Treatment of Radioactive Reactive Mixed Waste

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ABSTRACT

PacificEcoSolutions, Inc. (PEcoS) has installed a plasma gasification system that was recently modified and used to destroy a trimethylaluminum mixed waste stream from Los Alamos National Laboratory (LANL.) The unique challenge in handling reactive wastes like trimethylaluminum is their propensity to flame instantly on contact with air and to react violently with water. To safely address this issue, Pacific EcoSolutions has developed a new feed system to ensure the safe containment of these radioactive reactive wastes during transfer to the gasification unit. The plasma gasification system safely processed the radioactively contaminated trimethyl-metal compounds into metal oxides. The waste stream came from LANL research operations, and had been in storage for seven years, pending treatment options.

INTRODUCTION

PacificEcoSolutions, Inc. has a number of processes that treat a wide variety of radioactive and radioactive mixed wastes. These processes include:

<u>Mixed Waste</u>
1. Plasma Furnace destruction,
2. Rotary Kiln thermal desorption,
3. Stabilization/Microencapsulation
4. Neutralization,
5. Macroencapsulation

<u>Low Level Radioactive Waste</u>
6. Thermal Treatment,
7. Sorting
8. Super-Compaction/Volume Reduction
9. Decontamination
10. Decay Storage.
11. Survey for Release

Low-level radioactive mixed liquid wastes are thermally destroyed using a Plasma Furnace. The Plasma Furnace utilizes a 200-kW transferred plasma arc torch to heat material to 1,100^{o}C. Fig. 1 depicts the Plasma Furnace and its primary offgas equipment.

The offgas generated is used as supplemental fuel in the downstream Secondary Reaction Chamber. The reaction chamber burns natural gas to generate up to 140,000 Btu/hr of heat. Compounds, such as hydrochloric acid, are removed from the offgas and neutralized with sodium carbonate utilized in the Dry Acid Absorption system. The offgas is then cleaned further via Bag House filtration and high efficiency particulate air filtration before being released through an elevated stack.

