Note:
This is a translation of the summary information paper entitled
“Freigabe radioaktiver Stoffe und Herausgabe nicht radioaktiver Stoffe aus dem Abbau von Kernkraftwerken”.
In case of discrepancies between the English translation and the German original, the original shall prevail.

E S K

Clearance of radioactive material and removal of non-radioactive material from the dismantling of nuclear power plants

INFORMATION PAPER – **Summary**

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1 Background

Both the operation and dismantling of nuclear power plants as well as other handling of radioactive material in medicine, research and industry produce waste for which it has to be decided whether it must be disposed of in a repository as radioactive waste or can be recovered or disposed of in the same way as normal, conventional waste due to its negligible level of radioactivity. For buildings or sites of nuclear power plants it also has to be decided under what conditions they can continue to be used for other, conventional purposes or demolished. This decision is referred to as “release from supervision under nuclear and radiation protection law” or “clearance” in short. The material resulting from clearance does not require any further monitoring after release from regulatory control from a radiological point of view. Thus, the concept of clearance is based on the fundamental principle of law that minor matters are not regulated in a standard (“de minimis non curat lex” – the law does not concern itself with trifles).

According to the current state of knowledge, there is no threshold known for health effects from exposure to ionising radiation. For radiation protection purposes it is therefore assumed that even the smallest radiation dose can cause damage to health; however, the lower the radiation dose, the lower the probability for it. In the late 1980s, it was agreed at international level to consider a radiation dose of 10 to 100 microsieverts (µSv) per year as minor. Minor means that regulations to further reduce the radiation dose are not required. The clearance levels applicable in Germany according to the Radiation Protection Ordinance have been defined such that a radiation dose (hereinafter referred to as "dose") of 10 µSv per year is not exceeded.

A dose of 10 µSv per year is associated with a theoretical additional risk of damage to health of the order of 1:1 million; the risk is thus extremely low. The underlying detriment due to radiation includes deaths from cancer as well as genetic damage and other non-fatal diseases. In this respect, the effects of different types of radiation and the sensitivity of different body organs are also taken into account. The insignificance of this dose in practice is also shown by the comparison with the dose from natural sources in Figure 1. Since the natural dose depends on the place of residence and nutritional and lifestyle habits, it differs from individual to individual and in Germany ranges from about 1,000 to 10,000 µSv per year. The average natural dose to which every person in Germany is exposed is approximately 2,100 µSv per year. A dose of 10 µSv per year, up to which clearance is permitted, is extremely low both in relation to the average natural dose and to its bandwidth.

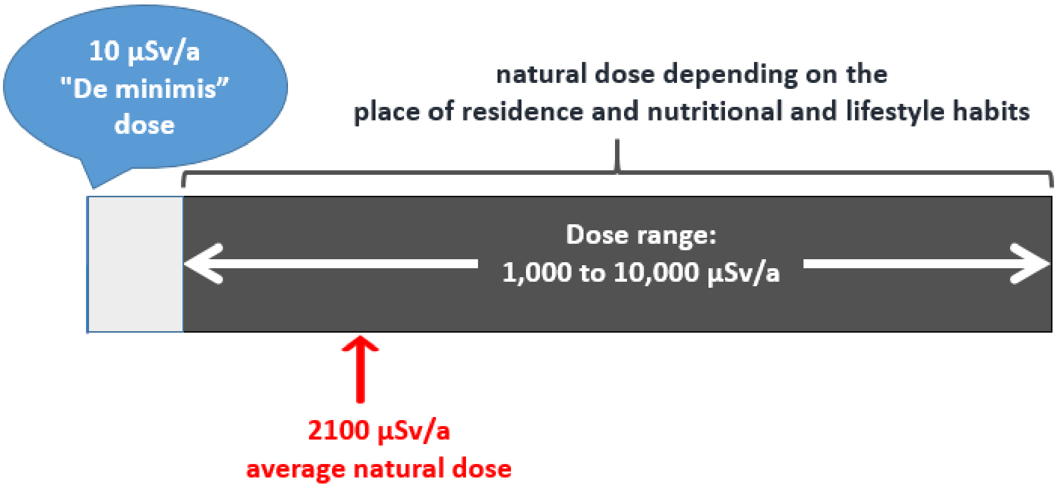

Figure 1: Dose range of the annual natural dose in Germany
(Data from: Federal Office for Radiation Protection, http://www.bfs.de/EN/topics/ion/environment/natural-radiation-exposure/natural-radiation-exposure_node.html)

Figure 2 illustrates the range of radiation exposure by comparing the average annual dose with the naturally occurring radioactive noble gas radon and its progenies in dwellings: A change of residence, for example from the Hanover region to the districts of Passau or Fulda, can lead to an additional radiation dose of about 900 µSv per year.

