



Radiation Protection at Decommissioning Stage

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- ▶ **Introduction**
- ▶ **Radiation protection planning for decommissioning of highly activated or highly contaminated systems**
- ▶ **Example: Calculations for dismantling and packaging of reactor pressure vessel (RPV) parts**
- ▶ **Conclusion**

Introduction

Initial situation

- ▶ High activity inventory of RPV and primary circuit
- ▶ Activation products define local dose rates (gamma)
 - ◆ In work locations
 - ◆ Within casks

Specification of radiological boundary conditions for

- ▶ Permission by authorities
- ▶ Technological planning (ALARA, shielding, process decisions, ...)
- ▶ Decommissioning and waste concept

Introduction (2)



Necessity

- ▶ Definition of activities of RPV, RPV internals, bio shield
- ▶ Definition of activation / contamination of components (SG, RC pumps and piping)
- ▶ Definition of airborne and medium contained activities in buildings, on plant site

Radiation protection planning for decommissioning / back fitting of highly activated or highly contaminated systems

Radiation protection planning for decommissioning / back fitting of highly activated or highly contaminated systems



- ▶ **Determination of local dose rate**
- ▶ **Planning of shielding incl. shielding calculations**
- ▶ **other RP measures**
- ▶ **Planning of survey**
- ▶ **Scheduling**
 - ◆ **labor time scheduling**
 - ◆ **employment of staff**
 - ◆ **tools, especially remote controlled tool**
- ▶ **Optimization of labor und RP measures**

Radiation protection planning for decommissioning / back fitting of highly activated or highly contaminated systems



AREVA NP has performed

- ▶ **More than 10 plant SG replacements**
- ▶ **More than 3 plant RPV nozzle exchanges**
- ▶ **Dismantling of RPV and RPV internals**

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Example:

**Calculations for dismantling
and packaging of RPV parts**

Example: Calculations for dismantling and packaging of RPV parts

Motivation:

- ▶ Handling of cut segments (shielding, distance, time)
- ▶ Container type / disposition
- ▶ Minimization of number of containers
- ▶ Limits for activity inventories and dose rates due to repository conditions

Actions:

- ▶ Calculation of nuclide specific activity inventories of cut segments und filled containers
- ▶ Calculation of local dose rates at work shops for handling these segments
- ▶ Calculation of local dose rates outside container
- ▶ co-operation with cut planning and packaging to optimize filling of containers (minimization of number of containers)
- ▶ Documentation: Planning, measurement schedule, check lists

