Uranium Aerosol Characteristics at a Nuclear Fuel Manufacturing Site – The regulators perspective

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N. Addo, Strålsäkerhetsmyndigheten SSM (Swedish Radiation Safety Authority) NSFS Roskilde 2015 presentation nr. S7-O1.

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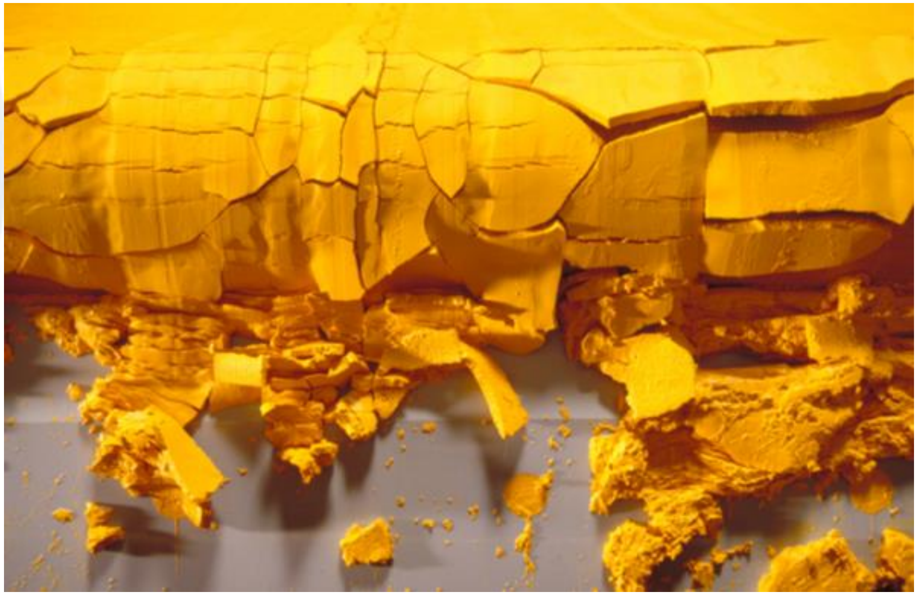
Air concentration of radioactivity, Bq / m^3



https://www.kkl.ch/kraftwerk/alles-ueber-kernenergie/kernbrennstoff-uran/brennstoffkreislauf.html

http://www.energinyheter.se/sites/default/files/story/2014/jan/83676_krnbrnsle3.jpg

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- **Regulations:**
  - **SSMFS 2008:51, basic provisions for the protection of workers and the general public**
    - Intake
    - Dose limits
    - Record keeping
    - Controlled area monitoring
    - The committed effective dose

  - **SSMFS 2008:26, on Radiation Protection of Individuals Exposed to Ionizing Radiation at Nuclear Facilities**
    - Calibration and instruments checks
    - Contamination checks before leaving the area
    - Whole body counting
    - Urine or feces sampling
    - Documented procedure approved by the Swedish Radiation Safety Authority
    - Single event with committed effective dose **of 5 mSv or more** shall be reported
      - **type of intake**
      - **committed effective dose and the basis for these calculations**
      - **circumstances**

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The study has been conducted by Linköping University for the Swedish Radiation Safety Authority, SSM.

The conclusions and viewpoints presented in the report (2015:18) are those of the author/authors and do not necessarily coincide with those of the SSM.

The regulators perspective

From SSM's point of view it is interesting to present how this research project will support regulatory supervision at nuclear facilities with airborne radioactive particles present.

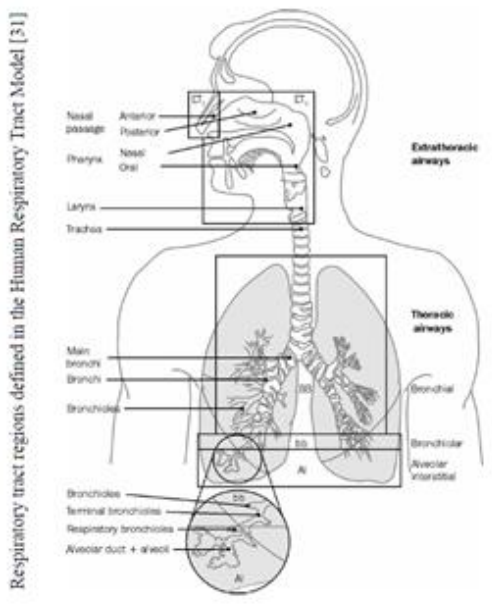
The authority has a challenge at nuclear facilities to understand and follow up how the uncertainties in the different parameters are handled concerning data collection for calculating the committed effective dose.

