8. Case Study 5: Optimization and major dismantled NPP component in a waste handling process

Plan of the Case study

I Description of the technical aspects

- Presentation on the waste handling process in Sweden
- The “Steam Generator” case
- Technical treatment concept envisaged for volume reduction
- Conclusion

II Optimization

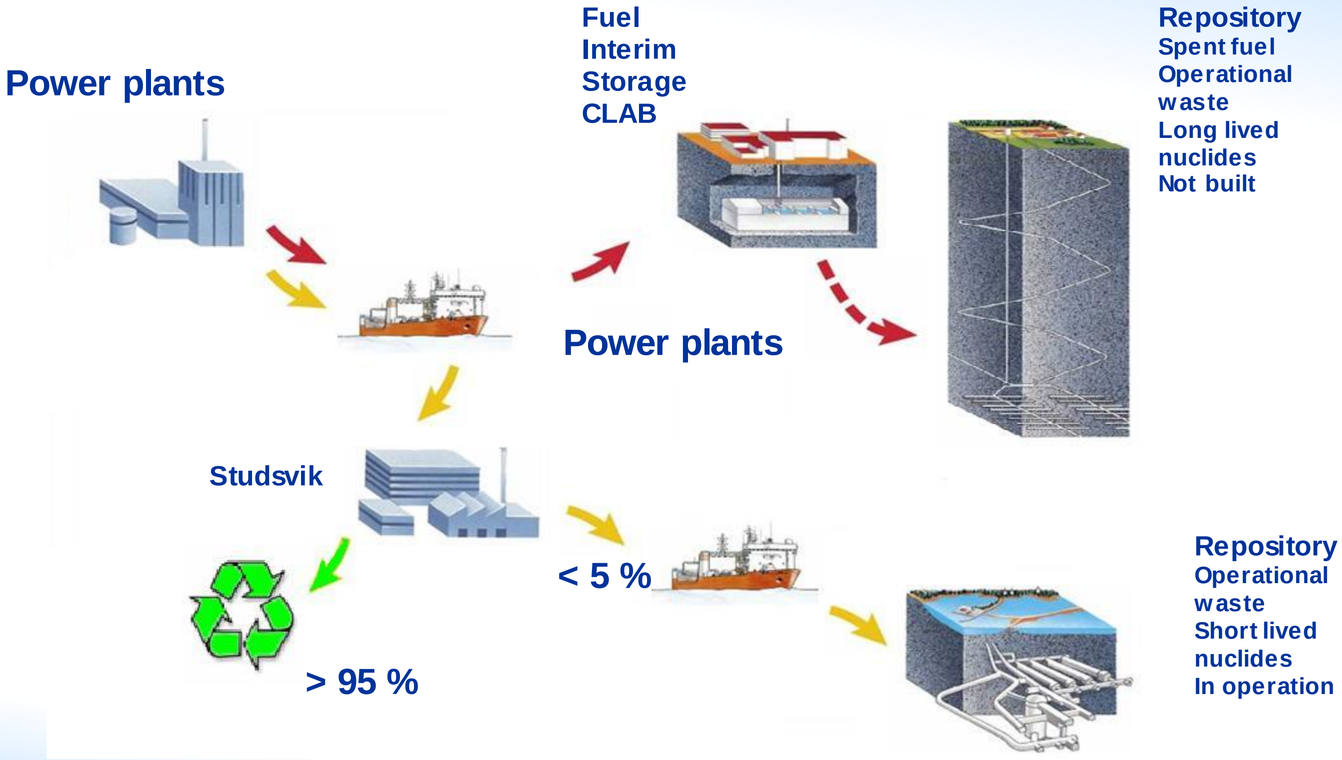
- The general ALARA scheme for optimization implementation (optimization towards minimization)
- Importance of dose rates and contamination rates mapping
- How to set up optimised objectives: the protection actions
- ALARA : a continuous process

PART I

Description of the technical aspects

- Presentation of the waste handling process in Sweden
- The “Steam Generator” case
- Technical treatment concept envisaged for volume reduction

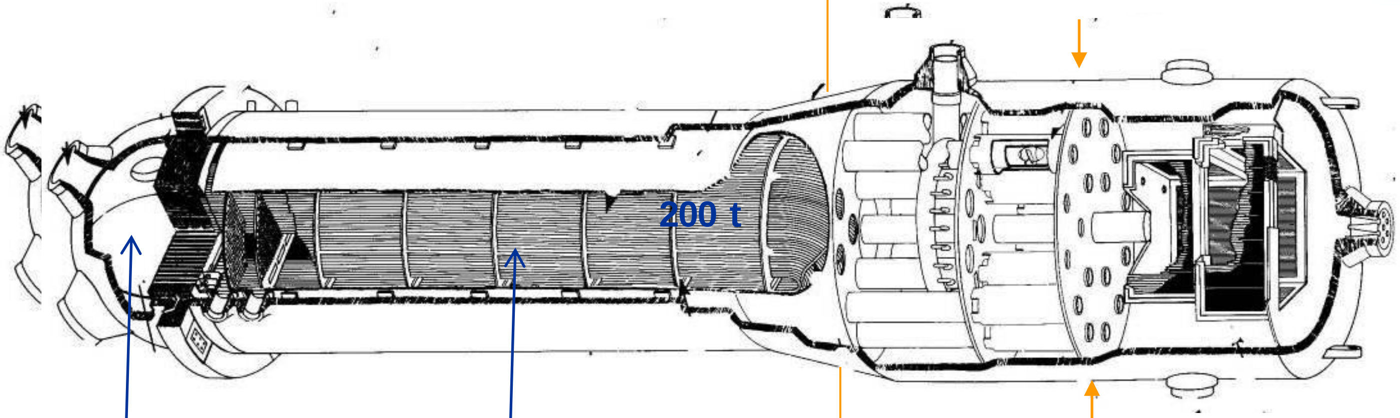
The Swedish system



Steam Generator - Technical data

200 t

110 t



4700 tubes (~75 km)

