

## SOFT-SIDED PACKAGINGS FOR LOW ACTIVITY RADIOACTIVE WASTES

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### INTRODUCTION:

For several years in the United Kingdom, Low Level Radioactive Waste (LLW) has been transported, interim stored, and disposed of primarily in half-height ISO containers (HHISO). The performance of these containers in this service has been good, with few safety occurrences. The containers are used under the regulatory oversight of the Department for Transport (DfT), the Environment Agency (EA), and the Nuclear Installations Inspectorate (NII). The use of HHISO containers brought about a significant improvement in environmental, public, and worker safety from the days of tumble tipping wastes into shallow trenches at the Low Level Waste Repository (LLWR) near Drigg and other locations.



*The use of HHISO containers at LLWR*

With the advent of the Nuclear Decommissioning Authority's (NDA) mission to shut down, decommission, decontaminate as required, and demolish some nineteen aged nuclear facilities, a need was created to once again take a look at how LLW is managed transported and disposed of. With this need in mind, the NDA's Parent Body Organization (PBO) contract for the LLWR calls for the contractor to identify, evaluate, and implement better, more efficient, less expensive, and at least equally safe means of managing VLLW & LLW in the UK. This work is now underway, working with waste generators, consignors, regulators, and Tier 2 firms from the nuclear industry supply chain.

One of the waste (low activity) packaging concepts being evaluated in the UK is that of soft-sided packaging. This type of packaging has been used in the United States for approximately 15 years in similar services to the HHISO containers for UK LLW. Over 25,000 soft-sided packages have been

safely deployed and used across the US nuclear industry as well as for hazardous non-radioactive applications. This paper presents the development of the soft sided package design for use in the UK for transporting very and low level radioactive wastes.

**SOFT-SIDED PACKAGE DESIGN AND FEATURES:**

Soft-sided waste packages, like the half-height ISO containers, are engineered products, fabricated under strict quality controls, and are tested and certified to IAEA Standards IP-1 or IP-2, as required by the intended application and user requirements. Drop tests, stacking tests, simulated transport conditions, meteorological changes, and the like are all tests that soft-sided packages have been subjected.



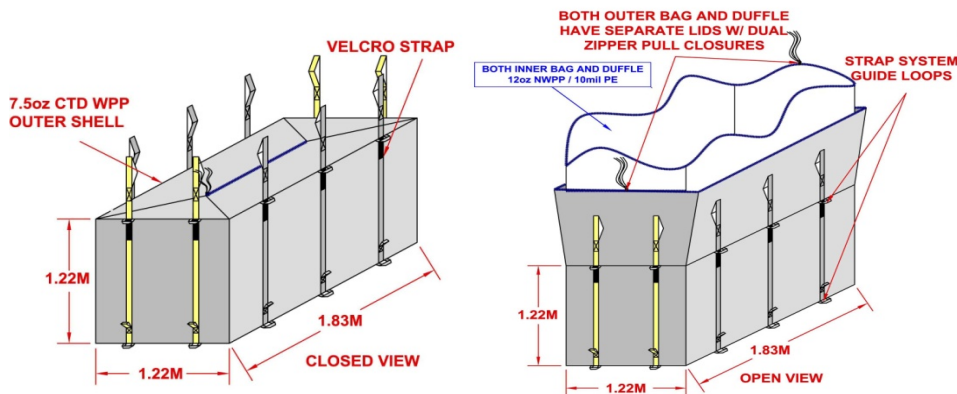
*LiftPac bag stack test with 54,515 kg of weight*



*LiftPac bag lift test*

In the UK, the LLW Repository is developing a reusable transport system to transport the disposable soft sided packages. They are choosing to use the soft sided package as an inner unit (utilizing the containment integrity of the soft sided inner unit) and are in the process of designing a bespoke transport system that is compatible with existing NDA transport infrastructure.. The LLW Repository is presenting a paper on the new LLWR/TC-11 design in another session during this conference.

