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AREVA Experience in Dismantling of the Primary Circuit

ENKO 2014

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Dismantling of Primary Circuit Components Content

- Introduction of AREVA
- Optimized Primary Circuit Dismantling
- Competencies
- Project References
  - Boiling Water Reactor (Wuergassen RPV and Internals)
  - Pressurized Water Reactor (Stade RPV Internals)
- Summary

Our operating organization

Supervisory Board

Executive Board

Mining BG

Front End BG

Reactors & Services BG

Back End BG

Renewable Energies BG

Engineering & Projects

International Commercial Organization

Functional Departments

Regional Departments (Germany and North America)

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Positioned as a leader in the back end of the cycle

Recycling

More than 75% of the global treatment market

D&D

Center of Competencies for D&D of NPP in Germany

Cleanup

Active at all nuclear sites in France

Logistics

No. 1 in nuclear transportation worldwide and No. 1 in SNF dry storage

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Introduction
AREVA's Business Unit D&D

BU current footprint

- ***Nuclear site reutilization projects worldwide***
  France, US (DOE), UK (Sellafield), Japan (Fukushima), Germany
- ***1,400 employees, at 10 locations***
- ***400 MEUR revenue / year***
- ***D&D Competence Center at AREVA Germany***
  - *Assistance during post-closure phase / deregulation*
  - *D&D engineering services and licensing support*
  - *Project and site management*
  - *Efficient decontamination (full-systems, components and equipment)*
  - *Radiological characterization and nuclear measurement*
  - *Disassembling, handling and packaging of highly activated components*
  - *Spent fuel and radioactive waste management*

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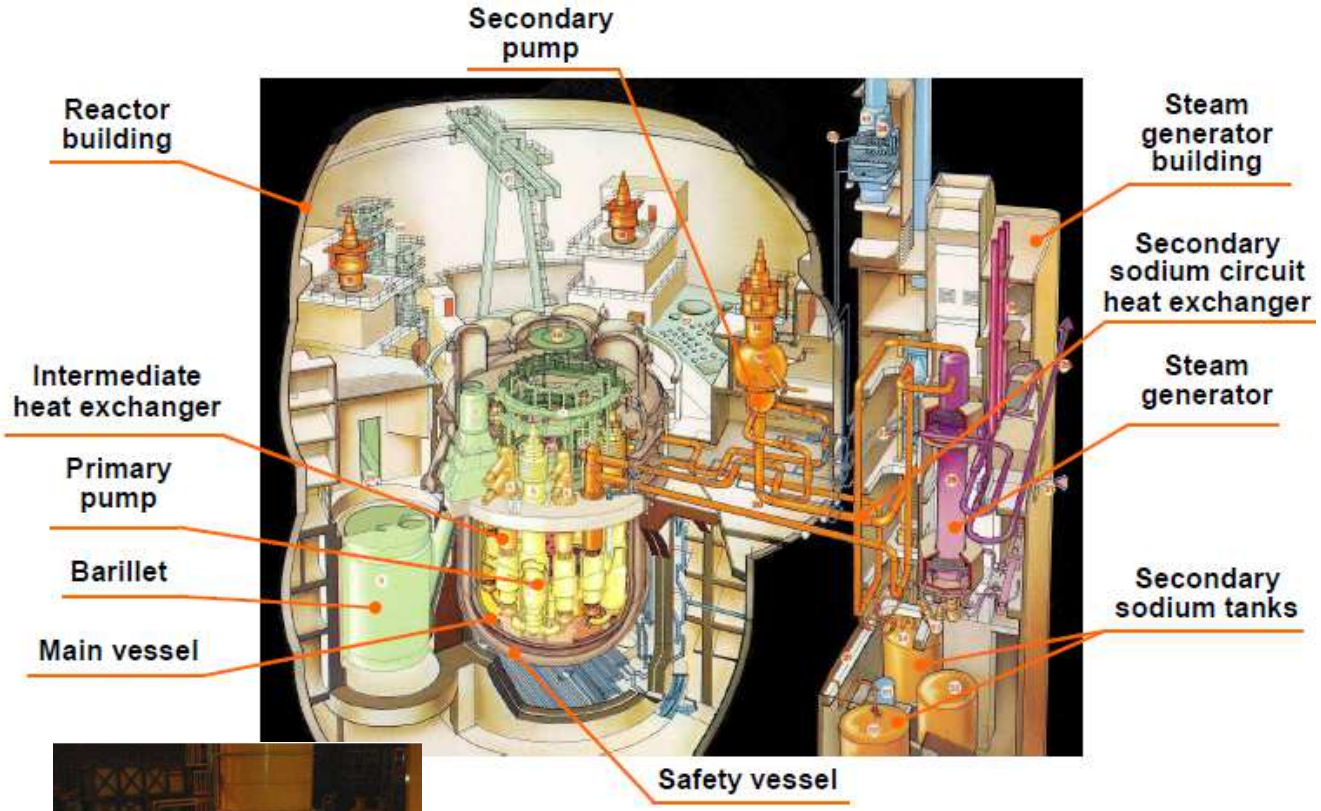
Superphenix Reactor D&D



- **Engineering and licensing support**
- **Procurement, erection, commissioning and operations**
- **Core unloading, fuel handling and storage**
- **Sodium draining, removal, neutralization, conditioning and storage**
- **Decontamination**
- **Large components removal, segmentation and packaging**

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Processes and Lessons Learned

- Plants of the fuel cycle-

Challange

***Marcoule*: Dismantling of a military reprocessing plant**

- Lifetime 40 years
- 1,000 plants to clean up
- 30,000 tons waste, where of 2% high level waste

***Cadarache*: Dismantling of a MOX fabrication plant**

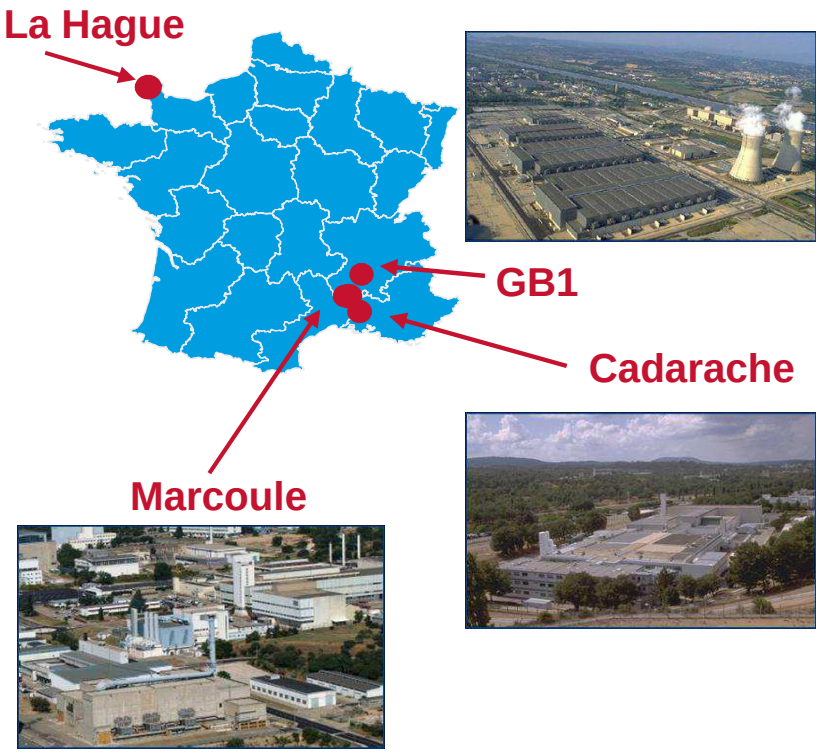
- Lifetime 2007 to 2013
- > 400 glove boxes, ca. 40 casks
- 600,000 working hours

***La Hague*: Dismantling of a civil reprocessing plant**

- Dismantling and waste recycling combined
- 32,000 m3 waste to clean up
- 6,000,000 working hours

***GB1*: Dismantling of an enrichment plant**

- ca. 150-200 kilo tons, α-contaminated
- D&D start 2015



» *On-site* management (operational *safety, health physics, environment protection, Process organization…) as one of the essential challenges*

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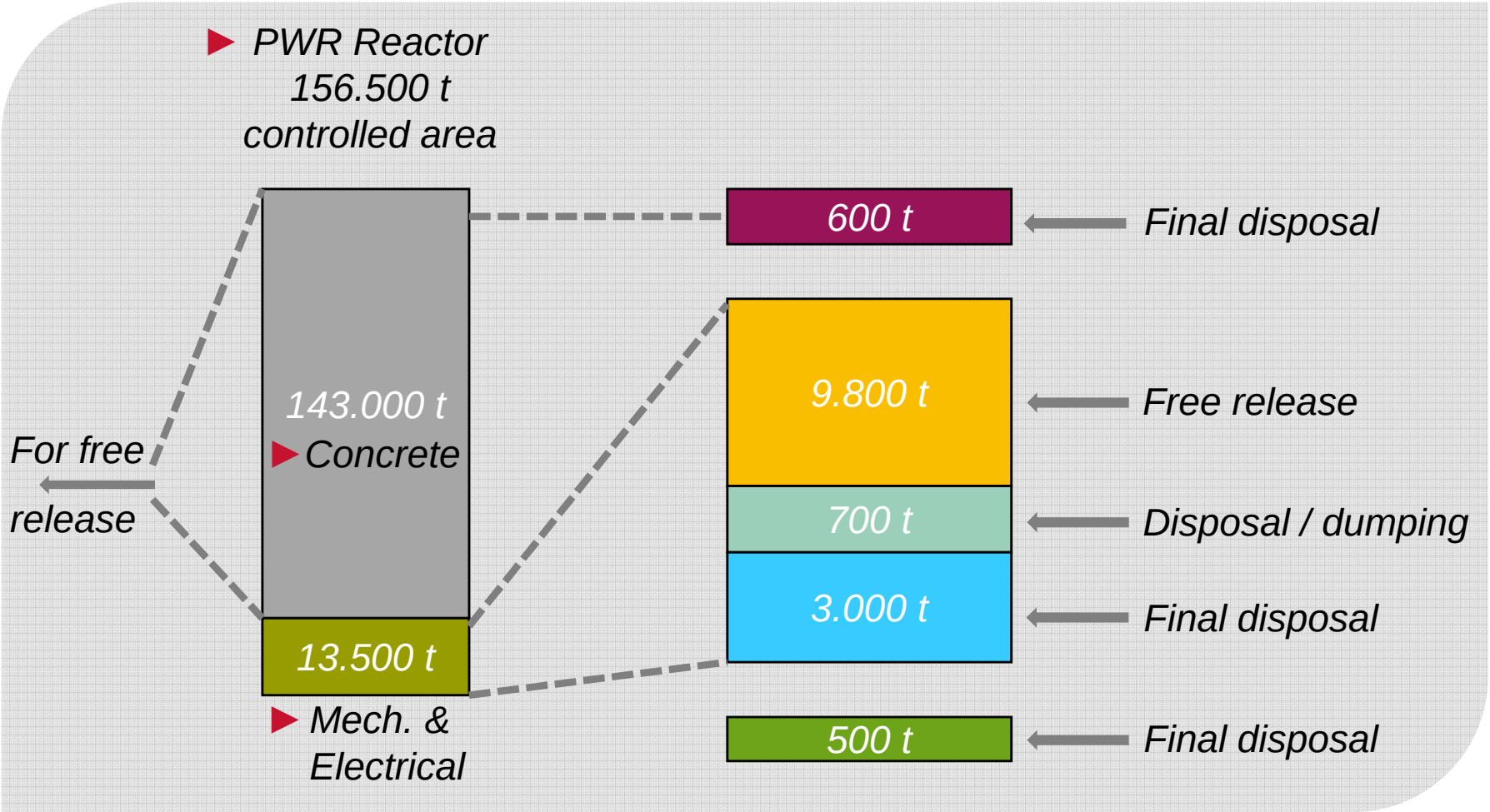
Quantities of waste with the corresponding breakdown



Approx. 2% of the total waste of the controlled area has to be permanently disposed