Example: Calculations for dismantling and packaging of RPV parts

▶ Reactor pressure vessel (RPV), example

◆ Flange

- Base material: 417 mm
- Cladding: 8 mm

◆ Cylinder

- Base material: 130 mm
- Cladding: 8 mm

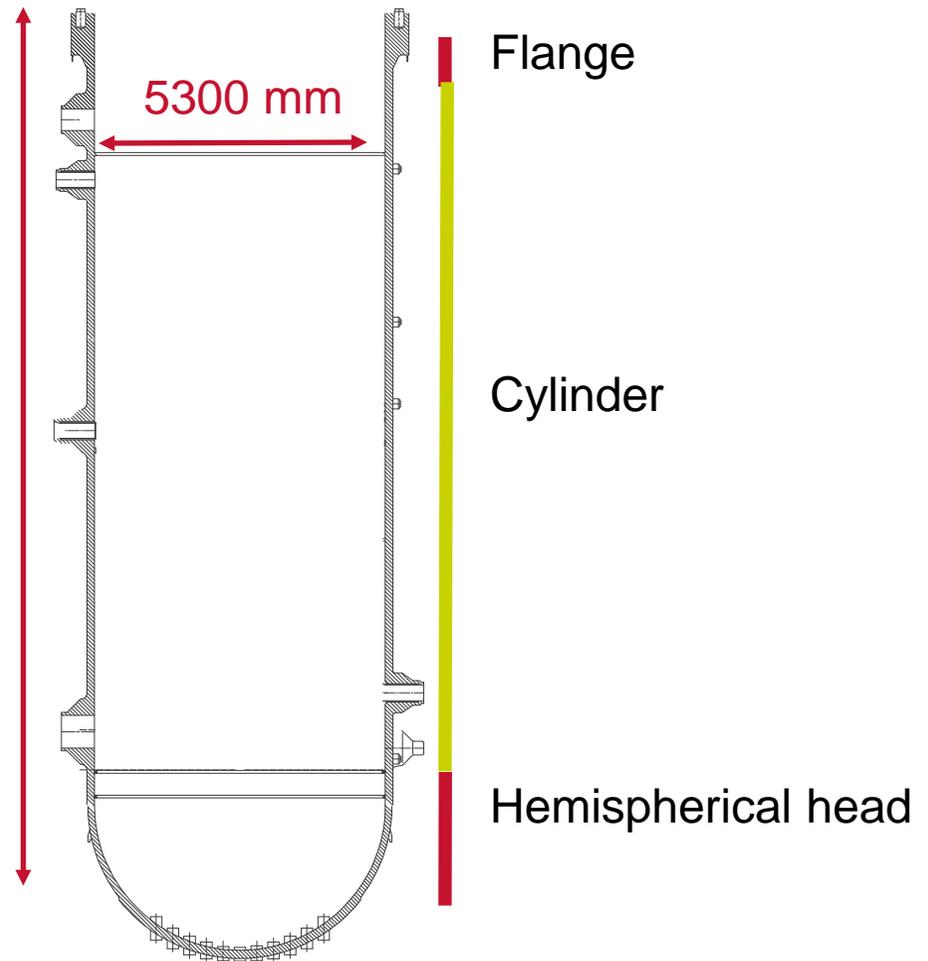
◆ Hemispherical head

- Base material: 120 mm
- Cladding: 8 mm

◆ Base material: ferritic steel

◆ Cladding: austenitic steel

17300 mm



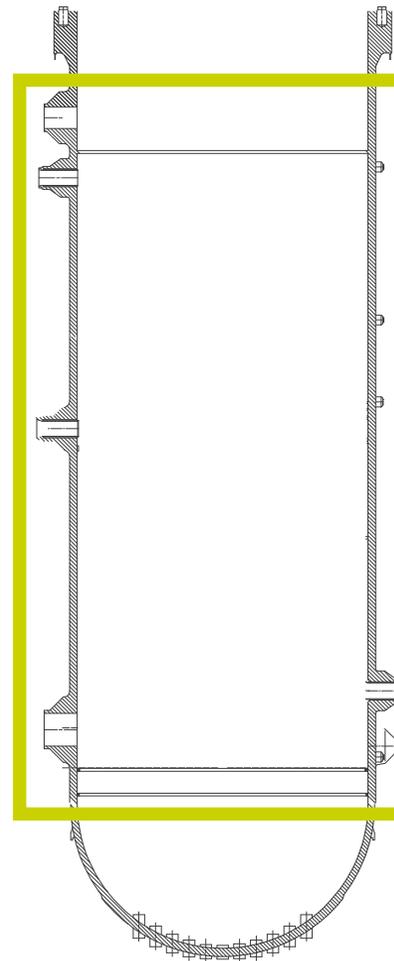
Example: Calculations for dismantling and packaging of RPV parts

