Assessing the Need for Continued stable Iodine Distribution around the Calderhall Nuclear Power Reactor Site, Sellafield Cumbria

Calderhall Power Station, a nuclear powered electricity generating site, has four gas cooled reactors (magnox reactors). They were the first industrial scale nuclear reactors in the world and were commissioned from 1956 to 1959. They originally had the function of generating power and supplying weapons grade plutonium to the military. Since the mid-nineties when it was re-licensed for a further 10 years, up till 2006, its role has been purely generating power. The operator for all the gas cooled reactor (Magnox) sites in this country is British Nuclear Fuels Limited (BNFL). The reactors at Calder Hall are the oldest operational reactors in the world.

Due to changes in the electricity market and some difficulties with maintenance both at Calder Hall and its sister site at Chapelcross, BNFL have decided to decommission the stations early. Out of the original 26 gas cooled reactors originally commissioned, prior to the decommissioning at Calder Hall, only 12 are still operational and after Calder Hall closes, there will be only eight.

During the early phase, after shut down, the fuel rods will be left in place in the reactor and allowed to cool with subsequent removal after two years. During this phase the radioactivity reduces considerably and the radioactive isotopes with shorter half-lives measured in days or weeks will lose virtually all their radioactive within 3-6 months. Only one of the four reactors is currently operational. During this phase, the accidental reactivation of a nuclear (fission) reaction is virtually impossible.

The Health Authority has for many years been an integral part of the emergency planning team for the Sellafield site, and since 1993, Directors of Public Health have been given responsibility for ensuring that effective plans exist for the distribution of stable iodine (Potassium Iodate) around the Calderhall site. With the formation of the Primary Care Trusts (PCT), this responsibility has moved to the West Cumbria PCT supported by the Cumbria and Lancashire Health Protection Unit.

Radioactive iodine is produced as a by-product of the fission processes used in the generation of nuclear power. It produces a number of radioactive isotopes of iodine, the most important one of which is I^{131}.

If there were a release of radioactivity to the environment from the Calderhall site and the site was still active, then the release would almost certainly have a large component of radioactive iodine within it. The effects of radioactive iodine on human health are that it accumulates in the thyroid gland and can in the young (those less than 15 years) cause a form of thyroid cancer if the dose is sufficiently large. In the older population, this effect is less and in those over forty years, there is considerable doubt regarding the need for stable iodine prophylaxis in the context of an accidental exposure and protection of the thyroid gland.

The action of stable iodine is, if it is taken sufficiently early, either prior exposure to radioactive iodine or very soon afterwards, is to block the uptake of radioactive iodine into the gland. The routes of exposure to radioactive iodine are inhalation and through milk.

With the closure of the four reactors at Calder Hall, this effectively stops the production of radioactive iodine as a by-product on the Sellafield site and hence the need for the distribution of stable iodine (Potassium Iodate) to the local community.

The local community is covered by the currently pre-distributed supply of Potassium Iodate until the end of its shelf life in July 2003. The reactors are due to finish generating power on the 31st March 2003. The need for continued pre-distribution and special arrangements for potassium iodate around the site need to be reviewed.

The site will close about 112 days before the expiry date for the Potassium Iodate tablets. A worst-case scenario has been considered to assess the continued need for these tablets after the expiry date of the current tablets.

The production of radioactive iodine will cease when the reactor is shut down on the 31st March. Thereafter the amount of radioactive iodine within the plant will decrease at a rate dependent on the half-life of the isotope (The half life is the time taken for the radioactivity produced by the substance to fall by 50%). The half-life with radioactive iodine isotopes is in the order of minutes to days, with the exception of iodine 129, which has a half-life measured in the millions of years. Given this fact, iodine 129 is not considered to be a hazard as it is only very mildly radioactive and will not add significantly to the dose received from background radiation.

The accident at Chernobyl has been used to model a 'worst case scenario' on. Chernobyl is a significantly larger event that could possibly occur at Calder Hall. The reactors at Chernobyl generated 20x the amount of the reactors at Calder Hall and were of a different design. The radioactive inventory has not been calculated to the same degree of accuracy for most plants and the releases experienced at Chernobyl is likely to be many times greater than would be produced by a severe accident at a Magnox station.

The inventory from the release from Chernobyl has been used as the basis for a calculation for the remaining radioactive activity both within the facility when it has a Chernobyl type accident whilst still active, and from a catastrophic release 112 days after shutdown, when the potassium iodate tablets expire. These results are given in figure 1.