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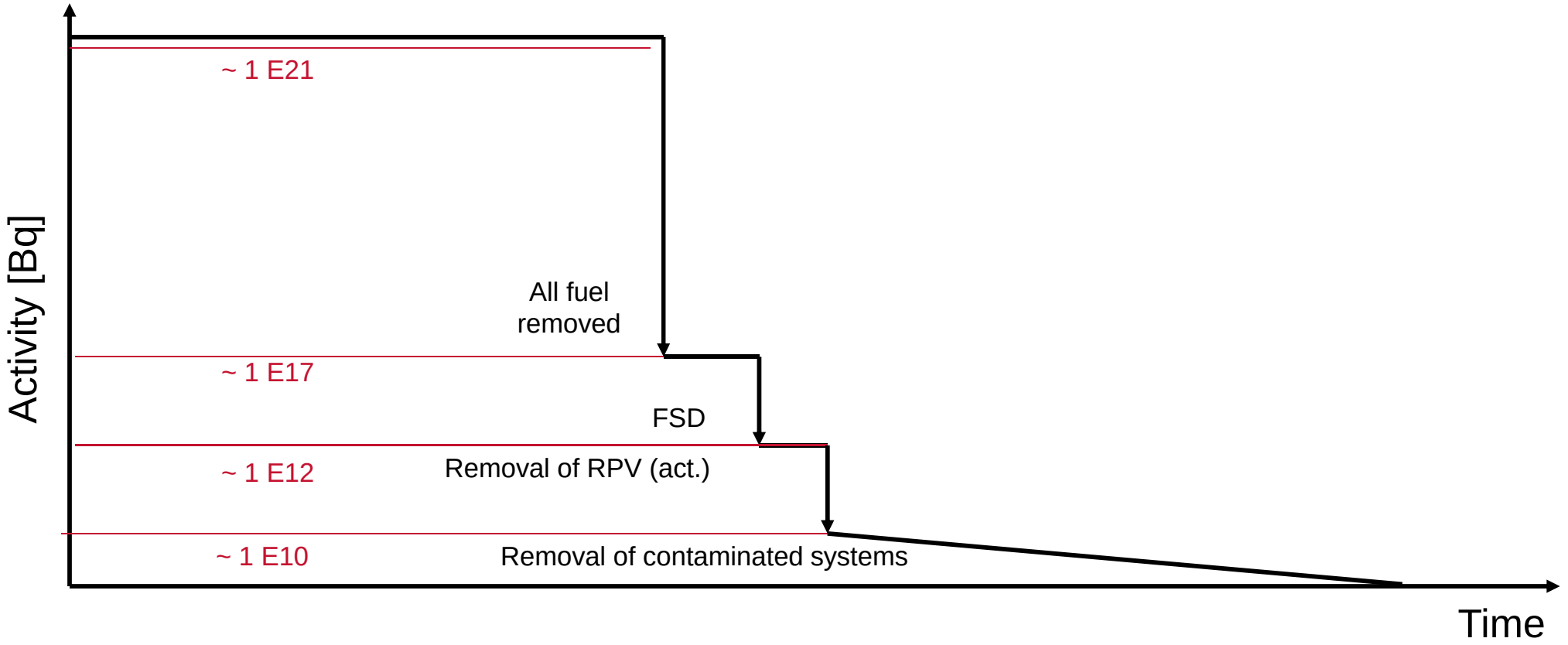
AREVA Decommissioning Approach for an optimized D&D Concept

- From "Hot" to "Cold" → fastest possible reduction of the radiological inventory



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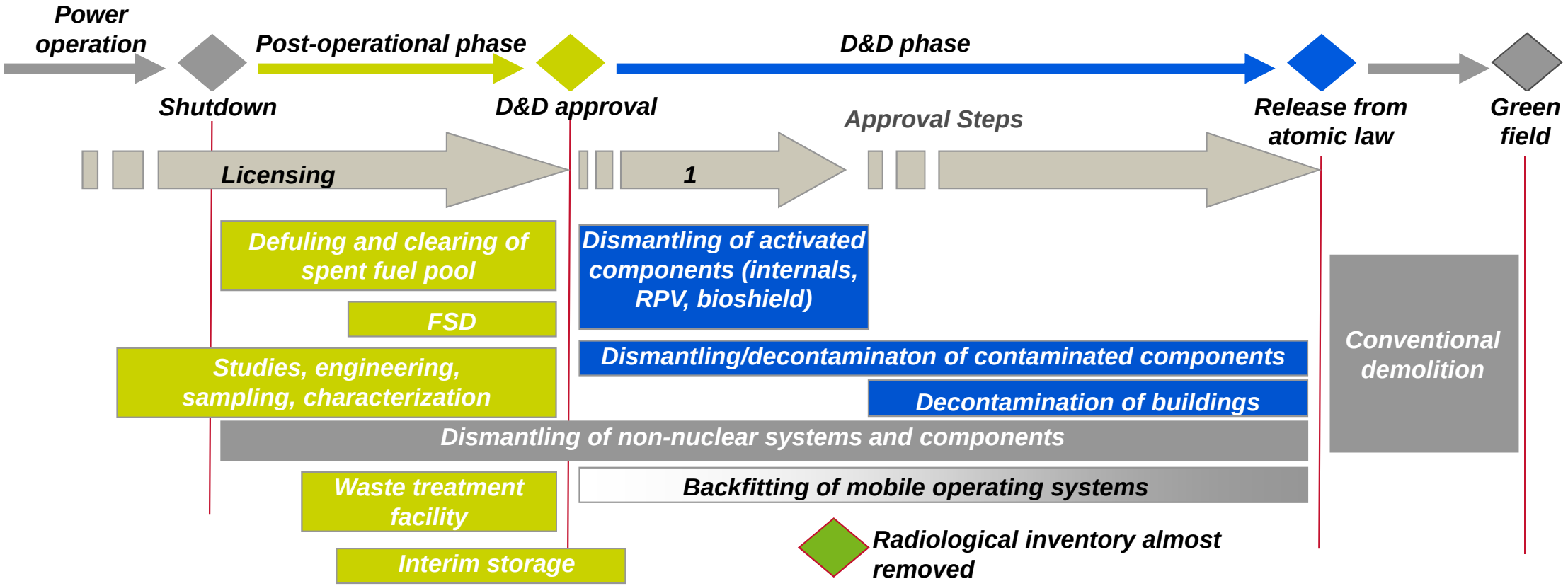
Optimized Primary Circuit Dismantling Optimized Sequence



- From „Hot“ to „Cold“ → early removal of radiological inventory
- Installation mobile operating systems → faster clearing possible
- Awarding of overall work packages → Optimization of interfaces and usage of synergie effects

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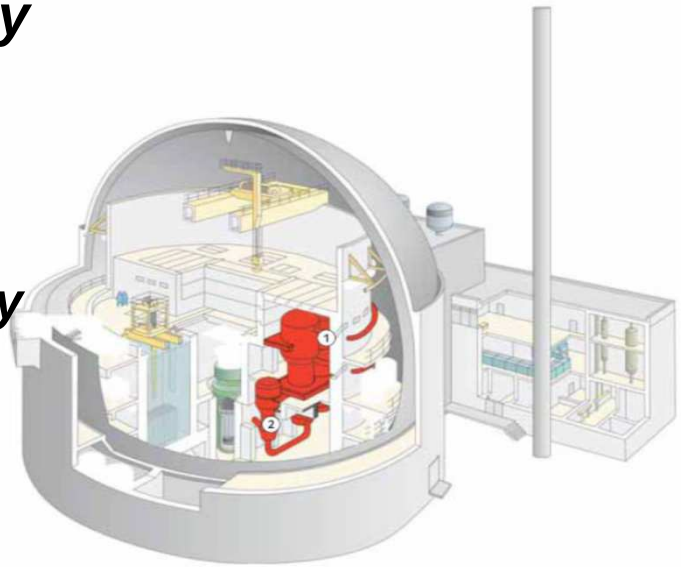
Optimized Primary Circuit Dismantling Hot to Cold

- *Dose rates on-site for subsequent lots reduced significantly*
- *Potential for radioactive release reduced significantly*
- *Early back fitting of mobile operating systems possible*
  - *Power supply with less stringent requirements*
  - *Aerosol monitoring / ventilation simplified significantly*
  - *Fire protection measures reduced and adapted to the dismantling activities*
  - *Waste water treatment simplified*
- *Supervisory procedure simplified*
- *Use of industry standards (instead of KTA-rules possible)*



Nearly 100% of the radiological inventory removed early.
Significant simplification of further dismantling steps.

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Optimized Primary Circuit Dismantling Hot to Cold

Target: Fast reduction of the hazardous potential of the NPP – actually factor 100 Billion by 3 main measures.

factor 10.000

factor 100.000

factor 100

Plant shut down	*Fuel unloaded*	*Full System Decont. performed*	*Activated inventory dismantled*
~ 1 E21	*~ 1 E17*	*~ 1 E12*	*~ 1 E10*

Activity inventory of a NPP [Becquerel]

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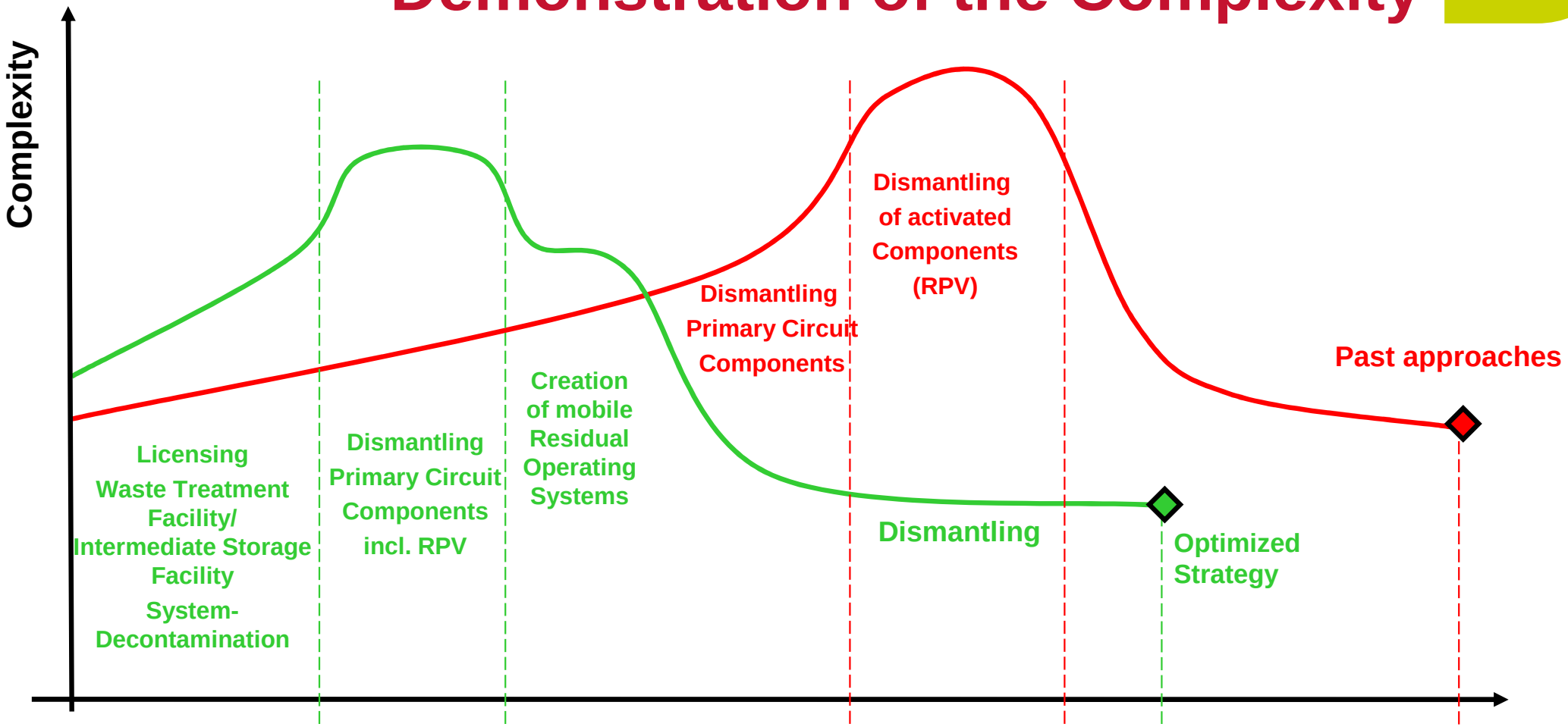
Phases of Decommissioning
Demonstration of the Complexity



Note: Equivalent effort for licensing, planning and engineering before execution.

