PREDEC 2016

International Symposium on PREparation for DECommissioning

Influence of Decontamination

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Decontamination

- Overview of reasons for decontamination
- Different methods
- Advantages / Disadvantages
- Influence on decommissioning planning and radiological characterization
- Criteria to choose a decontamination
- Conclusions

Reasons for Decontamination

- Decontamination reduces the dose rate what is helpful especially for the dismantling work, when many workers spent a lot of hours in radiation field

  → reducing the collective dose.
- In most countries it is required by law to minimize the amount of generated radioactive waste.
- A main point are the costs: often it is cheaper to decontaminate than to bring waste to the disposal facility.
- Decontamination leads to more material for the clearance process.
- More materials could be recycled or used directly.
- It helps to save space in the repository.

From small parts up to Full System

Masses expected during decommissioning

Decontamination Costs for Clearance

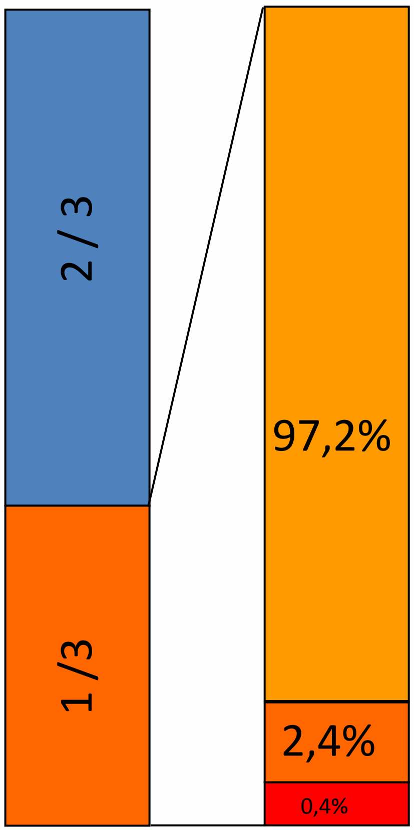
are cheaper than

Conditioning Costs for RadWaste

(experience from other German decommissioning projects)

Supervised zone

Controlled zone



Clearance / Exemption (several paths are possible)

- Unrestricted release
- Recycling
- Land filling

Radioactive waste

Reuse (under defined circumstances)

The fractions are valid for BWR and PWR

Experience

- But experience also has shown, that the mass distribution as displayed above needs:
  - Fine decontamination techniques;
  - The conditions for clearance should be stable for long terms;
  - A good path for concrete / building rubble;
  - An interim storage, or
  - A repository.

The advantages, disadvantages and experiences may lead to a situation where single strategy fit with all requirements, but mixed strategies can be more effective.

Use of Different decontamination techniques

- Small parts
  - Same procedure as in operation
- Components
  - Same procedure as in operation
- Systems
  - Same procedure as in operation
- Full System Decontamination
  - Decontamination of the primary circuit together with the auxiliary systems
  - Reducing the radiation level in the whole controlled area
  - Preparing good conditions for the dismantling works as well as for clearance

Use of Different techniques

- Cleaning by wiping with or without ingredients
- Cleaning by pressurized water – cold / hot / steam cleaning
- Mechanical cleaning
  - Blasting with hp water, abrasives, CO_2-Ice
  - Polishing, Drilling, Milling, for concrete Needling
- Strippable coatings
- Melting

Measuring concrete

Demolishing concrete

Measurement by ɣ-in situ

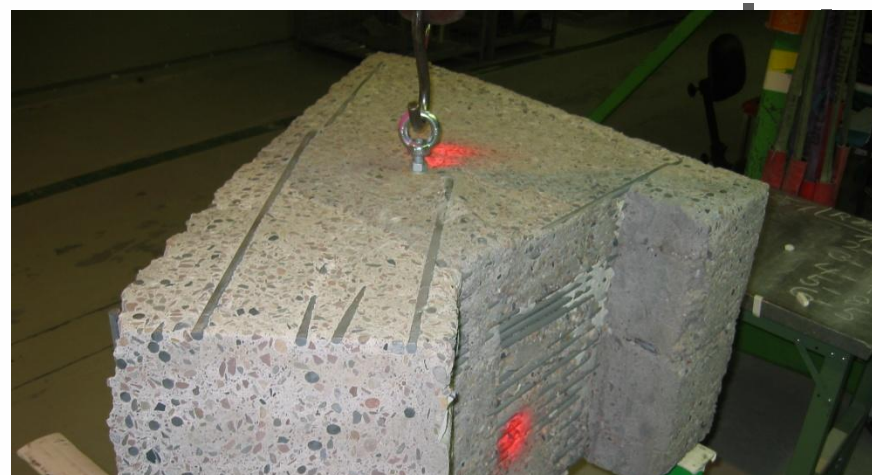
- Averaging over some square meter
- Fast decision for great parts or buildings
- Geometrical factors could be calculated
- Penetration of nuclides in the concrete could be evaluated / calculated