The LLWR IP-1 variant soft sided designs variant has been subjected to extreme re-assurance testing, to demonstrate that no loss or dispersal of contents can occur during routine conditions of transport within the UK.. The results of these tests are included in this paper and will be discussed later.



The materials used to fabricate soft-sided packages are robust, and include woven and non-woven polypropylene, polyethylene, nylon, and other special materials. The soft-sided waste package is a large rectangular bag, with special closures, including zippers and a unique lifting system. In that each bag is individually fabricated, there are several options available regarding size, volume, closures, lifting devices, internal stiffeners, and so on. Smaller, scaled down bags can be used where space is limited, for example.

Bag seams are strongly constructed and are carefully manufactured, and may require double stitching or other methods to ensure strong, tight joints, depending upon applications. Custom liners can be added to the bag for wet applications. Each bag receives quality control inspections throughout the manufacturing process and independent lab tests, as required. Note from the Figures that the lifting straps are held in place in such a way that they are readily accessible to the operators responsible for loading, closing and moving the bag. Soft-sided packaging is manufactured in special purpose facilities, with ISO quality manufacturing certifications.

#### **USING SOFT-SIDED WASTE PACKAGES:**

The waste packages are usually loaded while positioned inside a loading frame. The lightweight loading frames are easily assembled and moved by two operators, and the standard loading frames may require simple lifting equipment. The training required to enable operators to position, load, and close the bags is not extensive. Soft-sided packages are easily handled and stored when empty. Two operators can easily move and stack an empty soft-sided package.



*Lightweight or EZ loading frame*



*Standard loading frame for soft-sided packages*



*Closure details of soft-sided packages*



*Pallet of 30 empty LiftPac bags*

### APPLICATIONS:

It is anticipated that the applications in the UK which will require the greatest number of soft-sided waste packages will be the storage, transport, and disposal of Very Low Level Waste (VLLW). Transport and disposal of contaminated soils and demolition debris are also expected to require large numbers of soft-sided waste packages. Half-height ISO containers could be used for the same applications, however the cost of these containers, the handling equipment required, and the characteristics of the waste package itself will argue against using HHISO containers for these applications. LLW can also be stored, transported, and technically disposed of, subject to disposal facility safety case acceptance in soft-sided waste packages. According to the 2007 NDA Waste Inventory figures, the LLW future predicted arisings for the UK was 3.2 million m<sup>3</sup>. However the volumes of LLW are known to be much smaller than those of VLLW. .

Other applications for soft sided waste packaging that have been tested and proven in the USA DOE market, are Low Specific Activity (LSA) and Surface Contaminated Objects (SCO) wraps, and demolition debris bags. The demolition debris bags fit large dump trucks and are used to receive, transport and dispose of large quantities of lightly contaminated demolition rubble.



*IP-2 LiftPac*



*LSA/SCO Wrap*



*LiftPac bag loaded into rail wagon*

### DISPOSAL APPLICATION:

Soft-sided waste packages are able to conform, to some extent, to the space or cavity they are placed in, as in a repository. Since grout is not used in soft-sided packages, the waste loading efficiency is higher for soft-sided packages than for the half-height ISOs, thus allowing more waste to be disposed of per unit waste package volume.



*Stacked LiftPac's at NTS (Nevada Test Site, NV USA)*

The materials of construction of soft-sided packages are resistant to moisture, and do not corrode, as does mild steel. Actual performance data for long-term exposure of soft-sided packaging materials in



repository conditions is not yet available; however polyethylene and polypropylene in similar conditions are known to be extremely robust and long-lived upwards of 500 years.

### TESTING:

Soft-sided packaging has been tested and certified to IP-1 and IP-2 standards per 49 CFR 173.411 and can also meet IAEA Safety Standards TS-R-1 Section VI Requirements for Industrial Packaging. The soft sided package application for use in the UK has been reviewed by the EA, NII and the NDA and presented to the UK Competent Authority Department for Transport (DfT).

