Effect of the Payload Configuration on the Performance of a 205 Litre Drum During Impact Testing.

Authors

G Holden CEng MNucI
Onet Technologies UK Ltd
Claylands Rd
Bishops Waltham
Hants
SO32 1BH
UK
Phone +44 (0)1489 897300
gholden@onet-uk.com

and

M Flynn
LLW Repository Ltd
Pelham House
Calderbridge
Cumbria
CA20 1DB

Abstract

LLW Repository Ltd is a waste management company that provides services in the UK to treat and dispose of low level radioactive waste. On behalf of the Nuclear Decommissioning Authority, they manage the national Low Level Waste Repository in West Cumbria and oversee a national Low Level Waste programme to ensure that lower activity waste is managed effectively.

Work was conducted in late 2012 by Onet Technologies UK on behalf of the LLWR to approve a heavy duty 205 litre drum for a variety of radioactive waste materials up to SCO-II/LSA-II limits.

The payloads varied from rubble to wood and metals and were configured for maximum packing efficiency and not for their behaviour during an impact test. However, during the testing an unexpected failure occurred. This was investigated, the payload reconfigured to take account of the effect the payload had on the impact test, and another test conducted.

This paper reports on the findings of the tests for the various payloads, describe the failure, the investigation and the subsequent limits put on the payload configuration.

The paper discusses the criteria for meeting the 'no loss of contents' requirement of the IAEA Safety Standards TS-R-1 Regulations for the Safe Transport of Radioactive Material 2009 Edition, within the context of the results.

The paper also considers the implications and issues arising when using UN drums (which are generally tested with homogenous payloads) to transport decommissioning waste (heterogeneous solids).

1.0 INTRODUCTION

The LLW Repository Ltd as the UK LLW National integrator continues its mission to standardise Packaging for all its LLW disposal or treatment services. To support LLWR's Supercompaction Service, the VLLW diversion to authorised Land Fill site service and the waste incineration service, LLWR recently (late 2012) introduced an IP-2 Drum supply service for its customers.

Prior to this service being offered to LLWR customers, LLWR contracted Onet Technologies UK Ltd at its Bishops Waltham site, to submit the chosen off the shelf UN approved drum design to parameter finding tests using LLW simulant contents. The drum design was designated as LLWR/TC14.

The TC14 packages are designed for surface transport of LLW with a radioactive content meeting the SCO-II/LSA-II criterion. The Drum was required to meet the tests for a Type IP-2 package carrying solid or liquid radioactive material. One such test to fulfil part of the IAEA requirements for an IP-2 Package is that the package must withstand a 1.2m drop test onto an unyielding surface without any loss of contents.

The objective of this test programme was to confirm the suitability of the TC14 design as a Type IP-2 package in accordance with paragraph 622 of the Regulations (reference 1) which states that:

> *A package to be qualified as a Type IP-2 shall be designed to meet the requirements for Type IP-1 as specified in para. 621 and in addition, if it were subjected to the tests specified in paras 722 and 723, it would prevent:*
>
> *(a) Loss or dispersal of the radioactive contents; and*
> (b) *More than a 20% increase in the maximum radiation levels at any external surface of the package*.

Para 722 Free drop test; requires that the specimen shall drop from a height of 1.2m onto a target so as to suffer maximum damage in respect of the safety features to be tested. To satisfy these requirements, when subjected to the tests outlined in this report, there should be:

a) No leakage of material from the containment system or disruption of the seal.
b) No damage to the package to such a degree that shielding integrity is significantly reduced

2.0 TEST SPECIMEN PREPARATION

The TC14 Package comprises a UN approved design to Packing Group II, which is approved to transport liquids and solids. It is a nominal 210 litre open top drum, 885mm in height and 606mm in diameter. It has a steel fused welded main body with a 1.5mm wall thickness, constructed with two rolling hoops and has a maximum rated gross weight of 328kg. The TC14 package has the option of being operated with one of two possible lids, which both incorporate an EPDM elastomer seal, secured to the drum body by a zinc coated steel closure ring with a heavy duty nut and bolt fastening.

Two different simulated payloads (VLLW simulated contents and Supercompactable simulated contents) were used for this testing, so two drop test specimens were prepared.

Specimen A - comprised of a payload of uncompressed oil soaks, compressed wood shavings, cut wood blocks and steel offcuts (Supercompactable waste simulant). Note – The LLWR waste acceptance criteria for the supercompaction service included a heavier/more variable payload than the combustible waste acceptance criteria, hence the supercompaction waste simulated contents bound the test for specimen A

Specimen B comprised of a payload of soil, pebbles, assorted rubble and 12mm rebar (VLLW simulant).