Demolishing concrete

Broken concrete could be used after clearance for

- Worst case: landfill (waste site)
- Road construction
- New buildings constructions

Decontamination of structures

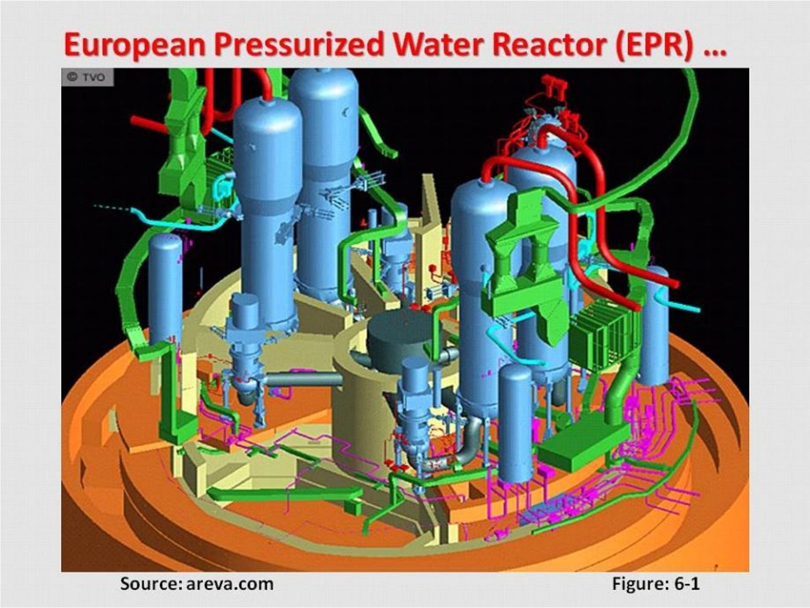


Decontamination of buildings

Removal of contaminated concrete from floors and walls

Use of Different Techniques

- Chemical cleaning
  - Decontamination in chemical bathes
  - Decontamination in ultrasonic bathes
  - Electro polishing



- Full System Decontamination

Full System Decontamination

A very powerful kind of decontamination

- Cleaning the primary circuit and the auxiliary systems
- Decreases the dose rate: important for dismantling works
- Allows easier conditioning procedures

- But terminates the operational history
- But possible shifts the nuclide vector

Of which amount of activity inventory we talk?

Activity inventory without nuclear fuel:	ca. 1 E 17 Bq
Formed by activation:	ca. 95 + %
Cleanout per FSD:	ca. 1 E 14 Bq

How to decontaminate?