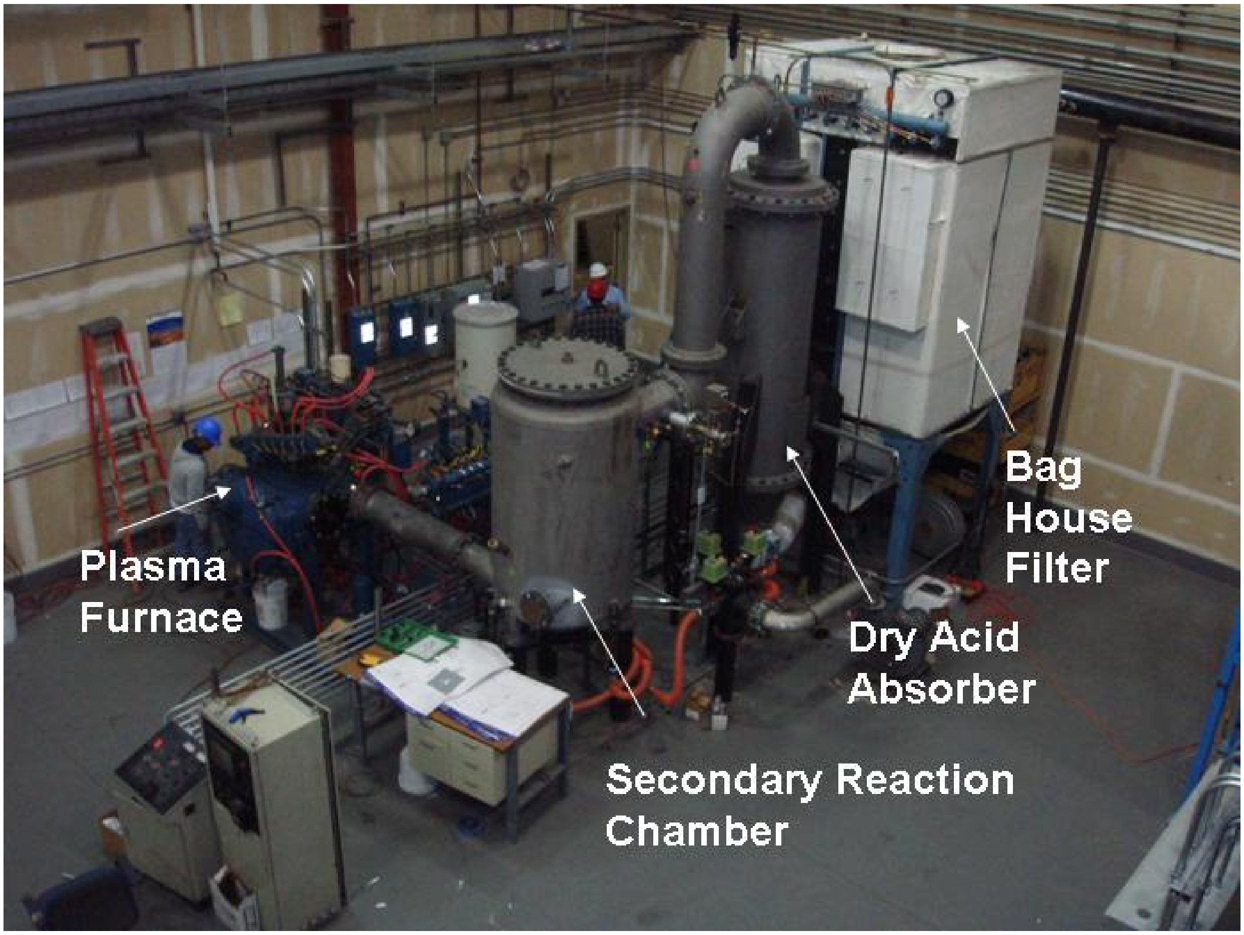

Fig. 1. Plasma furnace and primary offgas equipment

WASTE FEED SYSTEM DESIGN

The feed system is comprised of four major processing steps. The processing steps are:

1. Receive waste container from client.
2. Store the containers where they can be safely handled.

3. Thermally Destroy the waste using the Plasma Furnace system.
4. Dispose of the empty container.

CONTAINER RECEIPT

Waste is received from clients in various sizes and composition. A typical container for pyrophoric material is shown in Fig. 2.