The decrease in radioactive iodine is 99.996% in those 112 days. The reason for this is the short half lives of the iodine isotopes, as they are unstable. This compares with radioactive isotopes of Caesium which caused many of the problems in this country following Chernobyl, where the decline in activity is only 4.4%. Overall, the decrease in radioactivity within the facility is 90.7% in 112 days.

The amount of iodine released from any incident after the expiry of the tablets would be insufficient to reach the lower of the emergency reference levels (a committed dose of 30mSv to the thyroid gland) for the taking of Potassium Iodate as a countermeasure at the nearest habitation. Given this, the justification for a further distribution of potassium iodate tablets to the community is not justified.

After Chernobyl, the doses to the population living up to 30 kilometres away were calculated. The doses to the thyroid gland from inhalation were calculated at between 0.02-1Sv for adults and 0.02 - 6Sv for children. Taking the 6Sv dose as the dose to which the residents of the nearest habitation to Chernobyl were exposed to, the equivalent dose for the day Potassium Iodate tablets expire (day 112), would be .004% of that level, this equates with 0.24mSv, which is below 1% the level currently recommended as the lower emergency reference level.

This situation represents a worst-case scenario and if such an accident did occur other components of the release would pose considerably more risk to health.

The regulatory position of potassium iodate is that it is a Prescription only medicine, and experience elsewhere shows that accidental ingestion by children in the context of pre-distribution is not rare; 1/1700 household years (unpublished data), though is unlikely to result in serious harm. **The benefits of a further pre-distribution after the expiry of current stock is not seen as having any direct health benefit in the event of an accident at the site.**

It is also doubtful if, after the closure of the site, the Department of Health requirements for pre-distribution are met.

The health services should however, give recognition to the fact that until the site is closed, there needs to be the plans for the continued provision of potassium iodate tablets and this is also a regulatory requirement, until the site reaches agreement on this issue with the regulators

Recommendations

1. That pre-distribution to individual households of potassium iodate is not implemented after the current stock expires.
2. That new stock purchased by British Nuclear Fuels be deployed to two rest centres to the North and South of Calder Hall in secure conditions, to supplement supplies prior to the expiry of the current stock and to only be distributed after that date to an evacuating population if the national criteria as set by the National Radiological Protection Board are met.

Action

1. The board is asked to note this paper and approve the recommendations.

Figure 1: Release Inventory for Chernobyl and remaining activity after 112 days

Radio-isotope	Core Inventory (PBq)		% of Inventory Released	Half-life (days)	Release Inventory (PBq)	
	Day 0	Day 112			Day 0	Day 112
33 Xenon	6500.00	0.00	100.00	5.30	6500.00	0.00
131 Iodine	3200.00	0.21	55.00	8.07	1760.00	0.12
132 Iodine	1040.00	0.00	55.00	0.10	572.00	0.00
133 Iodine	910.00	0.00	55.00	0.88	500.50	0.00
124 Iodine	25.00	0.00	55.00	0.04	13.75	0.00
135 Iodine	250.00	0.00	55.00	0.28	137.50	0.00
134 Caesium	180.00	161.84	30.00	730.00	54.00	48.55
137 Caesium	280.00	278.02	30.00	10950.00	84.00	83.41
132 Tellurium	2700.00	0.00	42.50	3.33	1147.50	0.00
89 Strontium	2300.00	516.84	5.00	52.00	115.00	25.84
90 Strontium	200.00	198.49	5.00	10220.00	10.00	9.92
140 Barium	4800.00	11.15	5.00	12.80	240.00	0.56
95 Zircomium	5600.00	0.00	3.50	0.06	196.00	0.00
99 Molybdenum	4800.00	304.96	3.50	28.17	168.00	10.67
103 Ruthenium	4800.00	675.84	3.50	39.60	168.00	23.65
106 Ruthenium	2100.00	1697.65	3.50	365.00	73.50	59.42
141 Cerium	5600.00	532.73	3.50	33.00	196.00	18.65
144 Cerium	3300.00	2513.13	3.50	285.00	115.50	87.96
239 Neptunium	27000.00	0.00	3.50	2.40	945.00	0.00
238 Plutonium	1.00	1.00	3.50	31390.00	0.04	0.03
239 Plutonium	0.85	0.85	3.50	8906000.00	0.03	0.03
240 Plutonium	1.20	1.20	3.50	2401700.00	0.04	0.04
241 Plutonium	170.00	167.28	3.50	4818.00	5.95	5.85
242 Curiumm	26.00	16.15	3.50	163.00	0.91	0.57
Totals (|PBq)	**75784.05**	**7077.34**			**13003.22**	**375.28**