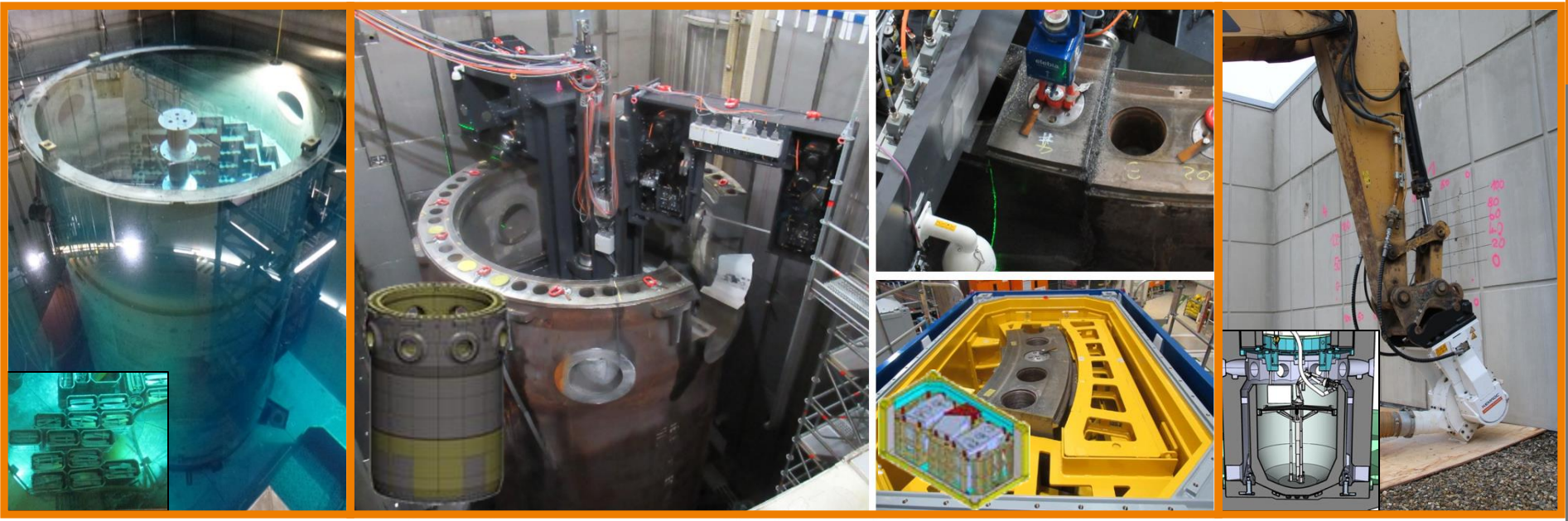


Decommissioning of Activated Reactor Components in Germany and Lessons Learned

Dr. L. Schlömer, B. Könning, T. Eichhorn, P. Sommerer, Dr. Josef Kim

Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22-23, 2025

AiNT
GNS-Gruppe

Agenda

- Company Presentation
- Decommissioning in Germany
- D&D
  - Reactor pressure vessel internals
  - Reactor pressure vessel
  - Activated concrete structures
- Know-How Transfer
- Key Takeaways

About us …

- **Academy**
  - ICOND
  - Seminars on nuclear technology, transportation, interim and final storage and the release of radioactive waste
  - Cask training – NEW – in cooperation with GNS!
- **R&D**
  - Development of innovative radiation measurement technology and associated software
  - Non-destructive material characterization
  - Consortium leader in research projects as a central innovation hub
  - Research network with universities
  - Use of AI in the nuclear environment
  - Conducting experiments in our own control area (technical center)
- **Consulting and Services**
  - Supporting products from research projects to market readiness
  - Qualification of radiation measurement technology for the measurement purpose
  - Performing measurements
  - Calculations for Radiation protection

AiNT
GNS-Gruppe

- Contact
  - Technical topics:
    - Dr. Dominik Winter
    - E-mail: winter@nuclear-training.de
    - Phone: +49 (0) 2402 102-1502
  - Academy:
    - Helena Schunk
    - E-mail: schunk@nuclear-training.de
    - Phone: +49 (0) 2402 102-1503

Save the Date!

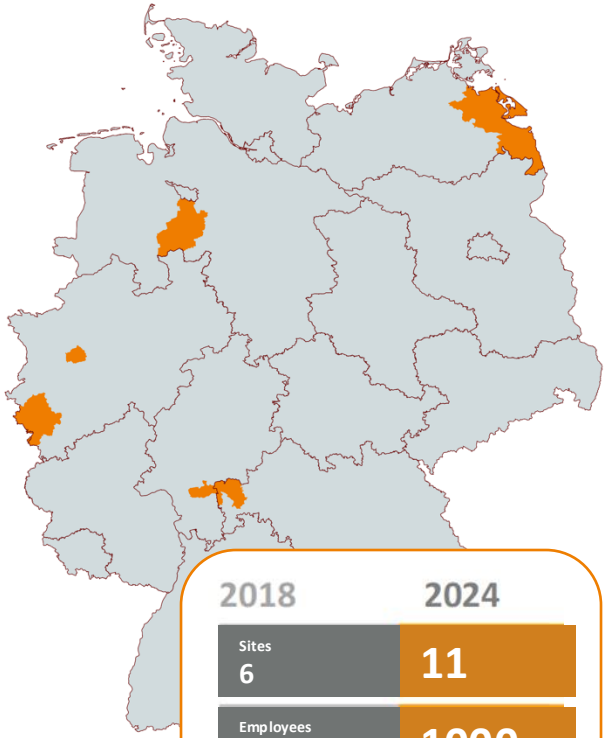
Where to find us …

Where to find us …

GNS
Excellence for Nuclear.

