Reduction of internal exposure from an alpha foil production operation

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ABSTRACT

Nycomed Amersham plc is a world leader in the production of foil disc sources for use in industrial and domestic smoke detectors, industrial gauging and reference sources. This work has been undertaken on the Amersham Laboratories site since the 1960's.

The manufacturing process involves the encapsulation / rolling of a precursor Americium-241 briquette into foil strips that are up to 4.5 metres long with a nominal activity of 0.7GBq per foil. Disc sources are then produced by inserting the foil through a blanking press. In 1998 **28 million** disc sources were produced using this method.

The finished foil operation is undertaken in one particular building on the Amersham Laboratories site. The operators are dedicated to this particular operation and rotate between specific tasks within the manufacturing lifecycle.

The dose history of staff manufacturing this product has always included an internal dose component. Since 1994 both the collective and maximum individual internal dose component to staff in this area has reduced three fold (57mSv to 19mSv and 8.9mSv to 2.6mSv respectively). This reduction has been achieved by a number of methods including engineered solutions and ALARA driven systems and process reviews undertaken by both Manufacturing Management and Health Physics.

This paper details what the main problems were in the laboratory, what remediation measures were introduced and the lessons that were learnt.

1. BACKGROUND

1.1 Doses

Body doses on the Amersham Laboratory site are measured by summating the external dose measured by film badges and internal dose assessed using Personal Air Samplers (PAS)

To ensure that all doses are ALARA, Nycomed Amersham bases it's dose control strategy on:

- Company dose limits which cannot be exceeded (Barring accidents)
- Control levels which can be exceeded only if approved and justified in advance by a Radiation Protection Adviser (RPA).
- Investigation levels which can be exceeded without the approval of the RPA but requires formal retrospective review.
- Local action levels for dose per issue period and dose per year. These are targets not limits.

In 1990 the Company limit, Control and Investigation levels were set at 20, 15 and lOmSv respectively. In 1995 the levels were reduced to 20, 10 and 8mSv and have remained at this level since.

To understand where foil manufacturing and internal doses fit into the site dose picture, the following tables are presented.

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Table 1: Total number of Amersham Site Staff and Alpha Foil Staff exceeding 8mSv and l0mSv, 1994 -1998.

Year	Number of Staff in the range 8 - l0mSv		Number of Staff exceeding l omsv	
	ALPHA FOIL	TOTAL	ALPHA FOIL	TOTAL
1994	3	37	4	6
1995	1	29	0	1
1996	0	7	0	0
1997	0	0	0	0
1998	0	8	0	0

The body doses received by the foil manufacturing staff are given below.

Table 2: Total body dose for staff dedicated to Alpha foil manufacturing, 1994 to 1998

Whole Body Yearly Dose (mSv	1998	1997	1996	1995	1994
Total number monitored	27	28	27	20	20
Collective internal (mSv)	19	25.7	22.5	25.2	57.2
Maximum internal (mSv)	2.6	5.7	4.4	3.3	8.9
Collective (man mSv)	61.8	63.1	69.4	79.9	119.1
Average (msv)	2.3	2.3	2.6	4.0	6.0
Maximum (mSv)	6.4	7.6	6.9	8.1	10.9

The key points from tables 1 and 2 regarding alpha foil manufacturing are:

- The doses received in 1994 were amongst the highest on the Site. 4 of the 6 staff that exceeded the Control level (l OmSv) were from Alpha Foil manufacturing.
- In 1994 internal dose contributed 48% of the group collective dose. By 1998 the internal dose contributed 31% of the group collective dose.
- In 1994 the internal dose contributed 82% of the 10.9mSv received by the most exposed individual in the group.
- Since 1994 the internal dose component has reduced three fold (57.2 to 19mSv)
- Since 1994 the maximum individual internal dose component has reduced three fold (8.9mSv to 2.6mSv)

All the internal doses referred to in Table 2 are derived from PAS assessments, this is discussed in more detail below.

1.2 Personal Air Sampler Results

Personal Au- Samplers (PAS) are issued to employees to assess possible intakes of airborne radioactivity. PAS are issued on a routine basis to staff who work with transuranic nuclides. In the course of a year approximately 2000 are issued.

Health Physics local action levels are set at 1 and 10% of the Annual Limit on Intake (ALI). Any PAS result >10% triggers Bioassay monitoring. Any PAS below 10% ALI is automatically entered onto the operators dose record without initiating bioassay monitoring. An indicator to the performance of a manufacturing area is the number of staff that fall into these 2 categories. The results for the alpha foil manufacturing and the rest of site during the period 1994 -98 are given below:

Table 3 : Total number of Alpha foil staff compared to the rest of site in the categories 1-10% and >IO'% ALI trigger levels as measured using a PAS, 1994 -1998.

