UK atmospheric nuclear weapons tests

Factsheet 1

Background

Exposure to radiation in all its forms is part of being alive. Ionising radiation is taken to mean radiation of high-enough energy to displace electrons from atoms and includes cosmic rays, gamma rays, X-rays, alpha and beta radiation. The average level of exposure to natural background radiation varies throughout the world dependent mainly on the geology of the underlying earth. In the UK it is about 2.2 mSv (millisieverts) per annum average. There is, however, a range and it is much higher in areas of igneous rock such as occur in Scotland. The Health Protection Agency's latest survey (p19, Watson et al, HPA-RPD-001, 2005) specifies that the range in the annual average background UK dose is between 1 and 100 mSv, although doses in UK homes with the highest radon levels can reach a few hundred mSv.

Tissues vary in their sensitivity to ionising radiation and different types of ionising radiation have different capacity to cause tissue damage and hence adverse health effects. As no dose of ionising radiation is considered safe, natural background is generally considered the cause of a proportion of the cancers which occur in a population. In the UK about a third of the population is affected by, and about a quarter will die of, malignant disease. However, there is no clear correlation of background level with cancer incidence and areas with high total backgrounds (such as Kerala and the Andes) demonstrate no excess malignancy. By contrast the UK with one of the lower average backgrounds has one of the highest cancer incidences in the world. A synopsis on **ionising radiation dose, radiological protection and the health effects of ionising radiation is in Factsheet 4.**

Fission and fusion

The atomic bombs dropped on Hiroshima and Nagasaki relied on energy release by a chain reaction through the *fission* (splitting apart) of the heavy nuclei uranium 235 or plutonium 239. In contrast, thermonuclear devices such as were detonated in the UK atmospheric nuclear tests are 2-stage weapons with much higher yields than the original atom bombs. They rely on the *fusion* (joining together) of light nuclei - isotopes of hydrogen – that can occur only at the extremely high temperatures created by an initial fission reaction. Fusion reactions generate neutrons with very high energy, which in turn cause fission of uranium 238.

The tests were carried out to the highest contemporary radiological standards, including the use of high air-bursts and tower-mounted detonations to minimise the radiation exposure of participants. Following the early Australian tests in which *everyone* was monitored for radiation exposure, it was clear that measurable exposure was unlikely: so routine monitoring ceased and instead a targeted approach was adopted. Those personnel at risk because of their location or duties were monitored.

Most explosions at Christmas Island and Malden Island were high air-burst, whilst in Australia there were more ground-bursts or detonations in low towers. The latter *theoretically* increased the risk from ingestion of food, which generally is the most important single route to human contamination; however, in Australia personnel ate little locally-produced food, so in fact inhalation was actually the greater hazard.

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Between 1952 and 1958 the UK carried out 21 atmospheric nuclear tests (12 in Australia, 9 at Christmas Island, now called Kiritimati), in the south pacific. The radiological safety standards at the UK atmospheric nuclear trials in the 1950s were based on the then-consensus of international scientific opinion as formulated by the International Commission on Radiological Protection. A fundamental principle was to keep any exposure as low as possible. Many of the detonations involved high air-bursts falling freely. The risk of significant contamination of land occupied by service or civilian participants from these air bursts was avoided by careful selection of weather conditions and environmental monitoring following the tests. The natural background radiation at Christmas Island is very much less than that of average UK locations (averaging 0.58 mSv per annum, as confirmed by the National Radiation Laboratory of the New Zealand Department of Health in 1981). Overall it is considered that almost all the British servicemen involved in the UK nuclear tests received little or no additional radiation exposure as a result of participation. **Further details of the tests can be found in Factsheet 5**.

Environmental contamination – Christmas Island

During and following the Grapple trials on Christmas Island, environmental monitoring showed that no significant fallout had occurred on the island. The fallout measured was due to the nuclear weapons testing programme of all the nuclear weapon states which had caused global pollution. During and after the trials, the assembly and decontamination areas were fenced and controlled to prevent general access. Every effort was made to minimise contamination of the island because it was intended to be used for future UK trials programmes.

Extensive environmental monitoring took place at the time of the tests and fish were regularly caught and assayed for traces of radioactivity on the island. Fish were also caught in the island's lagoon to confirm that there was no radiological hazard in a favourite area for fishing and swimming. No harmful levels of radioactivity were detected on or in any fish caught at Christmas Island, or anywhere else in the pacific.

Environmental surveys were undertaken on Christmas Island during and after the UK trials. As a result of these surveys, the island was declared generally free from measurable radioactivity except for a few specified areas. These areas include the decontamination and radioactive assembly working areas, where residues from fallout and weapon debris were known to be present. Access to these areas was controlled throughout and following the operations. The original survey data were supported by subsequent surveys of the island in 1964, 1975, 1978, 1981 and 1998. All have shown that while traces of residual long-lived radionuclides from global fallout were detectable on the island in a few localised sites, the radioactivity from naturally-occurring radionuclides was significantly greater.