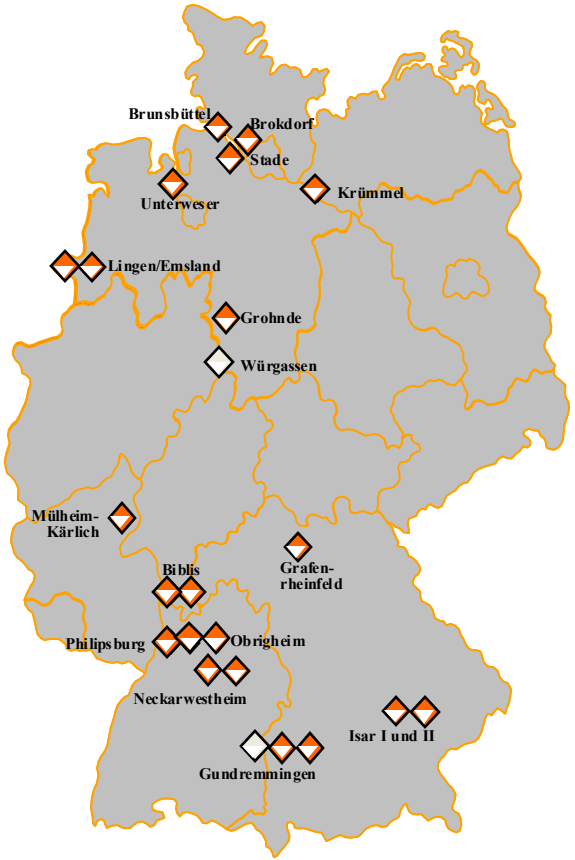
AiNT
GNS-Gruppe

- Peenemünde: Eisenwerke Bassum GmbH
- Sulingen: Eisenwerke Bassum GmbH
- Bassum: Eisenwerke Bassum GmbH
- Essen: GNS Gesellschaft für Nuklear-Service mbH
- Gladbeck: GNS Power Alloys GmbH
- Mühlheim an der Ruhr: GNS Gesellschaft für Nuklear-Service mbH
- Jülich: WTI Wissenschaftliche-Technische Ingenieurberatung GmbH
- Jülich: GNS Gesellschaft für Nuklear-Service mbH
- **Stolberg: Aachen Institute for Nuclear Training (AiNT) GmbH**
- Mainhausen: Höfer & Bechtel GmbH
- Alzenau: GNS Gesellschaft für Nuklear-Service mbH



	2018	2024
Sites	6	11
Employees	450	1000
Turnover in million €	255	397

Nuclear Power Plants in Germany 2025



- 0 reactors in operation
- ◆ 21 under decommissioning
- ◇ 2 completely dismantled (but storage facility remaining)

Situation:
After shut-down all German nuclear power plants have to be decom-missioned.

commercial reactors

name	type	operator	start of operation	end of operation
Würgassen	BWR (AEG)	PreussenElektra	11.11.1975	26.08.1994
Unterweser	PWR (KWU, Gen.2)	PreussenElektra	06.09.1979	06.08.2011
Stade	PWR (Siemens-KWU Gen.1)	PreussenElektra	19.05.1972	14.11.2003
Philippsburg 2	PWR (KWU Vor-Konvoi)	EnBW	18.04.1985	31.12.2019
Philippsburg 1	BWR (KWU-Baulinie 69)	EnBW	26.03.1980	06.08.2011
Obrigheim	PWR (Siemens Gen.1)	EnBW	01.04.1969	11.05.2005
Neckarwestheim 2	**PWR (KWU Konvoi)**	**EnBW**	**15.04.1989**	**15.04.2023**
Neckarwestheim 1	PWR (KWU Gen.2)	EnBW	01.12.1976	06.08.2011
Mülheim-Kärlich	PWR (Babcock-BBC)	RWE	01.10.1987	09.09.1988
Lingen	BWR	RWE	01.10.1986	05.01.1979
Krümmel	BWR (KWU-Baulinie 69)	Vattenfall	28.03.1984	06.08.2011
Isar/Ohu 2	**PWR (KWU Konvoi)**	**PreussenElektra**	**09.04.1988**	**15.04.2023**
Isar/Ohu 1	BWR (KWU-Baulinie 69)	PreussenElektra	21.03.1979	06.08.2011
Gundremmingen C	BWR (KWU-Baulinie 72)	RWE	18.01.1985	31.12.2021
Gundremmingen B	BWR (KWU-Baulinie 72)	RWE	19.07.1984	31.12.2017
Gundremmingen A	BWR	RWE	12.04.1967	13.01.1977
Grohnde	PWR (KWU Vor-Konvoi)	PreussenElektra	01.02.1985	31.12.2021
Grafenrheinfeld	PWR (KWU Vor-Konvoi)	PreussenElektra	17.06.1982	27.06.2015
Emsland	**PWR (KWU Konvoi)**	**RWE**	**20.06.1988**	**15.04.2023**
Brunsbüttel	BWR (KWU-Baulinie 69)	Vattenfall	09.02.1977	06.08.2011
Brokdorf	PWR (KWU Vor-Konvoi)	PreussenElektra	22.12.1986	31.12.2021
Biblis B	PWR (KWU Gen.2)	RWE	31.01.1977	06.08.2011
Biblis A	PWR (KWU Gen.2)	RWE	26.02.1975	06.08.2011

Managing the “Big Five” of the primary circuit and activated concrete

Complete Defueling

- Delivery of CASTOR® casks
- Planning and construction of storage buildings

Full System Deco

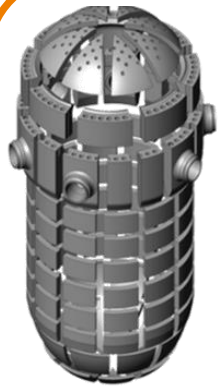
- Drying/Dewatering of resins
- Delivery of MOSAIK® casks

(1) “Internals”

Dismantling of Core Internals

- Cutting and packaging of core internals
- Engineering and activity calculations („ActiAtlas®“)
- Delivery of MOSAIK® casks

(2) “ReaDi”



“The Squaring of the Circle”

Getting Cylindrical components into Boxes

Dismantling of RPV

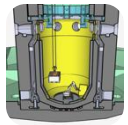
- Cutting and packaging of RPV
- Engineering and activity calculations („ActiAtlas®“)
- Delivery of containers