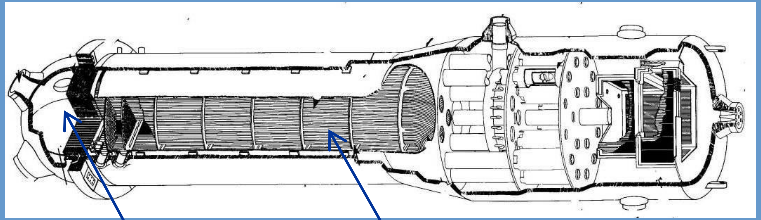
4.4 m

21m

Water chambers

Tube bundle

Steam Generator – first dose data and stakes

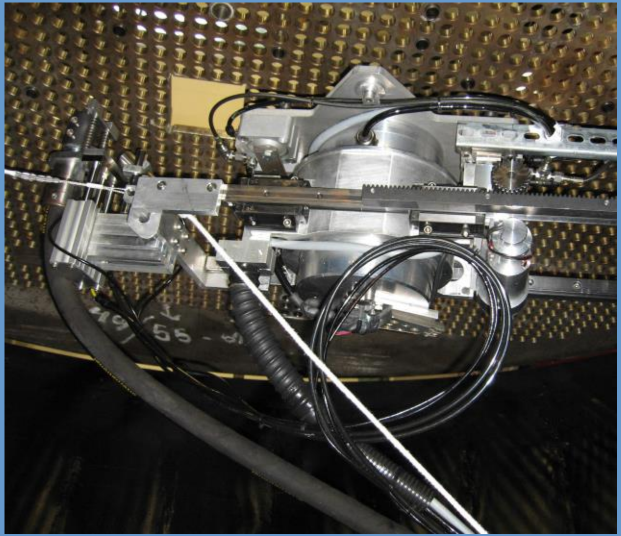


By experience it was well known that dose rates in the water chambers were of the order of magnitude of 10mSv/h, and during maintenance operations “jumpers” were not allowed to stay more than a few minutes and as possible had to be replaced by remote tools; contaminated and corroded areas are the water chambers and the inside of the tubes in the tube bundle.

Therefore there were 2 risks: external exposure with a potential to exceed the dose limit in a few hours (to be optimized); internal exposure in particular with Co-60 (to be avoided).

Why to invent? – Use existing knowledge!

- Optimization is very often to gain from experience
- Just to adapt and to try to improve for steam generator waste processing



