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A Study on Clearance of Radioactive Material for Decommissioning NPP according to Germany Regulations, Procedures and Experiences

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1. Introduction

During the decommissioning of a Nuclear Power Plant (NPP), non-radioactive and radioactive materials with different radiological properties and health risks are encountered. These materials need to be assigned to adequate disposal routes. In this case study, information about the disposal route of clearance of radioactive material is delivered. This topic is presented based on the Germany regulations, procedures and experiences. The study is focused on the topic of clearance during the decommissioning phase of Germany NPP, however the given information, processes and possibilities can be adapted to the operational phase of NPP, to other nuclear facilities or other selected oversea countries.

2. Clearance Methodology

In Germany, different disposal routes exist, which represent alternatives to the disposal as radioactive waste. These alternative routes are quite important. The assignment of radioactive material to a foreseen disposal route made during the operation or dismantling and the steps till reaching the finally realized disposal route are displayed in Figure 1.

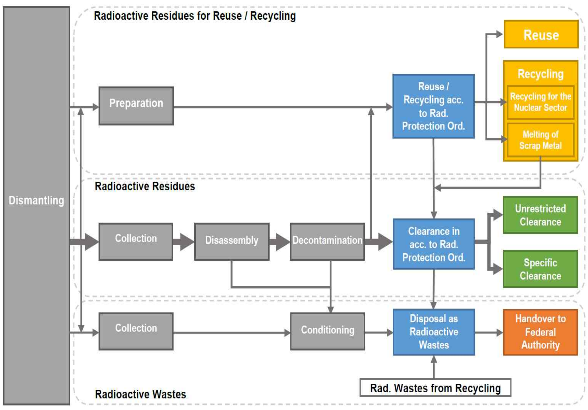

Fig. 1. Simplified overview of possibilities for disposal of radioactive material and possible interaction points.

Keeping the scheme from Figure 1 in mind, it is important to know, that the assignment of the masses of waste to the realized disposal routes is influenced by the objective of radioactive waste reduction. This requirement of radioactive waste reduction is based on the waste hierarchy according to the Recycling Economics Act, which defines the general demand of waste reduction. Within the field of disposal of radioactive material, the additional aspect of radioactivity, its hazard potential as well as connected high disposal costs for radioactive waste need to be considered. Against this background, reuse and recycling are prioritized over the route of removal (supervised area), followed by clearance in order to use or recycle, followed by clearance for disposal as conventional waste, and followed finally by disposal as radioactive waste.

2.1 Reuse and Recycling

In Germany, 'reuse' and 'recycling' are distinguished in the route of dispose of radioactive materials. 'Reuse' describes the process of passing on functioning equipment like instruments and pumps from the controlled area of one license holder to the controlled area of another license holder for a later use. 'Recycling' is used to process radioactive scrap for the later usage in the nuclear field. This ensures that no radioactive waste is passed on. In this context it is important to underline the difference between a reusable radioactive material or object (connected with a future use) and radioactive waste (without future use).

2.2 Clearance

The basis of the currently applicable clearance values for the unrestricted clearance in Germany are the exposure scenarios derived in IAEA-Recommendation SR 44 [2] and applied in the Safety Guide No. RS-G-1.7 [3]. After clearance the materials and objects are considered as non-radioactive in a legal sense. The effective dose occurring for members of the public from the cleared materials and objects may only be in the order of 10 μSv per year (10-μSv concept) [4]. The applicability of the 10-μSv concept, on which clearance is based, was confirmed in several nuclear regulations and guidelines reviews [1].

2.3 Disposal of Radioactive Waste

The radioactive waste has to be achieved by disposal of the waste inside a permanent repository in deep geological structures [5]. Until the delivery to a permanent repository is possible, the waste has to be conditioned and stored in an interim storage facility.

2.4 The Step by step Process of Clearance

The simplified process of clearance is presented in Figure 2. These general steps need to be performed in every Land of Germany.

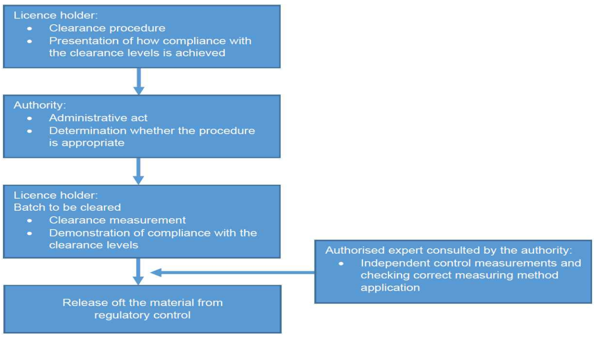

Fig. 2: Simplified representation of the process of clearance [1]

2.5 Clearance Option

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 [1].