Savings of overall costs by reduced time line & riskless phase out

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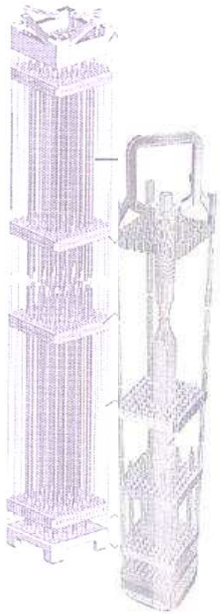
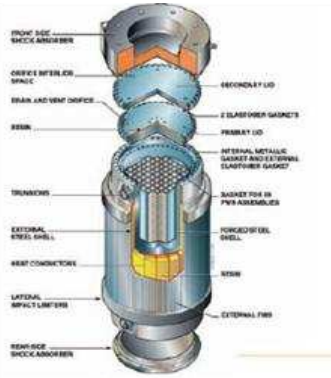
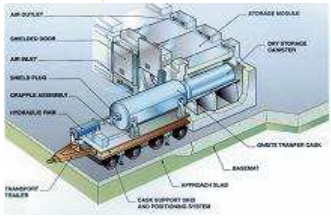
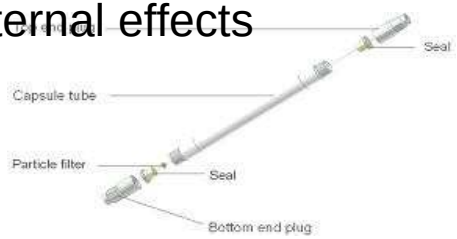
Competencies in Fuel Handling

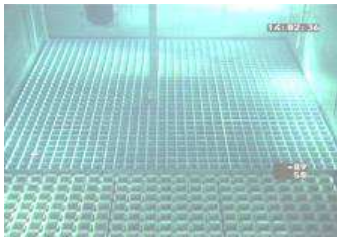
- **As a lead manufacturer familiar with all requirements of a safe handling and storage**
  - Analysis of fuel rod integrity under given storage conditions
  - Studies and investigations about the fuel element characteristics under long term storage conditions
- **Design, manufacturing and operation of facilities for the storage and treatment of spent fuel elements**
  - Casks for transport and dry storage (TN24E)
  - Modular Dry Storage (NUHOMS)
  - Compact storage frame, Absorber Cartridge
  - Wet storage with passive cooling and protection against external effects
- **Service of fuel elements**
  - Fuel element inspection and repair
  - Encapsulation of defect fuel elements
- **Conditioning of used core internals**
  - Neutron source
  - Control rods, Instrumentation lance, Fuel element- components











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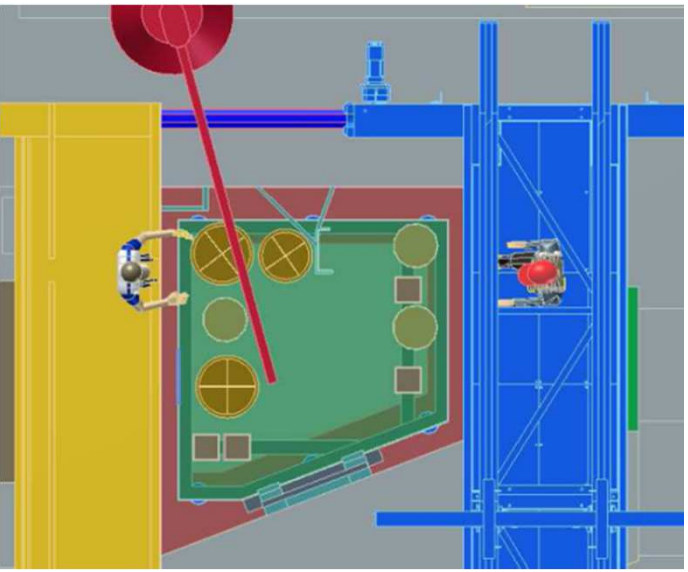
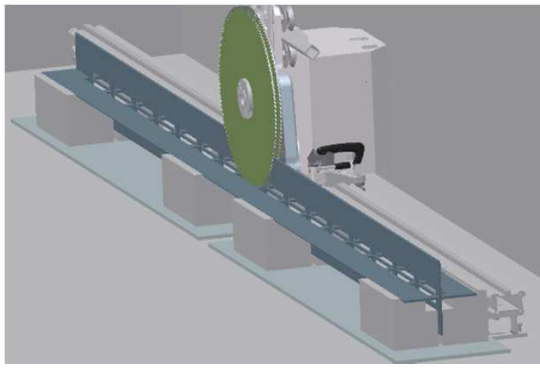
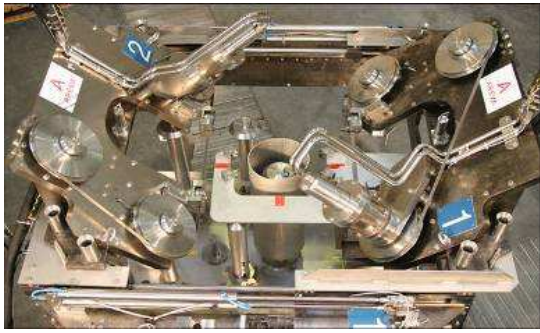
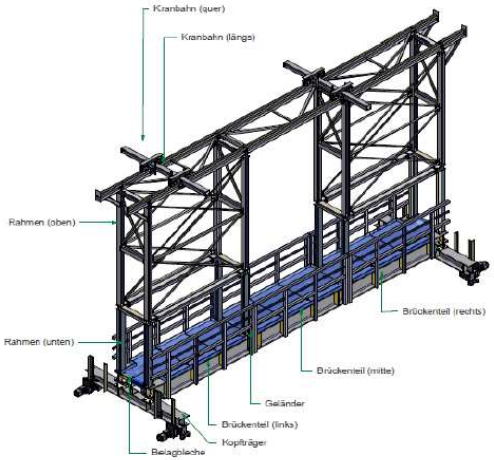
Competencies
Core Waste Processing in Spent Fuel Pool

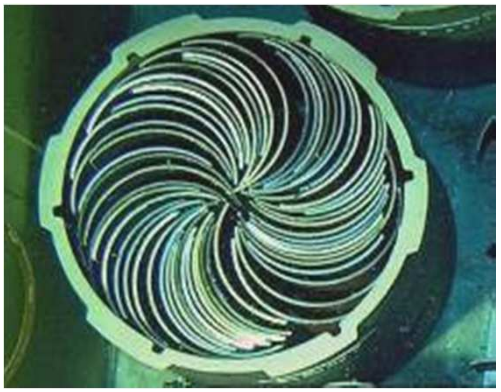


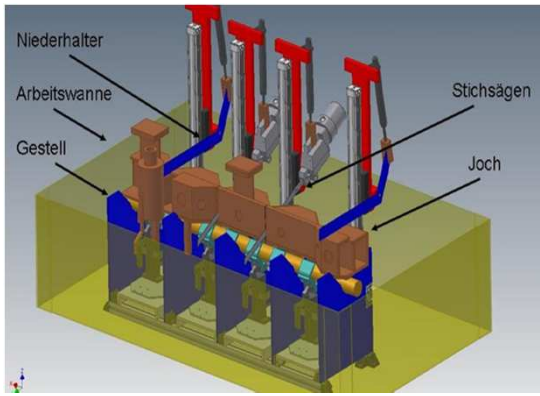
- ***Cutting, Processing & Packing***
  - ***Control assembly***
  - ***Fuel element channel***
  - ***Control rod guide tube***
  - ***T-bolt***
  - ***Core instrumentation detector with yoke and shaft***
  - ***Drive rod***
  - ***Filter etc.***











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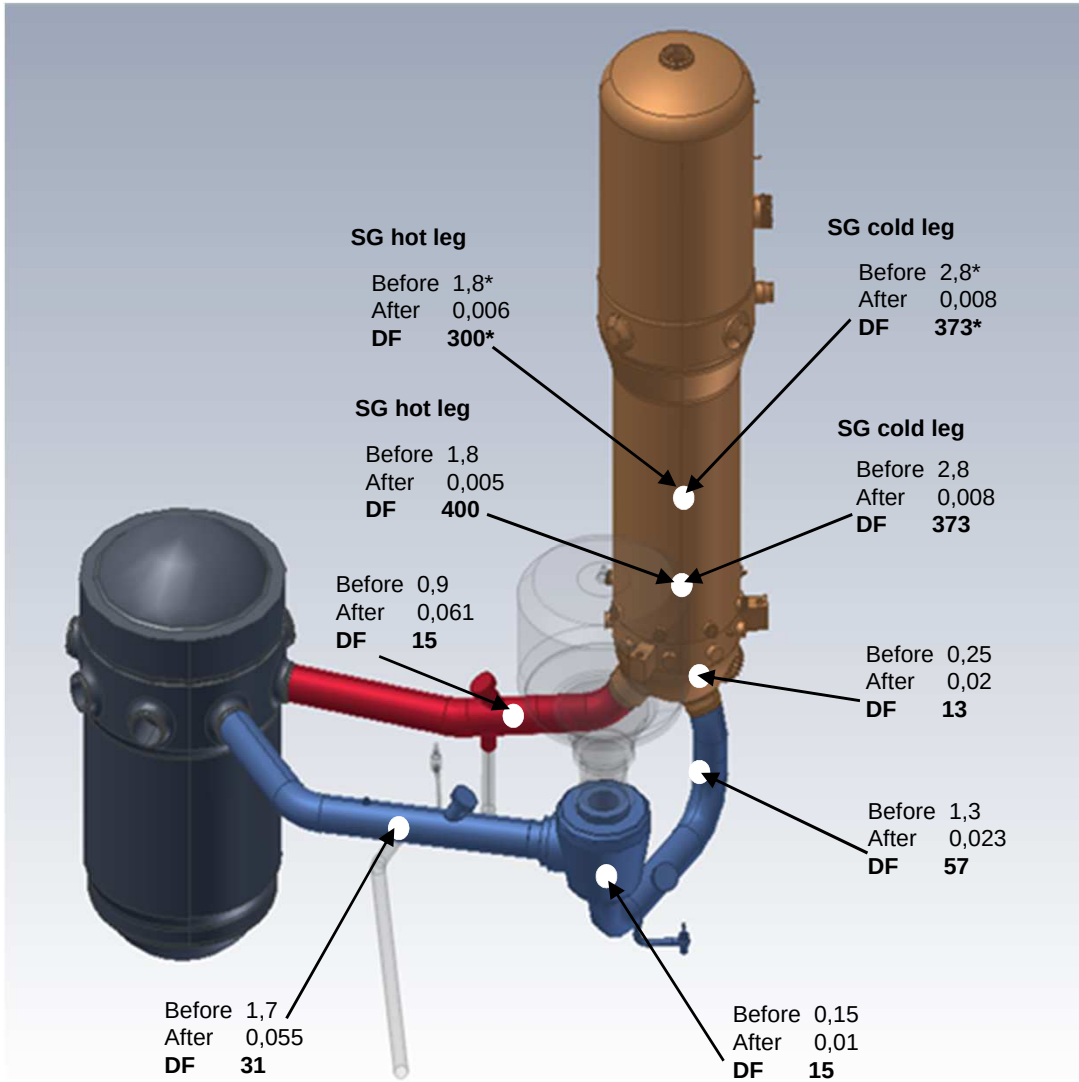
Competencies
Full System Decontamination

Benefits

- Reduction of personnel radiation exposure due to dose rate reduction
- Flexibility of D&D concept
- Facilitation of dismantling activities
- Reduction of overall radwaste volume during decommissioning

Recommendation to perform the FSD directly after shutdown

- All plant systems are fully operational
- Personnel with plant experience is on site
- Earlier benefits from dose reduction, leading to lower overall accumulated dose during Post operation and D&D



Note: All dose rates in mSv/h;
*dose rate estimated by KKS radiation protection

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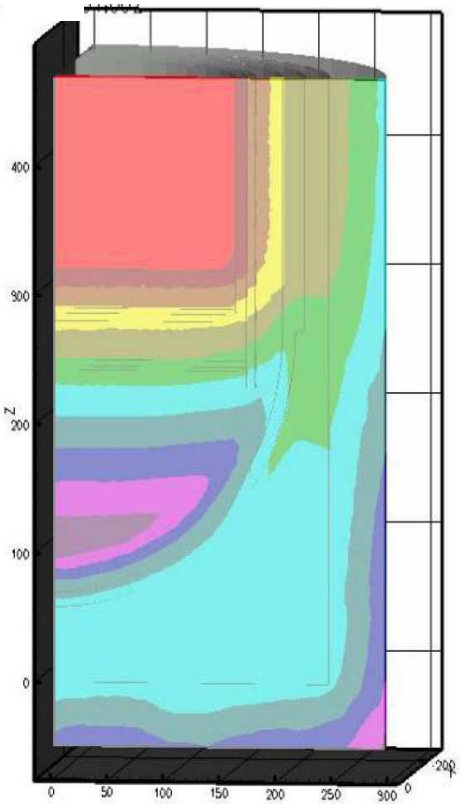
Competencies
Getting the Radiological Status

- Keyfactor for the Waste-Minimising:
  - Detailed knowledge about the radiological configuration of the components
- Combination of calculation and sampling
  - 3D-Activation-Calculation (specific activity and resulting dose rate
  - Additional sampling for verification
- The aim is an as much as possible realistic judgement of the technical and radiological required measures
  - Avoidance of conservative considerations
  - Optimization of the waste packing and conditioning concept by minimizing the need of waste drums
  - Reducing the total dose rate (ALARA) of involved workers
  - More precise documentation for disposal application



Beispiel eines 3D-Aktivierungs-modells (RDB und Bioschild)
Quelle: DSR

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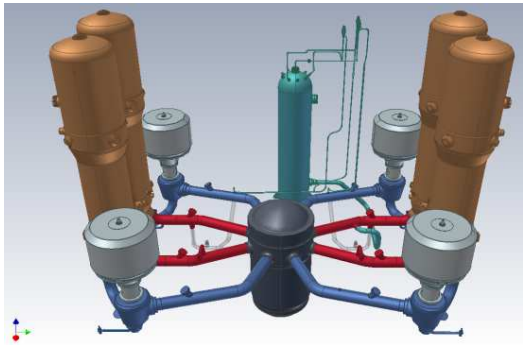
Competencies
Component Dismantling