Transportation

Departure Ringhals

Arrival Studsvik

Waste treatment site

Metallic waste processing incl. Melting–main targets

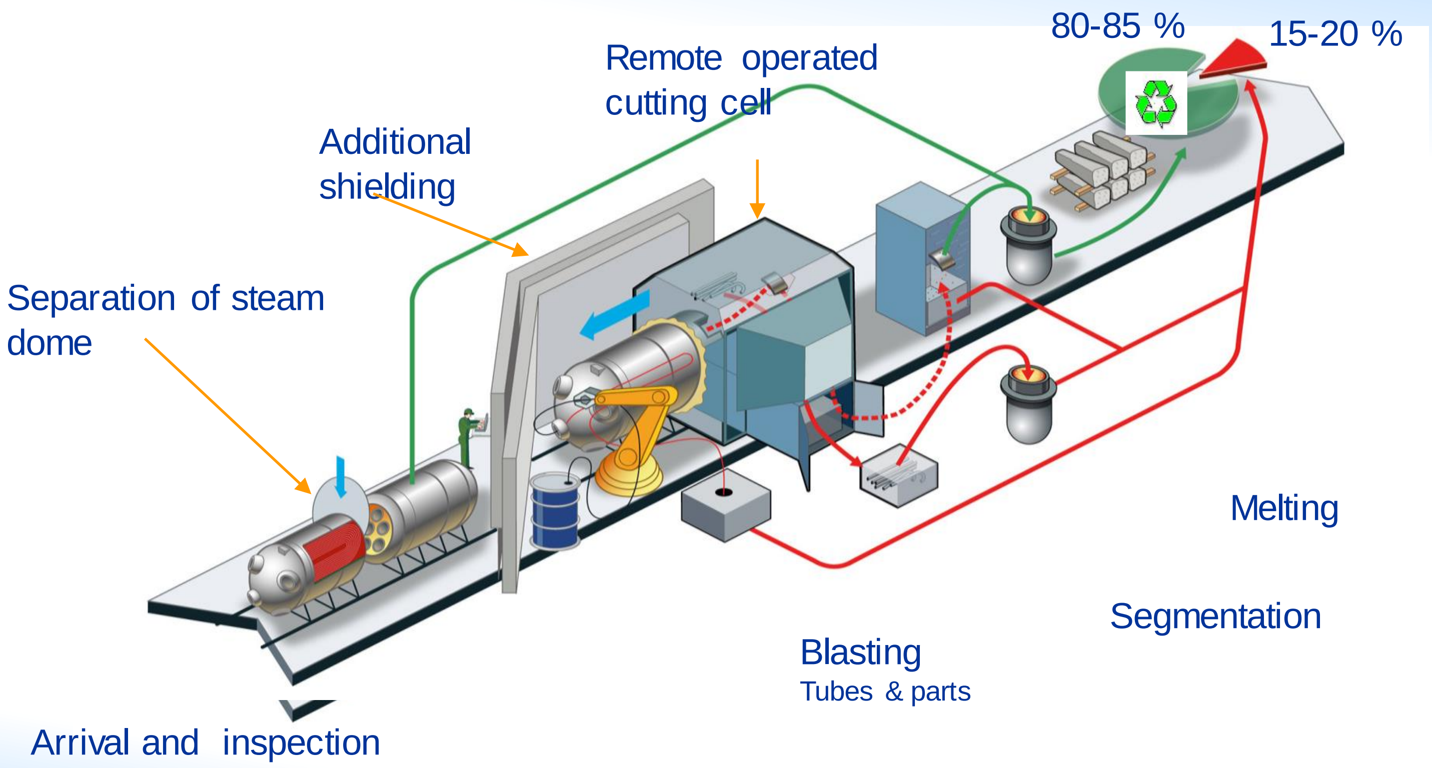
Achieve maximum volume reduction > 95 %

- From more than 400 m^3 to less than 40

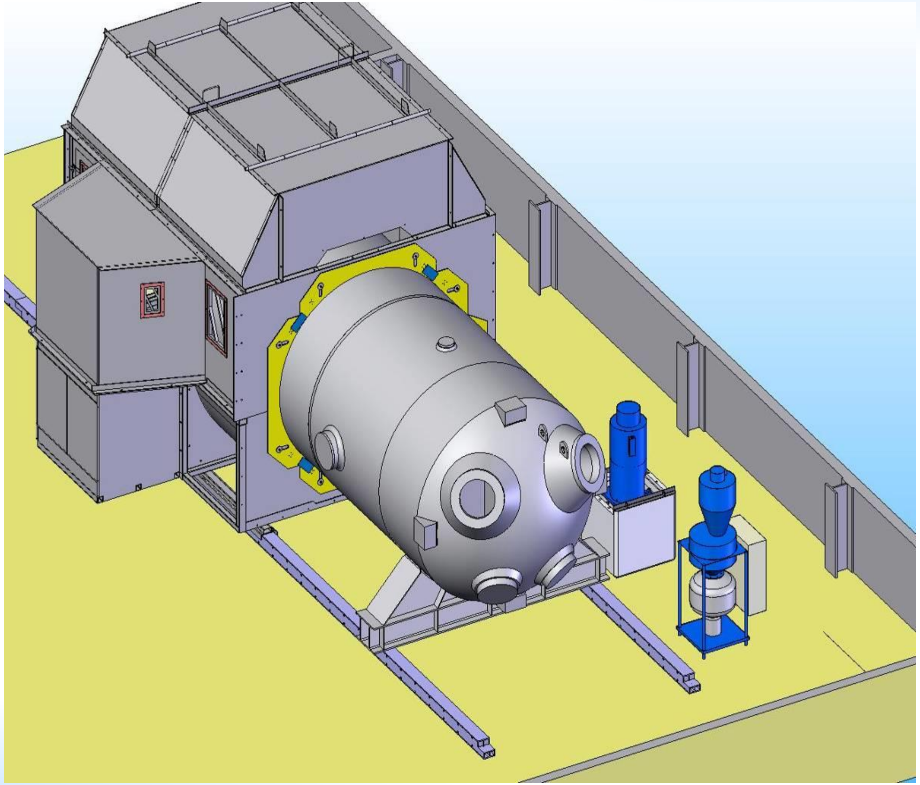
Homogenize the metal for robust characterization for nuclide specific free release by weight.

Provide an opportunity for reuse and unrestricted recycling of material of valuable material.

Technical concept



Tube blasting



Large part of the radioactivity should be removed by blasting with steel grits

Blasting nozzles positioned with a robot

Other operations

Tube package material compacted for volume reduction

Outer shell, water chamber and tube plate segmented and melted

Main part of material for free release either directly after melting or after decay storage

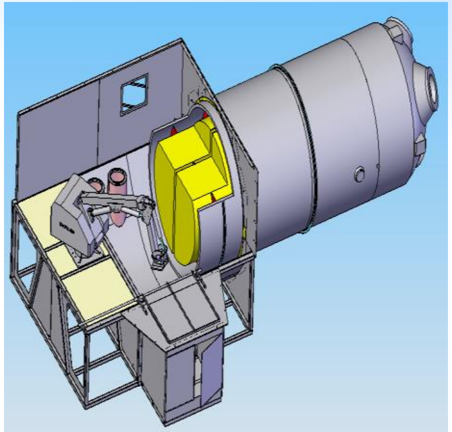
Segmentation in the cell

Remote functions

- grinding machine
- Torch
- Shovel
- magnetic lift

Support systems

- Hydraulics
- Bag house filter
- HEPA filters



Metallic waste processing incl. melting

Part II : Optimization

- The general ALARA scheme for optimization implementation (optimization towards minimization)
- Importance of dose rates and contamination rates mapping
- How to set up optimized objectives: the protection actions
- The results
- optimization : a continuous process

The ALARA Scheme (1)

Preparation

Mapping of sources
optimizing shielding.
Setting dose goals
Min dispersion of contamination.
no intakes

