA Lead Engineer.

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May 29, 1980

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1.0 SUMMARY

This Source Category Survey Report presents information gathered on processes, pollutants, and control equipment associated with the manufacture of detergent by spray drying. The source category is a subpart of Standard Industrial Classification (SIC) Code 2841. The production of liquid detergents, soap, scouring powders, and glycerin and the dry mixing of powdered detergent were not considered in this report because there was no evidence of significant emissions from these processes.

There are 33 plants in 17 states which currently spray-dry detergent. Numerous additional small plants produce a small amount (less than 5 percent of the total U.S. detergent production) of powdered detergent by dry mixing of raw materials.

In 1977, there were 1.5×10^6 Mg (1.7×10^6 tons) of powdered detergent produced by spray drying or dry mixing. Average production of spray-dried detergent was 45,000 Mg/yr (50,000 tons/yr) per plant. Production of powdered detergent has increased slowly in the past 10 to 15 years and is projected to grow about 1 to 2 percent per year through 1982. Growth of the market will be affected by population growth, laundry habits, and competition from the liquid detergent market.

The major steps in manufacturing spray-dried detergent are: mixing raw materials to form a detergent slurry, drying the slurry by contacting it with hot air in a spray-drying tower, cooling product granules, adding heat-sensitive materials, and packaging.

The main pollutant from the production of powdered detergent is particulate in the form of detergent dust from the exhaust of the spray-drying tower. An average of 13 emission tests show that typical controlled emissions from the spray dryer are 5 kg/h (11 lb/h). Nationwide controlled emissions were calculated to be 164 kg/h (363 lb/h) or

988 Mg/yr (1,089 tons/yr). Emissions from raw material and final product transport and handling are estimated to be minor.

Presently, two basic systems are used by the industry to control emissions from the spray dryer. One system consists of one or more cyclonic impingement scrubbers which use a high-solids concentration detergent slurry. The other system uses dry cyclones followed by a water scrubber and electrostatic precipitator. Both systems allow for product recovery and are estimated by the industry and equipment vendors to be approximately 99 percent efficient.

Typical State Implementation Plan (SIP) particulate regulations for new plants are expressed by the process weight equation:

$$E = 4.1p^{0.67}$$

where E = allowable particulate emissions, in lb/h, and
p = process weight rate in tons/h.

The recommended method for sampling particulates from the detergent industry is EPA Reference Method 5.

2.0 INTRODUCTION

The authority to promulgate New Source Performance Standards (NSPS) is derived from Section 111 of the Clean Air Act. Under the Act, the Administrator of the U.S. Environmental Protection Agency is directed to establish air pollution standards and is accorded the following powers:

1. Identify those categories of stationary emission sources that contribute significantly to air pollution and could be reasonably anticipated to endanger the public health and welfare;

2. Distinguish classes, types, and sizes within categories of new sources for the purpose of establishing standards; and

3. Establish standards of performance for stationary sources which reflect the degree of emission reduction achievable through application of the best system of continuous emission reduction, taking into consideration the cost, energy, and environmental impacts associated with such emission reduction.

Detergent manufacturing was recently specified on a priority list of major source categories for which an NSPS should be developed.[1] This source category survey was performed to determine if an NSPS for the detergent manufacturing industry is needed and to identify the processes and pollutants which should be subject to regulation. Information about processes, air pollutants, and control equipment was gathered as follows:

1. Process and emission data were collected from literature searches, state and local air pollution control agencies, detergent manufacturing companies, and the National Emission Data System (NEDS).

2. Four detergent manufacturing plants were visited to develop an understanding of manufacturing processes and to collect data on air pollution control equipment and emissions.

3. Representatives of industry, government agencies, and trade associations were contacted to gather information on detergent production and projected industry expansion.

A detergent is any substance that lowers the surface tension of water. Detergents clean by acting as a wetting agent and by holding soils in suspension. Scientifically, the term detergent applies to both soap and synthetic detergents. However, in common usage (and for the purposes of this report), soap and detergents are distinguished both by their composition and by their cleaning performance. Soap precipitates as a calcium salt and therefore is not effective in hard water. Detergent, a synthetic organic compound, is augmented by water softeners, buffering agents, and builders and is effective in hard and soft water.[2 3 4 5]

The U.S. synthetic detergent industry grew rapidly in volume shortly after World War II. Prior to that time, essentially all cleaning and laundry compositions were based on fatty acid soaps derived from natural fats and oils such as tallow and coconut oil.[6] Modern soap and detergent formulations were shaped by a series of events which started in the 1930's when the first synthetic surface-acting agent (surfactant), a long chain alkyl-aryl sulfonate, was introduced.[4] Factors that contributed to increased consumption of synthetic detergent included the development of economical processes for the manufacture of alkyl-benzene, the discovery and utilization of phosphate detergent builders, introduction of automatic washing machines, steady growth in consumer purchases of clothes, an increase in washing frequency, and increases in the population.[6]

Numerous brands of laundry detergent are on the market. A large number of these have multiple formulas to meet regional phosphorus legislative requirements. There is no "typical" heavy-duty laundry detergent formulation; products may be characterized as high or low foamers, phosphate or zero-phosphate compositions, anionic or nonionic, built or unbuilt, and any combination thereof. However, most detergent formulations contain at least the following: surfactants, builders, foam regulators, solubilizers, corrosion inhibitors, and fillers and diluents. Table 2-1 gives common components of laundry detergent and their function.

