

A CLASSIFICATION SYSTEM FOR CONTAMINATION LIMITS CONSIDERING THE RADIOLOGICAL RELEVANCY FOR ALL RADIOACTIVE NUCLIDES

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INTRODUCTION

It is a common practice to examine persons and materials with regard to radioactive contamination when they leave restricted access areas.

Starting from a surface contamination limit of 0.037 Bq/cm^2 for persons leaving the restricted access area we have analysed the radiation exposure that may result.

In this connection the following categories of persons are being considered:

- occupationally exposed persons themselves
- persons in the non-monitored areas of the age groups of
 - 1 year
 - 10 years
 - adults

PATHWAYS LEADING TO EXPOSURE

The starting point for the radioactive nuclides are occupationally exposed persons, who leave their place of work daily, carrying a maximum permissible surface contamination of 0.037 Bq/cm^2 . For all nuclides this is taken as a basis for calculating the radiation exposure, i.e. we do not differentiate between alpha emitters, beta emitters and gamma emitters.

According to our experience the following pathways have to be taken into account, which lead to exposure of

- occupationally exposed persons: external exposure of their own skin
- occupationally exposed persons: external exposure of their whole body
- occupationally exposed persons: internal exposure through inhalation
- other persons: external exposure to the radiation of a contaminated occupationally-exposed person
- other persons: internal exposure through ingestion

- other persons: internal exposure through inhalation
- other persons: internal exposure via water-soil-plant

The ISH reports Nr. 63, 78, 80 (L1, L2, L3) give dose factors for about 800 nuclides. Nuclides with a half life smaller than 1 hour were omitted. 611 nuclides remained. When calculating the pathway of ingestion we applied the dose factors of the largest resorption.

The radiation exposures calculated for the different pathways were compared with the dose limitations given in the German Radiological Protection Ordinance (L4), where the following limits apply:

50/150/300/600 mSv	for category A occupationally exposed persons and different parts of the body,
1.5 mSv	for other persons outside monitored plant areas according to section 44 (1) of the above Ordinance

SUMMARY

In the vast majority of cases (497 nuclides), exposition through "ingestion by the age group of 1-year-olds" proves to be the leading pathway.

27 nuclides furnish the highest dose values by exposure through "ingestion via water-soil-plant".

In the case of 65 nuclides the pathway of "external irradiation of the skin" of the occupationally exposed person is predominant.

When calculating the ingestion we used the dose factors for the effective dose; the respective dose factors for parts of the body are often ten times higher. With I-129, for example, the dose factor for the thyroid gland is 30 times as high as the one for the effective dose.

As a result of our research the 589 nuclides we investigated into (another 22 isotopes of the inert gases Ar, Kr, Xe, Rn are irrelevant for our consideration) can be divided into categories according to their possible radiation exposure; in doing so, we always refer to the most disadvantageous pathway of exposure for each nuclide in relation to its dose limit. Category I means that the figures reach between 10 % and 100 % of the dose limit. In category II they attain between 1 % and 10 %, in cat. III between 0.1 % and 1 %, cat. IV between 0.1 % and 0.01 % and in cat. V they reach less than 0.01 % of the dose limit. Only Cm 250 (spontaneous fission) could exceed the dose limits.

In the following table the nuclides are listed according to

their radiological relevancy in 5 categories as mentioned above.

Category I 10 % - 100 % :

Po 210, Pb 210, Ra 226, Ac 227, Ra 228, Th 229, Pa 231, Np 237, Am 241, Am 243, Cm 245, Cm 246, Bk 247, Cm 248, Cf 249, Cf 251, Cf 254, Am 242 m

Category II 1 % - 10 % :

Cl 36, Fe 60, Sr 90, Nb 95, Tc 98, Cd 113, In 115, I 129, Sm 146, Sm 147, Gd 148, Hg 194, Ra 223, Ra 224, Ac 225, Ra 225, Th 228, Th 230, U 230, Th 232, U 232, U 233, U 234, U 235, Pu 236, Np 236, U 236, U 238, Pu 238, Pu 239, Pu 240, Pu 242, Cm 243, Pu 244, Cm 244, Cm 247, Cf 248, Cf 250, Cf 252, Es 254, Fm 257, Cd 113m, Ir 192m, Bi 210m