The Contamination Brusher

Outer layer, containing

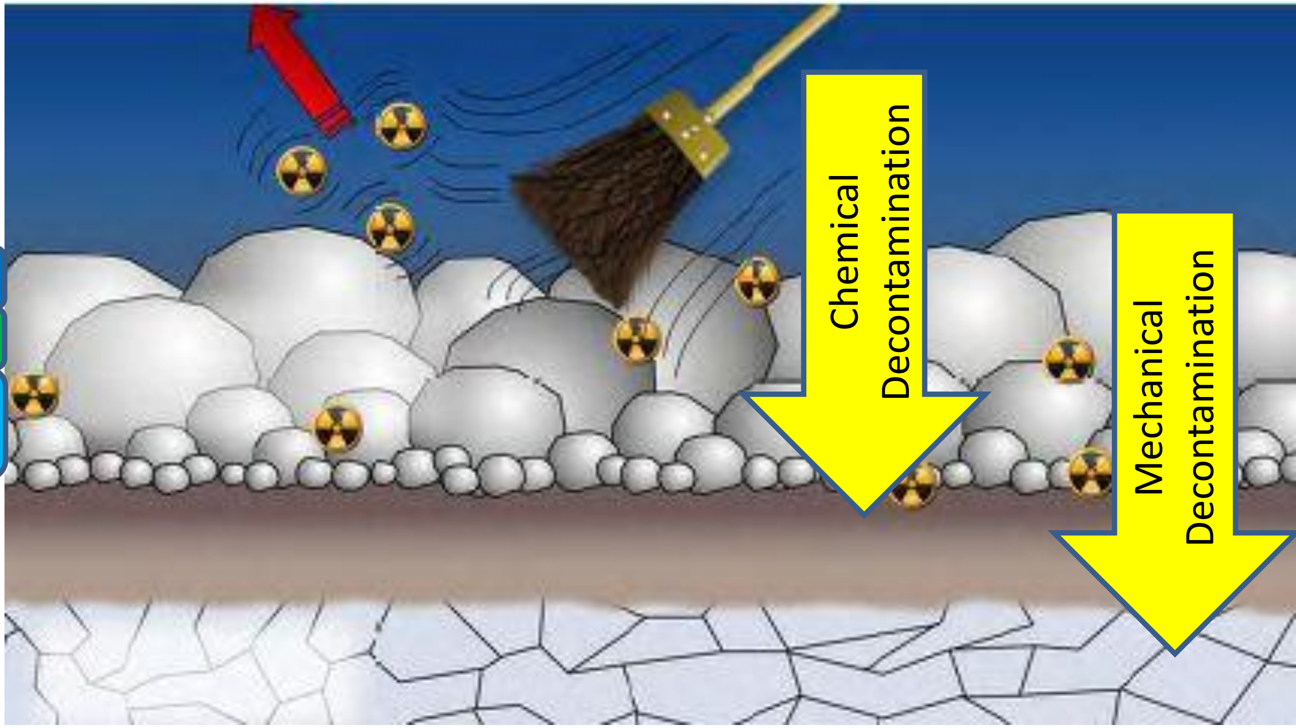
solvable

Chromium (2 – 10 µm)

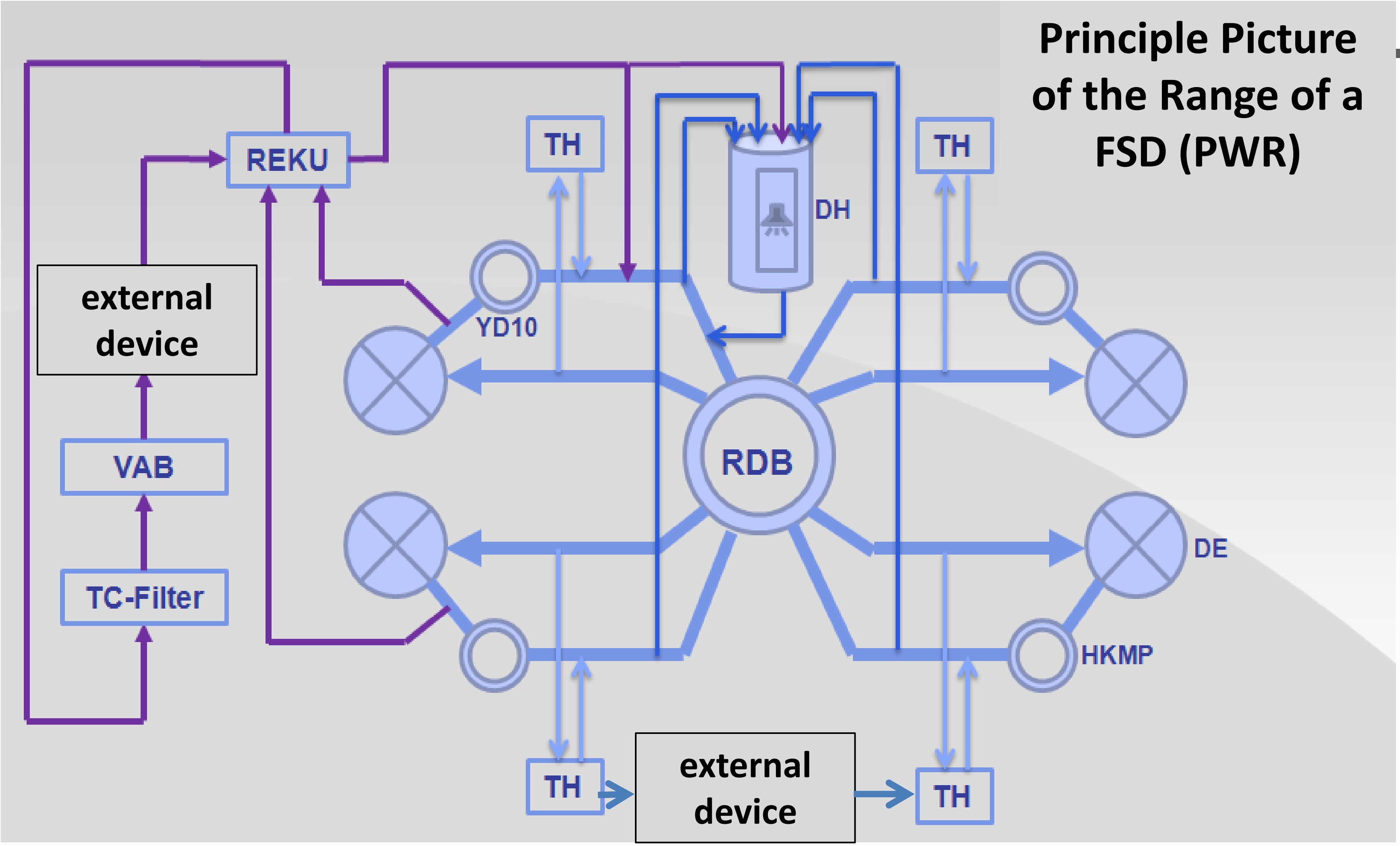
Oxide layer, CRUD, ferritic(1 – 5 µm)

