DISPOSAL OF SNL-DESIGNED ELECTRONICS ASSEMBLIES ASSOCIATED WITH THE NUCLEAR WEAPONS PROGRAM - CHALLENGES AND PROGRESS*

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ABSTRACT

One of the common waste streams generated throughout the nuclear weapon complex is "hardware" originating from the nuclear weapons program. The activities associated with this hardware at Sandia National Laboratories (SNL) include design and development, environmental testing, reliability and stockpile surveillance testing, and military liaison training. SNL- designed electronic assemblies include radars, arming/fusing/firing systems, power sources, and use-control and safety systems.

Waste stream characterization using process knowledge is difficult due to the age of some components and lack of design information oriented towards hazardous constituent identification. Chemical analysis methods such as the Toxicity Characteristic Leaching Procedure (TCLP) are complicated by the inhomogeneous character of these components and the fact that many assemblies have aluminum or stainless steel cases, with the electronics encapsulated in a foam or epoxy matrix. In addition, some components may contain explosives, radioactive materials, toxic substances (PCBs, asbestos), and other regulated or personnel hazards which must be identified prior to handling and disposal.

In spite of the above difficulties, we have succeeded in characterizing a limited number of weapon components using a combination of process knowledge and chemical analysis. For these components, we have shown that if the material is regulated as RCRA hazardous waste, it is because the waste exhibits one or more hazardous characteristics; primarily reactivity and/or toxicity (Pb, Cd).

INTRODUCTION

Most weapon hardware is an inhomogeneous aggregate of metallic and organic materials of unknown composition, designed in a time frame spanning over thirty years. Complex electronic assemblies may contain a variety of parts and materials including:

- polymeric and metallic structural materials;
- specialized cables, cable assemblies and connectors;
- electronic components including oil-filled capacitors, mercury switches, radioactive tubes, and explosively actuated devices;
- chemically reactive systems utilized as power sources.

"Process knowledge," obtained from engineering drawings, or design and development reports, does not provide sufficient data for waste stream characterization. This is primarily due to the fact that engineering design was oriented towards performance specifications and not necessarily composition unless material content was specific to the function. In many cases, particularly in older systems, discrete components were purchased commercially and the materials information was either proprietary or not specified and the original vendor is no longer in business.

The task of identifying hazardous materials in weapons begins with defining the fundamental regulatory and operational requirements applicable to the management of weapon hardware waste. While the Resource Conservation and Recovery Act (RCRA) is the primary regulatory driver, there are other environmental, safety, and security issues to consider due to the potential for:

- radioactive source or contamination;
- explosive devices;
- toxic substances such as, asbestos or PCB's;
- physical characteristics such as gas or liquid fill;
- classified design.

Under RCRA, the generator of a waste is required to ascertain if a waste must be regulated as hazardous (1). The U.S. Environmental Protection Agency (EPA) has provided guidance in identifying hazardous waste as follows:

- Listed Wastes- industry-specific and non-specific chemicals or process wastes. These "listed" wastes are referred to by their F, K, P and U codes.
- Characteristic Wastes- exhibit one or more "hazardous characteristics" thus regulating the material for disposal. These characteristics have D codes and include: Ignitability (D001); Corrosivity (D002); Reactivity (D003); and Toxicity Characteristic (D004-D043).

On analysis of these criteria we concluded that based on the EPA definitions, weapon hardware will not fall into one of the listed (F, P, K, or U) waste categories. On examination of the "characteristics" of hazardous waste, process knowledge

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of weapon hardware indicates that, in general, the waste will not be ignitable or corrosive. We have therefore, limited the scope of the RCRA-required information for the identification of hardware waste to primarily two hazardous characteristics:

1. Reactivity (D003) - principally a characteristic of self-contained sub-components such as explosive switches and thermal batteries which (ideally) can be segregated and removed, deactivated, or expended in situ.
2. Toxicity (D004-D043) - principally the RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver). It is assumed that there would be only minute, if any, quantities of residual D-listed solvents which may have been used during manufacture of the article.