ALARA a
continuous
optimization

Analysis of deviations
between predictions
and actual doses
New techniques
New protection options

Doses follow up
EWT follow up
Control of activity
transport and deposit
Mapping of radioactivity
for free release

Feedback experience

Execution

The ALARA Scheme (2)

Radiation Protection – ALARA

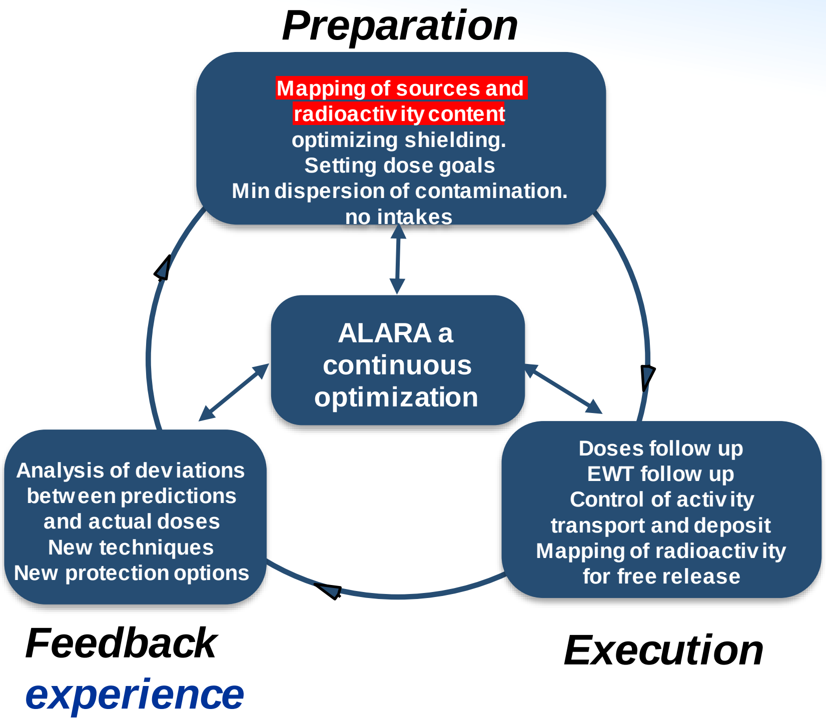
- Why to invent? – Use existing knowledge!
  i.e make use of feedback experience which implies to keep track of the feedback

- Use of the man sievert monetary-value (450 €/ man mSv) (now 1000)
  i.e to implement the optimization procedure : the quantification of criteria for the options and the decision aiding technique

- To rely on managers and workers involvement
  i.e to sensitize the stakeholders

- To use differences in companies (the Ringhals NPP and the Studvick repository) cultures and join forces
  i.e ALARA culture, good practices present different aspects depending on the firm, mixing them in a “good” manner shall be very positive

ALARA procedure



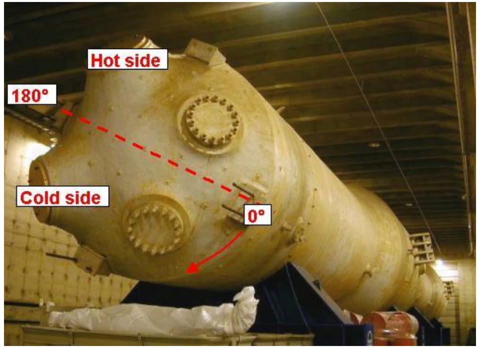
Mapping of the sources

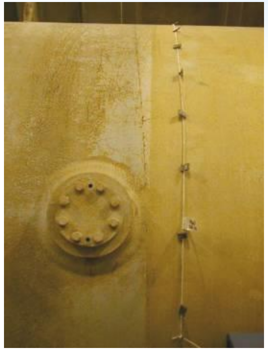
Dose rate

- GM- detector
- TLD (axial & vertical)

Activity

- Volume activity
- Surface activity
- (Induced activity)





Mapping of materials radioactivity content

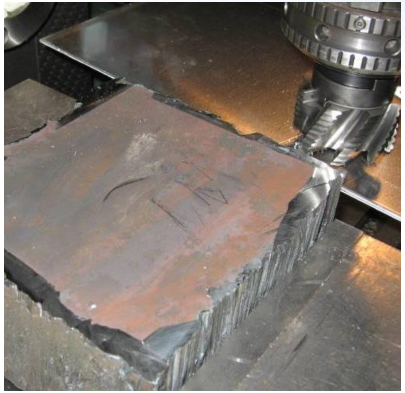
Steam generator jacket

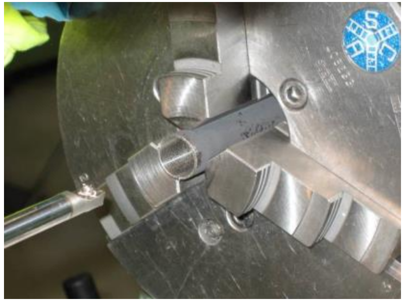
- NS oxide analyses (secondary. side)
- NS material analyses

Steam generator tubes

- NS oxide analyses (primary side)
- NS material analyses

Analyse of difficultly measurable nuclides, initial water chemistry data – verified to be much lower when measured on removed activity with blast-decon