Diffusion layer (< 20 µm)

Base material



Full System Decontamination



Full System Decontamination

- Which are the results?

The success of the decontamination is described by the decontfactor:

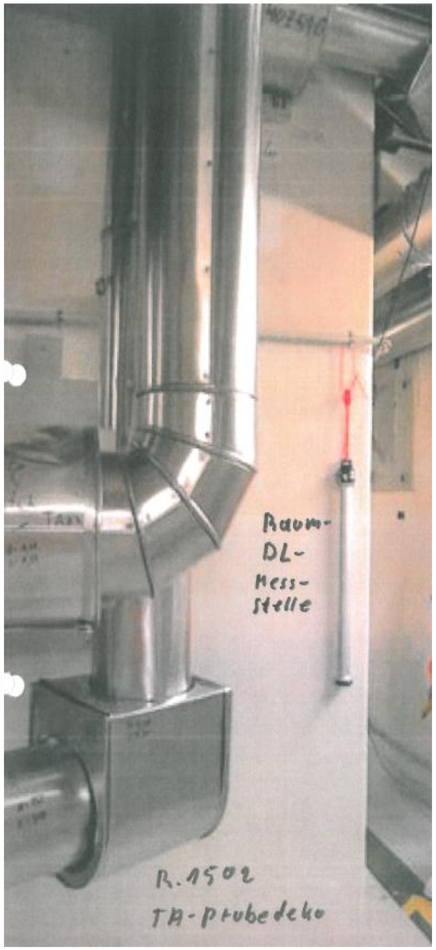
$$\text{Decontamination factor} = \frac{\text{Dose rate prior decontamination}}{\text{Dose rate after decontamination}}$$

Typical decontamination factors are between 10 and 75 (in some cases up to 100), this depends on different factors like the operation, the material, the surface, the decontamination fluid flow…

A decontfactor of 10 means a **90%** discharge of the contamination!!

