

Characterization of Solid Building Structures with NaI Gamma Spectroscopy

PREDEC 2016: February 16-18, Lyon, France

Nadine Liehr TÜE; E.ON Kernkraftwerke Isar, Dammstraße, 84051 Essenbach, Germany

The E.ON logo is located in the bottom right corner of the slide. It consists of the text "e.on" in a white, lowercase, sans-serif font, set against a solid red rectangular background.

Starting Situation

Introducing Kernkraftwerke Isar (NPP Isar)

Isar 1 (KKI 1) – Technical Data

Reactor Type	BWR
Gross Output	912 MW
Commissioned in	1977
Stop of operation	August 2011

Isar 2 (KKI 2) – Technical Data

Reactor Type	PWR
Gross Output	1485 MW
Commissioned in	1988



Starting Situation

Everything changed for NPP Isar after March 2011

- Withdrawal of permission for power operation on NPP Isar 1 based on the 13th amendment to the Atomic Energy Act of the July 31, 2011
- Event-related (Fukushima / 13th amendment AtG) planning for
 - the permanent post operation of KKI 1
and simultaneously
 - decommissioning and dismantling of KKI 1
considering a conditionally reversibility
- Challenge:
Sensible use of the multi-annual phase up to the granting of the decommissioning and dismantling permit for KKI 1 in accordance with the operating permit (§ 7 AtG).

Starting Situation

Preparation of KKI for Decommissioning Activities

- Set-up of required infrastructure for nuclear waste conditioning
- Creation of logistic infrastructure buffer, transport and storage areas
- Decommissioning and disposal of concrete slabs
- Enhancement and commissioning of additional measurement laboratories
- Set-up of facilities for clearance measurements
- Evaluation and introduction of novel methods, which might foster decommissioning activities

Starting Situation

Expected Masses During Decommissioning of KKI 1

total mass ~ 224.000 Mg	
inactive building structures ~ 200.000 Mg	activated / contaminated ~ 24.000 Mg



waste conditioning:
- decontamination & clearance measurements
- packaging, conditioning, measurements of radioactive waste
- preparation for reuse of resources in other nuclear facilities



release of building structures
(conventional waste)
~ 200.000 Mg
≈ 75.000 m²



release with or without restrictions,
reuse
~ 20.600 Mg



radioactive waste for intermediate or final storage
~ 3.400 Mg

Starting Situation

Measurement Setup – Contamination Monitor



- Widely spread state of the art technology
- Surface contamination is measured (Bq/cm^2)
- Dull and error-prone extensive manual labor

