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13.2 Case study 8: Examples of optimization in NORM industries: the copper industry in Australia

Part 2 : example of optimization in NORM industries

One example will now be presented in the copper industry. The optimization in the case of a process modification, inserting reverts smelting

Copper rich slag (Revert) recycling in a copper smelter leading to Po- 210 fumes the stakes

In 2004-2005, addition of revert to the Cu ore to be smelted at ~10 t/h resulted in airborne radionuclide concentrations of Po-210 inside a Copper Smelter that were not sustainable in the long term (estimation of highest dose potentially received ~18 mSv/12 months).

The risks were first pointed out by the RPO after identification of the airborne component.

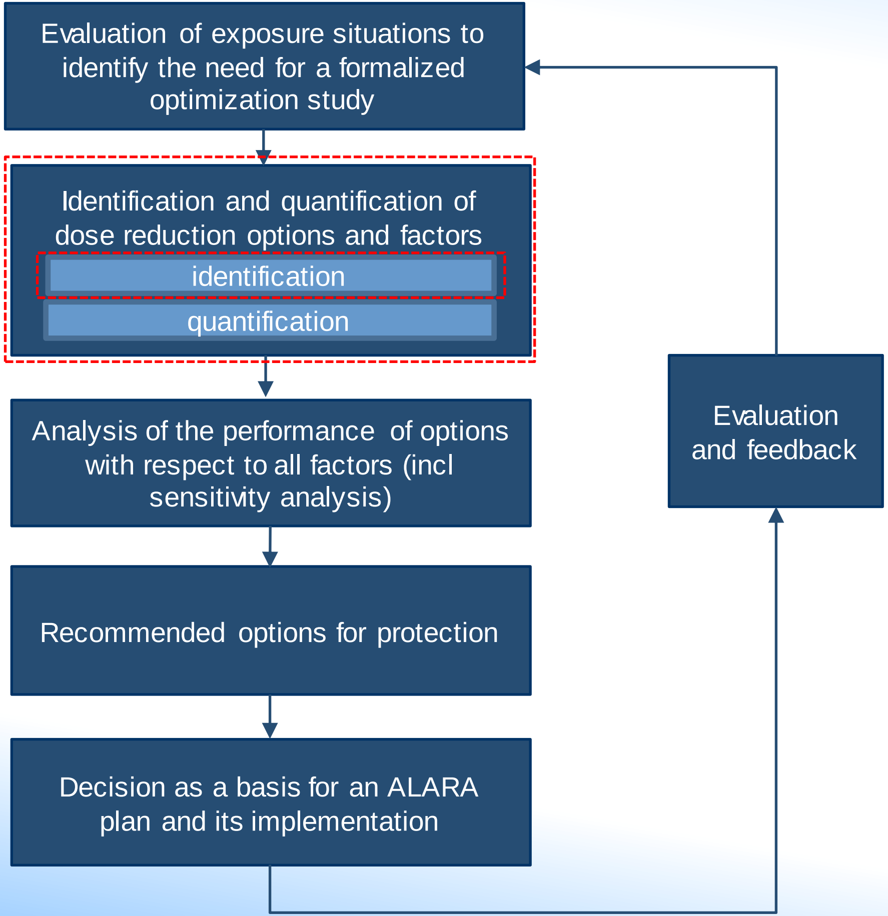
The estimation, was somehow conservative, with the hypothesis of workers staying 2000 h without any mask (which was not really the case). But doing that allowed to start thinking.

So then?

Due to these estimations of the stakes :

- the company informed the regulatory body and the workers of the estimated possible exposures;
- an investigation was decided to determine the effects of revert addition on exposure and identify protection measures;
- health physicists and production engineers elaborated plans as to how to reduce the exposures.

Step 1 being implemented



The following questions were:

What are the sources and their pathways, what are the doses they lead to?

