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## The Pecos project

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### Abstract

The recycling of batteries in the USA has become a challenge between balancing ever-increasing environmental regulation and cost, with efficient operations. Recovery & Reclamation, Inc.'s facility in Pecos, TX, USA, has developed into a facility doing multiple battery reclamation at a single location. This means essentially one stop shopping for battery recycling. The emphasis has been to design a facility to comply with environmental regulations, to eliminate wastes, and achieve total reclamation of all the spent batteries.

*Keywords:* Recycling; Spent batteries; USA

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### 1. Introduction

Recovery & Reclamation, Inc., was incorporated in the state of Texas on 13 February 1992, and is located in Pecos, TX. Recovery & Reclamation, Inc., is primarily involved in the collection, processing and distribution of recycled materials from the recycling of industrial and household batteries. The company has several contracts with the Railroad Companies throughout the USA, The Netherlands and other European countries and approximately 250 other generators within the continental USA.

Recovery & Reclamation, Inc., has received new, used and obsolete batteries containing hazardous and non-hazardous materials and processed them through their patented process, reclaiming all or portions of the batteries and reselling the reclaimed materials to secondary users to produce commercial products.

The single most important feature about the Recovery & Reclamation's battery operations is the capability to do multiple battery-type recycling at a single location. A unique feature about the Recovery & Reclamation, Inc. includes a trucking company, Recovery & Reclamation Trucking, Inc., formulated to pick up and deliver batteries to the Recovery & Reclamation facility in Pecos, TX. Another unequaled feature is the new 'battery-pak system', a program that is finding immediate acceptance among companies of all sizes with small or large amounts of household batteries to manage. The heart of the program is a color-coded container that simplifies the overall process of battery management. By maintaining specific battery streams in specific color-coded shipping containers, Recovery & Reclamation is able to proc-

ess the containers of batteries quickly. The clients purchase the containers (specific to battery-type), shipping box (including instructions and labels), prepaid shipping, and prepaid recycling fees. Once the batteries are received and processed, the clients are sent a 'Certificate of Reclamation' for their records.

### 2. Legal summary

Management of non-household batteries is complex because waste batteries from non-household sources are subject to the US Federal Resource Conservation and Recovery Act (RCRA) hazardous waste regulations. Batteries can be identified as hazardous because of their corrosivity, reactivity or toxicity.

Waste generators are responsible for determining whether their waste batteries exhibit hazardous characteristics. The US Environmental Protection Agency (EPA) has not independently verified industry data, but according to industry knowledge nickel-cadmium batteries typically exhibit hazardous waste characteristics, whereas low-mercury, alkaline and carbon-zinc batteries do not. Some lithium batteries might exhibit the reactivity characteristics. Regulated generators may send their wastes only to Federal and State Permitted facilities (or recyclers), such as Recovery & Reclamation, Inc., and must ship the wastes using a permitted hazardous waste transporter, such as Recovery & Reclamation Trucking, Inc., and a formidable and traceable collection of paperwork.

2.1. Current status

Under RCRA the Recovery & Reclamation, Inc.'s recycling activities are exempt from permitting regulations, though Recovery & Reclamation does have in effect a RCRA Part B Storage Permit for the storage of hazardous waste batteries as required under the regulations. The Permit allows for an enclosed container storage area with a maximum capacity of 110 000 gallons (500 tons) or less for storage of the wastes authorized by the Permit and outlined in Section 3 and Appendix A. The Recovery & Reclamation, Inc. facility is in compliance with the Federal and State Authorities.

3. Wastes authorized

Recovery & Reclamation, Inc., is authorized to manage hazardous wastes within the following Hazard Code Groups: (i) ignitable; (ii) corrosive; (iii) toxicity characteristic waste, and (iv) reactive waste. Waste descriptions are presented in Appendix A.

4. Basic process

Recovery & Reclamation processes on-site alkaline, lithium, magnesium, mercuric oxide, zinc-carbon and zinc-air

batteries (railroad and consumer). Lead/acid, nickel-cadmium, nickel-metal hydride, nickel-iron and silver oxide batteries are received on-site, repackaged, and shipped off-site for further processing and reclamation.