Dismantling of Large Components

- On site or „Rip‘n‘Ship“
- Cutting, packaging
- Transports and logistics

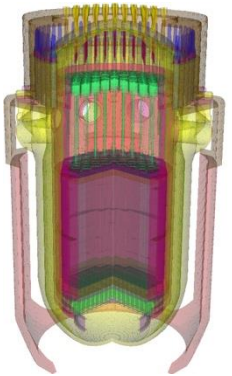
(3) Starting “concrete age”

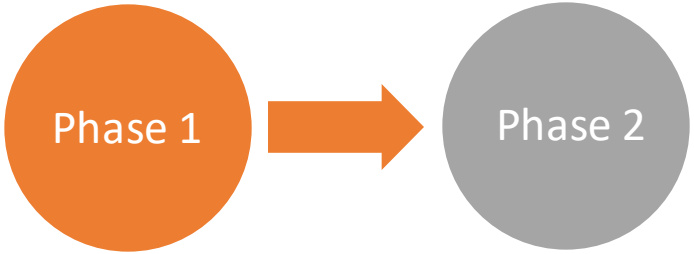
→ D&D of activated concrete



Classical Project Process

- Most of GNS projects are contracts for a „fleet“ of reactors, i. e. reactors of similar type → Synergies and learning effects ~ Decommissioning costs ↓
- Typical Split of the projects in “work phases”
  - Work phase 1 – Preparation phase
    - Concept development
      - Compilation of the radiological characterization → Activation calculations and analyses
      - Preparation of a packaging plan
      - Preparation of a radiation protection concept
    - Obtaining approvals, production & acceptance of the equipment
  - Work phase 2 – Execution phase
    - Assembly and installation of equipment,
    - Implementation
      - Cutting/segmentation,
      - packaging,
      - conditioning,
    - Removal of equipment and cleaning,
    - Documentation,
    - Grouting (if necessary)





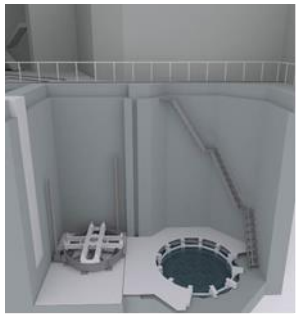
Projekt „Internals“ - Basics

Consortium:

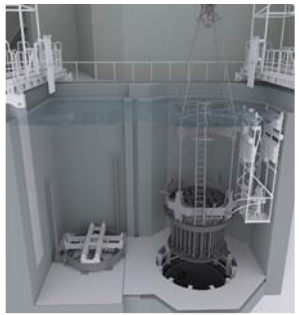
- GNS (leader)
- Westinghouse Germany
- Westinghouse Sweden

Scope of services

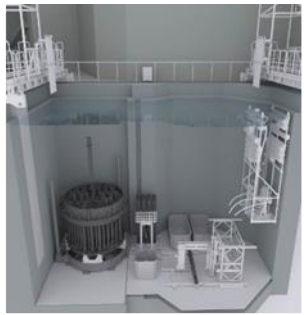
Dismantling and packaging of RPV internals (RPV-I) and of core components (operational waste, e. g. control rods) as well as documentation considering final disposal.