TABLE 2-1. COMPONENTS OF POWDERED LAUNDRY DETERGENT IN THE UNITED STATES[6]

Components	Commercial examples	Percent composition by weight	Function
Surfactants	Linear alkylbenzene sulfonates Alcohol sulfates Alcohol ethoxylates Alcohol ether sulfates	8-22	Lower surface tension; promote emulsification of oil and grease; facilitate penetration of the fabric structure; assist in dispersion of particulate matter; produce foam
Builders	Sodium tripolyphosphate Tetrapotassium pyrophosphate Tetrasodium pyrophosphate Sodium citrate Zeolites	20-60	Sequester calcium and magnesium ions; prevent redeposition of soil on fabric; maintain alkalinity necessary for cleaning; disperse and suspend dirt; increase the efficiency of the surfactant
Foam regulators	Soap Alkanolamides Fatty amine oxides Lauryl alcohol	0-5	Boost, stabilize, and control foam;
Solubilizers	Ethanol Sodium xylene sulfonate	0-2	Increase the ability of surfactants to go into solution when surfactant content is at a high level;
Antiredeposition agents	Carboxymethylcellulose	<1	Prevent removed dirt from returning to the fabric

TABLE 2-1. COMPONENTS OF POWDERED LAUNDRY DETERGENT IN THE UNITED STATES[6] (concluded)

Components	Commercial examples	Percent composition by weight	Function
Fluorescent whiteners and blueing agents		<1	Provide a blue-white whiteness to counteract the natural tendency of some fibers to yellow
Corrosion inhibitors	Sodium silicate	4-10	Protect metal parts of washing machine
Perfumes and colorants		<1	Improve aesthetic appeal
Fillers and diluents	Sodium sulfate Sodium carbonate Sodium silicate	20-40	Provide matrix for free-flowing powder formulations; provide medium for compositions; assist processing of the detergent formulation

The Standard Industrial Classification (SIC) number 2841 includes soaps, organic detergent (liquid and powder laundry detergent and dishwashing liquid), alkaline detergent (automatic dishwashing detergent), glycerin made from fats, and scouring powders. Surfactant, the active ingredient in detergents, is classified in a separate SIC number 2843.[7] Technical articles, emission data from state agencies, and discussions with industry representatives indicate that the manufacturing of spray-dried powdered detergent is a significant source of particulate emissions whereas other processes in the industry are not.[4, 8, 9, 10] Therefore, this study will focus on the production of spray dried powdered detergent.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

1. Growth in the liquid and powdered detergent industry has been slow for the past 10 to 15 years and is projected to be about 1 to 2 percent per year through 1982. No new spray dryers are expected to be built within the next 10 years because existing production capacity can meet the projected demands. No spray dryer modifications or reconstructions are expected because spray dryers last indefinitely.

2. The primary pollutant from the manufacture of spray-dried detergent is particulate from the spray-drying operation. Minor sources of emissions are raw material and product handling.

3. Control technology is available for particulate (detergent dust) pollution control. There are no uncontrolled plants in the United States because the value of recovered detergent dust justifies a high level of control.

4. Emission data are available for approximately two-thirds of the plants which manufacture spray-dried detergent. Test data show that particulate emissions from plants average 60 percent of emissions allowed by a typical SIP process weight equation.

5. The standard method for evaluating particulate emissions from spray-drying detergent is EPA Reference Method 5.

3.2 RECOMMENDATIONS

It is recommended that an NSPS not be developed at this time for the detergent industry. A stardard would have no impact because no facilities are expected to be covered by the standard in the next 10 years.

4.0 DESCRIPTION OF INDUSTRY

4.1 SOURCE CATEGORY

The source category considered in this report is the manufacture of spray-dried detergent. This category represents approximately 45 percent of the total products listed under SIC Code 2841.[11] The spray-dried detergent and soap source category is defined individually by NEDS Source Classification Code 3-01-009-01.

Table 4-1 shows that the number of establishments and employees associated with SIC Code ?841 has been rather stable for the past 20 years. The total number of establishments has decreased in the past 10 years, but this decline was probably offset by an increase in establishments with 20 or more employees. The total number of employees has increased from 30,800 in 1963 to 31,900 in 1977.[12 13 14 15]

Of the 227 establishments listed under SIC Code 2841 in 1977, 33 presently spray dry detergents (Table 4-2). Facilities are located in 17 states across the country. Three major companies, Procter and Gamble Company, the Colgate-Palmolive Company, and Lever Brothers Company, supply more than 90 percent of the retail market demand for detergent and produce detergent only by spray drying.[16] Several other companies, including Purex Corporation and Witco Chemical Corporation, manufacture spray-dried detergent to package under their own label or to sell to distributors. The remaining companies, although large in number, produce less than 5 percent of the total laundry detergent used in the United States. These small operations generally produce detergent by dry mixing ingredients rather than by spray drying.

TABLE 4-1. INDUSTRY STATISTICS[12] [13] [14] [15]

Year	Total No. of plants	No. of plants with >20 employees	Total No. of employees (1,000)	No. of production employees (1,000)
1977	638	227	31.9	20.4
1972	642	199	31.5	20.4
1967	668	207	30.3	20.2
1963	704[a]	172[a]	30.8[a]	20.1[a]
1958	608[a]	163[a]	29.6[a]	18.2[a]

[a]Data for 1963 and earlier are not directly comparable to more recent data because the industry classification was changed.

