Management of Response to the Polonium-210 Incident in London

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Abstract. On the 23 November 2006, Alexander Litvinenko died in London allegedly from poisoning by 210Po, an alpha particle emitter. The spread of radioactive contamination, arising from the poisoning and the events leading up to it, involved many locations in London. The potential for intakes of 210Po arising from the contamination posed a public health risk and generated significant public concern. The scale of the event required a multi-agency response, including top level UK Government emergency response management arrangements. The Health Protection Agency (HPA) had a leading role in co-ordinating and managing the public health response. This paper reviews the management of the incident response and the issues involved.

KEYWORDS: Radiological emergency, Incident management, polonium-210

1. Introduction

On the 23 November 2006, Alexander Litvinenko died in London allegedly from poisoning by 210Po, an alpha particle emitter. The spread of radioactive contamination, arising from the poisoning and the events leading up to it, involved many locations in London. The potential for intakes of 210Po arising from the contamination posed a public health risk and generated considerable public concern. The scale of the event required a multi-agency response, including top level Government emergency response management arrangements. The Health Protection Agency (HPA) had a leading role in co-ordinating and managing the public health response. This paper reviews the management of the incident response and the issues involved. It provides an overview of the scale of the incident, background information on the UK Emergency Response Framework and that of HPA and then summarises some of the key elements in the different parts of the response.

2. Overview of Scale of Incident

The public health response had to deal with thousands of concerned individuals. It was necessary to talk to and risk assess each of these together with staff and visitors at locations arising from the investigation, and to follow up where appropriate with urine analysis to measure levels of intake of 210Po. In the UK many hundreds of individuals were assessed: of these over a hundred had detectable levels of 210Po that could be attributed to the event. In addition to UK residents, a large number of those potentially exposed to 210Po were overseas visitors who had stayed in, or visited, one of the hotels or other locations involved in the incident. These needed to be followed up through diplomatic, public health and radiation protection channels.

In parallel to this the London Metropolitan Police Service (MPS) were undertaking a criminal investigation. As the investigation progressed it identified many locations where there was the potential for the presence of radioactive contamination. In order to manage and prioritise the monitoring and other emergency response resources in a rapidly changing situation, good liaison with the police and other agencies was essential. Polonium-210 contamination was found in tens of

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locations, including hospitals, hotels, offices, restaurants, bars and transportation. In some cases it was possible to carry out simple decontamination procedures at the time of monitoring and release the location as being safe for public access. However there were some locations where this was not possible and the levels of contamination were such that public access had to be prohibited until appropriate remediation or decontamination work had been undertaken.

Throughout the incident a range of operational criteria and guidance had to be developed by the HPA to support the response, to what was an unprecedented event. Often, particularly during the early part of the incident, decisions on courses of action had to be taken on the basis of limited information. A key element in this process was the maintenance of dynamic risk assessments. The acute phase of the response lasted into January 2007, with the recovery phase lasting into the summer.

3. Emergency Response Arrangements

3.1 UK Emergency Response Framework

The actual response to an emergency, whether it be a transport accident, infectious disease outbreak, flooding, radiological, chemical etc. can involve a large number of organisations that need to co-operate, support each other, and understand their roles and responsibilities in the combined response. To address this the UK has a generic national framework [1] for managing emergency response and recovery that is applicable irrespective of the size, nature or cause of an emergency, but remains flexible enough to be adapted to the needs of particular circumstances. The framework identifies the various tiers of management in emergency response and recovery, and defines the relationships between them. It provides a common framework within which individual agencies can develop their own response and recovery plans and procedures.

Within this framework, the management of the emergency response and recovery effort is undertaken at one or more of three ascending levels:

- **bronze** – operational level;
- **silver** – tactical level; and
- **gold** – strategic level.

Most emergencies, such as traffic accidents and fires, are of a small scale and do not warrant all the levels to be activated. However, where an event or situation has an especially significant impact or substantial resource implications, it may be necessary to implement multi-agency management at the “Gold” level. The multi-agency group, which brings together Gold commanders from relevant organisations, is called the Strategic Co-ordinating Group (SCG). Its purpose is to take overall responsibility for the multi-agency management of the emergency and to establish the policy and strategic framework within which individual agencies will work. The SCG is normally chaired by the police, particularly where there is an immediate threat to human life, a possibility that the emergency was a result of criminal activity, or significant public order implications.

