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Determination of leak integrity and behaviour of 'standard' 205 litre UN drum lids when subject to differential pressures.

Work was conducted in late 2012 by Onet Technologies UK on behalf of a UK client to determine how the 'standard' 205 litre UN drum used for the transport of solid radioactive materials (typically SCO II/LSA II) behaves when subjected to pressure differentials that would be encountered in transport by road.

The 'standard' drums are used widely in the transport of solid radioactive waste material by road in the UK, and by the wider community globally. For road transport most drums will never be subject to pressure differentials of greater than 25kPa.

Drums, which are similar in material thickness and geometry to these 'standard' drums, when transporting hazardous liquids are subject to a 'leakproofness test' and tested to a pressure differential of 30kPa as part of gaining the UN approval.

Should these drums be used by air they are required to withstand a pressure differential of 95kPa plus MNOP to meet the requirements of TS-R-1. Drums are not tested to that pressure for UN approval unless they are to be approved specifically for the carriage of liquids.

This poster paper reports on the findings of the work, completed early in 2013. It defines the leak integrity (as measured using Helium mass spectrometry and pressure drop) and describes the failure mode of the drum lid together with the pressure and lid deflection leading up to the time of failure.

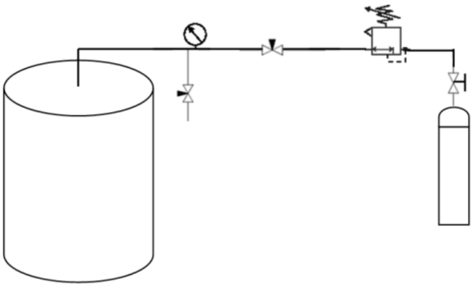
The work also explores how the drum behaves with its lid supported and determines the pressure at which leakage occurs in that configuration.

The Drum

This was a 1A2/X270/S/2012/GB 2702, 205 litre drum as shown below mounted in the test rig

The Test Equipment

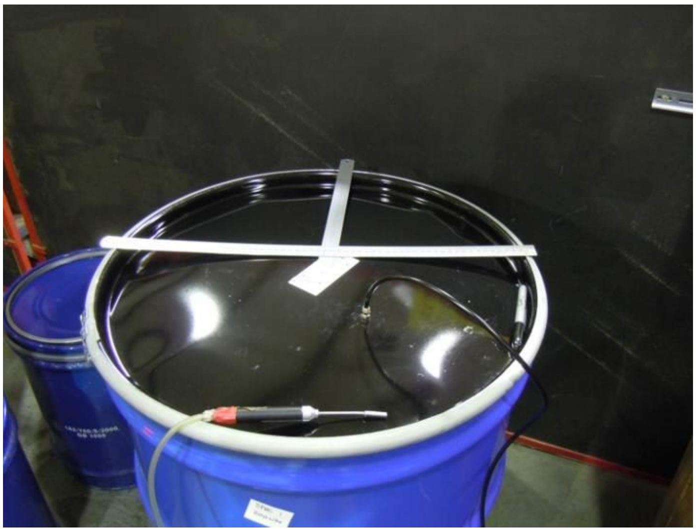
The schematic shows the Helium supply via a pressure regulator, flow control valve and digital manometer feeding into the drum lid centre via a bulkhead connector.
A self calibrating mass spectrometer was used to detect leaks of Helium.



The Test Method

Leakage/pressure test results for pressures up to 60kPa

A straight edge was laid across the top of the drum and the distance between its lower edge and a point on the face of the drum lid recorded to set a zero point for lid deflection. The two straight edges used are shown below.



The needle valve was opened to increase the pressure in the drum to 5kPa, monitoring this using the digital manometer. When the desired pressure was reached the needle valve was closed. The drum seam, base seam and area around the clamp band was checked for the presence of helium using the sniffer nozzle on the mass spectrometer.

The straight edge was laid across the top of the drum and the distance between its lower edge and the point on the face of the drum lid recorded to measure lid deflection at the pressures given.

