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Repackaging Of Two Bulged Crimp Sealed Cans Containing Plutonium Bearing Materials

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ABSTRACT

Two cans containing plutonium bearing materials were found during radiography surveillance activities to be bulged. The cans had been stored in DOT 6M shipping containers at the Savannah River Site. The material in the first can (Item CZA96-179) was packaged can/bag/can configuration with the inner and outer cans being crimp sealed. The crimp sealed innermost can was clearly deformed from the radiography picture taken for surveillance purposes. This material had been stored in the shipping container since the mid 1970’s. The second can (Item 50014440) contained plutonium bearing material of a different origin. The material had been repackaged at the Savannah River Site in the mid 1990's, and the repackaged can was stored in a 6M shipping drum.

A special puncturing tool, which secured the can and allowed for a very controlled puncture of both outer and inner cans was used in a glovebox. The glovebox has a dry air system and an argon supply. The puncturing tool utilized a non-sparking punch and an argon purge. The cans were repackaged into filtered outer cans. A description of the puncturing tool, repackaging activities, and of the materials will be provided.

I. INTRODUCTION

The first bulged can (Item CZA96-179) was discovered in December 2001 during a scheduled radiography surveillance of a Shipping Drum. The drum contained two food pack cans from account CZA96 that was packaged in 1974 at the Argonne National Laboratory East. The cans were positioned in the following top to bottom order in the 2R: Item CZA96-179A, dummy spacer can, then Item CZA96-179. The item was packaged in the can-bag-can configuration. The inner can top and bottom of Item CZA96-179 was outwardly bulging. The outer can did not show any signs of deformation. Item CZA96-179A and the dummy spacer can which were also in the drum showed no deformation.

Based on shipper records, Items CZA96-179 and CZA96-179A were both metal of the same material makeup with one exception, CZA96-179 was greater than 20-mesh and CZA96-179A was less than 20-mesh material. Both items were packaged in a can-bag-can configuration. Information from the scrap declaration showed the material came from Argonne National Laboratory East in 1975 via Hanford and was an alloy of 45% iron, 33% plutonium, and 13% enriched uranium with some unspecified quantities of chlorine, aluminum, carbon, tin, oxygen, and very small glass fragments present. The material was also described as “passivated Pu/EU alloy material” which meant that the metal was oxidized in a controlled manner to some degree to prevent uncontrolled oxidation of the metal when the inner can was opened. Unfortunately there was no documentation stating how much oxidation was done to the material. Efforts to contact anyone with specific knowledge of the material at Argonne National Laboratory East were unsuccessful. Although it was learned that the glass came from glass molds that were being used for casting at the time.

The second bulged can (Item 50014440, originally Item 5228) was discovered in September 2002 during the unpackaging of a shipping drum where the outer can was visibly bulged. The item was previously identified as being mechanically deformed based on radiograph images of the drum and repackaged in 1994. The bulged item was from 741 account HUA-20 which contained fuels grade plutonium oxide and depleted uranium oxide that was from the Fast Flux Test Facility (FFTF) fuel fabrication activities at Hanford and possibly Nuclear Materials and Equipment Corporation (NUMEC).

In February of 1994, Item 5228 was identified as being deformed by Operations personnel. The item was deformed on the top and bottom equally. The item was packaged in a can –PVC bag-can configuration. In order to determine the cause of the apparent pressurization, the item was sent to the Savannah River Technology Center (SRTC) for analysis.

Extensive testing was performed by SRTC on Item 5228, including sampling of the gas in the can, obtaining pressure readings of the can, sampling and analysis of the PVC bag, thermogravimetric analysis (TGA), and x-ray diffraction (XRD) of the oxide. It was determined that the cause of the can deformation was a result of internal gas generation, not mechanical failure, caused by both radiolytic and thermal degradation of PVC. No abnormalities were identified in the material. The item was repackaged in a slip lid can-polyethylene (PE) bag-sealed food pack can in October 1994 and labeled as 50014440. Item 50014440 was sent back in 1995 and stored in the shipping drum until September 2002.