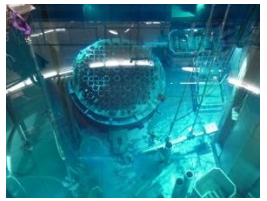
pool-protection and cutting table

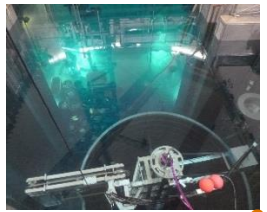


upper core grid

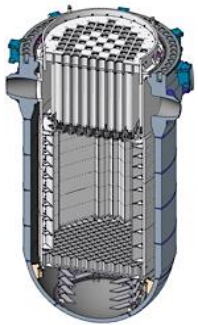


cutting of upper core grid





&ZerKon

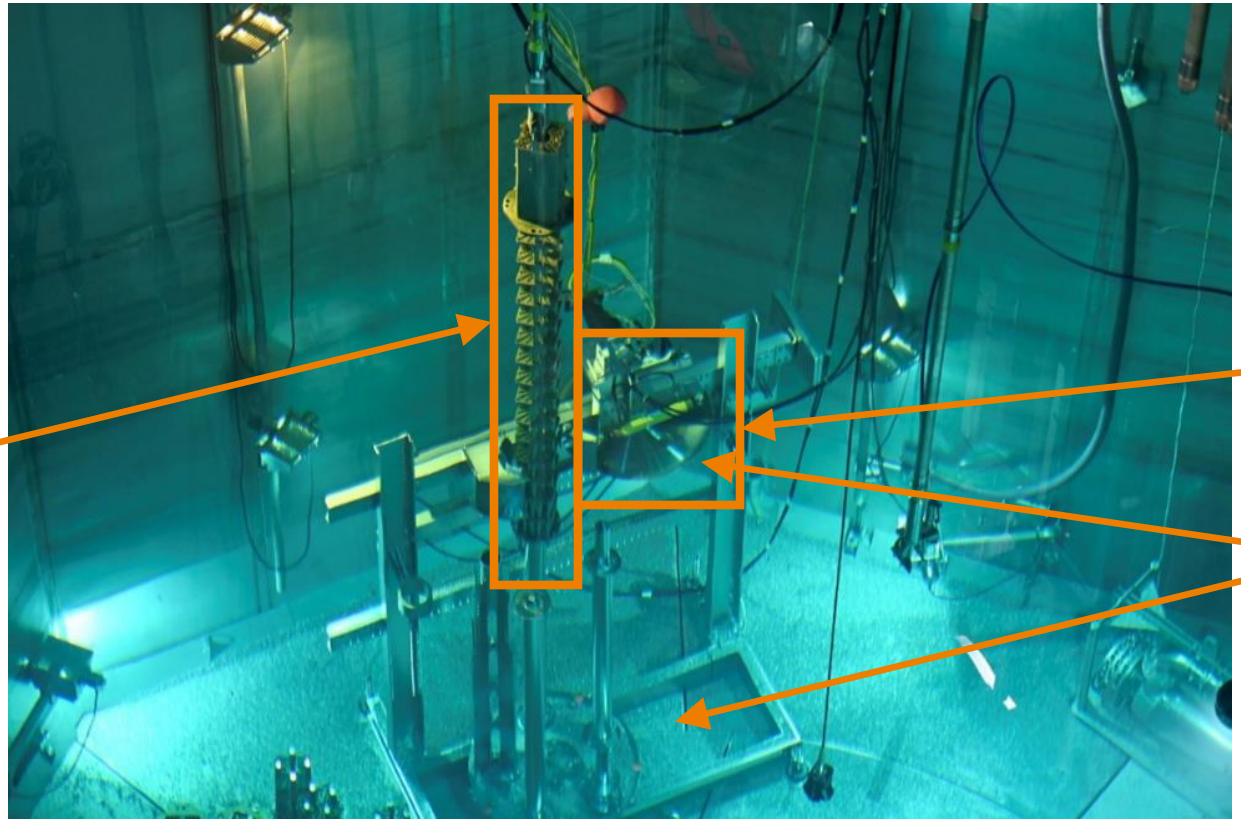


core shroud

cutting of core shroud

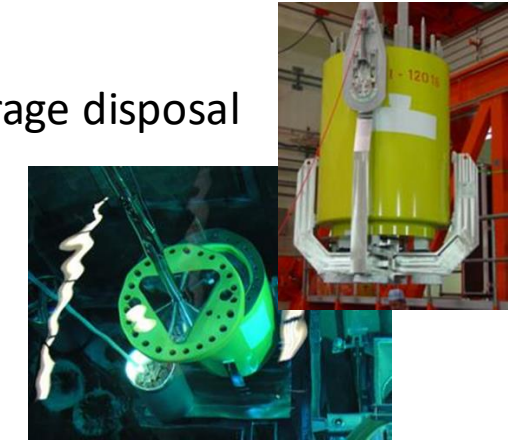
cutting of lower core grid

RPV Internals: Equipment
Mechanical cutting under water



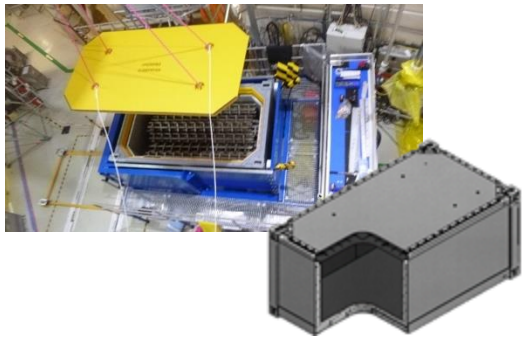
Operational fields for GNS casks in Europe

- Segmented parts must be packed → GNS casks
- GNS casks/containers are triple purpose casks – transport, storage disposal



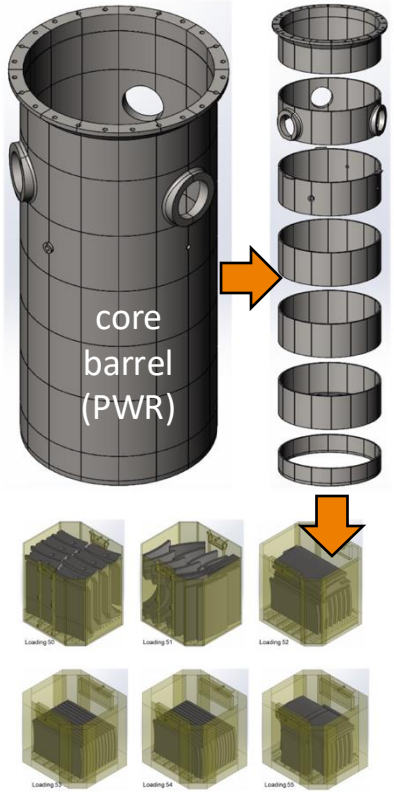
- Typical GNS container portfolio used across Europe:
  - MOSAIK® and GNS Yellow Box® product lines made out of ductile cast iron.
  - Focus: Higher end of the activity levels.

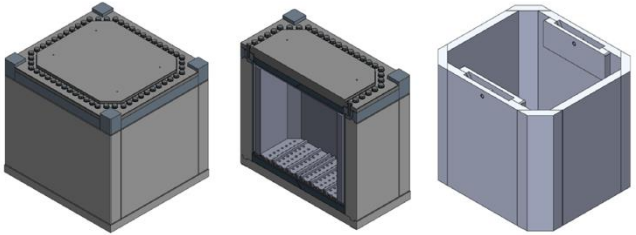
- Steel-sheet containers from Eisenwerk Bassum (GNS-group)
  - Mainly dedicated for the German repository “Konrad” → Radioactive inventory restricted by national regulations.
  - Called Konrad Container (KC), since occasionally used outside Germany.
  - Focus: Medium and low activity levels.