- **Studies, Concept development, Engineering, Licensing**
- **Dismantling & Replacement of Primary Circuit Components (NSSS)**
  - **Reactor Pressure Vessel (RPV)**
  - **Reactor Internals**
  - **Primary pipes, Pressurizer, Pumps, Steam Generator**
  - **Core Waste Processing (cutting & packing)**
  - **Equipment Design & Manufacturing (tools, machinery, water purification…)**



Over 30 years experience in Replacement & Dismantling of Primary Circuit Components (NSSS)

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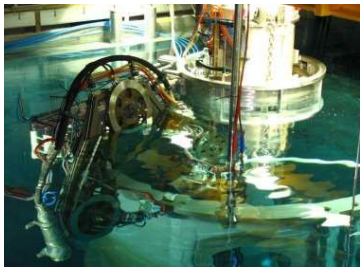
Competencies
Cutting Techniques and Equipment

Cold cutting processes

- Water jet cutting
- Sawing
- Milling
- Shearing
- Nibbling
- Unscrewing
- Grinding
- Drilling
- Wire sawing (rope, diamond)

Thermal cutting processes

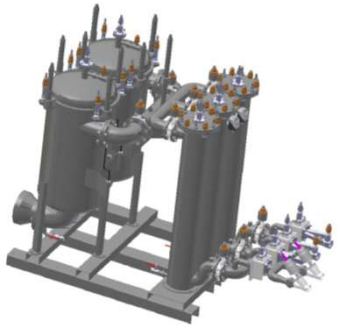
- Plasma cutting
- Torch cutting
- Powder flame cutting
- Laser cutting
- Oxygen lance
- Petrogen cutting (gasoline-oxygen)



- Electric discharge machining (EDM)
- Contact arc metal cutting (CAMC)

Specific Equipments

- Water Treatment System (mechanical filter / hydro cyclone)
- Cleaning Systems (high pressure water cleaning)
- Lifting devices, gripper, shears, press,



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Competencies
Waste Treatment Systems

- Waste water and waste treatment systems
  - Waste treatment concepts and studies
  - Supply of waste water and radwaste treatment systems
- Design of waste water treatment systems
  - Evaporation systems
  - Centrifugation systems
  - Filtration
- Design of liquid waste treatment systems
  - Drying systems
  - Cementation systems
  - Bituminization systems
- Equipment for solid waste treatment
  - Sorting boxes
  - In-drum compactors
  - Supercompactors
  - Balers
  - Shredders
  - Drying boxes

Drum Filling Station

Turn-key projects for:

- Hot Laundry
- Hot Workshops
- Decontamination Workshops
- HVAC systems

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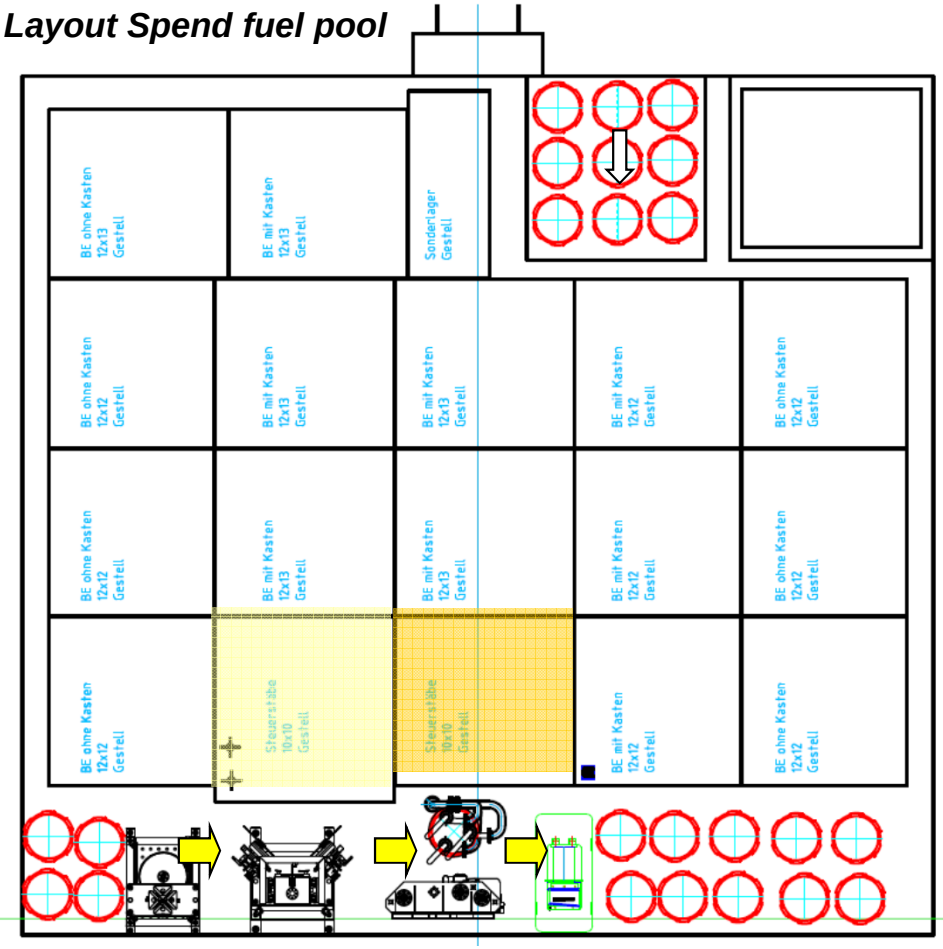
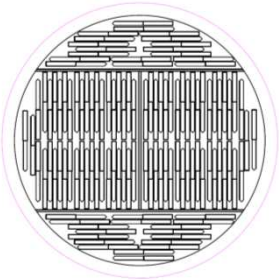
Project Reference
Core Waste Processing in Spent Fuel Pool

▶ *Dismantling of Control Rods NPP Isar 1*

Layout Spend fuel pool



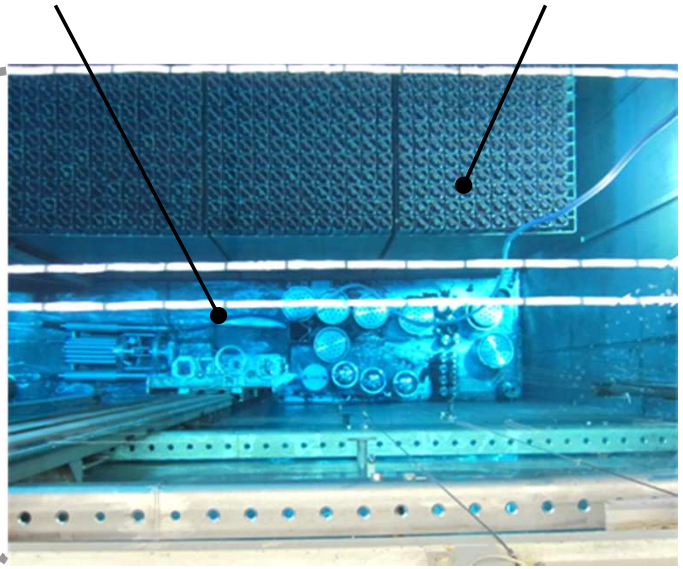
Packing Plan of Mosaik casks

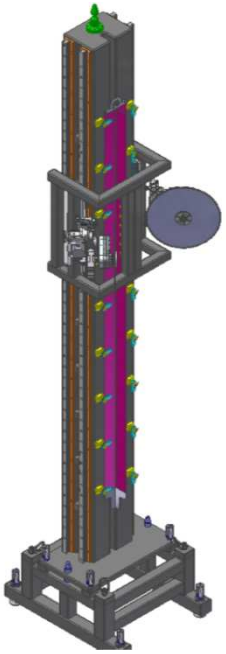


Sawing device

Spent fuel

Working area





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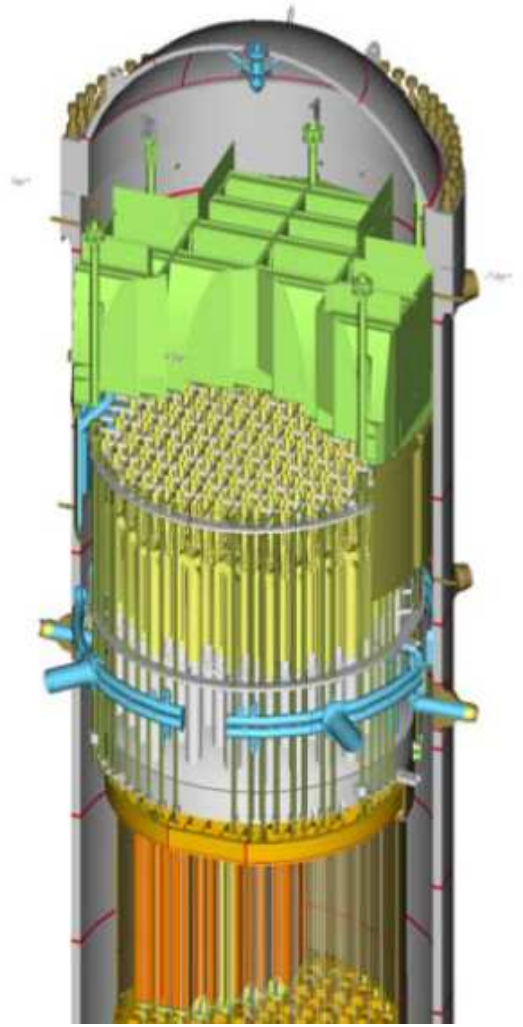
Project Reference: Wuergassen NPP (BWR) Dismantling of RPV Internals and RPV

Würgassen NPP (BWR, 670 MWe)



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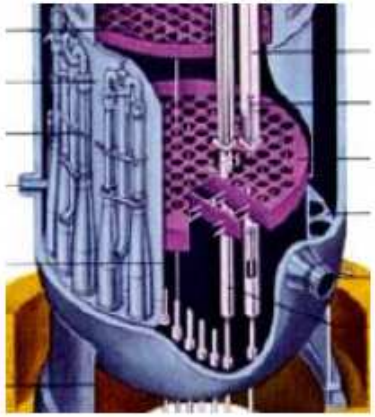
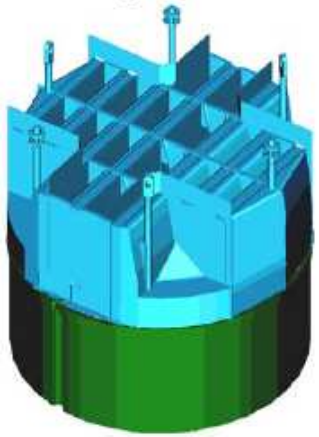
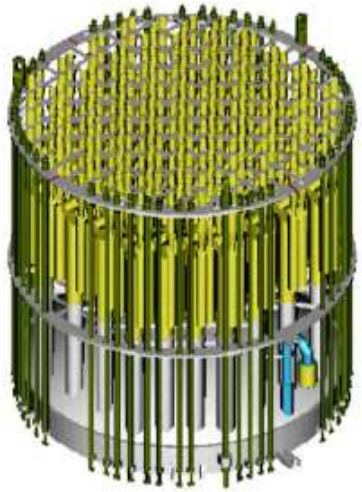
Project Reference: Wuergassen NPP (BWR)
Dismantling of RPV Internals



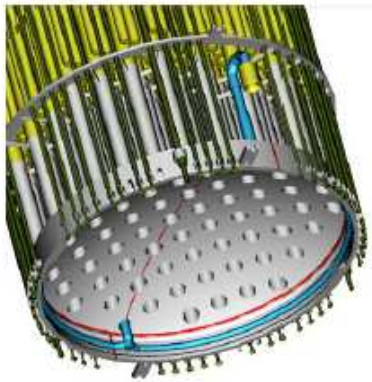
Jet Pumps & CRGT



Steam Dryer
(Scope NIS: wire sawing after concrete filling)



Steam-Water-Separator with T-Bolts



Project	Year
Contract for dismantling control rod guide tubes and jet pumps	11/2003
Successfully completed	12/2004
Contract for dismantling T-bolts of steam-water-separator	05/2004
Successfully completed	01/2005
Contract for dismantling the cyclones of steam-water-separator	10/2005
Successfully completed	11/2006
Contract for dismantling the remaining internals (core cover, upper core grid, lower core grid, core shroud, feed water sparger, jet pumps, etc)	04/2006
Successfully completed (TP91 phase 1 and 2)	11/2008
Contract for dismantling the reactor pressure vessel (cylindrical part)	02/2008
Successfully completed	02/2010