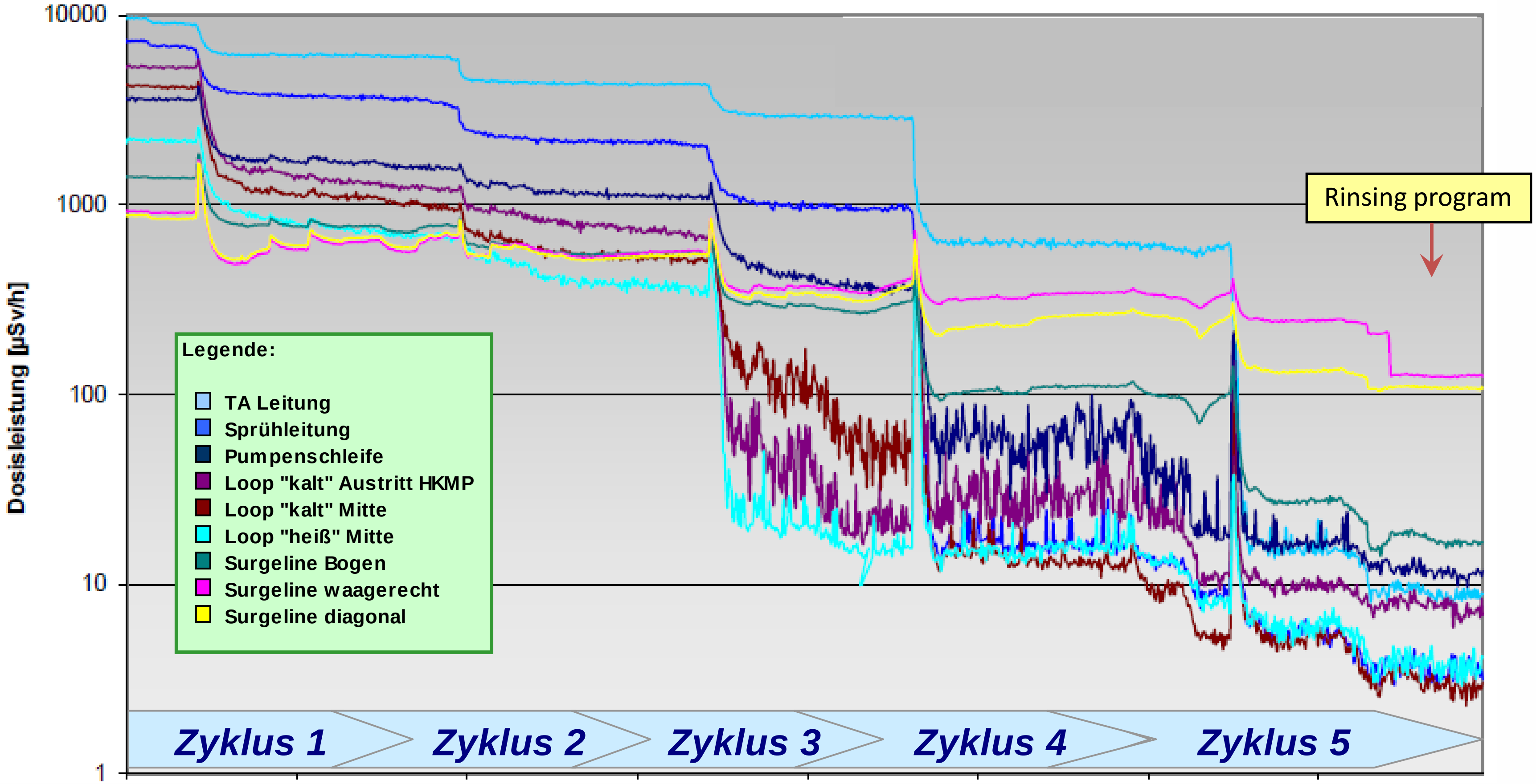
Full System Decontamination

Measuring the success of the FSD



Full System Decontamination

Dose rate during FSD



Quelle: E.ON KKU

Full System Decontamination

Doserate in the middle of the primary chamber (SG)
before: 150 mGy/h → after: 3 mGy/h