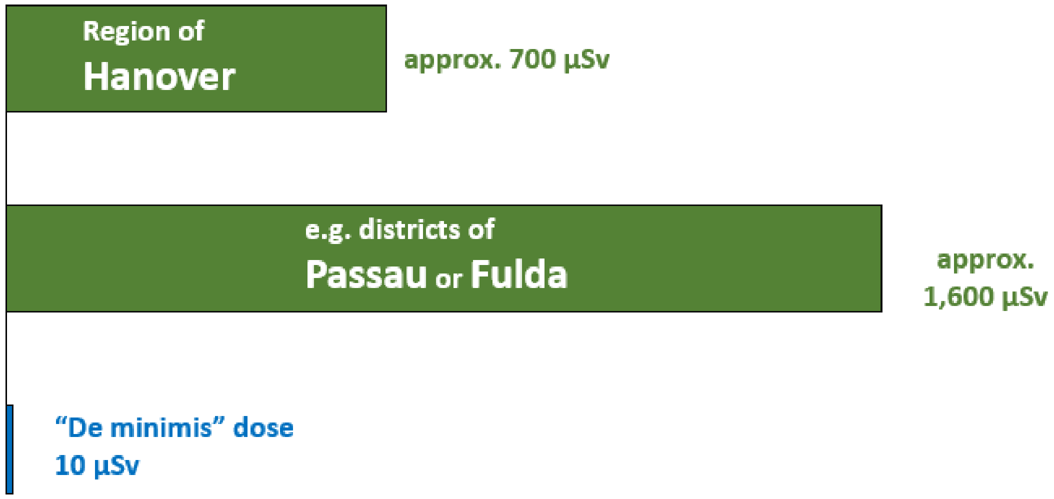

Figure 2: Estimation of the average contribution to the average annual natural dose by radon in dwellings (based on the values of the radon concentrations from Menzler S., Schaffrath R. A., Wichmann H. E., Kreienbrock L.: Abschätzung des attributablen Lungenkrebsrisikos in Deutschland durch Radon in Wohnungen. Landsberg/Lech: Ecomed Verlag 2006)

It is not possible to monitor whether a dose of 10 µSv per year is maintained by direct dose measurements. On the one hand, it is much too low for it and indistinguishable from doses from other radiation sources, and on the other hand, the doses that may occur in the distant future should also be limited to 10 µSv per year. Therefore, calculation models have been developed on the basis of which the clearance levels were derived such that in case of compliance with them, a dose of 10 µSv per year will not be exceeded.

Here, both persons dealing with cleared material in the context of their jobs as well as of the general public are considered in the calculations. For all persons, the same dose limitation applies, i.e. the limitation to 10 µSv per year. The general public also includes infants and their possible doses via their breast milk.

In accordance with the current state of knowledge about the effects of ionising radiation, the Nuclear Waste Management Commission (ESK) is of the opinion that the dose limitation to 10 µSv per year is therefore entirely appropriate for clearance since possible additional health risks are negligible compared to the ubiquitous risks from natural radiation sources and their dose ranges.

2 Why is clearance necessary in decommissioning?

Why not disposing of the entire mass of a nuclear power plant, or at least all parts of the controlled area (including building masses), in a repository?

In Germany, **all** radioactive waste is to be emplaced in deep geological formations in order to permanently keep it away from the human habitat.
The vast majority of the materials generated during the dismantling of a nuclear power plant (e.g. a large part of the massive concrete structures) are neither contaminated nor activated. Thus, there is no need to treat these materials as radioactive waste.

Another part of the materials, such as pipes from the controlled area, is only superficially contaminated and can be decontaminated by simple means, e.g. wiping or treatment with blasting media (e.g. water or sand blasting), and subsequently cleared.

