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Impact of Different Type 7A Drum Closure-Ring Practices and Parameters on Gasket Contraction

Edward Ketusky, Paul Blanton, John H. Bobbit,
Savannah River National Laboratory

ABSTRACT

Since the beginning of the nuclear era, 55-gallon open head carbon steel drums (i.e., UN1A2/DOT 7A) with the standard 12-gauge split ring bolted closure-ring have played a key role in transporting and storing Type-A quantities of radioactive material. With the history of the 55-gallon drum traceable back to the oil industry of the early 1900s, but on its own unique course of evolution, the manufacturers have driven the various improvements. In the U.S., with each manufacture responsible for self-testing of the Type-A packages, as well as developing the associated closure procedure, no commonly accepted closure torque exists, nor commonly accepted stress relief practice exists. With the regulatory free drop test requiring the Type-A drum to "suffer maximum damaged,' the torque and stress relief methods on gasket contraction and bolt closure distance were investigated.

The results of a literature search, showed that the recommended force applied to torqueing the both has generally increased from a force of 47 N m (35 ft-lbs) to now some manufacturers recommending up to 68 N m (50 ft-lbs), but with little documented basis. For stress relief, then hitting or tapping the closure ring with a hammer, then re-torqueing) is poorly defined, with basis limited to one or two text lines in old (1980 era) historical reports. Therefore testing of both were performed better understand the impacts.

The test equipment consisted of three similar 208 liter (55 gallon) drums including the standard bolted closure-rings, a calibrated torque wrench, 0.67 kg (1.5 lbs) and 1.4 kg (3 lbs) hammers, and a portable coordinate measuring machine (CMM). Parameters varied during the testing included the torque, as well as the direction and weight of hammer. Using the CMM, the X, Y, and Z coordinates were measured and recorded for the gasket contraction readings and bolt closure distance, 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) with variations in stress relieving applied (ie, none, hammer weight and direction of impact).

Results showed that the effect of torqueing between 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs), with or without stress relieving, there have little difference on the gasket contraction or bolt closure distance, meaning that either should be equally acceptable.

INTRODUCTION

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 evaluation and testing program to qualify Type A radioactive material packagings. This program was called the U.S. DOE DOT-7A Program (Ref. 3).

Most of the tests 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 Top-Down, Bottom-Down, Side, and center of gravity Over Top-Corner. Based on these concerns, 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 as the bolt was tightened (Ref. 4 and 5). Focusing on the same concerns for during accident conditions, the D0T-7A Type A Packaging Design Guide was developed (Ref. 1) and well as the Red Book (Ref. 3), Blue Book (Ref. 2), and White book (Ref. 1).

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 used standard bolted closure ring (Ref. 6). Under this scenario, the shallower the angle, more energy goes into rotation, but also a greater impact load to the lid plane. The lid in-plane force increases with decreasing drop angle until slipping occurs at the point of contact and then drop off. Depending on the in-plane load and when slipping occurs, the lid will buckle or worst come-off, and release the contents.

With the regulatory free drop test requiring the Type A drum to “suffer maximum damaged” with a standard 12-gauge split ring bolted closure-ring most commonly used, the torque and stress relief methods on gasket contraction and bolt closure distance were investigated.

METHODS

The following equipment was used during the testing:

- Three DOT 7A Type A 55 gallon open head carbon steel drums with standard 12 gauge bolted closure-rings and lids
- One calibrated 0 - 135.58 N m (0-100 ft-lbs) torque wrench
- One calibrated coordinate measuring machine (CMM), connected to a laptop with Faro ARM software
- One 0.67 kg (1.5 lbs) mallet and one 1.4 kg (3 lbs) 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. Caliper orientation after 47 N m (35 ft-lbs) and 61 N m (45 ft-lbs) reached, both before and after stress relief.
3. Stress relief shall occur by hitting closure ring with appropriate mallet (4 hits, 1 per quadrant)
4. 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.

The top of the three drums were marked with the gasket compression measurement points shown in Figure 1. Table 2 shows the test matrix used.

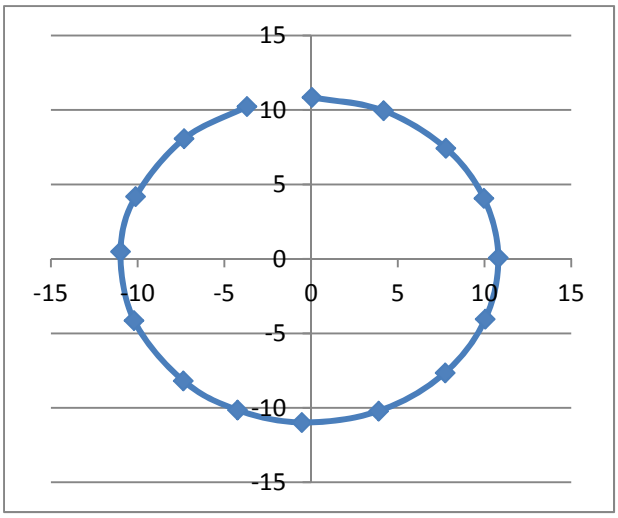

Figure 1. Location of Gasket Compression Measurement Points

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 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					

Similarly, measurement points were also applied for measuring the distance from the lug to the bolt head.

