# Dose reduction below de minimis level?

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## Introduction

According to the definition of the de minimis concept a radioactivity can be neglected if the contamination or specific activity is below the national clearance levels. These values were derived by model calculations based on a 10 µSv/a dose concept (de minimis concept – see next chapter). From this point of view a further decontamination of surfaces with a contamination being already below the clearance levels seems not to be necessary. This argument is often used in the case of large decommissioning projects e.g. nuclear power plants with a mass of more than 100 000 Mg partially with huge surfaces. The decontamination and control measuring of these surfaces are costly and one of the main works during the decommissioning. Therefore, it is reasonable that the operator wants to introduce a decision level for an acceptable remaining contamination.

## ALARA versus de minimis concept

"In case of contamination the resulting radiation exposure should be as low as reasonably achievable taking economic and societal factors into account."

This principle is one of the basic principles of the ALARA optimisation process, which is demanded by the International Commission on Radiation Protection (ICRP). According to ICRP 103 [1] dose constraints provide a desired upper bound for the optimisation process. From this upper bound the optimisation is a permanent mental procedure, always questioning whether all that is reasonable has been done to reduce doses. The decontamination can be finished as an optimised process when the efforts spent for the decontamination procedure run out of the proportion with regard to the result of the process (principle of commensurability). But in most cases the dose level for the personnel is quite low throughout the decontamination process and there is no potential range for dose reduction and, therefore, is not an argument to find an end for the decontamination work. Thus, the collective dose for the personnel gives no criterion to stop the decontamination process. The optimisation process is a top-down process starting at a constraint without defining a dose level below which the optimisation process should stop.

1988 it was concluded in the IAEA safety series No 89 [2] that for the purpose of exemption and clearance a level of individual effective dose equivalent of some tens of microsieverts in a year could reasonably be regarded as trivial by regular authorities. Each exempt practice could lead to individual doses to the critical group of the order of 10 µSv in a year. Therefore, in most European countries the protection goal for the public regarding clearance of materials is in the range of 10 µSv/a for each exempt practice.

Limits for specific activity and contamination were derived from this dose concept using deterministic and probabilistic models on a realistic basis. These limits are directly measurable so that compliance with the provisions of the exemption and clearance can be determined. The principle of exemption and clearance is a bottom-up process looking for a maximum of material for clearance to reduce the amount of radioactive waste and stopping at the de minimis dose level. This leads to the strategy to exploit the dose limit to full advantage, which is directly opposed to the ALARA principle.

## Practical Experience

In the following three cases of contamination of Sr-90 and Cs-137 will be discussed. For all cases the total amount of activity of 500 Bq related to an area of 1 m² is constant, but the area of contamination

is different (see table 1). According to German clearance regulations as an exemplary basis the acceptable contamination on materials for the nuclides Sr-90 and Cs-137 is 1 Bq/cm² related to an average area of 1000 cm². Thus, the contamination concerned in these cases is permitted by the regulations of the German Radiation Protection Ordinance [3].

In case a) the contamination is on a spot of 1 cm². This leads to a punctual contamination of 500 Bq/cm², which is very easy to detect, but it may be not easy to find, if the contamination is hidden. If the contamination is removable, a high risk of incorporation has to be assumed. A total uptake of the activity by an adult person would lead to the following dose:

Cs-137: 6,5 µSv Sr-90: 14 µSv

Although this assessment is very conservative, the de minimis dose concept of some ten microsieverts is still met.

The decontamination of this spot would lead to a few ten gram of waste with a specific activity of approx. 20 Bq/g. This waste would be not acceptable for a special clearance (clearance for landfill or incineration [4]). Therefore, the decontamination is an optimisation for this purpose.