TABLE 4-2. SPRAY-DRY DETERGENT MANUFACTURERS, 1980

Company	Location
The Procter and Gamble Company	Long Beach, California Sacramento, California Augusta, Georgia Kansas City, Kansas Alexandria, Louisiana Baltimore, Maryland Quincy, Massachusetts New York, New York Cincinnati, Ohio Dallas, Texas
The Colgate-Palmolive Company	Berkeley, California Jeffersonville, Indiana Kansas City, Kansas Jersey City, New Jersey
Lever Brothers	Los Angeles, California Baltimore, Maryland St. Louis, Missouri
Astor Products	Jacksonville, Florida
Chemithon	Seattle, Washington
Custom Spray Products, Inc.	Atlanta, Georgia
The Great Atlantic and Pacific Tea Company, Inc.	Brockport, New York
Los Angeles Soap Company	Los Angeles, California
Luseaux Labs	Gardena, California
National Purity Soap and Chemical Company	Minneapolis, Minnesota
Pacific Soap	San Diego, California
Plex Chemicals	Union City, California

TABLE 4-2. SPRAY-DRY DETERGENT MANUFACTURERS, 1980 (concluded)

Company	Location
Purex	Southgate, California St. Louis, Missouri Bristol, Pennsylvania
Safeway Stores, Inc.	Oakland, California
Stepan Chemical	Chicago, Illinois
Witco Chemical Corporation	Chicago, Illinois Paterson, New Jersey

4.2 PRODUCTION

Production of powdered detergent has increased slowly in the past 10 to 15 years. From 1963 to 1977, production increased 37 percent, from 2.4 to 3.3 billion pounds (Figure 4-1).[6 12 13 14 15] Growth in the detergent market (powders and liquids) is projected to continue at about 1 to 2 percent per year through 1982.[6 18]

The powdered detergent market will be affected by population growth, changes in consumer laundry habits, and competition from the liquid laundry detergent market.[6 16 17] Rising energy costs will also affect the spray drying manufacturing process. Although population growth is expected to increase the total detergent demand by 500 million pounds by 1985, changes in consumer laundry attitudes and competition from the liquid detergent market may offset the demand for powders.[6 16 17 18] The liquid detergent market has increased from 3.4 percent (1968) to 16.1 percent (1977) of the home laundry detergent market, and it is expected to increase to 18 to 21 percent by 1982.[6] Much of the growth in the total detergent industry is expected to be met by the expanding liquid market.[11]

No new spray driers are expected to be built in the next 10 years to meet the modest growth forecast for the detergent industry.[19 20 21] Industry representatives from two major companies have stated that they will probably never build another spray dryer. Excess capacity exists in the industry to meet projected powdered detergent demand; some plants spray-dry only two shifts per day, and others have idle spray dryers.[19 20 21] The average capacity utilization of spray-dried detergent is estimated to be near 60 percent.

4.3 PROCESS DESCRIPTION

Manufacture of spray-dried detergent has three main processing steps: slurry preparation, spray drying, and granule handling (Figure 4-2).

4.3.1 Slurry Preparation

Detergent slurry is produced by blending liquid surfactant with other powdered and liquid materials (builders and other additives) in a crutcher (a closed mixing tank). The blended slurry is held in a surge vessel for continuous pumping to the spray dryer. Solids content of the