..such parameters concerning uranium aerosols characteristics are:

1. particle size
2. the morphology *(shape)*
3. chemical form

4. density

Several ways to measure and calculate dose from intake of radionuclides



Activity in urine/feces	Activity in Lungs	Activity in air
Particle aerosol characteristics type of intake		
- Sampling technique - Natural intake - Intake GI - Calculations	- Background - Sensitivity - Corrections - Calculations	- Positioning - Relation PAS/SAS - Work log - Breathing protection
Uncertainties and errors?		

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Definition,

Activity Median Aerodynamic Diameter (AMAD)

The value of aerodynamic diameter* such that 50% of the airborne activity in a specified aerosol is associated with particles greater than the AMAD. Used when deposition depends principally on inertial impaction and sedimentation, typically when the AMAD is greater than about 0,5 μm.

*The aerodynamic diameter of an airborne particle is the diameter that a sphere of unit density would need to have in order to have the same terminal velocity when settling in air as the particle of interest.

Uranium Aerosol Characteristics

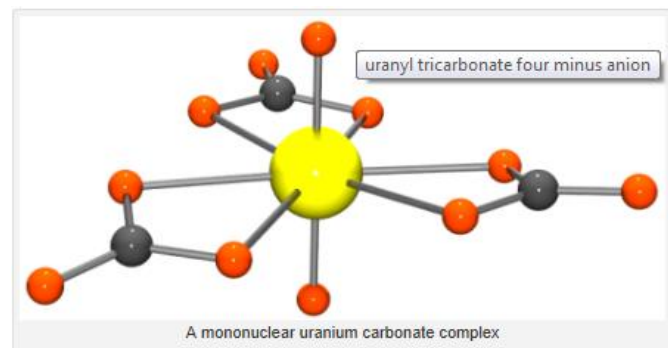
- Type of intake
- Committed effective dose
- The basis for internal dose calculations
- Circumstances about the intake

Type of intake

- Inhalation
- Ingestion
- Both inhalation and ingestion
- Both chronic and acute
- 2 or more following acute
- Wound
- Background levels

Committed effective dose

- Internal exposure, E (50)
- Route of intake
- Sample data; whole body counting, urine or fecal sampling, air concentration
- Time of intake; routine monitoring
- Chemical form and type of radionuclide (UO_2 , U_3O_8 , AUC; $(NH_4)_4(UO_2)(CO_3)_3$: (^{234}U 81,8%, ^{235}U 3,4%, ^{238}U 14,7%)
  - Particle size, μm AMAD
  - Shape factor (*IMBA default 1,5*)
  - Solubility
  - Density
- Biokinetic model
- Standard or Individual bioassay



A mononuclear uranium carbonate complex

https://markforeman.wordpress.com/category/uranium/

Particle Characteristics

Ex. IMBA, UO_2 (insoluble in water) = 81 Bq U_{MIX},

U_{MIX} ; ^{234}U 81,8%, ^{235}U 3,4%, ^{238}U 14,7%

Shape Factor: A correction factor called the dynamic shape factor is applied to Stokes's law to account for the effect of particle shape on particle motion (Hinds 1999).

