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REPORT ON AN UNUSUAL PLASTIC ITEM FOUND ON SANDSIDE BEACH ON 15TH DECEMBER 2006

ABSTRACT

During a routine survey for radioactive particles on Sandside beach in December 2006, a contaminated object was detected. In-situ measurements confirmed that the plastic-like material contained ^{137}Cs and the object was transferred to the Dounreay laboratories for photographing and further analysis. The contamination was shown to be inhomogeneous and was concentrated in an area occupied by what looked like a whitish-coloured plastic bottle with a small rubber cap. Isolation of this item confirmed that almost all of the ^{137}Cs activity was associated with it. In order to obtain further information on the contamination fingerprint, actinide analyses were carried out. Radionuclide ratios (137Cs, 241Am, 238Pu, 239+240Pu) obtained for two portions of the item were compared to other known or estimated fingerprints, but no clear match was obtained. The bulk object which contained the contaminated item was observed to float in seawater and could therefore have travelled long distances. Based on the proximity of the find to Dounreay, however, it is likely that it has its origins there, although other more distant sources cannot be ruled out.

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1. INTRODUCTION

During a routine survey at Sandside beach on the 15th December 2006 at approximately 1335, the alarms on the beach survey vehicle were triggered by a plastic-like item (Figure 1). It was found towards the eastern end of the beach, lying in seaweed close to the water's edge at coordinates 296726, 965472. Mr Minter from Sandside estate was contacted and his representative, Mr W. McIvor attended the scene. The radioactive contaminant which triggered the alarm was confirmed as ^{137}Cs using a handheld spectrometer. The item along with entangled flotsam such as seaweed was recovered to Dounreay, where it was analysed by UKAEA chemistry support services (CSS).

2. RESULTS

2.1 Field monitoring

Initial readings by Health Physics (HP) surveyors using an EP15 probe were 50cps beta gamma. The item was retrieved from the sand surface by the team and further dose rate measurements were taken by an RO2 instrument which gave12 µSv/hr beta/gamma and 2 µSv/hr gamma.

2.2 Laboratory measurements

At the labs the item underwent further analyses, including gamma spectroscopy and contamination and dose rate measurements.

Table 1 - Gamma spectroscopy results (Bq). Results qualitative only due to non-standard geometry

Sample reference	^{137}Cs result or LOD	^{60}Co result or LOD	^{94}Nb result or LOD
SS/06/19	4.6E+03	<2.4E-01	<1.8E-01

.To check for homogeneity of the contamination, a handheld probe was moved slowly across the item. The highest counts came from the middle of the item (400cps beta) with a radiation level of 11 µSv/hr at contact & <2 µSv/hr at 10cm measured by RO2 meter. It is therefore likely that the contamination was localized and could be a point source. The mini monitor measuring the beta count was an EP 15L which has a higher efficiency for ^{137}Cs than the field instrument.

A selection of photographs of the item are show in Figures 1, 2, 3 and 4. The main bulk of the item is black in colour and appears to have been melted and deformed, perhaps due to fire or being near some other heat source. In the area near the centre of the bulk item can be seen a whitish item at the top of which is a small black rubber-like cap (Figure 2) which was removed for closer examination (Figure 3). It is not clear if this whitish item was originally part of the bulk material or has subsequently become fused to it. The cap was able to be stretched during removal and appears to have been deliberately shaped with a bevelled appearance and is ridged near the middle. Removal of this cap revealed a flange-like end to the whitish material (Figure 4). The beta count rates were largely confined to this area of the bulk material where the whitish item was located. The ^{137}Cs contamination could be associated with it, or could be associated with a particle trapped in the bulk black

material, or associated with the part of the black material itself. Photographs have been circulated within UKAEA Dounreay in an attempt to recognize what the whitish item might be, on the assumption that it has originated from somewhere on site.

A pair of pointed tweezers were applied to the bulk material; it could be penetrated but only with considerable pressure. The whitish material was more flexible.

No part of the item reacted to the passing of a magnet over it.

Measurements were made of the weight and dimensions of the item and are shown in Table 2.

Table 2 - Approximate weight and dimensions of item.

Sample reference	Weight (g)	Length (mm)	Width (mm)	Height (mm)
SS/06/19	153	190	45	90

The bulk item was placed in a dish of water to see if it was buoyant. The item sank. From a measurement of the amount of water which was displaced, the density of the bulk item was assessed as close to 1.0.

Care was taken to retrieve particulate material which was released into the water phase. This material was retrieved and combined to form a sample for gamma spectrometry. The water used in the flotation test was also counted by gamma spectrometry. The rubber-like cap was also counted. The results of these measurements are shown in Table 3.

Table 3 - Gamma spectrometry results for additional samples. Result for rubber cap is qualitative due to non-standard geometry. ND = not detected

Sample	Weight (g)	137Cs (Bq/g)	137Cs (Bq)
Rubber cap	-	-	51
Loose particulate material	0.843	689	581
Test water	-	-	ND

To a first approximation, the amount of ^{137}Cs on the cap and in the loose material accounts for about 15% of the total ^{137}Cs estimated on the whole sample – see Table 1.