Where the scale or complexity of an emergency is such that some degree of government co-ordination or support becomes necessary, a designated Lead Government Department (LGD) takes responsibility for the overall management of the government response [1]. Collective decisions are made in the Civil Contingencies Committee (CCC) chaired either by a Government Minister or senior official from the LGD. To facilitate the co-ordination, the Government maintains dedicated crisis management facilities, the Cabinet Office Briefing Room (COBR). The acronym COBR tends to be used to refer to these overall government arrangements.

3.2 Implementation of the National Response arrangements

Following the confirmation that Mr. Litvinenko had been poisoned with $^{210}$Po, the Metropolitan Police briefed the Home Secretary. It was clear that the consequences posed a potentially serious threat to public health due to the spread of radioactive contamination. The scale of the problem was unknown
but it was certain to raise public concerns and attract significant media attention. In the light of this, COBR national emergency response arrangements were activated. The Home Office was the LGD, providing the chair of the Civil Contingencies Committee (CCC) meetings. In the later stages the COBR governmental co-ordination function was passed to the Incident Management and Recovery Working Group. From the start of the incident through to the end of March 2007, COBR provided the top level cross-government co-ordination, decision-making, resource allocation and tasking. The frequency of the COBR meetings, the need to provide these meetings with situation updates and the dissemination of the subsequent tasking set the top level “battle rhythm” into which the SCG and responding organisations had to fit. To ensure that all those attending COBR were using the same information, an updated Common Recognised Information Picture (CRIP) was produced for each meeting from the Situation Reports from each organisation. The latter had to be provided at least two hours before a COBR meeting, so that any conflicting information issues could be resolved before the meeting. The CRIP also provided underpinning for the identification of issues and proposed strategies. Typically it covered:

- new developments;
- the situation at the contaminated locations;
- capacity and resource issues;
- public health response and issues;
- international issues;
- media response.

For incidents with a public health component, the Department of Health would normally take the health lead, with the Health Protection Agency sitting beside them at COBR providing the necessary public health and scientific support. However, in view of the nature of the incident and the operational response required, the Department of Health tasked the Agency to take the public health lead; liaising with the Department of Health as needed. The HPA Chief Executive Officer (CEO) and senior staff provided regular briefings to ministers and senior staff at the Department of Health.

An SCG was established by MPS and this provided the main interface to co-ordinate strategies, for pursuing the police-led criminal investigation, the HPA-led public health response and the local authority-led recovery programme. The SCG meetings also addressed health and safety of responders, community impact, media issues and resources. It was clear that the incident would have a significant recovery phase and the SCG took an early decision to establish a sub-group, the Recovery Working Group (RWG) chaired by Westminster City Council (WCC).

The Agency had several staff liaising with the Police operations. Staff from the Home Office - police’s radiation protection advisers were also located there, and this arrangement facilitated good co-operation at the operational level.

3.3 HPA Structure and Emergency Response Arrangements

The Agency was established under the Health Protection Agency Act 2004, and brought into one organisation a number of previously established health sector specialist organisations; in particular the former National Radiological Protection Board became the HPA’s Radiation Protection Division (RPD). The functions of the Agency are "to protect the community (or any part of the community) against infectious diseases and other dangers to health". The HPA has a large network of approximately 3,000 staff based regionally and locally throughout England and at three major centres. The structure of the organisation is shown schematically in figure 1.

Whilst the RPD provided a key part of the response, significant support was drawn from the other Divisions, in particular the Local and Regional Services (LaRS) division. The functions of LaRS include local disease surveillance, alerting systems, investigation and management of the full range of health protection incidents and outbreaks, and ensuring local delivery and monitoring of national action plans for infectious diseases. Much of the work of LaRS is delivered through their Local Health Protection Units (HPUs). Each unit consists of a director, Consultants in Communicable Disease
Control (CCDC), nurses and other staff with specialist health protection skills. Currently there are 28 HPUs (each covering about 2.0 million population) grouped into nine Regions. The London and South East Regions, supported by the other regions, played a major part in the response to the incident.