RESULTS

The results of the differences in gasket compression (i.e., lid height) using the CMM are shown in Figure 2.

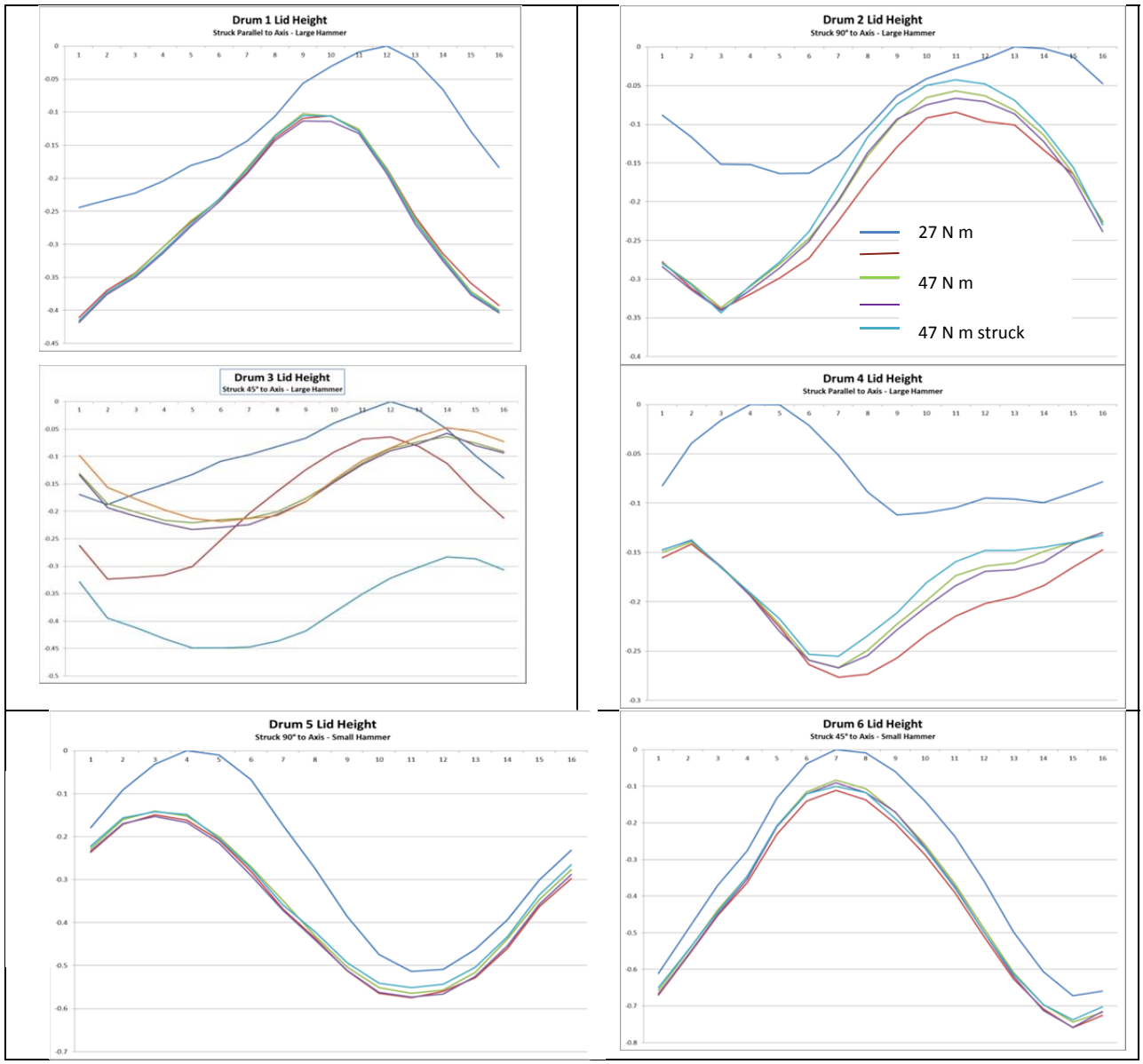

Figure 2. Gasket Compression at Measurement Points

Similar measurement points were also applied measuring the distance from the lug to the bolt head. The results of the variations in bolt closure distance (measured distance between the lug and bolt head using the CMM) are summarized in Figure 3.