Starting Situation

Measurement Setup – In-Situ Gamma Spectroscopy



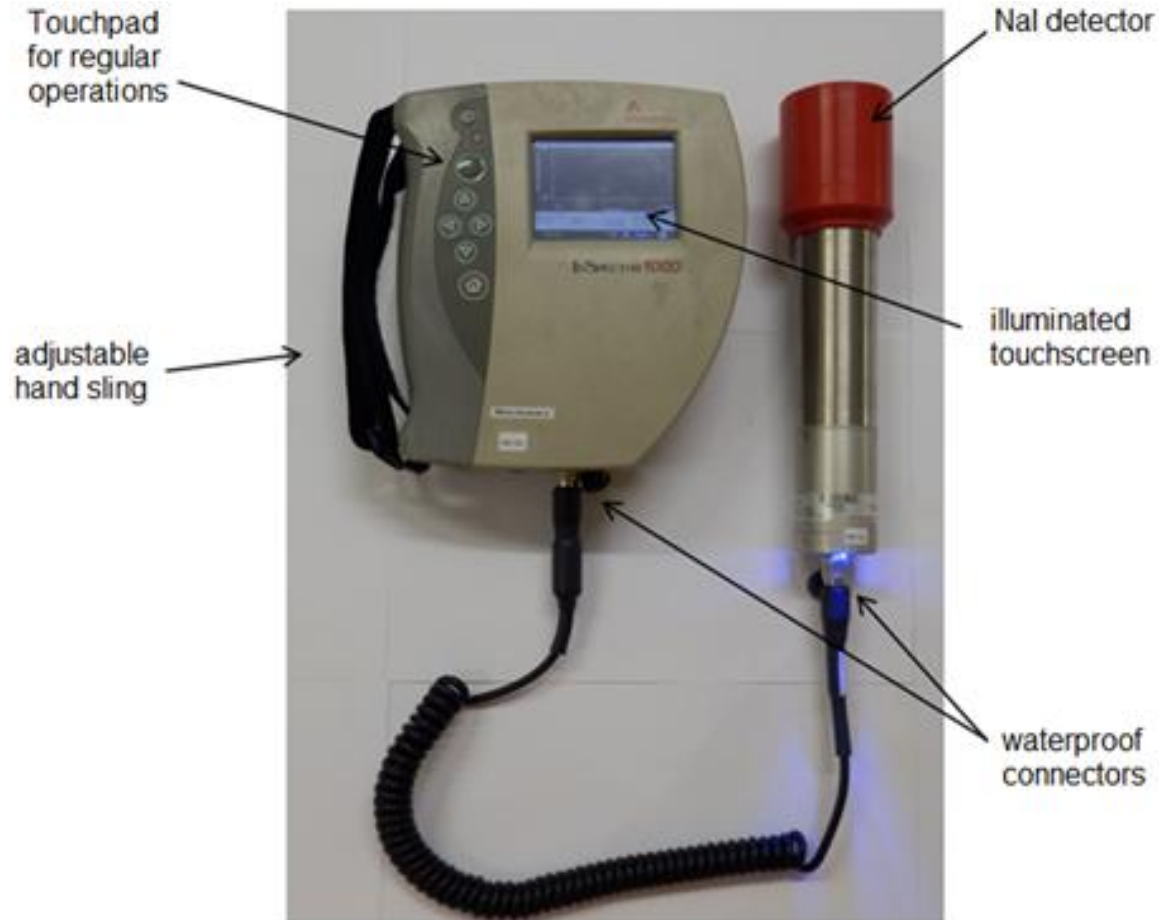
Starting Situation

Motivation

- Existing approaches for classification measurements come with obvious drawbacks like:
 - high demand for manual labor
 - high investment costs
 - special requirements for handling
 - As KKI 1 is currently blocked by the missing dismantling permit, now is a good time to investigate and implement improvements for decommissioning activities
 - Despite of the conditional reversibility requirement of all dismantling preparations at KKI, concrete structures with a total surface area of roughly 5.000 m², weighting 2.000 Mg need to be disposed in the short term
- ⇒ Establishing novel classification methods now and getting them approved by German authorities for use in our facility will help us tremendously, once the dismantling activities can finally start.

Introduced Measurement System

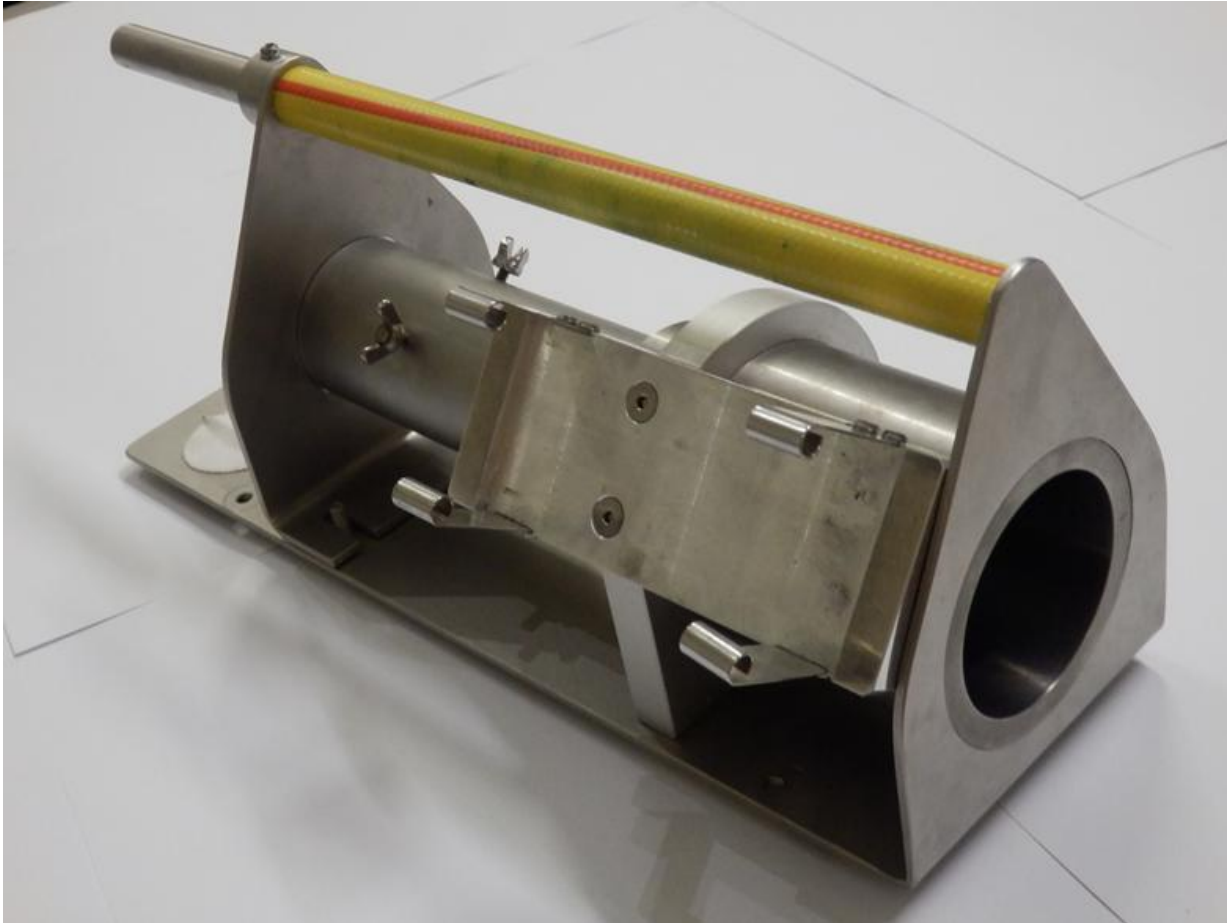
Measuring Device and Detector Utilized for KKI Setup