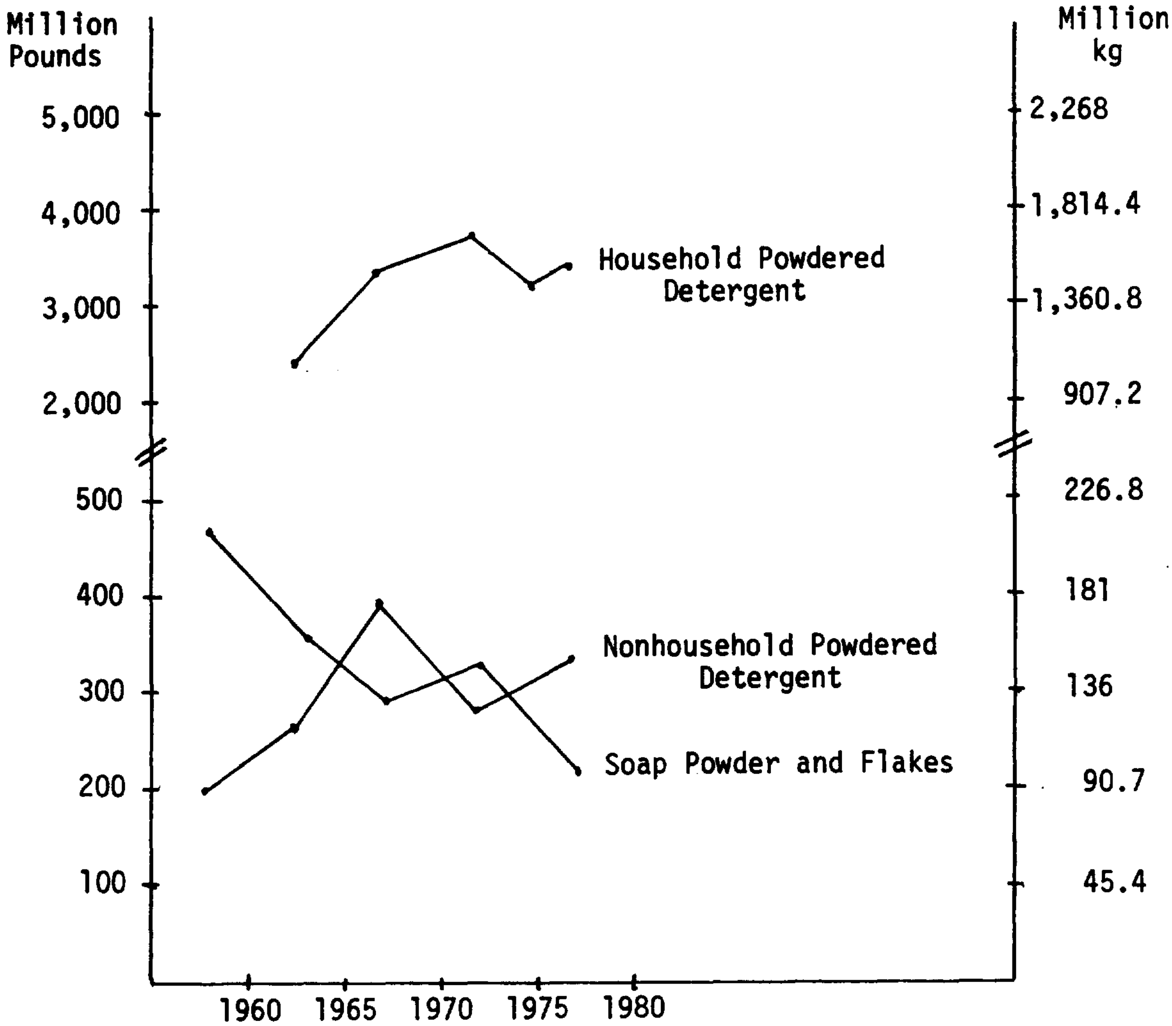

Figure 4-1. Production of Powdered Detergent and Soap

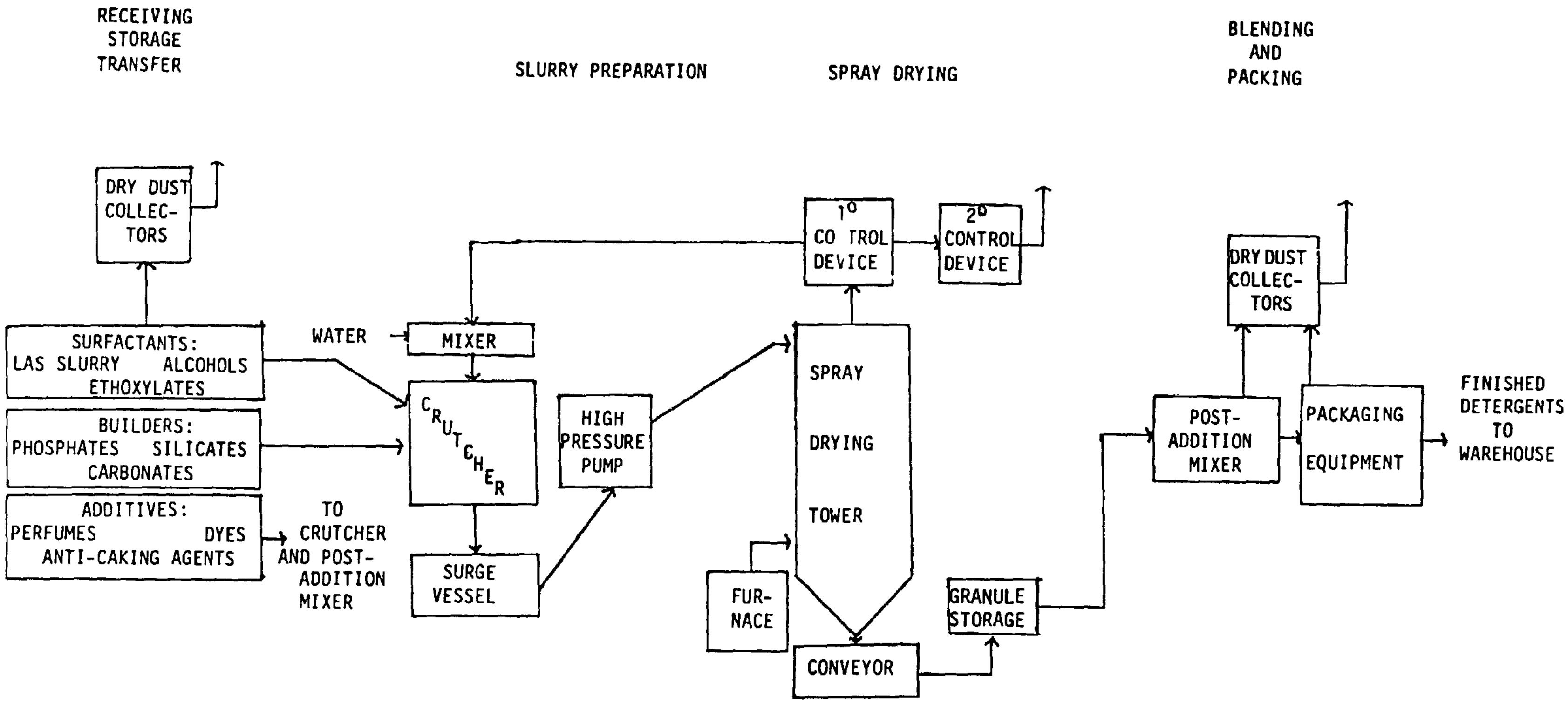

Figure 4-2. Manufacture of spray-dried detergents.

slurry varies from 50 to 70 percent by weight at most plants. Dust emissions are generated by handling and conveying of the powders, but these emissions are contained in the building or controlled with fabric filters and are not considered significant.[8 10]

4.3.2 Spray Drying

The spray-drying operation is the major source of particulate emissions from detergent manufacturing.[4 8 9 10] It is also a minor source of hydrocarbons when the product being sprayed contains organic materials with low vapor pressures.

