

Alpha Activity and System Decontaminations

Determination of actinides in waste repository and calculations of scaling factors for internal contamination

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Presentation Outline

- Introduction
- Method
- Results
 - waste
 - scaling factors
- Conclusions

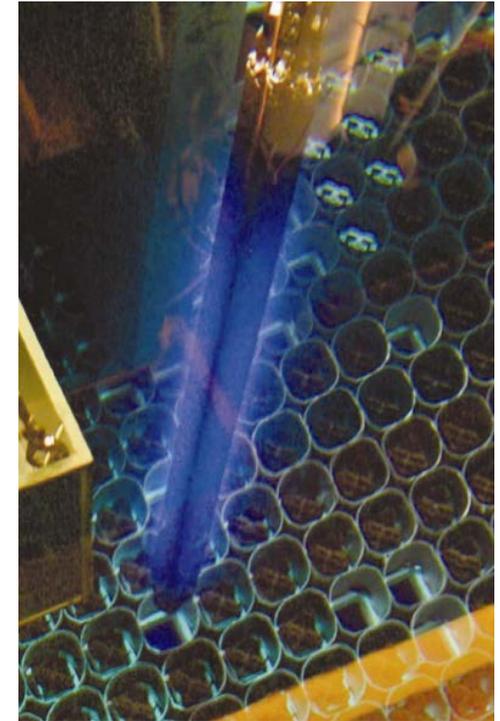
Forsmark NPP

- 3 BWR
- ASEA Atom, 1980-1985

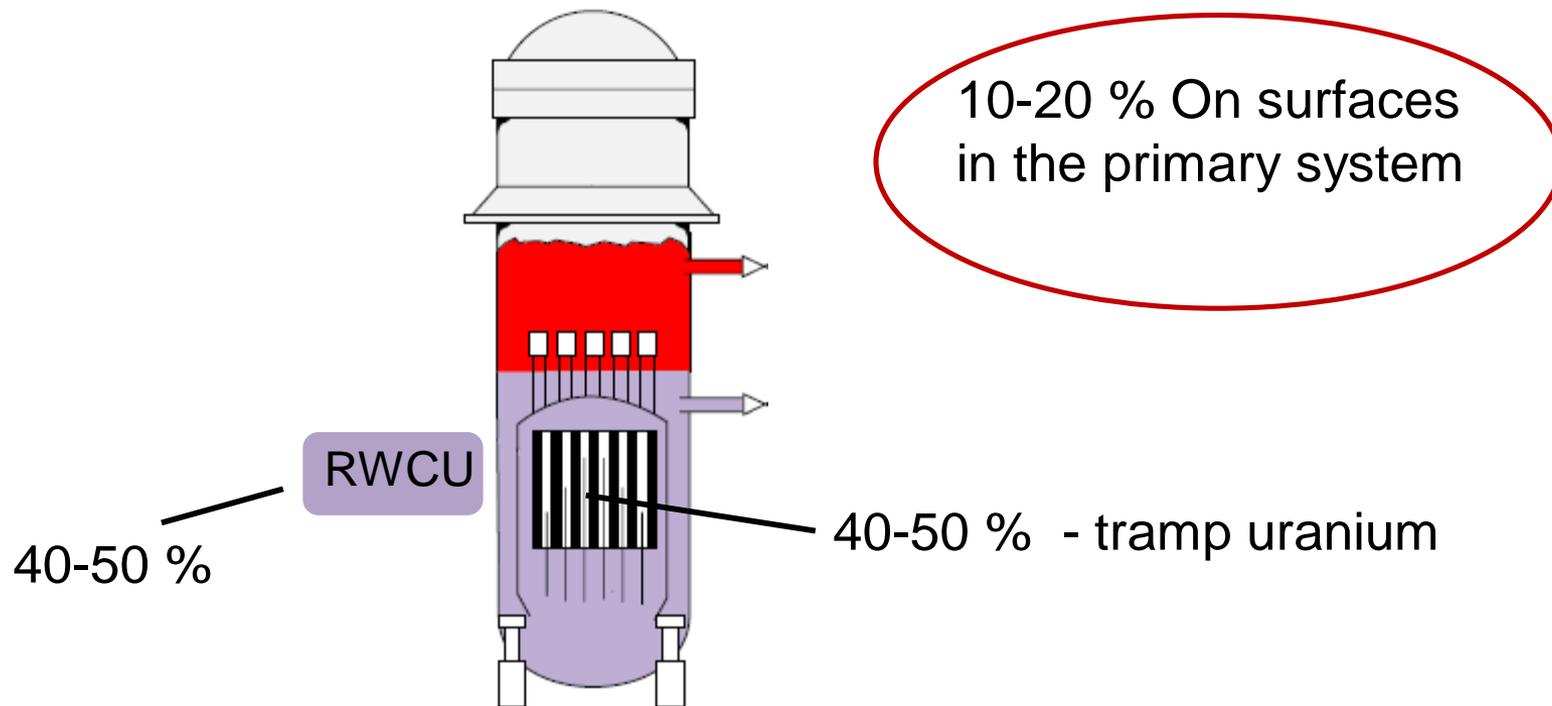


Introduction

- Alpha particles
 - High RBE → do not eat/inhale
 - Short range → hard to detect
