Impact of Different Standard Type A7A Drum Closure-Ring Practices on Gasket Contraction and Bolt Closure Distance– 15621

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ABSTRACT

The Department of Energy, the Savannah River National Laboratory, several manufacturers of specification drums, and the United States Department of Transportation (DOT) are collaborating in the development of a guidance document for DOE contractors and vendors who wish to qualify containers to DOT 7A Type A requirements. Currently, the effort is focused on DOT 7A Type A 208-liter (55-gallons) drums with a standard 12-gauge bolted closure ring.

The U.S. requirements, contained in Title 49, Part 178.350 "*Specification 7A; general packaging, Type A specifies a* competent authority review of the packaging is not required for the transport of (Class 7) radioactive material containing less than Type A quantities of radioactive material. For Type AF drums, a 4 ft. regulatory free drop must be performed, such that the drum "suffers maximum damage." Although the actual orientation is not defined by the specification, recent studies suggest that maximum damage would result from a shallow angle top impact, where kinetic energy is transferred to the lid, ultimately causing heavy damage to the lid, or even worse, causing the lid to come off.

Since each vendor develops closure recommendations/procedures for the drums they manufacture, key parameters applied to drums during closing vary based on vendor. As part of the initial phase of the collaboration, the impact of the closure variants on the ability of the drum to suffer maximum damage is investigated.

Specifically, closure testing is performed varying: 1) the amount of torque applied to the closure ring bolt; and, 2) stress relief protocol, including: a) weight of hammer; and, b) orientation that the hammer hits the closure ring. After closure, the amount of drum lid gasket contraction and the distance that the closure bolt moves through the closure ring is measured.

INTRODUCTION

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Type A fissile drum packages are required to undergo a series of tests that simulate both normal conditions of transport (NCT) and hypothetical accident conditions (HAC) as specified in 10 CFR Part 71. In the past, the U.S. Department of Energy (DOE) conducted an extensive program, which qualified Type A radioactive material packagings. As part of that effort the Type A7A standard 208-liter (55-gallon) drum with a standard 12-gauge bolted closure ring. A figure of the drum is shown in Figure 1.