▶ Main dismantling methods

- ◆ Cut with band saw
- ◆ Water abrasive suspension cutting process

▶ Final storage of cut segments

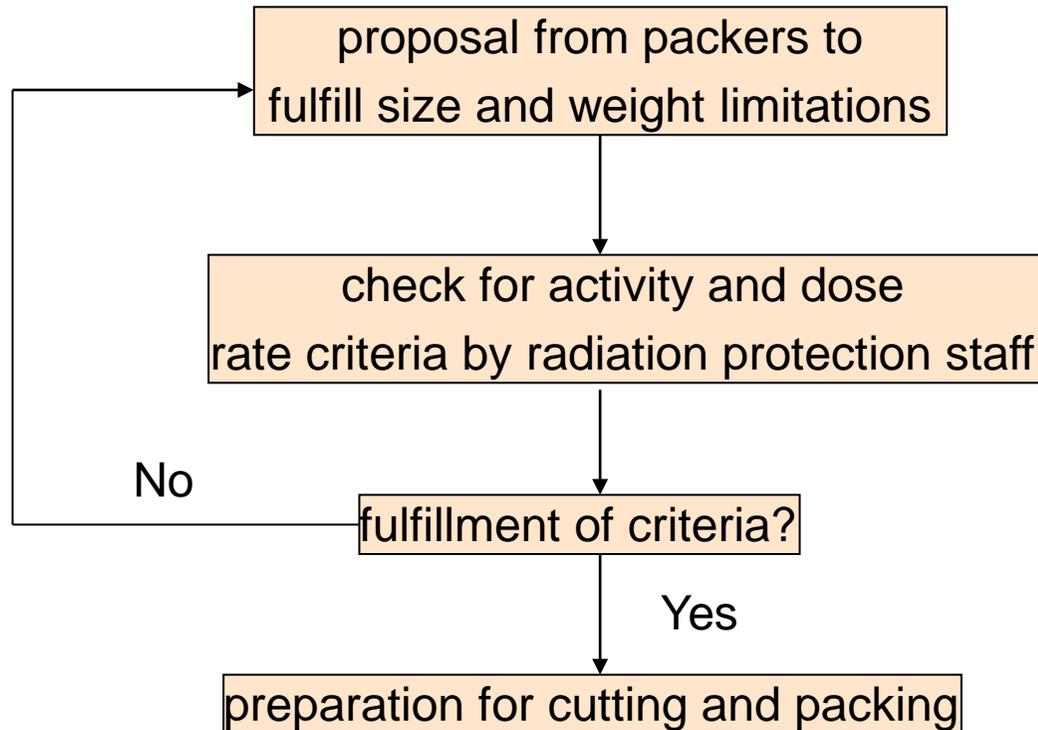
- ◆ Containers on-site
- ◆ Limits for Containers
 - Total mass
 - Total activity (depending on type of Container)
 - Dose rate (contact, 2 m distance)



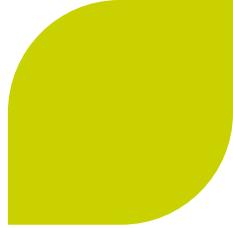
Cylindrical part

Example: Calculations for dismantling and packaging of RPV parts

Illustration of the iterative procedure for the packing

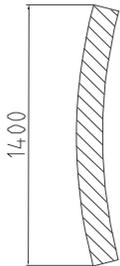
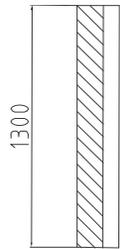


Example: Calculations for dismantling and packaging of RPV parts



Cut pieces (examples)

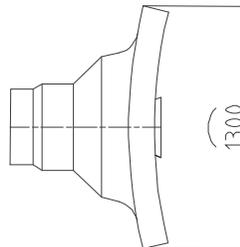
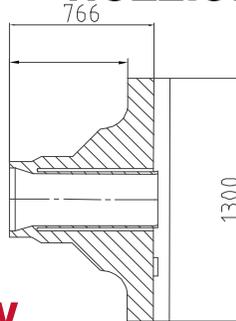
cylinder segment:



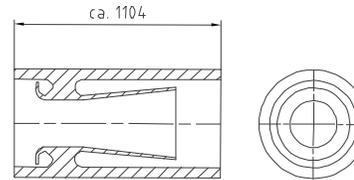
side view

top view

nozzle:



nozzle pipe:



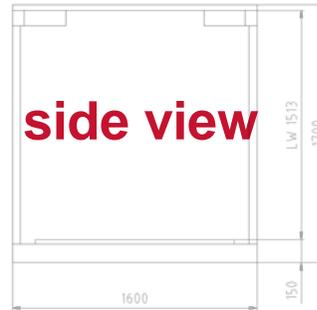
side view

Example: Calculations for dismantling and packaging of RPV parts

Dose rates and activity limits

KC Type II

KC Type III



Filling material:

Rubble

Concrete

Rubble

▶ Total activity

Ref. nuclide Co-60

defined limit

defined limit

defined limit

▶ Dose rate (contact)

2000 $\mu\text{Sv/h}$

2000 $\mu\text{Sv/h}$

2000 $\mu\text{Sv/h}$

▶ Dose rate (2 m)

100 $\mu\text{Sv/h}$

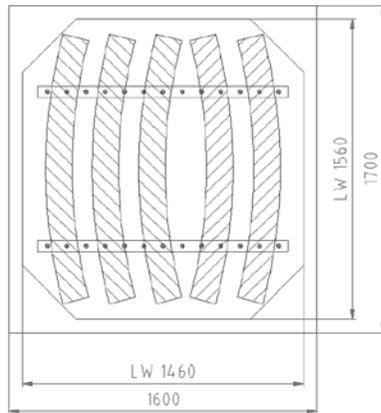
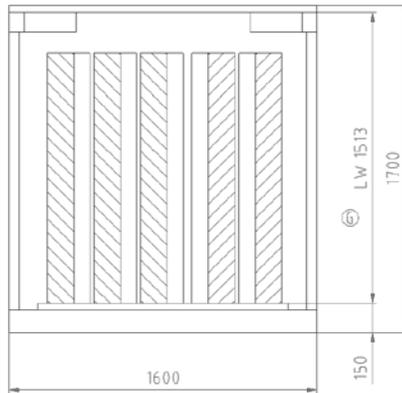
100 $\mu\text{Sv/h}$

100 $\mu\text{Sv/h}$

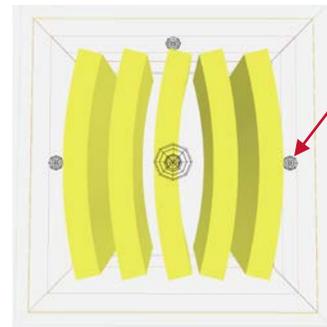
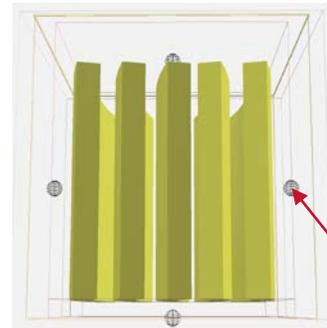
Example: Calculations for dismantling and packaging of RPV parts