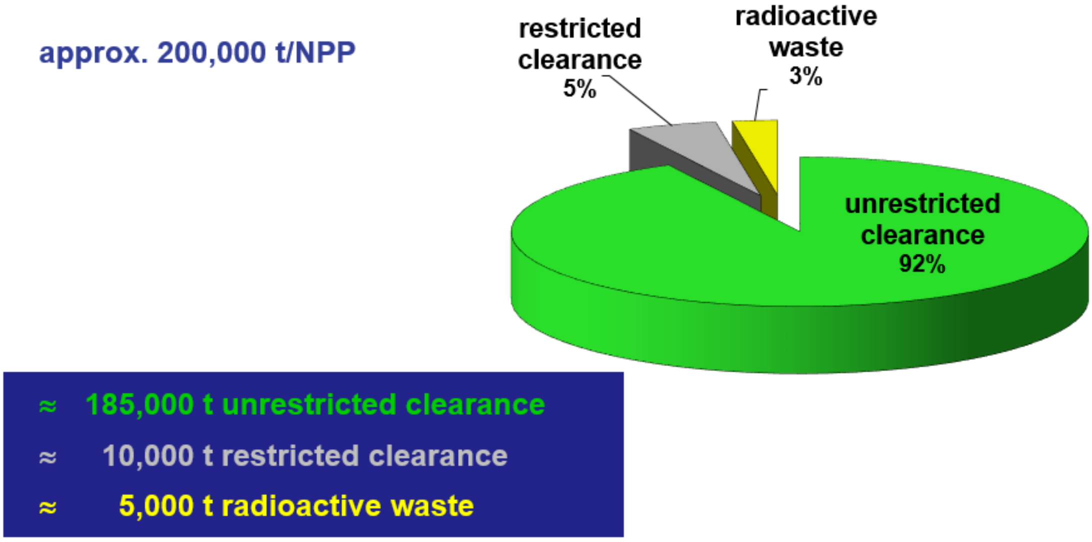

Figure 3: Approximate total mass from the controlled area of a German nuclear power plant (from the ESK presentation “Vergleich der Massenströme bei der Stilllegung von Kernkraftwerken in Deutschland und Frankreich” (Comparison of the mass flows from decommissioning of nuclear facilities in Germany and France) of 04.12.2014)

Emplacement of uncontaminated masses – which in Germany is essentially several million tonnes of building rubble – in a repository would require additional construction of such facilities, which, in view of the negligible hazard potential, from the point of view of the ESK is clearly to be rejected both economically and, in particular, ecologically.

Incidentally, the large masses from dismantling of the plants, e.g. the massive concrete structures, are **not** disposed of in a repository even in countries with surface disposal facilities for low- and intermediate-level radioactive waste (such as France) but assigned to the so-called “inactive zone” of the nuclear power plant and disposed of conventionally.

Alternative ways are increasingly discussed in public, such as the “abandonment of buildings after gutting”, i.e. refraining from demolition of the controlled area buildings of nuclear power plants. From the point of view of the ESK, this approach would not produce any safety benefits. On the contrary, the expenditure for the maintenance of buildings increases considerably with increasing age of the buildings. It would require considerable effort to maintain then useless buildings in a safe structural condition for long periods of time. Otherwise, the risks would increase significantly during inspections and a (much later) demolition since the stability of some concrete structures decreases sharply as the age of the building increases. In addition, access of groundwater could not be ruled out for many decades of simply leaving it standing. Furthermore, conventional pollutants such as oils and PCB could be present in a decommissioned nuclear power plant, which require proper conventional waste management and cannot simply remain in place.

Another proposal discussed in public, the landfilling or the long-term storage of cleared material at the site, does not offer any safety-related advantages either in the view of the ESK.

The creation of additional contaminated sites cannot be desirable in a modern industrial society. In addition, burdens from the use of nuclear energy, which today can be eliminated without endangering operating staff or the population, should not be passed on to future generations.

If, after completion of all dismantling work, the building has been decontaminated such that the clearance levels for buildings are complied with (see Figure 4), further use of the building rubble resulting from demolition is harmless from a radiological point of view.

Figure 4: Decontaminated building structures (PreussenElektra GmbH, Kernkraftwerk Würgassen)

For these reasons, Germany has deliberately decided to use clearance as an essential measure in the dismantling of nuclear power plants.

3 How does clearance work in practice and who controls it?

In principle, all objects or material that have been in an area where unsealed radioactive material has been handled (e.g. controlled area) or themselves constitute a controlled area are to be regarded as radioactive material. If it is intended to conventionally reuse or depose of virtually contaminant-free material from controlled areas, it must first undergo a clearance procedure.

According to the mixing ban of the Radiation Protection Ordinance, it is prohibited in the process of clearance to mix or dilute contaminated substances that exceed the clearance levels with low-contaminated or contamination-free substances in order to achieve clearance in a targeted manner.