• Unrestricted Clearance

All materials that go through the process of unrestricted clearance can be handled without further restrictions in all areas of daily life. Unrestricted clearance can be applied to solids as well as oils, oily liquids and organic solvents and coolants. Compliance with the mass-specific clearance levels is to be demonstrated for all these materials. The averaging mass for determining the mass-specific activity, i.e. the activity in relation to the weight, must not significantly exceed 300 kg [6], [1].

• Specific Clearance

Specific clearance also includes the incineration of material, the recycling of metal scrap, the clearance of buildings and the clearance of soil areas [1]. In Table I the limiting clearance values for the main options for specific clearance are summarized for the most important nuclides during decommissioning of a NPP.

Table I: Overview over different nuclides and selected limiting values for specific clearance.

Nuclide	Building rubble (Bq/g)	Soil areas (Bq/g)	Disposal in landfills (Bq/g)	Disposal via incinerator (Bq/g)	Buildings for reuse (Bq/cm^2)	Buildings for demolition (Bq/cm^2)	Metal for recycling (Bq/g)
H-3	6 E+1	3	6 E+3	1 E+6	1 E+3	4 E+3	1 E+3
C-14	1 E+1	4 E-2	4 E+2	1 E+4	1 E+3	6 E+3	8 E+1
Mn-54	E E-1	9 E-2	6	6	1	1 E+1	2
Fe-55	2 E+2	6	7 E+3	1 E+4	1 E+3	2 E+4	1 E+4
Co-60	**9 E-2**	**3 E-2**	**2**	**2**	**4 E-1**	**3**	**6 E-1**
Ni-59	3 E+2	8	3 E+2	3 E+3	1 E+3	9 E+4	1 E+4
Ni-63	3 E+2	3	1 E+3	6 E+3	1 E+3	4 E+4	1 E+4
Zn-65	4 E-1	1 E-2	8	3	2	2 E+1	5 E-1
Sr-90	**6 E-1**	**2 E-3**	**6 E-1**	**4**	**3 E+1**	**3 E+1**	**9**
Sb-124	5 E-1	4 E-2	3	9 E-1	1	2 E+1	5 E-1
Cs-134	**1 E-1**	**5 E-2**	**3**	**1**	**6 E-1**	**5**	**2 E-1**
Cs-137	**4 E-1**	**6 E-2**	**8**	**3**	**2**	**1 E+1**	**6 E-1**
Eu-152	2 E-1	7 E-2	4	4	8 E-1	6	5 E-1
Eu-154	**2 E-1**	**6 E-2**	**4**	**4**	**7 E-1**	**6**	**5 E-1**
Eu-155	8	2	1 E+2	1 E+2	2 E+1	3 E+2	3 E+1
Am-241	**5 E-2**	**6 E-2**	**1**	**1**	**1 E-1**	**3**	**3 E-1**
U-235	3 E-1		3 E-1	4 E-1	1	1 E+1	8 E-1
U-238	4 E-1		6 E-1	5	2	1 E+1	2
Pu-238	8 E-2	6 E-2	1	1	1 E-1	3	3 E-1
Pu-239	8 E-2	4 E-2	1 E-1	1	1 E-1	2	2 E-1
Pu-241	2	4	4 E+1	1 E+2	1 E+1	9 E+1	1 E+1

3. Conclusions

The establishment and further development of the disposal route 'clearance' is a result of experiences from the operation and dismantling of nuclear facilities in Germany. In the German decommissioning practice, most of the material resulting from dismantling in the controlled area is cleared, whereas all radioactive waste is disposed of in deep geological formations. Alternative waste management concepts for the clearable material from decommissioning (disposal in near-surface facilities, abandonment of buildings of the controlled area) offer no advantages. Emplacement of these masses in a repository would require the construction of near-surface facilities, which, in view of the negligible hazard potential, is to be rejected both economically and ecologically. For this objective, many regulations need to be established and reviewed and will be further developed in future based on experiences, to ensure clearance as safe and reliable as possible.

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