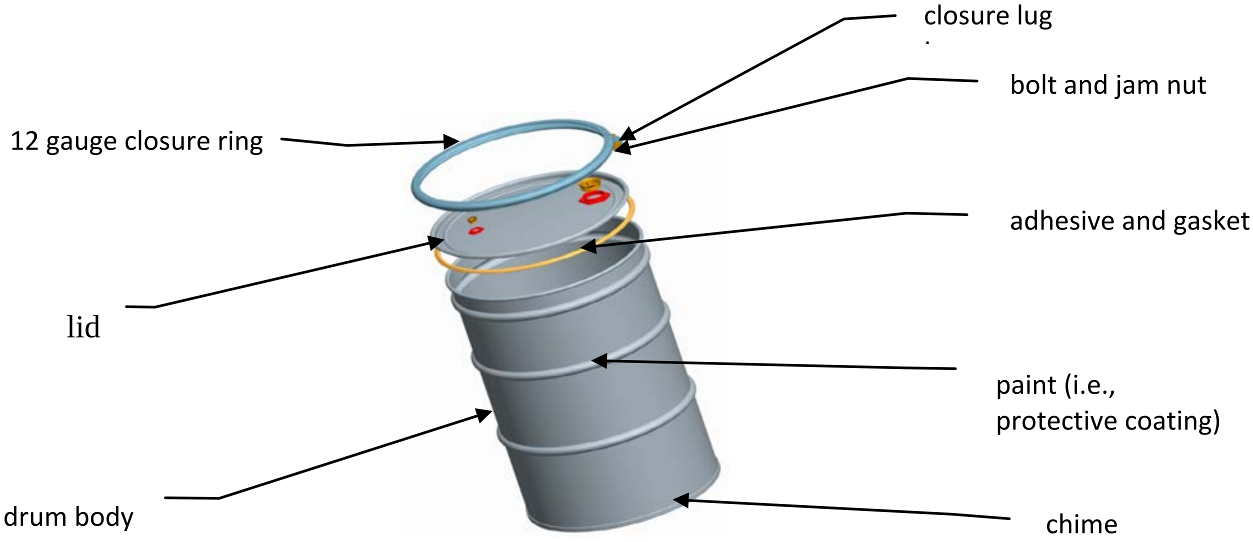


Figure 1. **Type A7A standard 208-liter (55-gallon) drum with standard 12-gauge bolted closure ring**

From 1975 through 1990 the U.S. Department of Energy (DOE) conducted, through several of its operating contractors, an evaluation and testing program to qualify Type A radioactive material packagings per U.S. Department of Transportation (DOT) Specification 7A (DOT-7A) of the Code of Federal Regulations (CFR), Title 49, Part 178 (49 CFR 178). The program was administered by the DOE, Division of Transportation and Packaging Safety, DOE/EH-33.3, out of DOE-Headquarters (DOE-HQ) in Germantown, Maryland. The program was known as the U.S. DOE DOT-7A Program (Ref. 1). Drums represented a significant portion of the testing.

The evaluation and testing program which qualified the packages as DOT 7A packages was documented the "DOE 7A Blue Book." Work was originally published in 1987 "*DOE Evaluation Document for DOT-7A Type A Packaging*" by Monsanto Research Corporation - Mound Laboratory (MLM), Miamisburg, Ohio, for the Department of Energy, Security Evaluation Program (DP-4) and later as the "*Test and Evaluation Document for DOT Specification 7A Type A Packaging*" by Westinghouse Hanford Company in Richland, Washington.

Most of the historic testing (i.e., circa 1970) assumed that the most unfavorable orientations were those that allowed the maximum amount of available kinetic energy to be used for package deformation. Therefore, drop test orientations of concern were considered to be the following: 1) Top-Down; 2) Bottom-Down, 3) Side; and 4) Center of Gravity (C.G.) Over Top-Corner. These are shown in Figure 2.

