12.15 Storage Battery Production

12.15.1 General[1-2]

The battery industry is divided into 2 main sectors: starting, lighting, and ignition (SLI) batteries and industrial/traction batteries. SLI batteries are primarily used in automobiles. Industrial batteries include those used for uninterruptible power supply and traction batteries are used to power electric vehicles such as forklifts. Lead consumption in the U. S. in 1989 was 1.28 million megagrams (1.41 million tons); between 75 and 80 percent of this is attributable to the manufacture of lead acid storage batteries.

Lead acid storage battery plants range in production capacity from less than 500 batteries per day to greater than 35,000 batteries per day. Lead acid storage batteries are produced in many sizes, but the majority are produced for use in automobiles and fall into a standard size range. A standard automobile battery contains an average of about 9.1 kilograms (20 lb) of lead, of which about half is present in the lead grids and connectors and half in the lead oxide paste.

12.15.2 Process Description[3,12]

Lead acid storage batteries are produced from lead alloy ingots and lead oxide. The lead oxide may be prepared by the battery manufacturer, as is the case for many larger battery manufacturing facilities, or may be purchased from a supplier. (See Section 12.16, "Lead Oxide And Pigment Production".)

Battery grids are manufactured by either casting or stamping operations. In the casting operation, lead alloy ingots are charged to a melting pot, from which the molten lead flows into molds that form the battery grids. The stamping operation involves cutting or stamping the battery grids from lead sheets. The grids are often cast or stamped in doublets and split apart (slitting) after they have been either flash dried or cured. The pastes used to fill the battery grids are made in batch-type processes. A mixture of lead oxide powder, water, and sulfuric acid produces a positive paste, and the same ingredients in slightly different proportions with the addition of an expander (generally a mixture of barium sulfate, carbon black, and organics), make the negative paste. Pasting machines then force these pastes into the interstices of the grids, which are made into plates. At the completion of this process, a chemical reaction starts in the paste and the mass gradually hardens, liberating heat. As the setting process continues, needle-shaped crystals of lead sulfate ($PbSO_4$) form throughout the mass. To provide optimum conditions for the setting process, the plates are kept at a relative humidity near 90 percent and a temperature near 32°C (90°F) for about 48 hours and are then allowed to dry under ambient conditions.

After the plates are cured they are sent to the 3-process operation of plate stacking, plate burning, and element assembly in the battery case (see Figure 12.15-1). In this process the doublet plates are first cut apart and depending upon whether they are dry-charged or to be wet-formed, are stacked in an alternating positive and negative block formation, with insulators between them. These insulators are made of materials such as non-conductive plastic, or glass fiber. Leads are then welded to tabs on each positive or negative plate or in an element during the burning operation. An alternative to this operation, and more predominantly used than the manual burning operation, is the

