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MAGNESIUM BATTERY DISPOSAL CHARACTERISTICS

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13. ABSTRACT (Maximum 200 words)

This study assesses the disposal characteristics of U.S. Army procured military magnesium batteries under current Resource Conservation and Recovery Act (RCRA) hazardous waste identification regulations administered by the U.S. Environmental Protection Agency. Magnesium batteries were tested at 100, 50, 10 and 0 percent remaining state of charge. Present findings indicate that magnesium batteries with less than 50 percent remaining charge do not exceed the federal regulatory limit of 5.0 mg/L for chromium. All other RCRA contaminates were below regulatory limits at all levels of remaining charge. Assay methods, findings, disposal requirements and design implications are discussed.

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Introduction

Over the past ten years, considerable work has been done to assess the disposal characteristics of U.S. Army Communications-Electronics Command (CECOM) procured military batteries. Using current U.S. Environmental Protection Agency (EPA) hazardous waste (HW) identification regulations, we have assessed the disposal characteristics of military magnesium (MG) batteries under Resource Conservation and Recovery Act (RCRA) regulations. This report presents previous results, current test methods and results, disposal requirements, and design implications for MG batteries of military design procured by CECOM.

Background

RCRA regulations define HW either by listing specific waste streams, or by the identifying specific characteristics under Title 40 Code of Federal Regulations (CFR) Part 261 Subpart C. Batteries are not listed, and therefore, in order for them to be identified as HW under RCRA, they must be found to be ignitable (D001), corrosive (D002), reactive (D003) or toxic (D004-D043) in accordance with established analytical procedures under this regulation. RCRA toxicity regulations became more severe in 1990, when test Method 1311 was changed from the Extraction Procedure Toxicity (EP Tox) test to the Toxic Characteristic Leaching Procedure (TCLP). This change means, in many cases, that a higher concentration of a TCLP contaminate may be extracted from the sample than was the case utilizing the EP Tox methodology. A solid waste is determined to be a HW when the extract concentration under TCLP for a particular contaminate is equal to or greater than the "regulatory level (mg/L)" in "Table 1, Maximum Concentration of Contaminants for the Toxicity Characteristic" of 40 CFR 261.24. All states must utilize RCRA requirements as a minimum for the determination of HW.

Previous Efforts

MG batteries[1] were analyzed by CECOM prior to TCLP requirements, and they were found to be non-hazardous solid waste (NHSW). When the TCLP methodology replaced EP Tox, additional studies were required to evaluate batteries for the toxicity characteristics under TCLP.[2] A finding of this later study indicated that MG batteries discharged to 50% capacity should be characterized as D007 toxic HW for chromium (Cr=9.1 mg/L) under RCRA's TCLP. The other RCRA characteristic tests for ignitability, corrosivity and reactivity were not affected by this 1990 regulatory change. This finding was challenged by a major battery supplier.[3] The supplier's findings suggested that the TCLP sensitivity for Cr was dependent on the battery's state of charge. This prompted an additional TCLP study to clarify this issue.

Analysis[4]

Method[5]

A random sample, n=20 (5/condition), of military MG batteries was selected from independent government test samples previously obtained. The samples were pre-conditioned to four levels of remaining capacity: State-of-Charge (SOC) remaining: 100% (un-discharged), 50% (50% capacity), 10% (10% capacity), and 0% (totally discharged).

The battery samples were then reduced to <9.5 mm particle size, and 100 g aliquots were extracted in accordance with TCLP methodology. The extracted leachates were analyzed for metals, volatile organic compounds and semi-volatile organic compounds, except for pesticides and herbicides, in accordance with SW-846[6] as required by Method 1311. Metal leachate samples were analyzed using atomic absorption spectrometry or inductively coupled plasm technique. Volatile organic compounds and semi-volatile organic compounds were analyzed using gas chromatography/mass spectrometry or high performance liquid chromatography as appropriate.

Results

Figure 1 shows that MG batteries discharged to ≤50% capacity did not exceed RCRA regulatory limits (RL) for Cr. Table 1 shows that for all SOC's no other metals exceeded the RLs established by 40 CFR 261 criteria. Findings were negative volatile organic and semi-volatile organic compounds.