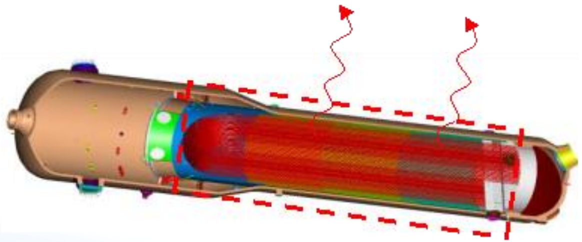
Radiological data

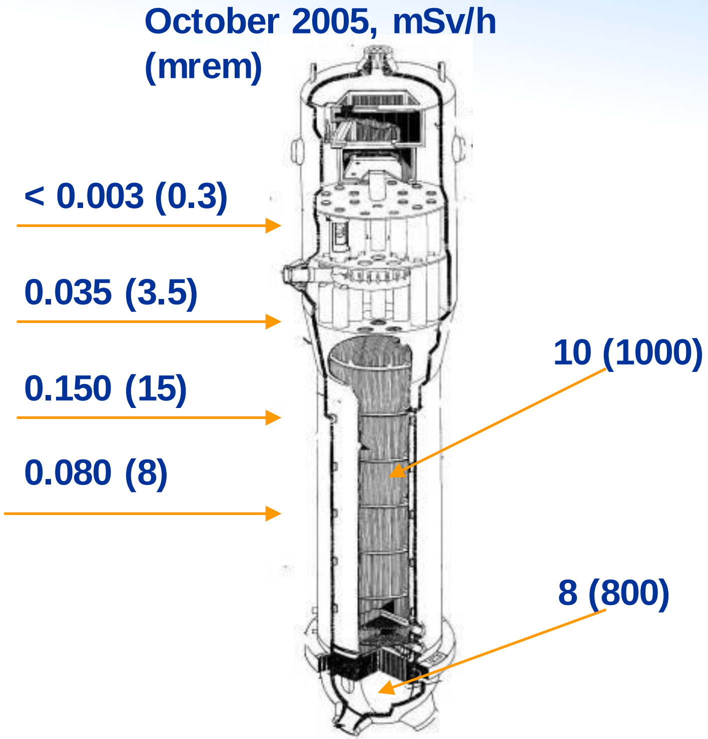
Radioactivity inventory (TBq - Ci)

- Total: ~1,3 - 35
- Co-60: ~ 0.65 - 17,5
- Ni-63: ~ 0,6 - 17

Activity distribution

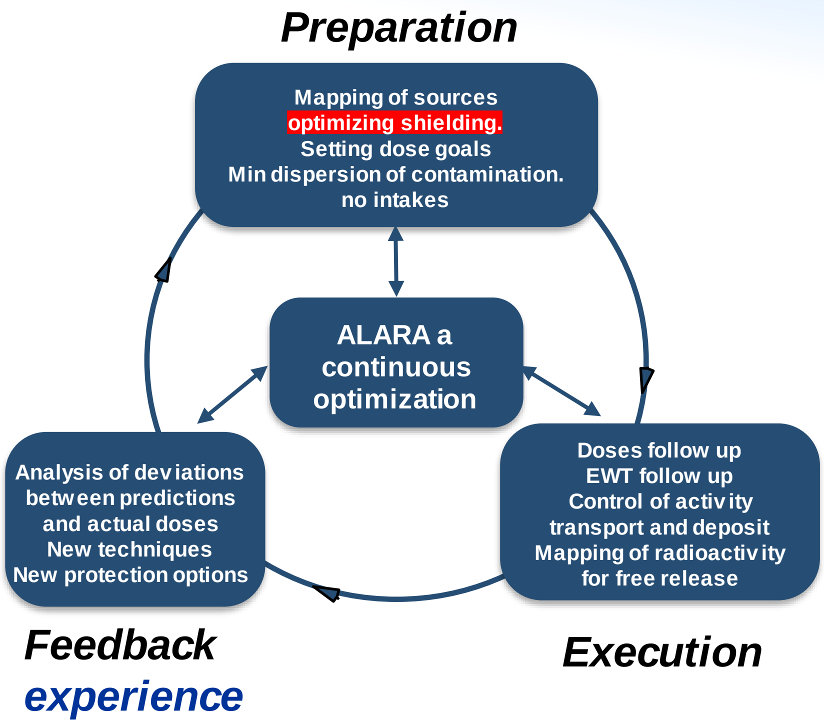
- 95 % in the tube bundle
- 5 % in the primary chambers





The mapping was fundamental but led to not surprising results according to what was known previously

Optimizing shielding



Optimized radiation shields

Take advantage of shields in-built

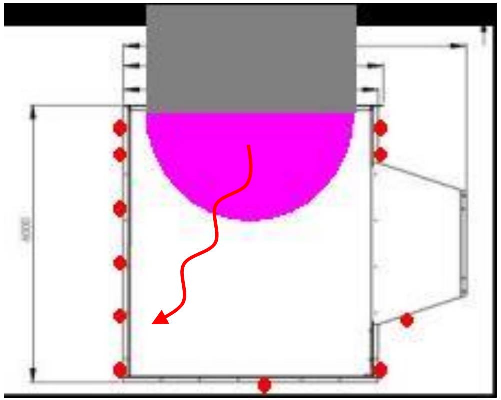
Use mapping data and source data to calculate each realistic situation

Calculate sufficient shields

- use of tools: MicroShield and Mercurad

Take care of possible variation and fluctuations of the sources to select the optimal size of the shield (conservative approach)