Slurry feed to the tower is atomized by spraying at high pressure through nozzles. Typical towers are cylindrical with cone-shaped bottoms and range in size from 3.7 to 7.4 m (12 to 24 ft) in diameter and 30 to 38 m (100 to 125 ft) in height. Typical feed rates vary from 5,400 to 6,800 kg/h (12,000 to 15,000 lb/h). Air is supplied to the tower from direct-heated furnaces fired by either natural gas or fuel oil. Most towers designed for detergent production are countercurrent, with slurry introduced at the top and heated air introduced at the bottom. A few towers are concurrent and have both hot air and slurry introduced at the top.

Tower operating parameters vary widely from manufacturer to manufacturer and product to product. Heated air supplied to the tower varies from 315°C to 400°C (600°F to 750°F). Moisture content of the final product varies from 10 to 17 percent. Exit gas temperatures range from 65°C to 120°C (150°F to 250°F).

In countercurrent towers, the low air velocities and large particle size allow most of the dried granules to fall to the bottom of the tower. The granules are discharged through a regulated opening (star valve) while still hot. In concurrent towers, the air is vented just above the bottom of the tower through a baffle, changing the direction of the air and causing the dried granules to fall to the cone bottom. The loss of detergent fines is higher from the concurrent towers than from the countercurrent towers because the particles produced in concurrent towers are smaller.[10]

4.3.3 Granule Handling

Granules are mechanically or air conveyed from the tower to a mixer to incorporate additional dry or liquid ingredients. Air conveying cools the granules during transport. At the end of the conveyor, centrifugal separators remove granules from the air. The cooled granules are screened to remove oversized or undersized particles, blended with final heat-sensitive additives, and conveyed to packaging and storage. The conveying, mixing, and packaging of granules cause in-plant dust emissions which are generally controlled by baghouses.[8] [10]

5.0 AIR EMISSIONS

5.1 PLANT AND PROCESS EMISSIONS

Emission test data for specific plants were requested from state and local control agencies and individual plants. Additional emission data were obtained from a previous EPA testing program, EPA's National Emissions Data System (NEDS), and other literature sources.[4 8 10] Table 5-1 presents a compilation of testing results and emission estimates obtained in this survey. The 22 plants for which data were obtained have a production and emission range which is characteristic of the 33 plants which spray-dry detergent in the United States. Emissions range from 0.6 to 20 kg/h (1.3 to 44 lb/h). Testing results show that the average emission rate is 5 kg/h (11 lb/h), which is 30 Mg/yr (33 tons/yr), assuming a 3-shift day and 5-day workweek, 50 weeks per year.

Table 5-2 shows the average emission rate (calculated by averaging emission test data) and SIP-controlled emission rate for a typical detergent plant. The typical SIP-controlled estimate was obtained by dividing the total 1977 U.S. production of powdered laundry detergent by the number of plants in operation. This production rate (in tons of detergent per year) was converted to an average plant detergent slurry feed rate (process weight rate). The process weight rate was used in a typical process weight equation:

$$E = 4.1p^{0.67}$$

where E = allowable particulate emissions, in lb/h, and
p = process weight rate, in tons detergent slurry/h.

This typical process weight equation is used in 10 of the 19 states which have detergent plants in the U.S.

TABLE 5-1. EMISSION DATA

Plant	Date of data	Method	Control device	Emission range lb/h	Emission average lb/h	Emission average kg/h	No. of tests
A	1972	EPA 5	cyclonic	0.7-2.4	1.66	0.8	3
	7/73	EPA 5	impingement scrubber	7.5-8.65	8.02	3.6	3
B	4/73	EPA 5	cyclonic impingement scrubber	6.35-16.81	9.35	4.2	3
C	5/72	EPA 5	baghouse	44.11-45.19	44.11	20.0	2
D	7/72	EPA 5	cyclone impingement scrubber	3.15-4.65	3.78	1.7	3
E	6/72	EPA 5	cyclone,	17.3-23.11	21.01	9.5	3
	1973	EPA 5	scrubber-ESP	--	25	11.3	-
F	4/73	EPA 5	cyclone, scrubber-ESP	6.4-9.03	8.1	3.7	3
G	1973	EPA 5	cyclonic impingement scrubber, fiberglass filter	8.6-13.6	10.6	4.8	3
H	2/74	EPA 5	cyclonic impingement scrubber	1.6-5.3	3.2	1.4	3

TABLE 5-1. EMISSION DATA
(Continued)