**Figure 1** Structure of the Health Protection Agency

The Agency can be involved in responding to a very wide range of incidents which may have an impact on public health. To address these threats, the Agency has a suite of linked plans. The Incident and Emergency Response Plan (IERP) provides overarching arrangements for the Agency’s response to, and management of, incidents and emergencies; and is designed to sit within the UK emergency response framework. The plan sets out the main arrangements for deployment, co-ordination and management of the Agency’s assets and resources; together with arrangements for interoperability with other responders and government. This provides the framework for more detailed, but consistent plans that address threat and location specific situations. One of the threat specific plans is the mature and well rehearsed Nuclear and Radiological Emergency Response Plan, which along with IERP was used in the polonium incident.

A key element of IERP is that for major emergencies HPA establishes a National Emergency Co-ordination Centre (NECC) and the relevant specialist Divisions establish their own Emergency Operations Centre (EOC) to support the NECC and implement the strategies and tasking. The primary functions of the NECC are to:

- take a strategic overview of the response to the emergency;
- provide a forward look to issues that are going to arise;
- provide and advise on policy as directed by the CEO;
- co-ordinate and direct operations across the Agency;
- liaise with the Department of Health and other government departments / agencies as necessary;
- be the route through which actions from COBR and SCG are implemented;
- ensure that responders “at the frontline” and elsewhere receive appropriate resources and support;
- provide Situation Report briefings to the CEO and others as necessary.

### 3.4 Implementing HPA Response Arrangements

The Agencies’ main sites each have dual purpose suites that have normal operation modes such as meeting rooms or training facilities, but are designed and equipped to function as Emergency Operations Centres (EOCs). It was clear from early on that the response to the incident would require significant resources from across the Agency. Therefore RPD activated its EOC in its Training Centre at Chilton, and the Agency’s NECC was established at the Headquarters EOC suite in Holborn Gate,
London. The EOC for the London Region of LaRS was also within the same EOC suite. The relevant HPA emergency plans provide for team-based infrastructures with command and control arrangements. These are shown schematically in figure 2: the HPA components are shaded grey and the various teams shown with bullet points.

Figure 2 Schematic of main elements of the HPA’s response arrangements in the incident

Whilst the CEO was in overall command, experience from previous emergencies and exercises had shown that the CEO often had to be away from the NECC for long periods e.g. at COBR, briefing ministers and officials etc. To address this, the plans require an Incident Director to be appointed and a small CEO team of senior staff to be established. The CEO team had a roaming function and was the main focus for liaising with and receiving actions from COBR and other arms of government. It was also responsible for proposing overall strategies and maintaining a top level risk assessment. The Incident Director had the lead command and control function in order to implement the strategies from the CEO and tasking from COBR and elsewhere. The Incident Director set and maintained a “battle rhythm” to deliver co-ordinated advice and support to the “front line” responders and the Government; and to manage the implementation of actions. Within the “battle rhythm” the Incident Director convened meetings of the Incident Response Coordination Team (IRCT) to progress management of the incident. The IRCT consisted of the Incident Director and Deputy and the various team leads. Remote teams, such as those from the RPD Centre Chilton and the police liaison team participated in the IRCT meetings via teleconference.

Two teams that were not in the original plan, but which had to be added, were the Overseas Advice team (see section 4.7) and the Records team. In previous incidents the information management team had been able to manage both the flows of information in and out, and its archiving. However in this
incident the volume of information, covering tens of locations and thousands of individuals was such that it was necessary to create a dedicated records team, who also kept track of lessons identified.

4. Incident Investigation and Response

4.1 Poisoning, Hospitalisation and Recognition

On 3 November Mr. Litvinenko was admitted to a north London hospital with vomiting, diarrhoea and abdominal pain. His condition deteriorated and he was transferred to University College London Hospital (UCLH). It was reported that he said that he had defected from the Russian security services and claimed he had been poisoned. Various possible causes of illness were investigated, including the effects of ionising radiation. With respect to the latter, contamination and dose rate measurements had been made in the hospitals with a radiation monitor, but the presence of radiation was not detected. Crucially alpha contamination is not expected in a medical environment and the monitors available are not designed to detect alpha contamination.

A few days before Mr Litvinenko died the MPS requested the assistance of their scientific advisers and the HPA in identifying what could have caused the clinical picture. Tests established that Mr Litvinenko had a significant quantity of the $^{210}\text{Po}$ in his body. Initial assessments by the Agency’s Radiation Protection Division (RPD) indicated that an intake in excess of one GBq ($10^9$ Becquerels) of $^{210}\text{Po}$ would have been required to explain the clinical course [2, 3]. Further, exposure to both his body fluids and any residual source material (which was likely to have spread) could pose a significant public health risk.

