An Overview of Methods for Nuclide Specific NPP Release Monitoring

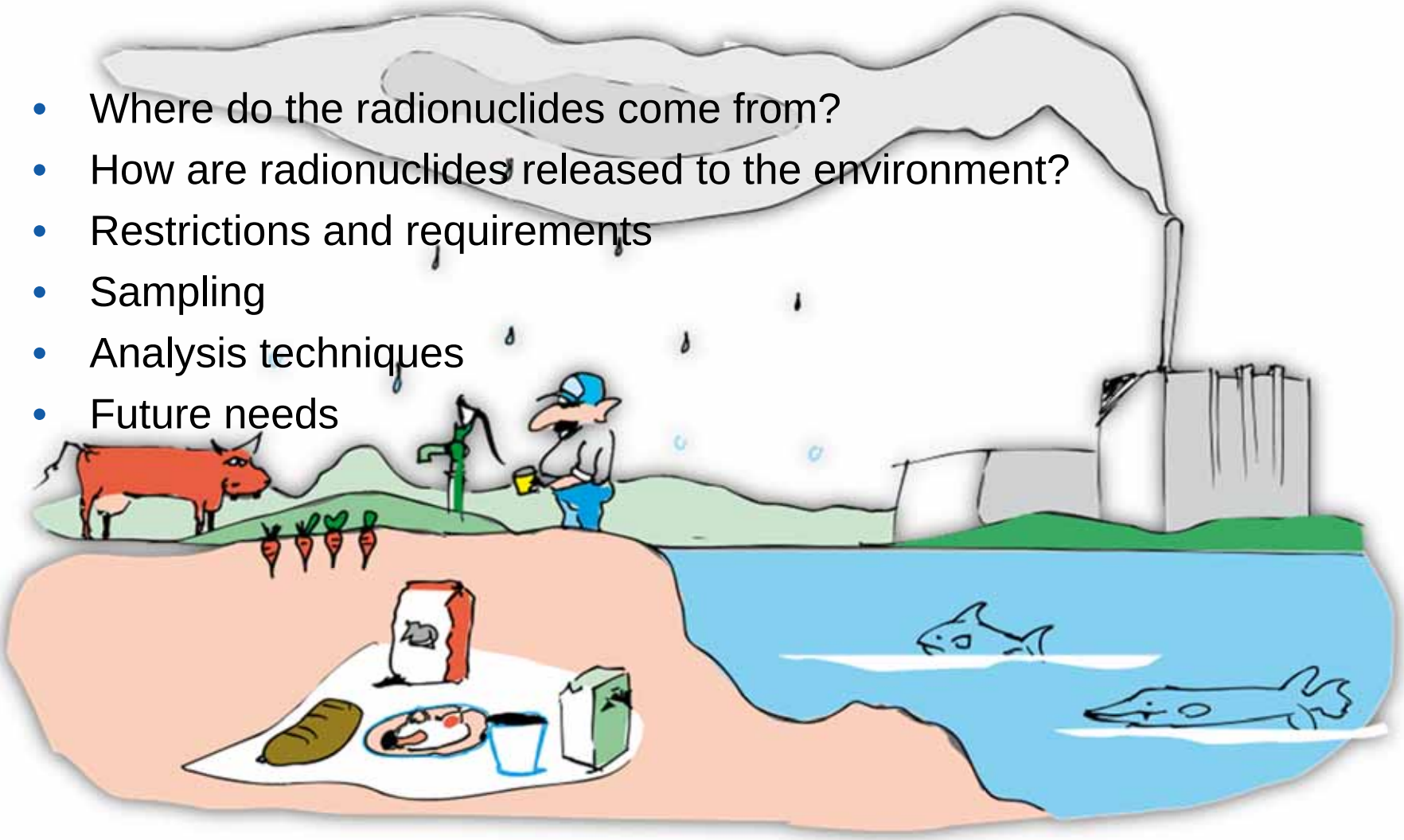
NKS Workshop, Roskilde

2013.09.06

Sekretessklass: Öppen (S1)