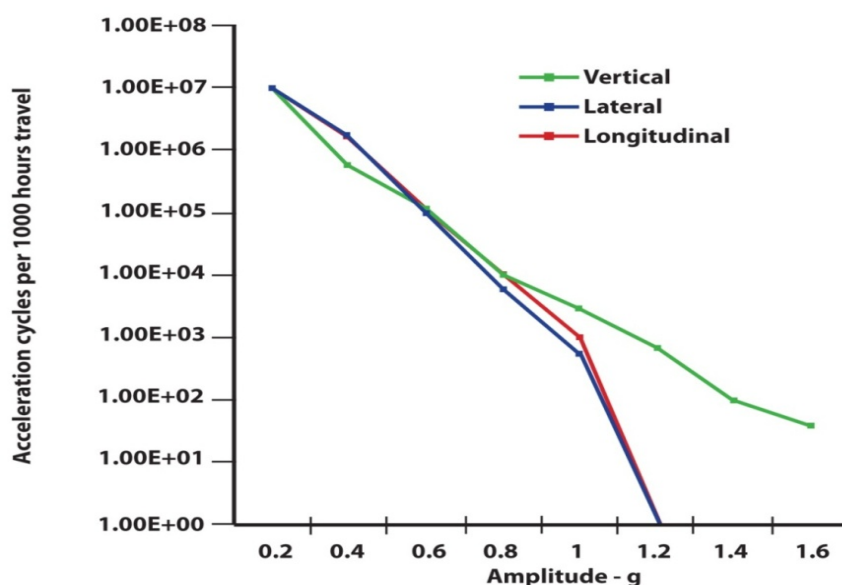
In August of this year, PACTEC working with the Low Level Waste Repository carried out some special testing of the soft sided package. The test was to confirm the leak tightness of the bag during routine conditions of transport and meteorological conditions in the UK, . The test method chosen was a vibration table test with associated pressure flow test with a tracer dust to detect release of any fine particulate dust during the test.

Testing was carried out by Wyle Laboratories in Huntsville, Alabama USA and incorporated a large vibration table, using military standard test procedures for cargo transportation “MIL-STD-810F”. The soft sided package, loaded with sand/soil, gravel and construction debris as well as a Fluorescein tracer dust was placed on the vibration table. To ensure that the test specimen represented the original design, the soft sided package containment barrier was not penetrated and a unique method of increasing the air volume was developed using a Co2 gas cylinder placed inside the bag. Establishment of the test parameters for Vibration Profile, Air Pressure/Volume are discussed below..

### Vibration Profile

The Vibration test profile was taken from the recognised UK Industry Forum “Transport Container Standardisation Committee” TCSC 1006 The Securing/Retention of Radioactive Material Packages on Conveyances” using table 6, load case 3, and Figure 14, (See below) for routine conditions of transport.

**Table 6** - The frequency of occurrence of a range of acceleration values – 20’ ISO freight container



**Figure 14 - Acceleration data 20' ISO freight container**

Load case	Longitudinal amplitude -g	Lateral amplitude -g	Vertical amplitude -g	Total number of cycles per 1000 hours
1	0.4	0.2	0.4	11.15 x 10 <sup>6</sup>
2	0.8	0.4	0.8	1.93 x 10 <sup>6</sup>
3	1.2	0.6	1.2	99.5 x 10 <sup>3</sup>
4	1.6	0.8	1.6	5.36 x 10 <sup>3</sup>
5	2.0	1.0	2.0	491

To simulate extreme ambient pressure changes Gravatom's methodology to simulate the Effects of Ambient Weather Conditions was deployed. (See below).

To calculate the combined effect of pressure and volume changes to set the test parameters the following "Gravatom developed" method was adopted

### **Pressure/Volume**

Pressure Changes were calculated by using meteorological data from 1870 to 1970 shows that the highest and lowest mean sea level pressures within the UK rounded to the nearest mbar are 1055 mbar (Aberdeen, January 1902) and 925 mbar (Ochertyre, January 1884).