Plant	Date of data	Method	Control device	Emission range lb/h	Emission average lb/h	Emission average kg/h	No. of tests
I	1975	EPA 5 Mod.	cyclonic impingement scrubber	5.2-9.5	6.9	3.1	4
J	1977	EPA 5 Mod.	cyclone, scrubber-ESP	--	14	6.4	-
K	1978	EPA 5 Mod.	NA	--	4	1.8	-
L	1978	EPA 5 Mod.	cyclone	--	1.4	0.6	-
M	--	EPA 5 Mod.	cyclonic scrubber	--	4.8	2.2	-
N	--	Estimate[a]	cyclone, scrubber-ESP	--	6.6[b]	3.0[b]	0
O	--	Estimate	cyclone, scrubber-ESP	--	15[b]	6.8[b]	0
P	--	Estimate	cyclone, scrubber,-ESP	--	10.7[b]	4.8[b]	0
Q	--	Estimate	cyclonic impingement scrubber	--	3.7[b]	1.7[b]	0
R	--	Estimate	cyclone, wet scrubber	25 tons/yr-82 tons/yr	17.8[b]	8.1[b]	0

TABLE 5-1. EMISSION DATA
(Continued)

Plant	Date of data	Method	Control device	Emission range lb/h	Emission average lb/h	Emission average kg/h	No. of tests
S	--	Estimate	cyclone	--	1.3[b]	0.6[b]	0
T	--	Estimate	cyclone, scrubber-ESP	--	6[b]	2.7[b]	0
U	--	Estimate	cyclone	--	9.6	4.4	0
V	--	Estimate	cyclone	--	1.6	0.7	0

[a]Esimates were made by state agencies based on efficiency of the air pollution control devices installed at the plant. It is not known if these estimates are accurate.
[b]Estimate assumes plants operate 6,000 h/yr.

TABLE 5-2. PARTICULATE EMISSIONS FROM A TYPICAL SPRAY DRYER

Typical spray dryer emissions:	
Uncontrolled	500 kg/h (1,100 lb/h)
Controlled for product recovery only	50 kg/h (110 lb/h)
Average controlled:[a]	5 kg/h (11 lb/h)
Typical SIP controlled:[b]	9 kg/h (19 lb/h)

[a]Average plant emissions were estimated by averaging available test results.

[b]Typical plant emissions were estimated assuming a production rate of 45,300 Mg/yr (50,000 tons/yr), a process weight rate of 57,000 Mg/yr (62,500 tons/yr), and an operating rate of 6,000 hours per year.

Data obtained from state agencies and detergent companies indicate that the detergent plants commonly emit less particulate than is allowed by SIP's. A comparison of the average emission rate and the SIP-controlled emission rate shows that plants are emitting 60 percent of the particulate allowed by the typical state regulations.

No uncontrolled detergent plants exist in the United States because it is not profitable for the plants to lose detergent powder to the atmosphere. Plants which use collection devices only for product recovery remove 85-95 percent of particulate emissions. These plants are estimated to emit 50 kg/h (110 lb/h).

5.2 TOTAL NATIONAL EMISSIONS

Baseline nationwide particulate emissions are estimated to be 988 Mg/yr (1,089 tons/yr). The nationwide emission rate was estimated by multiplying the average plant emission rate by the number of plants which spray-dry detergent in 1980.

6.0 EMISSION CONTROL SYSTEMS

6.1 CONTROL APPROACHES

There are three sources of particulate emissions in the manufacturing of spray-dried detergent: unloading, conveying, and mixing dry materials; spray-drying detergent slurry; and conveying and packaging the final product. The major source of emissions, the spray drying of detergent slurry, generally is controlled in two stages. A primary control device (dry cyclone or cyclonic impingement scrubber) is used largely for product recovery, and a secondary device [mist eliminator or scrubber-electrostatic precipitator (ESP) unit] is used for particulate air pollution control. The other emission sources are controlled by fabric filters which serve both for air pollution control and product recovery.

6.1.1 Emission Control for the Spray Dryer

6.1.1.1 Primary Collection Equipment. Two types of primary collection equipment are used by the soap and detergent industry to control emissions from spray drying--the dry cyclone and the cyclonic impingement scrubber. The dry cyclone is used in parallel or in series to collect particulate (detergent dust) and recycle the dry product back to the crutcher. The cyclonic impingement scrubber is used in parallel and collects the particulate in a scrubbing slurry which is recycled back to the crutcher.

The cyclone separates particulate matter from the effluent gas by changing the direction and velocity of the inlet stream. Centrifugal force moves the particulates to the outside wall for collection. The cyclone's collection efficiency is dependent on the inlet gas velocity and the particle size in the gas stream.

Because the particulates in the gas stream from the spray dryer are large (approximately 50 percent are greater than 40 microns), the cyclone efficiency is high.[8 22] Typically, a single cyclone is 90 percent efficient with a pressure drop of 1,000 to 1,250 Pa (4 to 5 inches of water).[10 26] Two cyclone collectors in series operate at 3,000 Pa (12 inches of water) and are reported to have collection efficiencies of 99 percent.[10]

In cyclonic impingement scrubbers, the air stream enters tangentially near the bottom and flows upward in a spiral. A countercurrent flow of high-solids-concentration slurry is used to contact the dust particles and absorb them. The scrubbing slurry drains out of the bottom of the unit, and the clean air leaves through the top.[4] The slurry is recycled through the scrubber at a constant solids concentration by continuously returning part of the slurry to the process and diluting the remaining slurry with water.

