

## Clearance of Buildings and Land after Decommissioning of Nuclear Facilities at the Risø Site

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## Nuclear facilities at the Risø-site

Reactor DR 1 (2 kW)



Reactor DR 2 (5 MW)



Reactor DR 3 (10 MW)



Hot Cells



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## Nuclear facilities at the Risø-site



Waste Treatment Plant



Buffer/Intermediate Store



Low Level Waste Facility



5,000 LLW drums

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## Clearance operations at the Risø-site

- ~ 15 000 – 18 000 tons of material (incl. buildings)
- ~ 5 000 m<sup>2</sup> of land
- ~ 15 000 m<sup>2</sup> of building surface
- ~ 5 000 drums with low level waste

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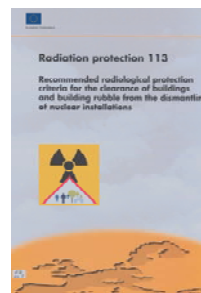
## Concept of Clearance

- Removal of radioactive materials, buildings and land from regulatory control
- Or more straightforward – when materials, buildings and land are considered to be 'non-radioactive'

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## Recommended Clearance Levels



IAEA  
SAFETY  
STANDARDS  
SERIES

Application of the  
Concepts of Exclusion,  
Exemption and  
Clearance

SAFETY GUIDE

No. RS-G-1.7



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## Examples on Clearance Levels (CL)

Surface-specific Clearance Levels      Mass-specific Clearance Levels

Item	
Solid materials and objects	RS-G-1.7/ RP-113(EU)
Buildings (reuse)	RP 113 (EU)
Land	????

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## Specific Clearance Levels

- In case of depth-distributed contamination, mass-specific levels (activity per unit mass) are used
- In case of surface contamination only, surface-specific levels (activity per unit area) can also be used

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## Examples on Clearance Levels (CL)

Radionuclide	Mass-specific Clearance Levels (RS-G- 1.7) [Bq/g]	Surface- specific Clearance Levels (RP 113) [Bq/cm <sup>2</sup> ]
<sup>55</sup> Fe	1,000	10,000
<sup>3</sup> H, <sup>63</sup> Ni	100	10,000
<sup>235</sup> U, <sup>238</sup> U	1	1
<sup>60</sup> Co, <sup>137</sup> Cs, <sup>152</sup> Eu	0.1	1
<sup>239</sup> Pu	0.1	0.1

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## Clearance Levels - Buildings

Based on conservative scenario calculations such as

- External doses from handling the waste
- External doses from living in a house made from cleared material
- Internal doses from inhaling dust from the cleared material
- External and internal doses to children in playgrounds made on cleared material

and a dose criterion of **0.010 mSv pr year**

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## Clearance Index, CI

The clearance index, *CI*, should be less than 1 and is defined as:

$$CI = \sum_i \frac{C_i}{CL_i} < 1$$

In practice there would always be a criteria for the uncertainty such as

$$CI = \sum_i \frac{C_i}{CL_i} + 1.65 \sqrt{\sum_i \frac{u(C_i)^2}{CL_i^2}} < 1$$

- *C<sub>i</sub>* is the concentration of nuclide *i*
- *CL<sub>i</sub>* is the clearance level for nuclide *i*
- *u(C<sub>i</sub>)* is the uncertainty of the concentration *C<sub>i</sub>*

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## Clearance Levels - Land

No recommendations internationally !!

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## Clearance Levels - Land

### External exposure

“Surface-contamination” giving an effective dose of 0.01 mSv/year

25 cm depth-distribution, 1000 m<sup>2</sup>, 1 m above ground-level

Radionuclide	“Surface-contamination” [Bq/m <sup>2</sup> ]
<sup>60</sup> Co	$2.7 \cdot 10^3$
<sup>65</sup> Zn	$1.1 \cdot 10^4$
<sup>106</sup> Ru/Rh	$3.2 \cdot 10^4$
<sup>134</sup> Cs	$4.4 \cdot 10^3$
<sup>137</sup> Cs	$1.1 \cdot 10^4$

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## Clearance Levels - Land

### Internal exposure

“Surface-contamination” giving an effective dose of 0.01 mSv/year

Radionuclide	“Surface-contamination” [Bq/m <sup>2</sup> ]
<sup>60</sup> Co	$5.7 \cdot 10^5$
<sup>90</sup> Sr	$1.1 \cdot 10^4$
<sup>137</sup> Cs	$1.6 \cdot 10^4$
<sup>152/154</sup> Eu	$5.7 \cdot 10^6$
<sup>239</sup> Pu	$1.9 \cdot 10^5$

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## Clearance Levels – Land

Calculated - Based on 0.01 mSv/year

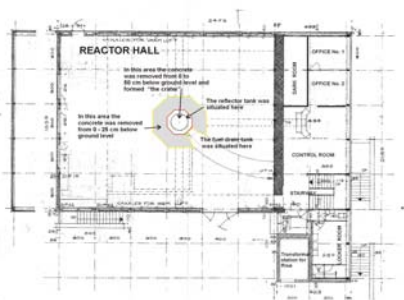
Radionuclide	Clearance Levels [Bq/m <sup>2</sup> ]
<sup>60</sup> Co	$5.7 \cdot 10^5$
<sup>90</sup> Sr	$1.1 \cdot 10^4$
<sup>137</sup> Cs	$1.6 \cdot 10^4$

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## DR 1

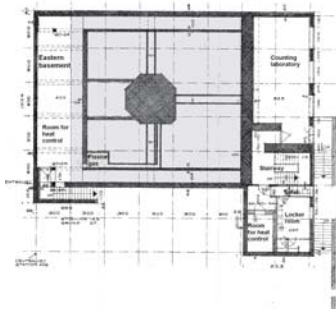


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## DR 1



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## Clearance Classification

No contamination	Very low probability of contamination above CL Class 2	Possible contamination around or slightly above CL Class 1 “default”	Contamination above CL
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Few measurements

10 - 50% coverage

100% coverage

No clearance measurements

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## Classification (Building)

### Basement

Most of the rooms were classified as class 2 areas

The Counting Laboratory was classified as a class 1 area

### Ground floor

Most of the rooms were classified as class 2 areas

The Locker room and the Reactor Hall were classified as class 1 areas

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## Measuring method(s)

Wherever suitable :  
Contamination monitors

Otherwise:  
Germanium detectors

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## Clearance measurements (building)



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## Clearance measurements - buildings



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## Classification (Land)

### Forecourt

The asphalt north of the building was classified as a class 1 area

Rest of the surrounding area was classified as a class 2 area

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## Clearance measurements on land



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## Clearance measurements on land



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## Short history of the DR 1 building



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