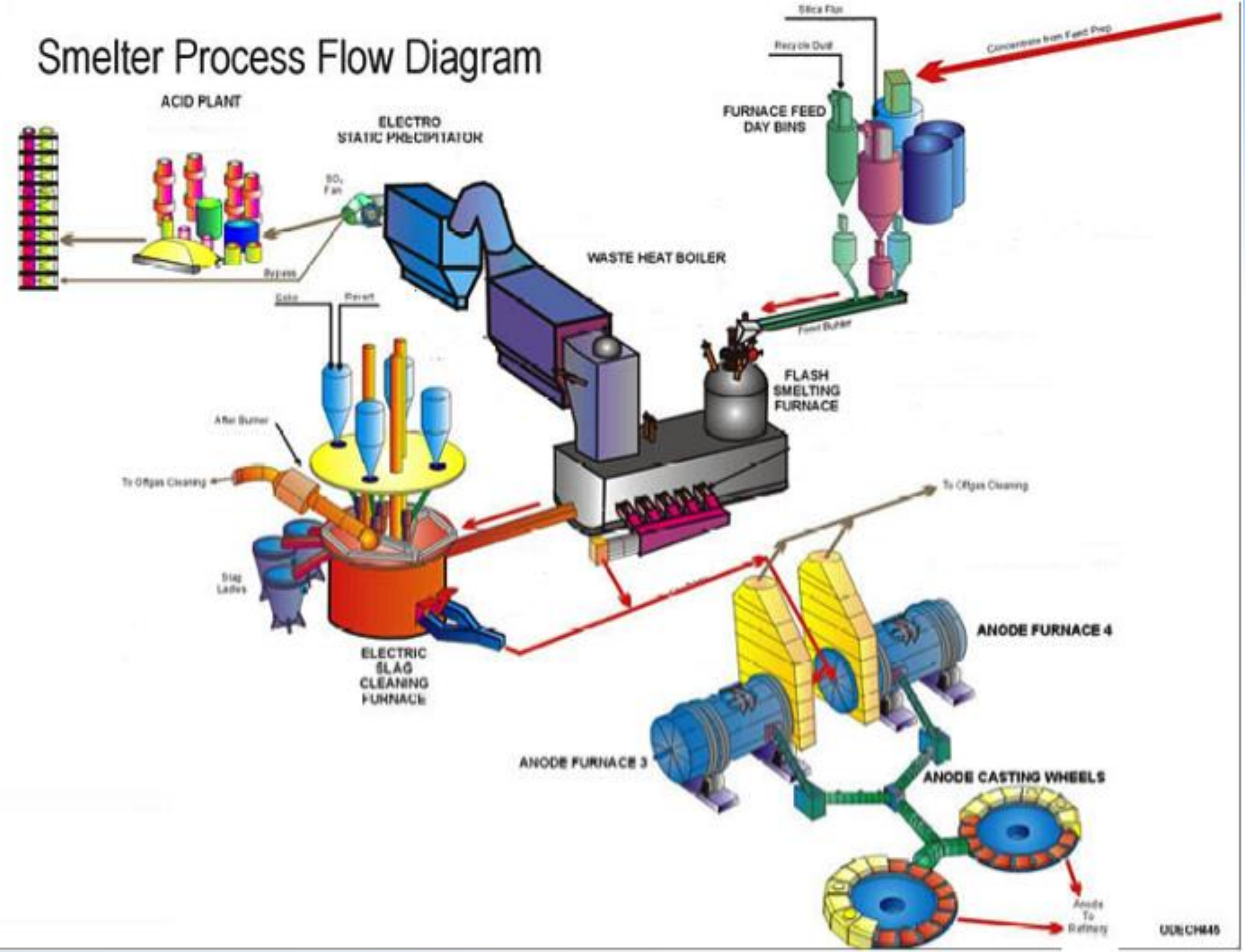
To answer these questions an analytical process started

Where and when are the doses undertaken?

What are the possible protection actions?

Have we the right tools for answering these questions?