II. PUNCTURING DEVICE

Several different ideas were evaluated to determine the best device to puncture the outer and inner cans of Item CZA96-179. Before determining which device to fabricate, each design idea was evaluated against the following criteria: safety, ease of use in a glovebox, size, stability, efficiently in performing the task, fit into glovebox, and cost. A horizontal flanged pipe device that punctures the can from the side utilizing a non-sparking beryllium copper alloy punch, which is screwed into the can by a bolt, was selected. It is a sealed unit with a connection for an argon purge and exhaust vent. The device also has inside supports to keep the can from rolling when the punch interfaces with the can.

The Argonne National Laboratory East data stated that Item CZA96-179's outer can was a 46 oz Juice Can (404 x 700), the inner can is a 19 oz #2 Can (307 x 409), and was in a can-PVC bag-can configuration. However, the item was packaged in the early 1970's and there could have been some difference in the cans used then verses the cans used to evaluate the can puncture device. Therefore several different can sizes, wall thickness', and configurations were evaluated.

The can puncture tests were successful. A brass punch was tried in an effort to find a non-sparking substitute for the beryllium copper alloy punch. As expected the brass proved too soft to be used as a punch, because it bent when it came in contact with the steel food pack can.

Plastic was expected to potentially cause some problems, such as binding, with the punch however, the tests demonstrated it was not an issue. Even an excessive amount of plastic did not prevent the punch from going through the can. Other tests were made of nonstandard can configurations, which involved dented, fully opened, and partially opened cans. These too did not pose a problem for the can puncture device and were successfully punctured without losing their shape. Likewise there was no difference in whether the can had a ribbed wall, plain wall, or thick wall.

In theory a bulging can is the result of pressurization assumed to be from the generation of hydrogen gas inside the can. Likely sources of hydrogen are plastic bagging (especially if it is in contact with material), radiolytic reactions with moisture, metal reactions with moisture (oxidation), or a breakdown of contaminates such as organics. Based on packing information, there was no plastic in contact with fissile material. Additionally, water was an unlikely source since a nominal amount of adsorbed moisture would produce more pressure than indicated.

The pressure of the Item CZA96-179's inner can was estimated to be about 25 – 35 psig based upon food pack can test data. Item 5228 was estimated to be pressurized between 13.5 – 16.5 psig with both the top and bottom deformation extending beyond the lip seal. Item 50014440 was not deformed to the degree that Item 5228 was, with only the top lid deformed slightly above the lip seal on one side. The bottom only showed minor bulging which was difficult to detect.

Because the radiograph indicated no sign of bulging with Item CZA96-179's outer can three scenarios were possible: the inner can had not leaked, the pressure in the outer can was not enough to show deformation if the inner can had leaked, or the outer can seal was bad.

A spreadsheet analysis was performed to determine what hazard Item CZA96-179 would pose assuming specified pressures within the cans. Using the ideal gas law equation, the moles and percentage of hydrogen were calculated as a function of pressure from 0 to 50 psig. At 45 psig the hydrogen concentration was above the UFL (Upper Flammability Limit) for hydrogen in air.

The gas mixture for Item CZA96-179 was assumed to be flammable (35% hydrogen); however, the total energy released from combustion would be relatively small (6.7 kJ). Nevertheless the glovebox ventilation was sufficient to rapidly dilute the hydrogen below LFL (Lower Flammability Limit) when the can was punctured.

Of the three scenarios developed for CZA96-179, scenario 2 applied to Item 50014440. Thus the handling of Item 50014440 is bound by the analysis for CZA96-179.

In the calculations that were performed on the time to vent and the thrust generated by the gas jet as a function of the diameter of the hole created, it was assumed that both the inner and outer cans were at a gauge pressure of 2 atm

(29.4 psig) and the maximum thrust was no greater than 1.6 lb_f, but in most cases it was less than 1.0 lb_f. The amount of thrust calculated did not pose a problem with CZA96-179 which only weighed 1 lb. The design of the puncturing tool and the horizontal orientation of the can when punctured was expected to keep the maximum expected thrust much less than that required to move CZA96-179.

