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Introduction

Batteries are one of the most commonly purchased items in the United States. Each year, billions of batteries are purchased, used, and discarded. According to statistics generated by the US Environmental Protection Agency, in 1998 alone over 3 billion batteries were purchased. The EPA has estimated that the demand for batteries will increase by 5.8% each year through the year 2002.

Many batteries contain toxic elements (such as mercury and cadmium), and those batteries may pose a potential health hazard to the public if they are not disposed of properly. Again, according to the EPA, the percentage of disposed batteries is not a significant portion of the municipal solid waste stream. But, because of the toxic elements that they contain, batteries represent a very disproportionate amount of the toxic heavy metals found in the municipal solid waste stream. Some authorities note that while batteries may constitute 1% or less of the municipal solid waste stream, they may represent as much as 88% of the mercury and 54% of the cadmium found in the municipal solid waste stream.

Because these batteries are such significant contributors of toxic heavy metals, the EPA includes them under its Universal Waste rules (for more information about the Universal Waste rules, please go to the EPA website at www.epa.gov/epaoswer/hazwaste/id/univwast.htm).

As a general categorization, batteries may be classified as being rechargeable or non-rechargeable. Each category has its particular strengths and limitations, and each category has demonstrated extraordinary recycling success.

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Lead-Acid Batteries - The Ubiquitous Battery In Our Lives

Batteries come in many different sizes, voltages, configurations and compositions. The specific components used in each battery dictate the best course of action for disposing and recycling it. Perhaps the most commonly encountered battery in everyday life for most people is the lead-acid battery.

The positive pole of a lead-acid battery is made of lead, and the negative pole is made of lead dioxide. The battery contains an electrolyte solution of sulfuric acid. The battery cell generally contains anywhere from 60-75% lead and lead oxide (measured by weight), and the electrolyte solution contains anywhere from 28-51% sulfuric acid (measured by weight). The sulfuric acid electrolyte can cause very severe skin irritation and burns if it comes in contact with the skin. The sulfuric acid electrolyte can also cause very severe eye injuries if it splashes into the eyes.

Because lead-acid batteries have been around for so long and they have such an extensive presence in everyday living, they have been one of the most consistently recycled of all the battery types. The lead is so valuable that approximately 96% of the lead is recovered through recycling. One of the reasons that the recycling rate is so high is that the lead-acid batteries have a life cycle that is essentially a closed system. Industry information indicates that a new lead-acid battery contains between 60% and 80% recycled lead and plastic. The system is so efficient that the lead that is in batteries used in automobiles, boats, wheel chairs, lawn tractors, snow blowers, and motorcycles has probably been recycled many times. Lead-acid batteries with recycled lead are one of the most frequently used and significant back up systems for emergency power outage use.

While the recycling rate for lead-acid batteries is approximately 90%, there are many lead-acid batteries sitting in garages, storage units, warehouses, basements, and other places where people stash things and then forget about them. Generally, the recycling process begins when a battery is dropped off at a service station, a salvage operation, a battery retailer or some other local collection site. Colorado Recycles has listed many of these local recycling sites on a county-by-county basis in our Colorado Recycling Guide®.

Once the drop off center has accepted the lead-acid batteries, they are sent to a secondary processor, which is usually a lead smelter operating under strict environmental controls and regulations. It is at these secondary processors that the lead and plastics are melted, separated and refined. Plastics are usually sent on to a specialized reprocessor where it is remanufactured for use in other plastic products, including the plastic cases that hold the batteries. The recovered lead is very pure by the time the secondary processor has completed the reprocessing, and it is then shipped to battery manufacturers and other industries that use lead in their products.

The caustic sulfuric acid electrolyte is also reprocessed. It is often neutralized with a compound which is very similar to baking soda that converts the acid to water. The residual water is tested and treated to comply with regulatory requirements for clean water, and then it is discharged into the sanitation system. Sometimes the sulfuric acid is reprocessed to produce sodium sulfate, which is, in turn, used in laundry detergent and the manufacturing of glass and some textiles.

Because lead-acid batteries pose potential health and environmental hazards, they must be treated with respect. Information about handling and storing lead-acid batteries is easily obtainable from local drop off sites, battery retailers and other sources. As general rules, however:

- Keep the battery away from fire, sparks and flame and secure from freezing temperatures

- Do not place metal objects on top of the battery
- Do not handle batteries while wearing jewelry, such rings, chains, etc.
- Always wear protective gloves and eye protection when handling batteries
- Keep the battery upright
- Wash any clothing that comes in contact with the caustic materials
- Transport the battery in a nonmetallic, leak-proof container
- Be very careful when lifting and carrying - consult your local drop off site about securing a battery carrier
- Avoid subjecting the ends of the battery to blows, pressure or other potential circumstances that might crush or puncture the battery or its case
- Spilled acid should be neutralized and cleaned up immediately
- Acid which comes in contact with skin or eyes should be treated as a first-aid emergency

Legal and Regulatory Requirements - A Brief Digression

It should be noted that over one-half of the states have enacted laws which specifically govern the handling and disposal of lead-acid batteries. Colorado is one of the states that has not enacted a specific state law, but there are regulations adopted by the Colorado Department of Public Health and Environment that govern disposal. Additionally, there may be municipal and county ordinances that govern handling, storage and disposal within that particular community, Colorado Recycles recommends that you check with state and local officials before disposing of lead-acid batteries. Local drop off sites and centers should also be able to provide you with important information about state and local restrictions.