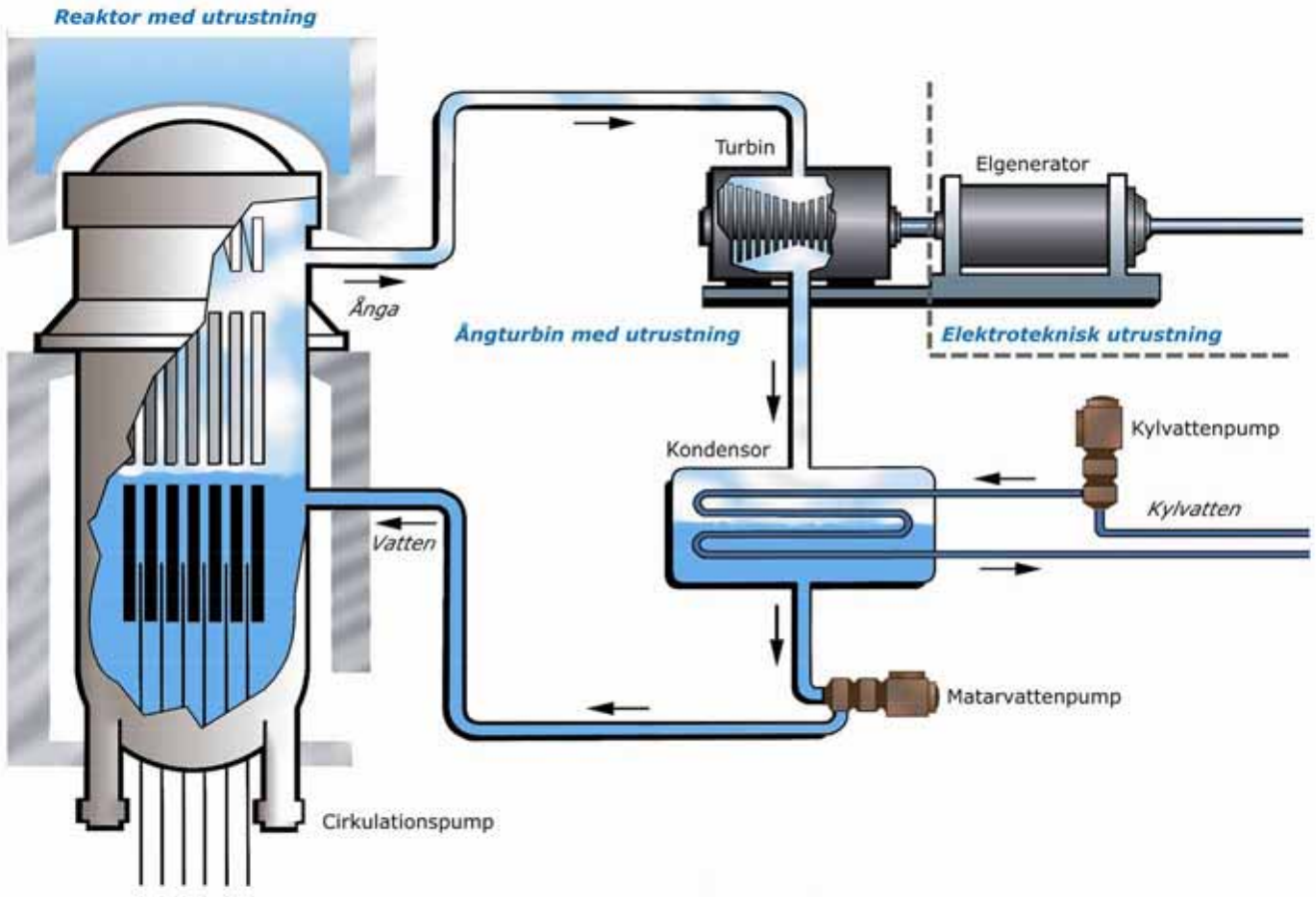
Outline

- Where do the radionuclides come from?
- How are radionuclides released to the environment?
- Restrictions and requirements
- Sampling
- Analysis techniques
- Future needs



VATTENFALL

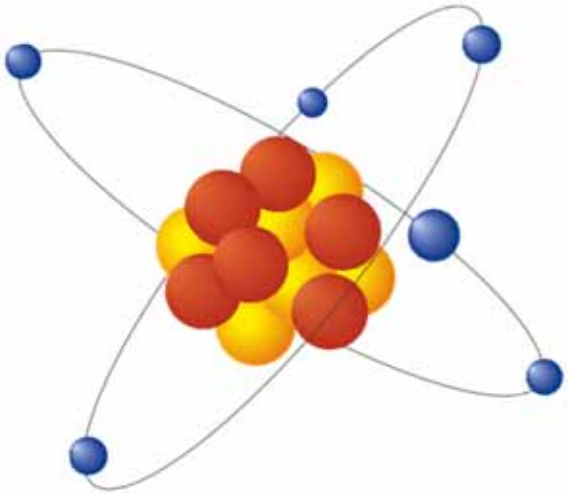
Radionuclide sources in BWR NPPs



VATTENFALL

Radionuclide sources in BWR NPPs (cont)

