

IP-2 PACKAGE CONTAINING PLUTONIUM CONTAMINATED SLAG POTS

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ABSTRACT

Croft Associates were approached by PC Richardson to carry out the licensing of an IP2 package containing Plutonium contaminated slag pots. This project provided several unique challenges for all those involved.

The slag pots belonged to Outokumpu a steel company based in Sheffield. During use, sampling indicated a high level of plutonium in the form of Pu 238 was present in a slag pot. Further sampling identified that 4 slag pots were contaminated with Pu 238 and required disposal. The source of the Pu-238 contamination was believed to be a single heart pacemaker present in scrap that was melted down for reuse.

All 4 slag pots weighed between 50 to 60 tonnes and 3 had large patched cracks. The size and nature of the contamination prevented the slag pots being broken up therefore they had to be packaged and transported intact.

REMAC designed a steel box to package the slag pots. It was the responsibility of Croft to license this package. Several challenges were faced when licensing: firstly the weight, size and contents prevented any physical drop testing of the package. Secondly the box was to be assembled around the slag pot, limiting the leak testing that could be carried out.

All drop testing was therefore carried out by finite element analysis by AMEC NNC. This approach was also used to check the tie down and lifting systems. Leak testing was carried out via the soap bubble method on the assembled box prior to grouting. The transportation box, once assembled and licensed, was transported to Drigg from Sheffield by road.

INTRODUCTION

During routine sampling operations, steel manufacturer Outokumpu discovered a slag pot was contaminated with Plutonium 238; further sampling showed that in total 4 slag pots had been contaminated. This contamination required the slag pots to be decommissioned and removed as radioactive contaminated waste material. A Best Practical Environmental Options report was carried out and identified the best route of disposal. The route identified was to dispose of the slag pots intact to the Low Level Waste Repository (LLWR) at Drigg. The design, licensing and transport of these pots provided several challenges to the stakeholders involved. These challenges are addressed in this paper.

CONTAMINATED SLAG POTS

Figure 1 shows a contaminated slag pot.



Figure 1 - Contaminated Slag Pot

The size, weight and external fabric of the slag pots provided the first challenge to the transport process. The slag pots each weighed between 50 and 65 tonnes, they were 3060 mm in height and had a pot rim of diameter 3930 mm. Therefore any package containing these pots would be heavy and large. The levels of contamination, pot dimensions and weight are given in Table 1.

Physical Slag Pot Data Taken from BPM						Radiological Slag Pot Data Taken from BPM					
Pot No	Current pot Wt (tonne)	Height to pot rim (mm)	Dia. of pot rim (mm)	Distance over pot trunnions (mm)	slag surface below rim (mm)	Total Pu 238 (Bq)	Pu 238 Conc in slag (Bq/g)	Pu238 conc in whole pot (Bq/g)	Total Am 241 (Bq)	Am 241 conc in slag (Bq/g)	Am 241 conc in whole pot (Bq/g)
19	50.1	3060	3930	4670	700	1.34 E+10	1861	267	1.60 E+07	2.22	0.32
74	55.2	3060	3930	4670	150	1.51 E+10	1276	273	2.38 E+07	2.4	0.51
91	57.0	3060	3930	4670	560	1.41 E+10	630	247	3.74 E+07	1.67	0.66
97	65.1	3060	3930	4670	420	1.99 E+11	6700	3057	2.38 E+08	8.0	3.65

Table 1 - Slag Pot Information and Weight Estimates

Due to the nature of the use of the slag pots, 3 of the 4 pots contained several cracks and had been patched on several occasions.

These cracks precluded use of the pot structure for the outer vessel of the package and it therefore they had to be carried in a separate container. It was concluded that the only practical way to package the pots effectively was to support the pots within the transport package using grout.

DESIGN OF THE TRANSPORT PACKAGE

REMAC were contracted to design the transport package. There were several restrictions placed on the design.

- The weight of the package could not exceed 120 tonnes
- The combined height of the package and the trailer could not exceed 4.9 m.
- The pressure the package transmitted on the LLWR Drigg vault floor could not exceed 30 kN/m² per meter of package height.
- There could be no significant void in the package that could not easily be filled with grout at LLWR Drigg.

The first two points arose from the UK road transport regulations and the final points from the Drigg repository requirements.

As indicated previously, the weight and size of the pots took up a great deal of the weight allowance. Therefore the packing material and the design of the transport box were restricted by the weight. Current UK road regulations restricts the weight of any package to 120 tonnes [Ref 1], therefore the packaging weight was restricted to a maximum mass of 55 tonnes.

The transport box was therefore designed with a concrete base over a steel plate and a steel support frame. The frame was clad with carbon steels panels. An illustration of the steel frame is given in Figure 2.