InSpector™ 1000 from Canberra Industries with 2" x 2" temperature stabilized IPROS-2 NaI detector

Introduced Measurement System

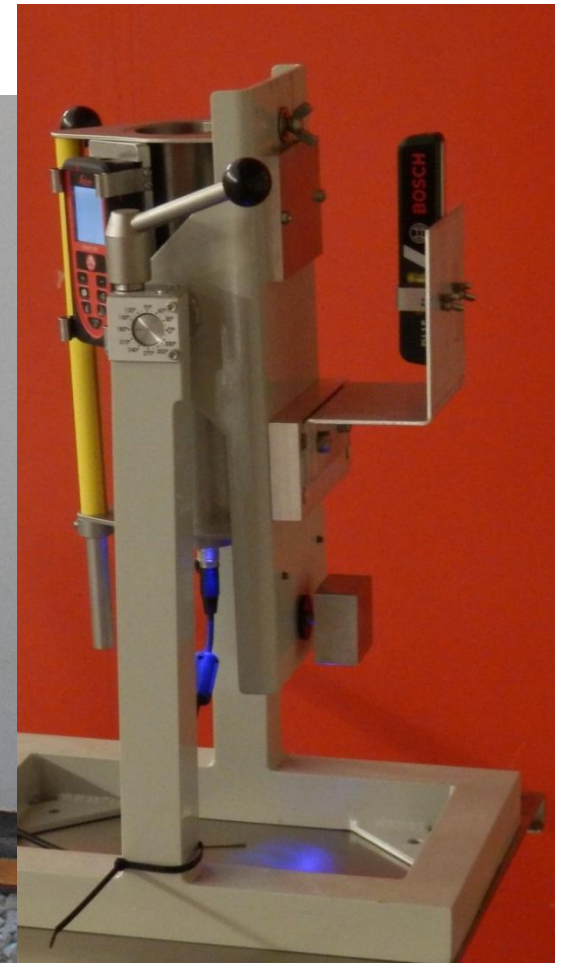
Collimator Utilized for KKI Setup



Tungsten – collimator, 1 cm thickness, without detector

Introduced Measurement System

Measurement Setup



Measurement system as used in the KKI, probe inserted into the collimator, complete with handling frame, laser range finder and laser pointer

Introduced Measurement System

Technical Data

Dimensions:

(handling frame w. collimator)