Quelle: E.ON KKU

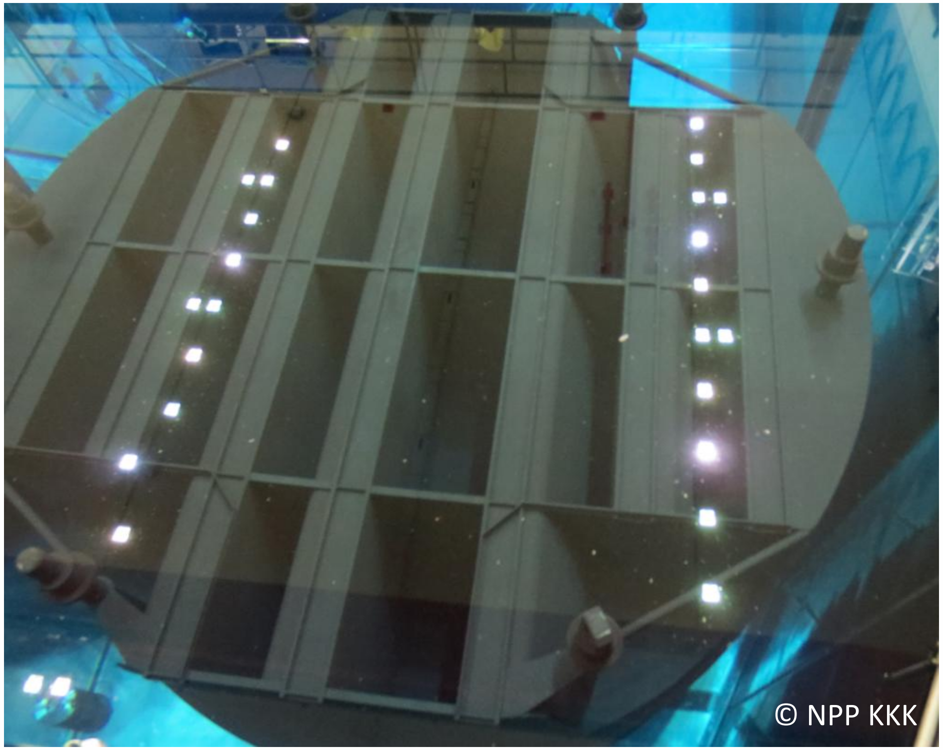
Impact on waste management

- Direct dismantling of big components

Full System Decontamination

Impact on waste management

- Easier dismantling of components like steam dryer or water separator without need in under water remote techniques

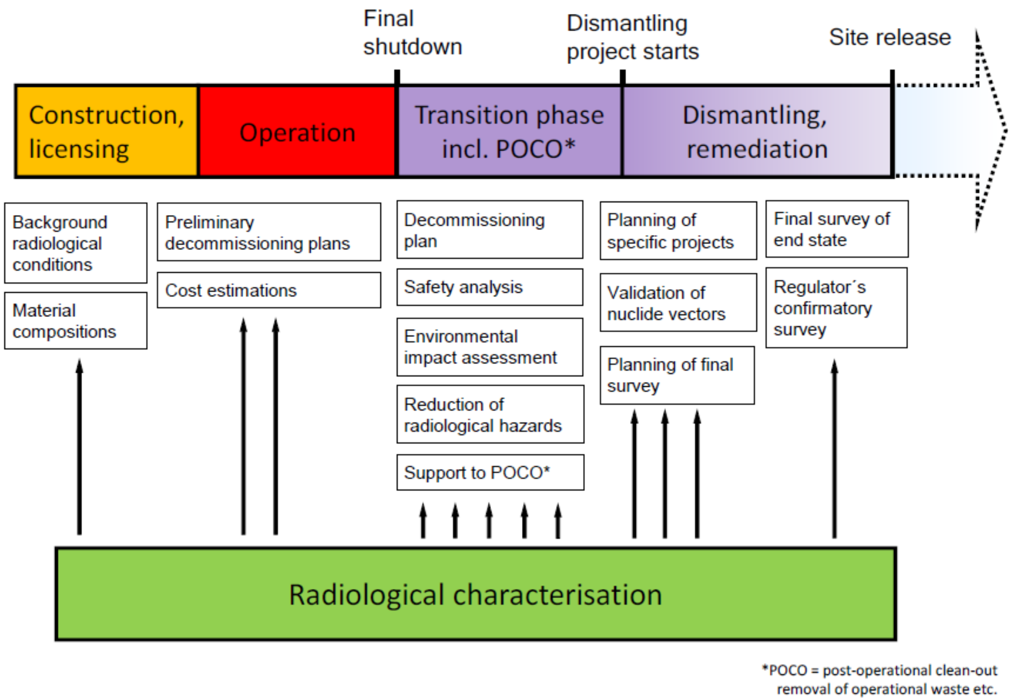


Full System Decontamination

But what is left
if the chemical
metering is too high
or the procedure is not
steered in the right way?

Influence on the Radiological Characterization

- Because of the high cleanout of contamination it is necessary to do the radiological characterization for waste management and clearance after the FSD. The possibility of shifting the nuclide vector must be considered.
- The cleanout per FSD has no impact on the activated nuclides!