4.2 Public Health Strategy

To address the hazards associated with the incident, the Agency developed key objectives for the public health response: in brief:

- **To prevent further exposure of the public:**
  - work closely with the police to aid their criminal investigation and identify sites and individuals that may be contaminated;
  - develop an environmental monitoring strategy to support this;
  - assess and advise on public access and remediation of contaminated sites.

- **To assess risks to those potentially exposed:**
  - develop and implement risk assessment criteria ;
  - offer, implement and report on personal monitoring through urine analysis.

- **To provide advice and reassurance to those exposed and the public.**

The activities necessary to achieve these objectives included identifying where contamination might be or have been since the poisoning; obtaining environmental monitoring information and a knowledge of the activities undertaken at these locations, assessing the possible patterns and magnitudes of intake of $^{210}\text{Po}$, and then identifying and prioritising those that might need to undergo a clinical examination or individual monitoring. Of particular concern were:

- the potential for other individuals to have had intakes of $^{210}\text{Po}$ sufficient to produce clinical effects (but which may not have been recognised as to their cause), or

- the possibility of as yet undetected large “reservoirs” of contamination that could be life threatening.

4.3 Environmental Monitoring

RPD environmental monitoring teams were deployed initially to the hospitals where Mr. Litvinenko had been treated. There was a clear potential risk that body fluids from him were a source of contamination. Low levels of contamination were found at the hospitals; however with an aggressive hospital cleaning policy in place it is likely the contamination levels at the time of treating Mr. Litvinenko would have been significantly higher. Therefore, it was considered necessary to carry out individual monitoring for staff that had come into contact with him. Some intakes were detected but
were relatively low, partly due to the routine use of Personal Protective Equipment (PPE) and procedures to avoid infection.

In the national response arrangements for civil and military nuclear emergencies, the HPA has the role of co-ordinating the monitoring programme outside any exclusion zone. Accordingly, in this incident, the Agency was responsible for co-ordinating the monitoring of areas outside crime scenes or where there was concern for public health. Early on it was clear that the Agency’s own monitoring resources would not be sufficient to deal with the many locations being identified by the police. Through COBR, further monitoring resources were obtained from contractors to the Government Decontamination Service (GDS), the Ministry of Defence and from the civil nuclear utilities. At the peak of operations, there were 70 monitoring staff working in shifts.

A key observation from this was that the contamination was not uniformly distributed, but was in discrete patches, and on hard surfaces it was largely fixed to the surface, not readily removable and therefore not readily available to be taken into the body. Where the monitoring teams could easily clean small spots of contamination, or remove small contaminated items, this was done and the location identified as suitable for public access. Where this was not possible the site was recommended as requiring remediation. Through liaison with the location occupier and the local authority, the site was made secure against further access. Detailed monitoring reports were prepared for each location.

4.4 Radiological Assessments

Using modelling techniques, the RPD Environmental Assessments Team made estimates of the ranges of potential radiation doses to people in restaurants, bars, offices, hotels, hospitals, cars, and transportation identified as having areas contaminated with \(^{210}\)Po and to those who came into contact with individuals potentially contaminated with \(^{210}\)Po (e.g. transfer via handshakes). Intakes of \(^{210}\)Po into the body via ingestion, inhalation or wounds were considered from various objects and surfaces (e.g. walls, doors, upholstery on chairs, crockery etc.) contaminated either directly or through body fluids (e.g. sweat, blood, and urine). These assessments provided the underpinning to the triage questionnaires covered in section 4.5.

The potential radiological impacts of the discharges of \(^{210}\)Po to sewers from the two hospitals and from the incineration of clinical wastes were also considered as were the potential implications of the burial or cremation of Mr. Litvinenko’s body. Support was also given in the development of criteria for the remediation of contaminated areas. Of particular note was the development of a reference level of 10 Bq.cm\(^{-2}\) for fixed contamination on hard surfaces. Below this level, if the contamination could not be readily removed, it was not considered to be a cause for concern.

4.5 Public health response

The HPA in London, part of the Local and Regional Services (LaRS) of the Agency led the public health response [4]. Three main groups had to be reassured or assessed; namely, thousands of individuals who contacted authorities because they were concerned about exposure to radiation or in response to a call from the Agency for them to do so (see 4.7); known visitors and staff at locations arising from the investigation; as well as persons normally resident abroad who were associated with those locations (see 4.7). LaRS staff also co-ordinated the follow up, where appropriate, with urine analysis to assess levels of intake of \(^{210}\)Po. In the UK, many hundreds of individuals were assessed.

