This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-96SR18500 with the U. S. Department of Energy.

PRESSURE INDICATION OF 3013 INNER CONTAINERS USING DIGITAL RADIOGRAPHY

S. J. Hensel
Westinghouse Savannah River Co.

ABSTRACT

Plutonium bearing materials packaged for long term storage per the Department of Energy Standard 3013 (DOE-STD-3013) are required to be examined periodically in a non-destructive manner (i.e. without compromising the storage containers) for pressure buildup. Radiography is the preferred technology for performing the examinations. The concept is to measure and record the container lid position. As a can pressurizes the lid will deflect outward and thus provide an indication of the internal pressure. A radiograph generated within 30 days of creation of each storage container serves as the baseline from which future surveillance examinations will be compared. A problem with measuring the lid position was discovered during testing of a digital radiography system. The solution was to provide a distinct feature upon the lower surface of the container lid from which the digital radiography system could easily track the lid position.

I. INTRODUCTION

The Department of Energy (DOE) has a standard for Long Term Storage of Plutonium Bearing Materials (DOE-STD-3013-2000) [1]. This standard requires plutonium bearing materials to be packaged into a welded stainless steel inner container (e.g. inner 3013) which is then packaged inside a welded outer stainless steel container (e.g. outer 3013). The standard requires that the inner 3013 container allow for a non-destructive indication of a buildup of internal pressure at less than 790 kPa (100 psig). The build up of pressure in the 3013 inner container will be evaluated during surveillance.

The 790 kPa (100 psig) threshold was chosen to minimize false positives (improper indication that pressurization has occurred) yet be well below pressures at which integrity of the inner container may be compromised. Radiography is the preferred non-destructive method for pressure indication.

At the Savannah River Site (SRS) and Hanford Site the 3013 inner containers are called Bagless Transfer Cans (BTCs). BTC's may be short (two stacked fit within an outer 3013) or tall (one per 3013). The outer diameter of a BTC is 11.68 cm (4.6 in.), and the height of short and tall BTC's are 13.72 and 22.86 cm (5.4 and 9.0 in.), respectively. The lids used for both short and tall BTC's are identical. The lid thickness of these cans is 3.05 mm to 3.30 mm (0.120 to 0.130 in.). As such, 790 kPa (100 psig) pressurization results in about a 0.38 mm (15 mil) deflection. A 0.38 mm (15 mil) deflection is well above the 0.05-0.08 mm (2-3 mil) threshold of detection for a digital radiography (DR) system. A DR system was designed, and constructed at SRS to support 3013 packaging operations.

II. RADIOGRAPHY AND DEAD ZONE

Several empty BTC's were pressurized and the lid deflections were measured for each BTC at several pressures using both a dial indicator micrometer and digital radiography. The mechanical measurements are taken on the lid top, while the DR system tracks the lid bottom surface. The objective of the test was to validate the radiography system. The BTC lids are welded such that in general they are concave (downward bulging) with the center position being the low point. As the can pressurizes, the lids flatten out. Typically, the lids remain concave even at 790 kPa (100 psig). However, during testing the measured DR position of the lid became dampened as the lid became nearly flat (see data as indicated by triangle symbols in Figure 1). In reality the lid approached a nearly flat position during pressurization (starting from a concave or downward bulging position). However, the DR overestimated the concavity of the lid (that is how much the lid position is below flat) and thereby underpredicted the change in lid position during pressurization. This non-conservative measurement during surveillance could lead to a false negative (conclusion that pressurization has not occurred or under estimation of pressurization, see triangle symbols in Figure 1 above 100 psig). The dampened measured response of the lid is referred to as the DR "dead zone". The onset and extent of the dead zone is a function of lid tilt and non-uniformity (e.g. non-uniform lid thickness). Each BTC has its own unique dead zone.