Specimen Tested	Drum Gross Mass as Tested	Payload made up of approximately:
TC14 - Specimen A super compactable/ combustible waste	323.5 kg	Uncompressed oil soaks: 20 litres Compressed Wood shavings: 103 litres Cut wood blocks: 123 litres Steel off-cuts: 241kg (31 litres approx.)
TC14 - Specimen B solid very low level waste	329 kg	1 te of soil 1 te of pebbles Assorted rubble 6m of 12mm rebar

3.0 DISTRIBUTION OF TEST PAYLOADS IN THE TEST SPECIMENS

The following photographs show the preparation of the test specimens.

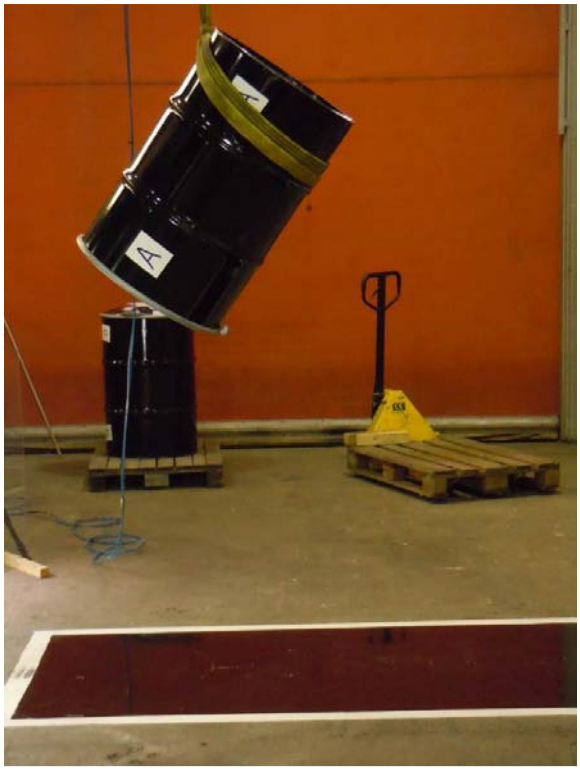
Specimen A (Super compactable/combustible waste)


A layer of test dust was placed in the base of the drum which was filled progressively with wood blocks, wood shavings, steel bars and oil soaks. The load was topped off with a steel plate with wood shavings on top and more test dust added prior to securing the lid.

TC14 - Specimen B (Solid very low level waste)


A layer of test dust was placed in the base of the drum which was filled progressively with soil, rebar, pebbles and rubble with rebar tapped into the top soil/rubble layer simulating a sharp penetrative object in the top of the drum. More test dust was added prior to securing the lid

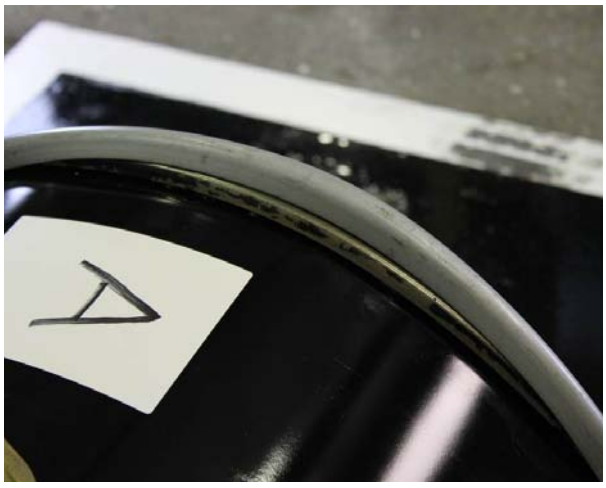
4.0 DROP TESTING

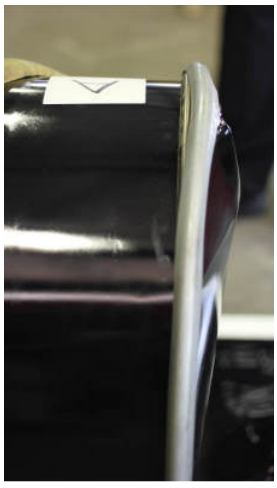


In all cases the 1.2m drop test was performed by suspending the package from the drop test hook and allowing it to drop onto an unyielding steel test plate. The orientation was such that the centre of gravity was directly above the point of impact which had been set up to be the nut and bolt on the closure ring (Specimen A shown).