The efficiency of the cyclonic impingement scrubber depends on a proper balance between the air and the scrubbing slurry flow rates.[23] Pressure drop varies from approximately 500 to 2,000 Pa (2 to 8 inches of water), and the slurry flow rates vary from 0.5 to 1.3 liters of slurry per cubic meter of air (4 to 10 gpm slurry per 1,000 cfm air).[10] The equipment manufacturer states that this type of scrubber has an efficiency of at least 99 percent for particles greater than 3 microns.[24 25]

6.1.1.2 Secondary Collection Equipment. Secondary collection equipment is used at well-controlled detergent plants to capture the fine particulates that have escaped from the primary devices. Plants with cyclonic impingement scrubbers often use mist eliminators as secondary collectors. Dry cyclones may be followed by fabric filters or, more commonly, by scrubber-electrostatic precipitator units. Generally, it is not economical to recover the portion of the product captured by secondary devices; collected material is disposed as solid or liquid waste.

A typical scrubber-ESP unit is enclosed in a cyclindrical vessel about 4.3 m (14 ft) in diameter and about 12.2 m (40 ft) high. A tubular type ESP is located in the upper part of the vessel. The scrubbing section, in the lower part of the vessel, contains a 23-cm (9-inch) layer of pall ring packing with spray nozzles underneath. Each scrubber uses fresh water at about 4.1×10^{-3} to 5.7×10^{-3} m^3/s (65 to 90 gpm). The collected material is washed from the ESP tubes with water every 3 to 5 days while the unit is shut down.[26] The scrubber-ESP unit collects small particle sizes, has low pressure and temperature drops, operates continuously, has a low maintenance costs, and requires little power to operate.[10] It is approximately 50 percent efficient.[26]

Although fabric filters have been used by some companies to control the spray dryer, few are presently used for this purpose. Problems with bag blinding and bag burning made fabric filters undesirable control devices for the spray dryer.

6.1.2 Emission Control for Raw Material and Final Product Handling

Fabric filters are used extensively for the control of dust emissions from raw material unloading, conveying, and mixing, and from product conveying and packaging. Filter material such as polyester and Dacron is used to control emissions from raw material handling because it is resistant to alkaline powders. Fabric filters used for final product emission control may be made of cotton sateen.

The fabric filters used in the industry vary in inlet capacity from 9.4 m^3/s (20,000 acfm) for small units to 37.8 m^3/s (80,000 acfm) for large units.[10] Air-to-cloth ratios range from 2.5 to 1 to 6 to 1.[10 27] Some manufacturers report efficiencies of fabric filters exceed 99.8 percent.[27]

6.2 "BEST SYSTEMS" OF EMISSION REDUCTION

Two major control systems are used by the soap and detergent industry. The control system most widely used consists of a cyclonic impingement scrubber occasionally followed by a mist eliminator or similar type of secondary aftercollector. A second system consists of cyclones in parallel, followed by a scrubber-ESP unit. Both systems can achieve effective product recovery and air pollution control. Design collection efficiencies for both systems are approximately 99 percent according to the detergent companies and control equipment vendors.

7.0 EMISSION DATA

7.1 AVAILABILITY OF DATA

Emission data were obtained through telephone and letter contacts to state and local control agencies, visits and letters to individual companies, and the NEDS. In addition, particulate emission rates and particle size distribution were obtained from a previous EPA testing program of six detergent plants. Most of the emission data that was available was only for the spray-drying operation. Little data was found on other steps in the manufacturing of powdered detergent and on the manufacture of other detergent products (such as liquid detergent and bar soap). A small amount of data on NO_2, SO_4, PO_4, CO_4, and SiO_2 emissions from a spray dryer were provided by an EPA test at one plant.

Data on uncontrolled plants is not available in the United States because all detergent spray dryers are controlled to prevent loss of product.

7.2 SAMPLE COLLECTION AND ANALYSIS

Particulate emissions from detergent manufacturing are measured using EPA Reference Method 5. EPA Reference Method 9 is available for determination of opacity. Both EPA Reference Methods 5 and 9 are described in 40 CFR 60, Appendix A.[28]

8.0 STATE AND LOCAL EMISSION REGULATIONS

The following paragraphs provide information on pertinent state and local regulations. These data were compiled from telephone contacts and letter requests to specific pollution control agencies and from the Environment Reporter.[29]

Spray dry detergent manufacturing plants operate in 17 states. All 17 states have emission regulations for particulate, and all except two regulate opacity (Table 8-1). None of the states has developed emission standards specific to new or existing detergent manufacturing plants; most state regulations categorize this source as a "manufacturing" process.

Seven of the seventeen states listed in Table 8-1 use the following process weight rate equations to establish allowable particulate emissions:

$$E = 4.10\ p^{0.67} \qquad p \leqq 30\ \text{tons/h}$$

$$E = 55.0\ p^{0.11} - 40 \qquad p > 30\ \text{tons/h}$$

where E = allowable particulate emission rate, in lb/h, and

p = process weight rate, in tons slurry/h.

The remaining ten states have different process weight rate tables and equations. The California South Coast Air Quality Management District (SCAQMD) uses a more restrictive table than the other states. An average-sized plant (with a process weight rate of 10 tons/h) which would be allowed to emit 8.6 kg/h (19 lb/h) of particulate using the above equations would be limited to emitting 5.4 kg/h (12 lb/h) particulate in the SCAQMD.

Most states which have detergent manufacturing plants limit opacity to 20 percent with exceptions which permit higher levels for a small percentage of time in an hour or day.

