Radiological Hazards from Deposits of Tin-Smelting Slag and the Problems of Site Clearance and Disposal

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ABSTRACT

High background dose rates from tin smelting slag used as sea defences led to the identification of our client's site as one of a number with a potential external and airborne radiological hazard. Surveys showed that access to the affected area should be restricted as a precaution. Samples taken for analysis fell just below the level of activity which would require the material to be disposed of as radioactive waste. To ensure safe disposal a scheme is being developed to dilute the slag with general building rubble before disposal to an appropriate landfill tip.

INTRODUCTION

From the end of the nineteenth century until the early 1970's tin smelting was carried out in Bootle and surrounding areas near Liverpool and the river Mersey in the UK. The tin bearing ore contains significant quantities of the naturally occurring radioactive isotopes ^{238}U and ^{232}Th and their daughters. The specific activity is enhanced in the slag during the smelting process and in large quantities the slag can present a significant radiation hazard.

The collapse of the industry in a depressed area of the country means that the problem arises on derelict or semi-derelict land. In addition the owners of the land are often not familiar with radiation protection legislation and its implementation.

This paper describes the provision of advice and assistance in radiation protection to the owners of a trading estate part of which had once been part of a tin smelting works. Operations included advice on immediate protection measures, identifying and contacting the relevant authorities and the arrangements for clearing the site and disposing of the material.

DISCOVERY OF PROBLEM

The first indication of the existence of a radiological hazard came during a routine survey being carried out for Sefton Metropolitan Borough Council. Radiation levels over 10 times the normal background were traced to rocks in the river estuary put in place as part of sea defences. The rocks turned out to be made up of waste slag taken from local smelting works.

An assessment of the hazard to members of the public using the area concluded that the critical group were likely to be dog owners out exercising their animals (the area is away from beaches which are likely to be frequented during the summer). It was estimated that an individual would need to be exposed for 70 hours for doses to exceed 500 µSv which was thought to be considerably more than would occur annually. The council therefore decided that no further action was required with respect to the sea defences.

However, Her Majesty's Inspectorate of Pollution (HMIP), which is responsible, inter alia, for administration of the Radioactive Substances Act (ref 1), were informed. HMIP compiled a list of sites where a hazard may exist and notified the owners. Following a visit to an industrial estate, part of which had once been part of a tin smelting works, the owners of the site asked us for advice on immediate precautions which were likely to be necessary and long term measures to remove the problem.

NATURE OF THE HAZARD

The tin bearing ore contains ^{238}U and ^{232}Th and their daughters. The thorium decay series includes ^{208}Tl with a 2.6 MeV gamma emission. This means that although the specific activity is low large quantities can exhibit significant external dose rates because of the build up of radiation from within the bulk material. Each decay chain includes an isotope of radon gas which could result in significant radiation doses if it diffused into buildings constructed aver the slag without proper precautions.

From the point of view of the site owners the problem is therefore one of controlling the hazard from external radiation before any development takes place and taking steps to control the additional hazard from airborne activity in any buildings on the site. One such site in the area had been developed for housing and all the slag had had to be removed before building could commence to ensure that there would be no abnormal radon hazard.

In formulating a proposal for the disposal of the smelting slag a major consideration must be that the problem is not simply transferred to another site.

SURVEY RESULTS

The survey of the site carried out by HMIP had shown areas with dose rates up to 6.5 $\mu Sv\ h^{-1}$. While this is not particularly high in a nuclear establishment it is high for an area where there are no restrictions on access. An initial survey at the start of the contract confirmed the results and further defined the high dose rate areas as being associated with a particular type of material and a sample was taken for analysis.

A more detailed survey was carried out during which a number of samples of various types of material were taken for analysis from different depths with the aid of a mini-excavator. In areas previously inaccessible due to brambles dose rates up to 10 $\mu Sv\ h^{-1}$ existed at 1m above the surface. A plan of the site with associated dose rates is shown in fig 1.

Table 1 shows some results of the samples taken from the locations shown in fig 1. Only representative nuclides below and above the radon isotopes need be measured equilibrium levels soon become established after the processing. Values in brackets have been inferred from other measurements; samples were analysed by different laboratories but there was good agreement between them. The slag (samples 2, 3, B(2) and C(2)) is hard vitreous material but around 30% of the ^{220}Rn is lost before it decays to ^{216}Po and around 60% of ^{222}Rn diffuses out.

It was found that the area was covered with slag and rubble to a depth of approximately 1.5m. About 1000m^2 was found to consist of the more active 'black slag' with about 2500m^2 of less active 'grey slag' weighing approximately 1900 and 3200 tonnes respectively. The remainder of the material is building rubble.

