

# Dose assessment after an historic intake of uranium

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**Abstract.** A routine control of urine samples from staff members at the pellet production plant at Institute for Energy Technology revealed a significant level of uranium for one individual. The intake could not be related to any special incident in the laboratory. As neither the time of intake or if it could be attributed to acute or continuous was known, it was necessary to establish a series of measurements over a substantial time interval. Using ICRPs models for continuous intake through inhalation, the annual effective dose was estimated to 6.8 mSv.

**KEYWORDS:** *uranium, intake, bioassay*

## INTRODUCTION

Institute for Energy Technology operates two research reactors, the JEEP II reactor at Kjeller and the HBWR reactor in the city of Halden. In order to furnish the reactors with fuel elements, the institute operates a pellet production plant located at the Kjeller site. The plant was constructed in 1962 and has been in operation since then. However, given the limited need for fuel for the reactors, production does not take place daily. In the period between 1998 and 2000, the plant went through a substantial refurbishment before it was completely rebuild up to modern standards in 2006.

## FUEL PRODUCTION, CONTAMINATION AND DOSIMETRY

The starting point of the pellet production is to decant  $\text{UO}_2$  powder from storage cans. The enrichment of the uranium powder is normally 3.5 % for production of pellets for the JEEP II reactor and 6 % for operational fuel in the HBWR reactor. The HBWR does, however also utilize a smaller number of booster pellets having enrichment up to 19 %. The powder is milled and sieved with an in mix of 0.5 % Zink stearate. The next step in the process is to compress the powder into pellets using a hydraulic press. This is known to generate spill, and thus generate a risk for inhalation of airborne particles. The pellets are then sintered in an oven. After sintering, the pellets are grinded and polished into correct thickness. This will also constitute a risk for spreading of contamination although it is carried out with water spraying. The finished pellets are then sent off to the electron beam welding workshop for encapsulation into Aluminium or Zircaloy rods.

Personnel working at the pellet production plant are monitored for external radiation using TL dosimeters. Intake was controlled by whole body measurements. From 2005 a radiochemical method for analysing the presence of Uranium in urine samples was taken into use.

## METHOD FOR DETERMINATION OF URANIUM ISOTOPES IN URINE

A 24 hour urine sample is added: 50 ml of 65 %  $\text{HNO}_3$  per litre urine,  $^{232}\text{U}$ -tracer, 100 mg Ca-carrier, 3-4 drops of 1-octanol, and stirred while heating for 2 hours at 90 °C. Heat is then turned off and 2 ml concentrated phosphoric acid is added and the pH raised to about 9 to precipitate calcium phosphate. The phosphates are allowed to settle over night before they are collected by decantation and centrifugation. The phosphates are then destroyed by ashing at 450 °C and the ashes dissolved with 3 M  $\text{HNO}_3$ . Uranium is then extracted using UTEVA-Resin. The pure U-fraction is added 50 µg Ce(III), 1 ml 40

% HF and 1 ml 15 % TiCl<sub>3</sub> and fluorides are allowed to develop for 30 minutes. The fluorides are then collected on 0.1 µm membrane filter and the alpha activity determined using alpha spectrometry. The method has been tested and validated regularly by participation in PROCORAD inter-comparison exercises.

### THE URANIUM INTAKE INCIDENT

The first radiochemical analysis of uranium in urine samples was carried out in February 2005. For one staff member, the presence of <sup>234</sup>U, <sup>235</sup>U and <sup>238</sup>U was detected at levels well above the detection limit of 0.5 mBq/l. The activity concentration ratios between the Uranium isotopes were consistent with low enrichment uranium. Intake of natural Uranium was thus excluded.

It was decided to make multiple measurements in order to reduce the uncertainty. At this point, it was not clear whether the intake was a single intake in the past a continuous intake. No special incident, that could be the cause of an intake, was known to the operators.

The exposed individual started to work at the plant in 1991 and left in 2006. The initial assumption was that the intake most likely took place in the early years when personnel protection was less emphasised. This assumption did, however, later prove to be wrong.

The most likely intake regime is inhalation of airborne aerosols. The dust created in pellet production is generally of large particle size. A fraction of the particles are nonetheless expected to be of a size that renders them available for intake through the respiratory tract. Parameters, as recommended in (ICRP 61), used in the dose assessment are listed in table 1.

Intake regime	Inhalation
Particle size	5 µm AMAD
Absorption class	S (slow)
Effective dose coefficient <sup>234</sup> U	6.8·10 <sup>-6</sup> Sv/Bq
Effective dose coefficient <sup>235</sup> U	6.1·10 <sup>-6</sup> Sv/Bq
Effective dose coefficient <sup>236</sup> U	5.7·10 <sup>-6</sup> Sv/Bq

Table 1 Parameters used in the dose assessment

Repeated analysis of urine samples showed a rather large variation in uranium excretion rate. It was decided to analyse urine samples over an extended period of time before the result of the committed effective dose could be reported. The time series of measurements is presented in figure 1.