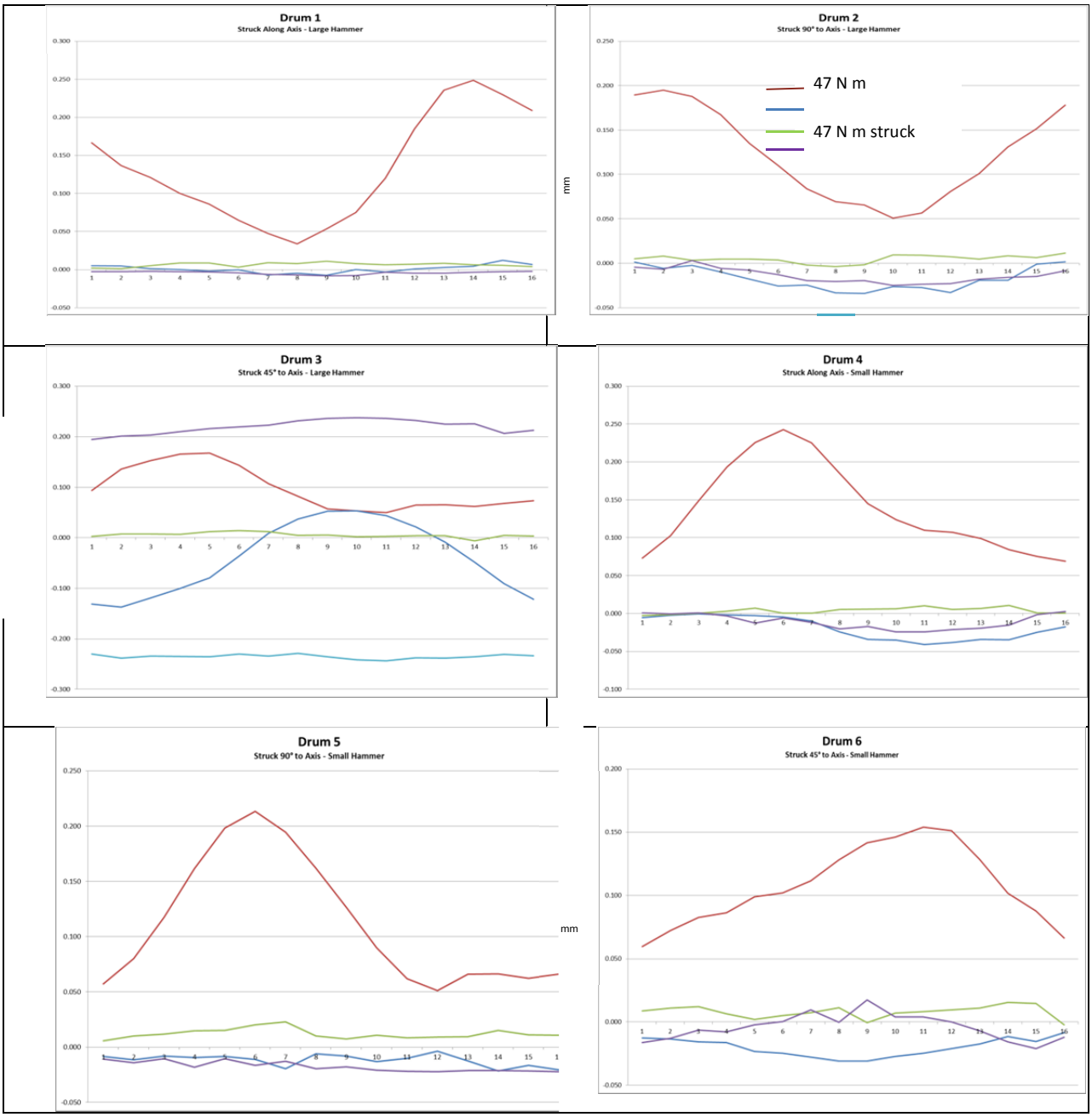

Figure 3. Variations in Bolt Closure Distance at Lug Measurement Points

A review of Figures 2 and 3 show that the effect of torqueing between 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs), with or without stress relieving, has little difference on the gasket contraction or bolt closure distance.

CONCLUSION

Using the CMM, the results show that little variation has little difference on the gasket contraction or bolt closure distance when torqueing either 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs), with or without stress relieving. This can be interpreted to mean that torqueing to 47 N m (35 ft-lbs), and 61 N m (45 ft-lbs), with or without stress relieving would results in similar effects during drop testing such that the drum will "suffer maximum damage."

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