

Introduction

On 17 March 2011 at 12:45 a shipment of airfreight from Hong Kong which originated in Tokyo, Japan caused a Project Cyclamen alarm at a major UK airport. Project Cyclamen is designed to pick up any radioactive material entering the UK at the various sea ports and airports around the UK. The load was spread over 4 air freight pallets and the manifest described it as 'musical instruments'. These belonged to an orchestra who had returned early from their tour of Japan on 15 March

As the appointed radiation protection professionals for the government department responsible for homeland security, two Nuvia Limited Radiation Protection Advisers (RPAs) duly jumped into a car and drove to the airport's freight terminal. Local security officers had determined of the presence of iodine-131 and caesium-137, with dose rates approximately 10 times background levels.

What followed was a week's intensive work to try and determine the reason for the alarm, the source of the radioactive material and then to try and unload, monitor and decontaminate all of the items on the 6 air freight pallets. The timeframe for this work was somewhat shortened by the need of the aforementioned orchestra to play a live concert on the evening of the 25 March. The work involved liaising with the regulatory authorities, ensuring the commercial aspects were in place, working with handlers at the airport who were contracted to the carrier to move the items around the airport, as well as other agencies, RPAs and stakeholders.



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The Alarm – 17 March 2011

Upon arrival at the airport in the late afternoon of the RPAs the 4 pallets had been isolated for investigation. The pallets were made up of a number of layers of plastic sheet covering the bulk of the cargo underneath. At this stage it was not possible to determine exactly how the pallets had been put together.

The initial investigations performed by the RPA on arrival at the site yielded the following information:

Dose rate information

Pallet	Position ¹	Average dose rates (nSv/h)	Maximum dose rates (nSv/h)
1	Bottom	120	150
2	Bottom	180	200
3	Bottom	200	240
4	Bottom	200	220

Dose rate measurements around the air freight pallets

Dose rate measurements were made using a Ludlum 12S.

Direct probe contamination measurements

Pallet	Direct readings- gross counts (cps)
1	Average: 30 Maximum: 60
2	Average: 50 Maximum: 150
3	Average: 50 Maximum: 100
4	Average: 30 Maximum: 60

Direct readings from packages using Electra-DP6

The direct readings were made using an Electra DP6 dual phosphor contamination probe.

Swab-to-probe measurements

Pallet	Location	Direct monitoring of wipe (gross counts, β, cps)
1	Right side	25
2	Back	24
3	Front	15
4	Front	15

Table 3: Swab-to-probe results from pallets

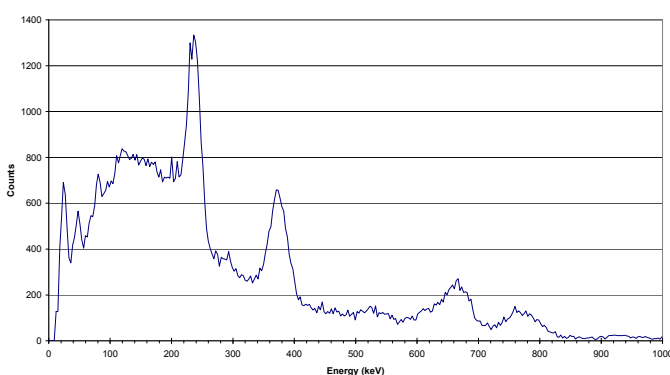
Swab-to-probe analysis was made using a dry wipe of the surface which was then presented to the Electra DP6. Each wipe was estimated to be 0.3 m² (3,000 cm²).

Table shows the highest values. Detectable contamination was found on all sides.

No detectable alpha contamination was found either by direct probe or swab-to-probe.

A low resolution handheld spectrometer (Exploranium GR-135) was used to obtain an energy spectrum from the loads to identify the nuclides present. An identiFINDER also used had identified iodine-131 and caesium-137, however due to the library on the GR-135 the isotopes were not identified by that instrument. The spectrum from the GR-135 has been reproduced in image 1. This image shows peaks at 225 keV, 368 keV, 662 keV, and 796 keV.