5.0 DROP TEST RESULTS

The following photographs show the drop test results for Specimen A (Super compactable/combustible waste)





Severe distortion to the lid and closure ring resulted in the lower part of the closure ring and lid detaching from the drum body opposite the impact point indicating a gross failure.

Examination of the drum and drop test plate using a UV lamp indicated there was no evidence of loss of test dust. However the closure ring on the side opposite the initial impact point was detached from the drum curl and it was evident that the lid to drum body joint, had been breached despite no dust having escaped.

Due to this the package was judged to have failed to meet the pass criteria for the following reasons:

- The closure ring had detached at a point, and the full detachment of the lid was only prevented by the lid being secured by the deformation at the impact point.

- There was significant distortion of the lid opposite the impact point and evidence of the topmost steel plate having been imprinted in the lid.

It is impossible, by testing just one specimen, to determine how close the drum was to total loss of the lid. There are many variables and the following questions arose;

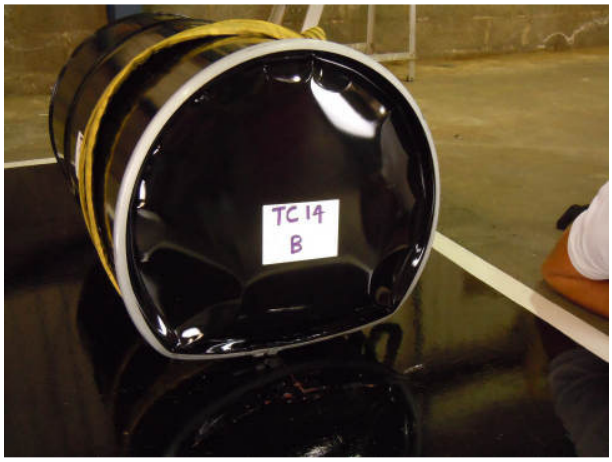
- if another drum from another batch had been used with different tolerances would a total failure have been more or less likely?

- equally had the drop test angle varied fractionally would a total failure have been more or less likely?

- similarly had the payload been softer (or harder) or of different density would that have reduced/increased the chances of failure?

It was decided to implement packing configuration restrictions of the payload (Specimen C). This was based on past experience from testing other drums and the fact that the nuclear waste sector could easily implement this restriction if the test was successful. The restrictions were to pack the drum with a less dense payload in the top third of the drum to reduce the impact dynamics of the payload on the lid to reduce damage to the lid.

The following photographs show the drop test results for Specimen B (VLLW simulant)



Specimen B met the test requirements with no loss of contents.

Note how the more 'fluid' granular contents allowed the drum to plastically deform more and better absorb the impact energy. The lid remained engaged with the drum curl at the point of impact after the closure ring was removed.

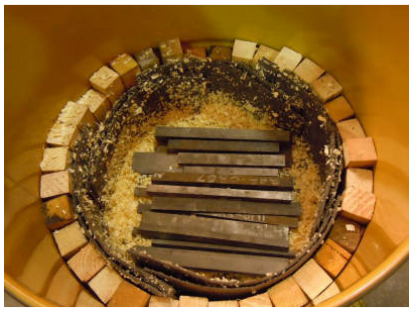
6.0 Reconfiguration of Specimen A payload - designated Specimen C

The payload was revaluated after specimen A was judged to have failed to meet the test criteria after the drop from 1.2m onto the test plate. As a result of the performance of specimen B, a new payload configuration was defined, for the compactable waste stream, and designated specimen C. This ensured that the top 30% of the TC14 drum (i.e. above the highest chime) was filled with material with a relative density of less than or equal to one only.

After discussion with LLWR this payload for specimen C was finally agreed as follows
Payload comprises for specimen C:

Oil soaks	20 litres uncompressed
Wood chips	103 litres compressed (infill only as required)
Cut wood blocks	123 litres
Steel offcuts	160kg
Lead shot	65kg
Gross mass	310kg

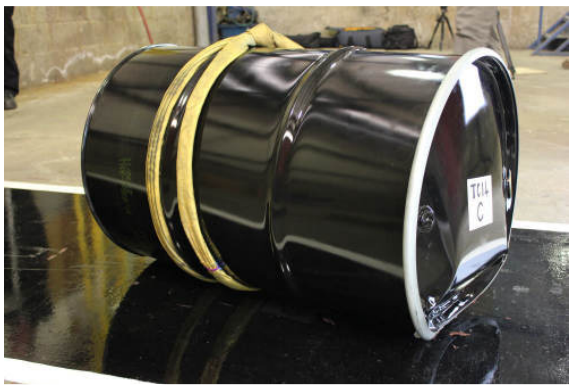
Specimen C (Super compactable/combustible waste)



The drum was progressively filled to the 70% level with wood blocks, wood shavings, steel bars and absorbent mats and a 65kg bag of lead shot. A bag of shredded paper and further wood shavings filled the drum with test dust added prior to securing the lid.

