Monitoring For Internal Contamination in the WAK-Reprocessing Plant

W.Kraut, H.-P. Wichmann, H.O. Willax
(Wiederaufarbeitungsanlage Karlsruhe, Betriebsgesellschaft mbH)

By choosing suitable dosemeters individual monitoring of external radiation causes no problems. The risk of exposure due to internal radiation, however, seems to us by far more difficult to control, especially in the case of unexpected events.
Besides the general guideline of keeping any exposure as low as possible, routine monitoring for internal contamination is required by a German BMI recommendation /1/ whenever 5 % of the annual limits of intake (ALI) are supposed to be exceeded.

In the WAK ca. 500 workers (staff and contractors) with working permits for contaminated areas are to be observed using the monitoring program.

A. General Aspects

In a reprocessing plant with direct maintenance, detailed knowledge of the radiological working conditions is essential for specifying the adequate protective outfit. Any lack of information thereupon has to be taken into account by prophylactic means of protection.
During the over 15 years of experience since reprocessing started at the WAK, there has evolved a certain classification of rooms according to which a standard protective clothing and equipment has to be worn.

Under real working conditions room-ventilation has to be properly controlled. Advantage can be taken of the fact, that in the WAK air is generally conducted from rooms with a lower contamination potential to rooms with a higher contamination potential by pressure gradients up to 700 Pascal.

Surface contamination measurements are taken by direct monitoring, in the case of too high a radiation background by wipe-tests. After work has finished surface-contamination monitoring is compulsory. Warning alarms are defined at $3{,}7\times10^{-2}$ Bq/cm^2 for α-particles and $3{,}7\times10^{-1}$

Bq/cm^2 for β-particles. It has proven advantageous to retain one wipe test for nuclide specifc investigations in the lab. In the case of any accidental exposure a quick estimate of the total intake of radionuclides is obtained by taking only a body-counter measurement on a "leading" nuclide like Cs-137 and with that equating the proportions of the other nuclides according to your wipe test. Analysis of excreta taken after the accident corresponded well with the first estimates. Relevant nuclides to be considered are shown in table 1.

Actinides	Fission products
uranium (U-238,U-234,U-232)	caesium (Cs-137,Cs-134)
plutonium (Pu-238,Pu-239,Pu-240)	strontium (Sr-90)
americium (Am-241)	ruthenium (Ru-106)
curium (Cm-242, Cm-244)	tritium (H-3)

Table 1: Relevant nuclides for internal contamination monitoring

- In many areas of the plant this looks like a spectrum calculated by the ORIGEN-Code. An exception may be given by Ru-106, which often shows different behaviour.

- Detailed analysis of all process-streams in the WAK shows that there is a relatively strong correlation between Cs-137 and Sr-90. As Sr-90 has a great radiological importance and a radiochemical analysis of Sr-90 is not immediately available a conservative estimate of a Sr-90 intake is possible by taking intake Sr-90 $\leq$ 2x intake Cs-137.

- Because of the low annual limits of intake for Pu (160 Bq for Pu-239 for example), the Pu-isotopes have to be considered in any contaminating event as possible contaminants, even if concentrations of Pu are very low.

B) Air Monitoring Systems

Air monitoring is an important tool for routine incorporation control. In the WAK there are about 50 rooms with continuous air sampling installed. The filters are analysed daily for α- and β-aerosols. Long term air surveillance of rooms which could be entered without protective mask showed Pu-activity concentrations of less than 10^{-4} Bq/m^3.

In operating rooms where there is a potential hazard of being contaminated and the need of longer working times for personnel, there is an additional continuous air-monitoring by means of pseudo-coincidence techniques, semiconductor and plastic-scintillator detectors for α- resp. β-aerosols.

Pseudocoincidence monitors are the most sensitive monitoring devices installed. With implementation of high volume samplers (~ 40 m^3/h) and large-size proportional counters a sensitivity of $2x10^{-2}$ $Bqxh/m^3$ for α and $5x10^{-2}$ Bqxh/m3 for β-particles and better is achieved.

Yet the conditions of a very low background radiation and very well defined Radon/Thoron activity concentrations cannot be guaranteed by routine operating practice in all plant areas. In these areas α-monitors with semiconductor detectors give a better performance. Selective air monitoring for Kr-85 is done in the fuel element reception hall only.

H-3 is continously monitored in the chemical make-up working area. Recovered HNO_3 in use in this area generally shows HTO contamination.

Iodine-air surveillance is only necessary when work is carried out on the iodine-filter systems.

C) Individual routine monitoring for internal contamination

Fission Products:
The WAK-routine monitoring program involves two whole-body counting measurements per year. This guarantees a safe monitoring of the investigation level of 5 % intake for Cs-137 (ALI = $1,3x10^6$ Bq) as a "leading" nuclide.

H-3:
Individual monitoring of excreta is foreseen only for those workers who are working in the chemical make up area.