Operational fields for GNS casks outside Europe

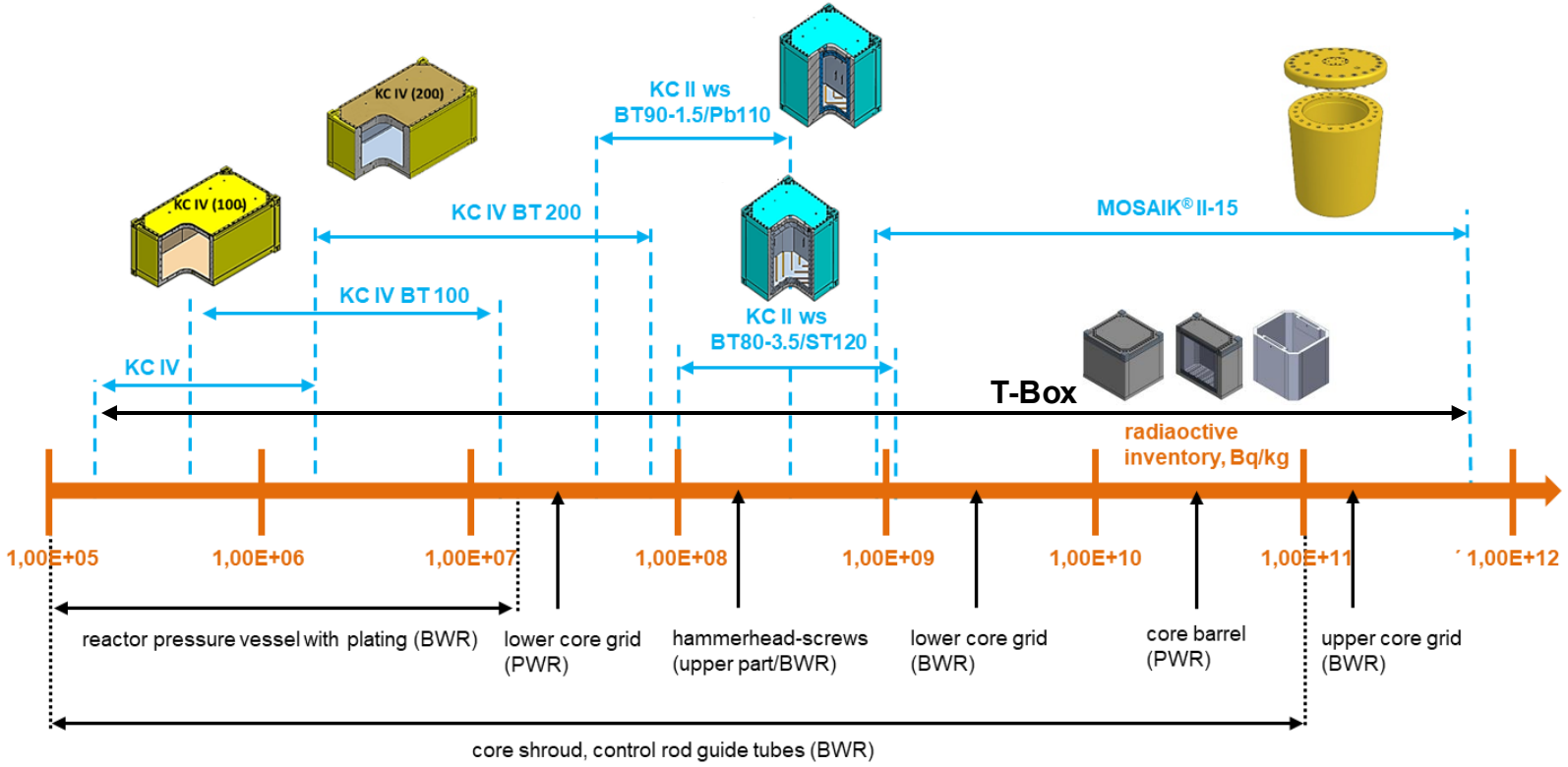
- Example: New container portfolio for Taiwan (“T-Boxes”)
- Development of 5 container types including one type B package covering medium and low activity levels up to the higher end.
- Manufacturing and design according to NQA-1.
- Licensing in dealing with local regulators.
- Development of a packaging plan for Taiwanese reactors.
  - Lower container numbers for D&D compared to a D&D plan following the German restrictions (20 Mg).





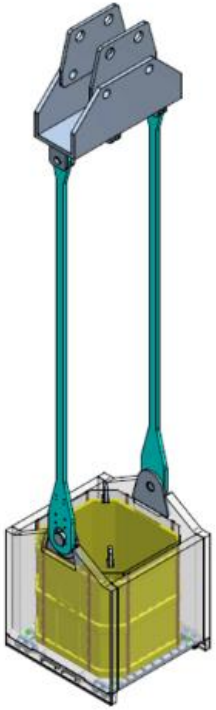
Operational fields for GNS casks

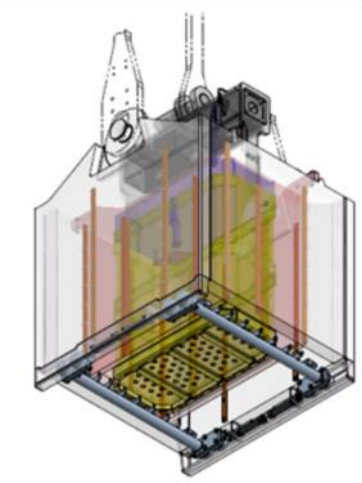
- Typical fields of application regarding D&D (without decay storage)

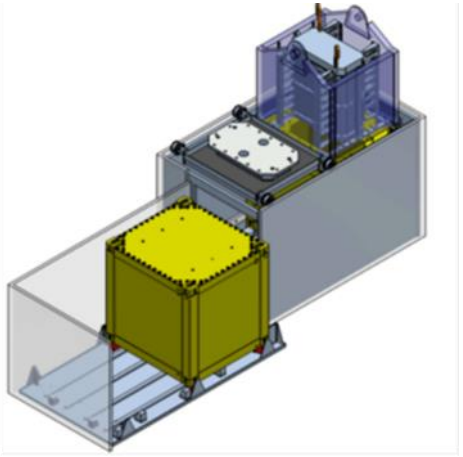


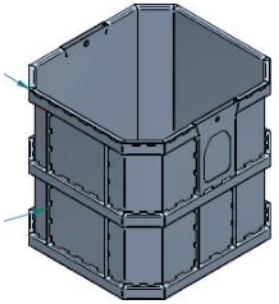
Handling of Parts from Segmentation for Container Loadings

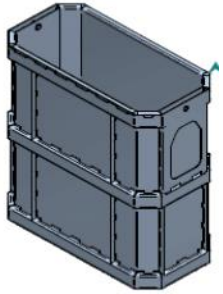
- Lifting tools and baskets for cuboidal or cylindrical containers
- Shielded bell