EXPERIMENT

A study was conducted to determine the feasibility of using the EPA Toxicity Characteristic Leaching Procedure (TCLP) for determining the regulatory status of excess weapon hardware. This study was part of a larger project at Sandia National Laboratories (SNL) to develop a process for characterizing hazardous materials in weapon components (2).

Two complex electronic assemblies from a single weapon system were selected for trial characterization. The Fireset and Pre-Flight Controller from this system are significantly different in both function and materials of construction. The circuitry and subcomponents of the Fireset are encapsulated within a solid epoxy block, cylindrical in shape, measuring approximately 12" in diameter by 2" thick. The Pre- Flight Controller is also encapsulated within a rectangular, epoxy-filled aluminum case, approximately 8"x6"x6", with numerous electrical connectors attached.

Design knowledge, obtained through personnel surveys, engineering drawings, and existing radioactive and explosive parts catalogs, indicated the presence of some discreet hazardous subcomponents in these assemblies as follows:

- Fireset
    - electronic tube with radioactive (^{85}Kr) fill gas
    - oil-filled capacitor which may contain PCB's
- Controller
    - thermal battery
    - electric squib (explosive igniter)
    - piston actuator (percussion explosive)

To minimize personnel hazards, these subcomponents had to be segregated or expended prior to any additional processing for sampling and chemical analysis. X-radiography was used along with engineering drawings to confirm the presence and location of the subcomponents. Removal of the radioactive tube from the Fireset was accomplished in conjunction with preparation for the TCLP, as described in the following section. The thermal battery and explosive switches contained in the Pre-Flight Controller were expended in situ prior to preparing the unit for the TCLP.

The selected components were shipped to Martin Marietta Energy Systems, Oak Ridge National Laboratories K-25 site, for analysis by the TCLP. Analytical Chemistry Department personnel at K-25 have considerable experience with the TCLP analysis, have the capability to handle classified and potentially radioactive material, and expressed a willingness to support our program.

RESULTS

For these tests, the entire component was reduced to 9.5mm strips at K- 25 using power saws and hand tools. By using process knowledge supported by documentation, personnel at K-25 were able to successfully remove intact the radioactive tube and capacitor from the Fireset prior to sizing the remainder of the component.

Following size reduction, a 100 gram sample was selected from each of the components for the leach test. These samples were selected by visually classifying the diverse materials and selecting a representative weight of each. Table I shows the results of the TCLP metals analyses for the two components. Also included in Table I are the results for a series of components analyzed by a commercial laboratory for the Pantex Assembly Plant (Mason and Hanger/Silas Mason Co.). These components were chopped on-site at Pantex in conjunction with a routine de-classifying/de-militarization procedure. The resulting pieces are approximately 1 to 2 inches in diameter, and samples were selected from this material for the TCLP analysis. Although these samples were not sized to the 9.5mm regulatory requirement prior to leaching, the information from these tests is still useful for comparative purposes.

Referring to Table I, the TCLP Toxicity Characteristic limits are listed at the top of the table for eight RCRA regulated metals. These are the concentration limits (mg/L) for metals leached from a solid waste sample, above which the waste is considered to be hazardous. Also shown at the top of Table I are the detection limits of the method for each metal. The underlined values are metal concentrations for which the component "failed" the test. A blank space indicates that the concentration of an element is below the detection limit of the method.

As shown in Table I, the Fireset sample failed the test for Pb, and the Pre-Flight Controller sample failed the test for Cd. Pb solder and Cd plated connectors are believed to be the source of these metals. The majority (25 out of 26) of the Pantex components failed for one or both of these metals as well. There is some question as to how representative these samples were of the whole component but nevertheless, it is significant that a majority of samples exhibited the toxicity characteristic for Pb and/or Cd.