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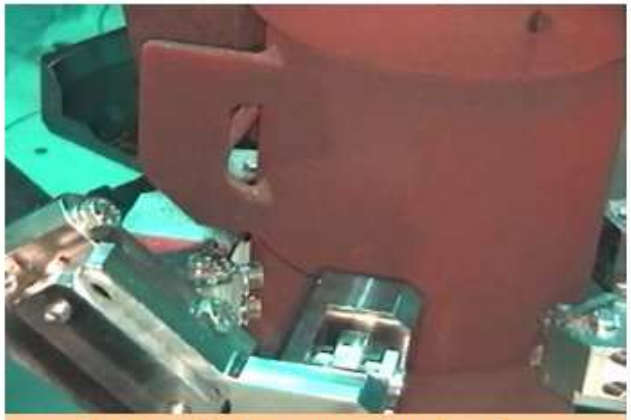
Project Reference: Wuergassen NPP (BWR) CRGT and Jet Pumps

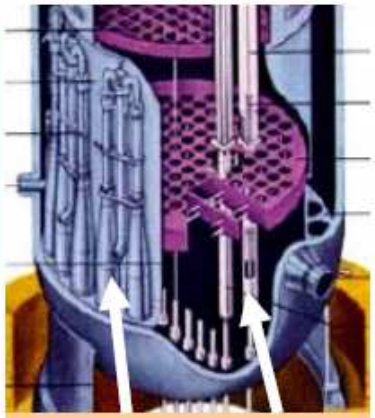


Cut through a jet pump using a band saw

Loaded primary cask

- On-site activities: 09 – 12/2004
- Cut mass: 22 tons
- 110 CRGT (L=410 cm, D=27 cm)
- 18 jet pumps (L=320 cm, D=19 cm)

Nibbling of cut tubes



Jet pumps and CRGT

- Remote handled cutting under water in spent fuel pool
- Pulling-out and pre-cutting by band saw
- Final cutting by nibbling and packing into primary cask
- Drying of casks and inserting into 200l-drums

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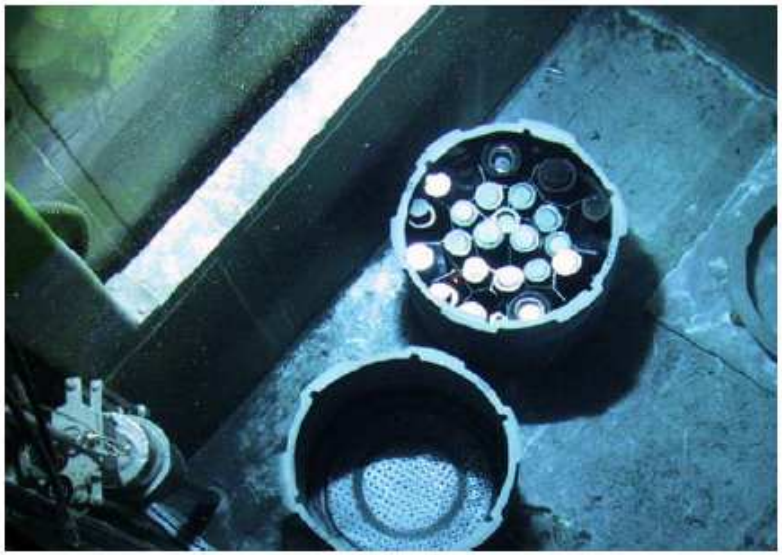
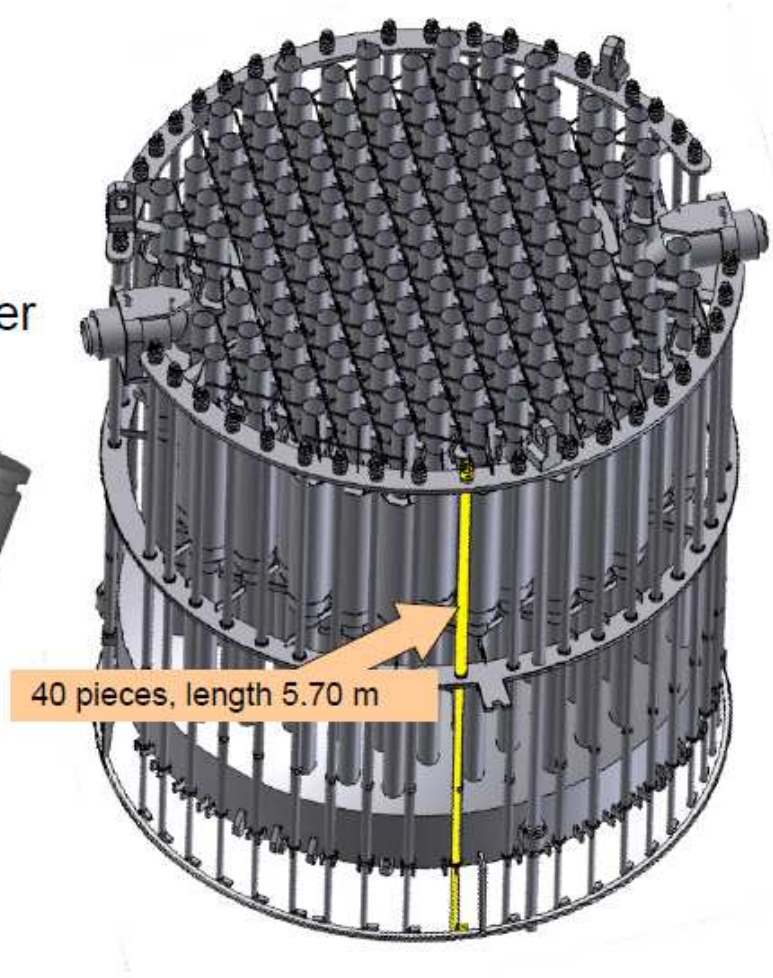
Project Reference: Wuergassen NPP (BWR) T-Bolts

- **40 T-bolts**
  - Total mass: 8 tons
  - Separating from steam-water-separator
  - Cutting of T-bolts using a band saw
  - Packing of cut parts into primary cask and after drying into 200l-drums





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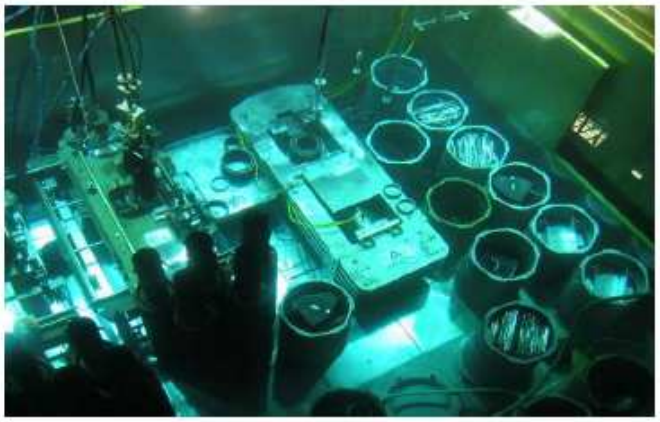
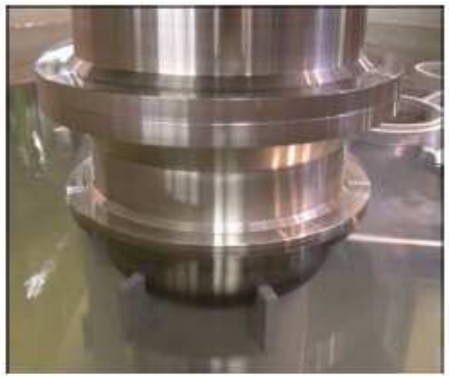
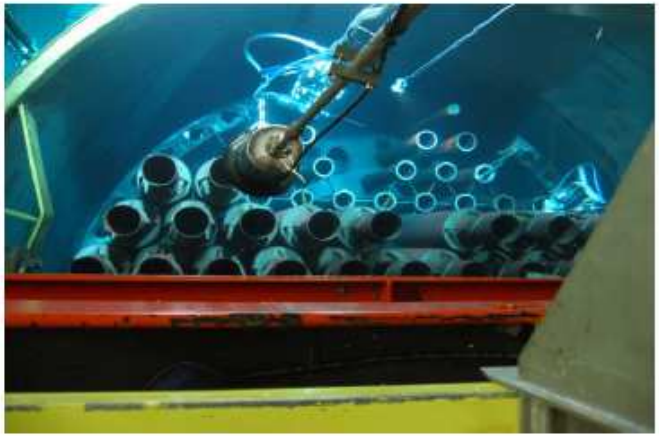
Project Reference: Wuergassen NPP (BWR) Steam-Water-Separator







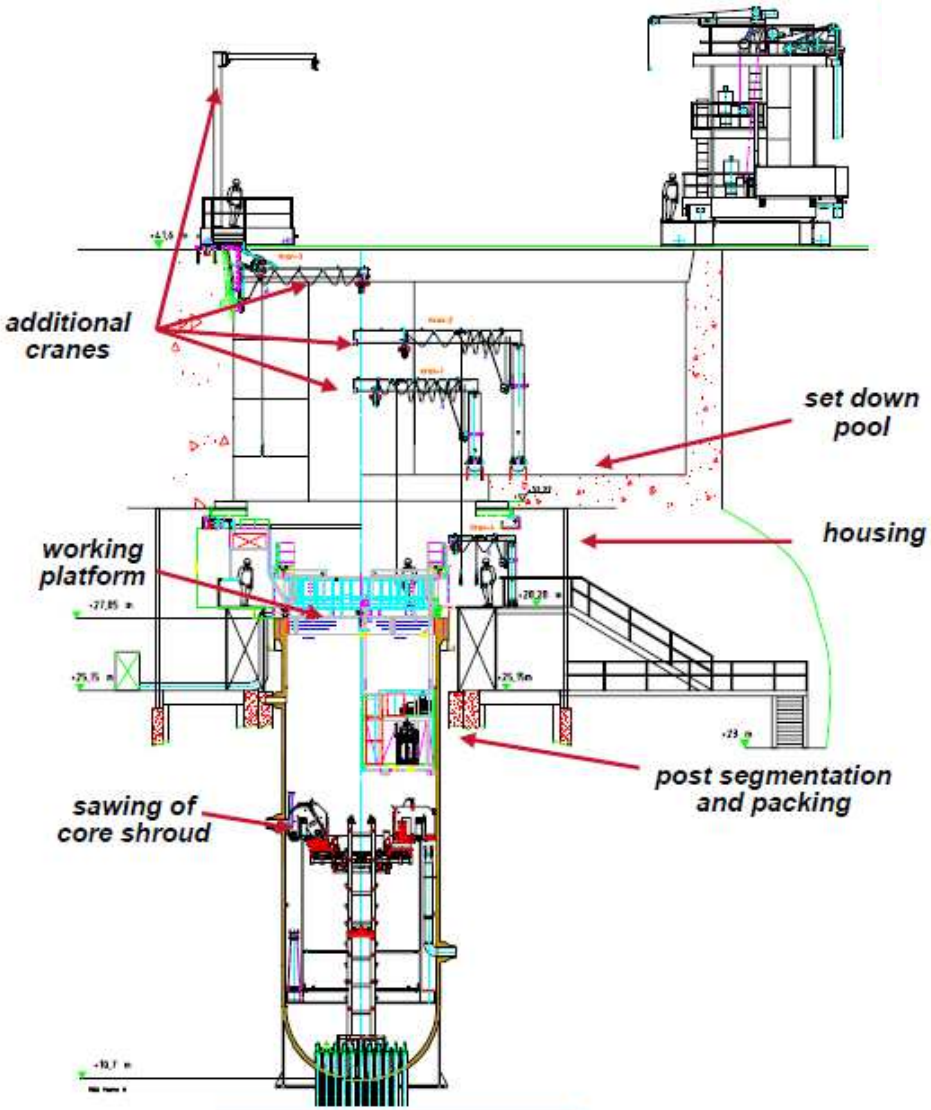
- Order receipt: 10/2005
- Engineering & procurement: 7 months
- Cutting & packing: 7 months
- UW-cutting in set down pool
- Core cover was dismantled later on

- Cutting of web plates via shearing
- Separating of cyclones via compass saw
- Cutting of median support ring via pot saw
- Separating of stand pipes via compass saw

- Cut mass: 35 tons (120 cyclones)
- Compacting of cut parts using an UW-compactor, packing into 200l drums

AREVA

Project Reference: Wuergassen NPP (BWR)
Remaining Internals



Phase 2 - Arrangement

- Order receipt: 04/2006
- Finished: 12/2008
- Total mass: ~ 55 tons
- On-site-dismantling in 2 phases:
  - Phase 1: 12/2006 – 10/2007
  - Phase 2: 03/2008 – 12/2008

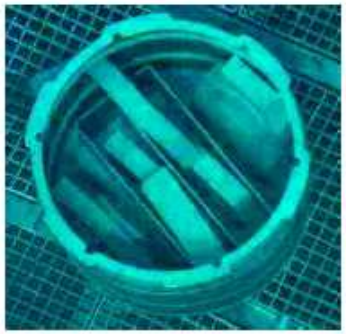
Rotatable working platform installed on RPV flange and post segmentation platform