7.0 DROP TEST RESULTS SPECIMEN C

Specimen C was subject to a 1.2m drop test in the same orientation as Specimens A and B. Specimen C met the test requirements with no loss of contents.



No test dust was found on the outside of the drum or on test plate following the drop test. Lid distortion was concentrated towards point of impact. Small creases occurred in the lid as a result of the impact but none which compromised the seal to the drum curl.

8.0 DISCUSSION/CONCLUSIONS.

While it may appear obvious that a dense solid payload would always cause significant damage to a lid in a drop test, when configured as specimen A, there was the belief that the presence of a steel plate positioned on the top part of the payload would protect the lid from being punctured and distribute the load evenly over the lid during and impact. Furthermore the drum tested was a qualified UN approved drum tested for this payload mass with a heavy duty clamp band secured by a 5/8" bolt.

The following is an extract from the Certificate of Packaging Performance

Packaging type: **1A2** *Description:*

Drum, steel, removable head

Test Contents:

Tested with fine sand, plastic pellets and lead shot for solids

To test levels of:		*The packaging is approved, as provided in the relevant transport rule, to contain solids of:*		
DROP HEIGHT (m)	**1.2**	*packing group*	*density (d)*	*gross mass (kg)*
		I	-	-
STACKED AT 3m with BD (d)	**1.5**	II	1.5	328
		III	1.5	328

(UN) 1A2/Y328/S/**/GB/ (Number deleted)

While the plate did protect the lid from being punctured, it severely compromised the drum seal and the specimen was judged to have failed, despite the fact that no observable release of test media (dust) had occurred because:

- The closure ring had detached at the point diametrically opposite the impact point, and the full detachment of the lid was only prevented by the lid being secured at the impact point.

- There was significant distortion of the lid opposite the impact point and evidence of the steel plate having been imprinted in the lid. This had distorted the lid so much that the lid became detached from the drum body.

It is usual only to test one specimen (relying on our experience of drum testing) and aim to impact the lid at the clamp band bolt since that represents the worst case. However, by testing just one specimen, it is impossible to credibly determine how close the drum was to complete loss of the lid and the following questions are pertinent;

- There are many variables and if another drum from another batch had been used or had the drop test angle varied fractionally would a total failure have been more or less likely or the result significantly different?

- Equally had the payload been softer or harder would that have reduced/increased the chances of failure?

It is prudent to err on the side of caution, and it may be said that all parties were expecting too much from the drum.

If the impact damage sustained by specimens B and C are compared side by side as below it can be seen that the damage is similar.

The tests of specimens B and C were successful and this is due to the fact that the drum body was able to deform due to the payload being essentially granular or ovoid, (and therefore able to yield) reasonably homogeneous and of uniform density.

The lids did differ in configuration but the build was arranged such that the filling features were not in the area subject to the greatest impact, and therefore the test would be representative of a drum lid without such features.

The damage sustained by specimen A shows little plastic deformation (probably as a result of the payload being unyielding)

It can be concluded that the payload does have an effect on the test results - as would be expected. This must be taken into consideration particularly when relying on testing conducted for UN Dangerous Goods Approval since payloads used in such testing are usually granular or ovoid (and therefore fluid as lead shot is), reasonably homogeneous and of uniform density.

Furthermore careful consideration must be given to the packing of waste forms with rigorous control during the packing of the waste in the drum and the distribution of its density. If the density of the whole payload is not uniform and the denser items in the payload unyielding there needs to be thought put into controlling the packing configuration to ensure the softer lower density material is placed in the top section.

In summary this test echoed concerns that UN tested packaging's, are not always suitable for the transport of heterogeneous solid radioactive material. All consignors using off the shelf UN tested packages as the soul justification for use as an IP-2/IP-3 (TS-R-1 paragraph 624) must re-assure themselves that the original UN test criteria bounds their intended use of the package. If in any doubt it must be assumed, as proven by the tests discussed in this paper, that the package may **not** maintain its containment integrity during normal conditions of transport.