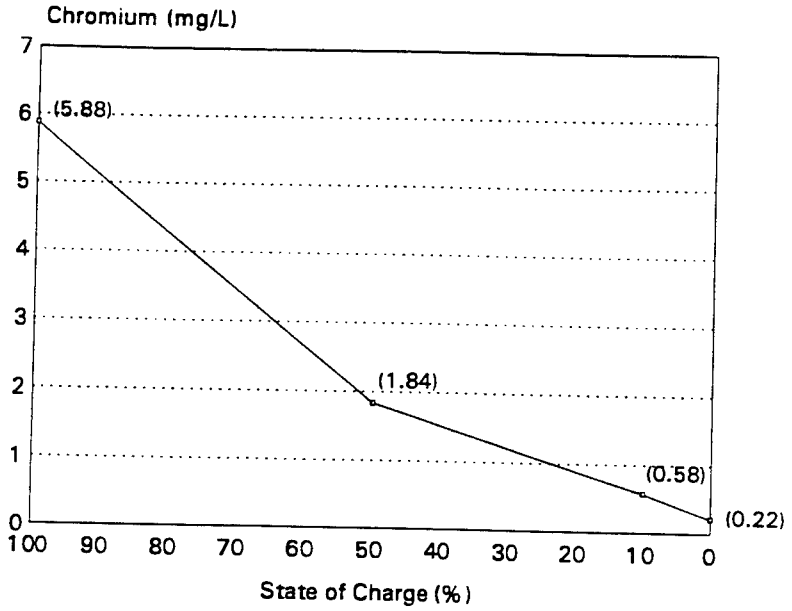

Figure 1. TCLP Analysis of MG Batteries

TABLE 1. Results of TCLP Analysis of Army Procured Magnesium Batteries (sample size: n=20)

State of Remaining Charge (%)	Toxic Characteristic Contaminant Sample Mean Concentration (mg/L)							
	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
0	0.100	14.800	0.003	0.224	0.100	0.002	0.100	0.010
10	0.100	7.160	0.003	0.582	0.100	0.002	0.100	0.010
50	0.100	2.440	0.003	1.840	0.100	0.002	0.100	0.010
100	0.100	1.334	0.003	5.880	0.100	0.002	0.100	0.010
Regulatory Limit	5.0	100.0	1.0	5.0	5.0	0.20	1.0	5.0

Discussion

Methods

The EP Tox method uses a structural integrity test (SIT) to determine the particle size prior to extraction. During previous analysis, many battery cells survived the SIT intact, and internal battery/cell structures could not be extracted prior to analysis. This model is inadequate, because over time most batteries/cells lose integrity in a landfill disposal site. The TCLP does not utilize a SIT. TCLP requires all components to be "crushed, cut, or ground", such that the sample particles will pass through 9.5 mm sieve prior to extraction and analysis. Solids and liquids, as well as volatiles, are amenable to extraction in a "zero-headspace extractor" utilized by this method.

Findings

Our findings support the manufacturer's data, which indicate that available Cr is affected by the battery's state of charge.[3] Results of the TCLP analysis shows that MG batteries with ≤50% charge do not exhibit Cr in excess of the RCRA RL.

Environmental Regulations

The characterization of HW for disposal depends on your location and its applicable regulations. Management guidance must be provided to user activities, so that users may test battery capacity prior to disposal. Findings aside, we must deal with each case on a case-by-case basis. It is important to get to know your regulator. Even if findings indicate that the material for disposal is an NHSW, the county officials may not allow the waste at the landfill site without a special permit. And with regard to permits, the disposal site's permit must include your waste stream, or your organization may not use the site.

Waste minimization is another important concept. We have recently commented regarding Docket No. F-93-SCSP-FFFFF,[7] which affects the recycling and reclamation of batteries. Presently New Jersey's code requires battery recycling. It is important that industry continues to take positive steps to ensure a means to recycle and market spent batteries/cells to reduce the HW stream.

Design

We have already incorporated a complete discharge device in military procured Li-SO_2 and Li-$SOCl_2$ batteries to eliminate their reactivity prior to disposal. Since MG batteries with ≤50% capacity are not HW under RCRA, the same approach may be considered.

Conclusion

The challenge for the future is to identify, isolate, and properly manage hazardous waste to prevent its entering the waste stream. We should and must minimize waste in order to protect our environment and that of our children. This is called pollution prevention, which is the thrust of the Pollution Prevention Act of 1990. We should strive to reduce the waste at its inception, that is, by designing our commodities for reuse, remanufacture or recycling. We should attempt to use less hazardous components. Manufacturers have reduced the mercury content in zinc-carbon and alkaline batteries. We are presently examining ways to reduce chromium in MG batteries.[8] This will help meet the requirements of Executive Order 12856. Only innovation can achieve these aims.

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(4) Painter, P.P. (1993), TCLP Study of Army Procured Magnesium Batteries, Northeastern Analytical Corp. (NAC), NAC Job 924371 Final, Marlton, NJ 08052.

(5) Title 40, Code of Federal Regulations, Part 261, Appendix II (1991), Method 1311 Toxicity Characteristic Leaching Procedure (TCLP).

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(8) Conversation with L. Jarvis, U.S. Army Research Laboratory, Fort Monmouth, New Jersey, 17 May 1994, Subject: Recent Developments in Magnesium Battery Technology.