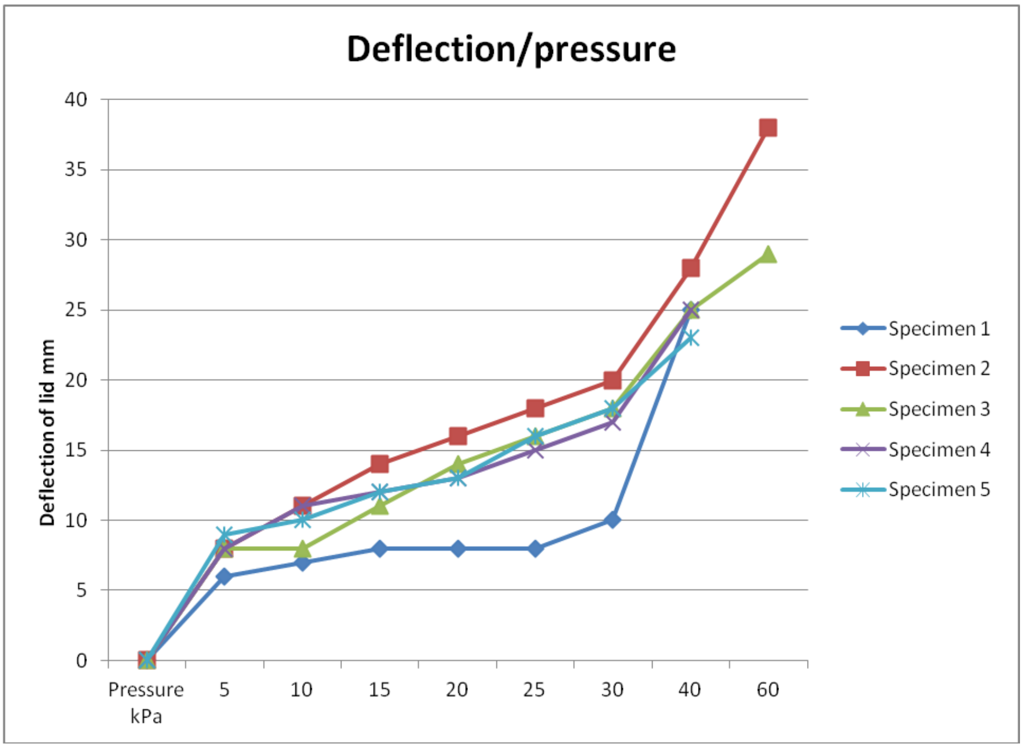
The test pressure was held for 15 minutes and the pressure reading taken on the manometer every 5 minutes to confirm that the drum was not grossly leaking. A range of pressures from 5 to 30 kPa were applied to each drum. The pressure was then vented to that of the previous test, and lid deflection checked.

The results are shown in the table for the first (of 5) 205 litre drum. The mass spectrometer was set to alarm at 1 x 10^{-4} mbar litres s^{-1} and never indicated a leak worse than 1 x 10^{-3} mbar litres s^{-1} (note 1 x 10^{-3} mbar litres s^{-1} equals 1 x 10^{-4} Pa m^3 s^{-1}).
There was no leakage around the base seam of the drum. Note in all cases where leak rates were recorded around the drum lid circumference the 6 o'clock position is taken at the clamp band joint. Note plastic deformation of lid of some 13 mm.

Pressure Range/setting kPa	Time minutes	Pressure kPa	Leak rate mbar litre/s	Deflection mm	Remarks
0	0			0	6.1kPa set after deflection recorded
0-5	5	6.1	<10E-3	7.5	Alarm set to 10E-4 mbar litres/s
0-5	10	5.5	<10E-3	7.5	occasional alarm at 1 to 3 o'clock
0-5	15	5.4	<10E-3	5.5	leak rate no worse than 10E-3 mbar litre/s ie meets soap bubble test criteria
0				5.5	
5	0			5.5	9.9kPa set after deflection recorded
5-10	5	9.1	<10E-3	5.5	Alarm set to 10E-4 mbar litres/s
5-10	10	8.9	<10E-3	4.5	alarm at 1 to 4 o'clock
5-10	15	8.9	<10E-3	3.5	leak rate no worse than 10E-3 mbar litre/s ie meets soap bubble test criteria
5				4.5	
10	0			9.5	15.6kPa set after deflection recorded
10-15	5	14.9	<10E-3	10	Alarm set to 10E-4 mbar litres/s
10-15	10	14.5	<10E-3	11.5	alarm at 1 to 4 o'clock
10-15	15	14.6	<10E-3	11.5	leak rate no worse than 10E-3 mbar litre/s ie meets soap bubble test criteria
10				10.5	
15	0			11.5	19.6kPa set after deflection recorded
15-20	5	19.4	<10E-3	13.5	Alarm set to 10E-4 mbar litres/s
15-20	10	19	<10E-3	13.5	alarm at 12 to 6 o'clock
15-20	15	18.9	<10E-3	13.5	leak rate no worse than 10E-3 mbar litre/s ie meets soap bubble test criteria
15				12.5	
20	0			13.5	30.3kPa set after deflection recorded
20-30	5	29.4	<10E-3	19	Alarm set to 10E-4 mbar litres/s
20-30	10	29.2	<10E-3	19	alarm at 9 to 6 o'clock

20-30	15	29.2	<10E-3	20	leak rate no worse than 10E-3 mbar litre/s ie meets soap bubble test criteria
20				17.5	
Drum vented to 0 in stages		15		16.5	
		10		16	
		7		15.5	
		5		14.5	
		0		13.5	

The lid exhibited some permanent deformation after the test sequence and was concave (ie dished inwards) when the test started. The first pressure cycle where the drum was pressurised to 5kPa for 15 minutes and then returned to 0 kPa was responsible for the first 5mm or so of deformation, and removed the concavity the lid had exhibited at the start of the test. Each subsequent increase in pressure via 10, 15 and 20 kPa added approximately 1mm of deformation per stage. The increase to 30 kPa added some 4mm of deformation. From this it may be deduced that permanent deformation of approximately 13mm may be expected when the drum was pressurised to 30kPa. A further 4 drums were tested to failure.