AREA	PAS results	1998	1997	1996	1995	1994
Alpha foil	>1 -10%ALI	13	16	16	25	46
	>10% ALI	0	1	2	3	3
Rest of site	>1-10% ALI	3	1	3	10	14
	>10°/a ALI	1	0	3	0	5

The key points that can be derived from this table include:

- The alpha foil area is the most significant on the site with respect to internal dose
- Since 1994, the number of PAS results in the 1-10% ALI category has reduced 3 fold for alpha foil (46 to 13)
- The incidence of PAS results exceeding 10% ALI for the entire site has dropped significantly from 8 in 1994 to 1 in 1998.
- 1998 was a milestone for the alpha foil manufacturing area in that no PAS initiated Bioassay monitoring was required during the year.

2. Working Environment

2.1 People

The number of staff working in the alpha foil area has risen from 20 to 27 in the period 1994 to 1998. The majority of staff have worked in the area for a number of years and are very experienced with respect to alpha foil manufacturing. The turnover of staff has been relatively low, the main contributor being retirement or transfers to other manufacturing areas on site.

2.2 Plant

The alpha foil operations are housed in the oldest buildings on site. The infrastructure, though currently acceptable looks dated. The operations are split between a number of small rooms which interlink with each other. Within theses areas are a number of distinct enclosure types:

- Depression enclosures - rolling mills, forging, storage of briquettes.
- Hybrid boxes (flow containment, gloved fascia) - intermediate foil handling.
- Slit boxes (flow containment)- source wiping, radiography, measurement and storage.

Examples of the enclosure types and a transport container (used to transfer intermediate foil stages between enclosures) are included at the end of this report.

2.3 Process

The process has remained relatively unchanged for a number of years. The most significant change occurred in 1996 when the length of each individual foil was increased from 1.5 to 4.5 metres. The significance of this is discussed in section 4.

The volume of sources produced in the laboratory has increased from 14 million in 1995 to 28 million in 1998.

3. RADIOLOGICAL CONDITIONS - WORKPLACE AND PERSONAL

On the Amershatn Laboratories site the key radiological monitoring procedures adopted are tabulated below:

Table 4: Workplace and Personal Monitoring Procedures

Monitoring Procedure	Group undertaking the work	Frequency	Results forwarded to
Area Monitoring - Radiological	Health Physics	Quarterly	Area Health Physicist
Area Monitoring - Radiological	Manufacturing	Daily	Supervisor
Personal	Manufacturing	At the end of each work period	Supervisor
Personal	Health Physics	Monthl	Area Health Physicist
Personal Air Samplers	Health Physics	Weekl	Area Health Physicist
Static Air Samplers	Health Physics	Daily/ bi weekly	Area Health Physicist
Laboratory coat Laund monitorin	Health Physics	Weekly	Area Health Physicist

From reviewing the history of Health Physics surveys the main areas of contamination have been the enclosure fascias, transport containers and the floors. The contamination was present as either metal swarf (100's counts per second using a standard contamination monitor) or a few 10's counts of loose contamination.

Positive PAS results within the alpha foil manufacturing area are not often readily linked to personal contamination, laboratory contamination, static airborne results or real time in air results. Due to the high Activity Median Aerodynamic Diameter of Americium-241, which is increased by the foil process, any released particulate material does not lead to a continuous airborne problem. The airborne levels of activity are currently very low (<1% Derived Limit) and very few positive alpha in air alarms have been noted over the, past few years. Historically the airborne levels were higher (3-S% Derived Limit) but sporadic in nature indicating acute rather than chronic events. This follows the same pattern as the contamination. The current view is that a significant proportion of the PAS results do not represent real intakes, of those that do contribute (difficult to quantify) localised events are thought to be the main contributor.

4. ALARP PROCESS

Tables 1 to 3 indicate that internal doses have significantly improved during the period 1994 to 1998, the majority of which has resulted from subtle changes not involving excessive sums of money. A useful way of summarising the most significant changes with time is to look at the staff related issues, plant issues and the procedural / manufacturing process related components separately. For simplicity the headings are called people, plant and process. The most significant issues are detailed below.

