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Radiological characterisation - the Greifswald NPP approach

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Abstract

At the Greifswald site, 8 units of the Russian pressurized water reactor type WWER 440 are located, including several facilities to handle and store fuel and radwaste. After the reunification of Germany in 1990, the operating units 1 - 5 were switched off and the construction work at the units 6 - 8 was stopped. In 1990 the decision was taken to decommission the units 1 - 5 and in 1995 the decommissioning license was granted. Since then the decommissioning activities are proceeding effectively and today the project is close to the finish line and it will be finished in 2013/14.

The radiological characterisation of the technical plant parts started in 1993, followed by the characterisation of concrete structures and ground areas. The general approach for the radiological characterisation was based on the assessment of the operational history, the analysis of known or potential contamination paths, the classification in to 3 categories (no contamination, potential contamination, contaminated) and finally on preliminary measurements and sampling evaluations.

For the free release process of ground areas special features such as the existence of over- and underground facilities and the influence from the Chernobyl accident and/or nuclear weapon fallout had to be taken into account.

Today an area of ca. 1.23 km² has been measured, of which ca. 0.76 km² have been exempted from the atomic law. This very encouraging result supported the intention of EWN to develop the site in an industrial area, i.e. to provide properties to private investors as soon as possible.

1 Methodology of the Radiological Characterisation – EWN approach

1.1 Objectives

The overall objective with the radiological characterisation (or inventorization) was to obtain an overview of the radiological status of the plant systems, buildings and ground areas, i. e. dose rates and contamination levels[1]. The data accumulated were collected in the so called doserate and contamination catalogues respectively. This overview must be performed to such a depth that in view of planning and licensing the following work can be performed:

Licensing

- calculation of the dose commitment to workers, public and radiological influence on the environment
- preparation of safety analysis
- preparation of radioactivity flow schemes

Planning

- planning of the material management, logistics and treatment
- selection of dismantling techniques
- selection of decontamination techniques

Project

- preparation of time schedules
- preparation of the man power breakdown
- planning of costs and cashflow

It is clear that the dose rate catalogue is the basis for the estimation of the dose commitment, shielding and decontamination measures required, notably for hot spots. On the other hand, the contamination catalogue is important for the waste management logistic and treatment, selection (if necessary) of decontamination techniques and safety analysis (release values of nuclides). Obviously all these issues have a major influence on the project.

The results of the radiological characterisation were entered into a relational database, which can be coupled to other existing databases for planning and waste management purposes. As the decommissioning proceeds supplementary and/or more precise measurements will be added to the radiological database as needed.

1.2 Methodology

First of all it must be mentioned here, that the methodology applied is partly different for the three main objects of interest:

- systems,
- buildings, and
- ground areas.

1.2.1 Operational history

In view of the selection of the representative sampling places the following aspects should be considered:

- Influence of operational history and operating process on contamination

- Known or potential contamination paths

[1] Activated material was treated separately (first by theoretical calculations based on neutron flux and later with some sampling for verification).

- Influence of operation status of systems and other aspects on the spot
- Known radiological data from the operation of the plant

1.2.2 Analysis of contamination paths

Normally, all systems in the controlled area are assumed to be contaminated.

In addition to operational irregularities and site specific incidents, also e.g. the opening of systems during maintenance work could have led to cross contamination.

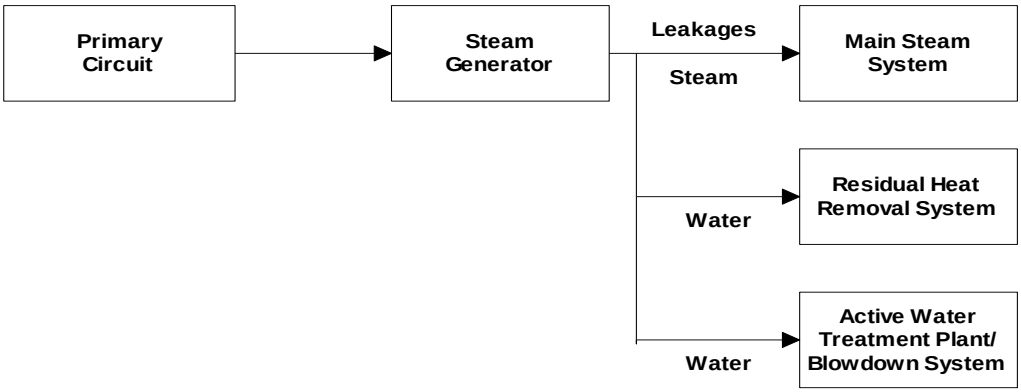

Figure 1: Example of contamination paths.