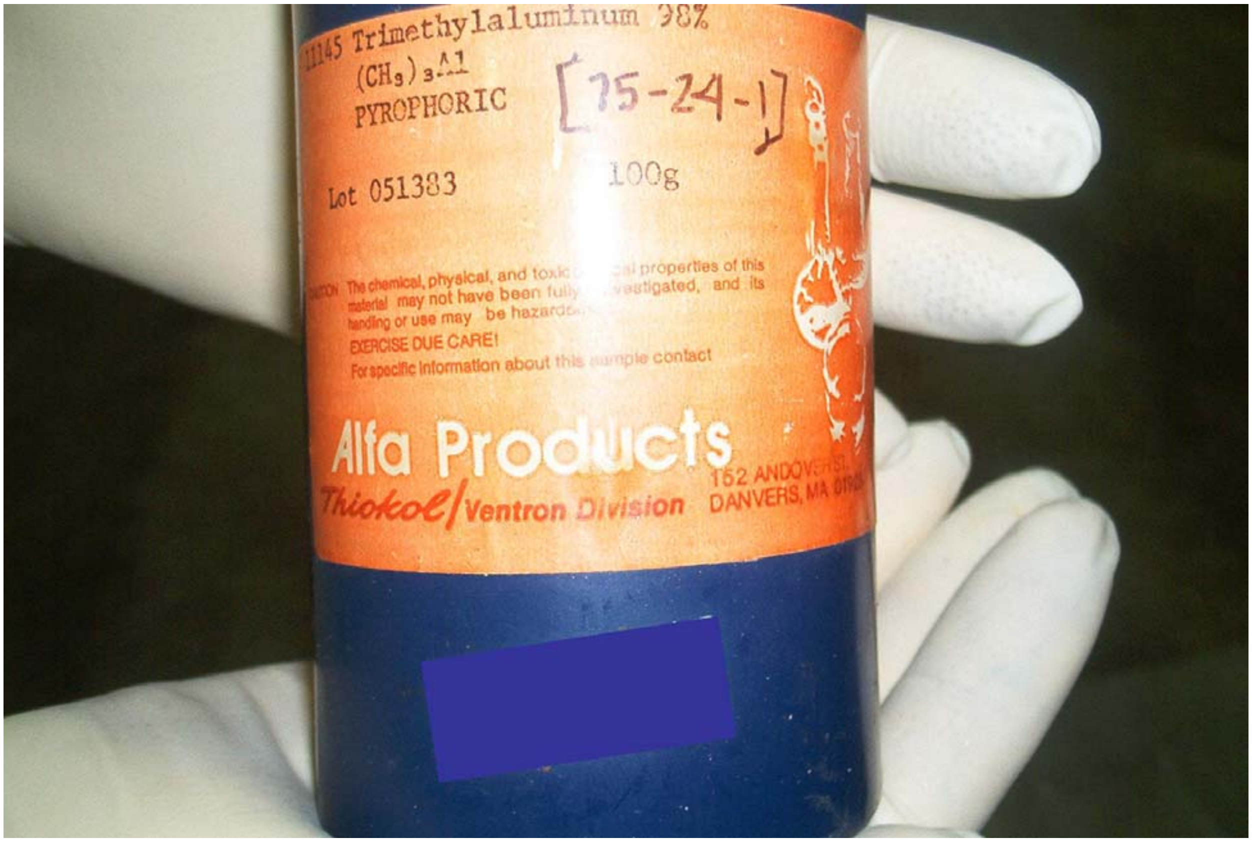

Fig. 2. Typical receipt of a radioactive reactive waste container

CONTAINMENT

Prior to processing, the waste container is placed in containment where it can be safely handled. The containment area used is a glove box (See Fig. 3 on the next page) which provides a barrier between the operator and a potential breached container. The glove box contains dry ice (CO_2) which, when it sublimes, combines with a nitrogen purge to create a near-inert atmosphere. The dry ice can also serve to cool a breached container, thus lowering the waste's vapor pressure.