4.1. Overall process

Fig. 1 presents the overall process flow chart of the Recovery & Reclamation, Inc.'s battery reclamation operations. The overall process for batteries other than lithium and railroad batteries consists of sorting out the batteries as per the type by trained personnel, shredding of batteries, drying of material using pyrolysis (patent pending), separation of components of the batteries, redox treatment of mercury vapors, and baghouse unit for particulate matter.

Fig. 2 presents the overall process flow for lithium batteries. The lithium batteries are deactivated in deactivation vats, after which they are fed to a shredding unit, and components are separated. Fumes, if any, are pulled by a suction fan into a water scrubber before proceeding to the stack.

Fig. 3 presents the overall process flow for railroad carbonaire batteries. Once unloaded the zinc-carbon batteries are drained to remove the electrolyte (potassium hydroxide), after which the batteries go into the sawing plant where they

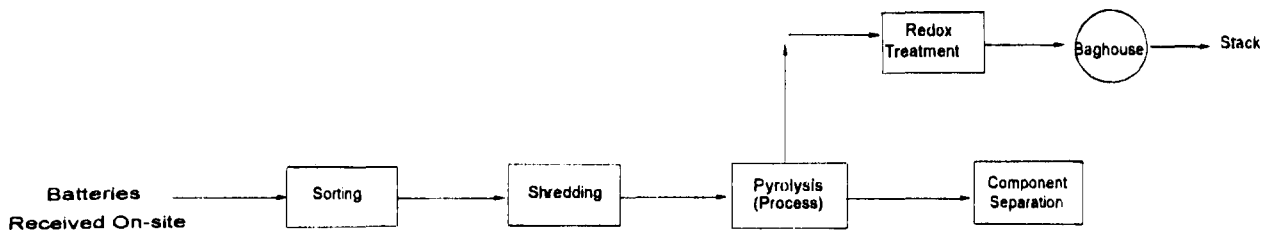


Fig. 1. Overall process flow.

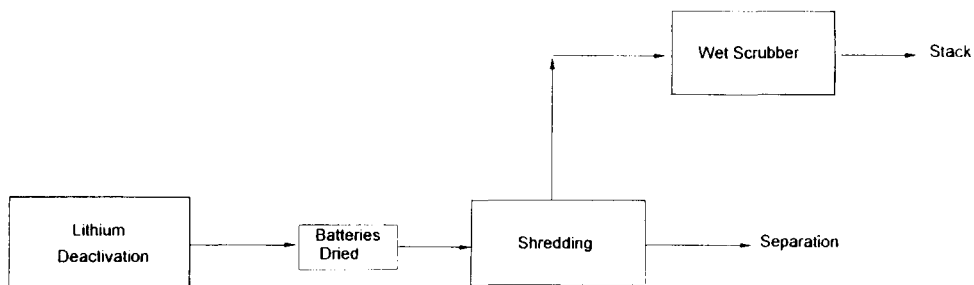


Fig. 2. Lithium battery processing.

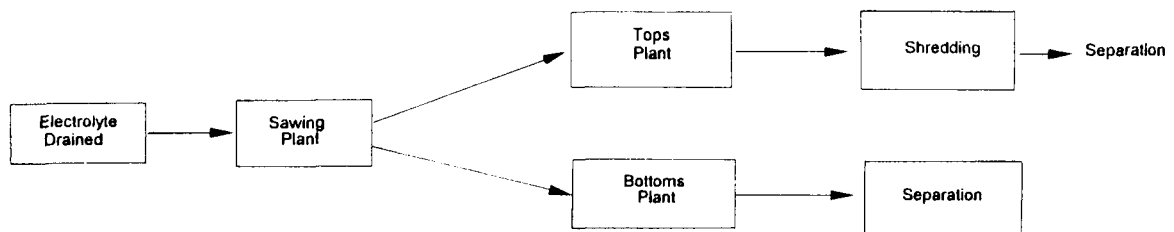


Fig. 3. Railroad-type battery processing.

are cut between the cells horizontally dividing it into tops and bottoms. The individual components are all separated, dried, bigger components shredded/ground, repackaged and sent to secondary users.