The total activity has been estimated to be 11.3 GBq ^{238}U and 26.9 GBq ^{232}Th.

REMEDIAL MEASURES

Following the initial site visit and discussions with the Factory Inspector from the Health and Safety Executive (HSE) the owners were advised to fence off the affected area. Strictly speaking as no operations were being carried out in the area it does not come within the category of work with ionising radiations but it was considered prudent to restrict access.

Normally before radioactive waste may be accumulated the operator must register under the Radioactive Substances Act. However, as the activity is naturally occurring an exemption order under the act (ref 2) applies and registration is not required. Similarly a licence is normally needed for the disposal of radioactive material with a specific activity exceeding very low limits (e.g. Thorium: 2.6 Bq m^{-3}. The exemption order allows disposal of waste containing natural activity up to 15 Bq m^{-3}.

As can be seen from Table 1 the levels of activity just fall below the limit and could therefore be disposed of without reference to HMIP. However, this would only transfer the problem from one location to another and it could resurface at a later date. The solution which has been proposed is to 'dilute' the active material with general building rubble. This has been used successfully on waste from other sites in the locality. In the current recession the site owner has no plans at present to develop the affected area and currently only requires a disposal route to be identified and an outline of arrangements to ensure the protection of workers during removal operations. These will be prepared in the near future in consultation with HMIP and the HSE and put on hold until such time as they are required.

REFERENCES

1. Radioactive Substances Act 1960 As Amended 1990

2. The Radioactive Substances (Phosphatic Substances, Rare Earths etc.) Exemption Order 1962

TABLE 1: Analysis Results

Nuclide	Sample Activity (Bq/g)					
	1	2	3	F	B 2	C 2
Th-232	(2.5)	(12.1)	(14.2)	0.09	12.1	14.7
Po-216	(2.5)	(8.7)	(10.2)	(0.07)	(8.7)	(10.6)
Tl-208	0.9	(2.9)	(3.4)	(0.02)	(2.9)	(3.5)
U-238	(1.6)	(5.3)	(6.2)	0.24	5.0	5.4
Po-218	(1.8)	(1.8)	(2.1)	(0.07)	(1.6)	(1.7)

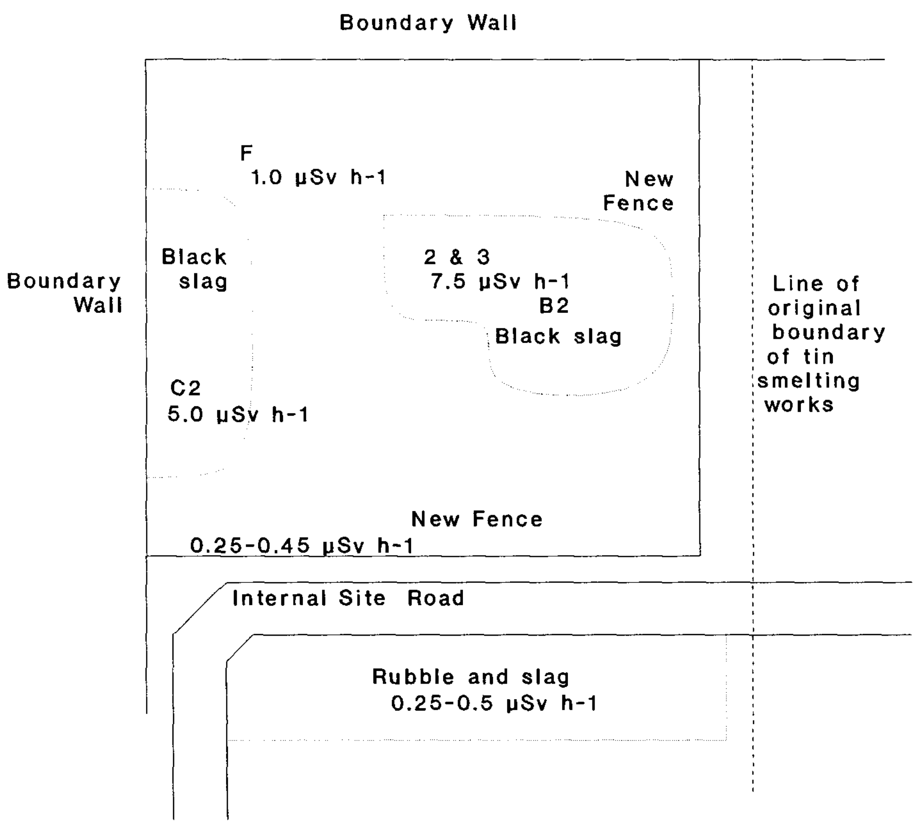

Figure 1: Plan of Affected Area