In December 2004, the Safety and Ecology Corporation of Tyne and Wear was awarded a contract to "clean up" the military waste left by the MOD after tests carried out in the 1950s and 1960s. This waste included vehicles which were neatly parked and stored before UK troops pulled out of the island. Corrosion had taken its toll, and the only radioactive waste which was cleared related to radium-luminised dials from these vehicles which were to be returned to the UK for safe disposal. Work on the island commenced in January 2005 and most of the debris was removed by the end of 2006.

Environmental contamination – Maralinga (South Australia)

It has been accepted that there would be some contamination of the Maralinga range from the trials held there. Appropriate safety measures, such as controlling access, health physics monitoring and respiratory protection were in place to ensure that no-one should have suffered adverse health effects as a result of these trials.

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New Zealand cytogenetic analysis

Concerns have been expressed regarding the clinical relevance of the findings of the recent (May 2007) cytogenetic study undertaken by Dr Rowland of Massey University in New Zealand. This showed significant levels of genetic damage in a group of 50 New Zealand veterans of the UK nuclear tests compared with carefully-matched controls. The study has yet to be peer-reviewed and published in the mainstream scientific literature. It is certainly of great interest and the first of its kind. It was carried out in a limited population and must be considered hypothesis-generating. Ideally the next stage would be replication with a bigger study group. The authors stress that their study, which is about chromosomal changes, makes no claims about the health status of the veterans. The MOD is always open to new evidence and will give very careful consideration to the study, its implications for the health of UK test veterans and our responsibilities towards them.

The NRPB nuclear test follow-up studies

As a result of concern amongst some test participants about the effects that participation could have had on their health, in 1983 the Ministry of Defence commissioned an independent study by the NRPB to investigate whether the health of participants showed any correlation with radiation exposure.

This comprehensive cohort study compared the mortality and cancer incidence in over 20,000 test participants with those of a similarly-sized control group of ex-servicemen who had not participated in the test programme.

The term 'test participant' has a particular definition in this context and includes servicemen present at the due dates, at any of the following test sites and experimental programmes.

Operation	Site	Date
Hurricane Mosaic	Monte Bello W Australia	April 1952-June 1956
Totem	Emu Field S Australia	August 1953-August 1957
Buffalo Antler Minor trials	Maralinga S Australia	April 1955-August 1967
Grapple X Y Z Brigadoon	Christmas Island S Pacific	June 1956-June 1964
Grapple	Malden Island S Pacific	October 1956-June 1964
	RAAF Pearce W Australia	May-August 1956
	RAAF Edinburgh S Aust.	Aug1956-Nov 1960

There is no requirement for presence at actual detonations.

At the RAAF sites the work included sampling and handling contaminated aircraft. RN ships were associated with tests at Monte Bello, Malden and Christmas Island. The Minor trials did not involve nuclear detonations and took place at Maralinga (Tims, Rats and Vixen A and B) and at Emu Field (Kittens). Major clean-up operations took place at Christmas Island in 1964 and Maralinga in 1964 and 1967.

The main conclusions of the first NRPB Report (Darby et al 1988) were that being present at the nuclear weapons test sites was associated with a slight risk of multiple myeloma and leukaemia (other than chronic lymphatic leukaemia) compared with a matched control-group of service personnel who were not present. This was <u>not</u> considered to be due to ionising radiation exposure. There was a particularly low rate of the conditions in the controls compared with the equivalent civilian general population. In addition, those sub-groups among the nuclear test veterans known to be the most highly radiation-exposed did not show the highest rates of the conditions.

Otherwise presence at the sites:

- did not have a detectable effect on the participants' expectation of life, and
- did not have a detectable effect on participants' risk of developing any other malignancy.

The study was extended and the second NRPB Report (Darby et al 1993) produced an additional seven years' data. It:

- confirmed the overall conclusion of the 1988 report, that participation in the tests had no detectable effect on the participants' expectation of life nor on their risk of developing most cancers;
- concluded that the small hazard of multiple myeloma suggested by the 1988 report was not supported by the additional data, although the possibility of some small risk of developing leukaemia (other than chronic lymphatic leukaemia) in the first 25 years after participation could not be ruled out.

With regard to other cancers the report concluded that:

- overall the number of deaths and cancer incidence amongst participants is lower than within the control group;
- as expected because a large number of diseases were considered, any excesses in participants are due to chance.

Following pressure for a further investigation into the alleged effects of exposure, a third NRPB study was commissioned. The report of this study, which extended the follow-up period to 1998, was published in February 2003 (Muirhead et al 2003). The report:

- reaffirmed the overall findings of the 1988 & 1993 reports that participation in the tests had no detectable effect on the participants' expectation of life nor on their risk of developing most cancers;
- confirmed the conclusion of the 1993 report on the alleged association between participation in the UK test programme and multiple myeloma, that there is no evidence to support a link;

- suggested, particularly 2–25 years after first test participation, a small increase in the risk of leukaemia (excluding chronic lymphatic leukaemia) among test participants relative to controls, although the difference in rates between the two groups is narrowing with longer follow-up. This is thought likely to have been a chance finding, related to very low cancer rates in the controls and the generally small radiation doses to participants.