Radiological Characterization in different phases of decommissioning / dismantling

Details, which shall be evaluated before licensing:

Intended purpose	System	Grade of investigation
Decommissioning Strategy (Application of dismantling steps)	Facility (all systems, buildings, area)	Operational History, Sum of Activity, Activation calculations, Key Nuklides of the contamination (Dose)
Accident examination, if occured Full System Decontamination (corresponding to the application)	Primary circuit (non destructive), Wastewater treatment, Waste package	Inventory in Systems, Tanks, etc Key Nuclides, (Dose)
Amount of expected waste, Waste Mangement Concept, Cost estimation	Systems, Building Structures, radioactive Waste	Contamination of Systems (in- & outside), Contamination of Buildings, if so, Penetration, Representative Nuclide Vectors for radioactive waste

Radiological Characterization in different phases of decommissioning / dismantling

Details, which shall be evaluated after licensing:

Intended Purpose	System	Grade of investigation
Radiological Work Protection, Work Permission	System- / Components demanding on the work progression	nuclide specific contamination, Focus on alpha-contamination, Dose; Detailled definition of the previous findings of the RC
Clearance procedure, Validation of calculated activities of radioactive waste	All systems demanding on the work progression	Complete Characterization incl. hard to measure nuclides; Detailed definition of the previous findings of the RC
Free release of the buildings, Free release of the site	Surface of the buildings, Site, buried Systems and Components	Surface contamination, Penetration behavior, Covered Areas

Advantage and Disadvantage of Decontamination

As shown above in the reasons:

- Better radiation protection for staff
- Decreasing dose rate
- Lower amount of radioactive waste
- More possibilities for dismantling
- Better transport conditions
- Easy conditioning / simple container

Advantage and Disadvantage of Decontamination

Some disadvantages:

- Production of secondary waste, in case of using organics
  it is difficult to dispose
- Increasing collective dose rate for the decontamination work
- Handling with hazardous agent
- Risky work (e.g. blasting)
- Shifting in the nuclide vector
- Complete removal of nuclides → which nuclide vector could be used? Taking a general one can build up fictive contamination.
- Cost / benefit analysis is necessary (especially for FSD)

Shifting in the Nuclide Vector

Decontamination shift the nuclide vector to some extent

- Some nuclides are more adherent than other
- During mechanical decontamination like blasting some nuclides are hammered into the base material
- During cutting, especially thermal cutting, it occurs with the molten material
- Recombination during a chemical process is nuclide specific

Shifting in the Nuclide Vector

In Numbers:

- During operation the relationship between ß/ɣ and α-nuclides:
  approx. 3000 / 1

- Shifting by decontamination:
  approx. 1000 / 1

- And in case of Co-60 after 5 years:
  approx. 500 / 1

This is in the region of limits for the measurements of airborne nuclides for radiation protection

Criteria to choose a decontamination

Radiation protection

- Decrease dose rate
  - For “Old” NPP
  - Short time after shut down
  - Especially by FSD
- Seal the contamination
  - Cleaning also below clearance levels
  - Reduce the amount of nuclides released in the environment

Criteria to choose a decontamination

Handling of material

- Easily possible after decontamination
  - Especially dismantling works on secondary treatment places
- Transport
  - Less shielding required

Criteria to choose a decontamination

Minimize the waste

- More material for clearance and recycling
  - Possible recycling even of parts from the primary circuit
  - Melting for shielding
  - Further use of concrete

- Immediate dismantling vs. deferred dismantling
  - Less decontamination effort due to decay

Sand blasting

Conclusions

- Decontamination is good practice
- Planning, waste management and radiological characterization are influenced
- “Old” NPP´s with more Co-60 in the components structure materials and/or with fuel damages more benefits from decontamination
- Concrete is not so easy to decontaminate (geometry, penetration depth, activation) but due to the masses the benefit is high
- Decontamination shifts the nuclide vector → problems for the radiation protection
- Clearance measurement need a nuclide vector but some decontamination leave nothing (milling, electropolishing)
- Otherwise a “best estimate” nuclide vector will be chosen with the build up of activities

The difference between theory and praxis is mostly in the praxis greater than in the theory!!!

Thank You
For Your Attention