- Alpha emitting nuclides
 - Actinides (U, Pu, Am, Cm)
 - Produced in the fuel.
 - Degraded fuel failure.
 - Long-lived.



Source of Alpha Active Nuclides at Forsmark



System Decontaminations

System decontamination of RHR and RWCU

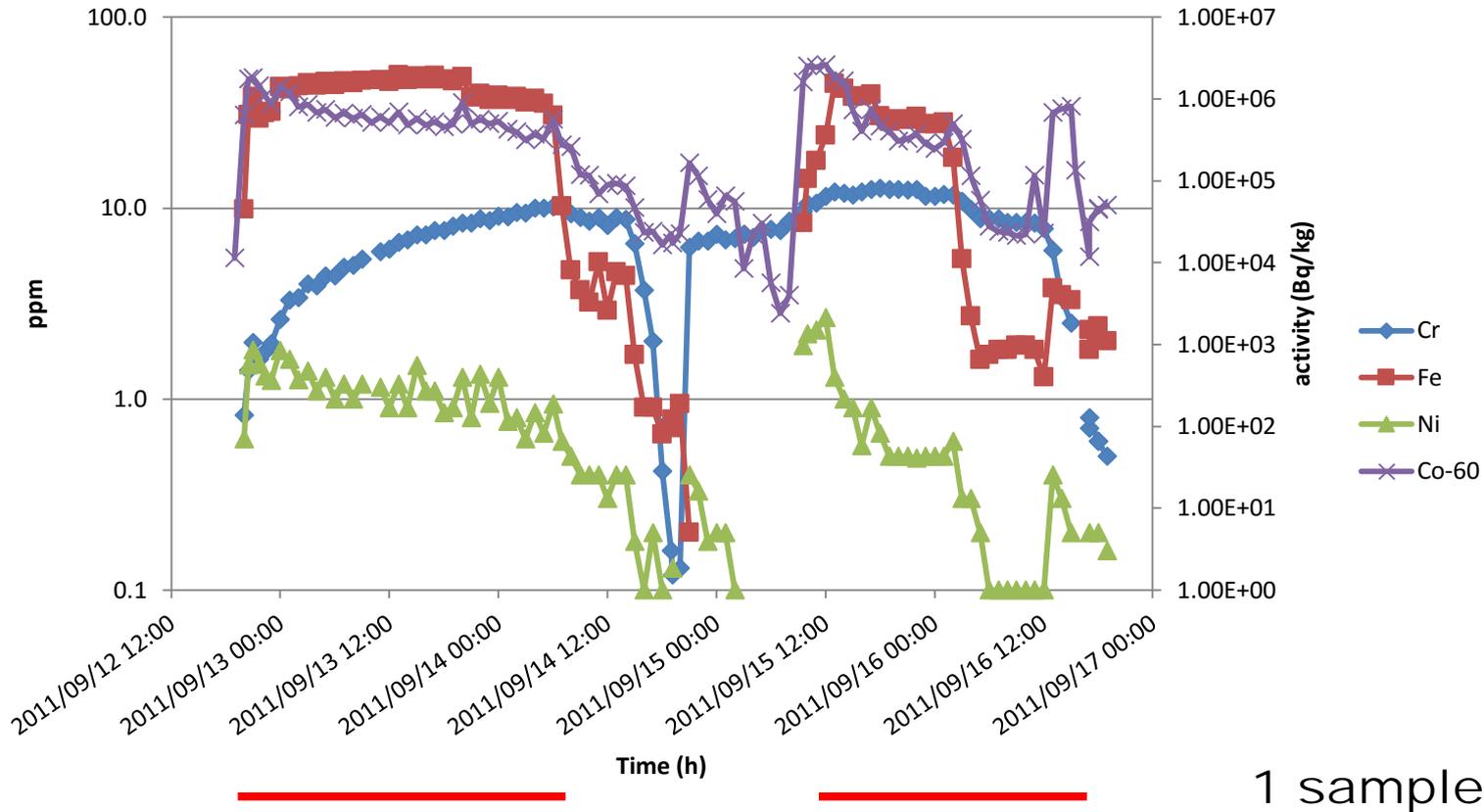
- Forsmark 3, outage 2011
- Forsmark 2, outage 2012

AREVAs CORD UV

- Chemical method that dissolves oxide layers on surfaces in the systems.
- Released activity and corrosion products are continuously deposited onto ion exchange resins.