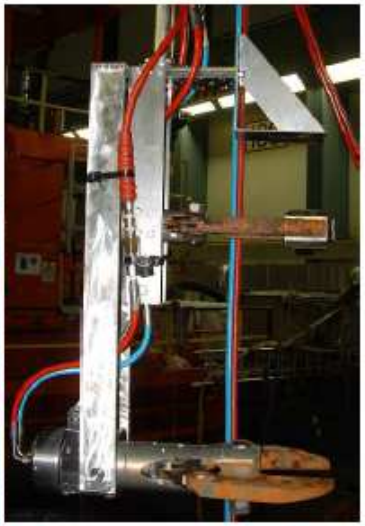
AREVA

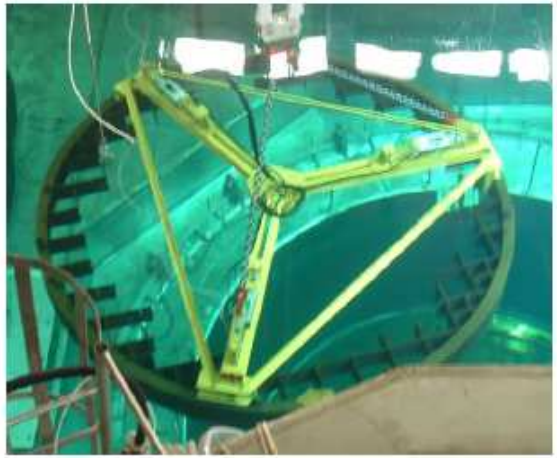
Project Reference: Wuergassen NPP (BWR)
Remaining Internals

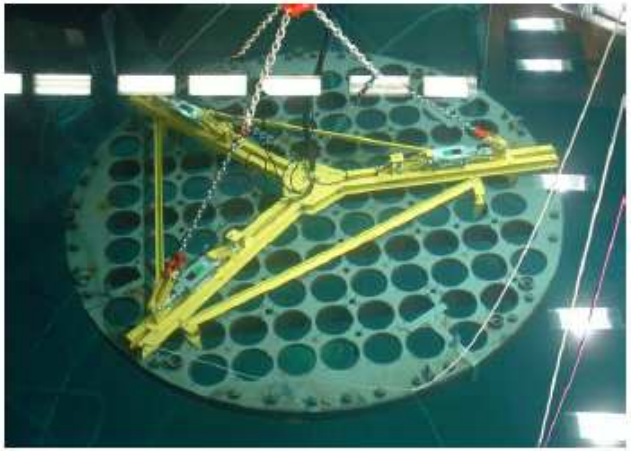
- **Phase 1: Mobile internals in set down pool**
  - Core cover (remaining from steam-water-separator)
  - Upper core grid
  - Lower core grid
  - Core Instrumentation

→ **Packing into primary casks & 200l drums**



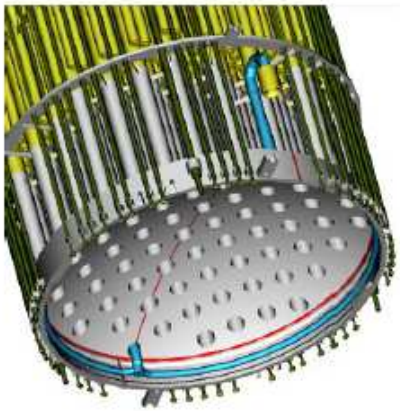






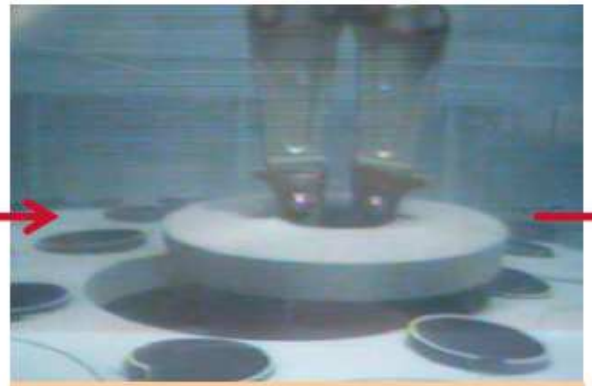
AREVA

Project Reference: Wuergassen NPP (BWR)
Cutting Activities Phase 1



- **Cutting of core cover**
  - **W**ater **A**brasive **S**uspension **S**licing - WASS
    (cutting speed ca. 50 mm/min)
  - Compass saw
  - Hydraulic shear

Mockup test at AREVA



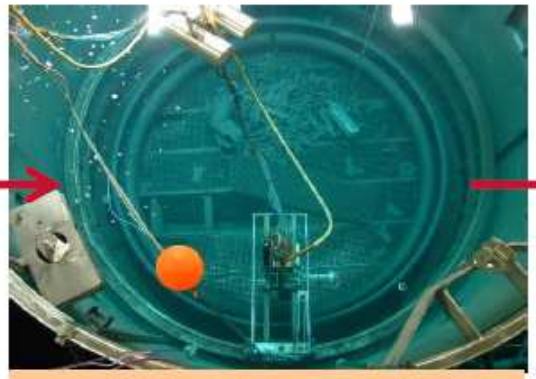
Gripping a calotte segment after cutting

Cutting of core cover calotte

AREVA

Project Reference: Wuergassen NPP (BWR)
Cutting Activities Phase 1

Packing of calotte segments



Cutting of spray heads

Cutting of core spray tube

Post segmentation of core spray tube

Cutting the outer ring of core cover

AREVA

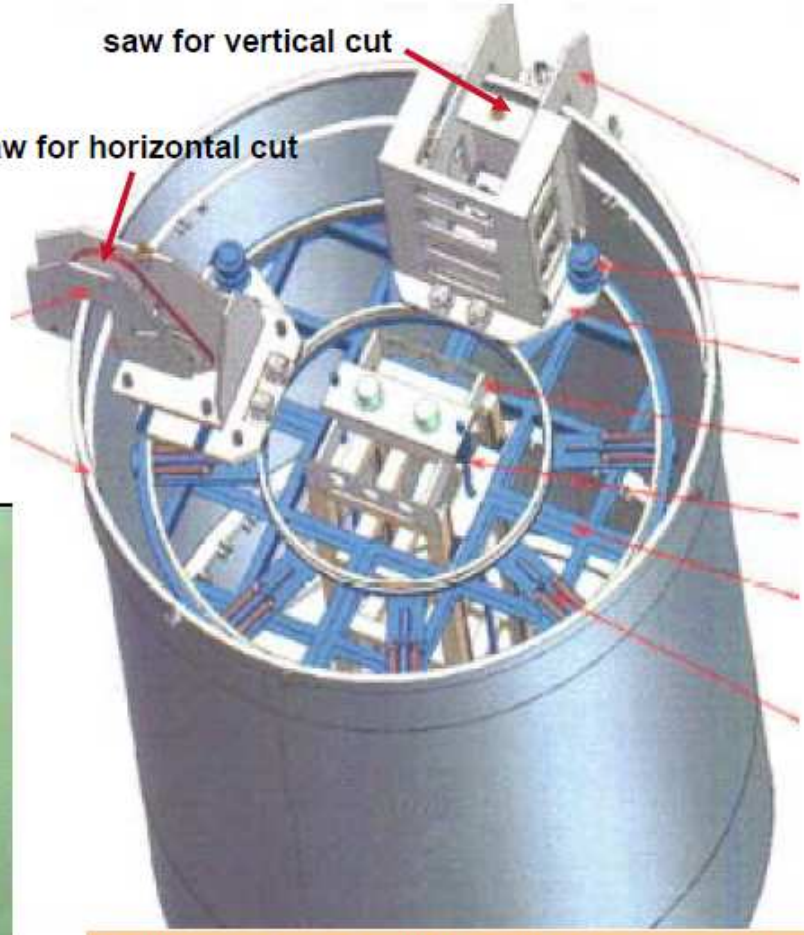
Project Reference: Wuergassen NPP (BWR)
Remaining Internals

- **Phase 2: Rigidly installed internals in RPV**
  - Core Shroud
  - Components close to RPV-wall
    e.g. sample magazines, standpipes of feed water sparger and jet pumps

→ **Packing into primary casks & 200l drums**

Final cutting of standpipe

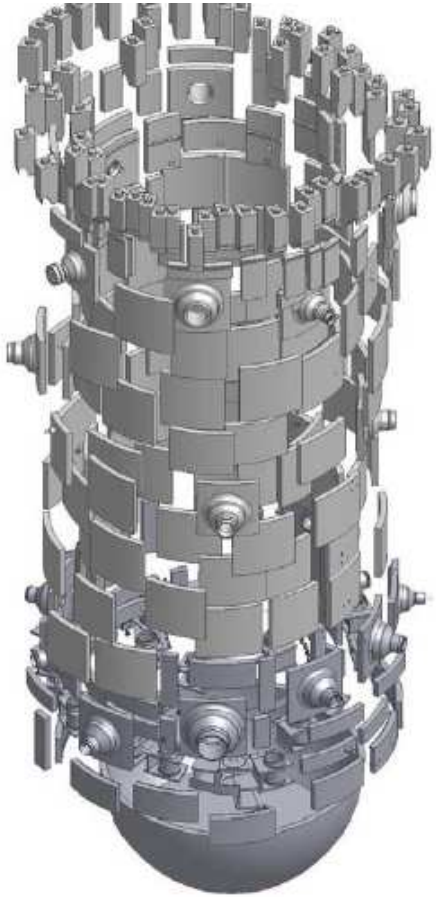
First cut on core shroud



Cutting of core shroud in RPV using a band saw

AREVA

Project Reference: Wuergassen NPP (BWR)
Cutting and Packing Strategy



Disposal

Area of steam dryer, steam-water-sep. **contaminated**

Decontamination and melting

Area of fuel **contaminated & activated**

Packing and conditioning into Konrad Containers (KC)

Total:

270 cut pieces

Thereof:

56 flange pieces

173 wall pieces

23 nozzle pieces

18 pieces of core shroud support ring

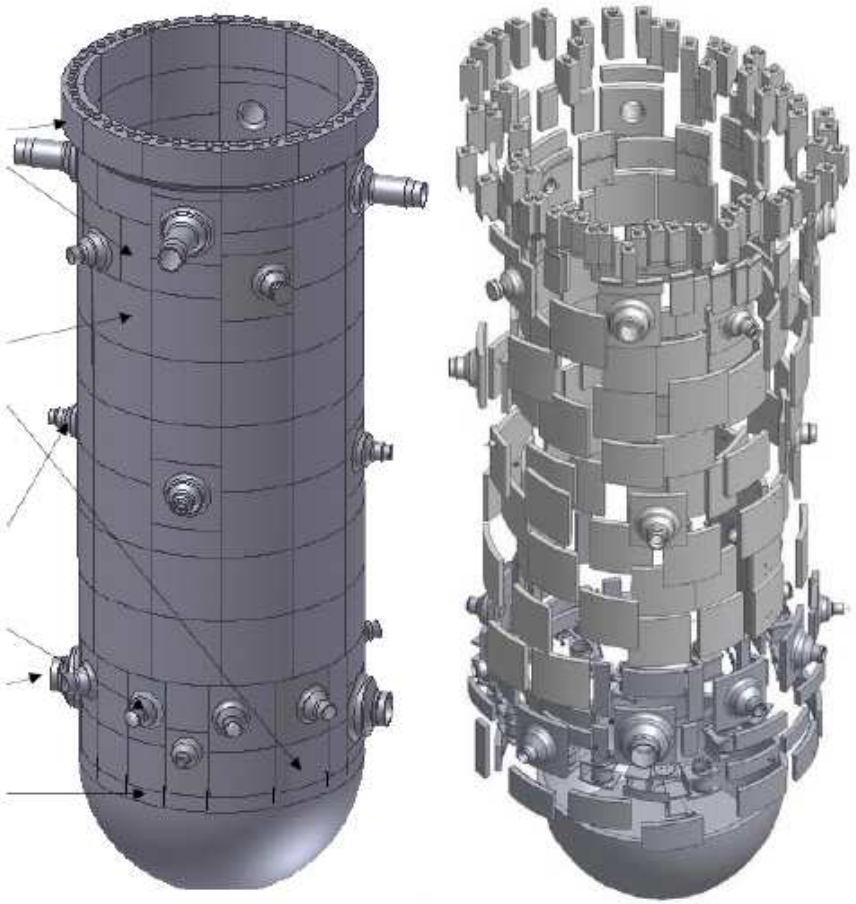
Complex cutting due to various nozzles.
Adapted grippers with force and form lock.