A shield should serve it's purpose, it don't have to be luxurious



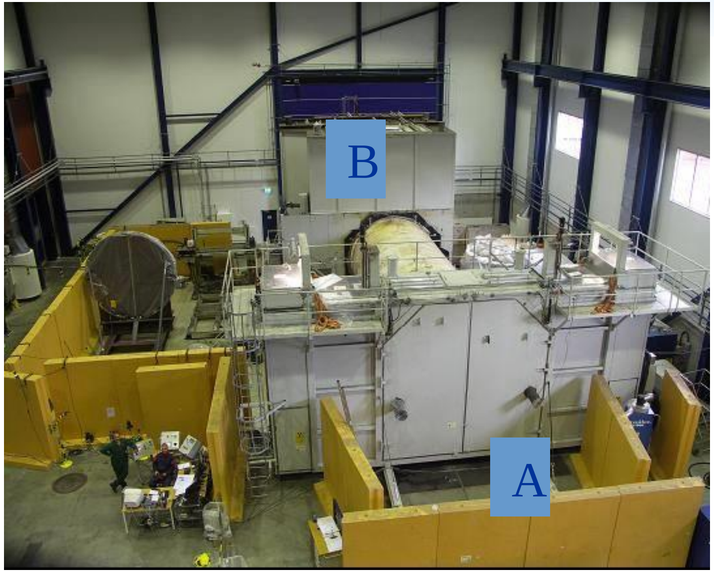
No (minimal) radiological impact on other activities

A. Use mobile shields

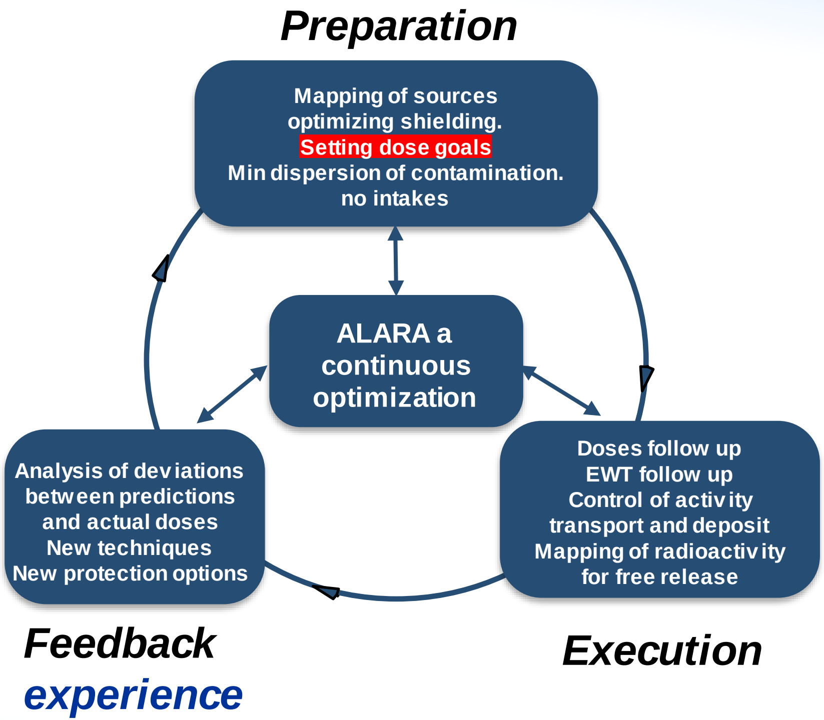
B. Design shields to protect surroundings

❑ Designate area solely for steam generator treatment

❑ Avoid exposure from passive sources



Setting dose goals



How to set a Dose Goal?

Complicated component to dismantle

New designed equipment and industrial standard equipment in radiation environment

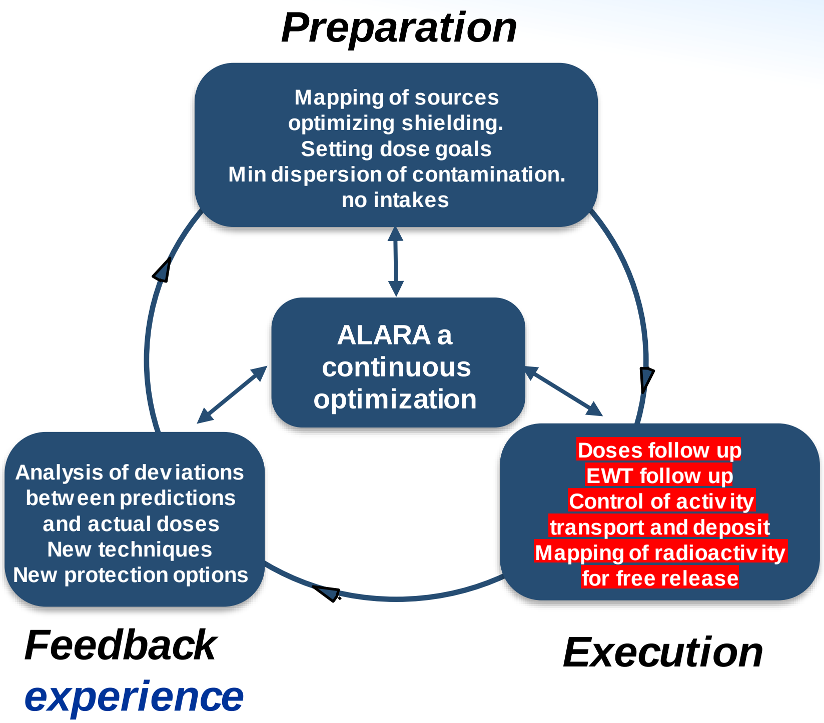
What is an acceptable dose for steam generator waste process?