Smelter Process Flow Diagram



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Radionuclide Pathways (external plus internal) according to an analytical approach of the process

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Copper concentrate addition to the flash furnace

- Po210 liberated in fume

Revert when being crushed

- Alpha emitting radionuclides in airborne dust concentrations
- Build up of gamma emitting material in crushing area

Revert when introduced to the electric furnace for smelting

- Po210 liberated in fume

Material inside furnaces when entered during an outage

- Alpha emitting radionuclides in airborne dust concentrations
- Gamma emitting material inside furnace

Radionuclide Pathways (external plus internal) according to an analytical approach of the process

Nearly 80% of the dose comes from dust and nearly 20% from gamma for the metallurgical plant as a whole

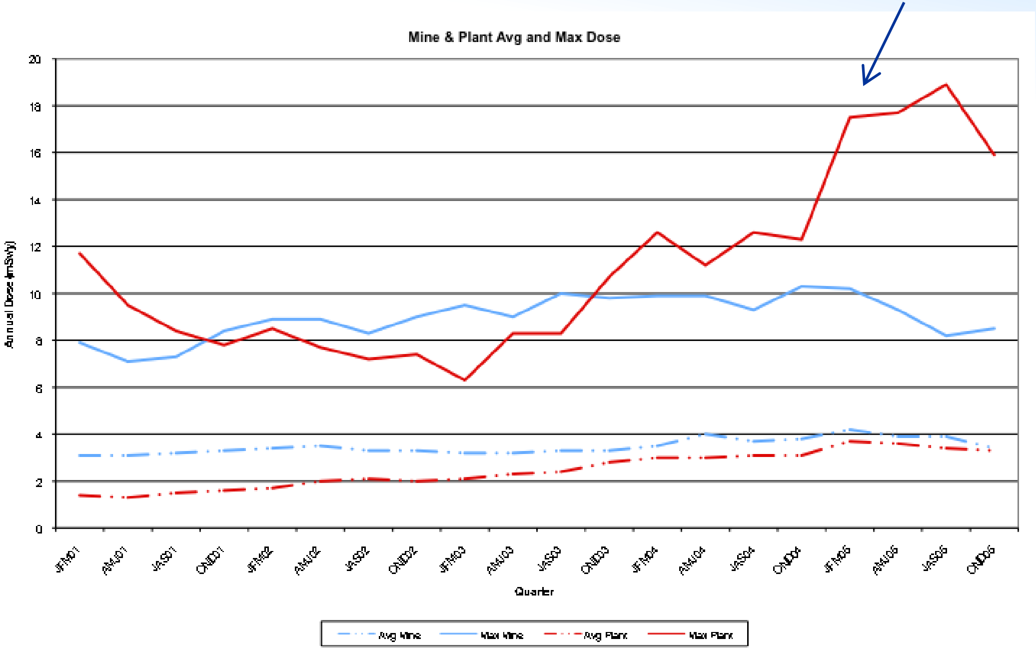
While for the workers working at smelter the dust component rises up to 85% of the total estimated individual dose

Therefore clearly inhalation of dusts is the main component on which efforts have to be put

Process plant doses

Enhanced dose due to revert smelting

20 mSv annual limit



- High individual doses at the process plant in 2005 the result of revert smelting
- Doses not acceptable

From limit compliance monitoring to monitoring adapted to dose optimization (1)

At that time it appeared clearly that manipulation and use of revert was at the origin of the individual dose increase

However doses were mainly theoretically assessed by multiplying different areas concentrations per hour by 2000 hours. This allowed to check the compliance with dose limits, not allowing to estimate the breakdown of the annual dose according to the different workshops

Revert use was stopped as a conservative action while making brainstorming for identifying protection actions and modifying the monitoring for coping with optimization needs (answers to previous questions as well as those on efficiency of actions)

From limit compliance monitoring to monitoring adapted to dose optimization (2)

As well the movement of personnel around the vicinity of the smelter was reduced to the bare minimum prior to the changes to reduce dose

A new monitoring system adapted to dose optimization was used for following a trial with theses actions: automated measurements of alpha through additional installed monitors were performed.

The question then was: “how to take care of individual doses ?”