For the time period between February 2005 and November 2006 when the individual left the plant, there was no clear decrease in excretion rate as would have been the case for a historic acute intake. The rather large scattering of measurement results make fitting of an excretion function difficult. A constant rate seems most probable. This is in accordance with a chronic intake or, in this case, rather many repeated intakes. A daily excretion rate of 23.8 mBq is found for <sup>234</sup>U. For <sup>235</sup>U and <sup>238</sup>U the daily excretion is 0.8 mBq and 2.0 mBq respectively.

After November 2006, the data points are best fitted with an exponential decay as expected when the intake is stopped.

The first assessment of effective dose was done manually with the help of excretion functions (ICRP 54, ICRP 78). An annual effective dose of 6.8 mSv was estimated for the working period of 15 years. The

remaining uranium will, after the intake is stopped, give rise to an effective dose of about 2.5 mSv. The total dose from the incident is thus estimated to 105 mSv.

Calculation of the total effective dose has been repeated lately using the computer code IMBA. The result from this calculation is in agreement with previous estimates.

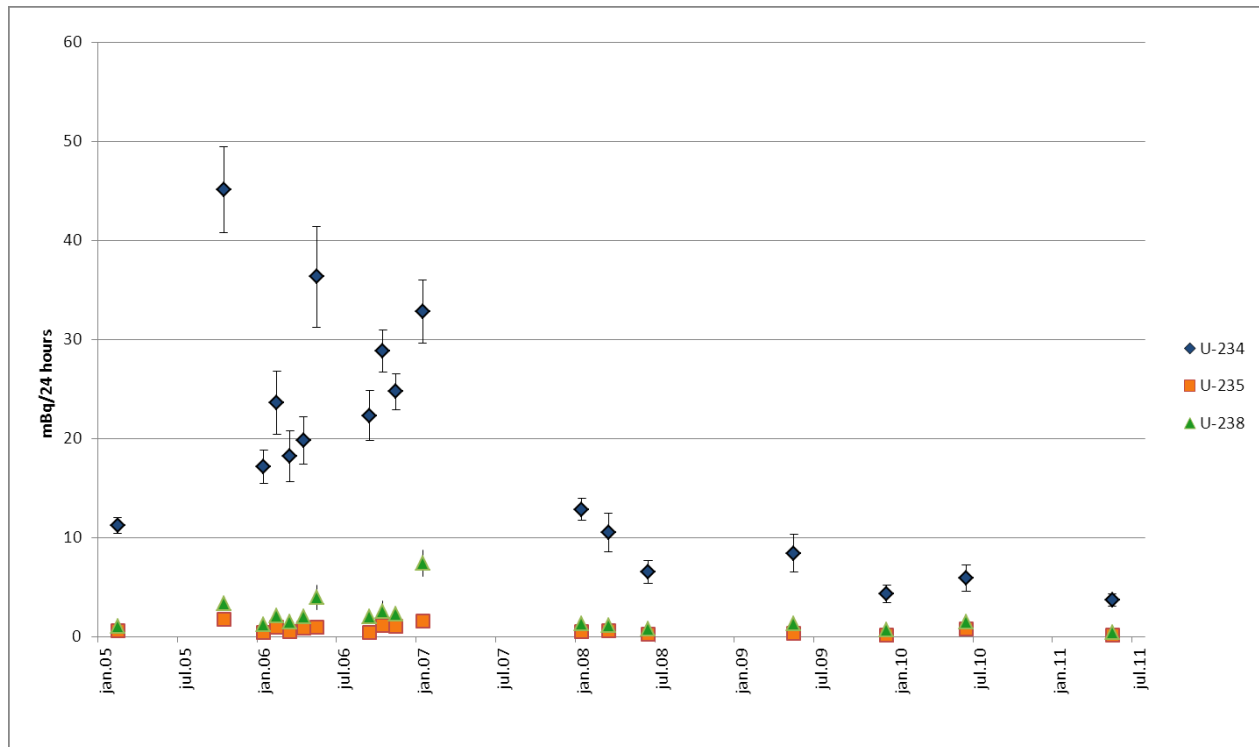


Figure 1 Daily excretion rates from the analysis of <sup>234,235,238</sup>U in urine samples

## REFERENCES

- ICRP 68                    ICRP publication 68  
Dose Coefficients for Intakes of Radionuclides by Workers  
Annals of the ICRP, 1995
- ICRP 54                    ICRP publication 54  
Individual Monitoring for Intakes of Radionuclides by Workers: Design and Interpretation  
Annals of the ICRP, 1987
- ICRP 78                    ICRP publication 78  
Individual monitoring for internal exposure of workers  
Annals of the ICRP, 1997
- IMBA                        IMBA Professional Plus  
Integrated Modules for Bioassay Analysis  
Health Protection Agency