Parameters

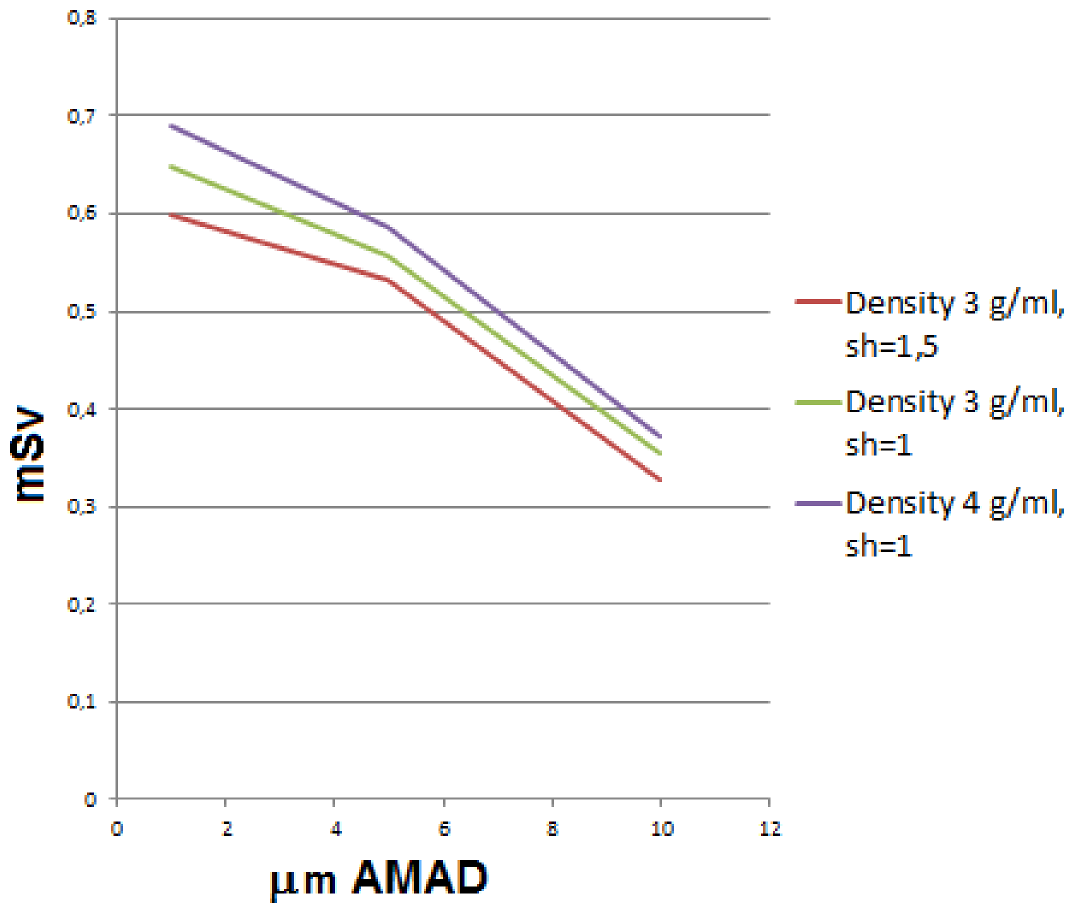
Breathing rate; *Hard working conditions*