Envisaged radiation protection actions according to the different operations (1)

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Crushing of Revert before smelting

- Collective protections for reducing sources and
  - Water sprays on all tipping points of crusher apparatus (quite low cost)
  - Covered conveyers (quite low cost)
- Individual protection (no cost, as already existing for industrial hygiene purpose)
  - Use of appropriate PPE for all activities
- Work organization (no cost)
  - Build up of material not allowed in work area
  - Significant distance between material and mobile equipment

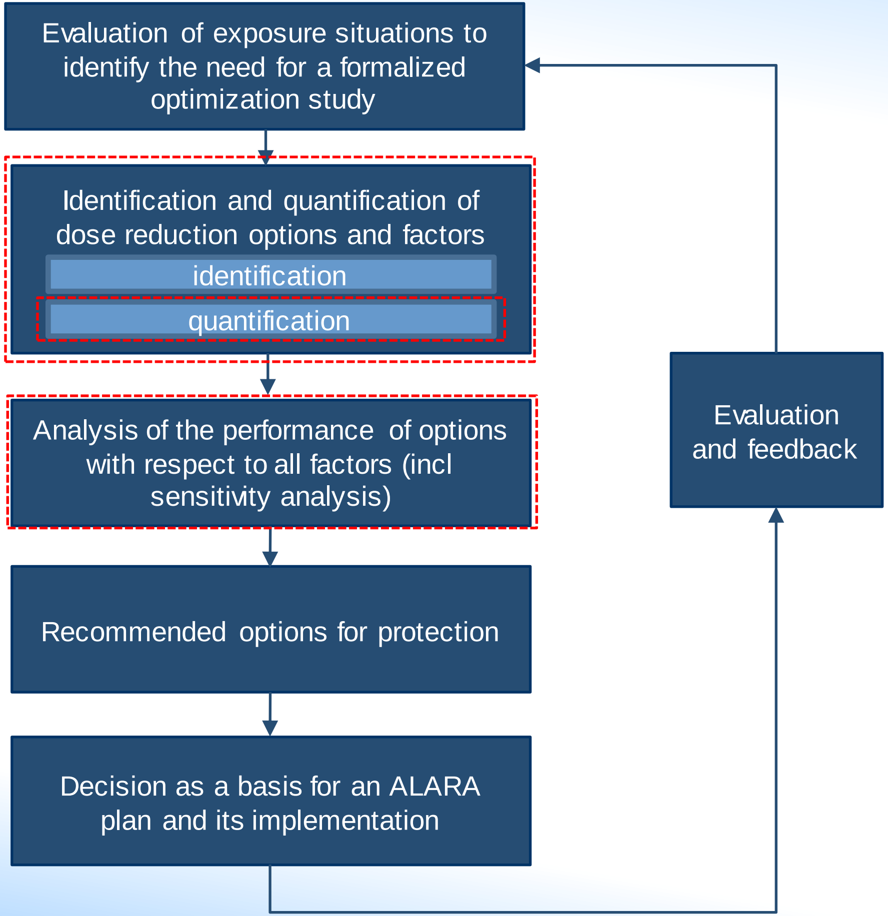
Maintenance of crushing machinery

- Wetting down machinery prior to maintenance (quite low cost)

Envisaged radiation protection actions according to the different operations (2)

Addition of Revert to the smelting

- Source reduction
  - To test Revert addition in a step increase from zero (in 2 t/h increments) that was conditional upon proven radiation monitoring results.
- Inhalation reduction
  - Significant increase in ventilation infrastructure and resulting volume of air flow rate



The following steps have been performed jointly by the health physicists and production engineers

The “a priori” hierarchy of actions

- Elimination
- Remove the radioactive source
- Substitution
- Use an alternative that is not radioactive
- Engineering
- Put in place ventilation, shielding or similar
- Administration
- Standard operating procedures, training, etc.
- Personal Protective Equipment (PPE)
- Respirators, overalls, gloves

Quantifying , analyzing, deciding

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action	cost	Dose reduction	Pulmonary disease reduction	Comfort in work
CRUSHING				
Build up of material not allowed in work area	zero	f(EWT)	yes	No change
distance between material and mobile equipment	zero	f(EWT')	yes	No change
Personal protective E	marginal	F(type)	yes	Reduced
Water sprays	low	Inhalation reduction	yes	No change
Covered conveyors	moderate	Inhalation reduction	yes	No change
MAINTENING				
Wetting down machinery prior to maintenance	marginal	Inhalation reduction	yes	Minor reduction
SMELTING				
2t/h	Waste ?	5 times	yes	No change
4t/h	NO	2,5 times	yes	No change
6t/h	NO	1,7 times	yes	No change
Increased ventilation	moderate	Inhalation reduction	yes	Increased

What about the cost efficiency?