The expected thrust of Item 50014440 when punctured was calculated to be the same as what was calculated for CZA96-179 because: 1) the pressure assumption in the calculation is greater than the estimated pressure in item 50014440, 2) item 50014440 weighs more than CZA96-179 (2 lb. vs. 1 lb.) resulting in a higher required force to move the can, and 3) the same puncturing tool and orientation will be used as in the puncturing of CZA96-179.

Due to the inner can height difference between CZA96-179 and Item 50014440 as slip lid can lid was placed vertically against the can bottom plate prior to the placement of Item 50014440 in the Can Puncture Tool to help ensure the inner can of Item 50014440 was punctured. The addition of a slip lid can lid was determined not to affect the thrust or movement of Item 50014440 when punctured.

The puncturing of both items was controlled so that the lower flammability limit (LFL) of hydrogen was not exceeded while puncturing items. With a 404x700 outer can pressure of 18 psig, the can would have to vent for 1 second in order to ensure sufficient dilution from the glovebox ventilation. This calculation bounds Item 50014440 because the volume of a 404x700 outer can is larger than the outer can of Item 50014440. Also, the pressure corresponding to the vent time above is greater than the estimated pressure in Item 50014440. CZA96-179 had a 10 second vent time between 3 punch revolutions to provide adequate vent time, which applies to Item 50014440 as well.

III. REPACKAGING OBSERVATIONS

In order to puncture Item CZA96-179 with the Can Puncture Device a existing facility repackaging procedure was modified temporarily by adding steps on how to operate the device. Since the material contained plutonium metal the following events were possible: 1.) plutonium metal-oxygen reactions that result in oxidation of the material, 2.) plutonium hydride reactions, and 3.) can failures from internal decomposition. As a result combustible material was kept away from the material and magnesium oxide sand was readily available when the food pack can was opened using existing proceduralized safety practices.

The puncturing and opening of Item CZA96-179 with the bulged inner can was successfully completed on May 20, 2002. The Can Puncture Tool worked as expected. The outer can, PVC bag and inner can were punctured on the first attempt. The inner can appeared to be completely sealed despite being significantly bulged on both the top and bottom ends. There were no abnormal events when the item was punctured or when the cans were opened. The material looked like brown rocks and powder; white rocks and powder (the largest white rock was reduced to all white power); some small blue/gray pellets; and some small blue/gray rectangle strips. A representative sample of this material was collected for laboratory analysis.

After the item was punctured and the inner can was opened, the material was repackaged in a slip lid can, bagged out of the cabinet, and placed into an outer filtered can. A filtered outer can was chosen since the cause of pressurization is unknown. Thus, if the material is still capable of gas generation the pressure would be relieved via the leaky slip lid inner can and outer filtered can.

Item 50014440 was punctured on October 2, 2002. The Can Puncture Tool worked as expected and punctured the inner can on the first attempt. The inner can was surrounded by two bags which were in excellent condition. The inside and outside of the inner can were also in excellent condition. The material was very dark, almost black oxide which was sieved and repackaged in a slip lid can-PE bag-filtered outer can configuration. Based on these observations, it is believed that Item 50014440 bulged due to adsorbed moisture.

IV. CONCLUSIONS

The facilities surveillance program that identified the two bulged cans was key to engineering personnel knowing what condition the cans were in, evaluating the potential hazards associated with each can and developing a plan to safely open the cans. As a result, the facility demonstrated its ability to safely handle pressurized items and allowing for any hazardous gas mixtures to escape passively using the Can Puncture Tool. Another reason for the success with processing these two items was the numerous dry runs preformed with the personnel involved in operating the can puncture device.

The current design of the Can Puncture Tool does not allow for a gas sample to be taken or for determining the actual pressure of the can. However, if the tool is used again plans are to try and modify the device to take a gas sample and determine the can pressure.

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