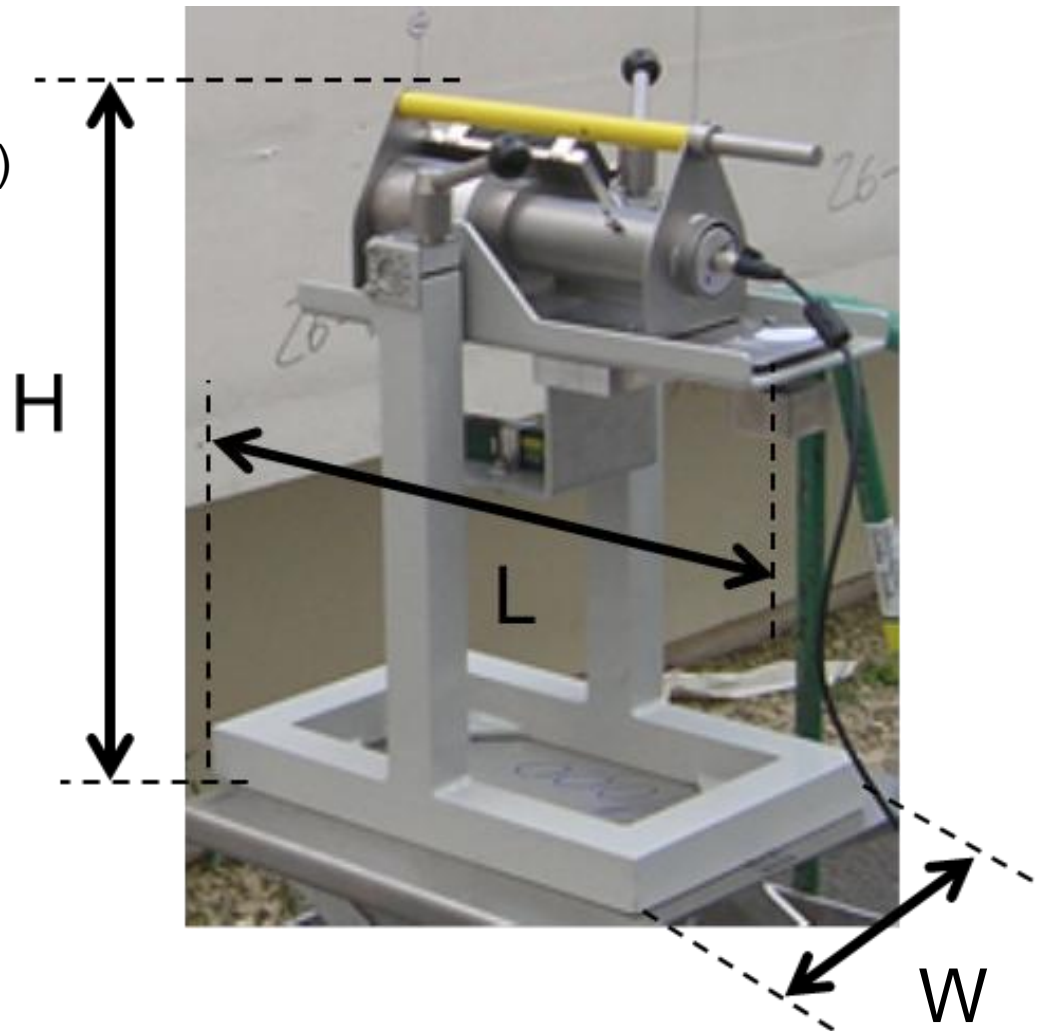
H: 510 mm

W: 260 mm

L: 460 mm

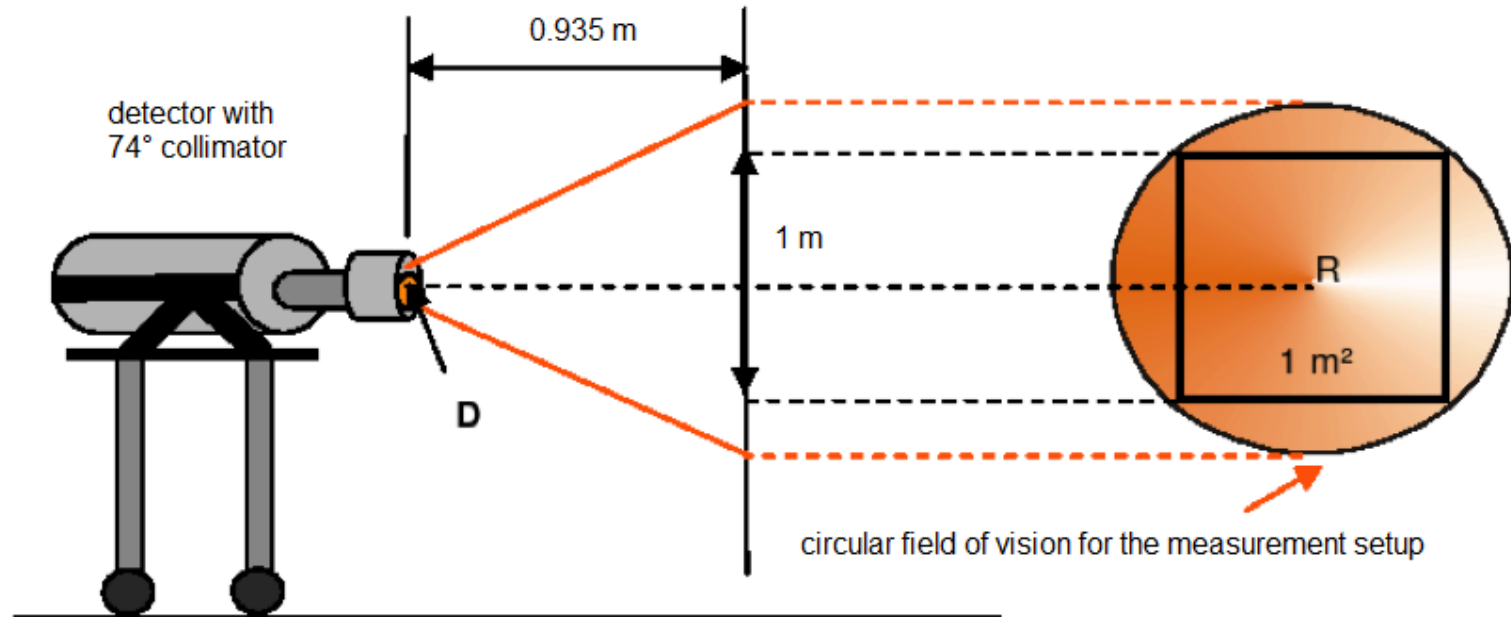
Weight:

- Collimator, handling frame and detector: ~ 16kg
- InSpector™ 1000: ~ 1kg
- Laptop: ~ 2.5 kg
- Total: ~ 20 kg



Introduced Measurement System

Measurement Setup



- Conservativeness of activity calculation: Measured activity will be considered as measured for 1.0 m² (real measured area: 1.6 m²)
- Activity with a penetration depth up to 1cm will be considered
- Required measurement time: 5 min
- 80 m² measured area per setup per day with one operator (1 m² per measurement, 10 measurements per hour, 8 working hours per operator)

Introduced Measurement System

Measurement Setup



Introduced Measurement System

German Regulations for Release Measurements

- Aim is to prove by measurement that the activity of:
 - the part of a concrete building or a plain concrete structure
 - averaged on a measured area of 1m²
 - lies below the permitted activity for the release of buildings, rooms and structural components as defined in App. III Table 1, **Col. 10** of the German Radiation Protection Ordinance (StrlSchV)