After sawing a small piece from one end of the bulk item, the internal structure was examined visually. The newly exposed faces were solid and black with no notable structure or voids.

Small pieces of material were removed from the black bulk material and from the flexible whitish material within it for analysis by EDAX and XRD.

EDAX results from the white material show the most abundant element to be carbon with significant amounts of oxygen. Examining three different spots on the sample gave the percentage weight of carbon to be between 75 and 80% and the percentage weight of oxygen to be between 15 and 20%. Some other trace elements were present which are consistent with sea water - these include sodium,

chlorine, aluminium, phosphorus, calcium, potassium, sulphur. The black material gave broadly similar results although with a wider range of 60-85% for carbon and 12-25% for oxygen. One spot also showed 9% nitrogen. Similar trace elements were also found. These results are consistent with the materials being some form of plastic.

XRD results were not conclusive for either sample. In both cases the potential matches being suggested are all long chain hydrocarbons but there are no exact matches. We are not confident with these to suggest anything more specific than long chain hydrocarbons. Hydrocarbons do tie in with the predominantly carbon elemental breakdowns from EDAX.

UKAEA will send all three main types of material (the bulk block-coloured material, the rubber-like cap and the whitish item) to a specialised external laboratory for further identification.

Figure 1 - Item retrieved from Sandside beach on 15th December 2006.

Figure 2 - Close up of whitish item near middle of bulk material. Rubber-like cap is visible behind the white material

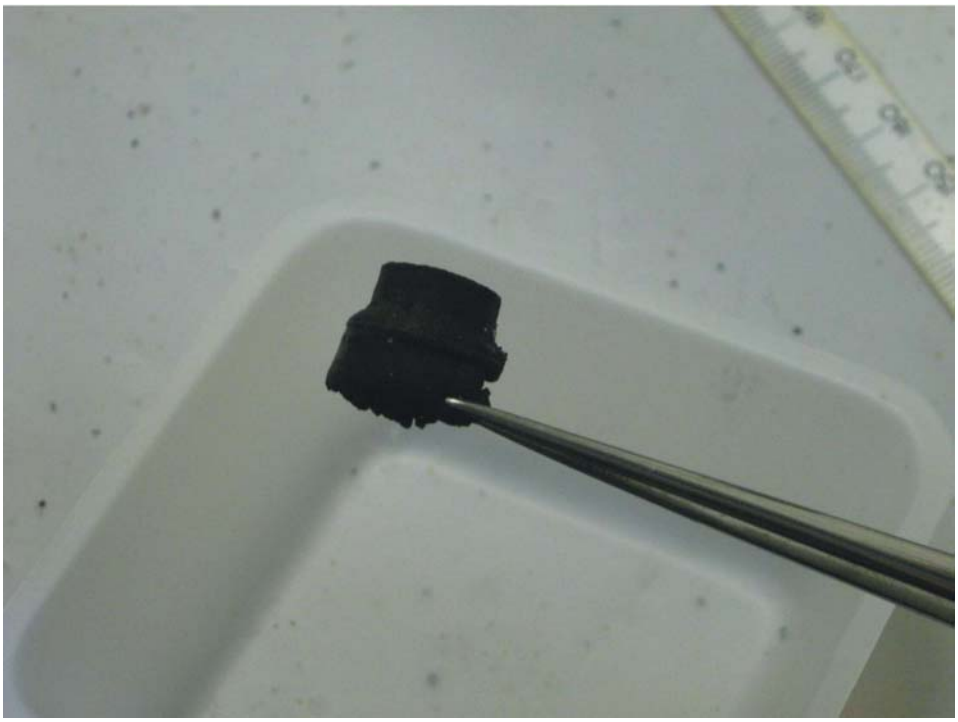

Figure 3 - Rubber-like cap after removal from whitish item

Figure 4 - Close up of whitish item after removal of cap

Further cutting was carried out on the most active part of the plastic i.e. the smaller whitish item within the larger black bulk material. Using a handheld probe to guide where the activity resided, the active item was cut into seven pieces, which ranged in count rate from 40 to 1000 cps. Only small count rates from the residual black material of about 10 - 15 cps were recorded, therefore almost all the activity resided in these 7 pieces.

The cps, ^{137}Cs and ^{241}Am levels in each piece is provided in Table 4. The highest activity piece (piece 1) is the one in the centre of the bottom row in Figure 5.

These results are consistent with the contamination being of a diffuse nature on the whitish item, rather than there being one or more irradiated fuel particles present. The Am/Cs activity ratio is approximetely 0.01 - 0.02 and is fairly consistent across the seven pieces. Typical Am/Cs activity ratios for MTR particles where we have measurements is around 0.001.

In the spreadsheet, the 'Previous Total' is the results for the larger piece, consisting of all 7 parts shown here, plus some surrounding black material. The 'activity balance' for all 3 measurements shows that the sum of the individual pieces accounts for the activity measured in the larger, composite piece, allowing for some counting geometry effects and counting uncertainties.