The lid of the BTC was re-designed after DR pressure testing of dummy BTC's revealed the "dead zone". The onset of the dead zone has been conservatively estimated to begin at about 0.29 mm (11.5 mils) concavity. The dead zone is an artifact of the lack of precision associated with BTC manufacturing and welding. When the lid becomes nearly flat the imperfections associated with the lid construction and welding overwhelm the DR system's ability to accurately locate the position of the lid center (this applies to both the top and bottom surface of the BTC lid). The DR system inaccurately reports the position of the lid. Pressure testing of dummy BTC's has revealed that when sufficient concavity exists (i.e. the lid is not very flat), the DR system does accurately detect changes in lid position.

A plot of mechanical and DR measurements of a BTC during pressure testing is shown in Figure 1. DR measurements based upon the lid top and bottom surfaces are provided. The dead zone is that region where neither the top or bottom surface responds to pressure increases. As seen in Figure 1, once the lid becomes sufficiently convex (upward bulging) the top surface accurately tracks the pressure response of the lid.

III. LID DESIGN FIX

The BTC lid was re-designed in order to ensure that the DR system can accurately determine the lid position from baseline (initial BTC radiograph) through 790 kPa (100 psig) pressurization. The re-design consists of a "button" on the lid bottom. The 12.7 mm (0.5 in.) diameter button is centered on the lid bottom and is 1.52 mm (60 mils) thick. The bottom of the button is the indicator of the relative position of the BTC lid. The button was created during machining of the BTC lid, and as such it is inherent to the lid.

Four prototype button designed BTC lids were manufactured, welded on dummy cans, and pressure tested. A summary of the tested prototypes is provided in Table 1. Both dial indicator micrometer and DR measurements were taken. The initial baseline position of the button bottom is shown in Table 2. This position is the distance of the button bottom from the lid bottom at the weld. Results for lids 1 through 4 are plotted in Figures 2 through 5.

Table 1: Summary of Button Lid Prototypes

Lid	P Range (psig)	Button Thickness (mils)	Lid Thickness (in.)	Button Dia. (in.)
1	0 - 125	60	0.120	0.67
2	0 - 125	40	0.120	0.34
3	0 - 150	60	0.140	0.67
4	0 - 225	60	0.100	0.67

Table 2: Baseline Position of Lid Prototype

Lid	Baseline Position (mils)
1	-83.4
2	-53.0
3	-65.5
4	-90.0

IV. TEST RESULTS

The test results in Figures 2 through 5 indicate that the DR system and mechanical micrometer measurements compare well (micrometer measurements are solid lines with filled circle symbols). In addition, the pressure response curves appear as expected, thus the presence of the button does not have a significant effect on the BTC lid response to pressure. Lid number 4 is very thin (below specifications and was pressurized to 1653 kPa (225 psig). This resulted in a deflection of nearly 3.05 mm (120 mils) as measured by the micrometer. The baseline position (where zero is flat and negative implies a concave lid) of lid four was -2.29 mm (-90.0 mils), which is less than the deflection at 1653 kPa (225 psig). At 1653 kPa (225 psig) the lid is convex to the extent that the bottom of the button is above the zero, and as seen in Figure 5 the measured DR deflection is underestimated. The button design provides a good indicator of lid position using the bottom surface of the lid as long as the button bottom remains below the zero position.

V. CONCLUSIONS

Creating a small button on the lower surface of the inner 3013 container lid eliminated the dead zone problem. The button is inherent to the lid (as opposed to welding it on after manufacture). All four prototype designs proved to be successful during testing. In addition, there were no adverse effects of the buttons discovered during testing. The 12.7 mm (0.5 in.) diameter 1.52 mm (60 mil) button design was implemented at the Savannah River Site for its 3013 containers.