Container with cut segments

Packing concept



Model



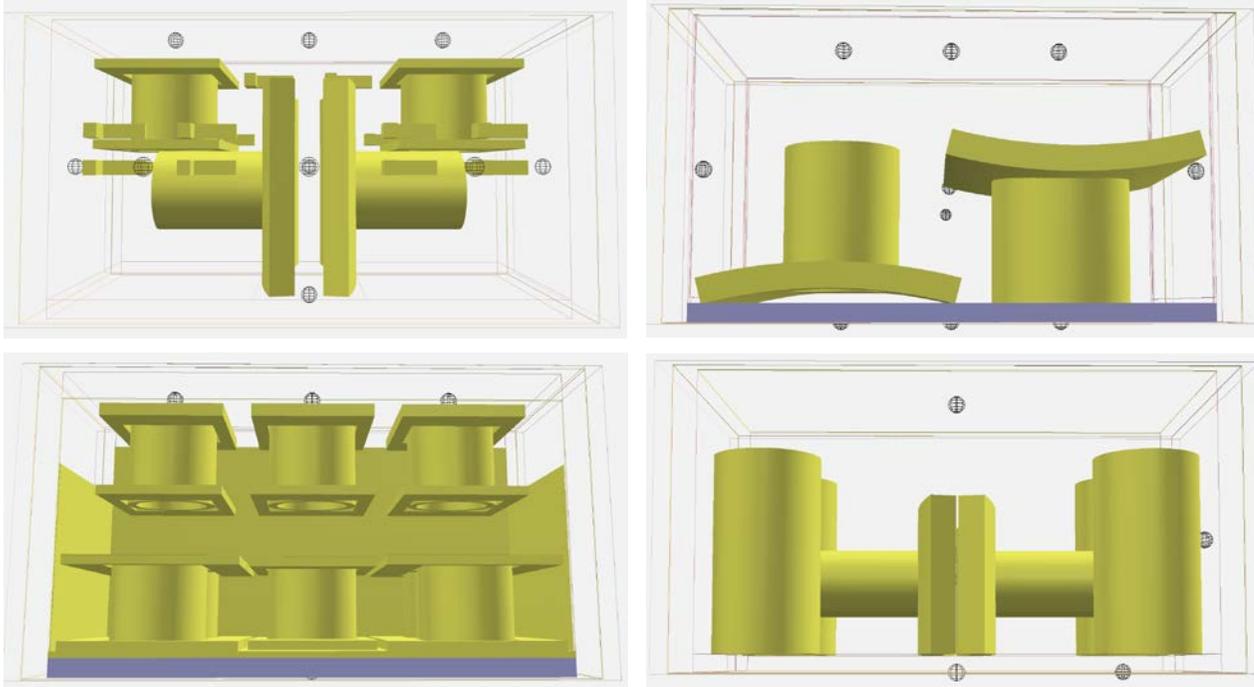
side view

top view

Dose points at centre of all faces (in contact with the outer surface and 2 m away from the KC)

Example: Calculations for dismantling and packaging of RPV parts

► Overview of more complicated loading



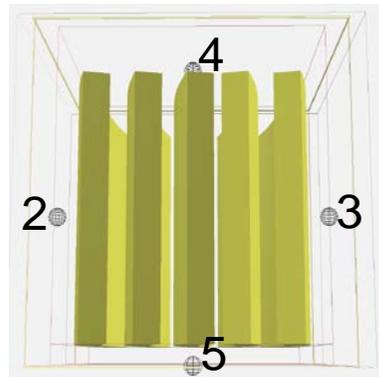
- In total 26 different models were developed for all cut segments which had to be packed.
- The radiological quantities of all final packages are below limits.

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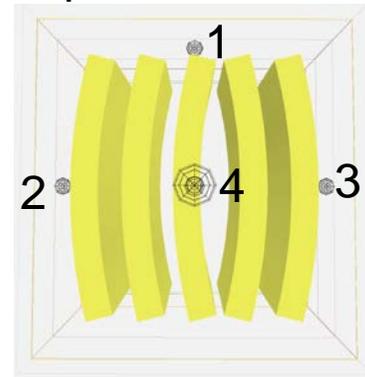
Example: Calculations for dismantling and packaging of RPV parts

Example:

Side view



Top view



example values

	Dose point 1		Dose point 2		Dose point 3		Dose point 4		Dose point 5	
	contact	2m								
	μSv/h	μSv/h								
calculated	386	16	9	1	9	1	253	37	437	63
measured *	200	10	5	<1	5	<1	270	28	410	30
calc./meas.	1,9	1,6	1,8	1,0	1,8	1,0	0,9	1,3	1,1	2,1

Measurements confirm calculation results!

Conclusion

Conclusion

- ▶ **RP of great importance for back fitting / decommissioning**
- ▶ **AREVA has performed comprehensive tasks for back fitting / decommissioning**
- ▶ **Example for RPV has been given**
- ▶ **Radiological assessment demonstrated the compliance of final packages with storage requirements**
- ▶ **Measurements confirm calculation results**
- ▶ **Radiological assessment is an important contribution to the minimization of the number of containers**



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End of Presentation

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