- Allowed activity for:
 - release **without conditions**: 1.0 Bq/cm² → 1m²: 1.0 E4 Bq (App. III Table 1 **Col. 4** StrlSchV; 100% Co-60 nuclide vector)
 - release **for demolition**: 3.0 Bq/cm² → 1m²: 3.0 E4 Bq (App. III Table 1 **Col. 10** StrlSchV; 100% Co-60 nuclide vector)

Radionuklid	Freigrenze			Oberflächenkontamination in Bq/cm ²	Freigabe										Halbwertszeit
	Aktivität in Bq	spezifische Aktivität in Bq/g	Aktivität HRQ/1/ 100 A ₁ in Bq		uneingeschränkte Freigabe von				Freigabe von						
					festen und flüssigen Stoffen in Bq/g	Bauschutt, Bodenaushub von mehr als 1 000 t/a in Bq/g	Bodenflächen in Bq/g	Gebäuden zur Wieder- Weiterver- wendung in Bq/cm ²	festen Stoffen bis zu 100 t/a zur Beseitigung auf Deponien in Bq/g	festen und flüssigen Stoffen bis zu 100 t/a zur Beseitigung in Verbrennungsanl. in Bq/g	festen Stoffen bis zu 1 000 t/a zur Beseitigung auf Deponien in Bq/g	festen und flüssigen Stoffen bis zu 1 000 t/a zur Beseitigung in Verbrennungsanl. in Bq/g	Gebäuden zum Abriss in Bq/cm ²	Metallschrott zur Rezyklierung in Bq/g	
Co-60	1 E+5	1 E+1	4 E+9	1	E-1	9 E-2	3 E-2	4 E-1	6	7	2	2	3	0,6	5,3 a