In case b) the contamination is spread on an area of 1000 cm². This leads to a contamination of 0,5 Bq/cm², which is still possible to detect and easy to find due to the dispersion of radionuclides. The risk of incorporation is lower than in case a), because it is unlikely to assume a total uptake of a contamination spread over 1000 cm². A portion of 10% as uptake seems to be conservative and leads to the dose:

Cs-137: 0,65 µSv Sr-90: 1,4 µSv

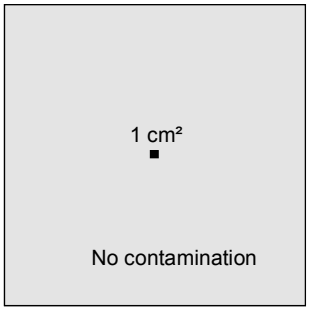
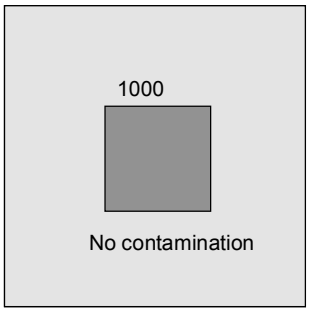
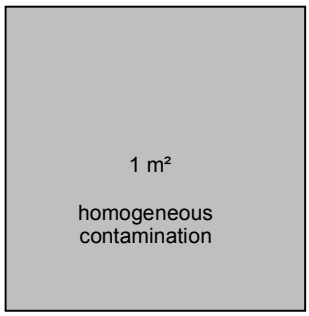
The decontamination of this area might lead to a waste amount of 1 kg with a specific activity of approx. 0,5 Bq/g. This waste would be acceptable for unrestricted clearance.

In case c) the contamination is distributed homogenously on the area of 1 m². This leads to a contamination of 0,05 Bq/cm², which is below the detection limit and therefore impossible to find. An incorporation of nuclides has not to be assumed.

As a result of this case study it has to be stated that decontamination is not necessary in two cases, as the waste, which would be generated during the decontamination, is also acceptable for clearance in case b) and c). The decontaminated activity would only be shifted from one material to another one and at least given to the environment but not kept back in the controlled area. This argumentation can be used as a guide to decide, whether the decontamination process is finished or not. As good practice on the ALARA basis high punctual contamination as mentioned in case a) will be usually given to the radioactive waste not only to reduce the activity which will be released to the environment but to keep the activity limits for clearance.

This case study was performed with a contamination of 50% of the permissible contamination according to the German clearance regulations. These values were derived from the EU-report RP-89 [5] dealing with the clearance of scrap. Even in the case of 100%-contamination of Cs-137 or Sr-90 or a 100%-contamination by an Alpha-emitter like Am-241 a maximum dose of less than 30 µSv is determined for the very conservative assumption of a total uptake of the radionuclides. This is still in compliance with the de minimis concept.

Table 1: Case study for the consequences of a contamination of 500 Bq

| | | |
|---|---|---|
| a) |  | • 500 Bq/cm²<br>• easy to detect, if you find it<br>• easy to decontaminate<br>• high risk for incorporation<br>• approx. 20 Bq/g for secondary waste<br>• secondary waste is radioactive waste |
| b) |  | • 0.5 Bq/cm²<br>• clearly detectable<br>• easy to find<br>• possible for decontamination, but not reasonable<br>• no risk for incorporation<br>• approx. 0,5 Bq/g for secondary waste<br>• secondary waste for clearance |
| c) |  | • 0.05 Bq/cm²<br>• not detectable<br>• impossible to find<br>• no decontamination<br>• no risk for incorporation<br>• no secondary waste |

If other limits (e.g. international limits of contamination for transport of goods 4 Bq/cm² for Cs-137 and Sr-90) are used as national regulation for clearance the dose values for incorporation will rise by a factor of 8 and will be more than 100 µSv for Sr-90. In this case the licensee has to give more respect to the ALARA principle during decontamination of materials, because generated waste might not be acceptable for any clearance pathways.