On Saturday 25 November, following a risk assessment, the HPA made a request via the media asking members of the public who were in specific potentially contaminated locations in a specified period to call NHS Direct (a 24-hour National Health Service helpline). To support this, in collaboration with NHS Direct, a questionnaire was developed to assist the collection of key information from callers. The details of any callers associated with relevant locations were forwarded to LaRS for further health assessment and follow-up. In addition, the Agency undertook to call back every member of the public
who wished it. This was organised with help from across LaRS in six different regions. Overall, there were 3,837 calls to NHS Direct with 1,844 questionnaires going to the Agency for follow up.

A LaRS public health team led by a medical Consultant in Communicable Disease Control (CCDC) was assigned to each of the main locations. The LaRS London regional epidemiologists, with input from RPD, developed site specific risk assessments and questionnaires to identify those at risk. LaRS staff organised the collection of 24-hour urine samples for analysis by RPD and reported back the results to the individuals tested. Throughout this it was necessary to explain the process and respond to the many concerns of the staff and management at the affected locations. A complicating factor was that for many hotel staff, English was not their first language.

For each location, risk assessments were updated in the light of new information, particularly results from urine analysis. The results associated with a particular hotel bar indicated that it had given rise to more significant intakes of 210\textsuperscript{Po} than other locations. This, and information from the police investigation changed the original risk assessment and, on 7 December, the recommendation for visitors to contact NHS Direct was widened to include a longer time period at this location.

Individuals identified from any source who reported symptoms which could be associated with radiation effects, or were seriously concerned, were referred to an Agency Clinical Assessment Team at Holborn Gate. Of the 186 reviewed, a total of 29 were referred to a special clinic at UCLH. None were found to be suffering any acute radiation effects [4].

4.6 Individual Monitoring

In order to assess the radiation doses which people may have received from possible intakes of 210\textsuperscript{Po}, it was necessary to carry out an individual monitoring programme for those most at risk. This required each individual to collect a 24-hour urine sample which was analysed by alpha spectrometry to measure the rate at which 210\textsuperscript{Po} was being excreted. This allowed an assessment to be made of the original amount of radioactivity (in Bq) which had been taken into the body and the consequent dose (in mSv) the individual was committed to receive. The underlying science of the assessment is complex and the results required some assessment of the relative proportions that ingestion and inhalation contributed to the intake [3,5].

Urine analysis for 210\textsuperscript{Po} is not often carried out in the UK. In this incident, RPD had to develop, calibrate and implement a technique on a substantial scale in a couple of days. From receipt of the sample at the laboratory, it took three or four days to process each sample. It was soon clear that the number of people in the UK requiring monitoring would exceed the capacity of the RPD laboratories. Arrangements were made with two other UK laboratories which had appropriate capabilities to process some of the samples. These were the Veterinary Laboratories Agency, Weybridge and the Centre for Environment, Fisheries and Aquaculture Science, Lowestoft. Both laboratories had to interrupt their programmes of work. As a contingency, preliminary arrangements were made to use other UK and European laboratories if necessary.

Urine samples from 752 persons were processed and assessed (one additional sample was uncategorised due to the small sample size). It was necessary to develop a reporting protocol that put the results into dose bands. Polonium-210 is naturally occurring and some is found in everybody’s urine. The minimum “Reporting Level” (RL) was set at 30 millibecquerels per 24-hour sample to ensure that any result above RL was likely to be due to the event. Where the intakes were above the RL an assessment was made of the committed effective dose. Aggregated individual monitoring data was routinely reported in the HPA Press Releases, the last being on 15 March 2007. In the following months a few further urine samples were analysed. However, there was no change to the significance of the overall pattern of doses. Overall there were:

- 86 ≥RL and < 1 mSv;
- 36 ≥1 mSv and < 6 mSv;
- 17 ≥ 6 mSv.
Of the highest dose group, 14 were staff and visitors to a Bar of one hotel, two were staff from another hotel and one was a family member caring for Mr. Litvinenko before he went into hospital. The highest assessed dose was for the family member at about 100 mSv.