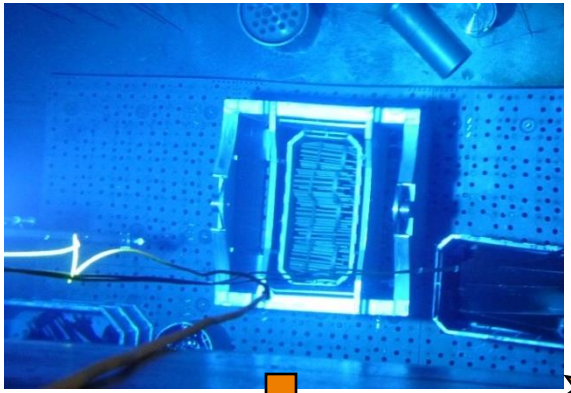


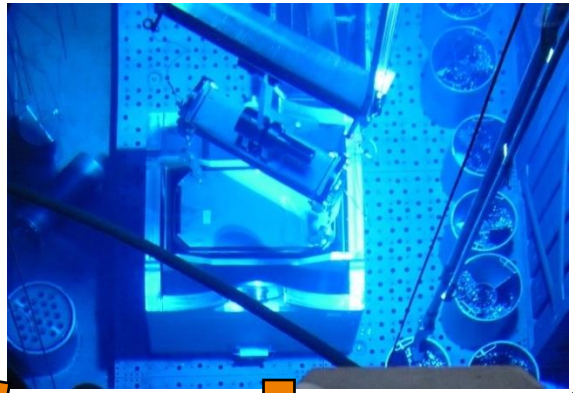


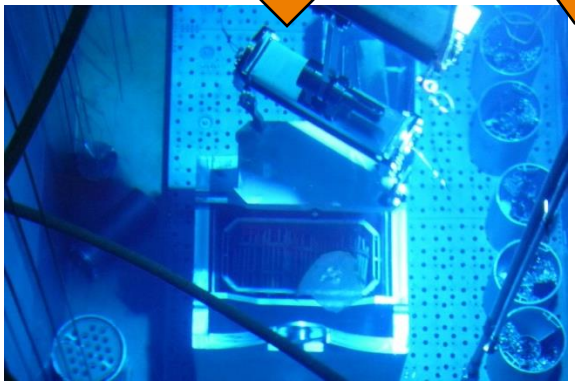


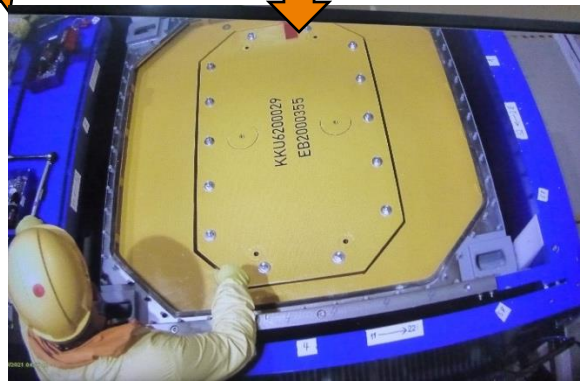


Handling of Baskets

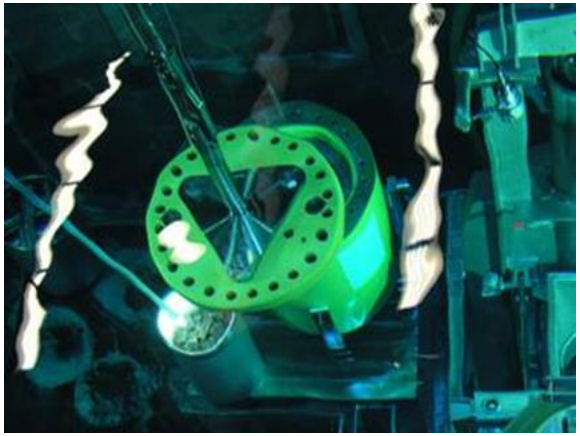


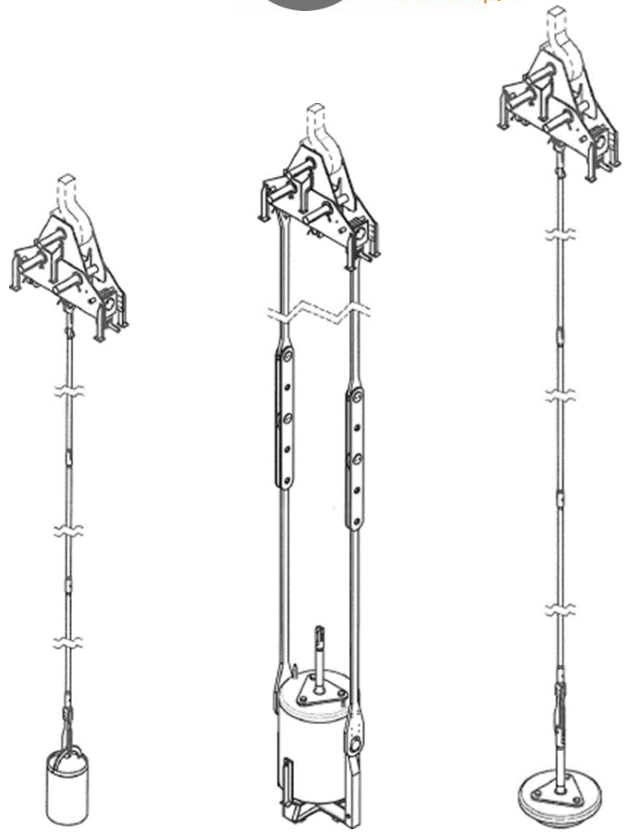






Handling of MOSAIK® casks for Higher Activated Components





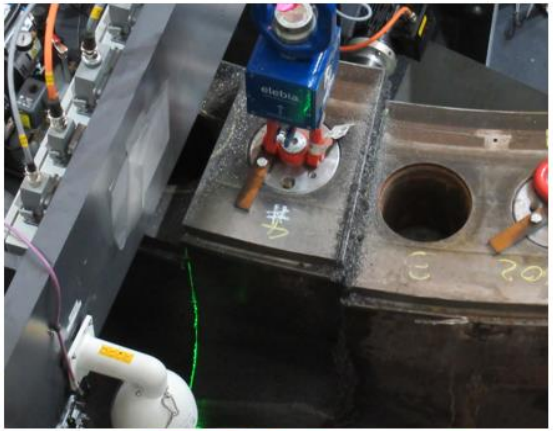
Projekt „ReaDi“ - Basics

Contractor:

- GNS group
  - Höfer & Bechtel
  - GNS

Scope of services

Dismantling and packaging of RPV and insulation as well as documentation considering final disposal