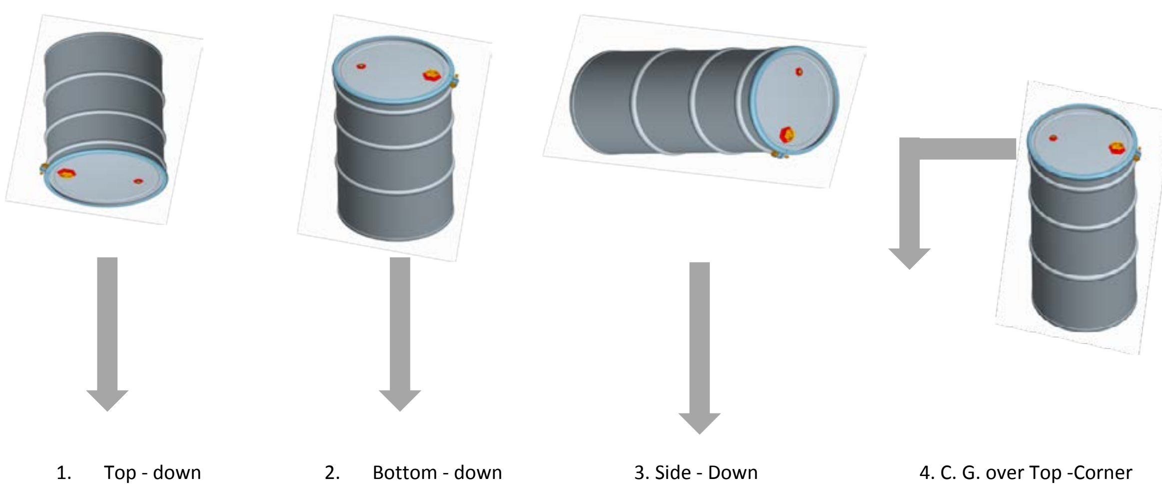


Figure 2. Historic Drop Testing Orientations

Based on these concerns (i.e., circa 1970), military type standard drums were often recommended because of their strength and close tolerances. Curls of military drums were 0.45 in. (1.14 cm) larger than those of typical DOT Specification drums. Closure rings were required to be at least 12 gauge and have dropped–forged lugs, with bolts of high strength steel. It was recommended that closure rings be tapped with a soft hammer during torqueing in order to relieve friction forces around the periphery of the closure. This was to be performed while the closure bolt was tightened (Ref. 2 and 3). Focusing on the same concerns during accident conditions, the D0T-7A Type A Packaging Design Guide was developed (Ref. 4) and well as the associated Red Book (Ref.1) and Blue Book (Ref. 5).

Recently, it has been suggested that shallow angle top impact, where a portion of the translational kinetic energy of the package is transformed into rotational kinetic energy at impact, would be a likely orientation that would lead to failure of drum packages that use a standard bolted closure ring (Ref. 6). Under this scenario, the shallower the angle, more energy goes into rotation, but also a greater impact load becomes transferred to the lid plane. The lid in-plane force increases with decreasing drop angle until slipping occurs at the point of contact and then the force drops off. Depending on the in-plane load and when slipping occurs, the lid can buckle or worse, come-off and release the contents. Since, this concern focuses on the lid coming off, to eliminate any potential difference based on the variants, the impact of the torque (force) and stress relief methods (hammer size and orientation) during closure on: 1) amount of drum lid gasket contraction and 2) amount of closure ring bolt distance were determined.

DISCUSSION AND METHODS

In general, a co-ordinate measuring machines (CMMs) is a mechanical system designed to move a measuring probe to determine coordinates of points on a workpiece surface. CMMs provide precise measurements of objects for design, testing, assessment, profiling, and reverse engineering of parts. CMMs are comprised of three main components: the machine itself, the measuring probe, and the control or computing system with appropriate measuring software. After placing a work piece on the machine table, a probe is used to measure different points on it by mapping the x, y, z coordinates. The probe operates either manually via an operator or automatically via a control system. These points are then uploaded to a computer interface where the data can be manipulated.

When determining how the amount of gasket contraction would be measured, as well as how closure ring bolt distance, one of the major concerns was ensuring that an accurate measuring method was applied. After some deliberation, because of the vendors’ stated accuracy range for measurements made, was decided to use a coordinate measuring machine (CMM) to measure 1) gasket contraction and 2) closure ring distance.

Therefore, the following equipment was used during the testing:

- Three DOT 7A Type A 208-liter (55-gallon) open head carbon steel drums with standard 12 gauge bolted closure-rings and lids
- A calibrated 0 - 135.58 N m (0-100 ft-lbs) torque wrench
- Calibrated coordinate measuring machine (CMM) - Arm with software
- One (small) 0.67 kg (1.5 lbs) rubber mallet, and one (larger) 1.4 kg (3 lbs) plastic coated mallet

An overview of the procedure steps is as follows:

1. Select three drums, open each drum; fully remove lid and closure ring. Inspect lid and closure ring seal for any damage and note as required. Identify drum, lid and closure of each drum.
2. Torque drum to finger tighten to 27 N m (20 ft-lbs), which is the baseline, 47 N m (35 ft-lbs) and 61 N m (45 ft-lbs).
3. Caliper orientation with CCM, both before and after stress relief.
4. Stress relief shall occur by hitting closure ring with appropriate mallet (4 hits, 1 per quadrant)
5. Following each complete closure, fully remove lid from drum, inspect seal, and allow seal to expand for at least 30 minutes. Tighten to 27 N m (20 ft-lbs) without striking and perform baseline measurements.
6. Repeat for other 2 drums.

The top of the three drums were marked with the gasket compression measurement points shown in Figure 1. Table1 shows the test matrix used.