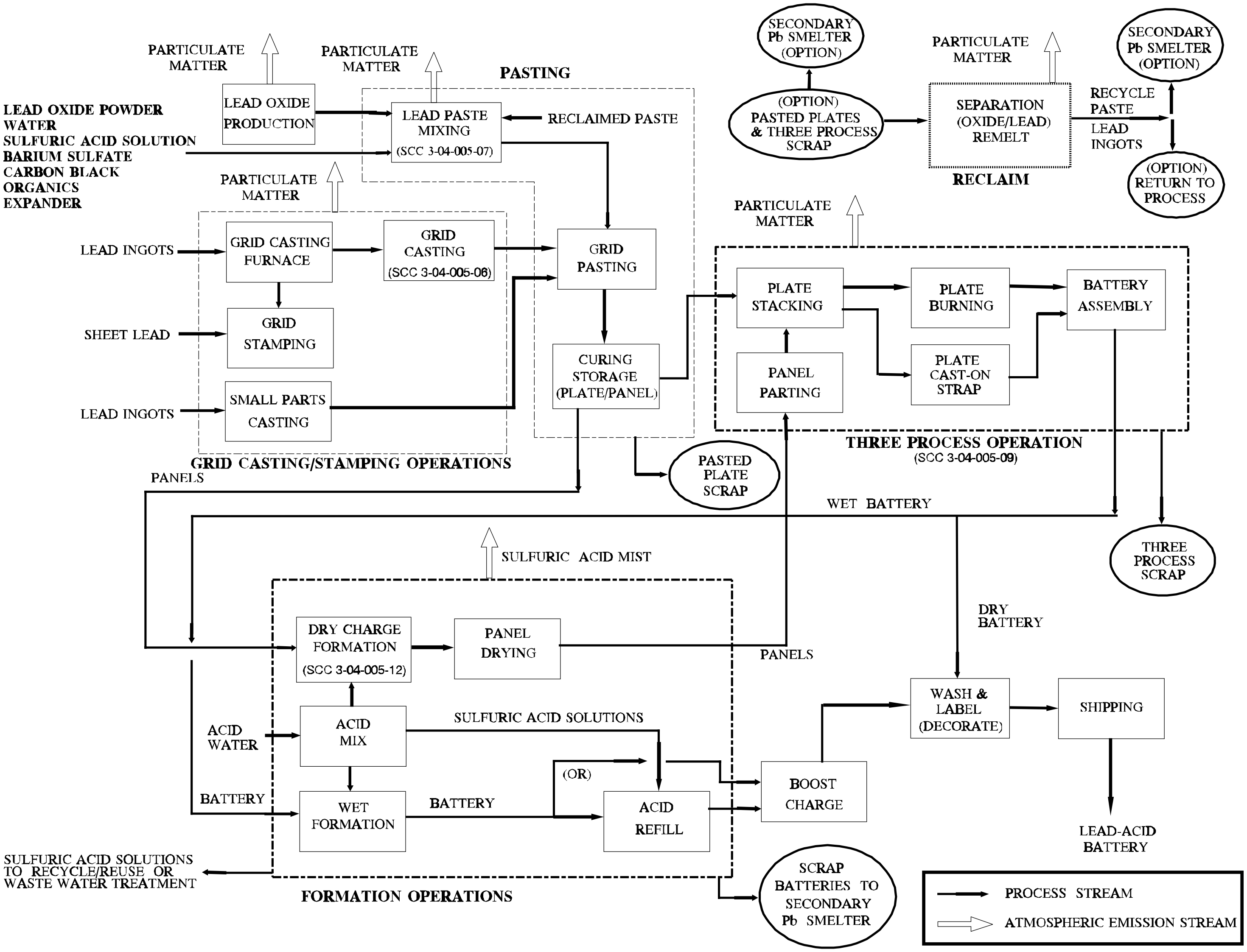

Figure 12.15-1. Process flow diagram for storage battery production. (Source Classification Codes in parentheses.)

cast-on connection, and positive and negative tabs are then independently welded to produce anelement. The elements are automatically placed into a battery case. A top is placed on the batterycase. The posts on the case top then are welded to 2 individual points that connect the positive and negative plates to the positive and negative posts, respectively.

During dry-charge formation, the battery plates are immersed in a dilute sulfuric acid solution; the positive plates are connected to the positive pole of a direct current (DC) source and the negative plates connected to the negative pole of the DC source. In the wet formation process, this is done with the plates in the battery case. After forming, the acid may be dumped and fresh acid is added, and a boost charge is applied to complete the battery. In dry formation, the individual plates may be assembled into elements first and then formed in tanks or formed as individual plates. In this case of formed elements, the elements are then placed in the battery cases, the positive and negative parts of the elements are connected to the positive and negative terminals of the battery, and the batteries are shipped dry. Defective parts are either reclaimed at the battery plant or are sent to a secondary lead smelter (See Section 12.11, "Secondary Lead Processing"). Lead reclamation facilities at battery plants are generally small pot furnaces for non-oxidized lead. Approximately 1 to 4 percent of the lead processed at a typical lead acid battery plant is recycled through the reclamation operation as paste or metal. In recent years, however, the general trend in the lead-acid battery manufacturing industry has been to send metals to secondary lead smelters for reclamation.

12.15.3 Emissions And Controls[3-9,13-16]

Lead oxide emissions result from the discharge of air used in the lead oxide production process. A cyclone, classifier, and fabric filter is generally used as part of the process/control equipment to capture particulate emissions from lead oxide facilities. Typical air-to-cloth ratios of fabric filters used for these facilities are in the range of 3:1.

Lead and other particulate matter are generated in several operations, including grid casting, lead reclamation, slitting, and small parts casting, and during the 3-process operation. This particulate is usually collected by ventilation systems and ducted through fabric filtration systems (baghouses) also.

The paste mixing operation consists of 2 steps. The first, in which dry ingredients are charged to the mixer, can result in significant emissions of lead oxide from the mixer. These emissions are usually collected and ducted through a baghouse. During the second step, when moisture is present in the exhaust stream from acid addition, emissions from the paste mixer are generally collected and ducted to either an impingement scrubber or fabric filter. Emissions from grid casting machines and lead reclamation facilities are sometimes processed by impingement scrubbers as well.