Table 5: People, Plant and Process Changes

Year	People	Plant	Process
1990	Staff were re-educated as a result of the actions stemming from the Periodic Review of Safety.	Actions completed from the 1990 Periodic Review of Safety included: All active work benches were converted into slit boxes. The room and enclosure ventilation systems were upgraded to the Site standard. In one specific room gauntlets were fitted to the slit box fascias. Transport containers were introduced improving the containment when transferring potentially contaminated foil intermediates between enclosures. A system was introduced for monitoring swabs prior to transferring product out of the enclosure Improved change room and monitoring facilities were rovided for the laborato	
1992		Real time alpha in air monitors and a hand and foot monitor were installed.	
1994	4 of the 6 staff that exceeded the Company Investigation level were from this group. Staff awareness increased by tabulating the dosimetry data differentiating intakes from gamma dose.		

1995	Actions from a manufacturing review group lead to significant process changes and increased staff awareness	Actions completed from the 1995 Periodic Review of Safety included The transport containers were replaced with an improved design All slit box fascias were retro fitted with perspex mounted sliding glove ports	The number of transfers and the storage of intermediate foil stages were rationalised. The number of transfers was reduced from 130 to 32. Bioassay protocol reviewed by Health Physics resulting in improved guidance. Key features included actions levels for the following scenarios • Positive urine result • Positive PAS result • Known contamination event and details of what action should be taken. Bioassay sampling protocol amended. Bioassay samples now provided at home, minimising false positives through the transfer of personal contamination. Improved progress chasing by Health Physics, action status formally reviewed at the Site Safety Review meetings held quarterly.
1996	Staff training broadened to include several aspects of the process rather than specific tasks	Redesigned transport containers introduced for transferring potentially contaminated foil between enclosures	Length of intermediate foils increased from 1.5 to 4.5m. This increased the process efficiency and reduced the number of transfers down to **10**.
1997	Section leader changed, coupled with no staff above the Investigation level -leads to a slight deterioration in working practices, as suddenly not a "perceived issue" New influx of staff - better trained gradually become the majority.		
1998	New influx of staff – better trained gradually become the majority	All sliding glove ports fixed and slit box openings filled in. Slit boxes turned into hybrid boxes Ad-hoc trashing out ports replaced with standard trash ports.	Peripheral changes - use of Kemira masks widened.

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5. LESSONS LEARNT

The lessons learnt since 1990 are set out below:

5.1 Review

Progress and Action Chasing
Up to 1995 progress chasing and the completion of actions from Periodic Safety Reviews and Site Safety Reviews (SSR) were inconsistent and relatively informal, often leading to delays in implementing them. After this period a more **formal SSR was put** in place to **chase the actions from:**

- The SSR itself
- Periodic Safety Reviews
- Inquiries (both radiological and non-radiological)
- Incidents/Events (both radiological and non-radiological)
- Formal Dose Control investigations

The review is now chaired by the Site Director and personal attendance by the Operations Managers (rather than deputies) is actively encouraged.

Regarding the two Periodic Safety Reviews undertaken in 1990 and 1995 and the actions specifically related to reducing internal dose, if the actions had been completed in a timely fashion reductions in internal dose would have been noted earlier.

Manufacturing Management Reviews
In the early part of the decade Management interest in body dose/ internal dose was low. Intakes were accepted as inevitable and the frequent removal of staff from the laboratory for bioassay monitoring after a suspected intake was considered to be the norm. The culture changed in 1995 with the introduction of the more formal SSR. This resulted in a high management involvement with internal review groups addressing safety and manufacturing problems. Crucial manufacturing process improvements resulted from these Management reviews, not from Health Physics input.

5.2 Auditing

Until recently auditing the manufacturing operations for compliance against the Company, Site Safety Arrangements and the Managers' local Safety Arrangements had been poor. To remedy this there has been a drive within Health Physics to provide a clearer definition of responsibilities to initiate further audits by both Health Physics and the Manufacturing Managers.

5.3 Monitoring

Collating, analysing and comparing the raft of personnel and area performance measures against the range of site and local investigation / action levels was unstructured during the first half of the decade. A systematic review of all performance measures and action levels was initiated in 1995 and as a result workable systems implemented leading to the changes included in Table 4.

5.4 Supervision

In 1994 a new Section Leader was appointed from within the Alpha foil manufacturing area. As a result of his extensive knowledge of the manufacturing lifecycle and operating procedures, a number of changes were made to improve staff awareness and their working practices.

6. SUMMARY

Over the last decade si-nificant time and effort has been invested in a drive to reduce internal doses to the most exposed manufacturing group on the Amersham Laboratories site. The key safety related issues have been summarised by categorising the separate components under the headings: people, plant and process.