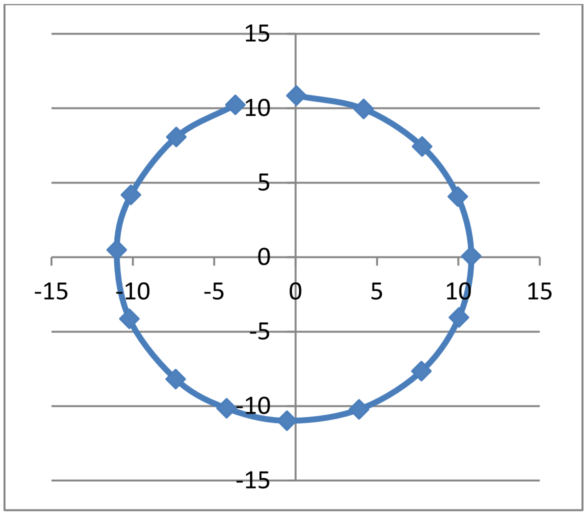


Figure 1. Location of Gasket Compression Measurement Points

Table 2. Test Matrix Impact of Torque and Stress Relief on Gasket Compression and Bolt Closure Distance

	Drum 1	**Drum 2**	**Drum 3**	**Drum 4**	**Drum 5**	**Drum 6**
Mallet	1.4 kg (3 lbs)	1.4 kg (3 lbs)	1.4 kg (3 lbs)	0.67 kg (1.5 lbs)	0.67 kg (1.5 lbs)	0.67 kg (1.5 lbs)
Stress Relief Impact Angle	parallel	90°	45°	parallel	90°	45°
Torque	27 N m (20 ft-lbs) (no stress relief)					
	47 N m (35 ft-lbs) (before and after stress relief) with applicable mallet					
	61 N m (45 ft-lbs) (before and after stress relief) with applicable mallet					

Using the CCM, the gasket contraction was determined by measuring individual 3D data points along the upper surface of the lid as shown in Figure 2 (i.e., using an articulating arm to trace the points resulting in the automatic collection of the data). Because the inside surface of the closure lug with the bolt could not always be reached with the probe, the location of the bolt head was measured.

RESULTS

The measured gasket compression (i.e., lid height) using the CMM is shown by Figure 3.