Using the gas law equation, if the bag is filled at a pressure of 1055 mbar and the pressure falls to 925 mbar during transport, the air volume  $V_2$  is given by:

$$V_2 = V_1 \times \frac{P_1}{P_2} = 0.5 \times \frac{1055}{925} = 0.570 \text{m}^3$$

Increase in air volume =  $0.57 - 0.5 = 0.07 \text{m}^3$  (a 14% increase in volume).

Altitude change was calculated by the average decrease of pressure due to increase in height; this is known to be approximately 12mbar per 100m. Considering typical road transport in England the M6 at Shap reaches a height of 914 ft. (278m) and the M62 reaches a height of 1221ft (372m). If maximum height of 400m is considered, the decrease in pressure due to change in altitude is 48mbar.

This is a change of nominally 5% resulting in a 5% increase in air volume from 0.5 to  $0.525 \text{m}^3$ , an increase of  $0.025 \text{m}^3$ .

### **Combined Effect**

Although extreme low pressures may in theory be experienced during transport, such pressures would result in cold wet conditions and would not coincide with the highest temperatures. It is reasonable to surmise that the highest temperatures would only occur at pressures in excess of 1000 mbar. If filled at the extreme maximum pressure of 1055mbar then transported at a pressure of 1000mbar this is a 5% decrease in pressure which would result in a 5% increase in air volume.

The following combined effects are considered:

Increase in air volume due to 50°C rise in temperature	= 18%
Increase in air volume due to 55mbar fall in pressure	= 5%
Increase in air volume due to 400m change in altitude	= 5%
<b>Total increase in air volume</b>	<b>= 28%</b>

### **Interpretation of Test Parameters**

To increase in the air volume by 28%, it was calculated that a 4oz's of Co2 would need to be released in the bag. Therefore a Co2 canister with a slow release valve set to release the predetermined amount of Co2 was placed within a metal box with predrilled air holes, and then placed inside the soft sided inner package to simulate the increased air volume that may occur during routine conditions of transport. Although a typical soft sided package would most likely not travel more than 5-10 hours, the test specimen was tested to failure, simulating over 180 hours of drive (transport) time\*. At set intervals during the test, inspections were carried out on the test specimen at 30 minute intervals using a fine mist water spray and a UV light, no dispersal of the contents were detected during the test parameters.

*\*1 hr. of test time is equivalent to over 180 hrs. of travel time:  $X = [(5\text{Hz} \times 60 \text{ sec/min}) / 99,5000 \text{ cyc}] \times 1000 \text{ hr.} = 180.9 \text{ hrs.}$*



*Soft sided package used in testing at Wyle Laboratories, Huntsville, Alabama USA*

### **SAFETY:**

Soft-sided waste packages have been proven to be safe when used for the applications they have been designed, tested, and certified for. More than 25,000 soft-sided LLW packages have been safely used in the USA over the last 15 years. In the US, the bags are DOT certified and also IP-1 or IP-2 certified as a Class 7 package.

**CONCLUSION:**

Soft-sided packaging solutions for LLW, VLLW and other hazardous waste streams are now available in the United Kingdom. Several organizations, including LLWR, RSRL, Sellafield LTD., Energy Solutions, SITA and Augean are engaged in evaluating this product. Soft sided packaging can be shown to meet the criteria for safe and fit for purpose packaging, by meeting the IAEA Standards for IP-1 and IP-2 including leak tightness.

Soft-sided waste packages are expected to become a useful, safe and economical option for waste generators and consignors. The soft-sided packages can help accommodate the large quantities of wastes anticipated under the global task of nuclear clean up

**REFERENCES:**

TS-R-1- "IAEA Safety Standards"

TCSC - 1006 "The Securing/Retention of Radioactive Material Packages on Conveyances"