For a review of the various state laws, please visit the website of the Battery Council International at www.batterycouncil.org.

The Colorado Department of Public Health and Environment regulates batteries that cannot be recycled as a type of hazardous waste under the Colorado Hazardous Waste Regulations (CHWR 6 CCR 1007-3). For the most current information about the CDPHE rules, regulations, interpretations and other controlling standards, please visit the CDPHE website at www.cdphe.state.co.us/hm.

There is federal law that regulates batteries. The Mercury-Containing and Rechargeable Battery Management Act (Public Law 104-142) was signed into law in 1996. The purpose of the law is to phase out the use of mercury in batteries and to provide for the efficient and cost-effective collection and recycling or proper disposal of used nickel cadmium batteries, small sealed lead-acid batteries, and certain other batteries. For more information about the law, please review the information provided by the Environmental Protection Agency. A link to the website of the EPA is provided in a preceding section of this report.

The Growth of Battery Powered Appliances - The Need for Rechargeable Batteries

It is not surprising that the purchase and use of rechargeable batteries has grown so significantly and so quickly. The growth in demand for batteries is directly related to the growth in cordless portable electrical products such as cellular phones, laptop computers, power tools, video cameras, remote controlled toys and other devices. It is estimated that at least 95% of American households own at least one type of cordless product, and the average household owns at least three such products. Not only has the growth in battery energized products increased, the particular growth in the use of rechargeable batteries (such as nickel-cadmium batteries) has grown even faster. The National Electrical Manufacturers' Association has estimated that demand

in the United States for rechargeable batteries will grow at a rate twice that of the demand for non-rechargeables.

In the United States, the most common types of products which are likely to rely on rechargeable batteries and the number of such products (as estimated by the Rechargeable Battery Recycling Corporation) are:

Cellular Phones	64.1 million
Camcorders	36.2 million
Cordless Phones	109.2 million
Laptop Computers	11.4 million
Cordless Power Tools	107.5 million
Cordless Personal Care Products	59.0 million
Cordless Household Products	44.0 million

It is thought that over 76% of the more than 430 million products such as those noted above use nickel-cadmium batteries for their power source.

Using Rechargeable Batteries Makes Sense

Using rechargeable batteries makes good economic and environmental sense. Some rechargeable batteries can be recharged up to 1,000 times before they reach the end of their useful life. Users of the products powered by rechargeable batteries recharge and reuse the batteries many, many times rather than buying non-rechargeable batteries and continually disposing them when their useful life expires. Rechargeable batteries have kept many millions of batteries out of landfills and the municipal waste stream.

Even though the initial cost of purchasing a rechargeable battery is higher than the cost of a non-rechargeable battery, the extended life spans of rechargeable make them far more economical in the long run. In comparing the costs, one only need calculate the cost of the total number of non-rechargeable batteries that would be required to equal the same useful life as the rechargeable battery.

Rechargeable Batteries Are Good Candidates For Recycling

Rechargeable batteries are particularly well suited for recycling programs. Because these batteries contain chemicals and materials which have economic value when they are reclaimed and reprocessed, recycling efforts are generally very successful.

The Particular Case of Nickel-Cadmium Batteries

The nickel in nickel-cadmium batteries is reclaimed and is used in the production of stainless steel, which then goes into a diverse number of consumer products (such as tableware) used by millions of people every day.

The cadmium in nickel-cadmium batteries is reclaimed and reprocessed to make new rechargeable batteries. Once recovered, the cadmium can be reprocessed to a purity level of 99.95%!

Most of the industrialized countries of the world began to enact laws in the late 1980's that require the proper handling and disposal of batteries. These actions resulted in several plants dedicated to recycling batteries to be built. Battery recycling plants sort the batteries that are received to separate the lead-acid and lithium batteries from those that are nickel-cadmium. Nickel-Cadmium batteries are classified by the EPA as a hazardous waste and must be recycled.

During the recycling process, the batteries are cut into small pieces, and are heated at temperatures high enough to make the metals liquefy. Combustible materials are burned off in the process, and the residual slag is skimmed periodically during the process. Because different metals and different alloys have differing weights, they tend to settle out quite predictably thus allowing them to be recovered.

Cadmium, for example, is a light metal, and it vaporizes readily when exposed to high temperatures. The cadmium vapor is blown into large containers which are then cooled by a water mist. The cooling mist causes the vapors to condense. Once the vapor has condensed into a solid, it is pressed into bales and sent to a facility where it is further processed to recover cadmium, zinc, silver, copper and other materials.