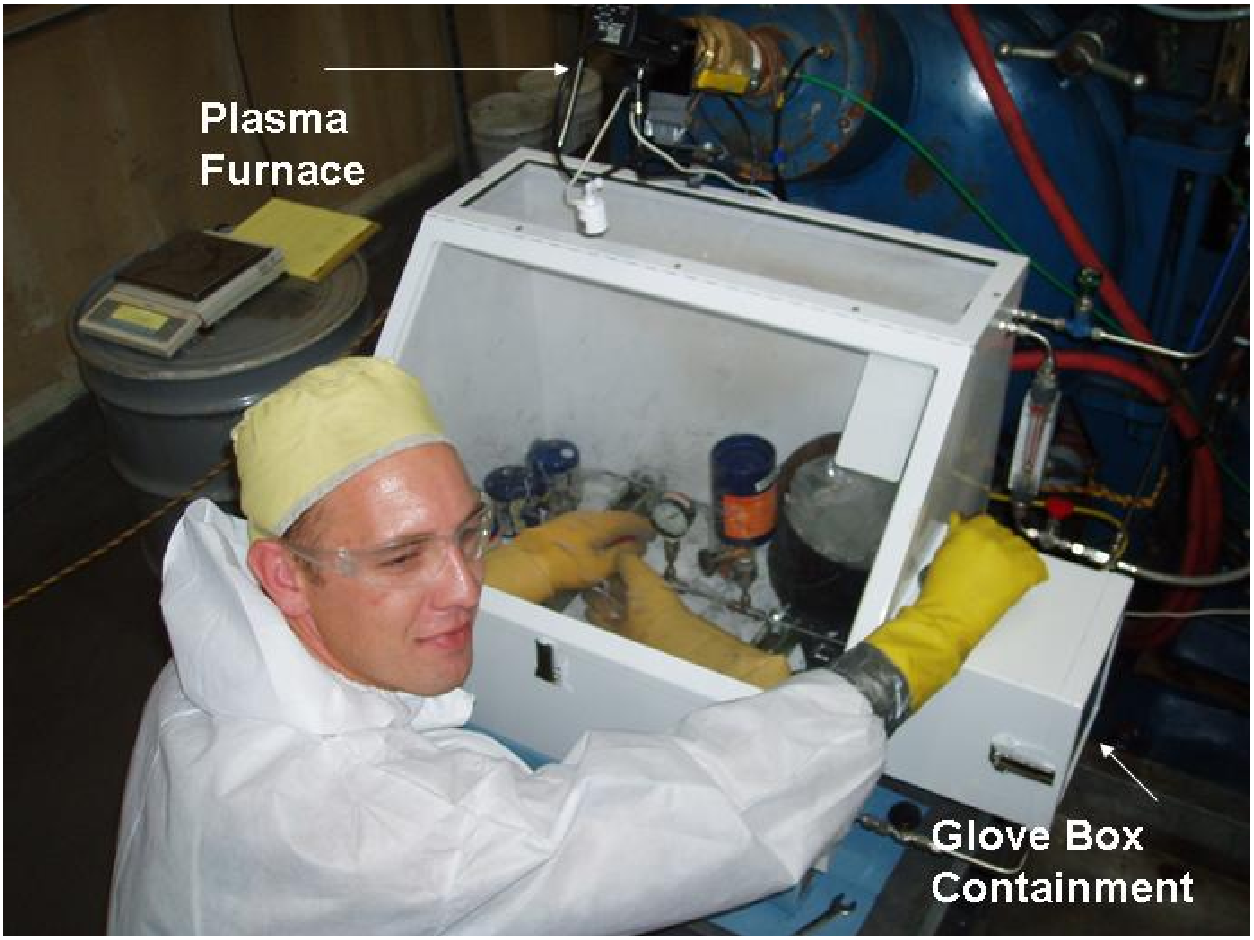

Fig. 3. Plasma furnace's containment system

THERMALLY DESTROY

The waste container is then connected to the Plasma Furnace feed system for thermal destruction. The waste container is placed in an inverted position inside the glove box. Fig. 4 depicts the feed assembly's piping and instrumentation diagram.

While the feed valve is open, nitrogen gas is purged through the feed assembly. The feed valve is then closed to slightly pressurize the waste container with the nitrogen gas bubbling up through the denser liquid waste. The feed valve is then re-opened; the now pressurized container pushes liquid waste into the Plasma Furnace. This process is repeated until the waste container is empty.

The glove box is ventilated directly to the Plasma Furnace which is pressure controlled to maintain a vacuum of -4" W.G. In the event of an inadvertent leak, the waste is either contained within the glove box's inerted atmosphere, or exhausted directly to the Plasma Furnace, where thermal destruction takes place.