The National Radiological Protection Board (NRPB) reports, of which a principal author was Sir Richard Doll, are in general highly regarded by the scientific community. Positive reactions include comment from Professor John Kaldor of New South Wales (Kaldor 1999) and the US Presidential Advisory Committee on Human Radiation Experiments (Thomas 1998).

In particular the following points are noted:

- The study identified the test participants, and followed them up to monitor the occurrence of disease and death in the participant population. It then compared this, over the same time period with the rates in both a service and civilian control population.

- The study involved 20,000 participants and an equal number of controls

- The reports describe in detail the efforts made to ensure sample completeness and to control bias.

- The study limitations are discussed by the authors and conclusions are reasoned and restrained.

Links to other Sources of Information

Health Protection Agency website http://www.hpa.org.uk/

Atomic Weapons Establishment: http://www.awe.co.uk

Veterans UK website (including War Pensions): http://www.veterans-uk.info/

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Glossary

Absorbed dose See **dose.**

Acute radiation syndrome (ARS) The onset, within hours of high **dose** whole body **irradiation,** of nausea and vomiting followed by destruction and diminished (or absent) replacement of essential blood cells resulting in vulnerability to serious infection and bleeding; recovery is possible but with increasing **doses** these effects are more severe and death is more likely.

Alpha particle A particle consisting of two protons plus two neutrons; emitted by a radionuclide.

Background radiation **Ionising radiation** from naturally occurring **radionuclides** both in the environment (from soil, rock and building materials and from space – cosmic radiation) and in the body.

Beta particle An electron emitted by the nucleus of a radionuclide. The electric charge may be positive, in which case the beta particle is called a positron.

Contamination The suspension in air or deposition of **radionuclides** upon, or in, the ground, water and other surfaces, and personnel and equipment

- **External contamination** Of a person or equipment - deposition, general or localised, of **radionuclides** upon all or any of clothing, hair, skin and/or equipment
- **Internal contamination** Of a person - deposition within the body, usually by inspiration, by ingestion or sometimes through penetration of (usually broken) skin by **radionuclides** which will then **irradiate** the cells of surrounding body tissues.

Cosmic rays High-energy ionising radiation from outer space.

Decay The process of spontaneous transformation of a radionuclide; the decrease in the activity of a radioactive substance.

Dose The amount of **ionising radiation** received, as deduced from the energy absorbed from an external radiation source

- **Absorbed dose** Quantity of energy imparted by ionising radiation to unit mass of matter such as tissue. Unit is the gray, symbol Gy. 1Gy = 1 joule per kilogram
- **Equivalent dose** The quantity obtained by multiplying the absorbed dose by a factor to allow for the different effectiveness of the various ionising radiations in causing harm to tissue. Unit is the sievert, symbol Sv
- **Effective dose** The quantity obtained by multiplying the equivalent dose to various tissues and organs by a weighting factor appropriate to each and summing the products. Unit is the sievert, symbol Sv.

Dosemeter A small device worn on the person to measure absorbed energy and from which a record of **Absorbed Dose** may be obtained.

Dosimetry The estimating, recording and maintaining of records of **dose.**

Emitter A **radionuclide** decays by emission of certain radioactive particles and/or electromagnetic radiation. A particular **radionuclide** may be described as an **alpha** or **beta** or **beta/gamma** emitter.

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Fallout The transfer of radionuclides produced by nuclear weapons from the atmosphere to earth; the material transferred.

Fission products The two, invariably radioactive, fragments remaining after an atom has been split (undergone fission).

Gamma ray A discrete quantity of electromagnetic energy without mass or charge, emitted by a radionuclide; similar to an X-ray but with higher energy.

Ionising radiation Radiation that produces ionisation in matter; examples include alpha particles, gamma rays, X-rays and neutrons. When these radiations pass through the tissues of the body, they have sufficient energy to damage the DNA.

Ionisation The process by which a neutral atom or molecule acquires or loses an electric charge; the production of ions.

Monitoring The process of searching for the presence of radiation and then measuring, reporting and recording radiation **dose rates** found within a given area or on a person.

Neutron A nuclear particle (similar to a proton but without electrical change); emitted during fission and fusion by only a few **radionuclides;** long range (kilometres) in air and highly penetrating; an external **hazard** only at detonation; densely **ionising.**

Non-ionising radiation Radiation that does not produce ionisation in matter; examples include ultraviolet radiation, light, infrared radiation and radiofrequency radiation. When these radiations pass through the tissues of the body they do not have sufficient energy to damage the DNA directly.

Radiation weighting factor (RWF) A factor intended to take account of the relative biological effectiveness of different types of radiation according to both their energies and how densely ionising they are.

Radionuclide An unstable nuclide (atomic nucleus) that emits ionising radiation.

X-ray A discrete quantity of electromagnetic energy without mass or charge, emitted by an X-ray machine; similar to a gamma ray but with lower energy.