The len(,thy timescale for achieving substantial reductions in internal dose has been significant, the main reasons for this have included:

- Inconsistent progress and action chasing with respect to the outputs from Periodic Safety Reviews and Site Safety Reviews
- Unstructured collation, analysis and comparison of the raft of personnel and area performance measures against site and local investigation/ action levels during the first half of the decade.
- Lack of auditing the operations for compliance against the Site and Local Safety Arrangements
- Low Manufacturing Management interest during the first half of the decade

Through Management "buy in" at all levels, Amersham Laboratories site now has more robust arrangements for the management of safety which has lead to a reduction in operator risk from all activities on the site including the alpha foil manufacturing area. Management "buy in" to the challenges in that area was particularly important and successful.

Since 1994 the internal dose component to the alpha foil manufacturing group has **reduced three fold** (57.2 to 19mSv). As well as dose savings there have been other key benefits such as:

- Production down time reduced
- Investigation time reduced
- Process efficiency increased.

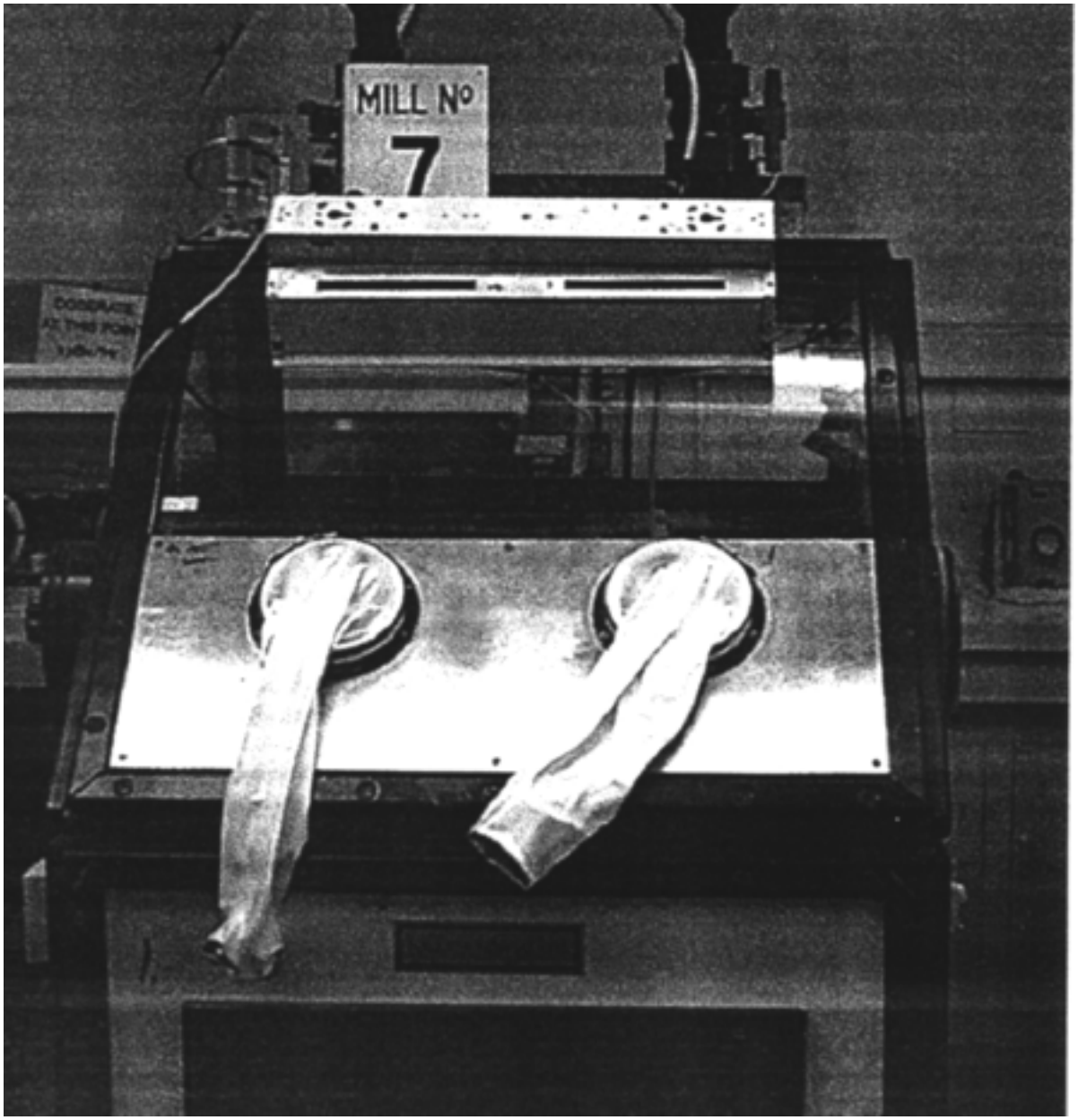

Photo 1:Typical depression enclosure

Photo 2:Typical hybrid enclosure