4.7 International Aspects

In addition to UK residents, a large number of those potentially exposed to $^{210}$Po were overseas visitors who had stayed in, or visited, one of the hotels or other locations involved in the incident. These people had to be followed up through diplomatic and public health channels. To address this, the Agency established an Overseas Advice Team (OAT) [6].

The Foreign and Commonwealth Office (FCO) arranged for an Agency Advisory Statement to go to all UK Missions (25 November) and briefings provided by the Agency were given on several occasions to representatives from overseas countries and territories. In addition, a briefing pack was sent to 180 countries and territories. A briefing for the International Atomic Energy Agency (IAEA), the World Health Organisation (WHO) and the European Commission (EC) was provided in January. To supplement these official routes, the OAT attempted to contact public health and radiation protection counterparts in affected countries. This proved to be difficult [6].

In total, attempts were made to follow up 664 individuals from 52 countries and territories. Significant difficulties were encountered in obtaining feedback on results due to data protection legislation in the various countries and medical-in-confidence issues. Nevertheless, results were received for about a quarter of the identified individuals. None had doses in excess of 6 mSv, five were in the range $\geq 1$ mSv to < 6 mSv and eight were above the Reporting Level but < 1 mSv [6].

4.8 Communicating with the Public and Media

Throughout the incident the Agency was determined to be as open as possible with the media and the public, whilst ensuring it respected the confidential nature of police investigations as well as the sensitivities of those individuals involved in the incident. The first Agency press conference on 24 November was vital in setting the tone. At this, the Agency Chief Executive Officer and the RPD Director announced that tests on Mr. Litvinenko had detected a significant quantity of $^{210}$Po. They explained the nature of alpha radiation and how $^{210}$Po was only a hazard if it was ingested, inhaled or absorbed through wounds. They also outlined the proactive monitoring the Agency was carrying out at the locations identified by the police.

During those first few days and weeks many interviews were given on radio and TV, and the Agency released press statements each day in the weeks leading up to Christmas, as well as responding to thousands of media calls and ensuring the website was up-to-date with information [7]. Significant effort was put into liaising with others involved in the response to ensure that the public received a coherent picture of what was happening. Media interest in the incident continued for over a year afterwards, although the focus shifted to the political aspects of the incident.

4.9 Recovery and Remediation

It was clear within the first day or so that the incident would have a significant recovery phase and the SCG took an early decision to establish a sub-group, the Recovery Working Group (RWG) chaired by Westminster City Council (WCC), who were acting on behalf of the various London Local Authorities in which the contaminated locations were situated. During the early response phases, the RWG developed a framework strategy and processes for remediation and clearance of locations. This has subsequently been published [8] and is commended to those who may have to plan for similar situations. The Agency provided significant support to WCC and the RWG.

The police retained the chair of SCG throughout the acute phases. Just before Christmas they handed over the chair to WCC for the recovery phase. By this time, several locations had been identified as requiring remediation before they could be released for unrestricted use. Indeed, in a number of cases
the remediation process had started. The key stages were: a radiological survey to characterise the
profile of contamination; a remediation proposal; approval of proposal, remediation work in line with
approved proposal and preparation of a final report: followed by verification and clearance. The
profiling, development of proposals and the remediation work itself was carried out by specialist
contractors facilitated by the arrangements of the Government Decontamination Service (GDS). The
proposals were approved by the relevant regulatory bodies (Local Authority, Health and Safety
Executive, Department for Transport and the Environment Agency). Finally, the Health Protection
Agency carried out the assessment of the effectiveness of the remediation and made the
recommendation that the location could be released for unrestricted use. This phase continued to June
2007.

5. Conclusion

The fatal poisoning of Mr Litvinenko with $^{210}\text{Po}$, and the associated public health hazard from the
spread of contamination to many locations across London, was an unprecedented event. Fortunately,
no one else is known to have suffered any acute effects. Results from the programme of individual
monitoring showed that whilst more than 100 people had measurable intakes of $^{210}\text{Po}$, only 17 had
assessed doses in excess of 6 mSv. The highest dose of about 100 mSv gives rise to an increased risk
of fatal cancer of about 0.5%, compared with the natural incidence of about 25%.

The incident required a co-ordinated and sustained multi-agency emergency response. The Health
Protection Agency, as the lead on public health matters played a significant role in this. Whilst
inevitably some lessons have been identified, the response is considered to have been very effective
and to have benefited from the wide spectrum of experience and expertise developed through normal
work, together with the effort put into emergency preparedness and the various emergency response
exercises.

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