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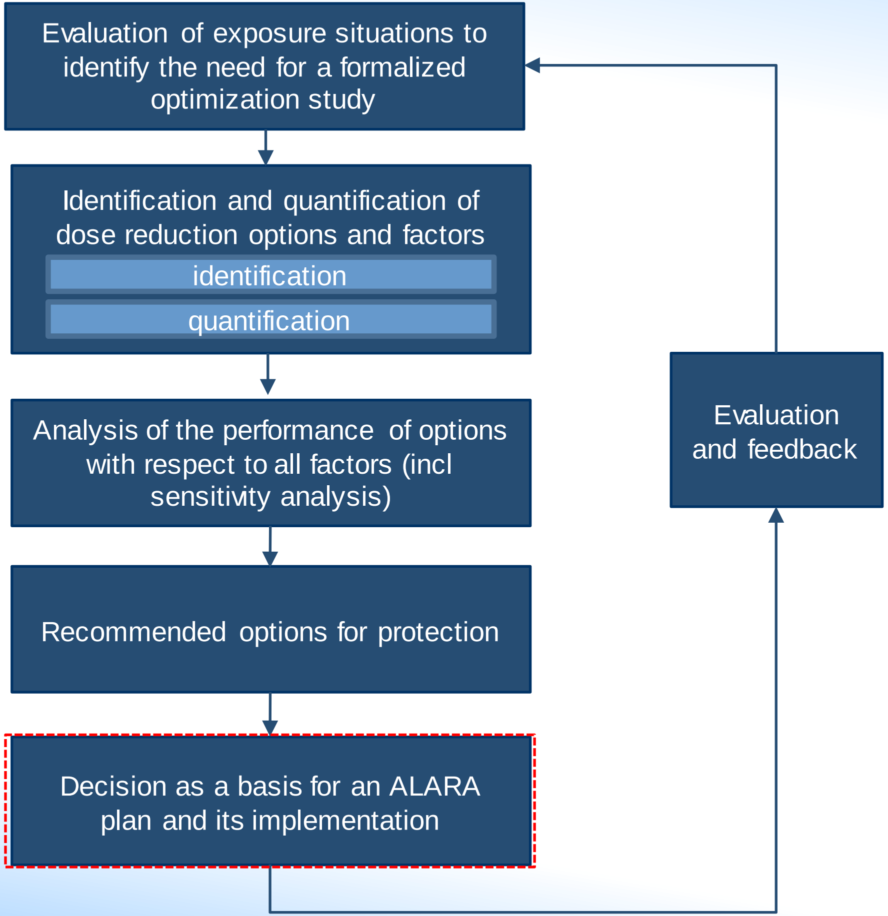
The efficiency of each option has been assessed and as well the costs

However the costs appeared either negligible or very reasonable with regards to the operation costs of the plant

Therefore they were just put into perspective with the efficiency and other criteria without formalizing it particularly