The prerequisites that must be fulfilled for clearance are regulated in the Radiation Protection Ordinance, which includes two basic clearance pathways: unrestricted and specific clearance. The main difference between these two clearance pathways is that the material that complies with the levels for unrestricted clearance can be used without restriction in all areas of daily life. For the management of material from the area of specific clearance, however, clearly defined boundary conditions must be adhered to, compliance with which must be demonstrated within the clearance procedure.

For individual specific clearance pathways, clearance levels are applied which deviate from those for unrestricted clearance. This is due to the circumstance that certain exposure pathways[1] can be excluded for this specific clearance. An example of this is the clearance of waste for landfill disposal. Further use of this material, e.g. as an object of everyday usage, can therefore be excluded. The specific clearance levels for landfill disposal are based on calculations that apply to landfills that meet specified minimum requirements.

Specific clearance also includes the incineration of material, the recycling of metals, the clearance of buildings and the clearance of soil areas.

Compliance with the 10 µSv-concept can also be demonstrated in individual cases, taking into account the specific properties and conditions of the respective waste management facility.

In the following, the basic process of clearance is briefly presented and illustrated for a better understanding. It comprises five steps (see Figure 5).

[1] The way in which a person is exposed to radiation.

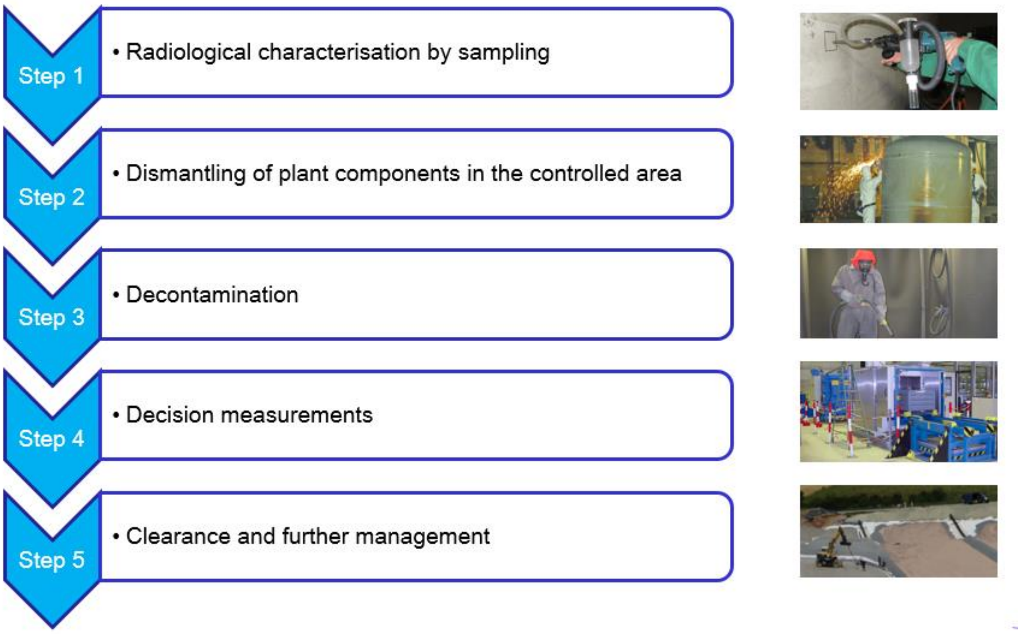

Figure 5: Basic process of clearance

Step 1 comprises the radiological characterisation of the material to be cleared by means of sampling to determine the occurring radionuclides. Samples can be, for example, disassembled parts, scratch samples or drill dust samples, which are then examined for the radioactivity contained. This is followed by a first classification of the material according to the clearance options of unrestricted or specific clearance.

Figure 6:
Room to be measured for clearance with sampling points
(PreussenElektra GmbH, Würgassen nuclear power plant)

Figure 7:
Drill dust sampling
(EWN Entsorgungswerk für Nuklearanlagen GmbH, Greifswald nuclear power plant)

In **Step 2**, plant components in the controlled area are dismantled and disassembled if necessary. In the course of dismantling, accompanying radiation protection measurements are performed on these materials, so-called orientation measurements, to check whether it is possible to go directly to Step 4 “Decision measurements”.

Figure 8: Dismantling and disassembly of containers
(EWN Entsorgungswerk für Nuklearanlagen GmbH, Greifswald nuclear power plant)

If plant components or building cannot go directly to Step 4 due to superficial contamination, they must first be decontaminated in **Step 3** in the controlled area. For this purpose, prior disassembly of the material may be necessary.