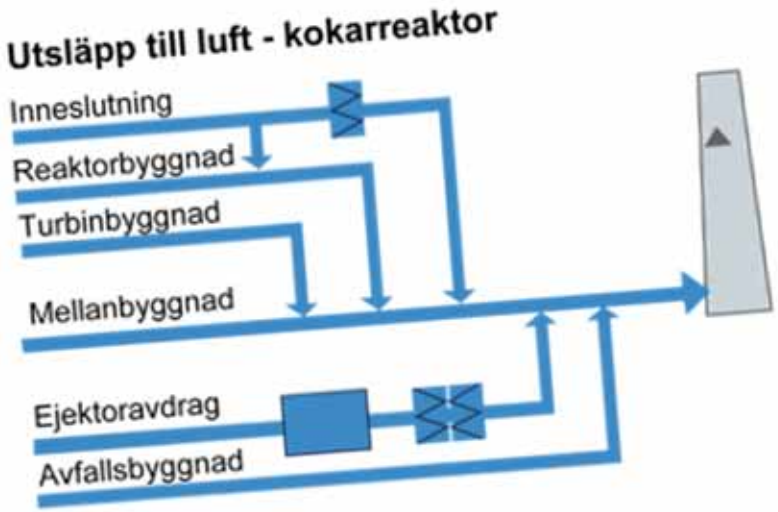
- In nuclear fuel – a ceramic form of U-235 and U-238
  - Fission products (Cs-137, I-131, Xe-133, Kr-85, Sr-90…)
  - Transuranium nuclides (Pu-239, Cm-242…)
- Activated corrosion products – all materials close to the nuclear core are subjected to neutron irradiation
  - Co-60, Co-58, Mn-54, Fe-59, Ni-63, Ni-59, Fe-55, Mo-99…
- Activation of reactor coolant (water)
  - C-14 from oxygen
  - H-3 from deuterium
  - Short-lived O and N isotopes from oxygen
- (NORM)



VATTENFALL

Release paths and limitations

- At Forsmark NPP a typical unit has two approved release paths:
  - Main stack – *ventilation air and condensor off-gases*
  - Cooling water outlet – *purified excess water*
- All releases must be continuously monitored. The released amount of radionuclides and their dose consequence to the public must be reported to the Swedish Radiation Safety Authority (SSM).
  - Maximum allowed dose in a year to a member of the public: 0,1 mSv
  - Typical annual dose to a member of the public: 0,00015 mSv



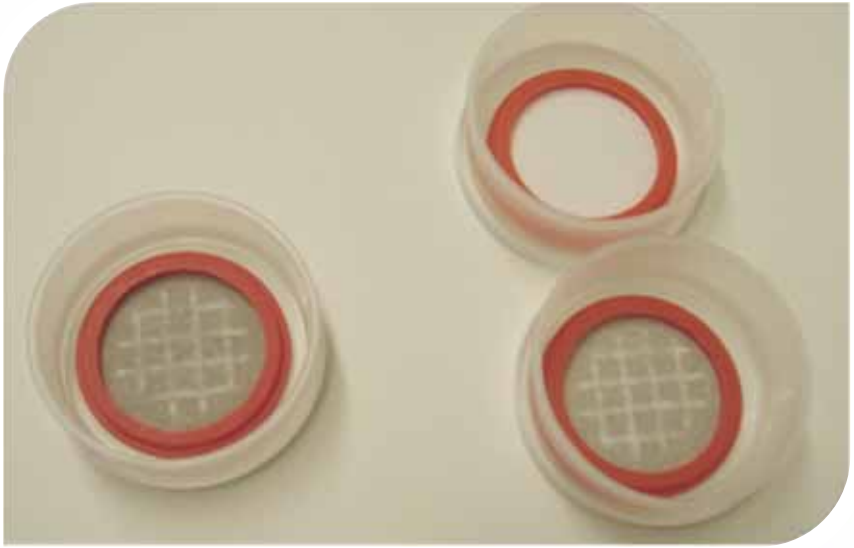
VATTENFALL

Methods – releases to air

- Noble gas nuclides:
  - On-line gamma spectrometry, flow-through sample vessel on the detector
  - Theoretical calculation of Kr-85 due to interference
- C-14 – integrated sampling
  - Liquid scintillation counting, flow-through sample vessel with $^{14}CO_2$ capture in NaOH (aq)
- H-3 – integrated sampling
  - Liquid scintillation counting, flow-through sample vessel with $^{3}H_2O$ capture in H_2O

VATTENFALL

Methods – releases to air (cont)



- Aerosols – integrated sampling
  - Gamma spectrometry on filters
  - Alpha spectrometry on leached filters, electro-deposition
  - Sr-90 on leached filters; two liquid-liquid extractions of Y-90, indirect calculation from the decay curve (Cerenkov counting in liquid scintillation counter)
- Iodines – integrated sampling
  - Gamma spectrometry on carbon cartridges