Shape Factor; *1* and *1,5*

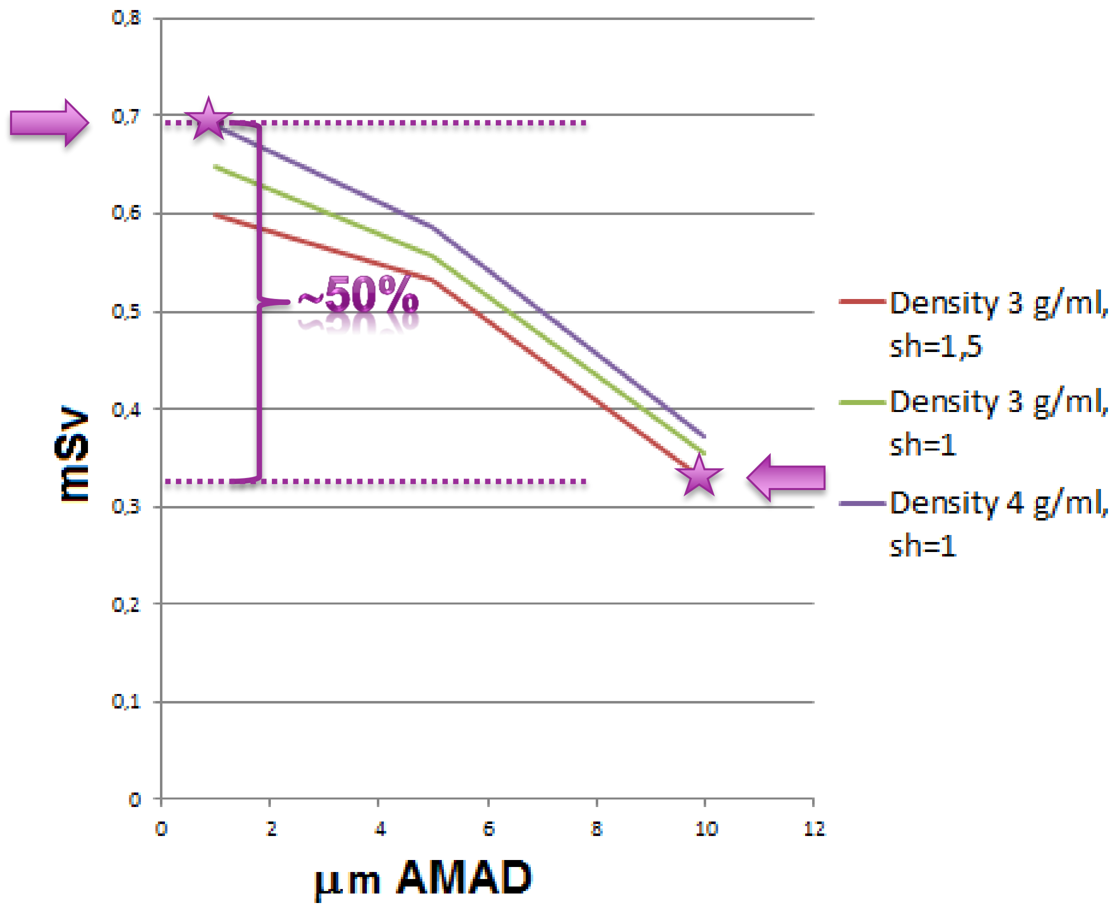
Density; *3* and *4 g/ml*

Particle size; *1*, *5* and *10 µm AMAD*

Committed effective dose as function of µm AMAD



Committed effective dose as function of µm AMAD



The basis for internal dose calculations

- Background levels of natural occurring radioactivity
- Routine monitoring
- Dose coefficients for specified radionuclides (Sv/Bq)
- Software for dose calculations
- Procedure for internal dosimetry dose calculation
- Competence and education
- Research can create new themes to research
- Technical equipment (PAS, SAS, ICPMS, Cascade Impactor, Scanning Electron Microscopy, Energy Dispersive X-ray)

Uncertainties

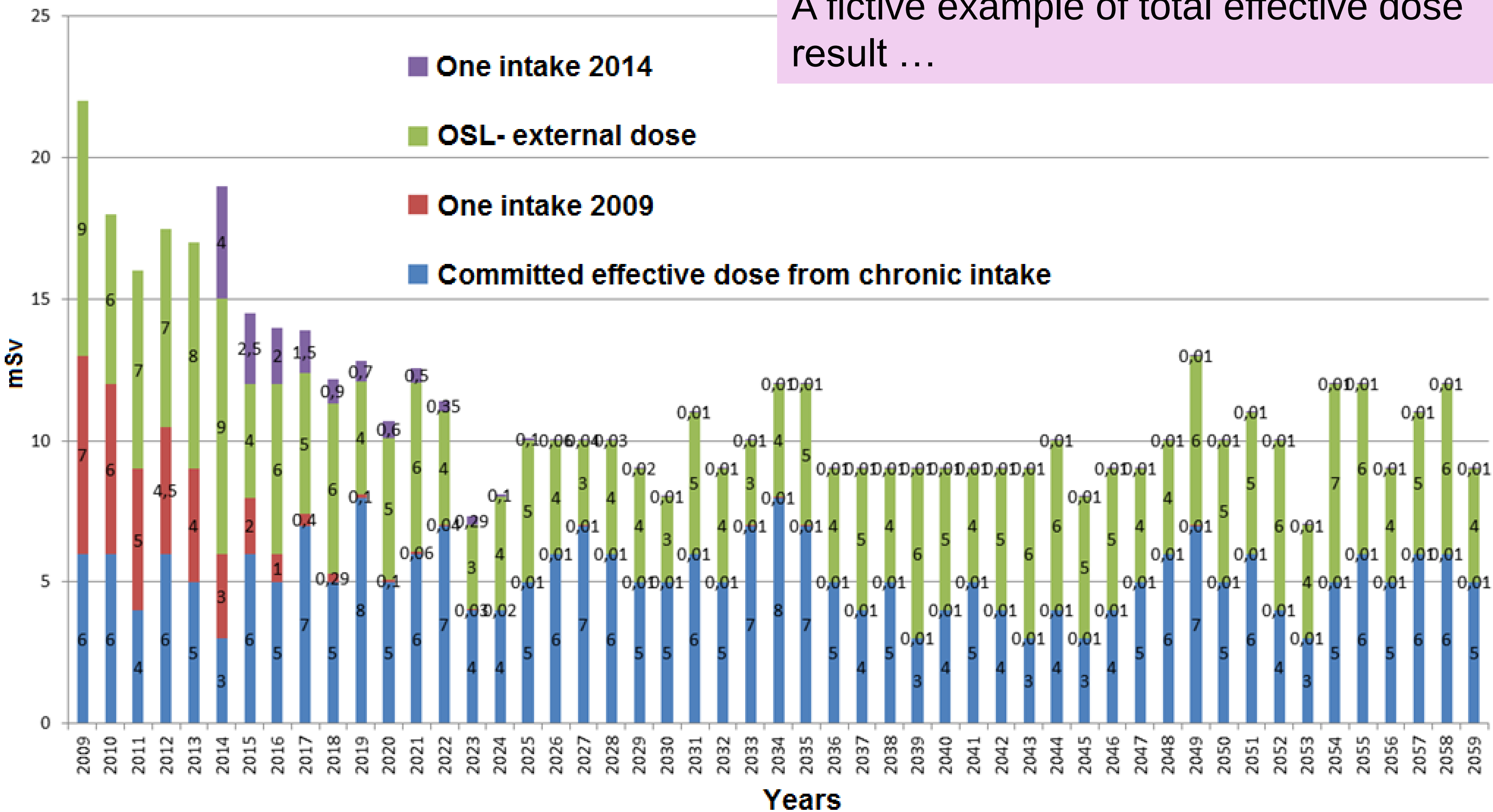
How big are the uncertainties??