Figure 9: Media blasting of metallic components
(PreussenElektra GmbH, Würgassen nuclear power plant)

In **Step 4**, decision measurements are carried out to determine whether the material can be cleared.

Figure 10: In-situ gamma spectrometer for decision measurements of buildings (Brenk Systemplanung GmbH)

Figure 11: Decision measurement of components in the clearance measurement facility with detectors installed at all sides (EWN Entsorgungswerk für Nuklearanlagen GmbH, Greifswald nuclear power plant)

In **Step 5** – after clearance notice by the competent authority – the material is recovered or disposed of according to the chosen clearance pathways. This can be, for example, dumping in suitable landfill sites.

Figure 12: Preparation of a landfill site for the subsequent dumping of conventional and cleared waste (waste management company of the district of Neckar-Odenwald (AWN – Abfallwirtschaftsgesellschaft des Neckar-Odenwald-Kreises mbH)

The entire clearance process is governed by an official communication and is carried out under the supervision of the competent authority under nuclear and radiation protection law or the independent expert commissioned by it. Before an operator can start the clearance process, all related procedures must have been reviewed and approved by the authority. The controls by the authorised expert consulted are also carried out on site during dismantling, disassembly and decontamination of materials as well as regards the radiological characterisation. Supervision also takes place on putting into service and operation of the technical equipment, in particular that used for radiation protection measurements. Furthermore, operator-independent control measurements are carried out on the material to be cleared.

All data and information demonstrating compliance with the clearance levels must be documented and retained for a period of at least 30 years.

4 What is removal?

Any material on the site of a nuclear power plant that is activated or contaminated must be measured and cleared as part of a clearance procedure before it can be reused or disposed of conventionally. In practice, this is interpreted such that already a reasonable suspicion of contamination, e.g. from operating history, requires subjecting this material to a clearance procedure, regardless of whether radioactivity can be detected on it at all. However, it is generally possible to plausibly exclude contamination for some materials outside the controlled area and apply the so-called removal. Examples include the security fence or the staff canteen of a nuclear power plant. For these and other facilities outside the controlled area, looking at the operating history may show that there is no plausible reason to suspect contamination from plant operation.

In addition to plausibility considerations, taking into account the history of the facility, the absence of contamination of material intended for removal is also to be demonstrated by random evidence preservation measurements. Here, levels of activity far below the clearance levels (approx. factor 10) must be detectable.

In the selection of the evidence preservation measurements, so-called accumulation points are also included at which activity that may be present in the supervised area would most likely to be found, such as sediment in gullies for drainage from asphalt surfaces.

If there is no indication of contamination both from operating history and from the results of evidence preservation measurements, the material can be conventionally disposed of or reused without clearance.

This removal is by no means at the discretion of the plant operator. Instead, the procedure must be approved, and the concrete implementation must be specified in procedural instructions. Furthermore, the supervisor can carry out control measurements and review the associated documentation.

The stipulation of a procedure for removal in the operating rules and regulations of nuclear power plants to be dismantled establishes an additional officially approved control procedure for non-contaminated, non-activated material for which no clearance is required before conventional reuse or disposal, as defined in the Radiation Protection Ordinance. This is advocated by the ESK as a safety-oriented measure.

5 Conclusion

The concept of clearance is based on the general principle of law that minor matters are not regulated in a standard (“de minimis non curat lex” – the law does not concern itself with trifles). The concept is therefore based on a definition of which additional health risk and which degree of contamination derived therefrom can still be regarded as negligibility. Annual radiation exposures in the range of 10 µSv are considered to be negligible.

In the German decommissioning practice, most of the material resulting from dismantling in the controlled area is cleared, and all radioactive waste is disposed of in deep geological formations. Alternative waste management concepts (disposal in near-surface facilities, abandonment of buildings of the controlled area) offer no advantages in the view of the ESK.

The clearance pathways contained in the Radiation Protection Ordinance have proven themselves in practice. They permit safe and proper management of material from dismantling and release of the site from supervision under nuclear and radiation protection law.

In Germany, clearance procedures are subject to comprehensive control by the supervisory authorities and the experts consulted.

For material not coming from controlled areas, removal is also possible, but only if there are no indications of possible contamination or activation from operating history and if evidence preservation measurements confirm this.

The ESK therefore advocates safety-oriented handling of all material from the dismantling of nuclear power plants which aligns the use of resources with the hazard potential. It considers clearance and removal as appropriate and necessary instruments in the process of dismantling of nuclear power plants to be able to return non-hazardous material to the material cycle or to dispose it of conventionally.