AREVA

Project Reference: Wuergassen NPP (BWR) Dismantling of RPV

- **RPV data**
  - Total weight of cylindrical part: 320 tons
  - Height: 15 m
  - Cut segments: 252 pcs.
  - Packing for final storage (29 KC)

- **Applied cutting techniques**
  - Water Abrasive Suspension Slicing
    - Water pressure: 2000 bar
    - Material thickness: 137 mm
    - Cutting speed: 20 mm/min
  - Band saw (for RPV flange)
    - Cutting height: 1100 mm
    - Flange thickness: 425 mm



Requirement: in-situ cutting on air

Project Reference: Wuergassen NPP (BWR)
Overview on installed Infrastructure

- *Shielding plate*

- *Complex RPV crane (handling tools and dismantled pieces)*

- *Rail systems and cranes for transportation (remote-operated)*

- *Rail system and cranes for container loading and conditioning (remote-operated)*

►Installation of cranes and auxiliary equipment

(e.g. steel structure) for transportation of RPV segments and packing into containers

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Project Reference: Wuergassen NPP (BWR) Shielding Plate

- Total mass: 32 tons
- Attached to rotating crane above RPV
- Lowered down following the dismantling progress

Reduction of collective dose

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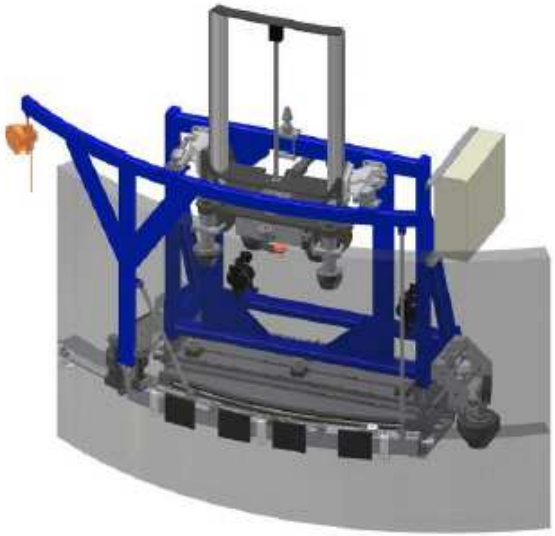
Project Reference: Wuergassen NPP (BWR) Rotating Crane

AREVA

Project Reference: Wuergassen NPP (BWR) Cutting Technique

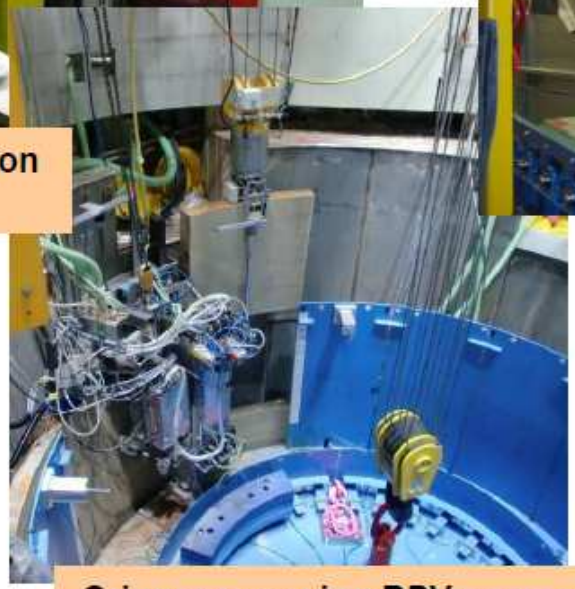
- **RPV flange**
  - Vertical cuts: band saw
    - Wall thickness: 450 mm
    - Avoidance of aerosols
  - Horizontal cuts: WASS
    - Avoidance of aerosols
    - Wall thickness: 140 mm
    - No jamming
- **RPV cylindrical part**
  - Vertical and horizontal cuts: WASS
    - Avoidance of aerosols
    - Limited clearance to insulation: 200 mm
    - No thermal impact to insulation



AREVA

Project Reference: Wuergassen NPP (BWR)
On-site Impressions

Vertical segmentation of RPV flange



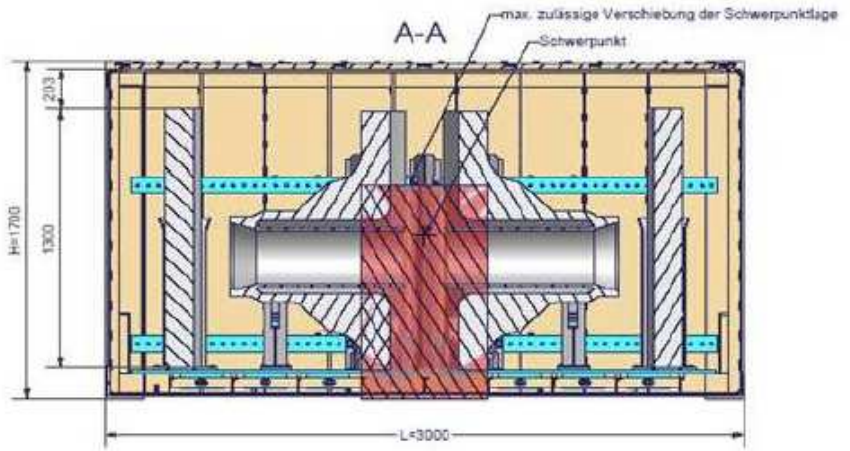
Gripper removing RPV segment

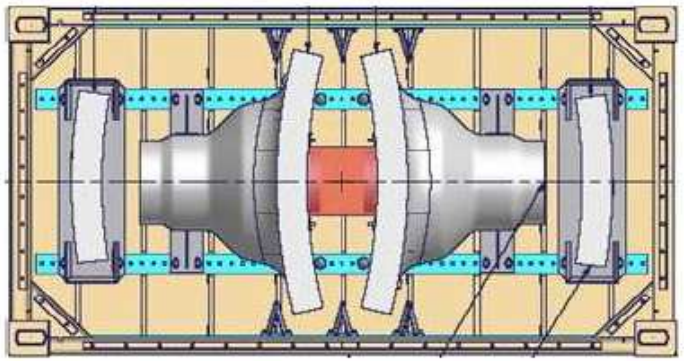
Positioning of RPV segment for transport to container loading station

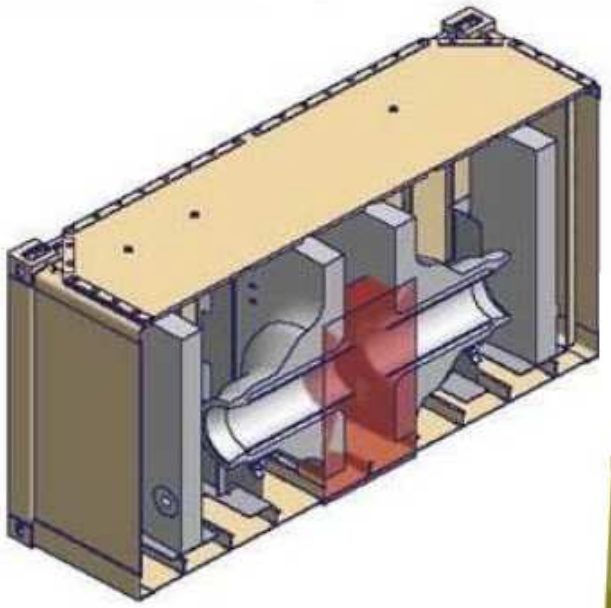
Packing of RPV segment into KONRAD container

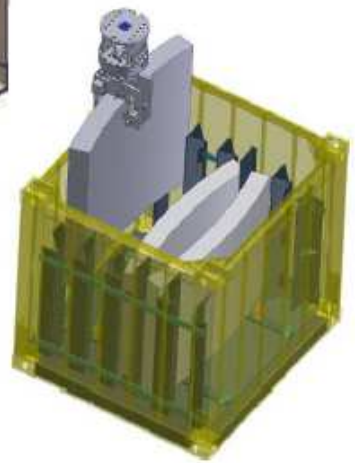
AREVA

Project Reference: Wuergassen NPP (BWR)
Cutting and Packing Strategy









- Total mass: < 20t
- Difference in center of gravity: < 10%

Correlation of cutting and packing plan for reducing the number of containers.

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Project Reference: Wuergassen NPP (BWR) Packing and Conditioning

- Rail system for up to 5 Konrad containers (KC)
- Cranes for handling of cut pieces, KC and concreting device
- Weighing system for KC
- Shielding plates for KC
- Camera surveillance
- Covering station

AREVA NP

AREVA

Project Reference: Wuergassen NPP (BWR) Water Purification

- Collecting the water-abrasive-kerf mixture
- Deposition of abrasive and kerf material using the principle of a hydro cyclone

» Deposition directly into 200l drums – no additional handling necessary.

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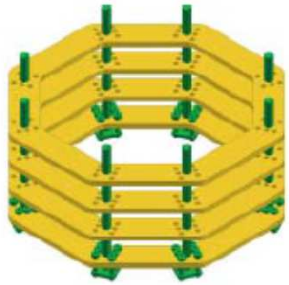
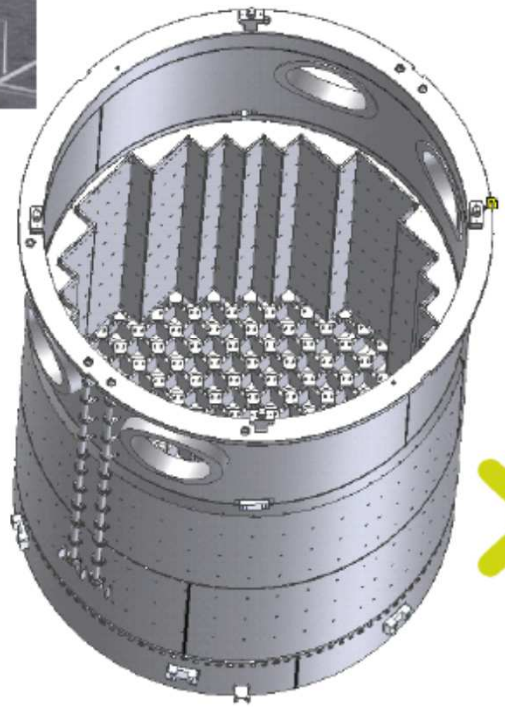
Project Reference: Wuergassen NPP (BWR) Schedule

	2008			2009			2010	
	Q2/08	Q3/08	Q4/08	Q1/09	Q2/09	Q3/09	Q4/09	Q1/10
Project duration	24 months							April 2010
Engineering phase	12 months							
Installation of cutting equipment				6 months				
Dismantling of RPV				13 months				

AREVA

Project Reference: Stade NPP (PWR)
Dismantling of RPV Internals

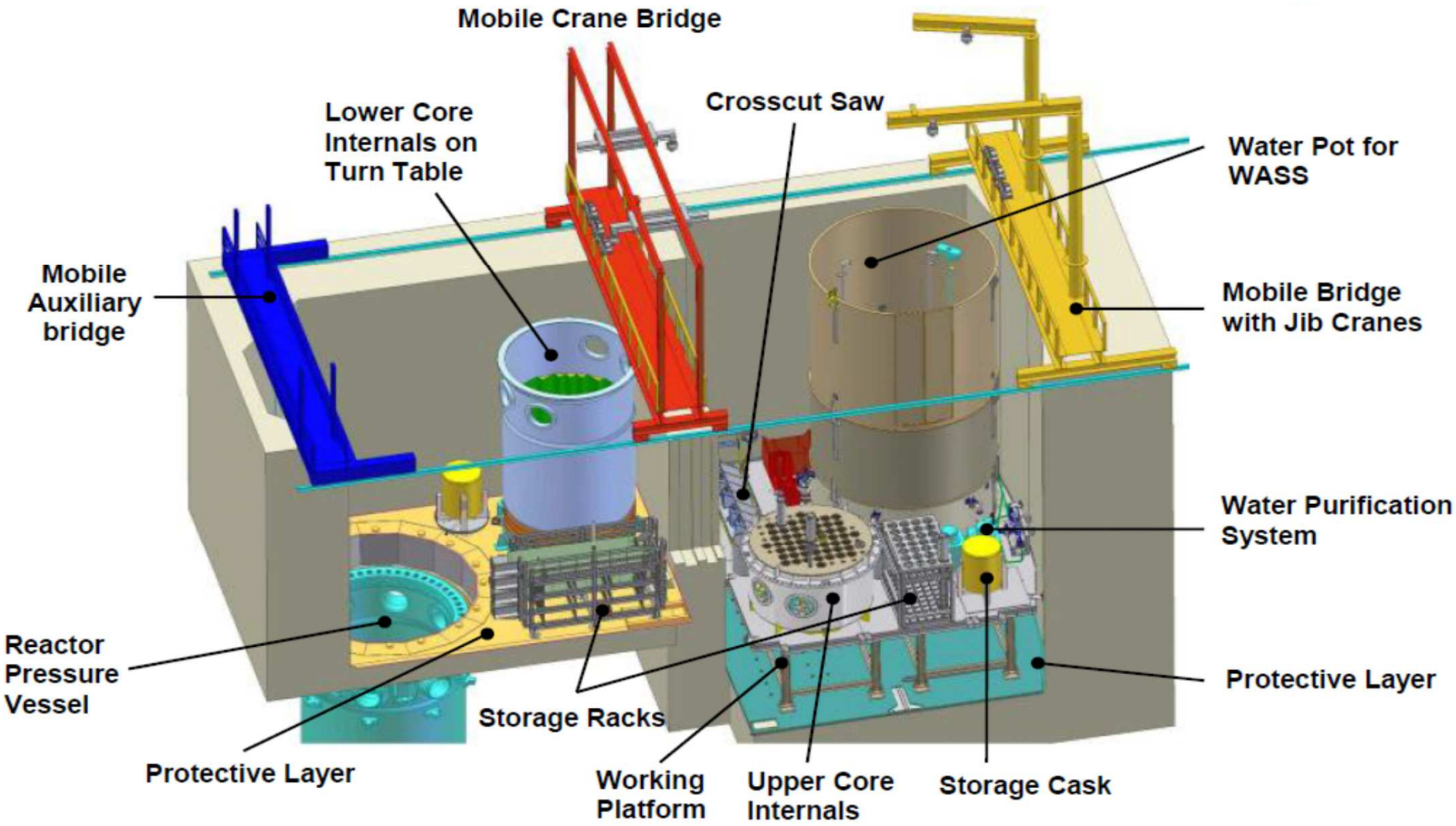




- **Dismantling conditioning and packing for final storage of RPV Internals (2007-2009)**
  - Remote controlled underwater segmentation and packing
  - Total mass of 85 tons
  - 158 shielded casks and 10 containers
    - Upper Core Internals
    - Lower Core Internals with Core Barrel
    - Core Support Structure

37 shielded casks were saved.
Project finished successfully in time.
Dose application limited as specified.
No accident at work.