All state and local agencies contacted indicated that their detergent plants were operating within applicable particulate regulations. To meet

TABLE 8-1. SUMMARY OF STATE AIR POLLUTION REGULATIONS

State	Particulate	Opacity	Air pollution regulation reference
California			
Bay Area	Equation Set 1[a]	≦20, exception	Bay Area Air Control District, Reg. IV. September 1977.
South Coast	Process weight rate table 405, Type A	≦20, exception	Rules and Regulations South Coast Air Quality Management District, Reg. IV. September 1977.
Florida	Equation set 2[b]	≦20, exception	Rules of the Florida Department of Environment Regulation. Chapter 17-2.13. September 1979.
Georgia	Equation set 1[c]	≦20, exception	Georgia Air Quality Control Rules. Chapter 391-3-1. November 1975.
Illinois	Equation set 3[d]	≦30, exception	Illinois Stationary Sources Standard. Rule 201, 202, 1977. May 1979.
Indiana	Equation set 1	≦40, exception	Indiana Air Pollution Control Regulations. APC-3. May 1979.
Kansas	Equation set 1	---	Kansas Air Pollution Control Regulations. Section 28. January 1974.
Louisiana	Equation set 1	---	Louisiana Air Pollution Control Regulations. 19.4 and 19.5. February 1978.
Maryland	≦0.03 gr/dscf	≦20, exception	Maryland State Department of Health and Mental Hygiene Regulations Governing the Control of Air Pollution. Area III. April 1979.

TABLE 8-1. SUMMARY OF STATE AIR POLLUTION REGULATIONS (continued)

State	Particulate	Opacity	Air pollution regulation reference
Massachusetts	Table 6	≤20, exception	Massachusetts Air Pollution Control Regulations. Section 7.09(u). October 1978.
Minnesota	Equation set 2	≤20, exception	Minnesota Air Pollution Control Rules, Regulations, and Air Quality Standards. APC-5. June 1976.
Missouri	Equation set 1	≤20, exception	Missouri Air Pollution Control Regulation. 10 CSR 10-5. December 1979.
New Jersey	≤.02 g/dscf or 99% reduction	≤20, exception	New Jersey Regulations on Air Pollution from Manufacturing Processes. Subchapter 6. May 1977.
New York	Equation set 4[e]	≤20, exception	New York Regulations on Processes and Exhaust. Title 6, Chapter III, Part 212. June 1973.
Ohio	Equation set 1	≤20, exception	Ohio Particulate Matter Standards. September 1978.
Pennsylvania	≤.02 g/dscf or or Equation 5[f]	≤20, exception	Pennsylvania Standards For Contaminants. Section 123. July 1978.
Texas	Equation set 6[g]	≤20, exception	Texas Regulation 1: Control of Air Pollution From Visible Emissions and Particulate Matter. Section 131. May 1979.
Washington	≤0.1 gr/dscf	≤20, exception	Washington General Air Pollution Regulations. WAS 173-400-040. December 1976.

TABLE 8-1. SUMMARY OF STATE AIR POLLUTION REGULATIONS
(continued)

Equations

E = allowable emission rate in lbs/h
p = process weight rate in tons/h

[a]Equation set 1:

(a) $E = 4.1p^{0.67}$ $p \leqq 30$ tons/h
(b) $E = 55p^{0.11}-40$ $p > 30$ tons/h

[b]Equation set 2:

(a) $E = 3.59p^{0.62}$ $p \leqq 30$ tons/h
(b) $E = 17.31p^{0.16}$ $p > 30$ tons/h

[c]Equation 1 (a) above is used for all existing equipment.

[d]Equation set 3:

(a) $E = 2.54p^{0.534}$ $p \leqq 450$ tons/h
(b) $E = 24.8p^{0.16}$ $p > 450$ tons/h

New sources are subject to the restrictions of this equation. Existing sources are subject to the restrictions of Equation Set 1.

[e]Equation set 4:

(a) $E = 0.024p^{0.665}$ $p \leqq 50$ tons/h
(b) $E = 39p^{0.082}-50$ $p > 50$ tons/h

[f]Equation set 5:

(a) $A = 0.76E^{0.42}$ where
A = allowable emissions in lb/h
$E = F \times W$
F = process factor in lb/unit = 30 lb/ton for detergent drying, and
W = production or charging rate in units/h.

TABLE 8-1. SUMMARY OF STATE AIR POLLUTION REGULATIONS
(concluded)

[g]Equation set 6:

$E = 0.048q^{0.62}$

q = stack effluent flow rate in acfm.

If the source has an effective stack height less than the standard effective stack height, the allowable emission level must be reduced.

increasingly stringent air pollution control laws in some states, the industry has added control equipment for particulate and opacity reduction and has increased maintenance checks on existing control equipment. Personnel from a few states mentioned occasional complaints about detergent "fallout," but stated that this problem was generally caused by equipment failure or process upset conditions at the plant. There are occasional complaints in some areas concerning odors from detergent plants, but these problems have usually been corrected by changes in the process or by further addition of control equipment.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Background information is presented on the detergent manufacturing industry for the purpose of assessing the need for new source performance standards. The report contains information on industry statistics and processes, air emissions, and emission control equipment associated with spray-dried powdered detergent. The spray dryer used to produce powdered detergent is the only major source of particulate emissions. No new spray dryers are expected to be constructed, reconstructed, or modified within the next 5-10 years. The report recommends that standards of performance should not be developed at this time.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Detergents Surfactants Spray dryers Air pollution Pollution control Standards of performance	Air Pollution Control	13-B

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