Intermediate decision



Therefore the followed up results will be packages of actions per workstation

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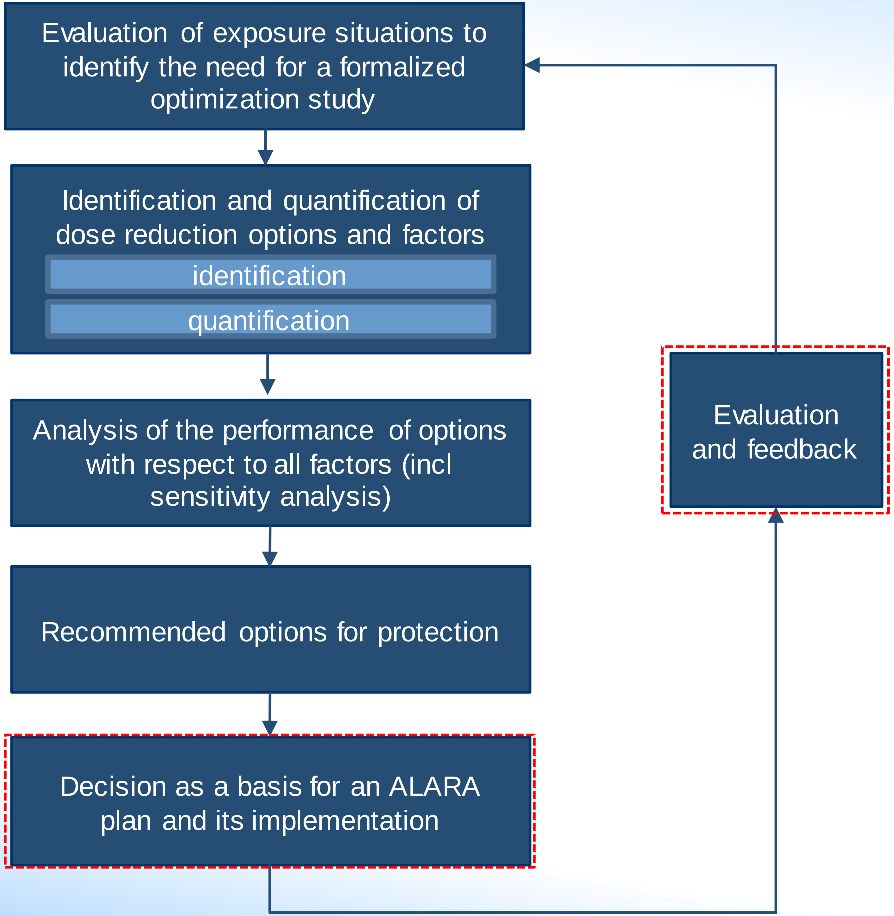
To implement all actions and to test the revert tonnage increase step by step

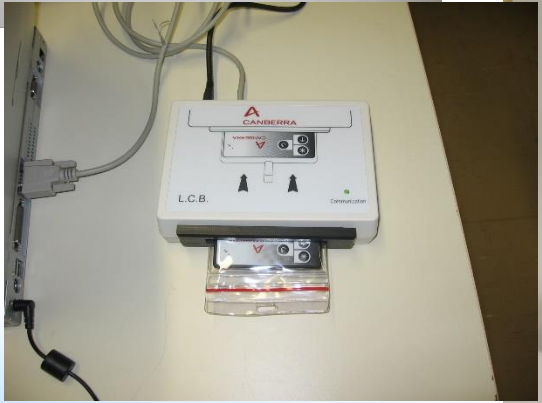


It was considered actually quantifying the efficiency in setting up (at least for a trial period) a new monitoring system both at the crushing and smelting facilities