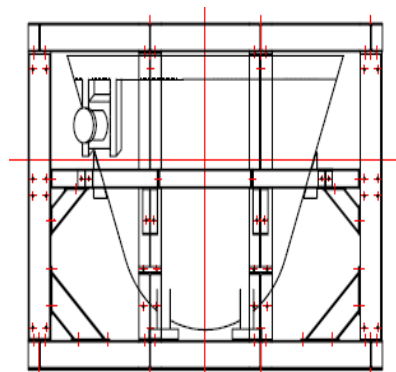


Figure 2 - Transport Box Steel Support Frame

MANUFACTURE OF THE TRANSPORT BOX

The manufacture of the transport box was carried out by PC Richardson. Initially the slag pots were filled with grout in order to fix the contamination. A slag pot was then

lifted onto the concrete slab which was cast in the centre of the base frame. Once the slag pot was positioned, the steel frame and cladding were assembled around it. The transport box was leak tested and then filled with lightweight grout by Propump. The grout had to be lightweight in order to achieve the weight limit for the package.

LICENSING OF THE TRANSPORT BOX

Agreement was obtained from the Department for Transport to transport this box as an IP-2 package in accordance with the IAEA regulations [Ref 2]. As an IP-2 Package it was required to undergo a 0.3 metre drop test and a stacking test, demonstrating on completion of these tests that there is no loss or dispersal of the contents or more than a 20% increase in the maximum radiation level at any external surface of the package.

Regulatory Tests

The drop test requirement presented several challenges, in particular, 3 of the 4 boxes would contain a cracked slag pot which could not be transported unpackaged, but there are only two test sites in the UK that can be used to test a package of this weight, both of which would involve transport of the package. Therefore the only option was to carry out a finite element analysis of the performance of the package under a 0.3m drop.

AMEC NNC carried out a finite element analysis and modelled a 0.3 m flat base, edge and corner drop. Analysis demonstrated that the light weight concrete and the concrete base absorbed 70% of the total energy in the system through the crushing of the concrete. This mechanism reduces any likelihood of damage to the slag pot or the steel transport box. Therefore it was concluded that drops in these attitudes could not cause a loss of containment or a 20% rise in radioactivity at the external surface.

Each transport box was to be transported separately and due to the size of the box, no item would be stacked upon it in Drigg; therefore a staking test was not required and not carried out.

Retention of the Contents

The finite element analysis showed the contents were retained during testing, however retention of the contents on manufacture had to be demonstrated. The transport box was designed as a totally seal welded structure; having no door, door closure systems or filters. During the manufacture of the transport box, all welds were dye penetrant tested to identify any cracks or holes.

On completion of the manufacture of the transport box, it was leak tested using the soap bubble leakage test. The test was carried out with the slag pot in place, therefore precautions were taken during testing with regards to monitoring the individuals involved. The pass criteria set for leak tightness was $\leq 1 \text{ bar cm}^3 \text{ s}^{-1}$ SLR for an individual leak.

This leak tightness standard was chosen because it is within the sensitivity range of the soap bubble test and equates to a capillary diameter at a welded sheet joint of

about 75µm. The size of a capillary hole of this magnitude is very unlikely to be the cause of leakage because the contents of the transport box are immobilised solids, therefore no fine solids or powders are present and there is no credible mechanism through which the powders could become airborne. This is also an achievable standard with regards to manufacturing.

Tie Down and Lifting Points

Finite Element analysis was further used to demonstrate the suitability of the tie down system and lifting lugs under routine conditions of transport using the g factors taken from the IAEA advisory material [Ref 3].

Transport Restrictions

The transport box was manufactured from carbon steel: this steel does not provide any low temperature properties therefore the box had to be limited to transport within the UK ambient temperature range of -10°C to 28°C. Control was achieved through the operating procedures which did not allow transport to occur if the temperature was outside this operating range.

TRANSPORT OF THE BOX



Figure 3 - Photograph showing the Transport Box in Transit

The transport of the boxes was undertaken by GCS Johnson from the steelworks in Sheffield to the Drigg site. Due to the weight of the transport box, the vehicle was limited to a maximum speed of 20 miles per hour and therefore it took 3 days to complete the journey. Six police authorities were involved for the route. Transport with self escort was required for the majority of the journey with the police escorting the final section of the journey from Penrith to Drigg. Figure 3 shows a box in transit.

CONCLUSION

The 4 packages containing their contaminated Slag Pots were successfully packaged, and transported to Drigg for emplacement in the Drigg vaults. This project has demonstrated that large items, which cannot be further broken up, can be packaged, licensed and transported.

With the use of a lightweight design and grout to meet weight requirements and testing with finite element analysis this project has demonstrated how licensing and road requirements can be met in challenging circumstances. It must also be noted this project involved several specialized companies which all worked effectively together in order to achieve the goal of this project.

ACKNOWLEDGEMENTS

Information, pictures and diagrams were provided by the following companies: PC Richardson, the overall contractor and manufacturer for the project; REMAC the designer of the transport box; AMEC NNC who were responsible for the modelling of the transport box and GCS Johnson, who were responsible for the transport of the packaged Slag Pots.

REFERENCES

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2. International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Materials, 2005 Edition, Safety Standards Series No. TS-R-1
3. International Atomic Energy Agency, Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Materials, Safety Guide No TS-G-1.1 (Rev 1)