VATTENFALL

Methods – releases to water

- Integrated sampling followed by:
  - Gamma spectrometry on large volume
  - Alpha spectrometry on large evaporated volume
  - Sr-90 on large evaporated volume
  - Distillation and liquid scintillation counting for H-3
- Vector calculation:
  - Assume that the relative amounts of certain nuclides are the same in the reactor coolant as in the discharged water
  - Ni-63 analyzed in reactor coolant; separation with Ni specific DMG column from Eichrom, measured with liquid scintillation and interference corrected. *Related to Co-60.*
  - Fe-55 in the reactor coolant is estimated from neutron activation calculations. *Related to Mn-54 in integrated sample.*
  - Sr-89 in the reactor coolant is estimated from calculations on fuel and fuel leakage. *Related to Sr-90 in integrated sample.*

VATTENFALL

Future needs

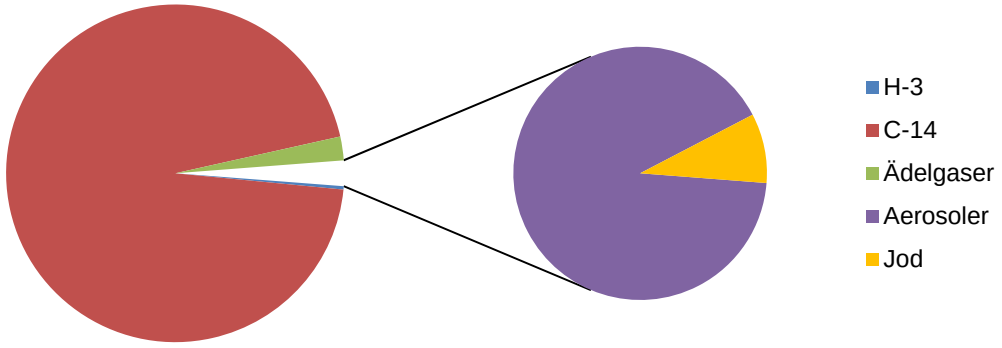
- Capability to measure more nuclides, possibly:
  - Fe-55
  - Kr-85
- Improve methods:
  - Ni-63 – *less interference*
  - Sr-90 – *less interference*
  - Alpha spectrometry – *separation*
- Systematic quality related work
  - Adapt to standard methods
  - Combined uncertainties
  - Improved QA

VATTENFALL

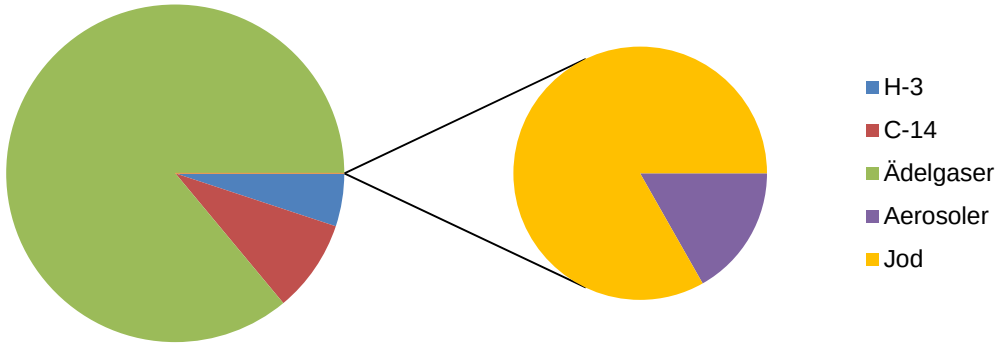
Thank you!

Radionuclides to air – relative amounts

Bq

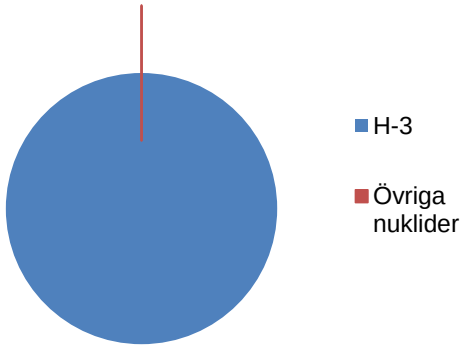


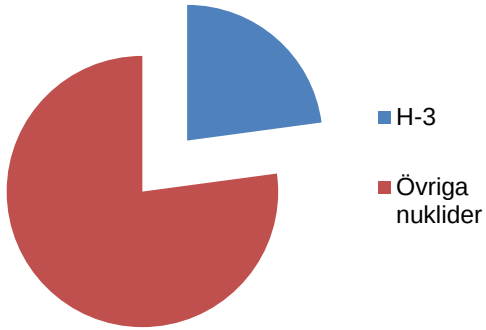
mSv



VATTENFALL

Radionuclides to water – relative amounts





Bq **mSv**

VATTENFALL