Technical Concept
Example: PWR

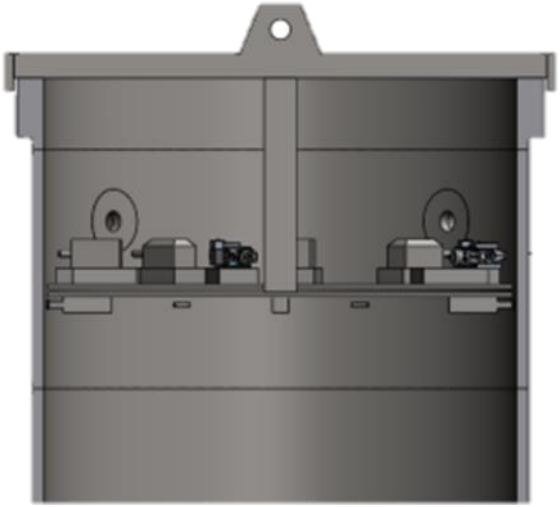
Sequence of Work

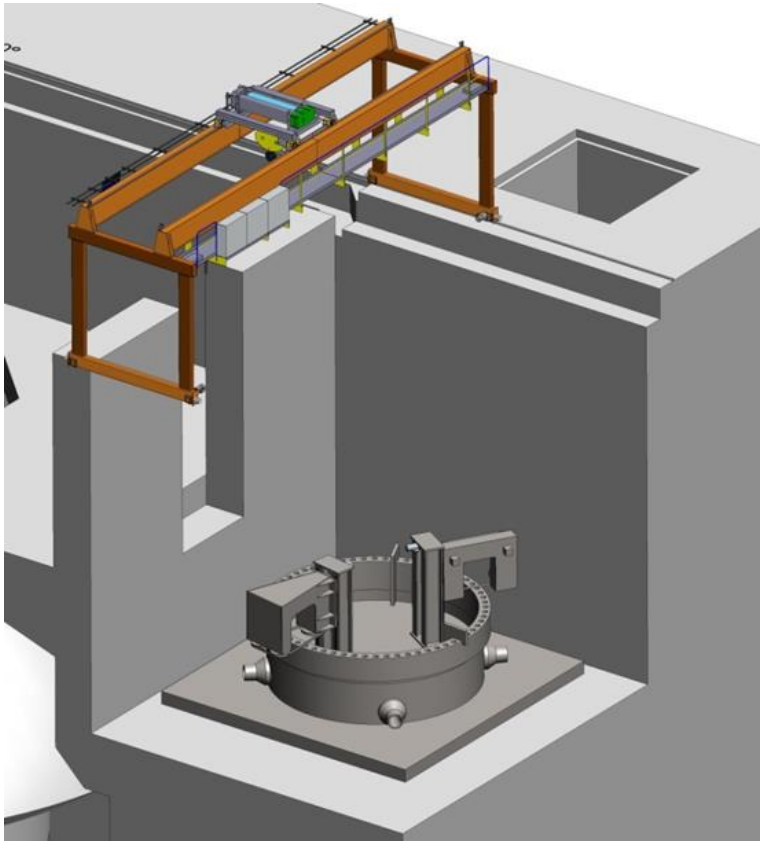
- Cutting of the primary loop tubes using a wire saw
- Lifting of the RPV into emptied SFP
- Cutting of the RPV using a large bandsaw system and packaging of the parts into steel sheet containers with shielding
- Cutting of the RPV calotte using also the large bandsaw system
- Option: Cutting of the RPV lid advance, in parallel or subsequently using a wire saw

Lifting the RPV

Segmentation of the BWR RPV

- In-situ cutting into rings
- Cutting of the rings on a support frame
- New crane for cut pieces in order to keep the reactor building crane available for other tasks



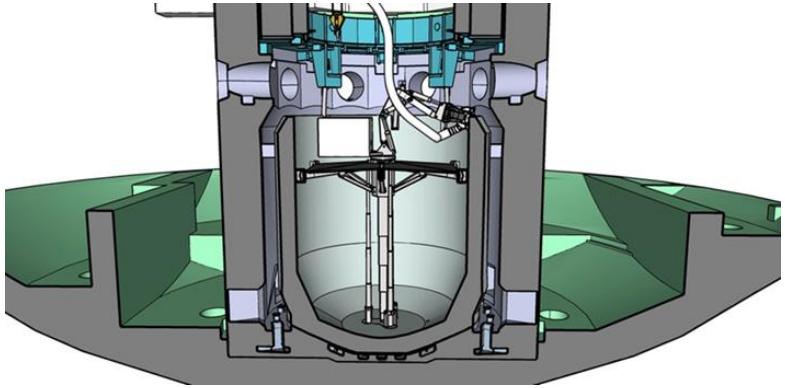


Packaging

- Loading next to cutting area
- Loading aids to keep cut pieces in place and facilitate later lashing
- Shielded workplace (scaffolding with lead blankets) for lidding of containers outside pool
- Documentation after discharge from the reactor building

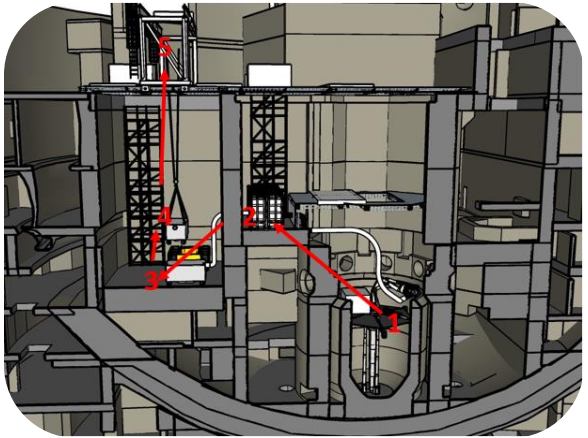
D&D of activated concrete structures

- New technical concept based on the use of milling technology.
- This technique is combined with direct suction and filling of the resulting waste product into containers
- Resulting waste product:
  - Concrete debris with defined bulk density
  - Reinforcing bars (iron) is removed by magnets and stored separately or recycled



D&D of activated concrete structures

- Economic advantages compared to conventional technologies:
  - Reduction of execution time → Minimizing transport and logistics operations.
  - Reduction of total dose rate during execution through (semi-)automation of processes
  - Reduction of the required final disposal containers (steel containers) by utilizing the voids during filling.
  - Remaining volumes of already loaded steel containers can be filled with concrete debris.
  - The removal of the concrete surface can be carried out with centimeter precision
    - Significant reduction in the volume of concrete waste to be disposed.
    - The amount of concrete for free release is significantly increased.