(a) Time of intake
(b) Sampling of urine (24 h, about 1,6 liter for men and 1,2 liter for women) or fecal
(c) Analysis of laboratory measured sampling results
(d) Measuring of uranium concentration in air, *continuously measuring* or *filter sampling* or *personal air samplers PAS*
(e) Particle size μm AMAD, density, grouped particle form, shape of particle, solubility, chemical form, enrichment, route of intake
(f) Assumptions regarding biokinetic model
(g) Individually characteristic

Circumstances about the intake

- What was the origin of radioactive aerosols?
- Start and stop time of release?
- Release duration?
- What kind of ”trigger” caused the release?
- Radiation protection equipment used (*filter type*)
- Interviews with the personnel
- Is all personnel involved taken into account?
- Measurements made
- Assumptions

A fictive example of total effective dose result …



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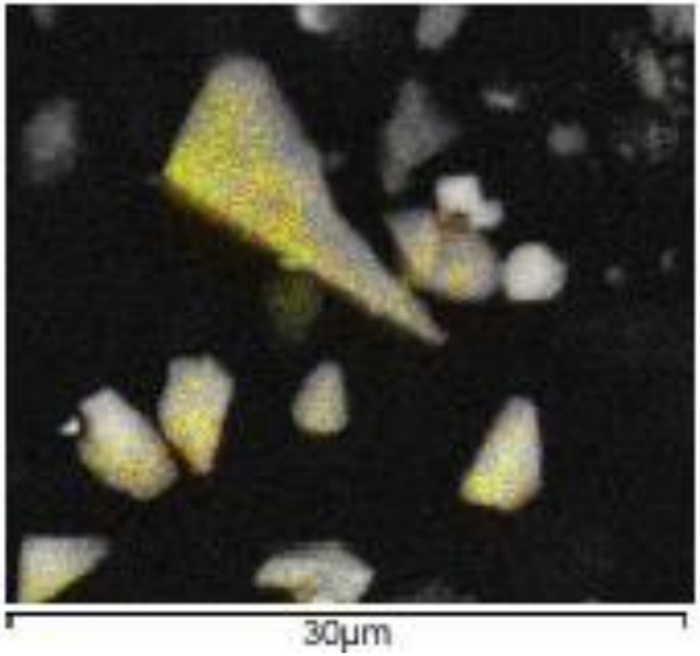
ALARA and summary of the study

In what process did the release occur of radioactive aerosols?

Can this give the answer?:

- Shape
- Size
- Chemical form
- Grouped with other particles
- Density
- Enrichment



Is the committed effective dose correct??

QUESTIONS?

http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Sakerhet-vid-karnkraftverken/2015/**SSM-Rapport-2015-18.pdf**

Thanks for your attention!

http://www.stralsakerhetsmyndigheten.se/Global/Publikationer/Rapport/Sakerhet-vid-karnkraftverken/2015/**SSM-Rapport-2015-18.pdf**