Siempelkamp
NIS Ingenieurgesellschaft mbH

VAK GmbH

Unrestricted Release of Buildings and Site of NPP Versuchsatomkraftwerk Kahl - VAK

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Unrestricted release of VAK

Contents of presentation

- History and initial situation
- Procedure release of buildings
- Results of release of buildings
- Procedure release of site
- Results of release of site
- Lessons learned
- Consequences of lessons

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VAK History

- First NPP in Germany
- Operator: Versuchsatomkraftwerk GmbH
  - Shareholder: RWE 80% - E.ON 20%
- Type: dual circuit BWR 16 MW electrical
- Supplier: AEG, Germany / GE, USA
- Erection: 1958 – 1960
- Operation: 1960 – 1985
  - Fuel Testing programs, operational experience, personnel training
- Production: 2,1 TWh
- Start decommissioning: 1988
  - 1988 – 2001: by VAK GmbH
  - 2001 – 2008: by NUKEM Technologies GmbH
  - 2008 – 2010: by VAK GmbH / NIS
- Green field: October 2010

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Initial situation I

VAK specific rules and standards for release

- **4. Decommissioning licence of 12.01.2000 (4. StG)**
  - 4 Nuclide vectors
  - Their examination during application
- **Operations Manual (BHB) with Radiation Protection Rules (SSO)**
  - Procedures for different types of material
  - Specification of averaged surface and mass for clearance measurements
  - Reference of clearance values to § 29 Radiation Protection Ordinance (StrlSchV)
  - Procedures for possible changes
- **Organisation Manual (OHB) with Operational Instructions**
  - Reference to operational history
  - Reference to specific buildings and site areas
  - Specification of measuring methods, size of sampling
  - Examination of nuclide vectors
- **Working procedures and worker briefing**
  - Procedures for decontamination, requirements for release, industrial safety

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Initial situation II

Advancing state of the art

- **Amended German Radiation Protection Ordinance (StrlSchV) in 2001**
  - Release limits more specific; partly much lower (column 7 – site areas)
- **Enhanced German Standard DIN 25457, parts 6 and 7**
  - Detailed, conservative specifications of release procedures,
  - Statistic procedures for locations of measuring and sampling
- **Enhanced generale licensing**
  - More restrictive
  - More focused to decommissioning

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General performance

Steps of performance

- Radiological characterisation
- Decontamination, attendant measurements and conditioning of materials
- 1. Clearance measurements by licencee
- Controle measurements / approval of release by authority
- Disposal of released materials and radioactive waste
- Release from application of German Atomic Act (AtG)

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Release of buildings

Contamat Measurement

Core drilling

Marking of contaminated areas

Radiological characterisation

Identification of nuclide vectors and distribution of radioactivity

- **Scanning of surfaces**
  - **Large area gas flow counters (Contamat)**
  - **Gamma scintillation counters (Scintomat)**
- **Evaluate depth profile on selected locations**
  - **„Stocker“-sampling, stepwise 2-5 cm**
  - **Core drilling**
  - **Analysis of samples at the Radlab**
- **Smear tests**
  - **Remaining equipment, e.g. fastening bars anchor slabs**
- **Marking the relevant areas on the spot**
- **Documentation of initial radiologic. situation**

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Release of buildings

Marking hotspot

Removal by scabbling

Surface decontamination

- Removal of local, near to surface „Hot Spots“ (< 2 cm) e.g.:
  - Material failures and crevices
  - Fastening bars
  - Wall plugs
- Removal of large portions of surface by:
  - Shaving
  - Steel shot blasting
  - Scabbling
  - Milling, wall / floor

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Release of buildings

Removal by manual pneumatic hammer

Surface decontamination

- **Migrated contamination or activation (> 2 cm)**
  - Deep material failures or crevices
  - Pipe penetrations,
  - Constructive gaps
  - Narrow rooms, wells
- **Deep removal**
  - Manual pneumatic hammer
  - Core drilling
  - Pneumatic rock excavator
  - Diamond wire saw (special cases only)