- The concept was commissioned by a German customer.
- The implementation phase will begin this year.

Maintaining Expertise and Knowledge Transfer
- Core Expertise @ AiNT -

- Lessons Learned Workshops:
  - After each project, a workshop is conducted with the customer to compile insights from the project.
- Developing Solutions:
  - Solutions are developed to make future projects more time and cost-efficient.
- Bundling of know-how in seminar modules that can be offered to external customers
- Seminars modules – „Key Facts“:
  - Competence building and maintenance through our modular seminar program
  - Expert instructors with practical experience
  - Customer-specific in-house trainings on demand
  - Networking among participants
  - Hybrid solutions
  - Flexible in terms of location
  - Available in English upon request

5 Key Takeaways
Based on Ongoing and Completed Projects

(1) Document Boundary Conditions
- Clearly document all boundary conditions in advance, including radiological characterization (activation and contamination) and local conditions (ideally via a 3-D laser scan).

(2) Parallel Preparations
- Preparations can often be parallelized to save time.

(3) Fleet Approaches
- Utilize fleet approaches to transfer proven technologies to nuclear power plants of the same or similar type.

(4) Logistical Planning
- Plan loading and dismantling logistically to occur in parallel.
- Coordinate handling (GNS task) and container removal (customer task).

(5) Composite Supplier Role
- The dismantler should ideally also be a composite supplier, designing and manufacturing containers and casks for transport, interim, and final storage of radioactive waste.

If you need support and experience from lessons learned for your D&D projects feel free to ask the GNS group – the market leader in Germany for D&D!

Q & A

Contact

Dr. Luc Schlömer

schloemer@nuclear-training.de

AACHEN INSTITUTE FOR NUCLEAR TRAINING GMBH (AiNT)

Cockerillstraße 100

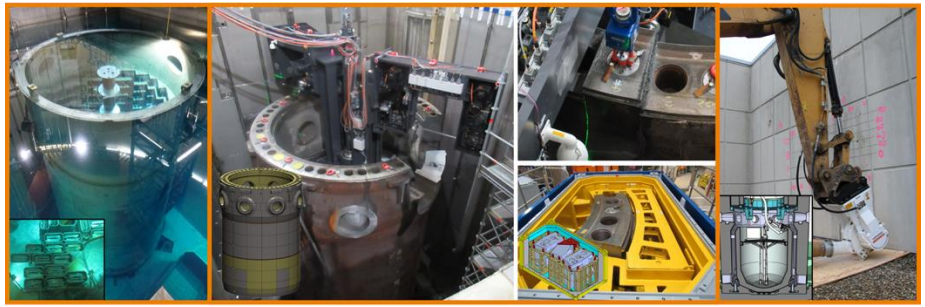
D-52222 Stolberg (Rheinland)

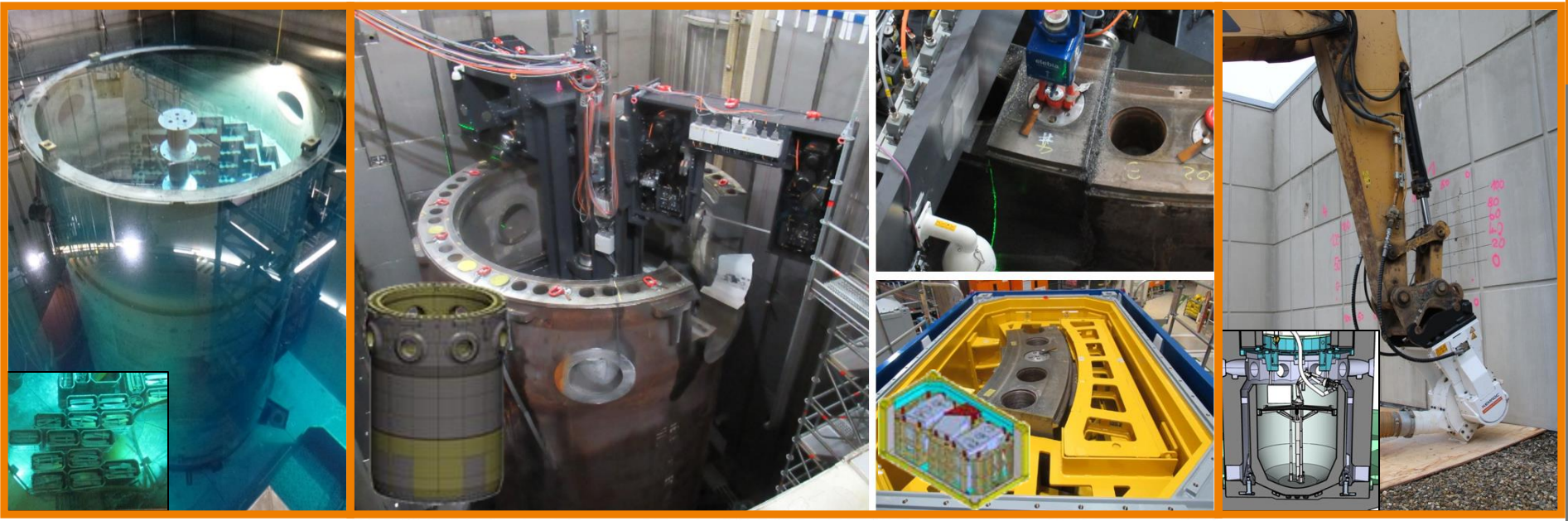
+49 (0)2402 10215-00

info@nuclear-training.de

AiNT
GNS-Gruppe

Excellence for Nuclear.





Decommissioning of Activated Reactor Components in Germany and Lessons Learned

Dr. L. Schlömer, B. Könning, T. Eichhorn, P. Sommerer, Dr. Josef Kim

Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22-23, 2025

AiNT
GNS-Gruppe