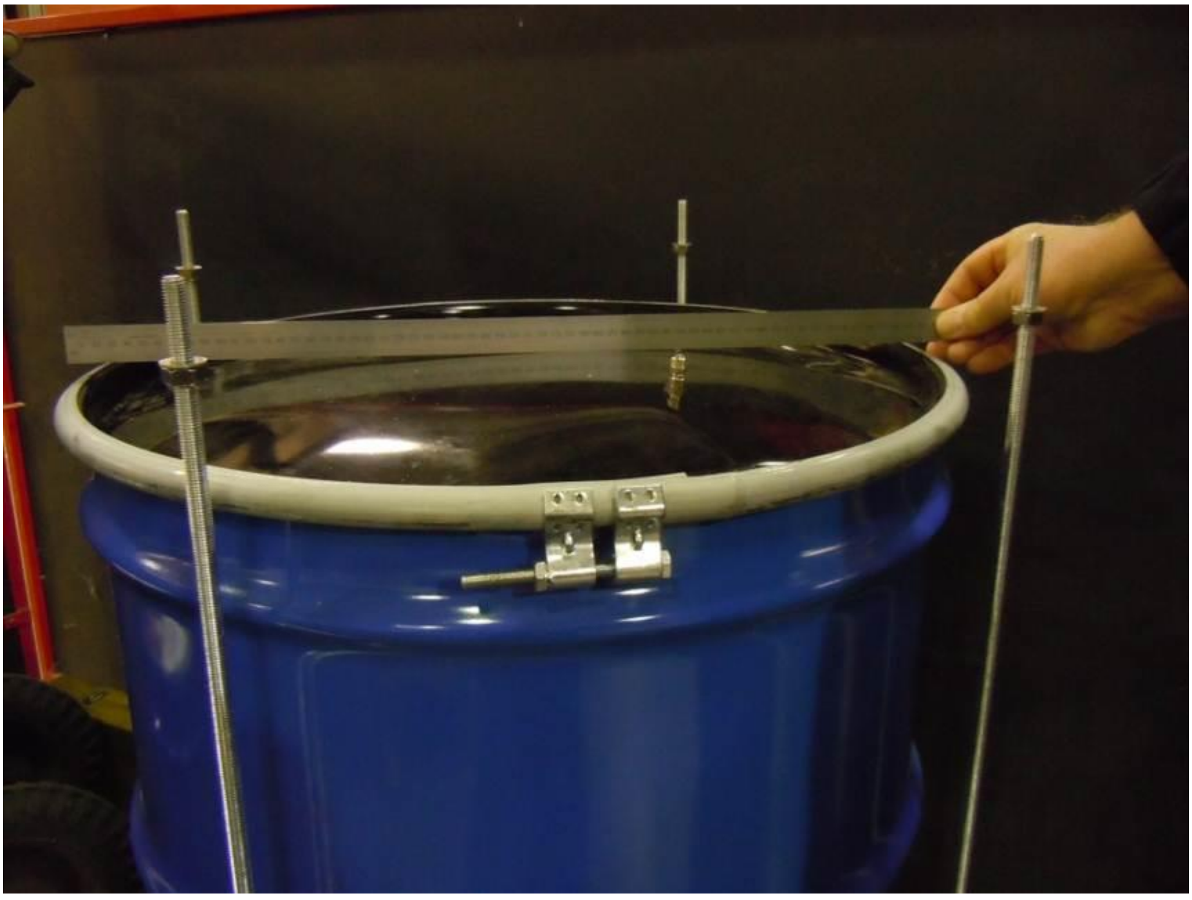


Note: The results for Specimen 1 deviates markedly from the others. This is probably as a result of it having been used to determine lid deflection in the first test to determine how the drum behaved at pressures up to 30kPa. It already had some 13mm of permanent convex deformation in the lid before the test plotted above and consequently it is not representative.

The test to determine the pressure at which gross leakage occurs indicated that the lid failed suddenly but was safely retained by the clamp band in all cases.

The drums failed at pressures of between 40kPa to 68kPa and the leaks were such that the internal pressure dropped rapidly and the leak was audible.

Close up of failure, note convex deformation of lid



Note plastic deformation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The Conclusions

The 205 litre drums; internal dimensions 570mm dia x 860mm high Ref No. 1A2/X270/S/2012/GB 2702 with their ends unsupported had good sealing properties up to differential pressures of between 20- 30kPa, equivalent to soap bubble testing. They failed to hold pressure (due to severe lid distortion at approximately 40 to 60kPa.

They are generally suitable for road transport in the UK

They are generally NOT suitable for air transport of Class 7 radioactive materials.

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