300 second low res gamma spectrum of Load 2 up to 1 MeV



Using the wipe-to-probe analysis and the maximum counts of 25 cps, a 10% pick up factor and 20% probe efficiency it was estimated that the contamination level was 0.4 Bq/cm². The total exterior area of the loads was estimated to be 60m² and as such the total activity across the four pallets was estimated to be 250kBq assuming the maximum loose contamination measured was present over all surfaces.

This information was enough to confirm that the load did not pose a threat under Cyclamen, and the contamination was likely the result of on-going problems faced by Fukushima Daiichi nuclear power plant following the tsunami of 12 March.

The Investigation – 18 March 2011

Following resolution of what had caused the alarm and the estimated of the level of contamination that was present, the following day one of the pallets was chosen to investigate which items exactly were contaminated within the package and a better understanding of the levels of that contamination.

Prior to the unwrapping of one of the pallets, the area for the investigation was prepared – an area of floor approx. 5m x 5m was monitored for alpha and beta contamination to attain background levels. The area was covered with a double layer of plastic sheets which were secured using duct tape.

Pallet 2 was chosen and a careful process of 'unwrapping' the pallet and monitoring each piece of 'wrapping' to discover which parts of the shipment were contaminated.

The dolly carrying the pallet was moved into the middle of the sheets using a fork lift truck, and the RPAs doing the work donned PPE (Tyvek suits, gloves and overshoes). The work began very circumspectly as the value of the shipment had been estimated at £15 million due to being made up of the instruments used by the orchestra during their tour of Japan.

The pallet was made up of an undersheet which was laid on the aluminium flight pallet. The flight cases were then loaded on to this with wooden blocks used as wheel chocks, and polystyrene pieces used as packing material and finally the cases were secured using ratchet straps. A number of clear plastic sheets and an opaque plastic woven tarpaulin were then placed on top to cover the load. Finally a cargo net was placed over the top of all of these to secure the load.

All of the plastic sheets were found to have similar levels of contamination on then with levels found to be 1–1.5 Bq/cm² beta by direct probe with the exception of the undersheet which was found to have approximately 7.5 Bq/cm² on it.

The flight cases contained on the pallets were found to have very low levels of contamination which appeared to be caused by transfer from the undersheets where they had been lifted and taped to the flight cases. The external contamination on the flight cases was removed, and the interior of the flight cases were found to have no contamination in them. Further the aluminium pallet used to support the load had no detectable contamination in the areas monitored.

The wheels of the flight cases were also found to have low levels of fixed contamination where the wheel had been in contact with base sheet. In these cases the only part of the wheel to show fixed detectable activity was the part of the wheel in contact during the flight. No additional detectable contamination was picked up from rolling the flight cases across the pallet so they could be lifted of with a fork lift truck.

This work was completed on the afternoon of Friday 18 March.

A further two air freight pallets arrived during the investigation, both of which also caused alarms for Project Cyclamen. The levels on these pallets were found to be consistent with the first four, and were the final part of the total consignment of 6 pallets.



Monitoring the airfreight



Monitoring flight cases

The Results

At 11:11 UTC on 18 March 2011 a 300 cm² damp wipe using a Whatman filter paper was taken from the plastic sheet used to wrap the pallet during unloading. This was taken to a nearby laboratory for analysis by hi-resolution gamma spectroscopy which was decay corrected to 15:21 UTC on the same day. The analysis showed a number of different fission products were present.