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Release of buildings

Reactor building: Radiological characterisation

- **Results**
  - **Deep (->70 cm), partly extensive migration of radioactivity into internal building structures**
- **Consequences**
  - **Removal of hotspot areas (radwaste) before demolition of internal building structures to avoid dilution of radioactivity**
    - **Surface specific release: „Col. 10 – buildings for demolition“: e.g. Co60: 3 Bq/cm²**
  - **Demolition of all internal structures inside steel containment before clearance measurements**
  - **Change of general procedure according to 4. Decommissioning Licence**

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Release of Reactor Building structures

Removal by
pneumatic rock excavator

Removal by diamond wire saw

Decontamination of all contaminated or activated structures

- **Complete removal of walls and floors**
- **Consideration of static requirements of remaining structures**
- **Elevation-wise demolition of Reactor Building internal structures**
  - **Pneumatic rock excavator**
  - **Diamond wire saw (special cases only)**

Mass specific clearance measurements

- **Mass specific release: „Col. 6 – building rubble“: e.g. Co60: 9E-2 Bq/g**

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Release of buildings

Concrete breaker at controlled area

Mass specific clearance measurements by licencee
(radioactivity migrated into building structures)

- **Conditioning of material to be measured**
  (Breaker, filling of drums)
- **In-situ-gamma spectrometry on drums**
  (alternatively: gross gamma measurements)

Filling of drums with concrete rubble

In-situ measurements of drums

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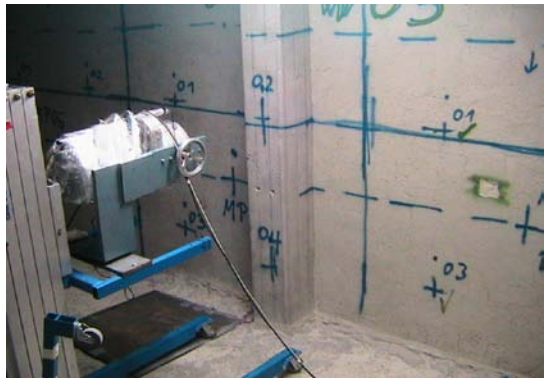
Release of buildings

In-situ gamma spectrometry on steel containment

Surface specific clearance measurements on structures by licencee

- In-situ gamma spectrometry, whole controlled area
- Alternatively measurements by Contamat on areas difficult to access
- Evaluation of depth profiles on selected locations by „Stocker“-sampling

The results of the final measurements were documented



In-situ gamma spectrometry

Measurements from lifting gear

Marking after in-situ measurements

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Release of buildings

Advantage of in-situ-gamma spectrometry

- Measurements consider also migrated radioactivity and activation inside building structures
- Calibration adaptable to measuring problem
  e.g. in relation to surface, mass and depth
- Facilitates selective identification of gamma nuclides
- Limited identification of low energy gamma radiation (e.g. Am 241)

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Release of buildings

Control measurements by in-situ gamma spectrometry

Control of measurements / release by authority

- **Checking of „final state“ documentation**
- **Inspection of „initial state“ and documentation of „accompanying measurements“**
- **Control measurements (In-situ, Contamat und depth profile)**
- **Written confirmation of release**

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Results of release of buildings

Reactor building

- **Duration in total 24 months;**
  thereof 12 months for removal of internal concrete structures

Mass specific clearance measurements - internal concrete structures:

- Mass of concrete 4.200 Mg -> filling into 200 l-drums
- Number of 200l-drums 14.000 -> in-situ drum measurements
- Control measurements by authority 2.100 drums (15%!)
- Cost of release procedure 2.300 €/Mg in total

The internally demolished and on its inner surface already released reactor building (steel containment) were afterwards cut into pieces and the pieces were measured from outside too

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Results of release of buildings

Waste treatment building (AG) and multi-purpose hall (MZH)

- **Duration** — ca. 18 months
- **Internal surface** — ca. 9.300 m²
- **Number of measurements**
  - In-situ (ca. 80 % of surface) — ca. 2.900
  - Contamat (ca. 20 % of surface) — ca. 118.000
  - Material and stocker samples — ca. 1.400
- **Specific costs**
  - AG: pre-measurement, decontamination of surfaces, removal of some internal walls* — > 300 €/m²
  - MZH: pre-measurement, decontamination of surfaces and clearance measurements — ca. 250 €/m²