Project Reference: Stade NPP (PWR) Pool Layout

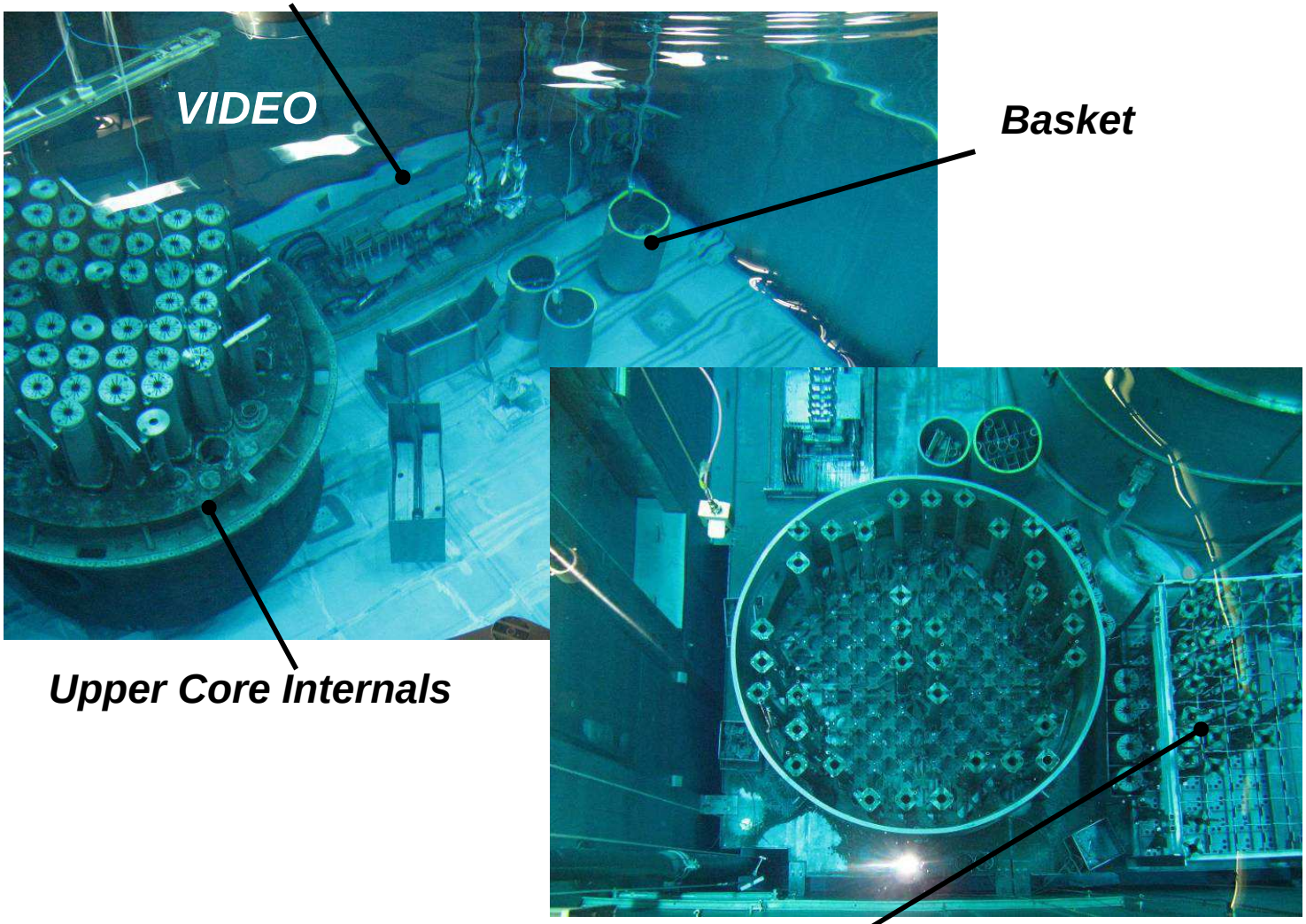


AREVA

Project Reference: Stade NPP (PWR)
On-site Impressions

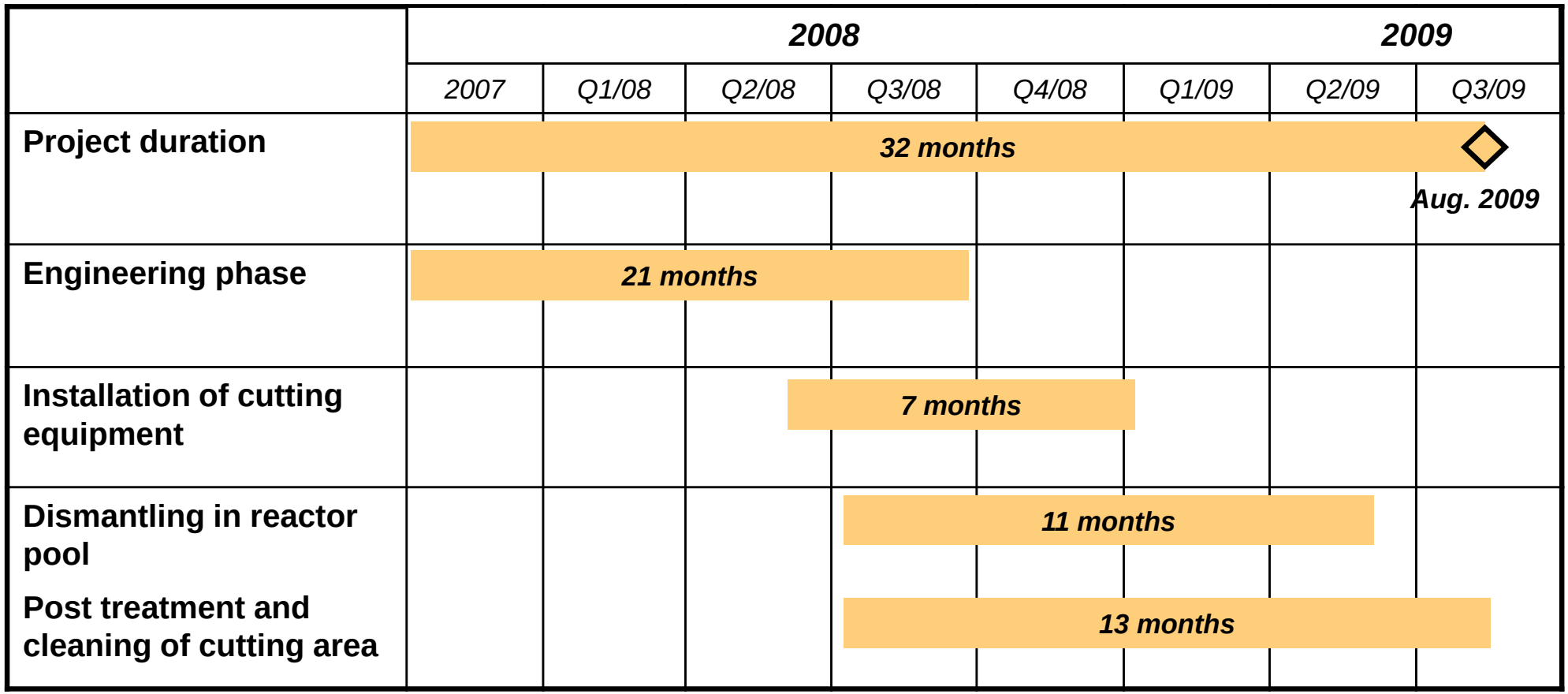
AREVA

Project Reference: Stade NPP (PWR)
On-site Impressions



AREVA

Project Reference: Stade NPP (PWR) Schedule



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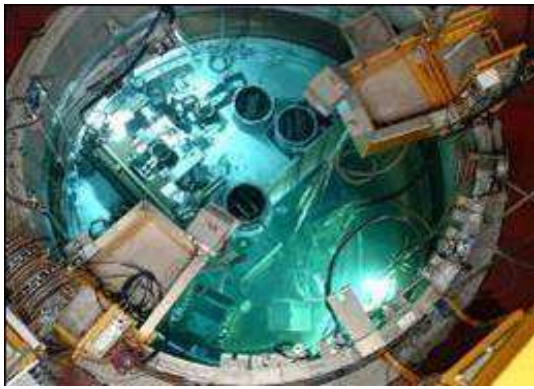
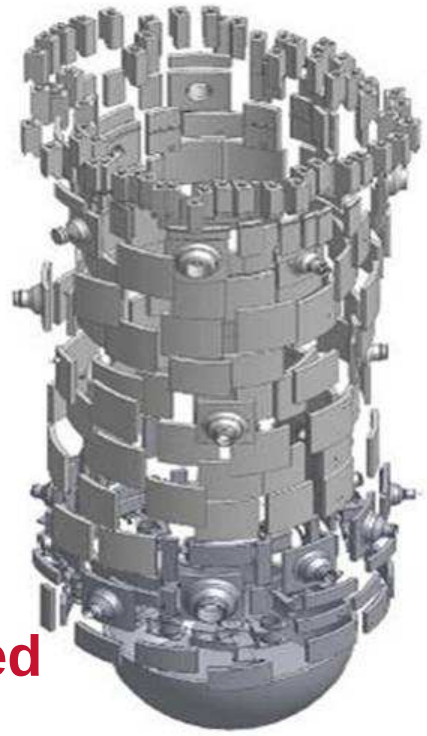
Würgassen (BWR) and Stade (PWR)

- Dismantling, conditioning and packing for final storage of RPV as well as RPV Internals
  - Stade RPV Internals (2007-2009)
    - Remote controlled underwater segmentation and packing
    - Total mass of 85 tons
    - 158 MOSAIK and 10 KONRAD containers
    - 37 MOSAIK containers were saved due to optimization of packing strategy
  - Würgassen RPV + Internals
    - Dismantling and packing of Internals (2003-2009)
    - Total mass of 160 tons
    - Dismantling and packing of RPV (2008-2010)
    - Total mass of 320 tons





» 10% to 20% of waste containers were saved - Projects were finished successfully in time - Collective dose limited as specified - No accident at work

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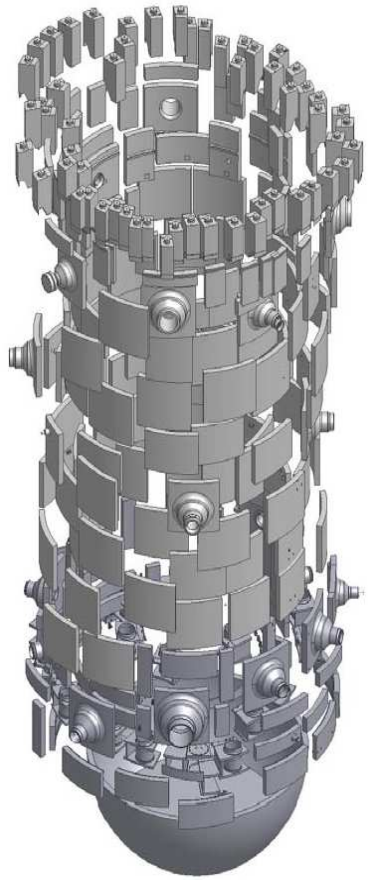
Optimized Primary Circuit Dismantling Summary

- ***D&D projects are driven by costs, to implement an optimization process from the very beginning is key***
  - *Optimized strategy and sequencing of the dismantling (hot to cold) will provide serious economical savings*
  - *Larger dismantling packages will reduce interfaces and ease the coordination efforts on site*
  - *Early usage of mobile systems will ease the large-scale release for dismantling*
- ***Social transition has to be addressed with priority and to be planned at an early phase in the D&D planning***
- ***Concept, Planning & Project Management will influence the success of the project much more than the used technique***



The AREVA Competence Centre for Dismantling provides a solid base for the successful execution of your decommissioning project.