Isotope	Radioactive half life	Activity on swab on 18 March 2011 (Bq)	Estimated Bqcm ⁻² 1
Caesium-134	2.07 years	16	0.11
Caesium-136	13.16 days	3	0.02
Caesium-137	30.2 years	17	0.11
Iodine-131	8 days	11	0.07
Iodine-132	2.3 hours	43	0.29
Technetium-99m	6 hours	0.3	2e ⁻⁶
Tellurium-132	3.26 days	54	0.36
Total			0.96

Results of hi resolution gamma spectroscopic analysis of wipe

Given the isotopes present it is likely this contamination is a result of the incident at Fukushima Daiichi nuclear power plant following the tsunami of

the 12 March 2011. The nuclear power plant is approximately 200km south-south-west of Tokyo airport

The Reason

Discussions with the airline that transported the consignment into the UK, and their colleagues in Japan who had loaded the flight cases on to the pallets reveal the reason for the contamination. It appears the pallets were prepared with the base sheet laying over the pallet on the tarmac at Tokyo Airport for a period of a couple hours prior to the flight cases being loaded onto the pallet and the pallet packaged up for transport.

It would be reasonable to deduce that during the period of time that the base sheet was laid on the pallet the radioactive material was deposited on the surface of the sheet as a result of a release from Fukushima Daiichi nuclear power plant. This was then wrapped up and contained within the shipment until they were detected by UKBA's Project Cyclamen.

The cargo nets, which are permanently attached to the airfreight pallets, would also have been laid out on the tarmac while the pallets were waiting to be loaded, hence the cargo nets being contaminated also.

The Clearance – 24 & 25 March 2011

Following the characterisation of pallet 2 so far as possible, the items were repackaged, as due to the 'emergency response' nature of the work, there was not the required man-power or capability to arrange a full clearance of the airfreight pallets.

Further as this was no longer a threat under Project Cyclamen the costs for clean up and disposal fell to the airline that transported the consignment. The need now existed for a commercial contract between the RPA and the airline. The need for expediency was becoming more apparent as the orchestra to whom the instruments belonged were due to play a live concert on Friday 25 March 2011. Over the following 5 days discussions took place with enforcement agencies in the UK (Health and Safety Executive and Environment Agency) to understand their enforcement position and ensure we were in a situation to complete the work legally.

Following commercial negotiations, engagement with the enforcement agencies (the final agreement coming from the enforcement agencies at around 6pm on Wednesday 23 March), and the completion of the required paperwork to ensure the work was carried out safely, the RPA and a team of 2 surveyors met at the Airport on the Wednesday evening to start work on Thursday morning.

Over the next day and a half all six airfreight pallets were unwrapped, the contaminated materials identified and bagged up for disposal. Any contamination found on the flight cases was easily removed. The contamination on the wheels of the flight cases was firmly fixed, despite repeated efforts to remove it. On the evening of the 24 March the orchestra picked up those flight cases which were available following discussions with the RPA, and their own health and safety people. The rest of the flight cases were collected at lunchtime on the 25 March.

The highest value for contamination measured on the flight case wheels suggested a maximum activity on one wheel was 150 Becquerels with typical values less than 100 Becquerels. All of the wheeled flight cases that were placed on the base sheets had different levels of activity on the wheels.

Using the dose coefficient of 1.8x10⁻⁷ Sv/Bq for iodine-131 (the most restrictive isotope present) for a baby taken from ICRP publication 72, applying a gut transfer factor of 1 (i.e. all the iodine is absorbed through the gut), and using the public dose limit of 1 millisievert gives a conservative annual limit on intake of 5500 Becquerels. Assuming probe efficiency of 20% would give an instrument reading of 1100 cps. Following this conservative assessment a clearance level of 100 cps was chosen which corresponds to an activity of 500 Becquerels and therefore a dose of 0.09 millisieverts (90 microsieverts) should the total activity of a wheel be consumed by a baby (a very unlikely event).

The following table outlines the total activity levels found on the base sheets, the cargo nets wooden pieces in the consignment. Note: these values are lower than previously quoted due to the short half life of the major contributory isotopes.

Waste Items	Activity (Bq)
Contaminated plastic sheets	1,600,000
Contaminated cargo nets	252,000
Wooden chocks	180,000
Total Activity	2,032,000

Estimated activity of all items disposed of from air freight