* without clearance measurements

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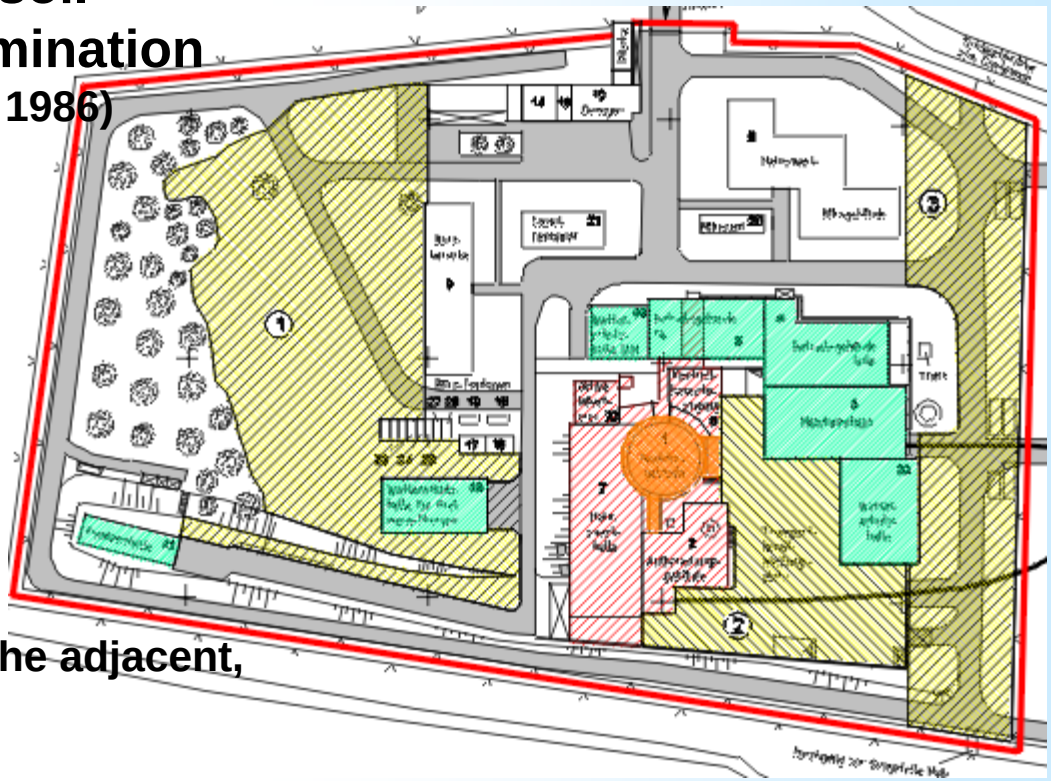
Release of site

Radiological characterisation: sampling program

- **Verification of nuclide vectors**
- **Evaluation of depth profile in soil**
- **Examination of foreign contamination**
  (Cs137, Sr90: bombs fallout, ChNPP 1986)

- **Internal VAK site**
  - **Paved surfaces**
  - **Unpaved surfaces**
  - **Sampling on surface layer, drill core soundings**
- **Outside VAK site**
  - **Sampling on surface layer**
  - **Literature study**
  - **Experience from dismantling of the adjacent, already dismantled HDR plant**



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Release of site

Examination of foreign contamination (RCh): Sampling on surface layer
Foreign contamination partly in the range of release limits!

NUKLIDE	Release limits StrlSchV,Tab1,col. 7 mBq/g	Measured RCh VAK mBq/g	Measured outside+literature mBq/g	Deducted foreign contamination mBq/g
Co 60	30	< 0,5	---	---
Sr 90	2	< 5	2 - 9	2
Cs137	60	18 – 330	8- 590	10

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Release of site

Drill core soundings on the site

Drill core sounding (RKS)

Drilling pattern	1-2/400m²
Number of RKS	108 x 2 m deep
	14 x 8 m deep
Additional	20 below buildings
Number of licencee samples	600
Max. measured value	
	Cs 137 < 9 mBq/g
	Co 60 < 6 mBq/g
Number of TÜV samples	147 (~25%!)