## 5. Air quality

Emission testing by an independent company under the supervision of State regulatory inspectors was performed to establish the actual pattern and quantities of air contaminants being emitted into the atmosphere from the battery processing operations and to satisfy the requirements of the RCRA permit. The mass emission rates were found to be below the permit allowable, highlighting the efficiency of the emission-control equipment while showing compliance with regulations. Hence, air emissions from the facility do not represent any significant risk. As a part of its 'safety first' policies, Recovery and Reclamation conducts daily testing throughout the entire facility to track any emissions.

Emission rates are presented in Appendix B.

### 5.1. Personnel exposure

Because the health and safety of the employees is of paramount importance to the company, Recovery & Reclamation exercises stringent safety procedures in handling any hazardous or toxic material and employs professional environmental experts at the facility. Recovery & Reclamation has on board a full time health and safety director to supervise the health and safety program.

Because of the various health effects and carcinogenicity classifications established for the battery metals, occupational health standards have been set by the Occupation, Safety and Health Administration (OSHA). Recovery & Reclamation conducts daily inspections and air sampling throughout the facility as a part of 'zero-tolerance' policy to ensure personnel and public health and safety.

All the employees undergo training as per the regulations and also receive continuous specialized training specific to their job. The training of the employees includes understanding of the material safety data sheets, emergency plan of the facility, hazards of battery waste management, safe management practices, spill response, evacuation procedures, and all other training as required by OSHA. Recovery & Reclamation has an effective hazard communication program in place to ensure proper communications in case of an emergency. Recovery & Reclamation also has in place an effective personal protective equipment program ensuring personnel safety.

OSHA recently conducted testing of the Recovery & Reclamation facility for mercury vapors and other metals. The results were very satisfactory in regards to the heavy metals and mercury, much below the OSHA standards. The noise levels within the plant are below regulatory levels, hence are of no concern. Recovery & Reclamation, Inc., is confident

that the facility is an insignificant source of emissions as validated by the OSHA testing and Recovery & Reclamation, Inc.'s own inspection program.

## 6. Market

Estimates of total batteries purchased in the USA vary from one pound to three pounds per person annually. This calculates from 245 million to 735 million pounds of battery solid waste discarded annually by the US population.

Sales statistics have shown that from the total, typically alkaline batteries contribute 60–70%, zinc-carbon 22%, nickel-cadmium about 10% of the market. At the present time there are few legitimate recyclers in the USA. Recovery & Reclamation, Inc., is the only facility doing multiple type batteries at a single location. In order to meet the growing demand Recovery and Reclamation has divided the USA into ten different regions. Recovery & Reclamation has appointed six environmental companies to form a network of regional representatives to manage the sales, marketing, management and transportation of waste batteries to Recovery & Reclamation from the ten regions. Recovery & Reclamation also has a representative for operations in Canada and overseas. Recovery & Reclamation has been receiving batteries on a regular basis from overseas through their representatives. As the regulations get more stringent and people realize the downfall of sending batteries to landfills, recycling will get more attention.

## 7. Conclusions

Only in its third year of operation, Recovery & Reclamation, Inc., is a recognized leader in the world of waste battery management. The company has grown from 35 employees to 180 employees in a year's time. The company has on board a full-time environmental staff working under the Vice President of environmental affairs, governing the environmental issues of the facility.