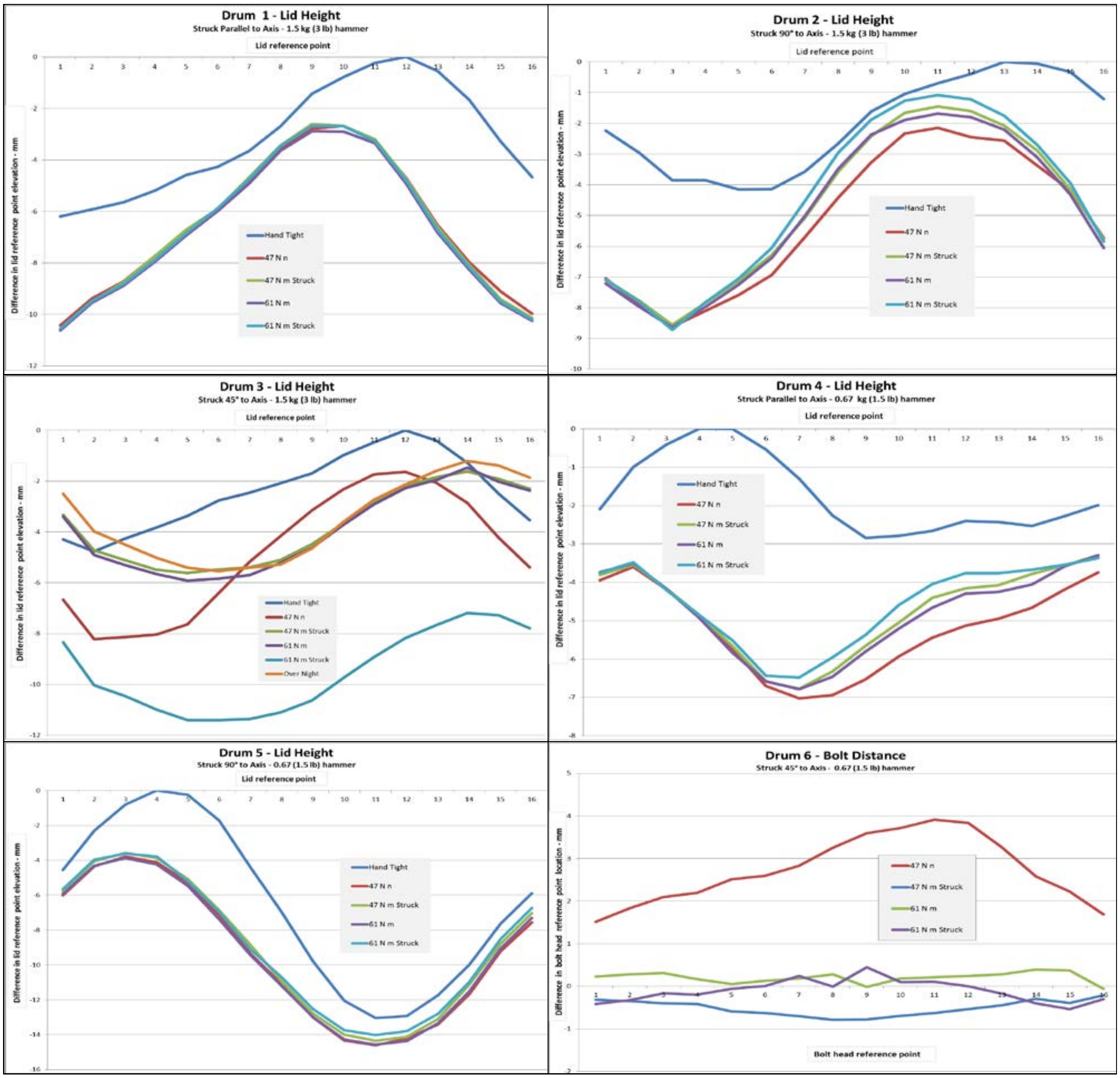
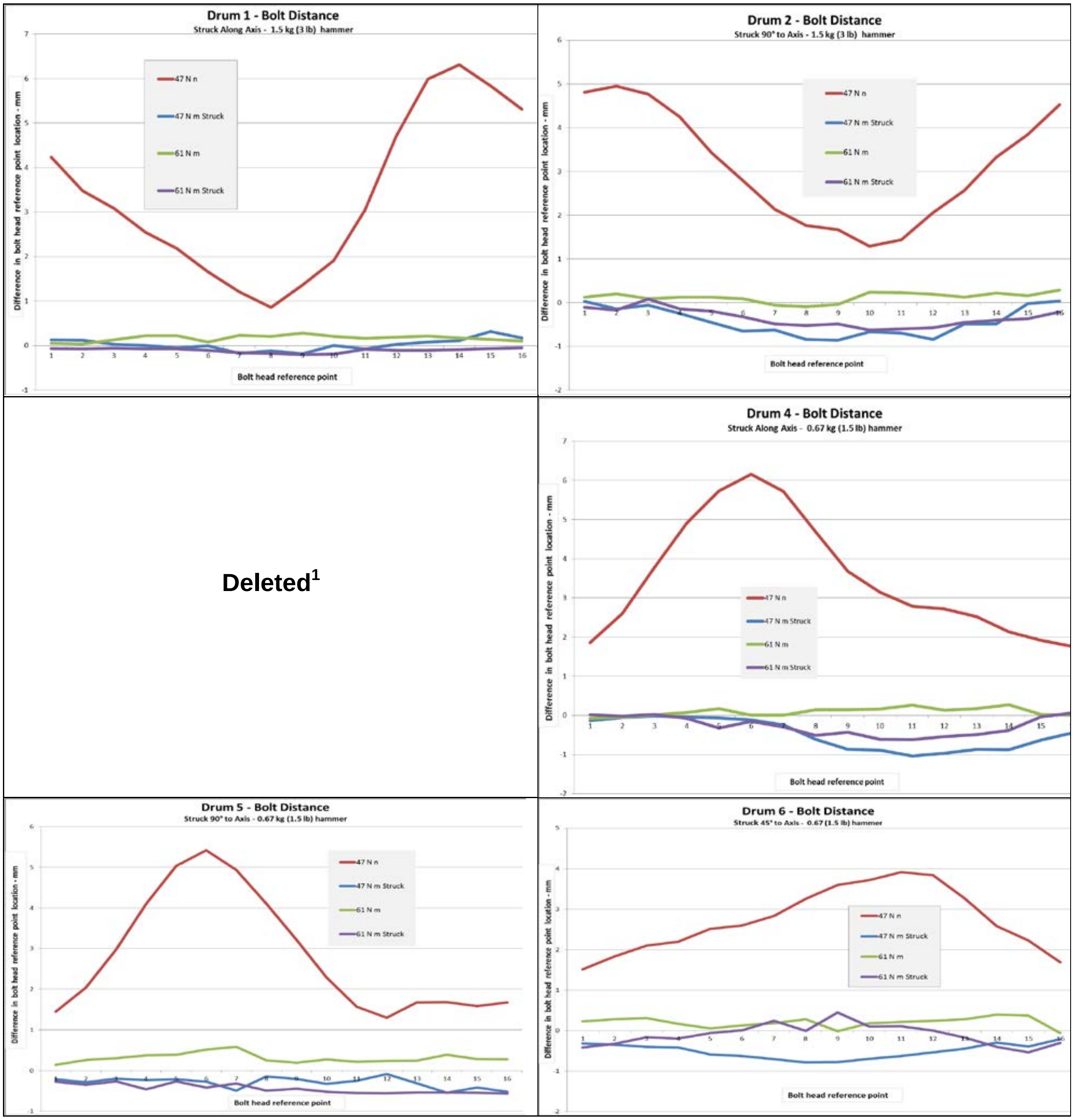