Figure 5 - Pieces of plastic separated from the active area. Each piece contained ^{137}Cs and ^{241}Am

Table 4 - Contamination results on pieces of plastic cut from item found at Sandside. The activity balance is total of the individual pieces divided by the previous total result from the original uncut material

Piece no.	cps beta-gamma	Cs-137 Bq	Am-241 Bq	Am/Cs activity ratio
1	1000	2292	55.4	0.024
2	70	295.8	10	0.034
3	400	1210	22.9	0.019
4	40	144	3.8	0.026
5	350	2729	26	0.010
6	150	1114	7.9	0.007
7	120	402.9	5.8	0.014
total	2130	8187.7	131.8	0.016
Previous total	1500	7000	75	0.011
activity balance	1.42	1.17	1.76	1.50

In order to provide some further information on radionuclide fingerprint, two of the seven pieces were seleted for radiochemical analysis of plutonium. Pieces 2 and 6 were analysed for plutonium isotopes ^{238}Pu and $^{239+240}$Pu. The radionuclide signatures for these two pieces are summarised in Table 5.

Table 5 - Radionuclide signatures for two analysed pieces of contaminated plastic

Sample	Piece 2	Piece 6
Radionuclides	Result (Bq)	Result (Bq)
^{137}Cs	296	111
^{241}Am	10.0	7.9
^{238}Pu	2.5	2.4
$^{239+240}$Pu	29.8	27.0
^{241}Am/^{137}Cs	0.034	0.071
$^{239+240}$Pu/^{241}Am	3.0	3.4
^{238}Pu/$^{239+240}$Pu	0.084	0.089

These radionuclide signatures can be compared to other signatures known for potential source terms. In the case of the Dounreay particles, typical activity ratios for MTR and DFR particles are available from extensive radiochemical analysis and from high resolution gamma spectrometry (1). Typical radionuclide activity ratios for the particles are summarised in Table 6. These are not a good match for the contamination on the plastic and in any case, the contamination is thought to be diffuse rather than from particles.

Table 6 - Typical radionuclide signatures for Dounreay particles

Dounreay particles	MTR type	DFR type
$^{241}Am/^{137}Cs$	0.0008	0.0000002
$^{239+240}Pu/^{241}Am$	0.285	125
$^{238}Pu/^{239+240}Pu$	5.1	0.18

In terms of levels of authorised liquid discharges from Dounreay, there will be quite a range in these nuclide activity ratios over different time periods. An item which has been contaminated by authorised discharges could exhibit an integrated signature over any time period since discharges began. The integrated signatures from authorised Dounreay discharges for recent years are shown in Table 7. An item could also be contaminated by a particular process on site, where the radionuclide ratios could be very different from those in bulk liquid discharges.

Table 7 - Radionuclide signatures for integrated liquid discharges

Liquid discharges Dounreay	2004	2005	2006
$^{241}Am/^{137}Cs$	0.00014	0.013	0.00051
$^{239+240}Pu/^{241}Am$	3.6	0.35	0.61
$^{238}Pu/^{239+240}Pu$	0.24	0.33	0.19

Since the bulk plastic item was observed to float in seawater, another possibility which arises is that the item and its integrated contaminated plastic could have travelled long distances, with the most likely travel direction from west to east along the north coast. It is also possible that the small contaminated item itself could have travelled to Sandside and subsequently been fused to the larger black material in a camp fire on the beach – there are anecdotal reports of fires being set on this local beach. It is known that an incident at Sellafield in November 1983 resulted in contaminated debris being stranded on a number of Cumbrian beaches (2). The contaminated items included plastic jetsam, bituminous material and other man-made items. One item, an irregularly shaped piece of 'whitish resin' was analysed by radiochemistry and gamma spectrometry. The radionuclide signatures from this item are shown in Table 8.

Table 8 - Radionuclide signatures for piece of contaminated 'whitish resin' found at the Cumbrian coast after an incident at Sellafield in 1983

$^{241}Am/^{137}Cs$	1.16
$^{239+240}Pu/^{241}Am$	3.5
$^{238}Pu/^{239+240}Pu$	0.27

More recently, other contaminated plastic items (plastic pipes) were recovered from beaches on the Isle of Man in December 2003 (3). One of these had a patch of radioactive contamination. Contaminated materials which float can, therefore, be transported to beaches distant from their point of origin. However, from the fingerprints available (Table 5), it is not possible to say if the contaminated plastic material found on Sandside beach in December 2006 was definitely from Dounreay. The fingerprint does not match that from MTR or DFR particles, or from Dounreays'

recent liquid discharge or from the single sample of contaminated material from the 1983 Sellafield incident. Given the wide range of radioactive operations at Dounreay throughout the history of the site, it is certainly possible that the contamination of the plastic material found at Sandside did originate from Dounreay, the closest nuclear site.

3. REFERENCES

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