Recovery & Reclamation has presently two alkaline battery processing plants operating full time capable of doing 2000 lbs/h of batteries, see Fig. 4. Recovery & Reclamation

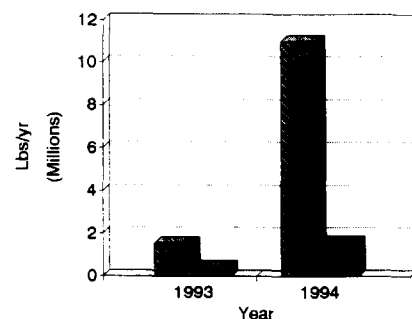


Fig. 4. Total amount of batteries processed at Pecos, TX, USA. (□) household-type, and (■) industrial-type batteries.

is in the process of adding three other units to process alkaline batteries in order to meet the growing demand. Estimates of total battery waste discarded annually in the USA is 245 million to 735 million pounds. This quantity of metal-rich material is clearly a candidate for recycling. Recovery & Reclamation has in its ongoing effort set up an efficient means of fulfilling this need for recycling as validated by the growth of the company. In its juvenile stage of operation Recovery & Reclamation has built a positive reputation with customers, community and regulators alike. As a result of its ongoing research Recovery & Reclamation has in effect a process capable of working within the environmental legal limits, capable to generate easily reusable products, capable to keep the costs within reasonable limits.

### Appendix 1: Waste descriptions

Waste authorized under RCRA permit for storage and processing at the Recovery & Reclamation, Inc., facility are as follows:

| Waste descriptions   | Hazard codes <sup>a</sup> |
|--|---------------------------|
| Zinc-carbon batteries, components and wastes                           | E, C                      |
| Lead/acid batteries, components and wastes                             | E, C                      |
| Nickel-cadmium batteries, components and wastes                        | E, C                      |
| Lithium batteries, components and wastes                               | I, E, C, R                |
| Nickel-iron batteries, components and wastes                           | E, C                      |
| Mercury batteries, components and wastes                               | E, C                      |
| Alkaline household batteries, components and waste (w/mercury content) | E, C                      |

|  |      |
|--|------|
| Alkaline household batteries, components and wastes (mercury-free) | E, C |
| Magnesium batteries, components and wastes                         | E, C |
| Nickel hydride batteries, components and wastes                    | E, C |

<sup>a</sup> E = toxicity characteristic waste; C = corrosive waste; I = ignitable waste, and R = reactive waste.

### Appendix 2: Summary of the results of emission tests

| Description                               | Average <sup>a</sup> | Permit allowable |
|---|----------------------|------------------|
| Pounds of battery (lb)                    | 1472                 | N/A              |
| Volumetric flowrate (dscf/h) <sup>b</sup> | 193100               | N/A              |
| Lithium (as LiOH) (lb/h)                  | $3.5 \times 10^{-3}$ | <0.01            |
| Total particulate (lb/h)                  | 0.081                | N/A              |
| HCl (lb/h)                                | 0.0012               | N/A              |
| Chlorine (lb/h)                           | 0.00080              | N/A              |
| Reduced sulfur (lb/h)                     | 0.032                | N/A              |
| Sulfur dioxide (lb/h)                     | 0.0013               | N/A              |
| Hydrogen cyanide (lb/h)                   | $1.2 \times 10^{-4}$ | N/A              |
| Metals                                    |                      |                  |
| Barium (lb/h)                             | $4.6 \times 10^{-4}$ | N/A              |
| Cadmium (lb/h)                            | $1.7 \times 10^{-5}$ | N/A              |
| Chromium (lb/h)                           | $1.5 \times 10^{-3}$ | N/A              |
| Copper (lb/h)                             | $1.9 \times 10^{-4}$ | N/A              |
| Lead (lb/h)                               | $1.1 \times 10^{-5}$ | N/A              |
| Lithium (as LiOH) (lb/h)                  | $3.7 \times 10^{-3}$ | <0.01            |
| Magnesium (lb/h)                          | $9.5 \times 10^{-4}$ | N/A              |
| Nickel (lb/h)                             | $2.8 \times 10^{-4}$ | N/A              |
| Silver (lb/h)                             | $1.8 \times 10^{-3}$ | N/A              |
| Zinc (lb/h)                               | $6.1 \times 10^{-4}$ | N/A              |

<sup>a</sup> Three runs were conducted from 17 Nov. 1994 through 18 Nov. 1994. Emission testing conducted by RSA, Inc., under supervision of Texas Natural Resources Conservation Commission.

<sup>b</sup> Dscf/h = dry standard cubic feet per hour.