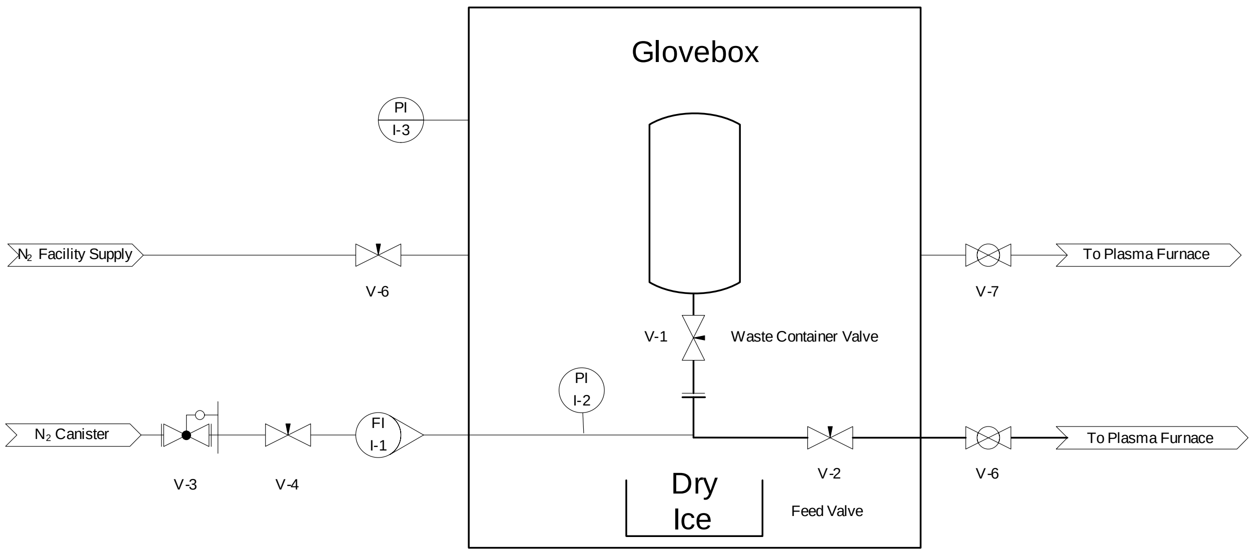

Fig. 4. Feed system’s piping and instrumentation diagram

EMPTY CONTAINER DISPOSAL

The container is visually inspected to verify that it is empty. If the container is not empty, the remaining material is reprocessed. The empty container is super-compacted and disposed of as low-level radioactive solid waste.

HAZARDS AND OPERABILITY ANALYSIS

A Hazards and Operability Analysis (HAZOP) was conducted during the early stages of the feed system’s design development. This analysis found the feed system can safely process radioactive reactive waste without undue risk to the public, operating personnel, environment, or facility.

The HAZOP was conducted using a team approach with Engineering and Operations personnel. The feed system’s piping and instrumentation diagram (see Fig. 4) served as the design media for conducting the HAZOP. A summary is listed in Table I.

Table I. Reactive Waste Feed System HAZOP Analysis

Process Step	Single Point Failure Mode	Credible Risks	Safeguards
I. Receive			
Receive and inspect waste container T-1.	Container dropped.	Container breach releases reactive waste into occupied space.	Wastes are contained in the original vendors' containers.
Check that waste container valve V-1 is closed.	Valve is failed open.	Release of reactive waste into occupied space.	Container has sealed end cap.
II. Contain			
Purge/inert glove box with nitrogen and carbon dioxide.	High nitrogen pressure.	Pressurizes glove box.	Pressure indication on glove box.
Place waste container T-1 into glove box.	Glove box fogged due to moisture/CO_2 condensation.	Operator can't see inside glove box and can't perform tasks safely.	Nitrogen purge removes oxygen and moisture from glove box.
Nitrogen purge feed line to the Plasma Furnace	Line is not adequately flushed with nitrogen.	Waste reacts in feed line.	Flow and pressure indication on line ensures adequate purge.
Disconnect the waste container's end cap.	Waste container valve V-1 failed open and cannot be quickly resealed.	Release of reactive waste into glove box.	Glove box under vacuum via ventilation to Plasma Furnace. Nitrogen purge removes oxygen and moisture from glove box. Container can be placed in dry ice (CO_2) to freeze contents.
Connect waste container to Plasma Furnace feed system.	Leaky connection	Release of reactive waste into glove box.	Connection is pressure tested prior to use.
III. Thermal Destruction			
Open the waste container's valve V-1.	Waste container valve is failed closed.	Container does not empty.	Container is inspected prior to removal from glove box.
	Waste container valve opened too quickly.	Potential temperature spike in Plasma Furnace.	Valve is a needle valve and can only be opened slowly.
Open and close feed valve V-2 until container is empty.	Waste contents are frozen.	Container does not empty.	Container is inspected prior to removal from glove box.
	Feed line is plugged.	Container does not empty.	Container is inspected prior to removal from glove box.
	High nitrogen pressure.	Waste container breach leading to release of reactive waste into occupied space.	Regulate nitrogen pressure to feed system to $\leq$5 psig. Redundant pressure indication on feed line. Valve is a needle valve and can only be opened slowly.
IV. Container Disposal			
Disconnect waste container. Open waste container valve V-1 and visually inspect.	Waste container is not empty.	Release of reactive waste into glove box.	Glove box under vacuum via ventilation to Plasma Furnace. Nitrogen purge removes oxygen and moisture from glove box.

Each process step was evaluated using failure modes (i.e., guide words) to identify credible risks. If the team believed the failure mode led to a credible risk, safeguards were identified and implemented to prevent or mitigate the risk.

CONCLUSION

The primary risk found during the HAZOP included a container breach or major leak that released radioactive reactive waste into an occupied space. The safeguards added to the feed system design to substantially mitigate this risk included:

1. Handling the waste container in an inerted glove box.
2. Cooling a breached container using dry ice (i.e., CO_2).
3. Ventilating the glove box to Plasma Furnace process.