Sampling from drill core sounding

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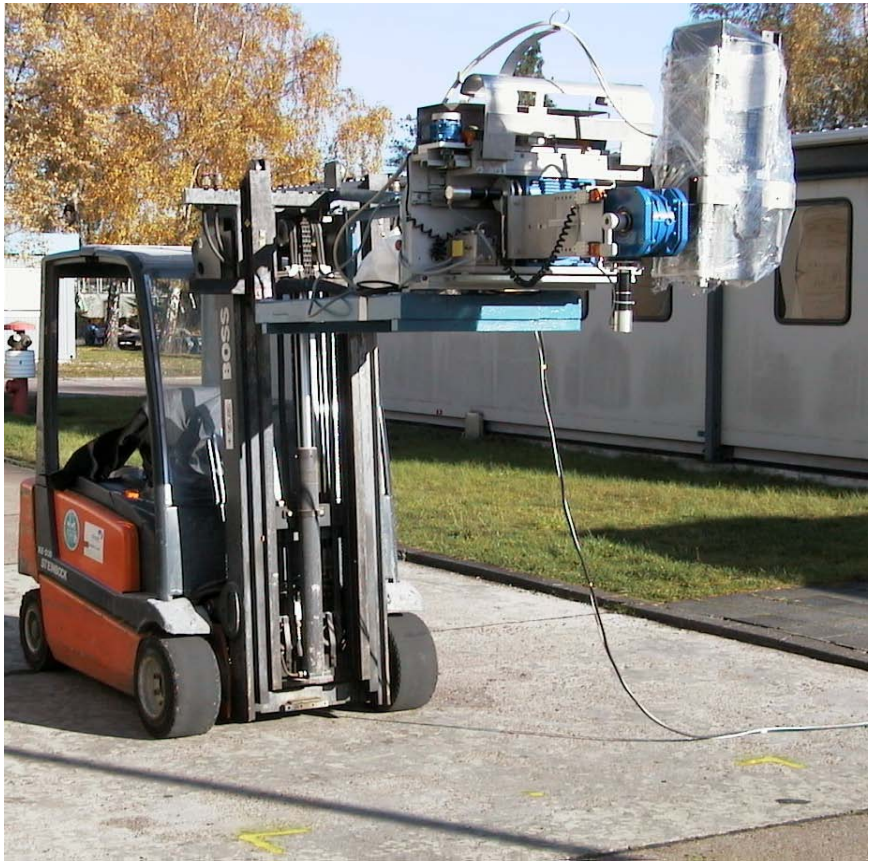
Release of site



Collimated in-situ gamma spectrometry on paved areas of the site

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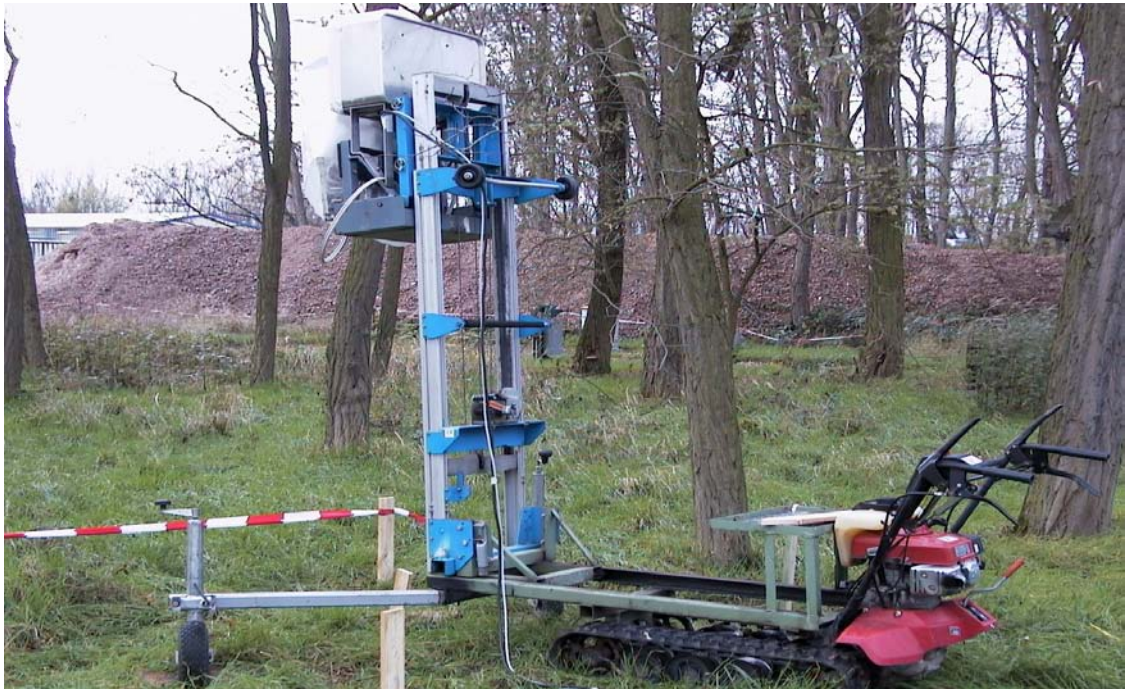
Release of site