**Perspective of clearance values**

The consideration of decision levels were made on the basis of the German clearance regulations, which are mainly based on the European recommendations. Meanwhile the IAEA adopted similar guidance in RS-G-1.7 [6] on the basis of scenarios to a large extent. The IAEA levels were not only developed for the purpose of clearance but mainly for the purpose of exemption. The Group of Experts of the EU came to the conclusion that for the sake of international harmonisation it should be considered to introduce the RS-G-1.7 values rather than the values of the European recommendation. The Group of Experts is also considering the introduction of the same concentration values for applying the concepts of exemption and clearance. The EC is expecting a great benefit to the simplification and understanding of the Basic Safety Standards [7]. With the same argumentation

IAEA is planning to implement these values for exemption and clearance in the International Basic Safety Standards [8].

Such a regulation would lead to serious consequences to the existing national clearance regulations. As the exemption levels are the upper bound for the clearance values the reduction of the exemption levels on the RS-G-1.7 level leads also to the point that specific clearance solutions are no longer acceptable. The RS-G-1.7 gives the following values for the radionuclides (actual clearance levels for landfill in Germany are given in brackets [3])

| | | | |
|---|---|---|---|
| Co-60: 0,1 Bq/g | Sr-90: 1 Bq/g | Cs-137: 0,1 Bq/g | Am-241: 0,1 Bq/g |
| (Co-60: 4 B/q/g | Sr-90: 2 Bq/g | Cs-137: 10 Bq/g | Am-241: 1 Bq/g). |

If the case study is based on these IAEA values, case a) by all means and case b) for a Cs-137 or Co-60 contamination are now cases, where the generated waste are not acceptable for clearance and a further decontamination should be done in the sense of ALARA.

**Conclusions**

According to the definition of the de minimis concept a radioactivity can be neglected, if the contamination or specific activity is below the national clearance levels. The principle of clearance is looking for a maximum of material for clearance to reduce the amount of radioactive waste and stopping at the de minimis dose level. This leads to the strategy to exploit the dose limit to full advantage, which is directly opposed to the ALARA principle, whereby in case of contamination the resulting radiation exposure should be as low as reasonably achievable.

As a result of a case study it was shown that decontamination is not necessary, if the waste generated during the decontamination is also acceptable for clearance. The decontaminated activity would only be shifted from one material to another one and at least given to the environment but not kept back in the controlled area. This argumentation can be used as a guide to decide, whether the decontamination process is finished or not. This decision guide is especially helpful for large decontamination processes of materials for clearance during the decommissioning of nuclear installations.

Such a decision level is direct dependent from modifications of clearance levels. In case of reducing the exemption values on the level of general clearance, as it is planned by IAEA and EC, not only the amount of waste would rise enormously but also the decontaminating of the materials and therefore the dose for the workers will increase.

**Literature**


[1] ICRP
ICRP Publication 103
The 2007 Recommendations of the International Commission on Radiological Protection
Elsevier, 2007

[2] IAEA
IAEA safety guide No. 89
Principles for the Exemption of Radiation Sources and Practices from Regulatory Control
Vienna, 1988

[3] Strahlenschutzverordnung – StrlSchV
Verordnung über den Schutz vor Schäden durch ionisierende Strahlen
20. Juli 2001, BGBl I S. 1714 etc

[4] Strahlenschutzkommission – SSK
Freigabe von Stoffen zur Beseitigung
Heft 54, 2007

[5] European Commission
Radiation Protection 89
Recommended radiological protection criteria for the recycling of metals from the dismantling of nuclear installations
1998

[6] IAEA
Safety Guide No. RS-G-1.7
Application of the Concepts of Exclusion, Exemption and Clearance
Vienna, 2004

[7] A. Janssens, EC
Main focuses of the new Euratom Basic Safety Standards
Berlin Radiation Protection Conference
19 June 2007

[8] IAEA
Safety Standard (Draft)
International Basic Safety Standards for Protection against Ionizing Radiation
Draft Safety Requirements DS 379 0.5
19.Sept. 2007