Water sampling every hour.

Sampling for Nuclide Specific Alpha Spectroscopy



Average concentration of water going through ion exchange resin.

Results

- Forsmark 3
 - Average decon factor: 84
 - Released gamma activity 8.4 E11 Bq (>70 % Co-60).
 - Released alpha activity 1.4 E8 Bq (68 % Pu-238/Am-241)
 - Decontamination of RHR in 2001.
- Forsmark 2
 - Average decon factor: 30
 - Released gamma activity 9.3 E11 Bq (40 % Cr-51, 20 % Co-60).
 - Released alpha activity 1.7 E7 Bq (62 % Pu-238/Am-241)
 - No previous decontamination.

Results - Waste

	Pu-239/ Pu-240	Pu-238/ Am-241	Cm-242	Cm-244	Total α activity	
F2 decon	3,5E6	1,1E7	6,2E5	3,0E6	1,7E7	Bq
F3 decon	3,3E7	9,3E7	8,8E6	9,7E6	1,4E8	Bq
F2 RWCU 2012	1,5E6	5,2E6	1,0E6	2,9E6	1,1E7	Bq
F3 RWCU 2011	8,0E6	2,0E7	1,3E7	1,9E6	4,3E7	Bq

- More actinides in the waste from the decontamination than from one year of operation (fuel failure at F3 2011).
- Resins from RWCU to short-lived operational waste.
 - Restrictions on the amount of long-lived nuclides.

From Decontamination to Dose Calculation



Scaling Factors / Nuclide Vectors

Ratio between hard-to-detect (HTD) nuclides and Co-60.

	(Bq/kg)	Scaling factor vs. Co-60
Co-60	12 000	1
Pu-238	1,7	0,00014

Scaling Factors from Samples vs. Theory

	Sampling		
	SAR 321 (Bq/kg)	F2 (Bq/kg)	F3 (Bq/kg)
Co-60	10 000	250 000	550 000
Pu-239/-240	0,4	3	27
Pu-238/Am-241	1	9	76
Cm-242	8	0,5	7
Cm-244	1	3	8

Theoretical source term of the reactor coolant = SAR 321

Scaling Factors from Samples vs. Theory

	Sampling			Scaling factors vs. Co-60		
	SAR 321 (Bq/kg)	F2 (Bq/kg)	F3 (Bq/kg)	SAR 321	F2	F3
Co-60	10 000	250 000	550 000	1	1	1
Pu-239/-240	0,4	3	27	3,5E-05	1,2E-05	4,8E-05
Pu-238/Am-241	1	9	76	1,1E-04	3,6E-05	1,4E-04
Cm-242	8	0,5	7	7,8E-04	2,1E-06	1,3E-05
Cm-244	1	3	8	1,1E-04	9,9E-06	1,4E-05

Theoretical source term of the reactor coolant = SAR 321

- The amount of Pu and Am in the oxide layers in the RHR and RWCU systems of unit 3 can be underestimated by the theoretical scaling factors.

Dose Example

Internal contamination through inhalation of 50 kBq Co-60 + actinides calculated by two different scaling factors.

	Scaling factor 1	Scaling factor 2
Total effective dose	1 mSv	2 mSv
Co-60	35 %	18 %
Actinides (Am-241, Pu-238, -239,- 240, Cm-242,-244)	65 %	82 %

EPRIs level III >90%

- Actinides largely effects the total effective dose.
- Sampling is important for choosing a correct scaling factor.
- Protective breathing devices are routinely used for working in areas with airborne activity.

- EPRI Alpha Monitoring and Control Guideline
 - GAP-analysis in 2015.
 - Ongoing alpha characterization according to the guideline.

Conclusions

- The system decontamination resulted in significant amounts of alpha activity to the waste repository.
 - Representative sampling.
- Analysing decontamination liquid is a tool to evaluate surface contamination of HTD-nuclides inside the primary system.
- Alpha emitting nuclides can contribute significantly to the effective dose in the event of internal contamination by inhalation.
 - Sampling is needed.
 - Correct scaling factors.
 - Biological sampling.

Thank you!

Questions?