Actinides:

Routine urine excretion analysis is carried out for uranium and plutonium once a year. The sensitivity is about 1,5 mBq for Pu and 1 μg/l for uranium. If the results show any inconsistencies, there is a special follow up with further samples of excreta (urine+faeces) and additional analysis for americium and curium.

Despite the fact that urine excreta-analysis for transportable Pu has only limited sensitivity/2/, for example covering a 7-10 days surveillance period assuming a constant uptake on a 5 % ALI level and a detection limit of 1,5 mBq, you gain information on a much greater surveillance period by taking the samples equally spread over the year and thereby picking out representative candidates of each working group.

D) Special individual monitoring for accidental exposures

Criteria for this monitoring scheme are given by:

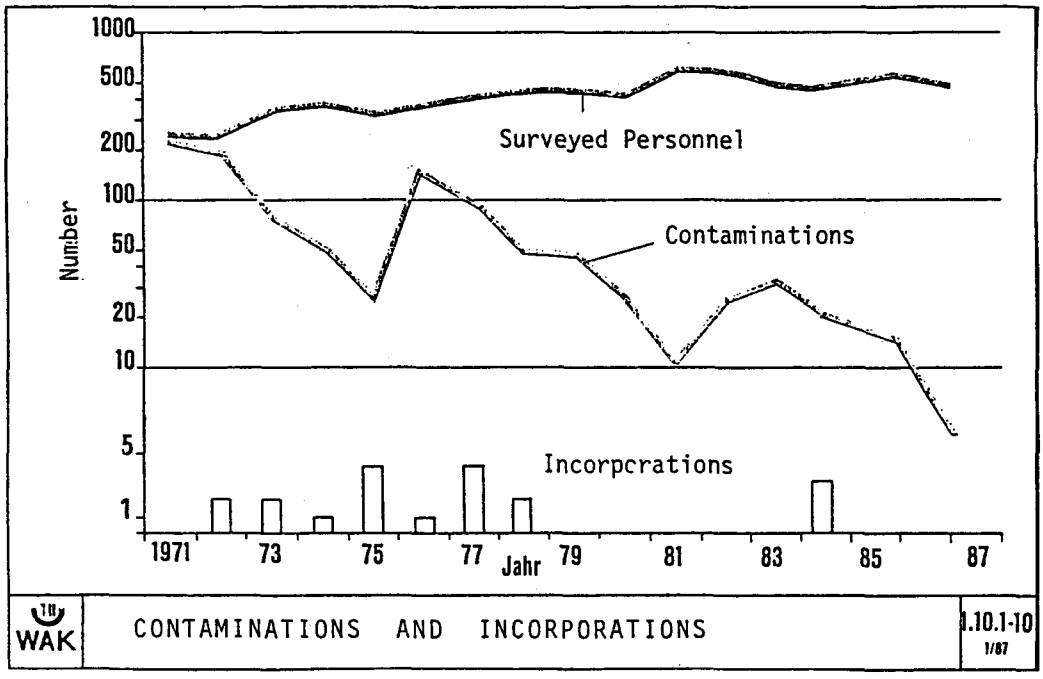
- skin contamination, especially face.
- damaged outfit.
- inconsistencies in routine monitoring especially values above detection limit
- any wound incurred in a contaminated area etc.

In the case of any of these criteria a series of special procedures is instigated.

- analysis of nose blows and throat swabs
- further analysis of excreta (urine+faeces)
- lung and whole-body monitoring
- wound detection
- analysis of blood samples.

In all these procedures the medical department is directly responsible.

The following foil shows statistics of incorporation events (> 5 % ALI) for the WAK.



E) Interpretation of results

From the data the total body-intake of radioactive material has to be defined.

Dose calculations are to be carried out according to the German BMI recommendations whenever 50 % ALI are exceeded. In general in the WAK a dose is recorded at intakes ≥ 10 % ALI. In nearly all dose calculations one can in fact take a class W solubility according to ICRP. Pu-oxide (class Y) can be ruled out for the majority of working areas in the plant.

Investigations of aerosol particle sizes in ventilated WAK rooms are in the 1 μm AMAD range, so the ICRP recommendations readily apply.

F) Conclusions

- WAK experience in monitoring for internal contamination shows that air monitoring is an important tool for routine incorporation control, especially in view of the difficulties in Cs-137 individual monitoring after the Tschernobyl incident.

- In any case of a positive monitoring for fission products Pu-isotopes had to be controlled too by excreta-analysis.

- Sampling of faeces is regarded as a non-routine measure, not only because of a psychologically motivated lack of acceptance, but also because there are indications that positive findings in faeces on a mBq detection level cannot be totally excluded in reference groups not engaged in the nuclear industry.

Literature

/1/ "Richtlinie für die physikalische Strahlenschutzkontrolle".
Bek. d. BMI vom 5.6.1978.

/2/ "The Assessment of Internal contamination resulting from Recurrent or Prolonged Uptakes".
ICRP Publication 10 A, 1971.