All systems, rooms and ground areas were investigated systematically in this manner.

1.2.3 Contamination classification

On the basis of the information of the operational history and the contamination paths all systems, buildings and ground areas (including especially transport routes like roads, rails, loading area and underground systems like process channels and cables) can be classified in the following three categories:

Category I:	contamination-free (*no connection to the controlled area and contaminated systems possible)*
Category II:	potential contamination (*paths from the controlled area possible*; i.e. contamination cannot be excluded)
Category III:	contaminated *(controlled area and known contamination due to identified contamination paths)*

For category I material control measurements (spot checks) are required for material release. For category II material, measurement of all material is required in order to decide on material release. Category III material is treated as radioactive waste and material can in some cases be released after decontamination and measurement.

Activated components and material is a category of its own and a release is only possible after decay.

New information concerning contamination are continuously added in the "Radiological Inventorisation" document. In this way this document is always up-to-date and represents the actual status of the plant.

1.2.3.1 Systems

The following tables give some examples on classification of systems in the controlled and supervised areas.

Table 1: Controlled area

No	System	unit	Interior surface contamination		
			no	potential	yes
1	Primary loops	1 - 5			x
2	Ventilation systems	1 - 5			
	supply air system			x	
	exhaust air system				x
3	Nitrogen system	1 - 4			x

Table 2: Supervised area

No	System	unit	Interior surface contamination		
			no	potential	yes
1	Main steam system	1 - 5		x	
2	Technical water and Intermediate cooling system	1 - 4		x	
	Auxiliary cooling system	5	x		
3	Turbine hall drain	1 - 4			x

1.2.1.2 Buildings

Meanwhile the decommissioning project has proceeded so far that the demolition of the first contaminated buildings were carried out. An example is the demolition of the Wet Spent Fuel Storage which was finalised end of 2010.

For these demolished buildings special free release procedures were prepared. The building structures were classified analogously to the system classification, if necessary decontaminated and subsequently the free release measurement was performed. After release of the building by the authority the conventional demolition started.

The presently favoured planning concept concerning the reactor buildings and special buildings is the following:

- decontamination of the Reactor Buildings 1 - 4 and the three Special Buildings up to a contamination level of ca. 20 Bq/cm² (Co-60);
- keep the building (no demolition);

- release/conventional demolition after decay (ca. 50 years);

This strategy has been applied and is presently discussed with/by different authorities.

1.2.1.3 Ground

Below a part of the Greifswald site (status after plan shut down) is shown with the categorisation of ground including roads and rails (yellow - category II; red - category III).