Also, not surprisingly, the rate of recycling batteries among businesses is high while it is low among households. Programs such as those sponsored by the Rechargeable Battery Recycling Corporation are expected to increase household battery recycling rates quite significantly. The RBRC program, in particular, makes it extraordinarily easy for everyday citizens to recycle their rechargeable batteries through a very comprehensive participation of retailers. We discuss the RBRC further on in this report.

Nickel-Metal Hydride Batteries - Emerging Market

Quickly emerging in the markets for rechargeable batteries are the newer nickel-metal hydride rechargeable batteries. They have been designed to have a 40% longer lifespan than that of Ni-Cd batteries. Generally, the Ni-MH batteries are considered more environmentally safe than Ni-Cd batteries. It appears that the Ni-MH batteries are very interchangeable with Ni-Cd batteries, and can easily replace the Ni-Cd in many applications.

As of this report, it appeared that nickel-metal hydride batteries are not classified by the EPA as a hazardous waste, and may be disposed of through normal solid waste services. This observation should be verified by checking directly with the EPA and other governing regulatory bodies before simply disposing of nickel-metal hydride batteries.

Lithium-Ion Batteries

Lithium-Ion (Li-Ion) rechargeable batteries are becoming increasingly prevalent in rechargeable battery applications. It is important to understand that lithium-ion batteries do not contain lithium metal. The element that is used is an ion form lithium that moves readily between the poles of the battery. As of this report, it appeared that lithium-ion batteries are not classified by the EPA as a hazardous waste, and may be disposed of through normal solid waste services. This observation should be verified by checking directly with the EPA and other governing regulatory bodies before simply disposing of lithium-ion batteries. However, lithium-ion batteries do lend themselves to recycling programs, and those avenues should be reviewed before simply discarding the batteries.

**Colorado Recycles and the Rechargeable Battery Recycling Corporation:
A Strategic Partnership for Recycling**

In mid-2000, Colorado Recycles and the Rechargeable Battery Recycling Corporation (RBRC) joined together to educate the public about recycling rechargeable batteries in Colorado.

The RBRC is a nonprofit public service organization formed in 1994 with the initial mission to be the leader in the environmentally safe collection, transportation and recycling of portable Ni-Cd batteries. The RBRC is funded by the licensing of the Environmental Protection Agency certified RBRC Battery Recycling Seal to the manufacturers and marketers of Ni-Cd batteries and battery powered products.

The RBRC charter provided that the organization is to advance and administer a comprehensive Ni-Cd rechargeable battery recycling program in communities, among businesses, and through public agencies in the United States and Canada. At the beginning of 2001, this chartered responsibility was expanded to include additional types of rechargeable batteries. In addition to the Ni-Cd rechargeable batteries, the RBRC has initiated programs and projects to recycle Nickel Metal Hydride (Ni-MH) batteries, Lithium Ion (Li-ion) batteries, and Small Sealed Lead Acid (Pb) batteries.

Since its program was initiated, the RBRC reports that recycling of Ni-Cd batteries in the United States and Canada has increased by 30%. For the year 1999, the most recent for which numbers are available, the RBRC reports that 3,500,000 pounds of rechargeable Ni-Cd batteries have been recycled in the United States and Canada.

Participation in the RBRC program is quite easy for businesses, organizations and individuals. Through the cooperative effort with the RBRC, we have incorporated their data base of recyclers who participate in their national program through our Colorado Recycling Guide®. We have listed, on a county-by-county basis, all the RBRC participants who accept rechargeable batteries from the public. Additionally, there are businesses and organizations that have established programs for the convenience of their employees, customers and others. Colorado Recycles encourages participation in this very valuable and very successful program.

For more information about the RBRC and its programs, please visit their website at www.rbrc.com

Other Resources and References for Further Research

(Also refer to resources in our Colorado Recycling Guide® under listings for "Batteries")

Contact Information				
The Rechargeable Battery Recycling Corp. (RBRC)	PO Box 141870 Gainesville, Florida 32614-1870	352-376-5135	352-376-5942 (FAX)	www.rbrc.com
The National Electrical Manufacturers Association	1300 North 17th Street Suite 1847 Rosslyn, Virginia 22209	703-841-3200	703-841-5900 (FAX)	www.nema.org
The Battery Council	401 North Michigan	312/644-6610	312-321-6869 (FAX)	www.batterycouncil.org

International	Avenue Chicago, Illinois 60611			
Portable Rechargeable Battery Association	1000 Parkwood Circle, Suite 430 Atlanta, Georgia 30339	770-612-8826	770-612-8841 (FAX)	www.prba.org
The Environmental Protection Agency	For information concerning product stewardship			www.epa.gov/productstewardship/
The Environmental Protection Agency	For information concerning hazardous waste and Universal Waste Rules			www.epa.gov/epaoswer/hazwaste/id/univwast.htm
The Colorado Department of Public Health and Environment Hazardous Materials & Waste Management Division	4300 Cherry Creek Drive South Denver, CO 80246-1530	303-692-3320 888-569-1831 (Toll-free)		www.cdphe.state.co.us/hm