Introduced Measurement System

Requirements Derived from Regulations

- Release measurement with allowed activities for demolition was performed
 - ⇒ an evidence for demolition needs to be documented
- Lead nuclide for KKI is Co-60
 - ⇒ release value is $3.0 \text{ Bq/cm}^2 \rightarrow 1\text{m}^2: 3.0 \text{ E4 Bq}$
- Translates to a detection limit $< 1.1 \text{ Bq/cm}^2$ for Co-60
 - ⇒ measurement duration of 300 s required
- As part of the process
 - structures need to be cleaned before measurements
 - screening tests need to be performed
 - nuclide specific analysis of material samples need to be done

Introduced Measurement System

Additional Requirements, Demanded by Authorities

- Single measurements need to overlap by 10cm
- Although a homogeneous surface contamination is expected, a conservative calibration geometry has to be used. Homogeneous activity 1cm below the concrete surface will be considered.

Results

Processed Concrete Structures

During 2013/2014

- No. of slabs: 180
- Total weight: 1.600 Mg
- Total area: 3.200 m²



Results

Processed Concrete Structures

2015

- No. of walls: 7
- Total weight: 200 Mg
- Total area: 300 m²

Release measurements during the reconstruction of a measurement laboratory.



Results

Comparison of Competing Approaches

	Contamination Monitor	Ge detector (semiconductor)	Nal detector (scintillation counter)
Tooling costs	low	high	low
Area / measurement	166 cm ²	40.000 cm ²	10.000 cm ²
Time / measurement	15 s	15-20 min	5 min
Measurements / h	40	2	10
Measured area / h	4 m ²	8 m ²	10 m ²
Measuring time / NPP	18.750 h	9.375 h	7.500 h
Tooling weight	2 kg	100-150 kg	15-20 kg
Tooling issues	<ul style="list-style-type: none">• Dull, unergonomic work• Detection gas required	<ul style="list-style-type: none">• Bulky setup• N2 cooling required• Labor-intensive maintenance	<ul style="list-style-type: none">• Battery holds for a 8-10 h working day

Results

Conclusion

- A measurement system for release measurements, employing a NaI detector, has been implemented
 - Comparisons with established systems for release measurements have been drawn
 - For release measurements of large concrete structures, the system has shown its advantages in term of costs, time consumption and required personnel
 - The required qualifications to use this system during dismantling activities at the German NPP Isar have been performed
- ⇒ The permission was granted by the responsible German ministry in July 2013 and the system was successfully commissioned.

Results

Outlook

- The current commissioning permission is limited to NPP Isar
 - ⇒ Approval should be pursued also for other NPPs
- Currently only measurements to release structures for demolition can be performed
 - ⇒ Modifications to the setup, which would allow measurements for unrestricted release, should be investigated
- Participations on regular comparison measurements, e.g. bi-annual comparison measurements arranged by University Regensburg
 - ⇒ Acquire additional comparison data
 - ⇒ Identify additional application scenarios

Thank you for your interest!



e-on

Backup

Introduced Measurement System

Comparison of Detector Types

Ge detector

(semiconductor technology)

- Established method, employed for release measurements
- Superior radio-nuclide energy resolution
- Small response capability for photons
- Cooling required to suppress dark currents
- Bulky and cost intensive setup required

NaI detector

(scintillation counter technology)

- Not yet established for release measurements in German NPPs
- Inferior radio-nuclide energy resolution (large peak width)
- High response capability for photons
- No additional cooling required
- Cheaper setup with less required handling effort

Starting Situation

Activities Before Dismantling Permission is Granted

- Planning and execution of the approval procedure for decommissioning and dismantling (§ 7 AtG)
 - Planning and implementation of infrastructures, fitting for the intended dismantling activities of KKI 1
 - Execution of a technical and radiological system characterization of KKI 1
 - Planning and execution of measures to reduce the critical path for the dismantling activities
 - Planning and execution of preparing activities for the decommissioning and dismantling
- ⇒ Preparation of an infrastructure for waste conditioning and disposal within the control area of KKI 1