VI. FIGURES

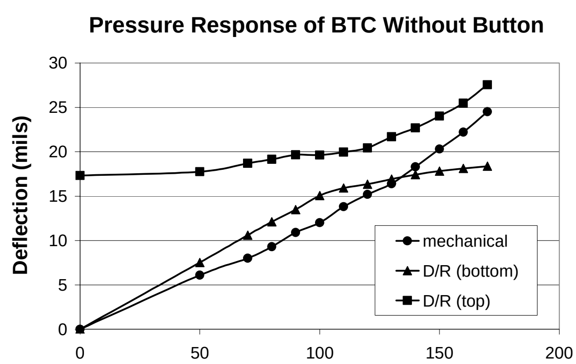

Figure 1

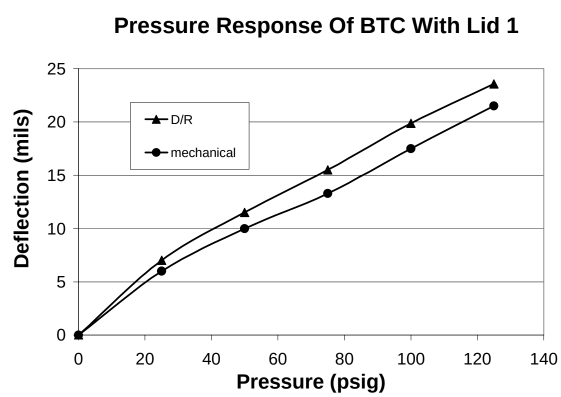

Figure 2

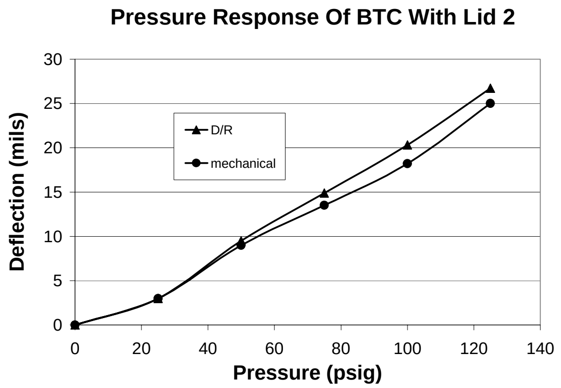

Figure 3

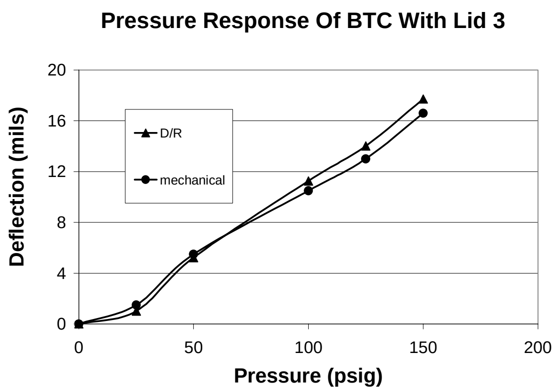

Figure 4

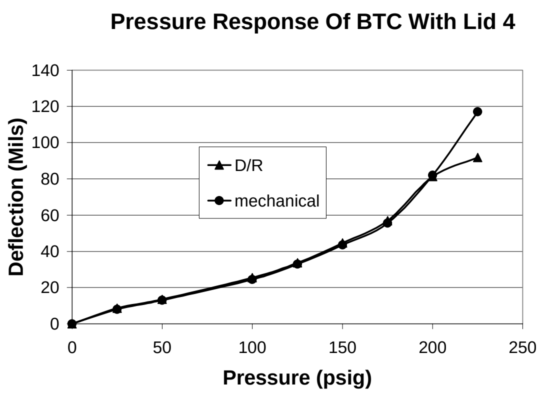

Figure 5

VII. ACKNOWLEDGMENTS

The information contained in this article was developed during the course of work under Contract No. DE-AC09-96SR18500 with the U.S. Department of Energy.

VII. REFERENCES

1. DOE-STD-3013-00, "Stabilization, Packaging, and Storage of Plutonium Bearing Materials", September, 2000.