Sulfuric acid mist emissions are generated during the formation step. Acid mist emissions are significantly higher for dry formation processes than for wet formation processes because wet formation is conducted in battery cases, while dry formation is conducted in open tanks. Although wet formation process usually do not require control, emissions of sulfuric acid mist from dry formation processes can be reduced by more than 95 percent with mist eliminators. Surface foaming agents are also commonly used in dry formation baths to strap process, in which molten lead is poured around the plate tabs to form the control acid mist emissions.

Emission reductions of 99 percent and above can be obtained when fabric filtration is used to control slitting, paste mixing, and the 3-process operation. Applications of scrubbers to paste mixing, grid casting, and lead reclamation facilities can result in emission reductions of 85 percent or better.

Tables 12.15-1 and 12.15-2 present uncontrolled emission factors for grid casting, paste mixing, lead reclamation, dry formation, and the 3-process operation as well as a range of controlled emission factors for lead oxide production. The emission factors presented in the tables include lead and its compounds, expressed as elemental lead.

Table 12.15-1 (Metric Units). UNCONTROLLED EMISSION FACTORS FOR STORAGE BATTERY PRODUCTION[a]

Process	Particulate (kg/10^3 batteries)	Lead (kg/10^3 batteries)	EMISSION FACTOR RATING
Grid casting (SCC 3-04-005-06)	0.8 - 1.42	0.35 - 0.40	B
Paste mixing (SCC 3-04-005-07)	1.00 - 1.96	0.50 - 1.13	B
Lead oxide mill (baghouse outlet)[b] (SCC 3-04-005-08)	0.05 - 0.10	0.05	C
3-Process operation (SCC 3-04-005-09)	13.2 - 42.00	4.79 - 6.60	B
Lead reclaim furnace[c] (SCC 3-04-005-10)	0.70 - 3.03	0.35 - 0.63	B
Dry formation[d] (SCC 3-04-005-12)	14.0 - 14.70	ND	B
Small parts casting (SCC 3-04-005-11)	0.09	0.05	C
Total production (SCC 3-04-005-05)	56.82 - 63.20	6.94 - 8.00	NA

[a] References 3-10,13-16. SCC = Source Classification Code. ND = no data. NA = not applicable.

[b] Reference 7. Emissions measured for a "state-of-the-art" facility (fabric filters with an average air-to-cloth ratio of 3:1) were 0.025 kg particulate/1000 batteries and 0.024 kg lead/1000 batteries. Factors represent emissions from a facility with typical controls (fabric filtration with an air-to-cloth ratio of about 4:1). Emissions from a facility with typical controls are estimated to be about 2-10 times higher than those from a "state-of-the-art" facility (Reference 3).

[c] Range due to variability of the scrap quality.

[d] For sulfates in aerosol form, expressed as sulfuric acid or particulate, and not accounting for water and other substances which might be present.

Table 12.15-2 (English Units). UNCONTROLLED EMISSION FACTORS FOR STORAGE BATTERY PRODUCTION[a]

Process	Particulate ($lb/10^3$ batteries)	Lead ($lb/10^3$ batteries)	EMISSION FACTOR RATING
Grid casting (SCC 3-04-005-06)	1.8 - 3.13	0.77 - 0.90	B
Paste mixing (SCC 3-04-005-07)	2.20 - 4.32	1.10 - 2.49	B
Lead oxide mill (baghouse outlet)[b] (SCC 3-04-005-08)	0.11 - 0.24	0.11 - 0.12	C
3-Process operation (SCC 3-04-005-09)	29.2 - 92.60	10.60 - 14.60	B
Lead reclaim furnace[c] (SCC 3-04-005-10)	1.54 - 6.68	0.77 - 1.38	B
Dry formation[d] (SCC 3-04-005-12)	32.1 - 32.40	ND	B
Small parts casting (SCC 3-04-005-11)	0.19	0.10	C
Total production (SCC 3-04-005-05)	125.00 - 139.00	15.30 - 17.70	NA

[a] References 3-10, 13-16. SCC = Source Classification Code. ND = no data. NA = not applicable.
[b] Reference 7. Emissions measured for a "state-of-the-art" facility (fabric filters with an average air-to-cloth ratio of 3:1) were 0.055 lb particulate/1000 batteries and 0.053 lb lead/1000 batteries. Factors represent emissions from a facility with typical controls (fabric filtration with an air-to-cloth ratio of about 4:1). Emissions from a facility with typical controls are estimated to be about 2-10 times higher than those from a "state-of-the-art" facility (Reference 3).
[c] Range due to variability of the scrap quality.
[d] For sulfates in aerosol form, expressed as sulfuric acid, and not accounting for water and other substances which might be present.

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