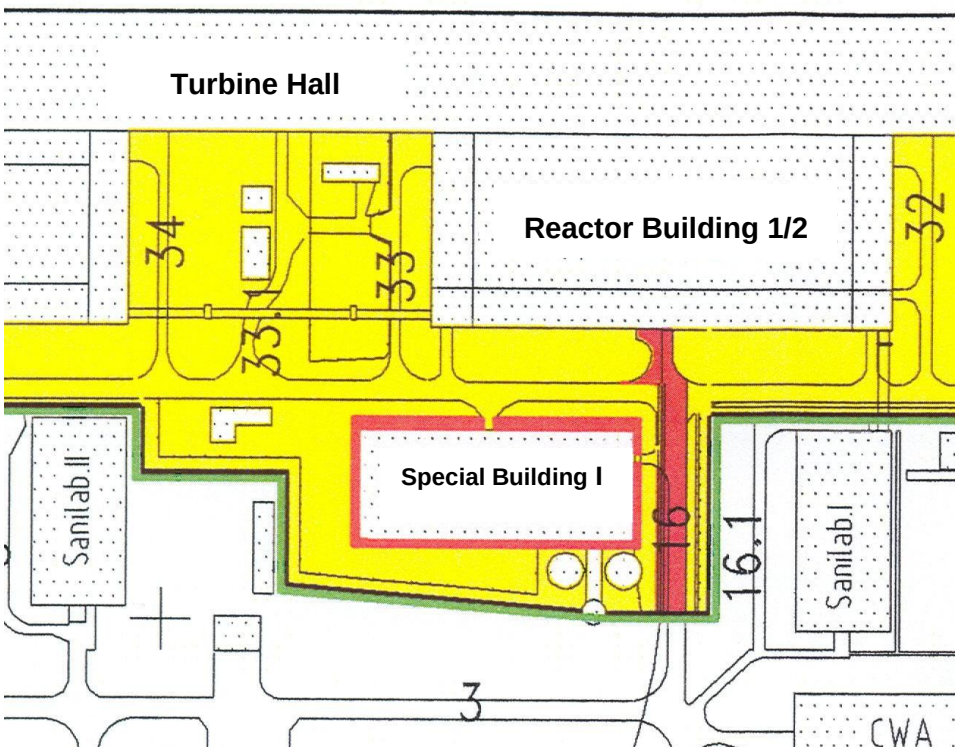

Figure 2: Categorisation of ground at the Greifswald site; extract from site layout plan

The categorisation of ground is based mainly on the known contamination paths and irregularities/incidents that have occurred. For some areas separate measurement programs have been executed in order to obtain more exact information, e.g. areas around special buildings (used for waste storage and treatment), areas in front of the entrance gates/transport corridors of the reactor buildings and warm workshop.

2 Measurement procedures and techniques for ground

2.1 Spot check measurements on ground areas free of contamination (Category 1)

The following measurements are performed of category 1 areas:

- Proof measurements for the confirmation of the correct categorisation based on the operational history (only deposition of airborne activity during 18 years of operation; indicator of contamination from operation: presence of Co-60)
- Proof that contamination has not deeply penetrated into the soil

The following techniques are used:

- uncollimated in situ gamma spectrometry
- gamma spectrometric analysis of samples

- Required detection limits for Co-60: **0.015 Bq/g or 0.1 Bq/cm²**

After measurements, no operations are allowed that could lead to a re-contamination of the areas.

2.2 Procedure for contaminated and suspected ground areas (Categories 2 and 3)

2.2.1 Prerequisites for the clearance procedure

For the clearance procedure of category 2 and 3 areas the following prerequisites are necessary:

- Availability of approved release limit values and boundary conditions (Notice of assessment or since 2004 Radiation Protection Ordinance § 29 and annexes III and IV have to be applied)
- Categorization of the ground areas
- Clearing of the areas and dismantling of all not permanently fixed constructions
- Preliminary investigations:
  - in situ gamma spectrometry measurements
  - nuclide vector determination
  - determination of penetration depth
- Choice of measurement procedure for clearance measurement
- If necessary, calculation of density of measurements
- Existence of a confirmed free release campaign

After preliminary investigations, no operations are allowed that could lead to a re-contamination of the area.

2.2.2 Clearance measurements

The clearance measurements can be carried out considering the boundary conditions below:

- Measurement density :
  - calculated for suspected areas
  - 100 % measured on contaminated areas
- Measurement techniques:
  - collimated and uncollimated in situ gamma spectrometry
  - gamma spectrometric evaluation of samples
  - evaluation of the material in the free release measurement facility
- Averaging area 1 to 6 m² (collimated) / 100 m² (uncollimated)
- Application of summation rule (sum formula) for nuclides
- in individual cases subtraction of the Cs-137 share from Chernobyl or nuclear weapon fallout possible (see paragraph 2.4)

2.3 Measurements with In Situ Gamma Spectrometry

Depending on the contamination classification (category) different requirements for the measurements must be taken into account:

Category I *(no contamination)*

Measurements:	spot check measurements without collimator 1 measurement per 1,000 m²
Measurement time:	3000 seconds

Category II *(contamination suspected)*

Measurements:	approx. 4 % of surface with 70° collimator averaging area 6 m²
	OR
	100 % of area without collimator averaging area 100 m²
Measurement time:	1000 **or** 3000 seconds

Category III *(contamination)*

Measurements:	100 % of the area with 70° collimator; averaging area 6 m²
Measurement time:	1000 seconds

2.4 Subtraction of Cs-137 Activity from the Chernobyl accident and Weapon Test Fallout (individual case)

In the issue 1/96 of the magazine „Strahlenschutzpraxis“ a graphic, which shows the contamination distribution within the FRG, displays a measured contamination interval from 2000 Bq/m² up to 4000 Bq/m² (1986) for the areas outside the NPP site (areas Greifswald, Demmin, Anklam and Ueckermünde).

To quantify these results in the surrounding area of the NPP Lubmin a measurement programme was developed and implemented in the year 2000. The boundary conditions and findings are summarised below.

At five places in the area around the NPP Lubmin (distance up to 25 km) in-situ-gamma spectrometry measurements were performed.

- The chosen areas outside NPP were mostly identical with the areas on the NPP site (grassy area, tree populations in greater distances, sandy soils with a density of approx. 1.3 g/cm³).
- The measuring points were spread within a range of ca. 200 m² up to 600 m².
- The scope of measurements amounted to 4% of the above mentioned areas, according to the decision measurements performed at category II areas.
- In total 75 measurements were performed.

Results:

The representative measurement values for the surface contamination amounts to 3419 Bq/m² (Cs-137) with a small standard deviation of ± 706 Bq/m².

From this an activity concentration of 52.6 Bq/kg at a penetration depth of 5 cm can be calculated.

This level of activity concentration was proved by samples from the NPP site, evaluated in the laboratory.

Influence on clearance procedure:

As a result of the performed investigations the externally caused Cs-137 share at the area of NPP Lubmin of

3100 Bq/m² (0.31 Bq/cm²) and

47 Bq/kg (0.047 Bq/g)

can be seen as underlying background radiation. These values consider the surface contamination caused by airborne emissions of NPP Lubmin which have been calculated by Brenk-Systemplanung with 300 Bq/m².

The value amounts to 50 % of the release limit value for Cs-137 for unrestricted release of ground areas.

For some specific sites with higher contamination risk the regulatory authority confirmed as site specific Cs-137-underground, which was not caused by the operation of the nuclear facility, the following values:

2700 Bq/m² (0.27 Bq/cm²) and

41 Bq/kg (0.041 Bq/g)

These values for Cs-137 can be subtracted from all clearance measurements.

3 Exemption of areas from regulatory control

The following prerequisites must be fulfilled before the authority can exempt a specific area:

- Confirmation that the area is free of contamination and/or approval of compliance with the release limit value
- Confirmation that neither over- nor underground facilities are remaining or confirmation that these ones are free of contamination and/or approval of compliance with the release limit value
- EWN files an application on changing the radiation protection areas
- An independant authorized expert checks the application and the licensing authority confirms it
- EWN files an application for exemption

After that a ‘Notice of Assessment’ released by the authority confirms:

- the unrestricted release of the areas and
- the exempted areas are described exactly and land register compatible with the Gauss-Krüger coordinates.

In total on the NPP site an area of 1.23 km² has been measured, of which ca. 0.76 km² have been exempted.

4 Conclusions

It can be concluded that:

- the approach to classify systems, buildings and areas into radiological categories has proved very useful
- the used measuring methods, especially the in-situ-gamma-spectrometry, are suitable for the assessment of areas
- the used measuring procedures are practical, flexible and very effective for the assessment of large areas
- procedures had to be developed in detail and approved by the regulatory authority to prove that the areas are free of contamination and/or release measurement of the areas are performed
- all necessary arrangements were made, to comply with the requirements deriving from the radiation protection ordinance, especially with § 29