In-situ gamma spectrometry on unpaved areas of the site

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Results of release of site

- **Surface of site** — **ca. 24.800 m²**
  - **Paved surfaces** — **ca. 15.800 m²**
  - **Unpaved surfaces** — **ca. 9.000 m²**
  - **Former controlled area** — **ca. 5.800 m² -> 100 % in-situ**
  - **Former supervised area** — **ca 19.000 m² -> 30 % in-situ**
- **Number of in-situ measurements (4m²; 1m²)** — **ca. 3.600**
  - **Paved surfaces (up to 2 cm deep)** — **ca. 1.200**
  - **Unpaved surfaces (up to 10 cm deep)** — **ca. 1.400**
  - **Additional after decontamination** — **ca. 1.000**
  - **Number of measurements by TÜV** — **ca. 500 (~ 14%!)**
- **Efforts**
  - Measurements — ca. 40-60 min each
  - Preparation / QA of measuring techniques — ca. 60 min/day

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Disposal of released material

Concrete breaker unit

Intermediate storage of clearanced concrete rubble

Disposal of released material

- Unrestricted disposal
- Reutilisation at landfill sites
- Disposal at municipal repositories
- Backfill at building pits
  (for VAK rejected by Authority)

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Lessons learned

- Operational documentation insufficient for decommissioning
- Contamination on RG-/AG-structures considerable deeper than expected
- Planned execution of RG´s demolition had to be changed
- Substantial more efforts to avoid dilution of activities during demolition
- Qualification of new measuring techniques
- Considerable more efforts for dismantling, decontamination and clearance under controlled area conditions
- Increased amount of radioactive waste due to deep migrated contamination
- External foreign contamination made the release of site more difficult
- Rise of requirements for the clearance procedures increases efforts
- Efforts of independent experts (TÜV) rose strongly

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Consequences of lessons

- Documentation during plant operation should also targeted to later dismantling
- Radiological characterisation should start asap
- Planned procedures should be early discussed with authorities
- Different measuring techniques should be applied
- Qualification of measuring techniques should be discussed with authority/TÜV
- Licence should be open for changes to new techniques
- Linking of decontamination of surfaces with measurements should be considered
- Fair accounting modes between customer and contractor

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Dismantling after release of site

Demolishing waste treatment building

Demolishing turbine table

Crushing concrete structures

Lower part of reactor building

Filling reactor building pit below –4 m

Preparation of soil surface

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Latest View to VAK site

Status of Green Field 23.09.2010

Release of the former VAK buildings and site from application of German Atomic Act (AtG) will be officially declared on 22. October 2010 within a ceremony on site

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Nuclide Vectors*

Area	Co 60	Sr 90	Cs 137	Am 241
RG	45 %	<1 %	54 %	< 1 %
AG	19 %	1 %	79 %	1 %
Site	8 %	2 %	89 %	1 %

* Rounded values of reference nuclides 2009