First attempt to calculated goal from average dose coefficient for produced standard waste packages in Ringhals 1997-2007 - 1,1E-11 mSv/ Bq (7 man.mSv)

Initial dose budget was set, with the "dream scenario" in mind, it was more realistic than the first attempt it was calculated taking care of the expected workload per task and of the expected dose rates and of the impact of the shieldings

It was then estimated to 40 man.mSv

Dose follow up



Mapping of the sources

The dose rate on the surface of the outer shell was 0.5 mSv/h, before the blasting and 0.01 – 0.02 mSv/h, after.

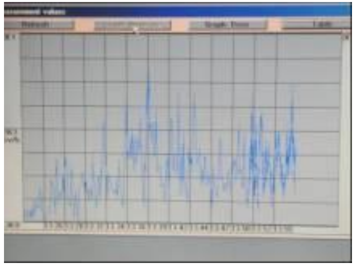
Of the 4674 tubes 4615 were decontaminated, the plugged tubes weren't possible to decontaminate. The result showed that > 85 % of the activity from the tube bundle was removed. …

Rigorous control (online) of activity transport and deposit

To have control over radioactivity movements is a necessity

- Online measurement to determine the actual decontamination factor (Df)
- Extremely important during decontamination for verify deposition
- Important during machining

Manual routine measurements and having a nose for deviations is crucial

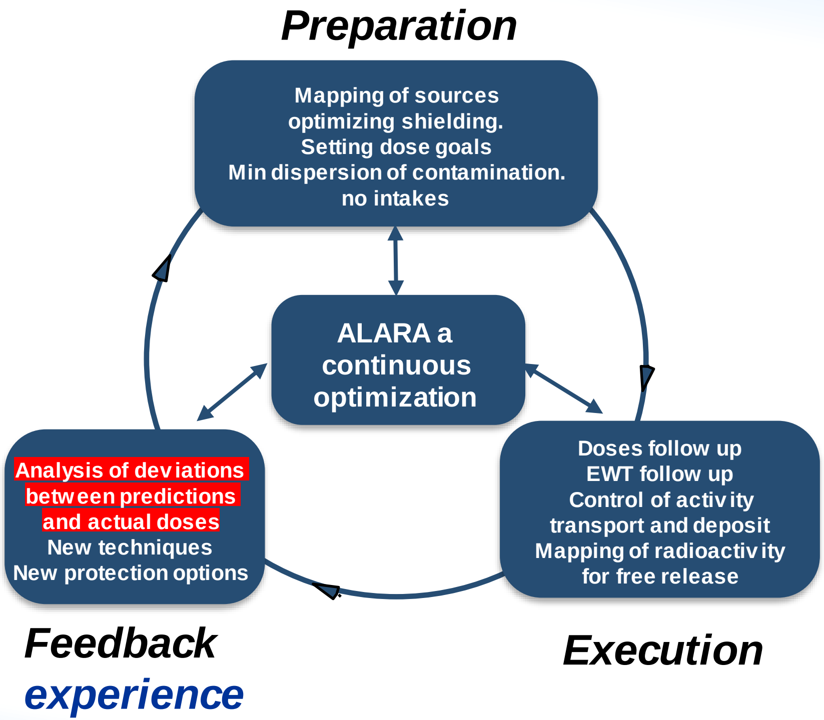


Same approach for contamination than for external exposure during preparation, follow up and feed back phases

Starting point is to minimize influence on personnel, plant and surroundings

- Look at the stakes (P)
  - Find out what is the potential risk situations
- Select protection options (P)
  - Establish under pressure in cells, tents
  - Filtrate auxiliary ventilation and keep your eyes on activity build up
  - Use local exhaust ventilation
- Establish online measurement for airborne activity (F)

Analysis of deviations between predictions and actual doses



Dose Results

The goal for the collective dose to the operators during the project was set to 30-40 man-mSv but

It became < 70 man-mSv at the end.

The largest individual external dose was < 6 mSv.

No internal doses were reported.

No accidents were reported.

Analysis

- The cause of the divergence between the prediction and the actual dose is mainly due to an increase in man-hours that wasn't accounted for.

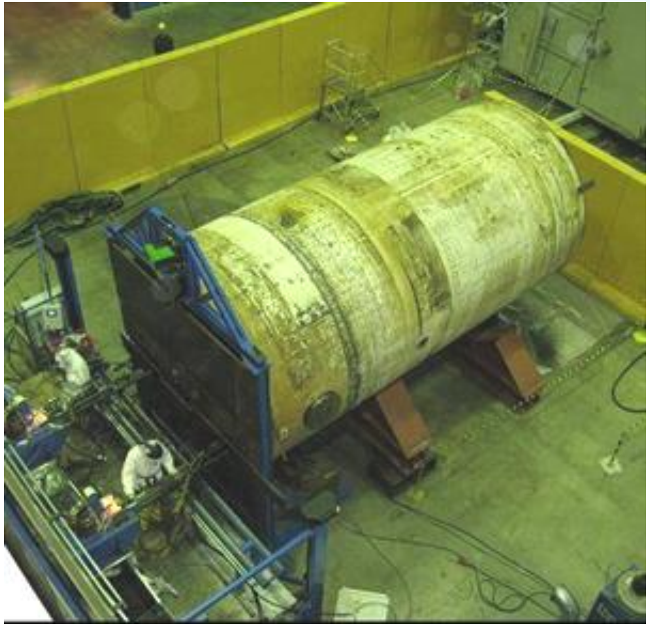
- We have already seen in other case studies that often when starting implementing the ALARA approach it is easy to overestimate the EWL (exposed workload) in confounding the "paid" workload with the exposed one.