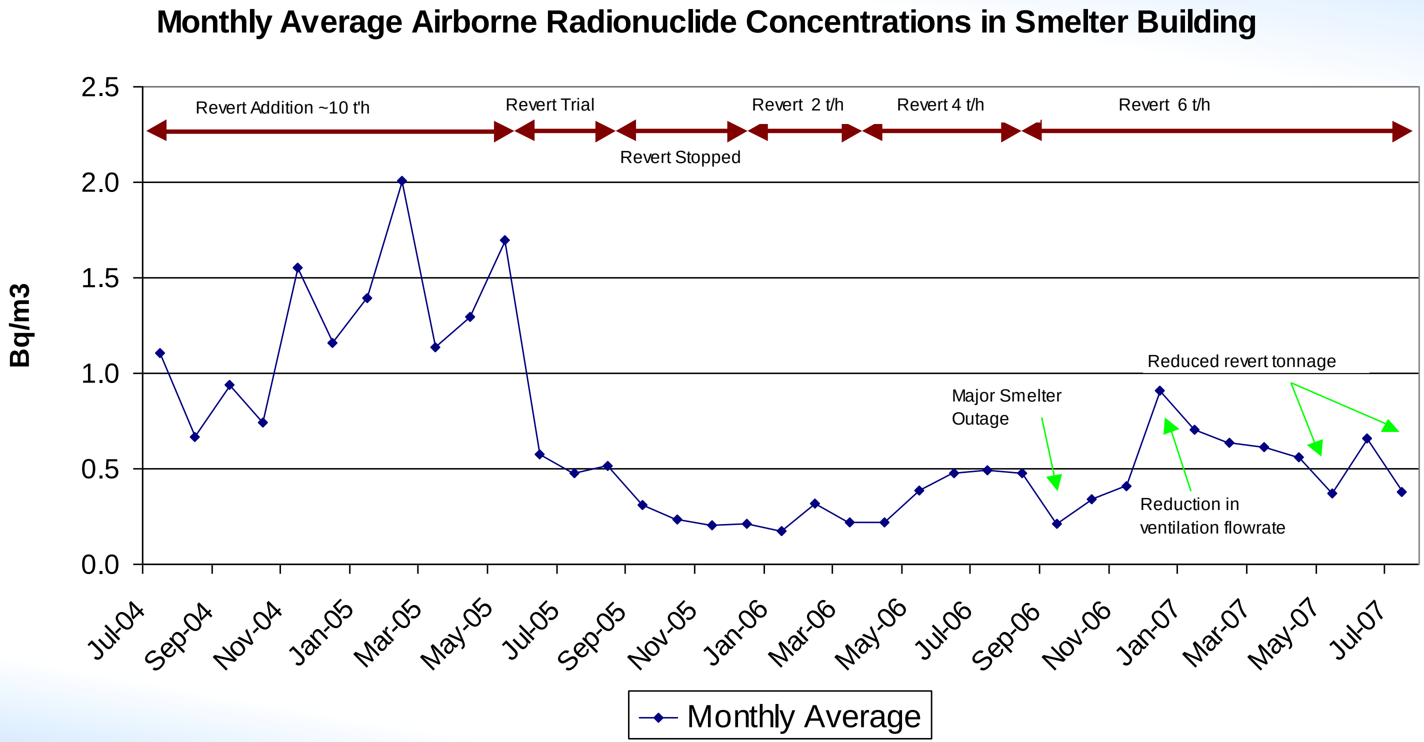
Making use of individual dosimeters and area and personal dust samplers (Adapted to quantifying radionuclide's concentrations)

Quick analysis and feedback to the workforce

PAS and SAS and Gamma monitors



Airborne Concentrations



Revert Crushing Project

In 2006, a trial was conducted to ensure that appropriate dust suppression methodology was employed

During both the trial and the project itself, intensive radiation monitoring was conducted including:

- Personal Electronic Dosimeters
- Area dust monitoring
- Personal dust monitoring

At completion of the six month project an extremely conservative estimate of dose resulted in a maximum dose of 3.7 mSv comprising of 2.2 mSv gamma and 1.5 mSv inhaled alpha particles