All component materials from the Fireset and Pre-Flight Controller were returned to SNL following TCLP analysis at K-25. Included with these materials were the "sawdusts" from the sizing operations. The sawdusts from each component were individually blended and sampled for analysis of total metal content by ICP-AES using EPA Method 3050 (3). These analyses were done at SNL and differ from the TCLP in that a complete acid digestion of the sample is required. The results are shown in Table II and are listed as either wt.% or mg/Kg for each metal detected. These results confirm the presence of heavy metals and illustrate the compositional differences of the two assemblies. The remaining material (non-metallic) is assumed to be organic and glass or ceramic. The blended sawdust was considered to be a representative sample of the entire component, and any additional chemical characterization that might be required by a hazardous waste Treatment, Storage, and Disposal Facility (TSDF) could be done on this type of material.

TABLE I

TCLP Analyses of Weapon Components

	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
	(mg/L)							
TCLP Toxic Characteristic	>5	>5	>100	>1	>5	>0.2	>5	>1
Detection Limit	<0.1	<0.5	<0.1	<0.1	<0.1	<.01	<0.1	<0.5
Component - SNLA								
Fireset			1.5	0.2			9.1	
Pre-flight Controller			1.2	42	0.24		1.4	
Component - PANTEX								
P.O. Switch			0.4	3.6				
Fireset			3.0	5.9			9.6	
Fireset			1.7				8.3	0.1
Timer			0.4	88				0.1
Inertial Switch (plastic case)			0.4				4.9	
Inertial Switch (aluminum case)			0.4	5.1			15	
Interconnect Box			1.9				11	0.1
Switch Pack			0.4	1.1			29	0.1
R/S Switch			0.4	7.3	0.1			0.2
Interconnect Box			0.5				16	0.2
Motorized Switch			0.4	14	0.2			0.1
Fireset			0.4	9.6				
Thermal Fuse			0.9				22	
Pressure Switch			1.1	1.9	1.1		9.9	0.1
Switch Pack (Bakelite case)			0.4				26	
Switch Pack (metal case)			1.4				38	
Filter Pack			0.4	230				
Fireset			1.3				23	
Fireset			11		0.1		8.3	0.1
Interconnect Box			0.5				19	
Pulse Plug			0.4	210	0.1			0.2
Fireset			0.9					0.2
Filter Pack			0.5	1.2			23	
Power Supply			2.4	4.2			17	
Filter Pack			2.0	61			11	0.1

CONCLUSIONS

Analytical methodologies for the characterization of excess weapon component hardware have been investigated and successfully implemented in trial applications. The preliminary indication is that electronic hardware from early weapon systems will be regulated under RCRA as hazardous Characteristic Waste due to Pb and Cd content. This conclusion is based on the TCLP analysis of two complex, potted electronic assemblies and the results from an additional 25 weapon hardware components that were analyzed by an alternate procedure.

Our results show that there are similarities in hazardous material content of functionally different electronic assemblies. As the time required for chemical analysis of every piece of component hardware designated for disposal may be excessive, particularly with respect to recently announced retirement schedules, the development of a waste "profile" based on statistical sampling and analysis of some representative fraction of retirement and excess hardware is being *considered.* Technical operations are also being developed for the sampling of selected components to include; physical segregation of discreet hazards, and size reduction and homogenization of the material for analysis.

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TABLE II

Metals Content of Complex Weapon Components

Element	Det.lmt. (mg/Kg)	Fireset (mg/Kg)	Fireset (wt.%)	Pre-Flight Controller (mg/Kg)	Pre-Flight Controller (wt.%)
Ag	7		0.02		0.16
As	50	<50		<50	
Ba	2		0.16		0.06
Cd	4	45			0.10
Cr	7		0.04		1.12
Hg	20	<20		<20	
Pb	40		0.63		0.39
Se	80	<80			0.02
Al	50		1.18		32.3
Co	7		0.02		0.04
Cu	6		4.15		7.02
Fe	7		6.55		8.12
Mg	30		0.04		0.19
Mn	2		0.03		0.11
Mo	8	<10			0.04
Ni	15		0.16		0.93
Sn	100		0.41		0.42
Tl	40	<40		<40	
V	8	<10			0.02
Zn	2		0.54		0.66
TOTAL			16.1		52.2

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