When people are more familiar with the ALARA approach and when they have set up tools such as electronic dosimetry for analytical purpose the risk becomes a risk of underestimation of the EWL. This is mainly due to the occurrence of mishaps in particular when performing a totally new operation. That is why often one considers as normal 5 to 10% due to mishaps.

Continuous Optimization process (1)

"There will be other steam generator dismantling. Optimization will be improved as the project proceeds."

"A project has been started to analyze the experience from the treatment of the steam generator and to come forward with recommendations for how to lower the radiation exposure to the operators, minimize the secondary waste for final disposal and to decrease the treatment time.

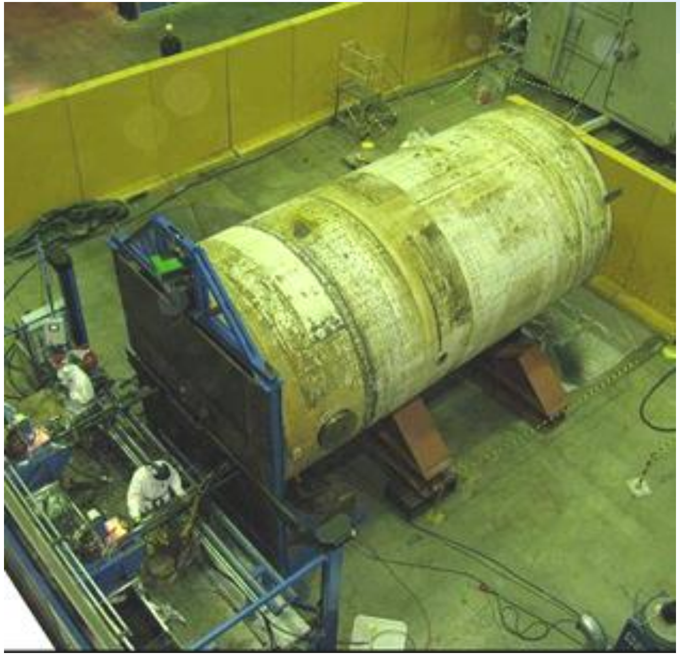


Continuous Optimization process (2)

Some actions are already taken:

A new larger treatment facility is built, >1000 m2. The new building will give the opportunity to work in a more effective way and that will give the possibility to lower the dose load to the personnel. Inside the building there will be flexible walls that can be located depending of the size of the treated object.

Tube pulling with a tailor made machine **is a new concept for the second steam generator**. The tubes are rolled and cut into like 10 cm pieces, down on a conveying belt into a steel cast iron mould. That stands for a large share of the total dose, this should have focus for optimization.



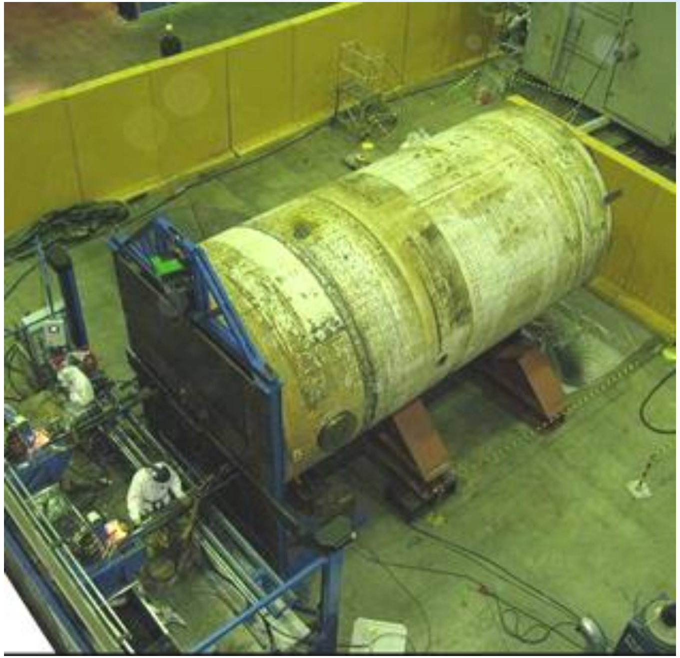
Continuous optimization process (3)

However the collective dose for the 6 initial steam generator (from Unit R2 and R3) has been 60 – 90 man-mSv !!

So what? The main reason collective doses were not lowered is total activity of gamma nuclides

At first steam generator , dismantled in 2011, there was 10 times more Bq of Co-58 and Co-58 was dominating. This has led to **changes in logistics and planning**, operations with open sources were put in the end of the treatment for using Co-58 energy's decay.

« It is very important to take into account half life reduction of energies for radiation optimization ».



Conclusions

It was a big challenge to treat a steam generator as a waste

“We have

- worked in accordance to the specified safety reviewed plan for the project (**except the exceeded dose goal 30/ 40 man.mSv, but we still do believe that this is possible**)

What to do

- **we must put more focus on dose optimization to achieve minimization (planning taking care of “half life”, shielding, remote control, discover new tools and develop methods etc.)**

We are proud but never satisfied”