Figure 3. Gasket Compression

Bolt head reference points were also used for measuring the Closure ring bolt distance. The results are shown by Figure 4.



Note: Faro arm became unsecured during testing , with resultant data suspect.

Figure 4. Bolt Closure Distances

A review of Figures 3 and 4 show that the effect of applying a torque between 47 N m (35 ft-lbs) and 61 N m (45 ft-lbs), with or without stress relieving, results in little difference to the amount of measured gasket contraction or amount of bolt closure distance.

CONCLUSION

The test equipment consisted of three similar Type A 7A 208-liter (55-gallon) drums with a standard 12-gauge bolted closure ring, a calibrated torque wrench, a 0.67 kg (1.5 lb) and 1.4 kg (3 lb) hammer, and a portable coordinate measuring machine (CMM) with its associated software. Parameters varied during the testing included the amount of torque applied, as well as direction, and weight of hammer applied as part of stress relieving. After torqueing the closure ring to 27 N m (20 ft-lbs) as a baseline, then 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs), and applying the stress relief, the X, Y, and Z coordinates were measured and recorded for the lid and bolt head.

The results show that the closure variants tested resulted in little difference to the amount of gasket contraction and closure ring bolt distance. This can be interpreted to mean that applying a torque between 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs) during closure, with or without stress relieving, will result in the same impact/ potential for the drum lid to pop off during drop testing.

REFERENCES

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3. D0T-7A Type A Packaging Design Guide WHC-SD-TP-RPT-017, Rev. 0, Washington Hanford Company, 1/24/95.

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