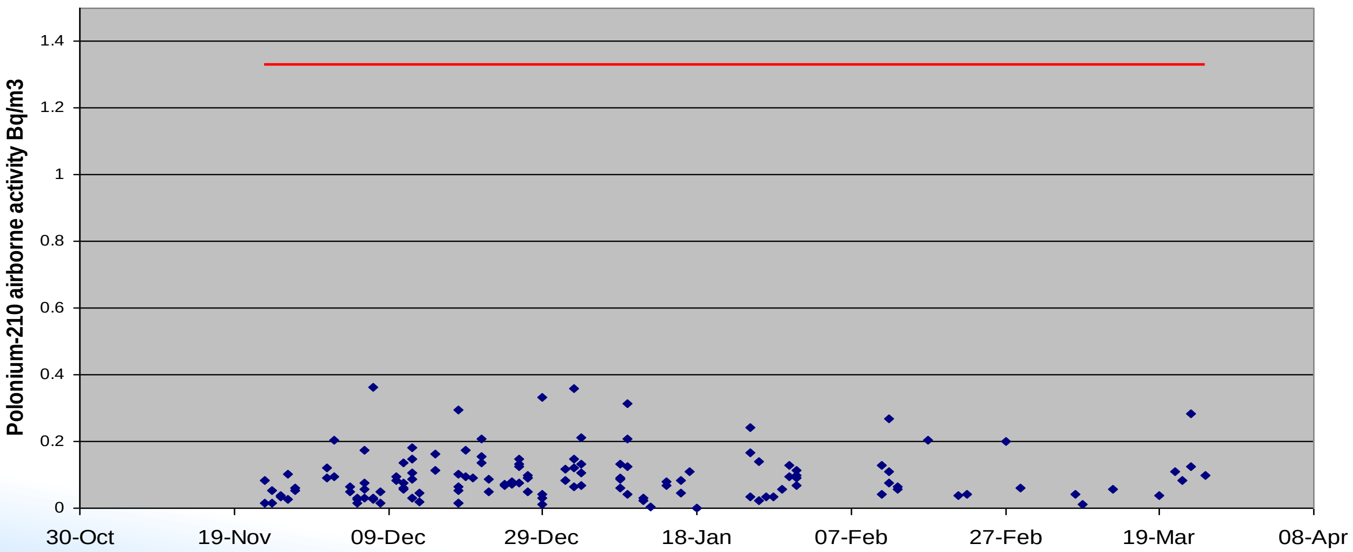
Revert Crushing - Trial

- Initial vs after corrective actions

Revert Crushing – Dust Exposure (after remedial actions)

- Dust exposure to workers (red line is the level which would give the occupational limit after a full year's exposure {2000 hours})

Revert Project - Personal Sampling Results



The final decision process and the future

Decision

- Doses are now under half the occupational limit with smelting of revert occurring at a sustainable rate
- It was decided to continue the revert addition following to RSO analysis of monitoring results
- Rapid analysis of results allowed a very fast feedback to the workforce (commitment)

Future

- Move to real time, continuously recording technology
- Prioritisation of real time monitoring based on dose results
- Relate dose to task
- Focus on achieving real reductions in dose

Conclusion and Lessons Learned (1)

Compliance monitoring alone is not sufficient : go to optimization

A detailed knowledge of radionuclide content and behaviour throughout each stage of the process is critical to effective management of radiation exposure

Appropriate ventilation in this environment is tied directly to operational exposure to radiation and this should be captured in design of plant and process where possible

Multiple fluctuating parameters mean that the radiation protection system must be both flexible and able to react to changes quickly

Education of the workforce and feedback of results (particularly during identified process changes) is paramount.

Conclusion and Lessons Learned (2)

Initial monitoring requirements may be high but may taper off as understanding of the process increases and proven occupational hygiene results are integrated into operational function.

A thorough understanding of radionuclide behaviour in the smelter has potential not only to reduce radiation exposure to personnel but also to improve safe production targets.

While this information has been sourced from an operational uranium mine, the concentration of uranium in ore is relatively low, thus these issues may be relevant to other similar smelter environments processing copper.

Follow up (1): a more analytical and realistic approach of the individual doses

A system allows now to take care of the time spent by each worker at each workstation; a computerised database has been set up for following that; the data are self recorded on a daily basis by each worker.

Each quarter the dust concentration (for each dust type) in each workstation monitored by PAS is multiplied by the time(s) spent by the worker in these workstations

Then his “inhalation quantities” are multiplied by the ICRP dose coefficients

Follow up (2) : optimization as a continuous process, more reactive now

In 2007, the Smelter Technical Services section commenced a project to examine the effects on increasing the amount of dust recycled

Monitoring had initially capture the baseline conditions before any changes to operational parameters.

The dust recycle coefficient was then incremented and kept at the new value for several weeks to allow the system to stabilise and sufficient monitoring to take place

Follow up (3) : optimization as a continuous process, more reactive now

The level of Po210 appears quickly to be too high with regards to the dose objectives, the level of recycling dust was immediately reduced and in depth technical analysis were performed on the potential recirculation of Po210.

This work has been conducted in parallel with ongoing work to further improve hygiene and ventilation systems within the smelter.

Therefore the working conditions are always changing and optimisation can never been considered as “ended”, it should really be an on going process.