Category III 0.1 % - 1 % :

C 14, Na 22, Na 24, Al 26, P 32, K 40, Ti 44, Co 56, Mn 56, Fe 59, Co 60, Ni 65, Zn 65, Ni 66, Se 75, Se 79, Sr 82, Rb 83, Rb 84, Rb 86, Zr 89, Sr 89, Y 90, Y 91, Sr 91, Y 92, Sr 92, Y 93, Zr 95, Zr 97, Mo 99, Tc 99, Rh 101, Rh 102, Ru 105, Rh 105, Ru 106, Cd 109, Ag 111, Sn 123, Sb 124, I 124, I 125, Sn 125, Sn 126, Sb 126, I 126, Te 127, Sb 127, Ba 128, Sb 129, Te 129, I 130, I 131, Te 132, I 132, I 133, Ce 134, Cs 134, I 135, Cs 136, Cs 137, Ba 139, La 140, Ba 140, Ce 141, La 141, La 142, Ce 143, Ce 144, Pr 145, Nd 147, Pm 148, Pm 149, Pm 151, Gd 152, Eu 154, Eu 156, W 188, Os 194, Pb 202, At 211, Pb 212, Ac 226, Th 227, Th 234, Np 238, Np 239, Cm 240, Pu 241, Am 242, Cm 242, Cf 246, Pu 246, Fm 252, Es 253, Fm 255, Sc 44m, Rh 106m, In 114m, Cd 115m, Te 125m, Te 127m, Te 129m, Te 131m, Cs 134m, Pa 148m, Eu 152m, Lu 177m, Hf 178m, Ir 194m, Es 254m,

Category IV 0.01 % - 0.1 % :

Be 10, Mg 28, Si 32, P 33, Ca 41, K 42, K 43, Sc 44, Ca 45, Sc 46, Sc 47, Ca 47, Sc 48, V 48, Fe 52, Mn 52, Mn 54, Co 55, Ni 56, Ni 57, Co 57, Co 58, Zn 62, Ga 66, Cu 67, Ge 68, As 71, Zn 72, Ga 72, As 72, Ga 73, Se 73, As 74, As 76, Br 76, As 77, Br 82, Sr 83, Sr 85, Zr 86, Y 86, Y 87, Rb 87, Zr 88, Y 88, Nb 89, Mo 90, Nb 90, Mo 93, Nb 94, Nb 96, Tc 96, Tc 97, Rh 99, Pd 100, Rh 100, Ru 103, Pd 103, Ag 105, Pd 107, Pd 109, Sn 110, In 110, In 111, Ag 112, Sn 113, Cd 115, Cd 117, Sb 119, Sb 120, Te 121, Sn 121, Sb 122, Te 123, Sb 125, Ba 126, Ba 131, Cs 132, La 132, Ba 133, Cs 135, Ce 135, Nd 138, La 138, Ce 139, Pr 142, Pr 143, Pm 144, Sm 145, Eu 145, Gd 146, Eu 146, Pm 146, Gd 147, Pm 147, Eu 147, Eu 148, Tb 149, Gd 149, Eu 155s, Eu 150, Pm 150, Tb 150, Tb 151, Eu 152, Sm 153, Tb 153, Gd 153, Tb 154, Eu 155, Tb 156, Sm 156,

Eu 157, Tb 158, Gd 159, Tb 160, Tb 161, Dy 166, Yb 166, Ho 166,
 Tm 166, Tm 167, Er 169, Lu 169, Yb 169, Tm 170, Lu 170, Hf 170,
 Er 171, Lu 171, Lu 172, Hf 172, Er 172, Tm 172, Lu 173, Tm 173,
 Lu 174, Hf 175, Yb 175, Lu 176, Ta 176, Lu 177, W 178, Lu 179,
 Ta 180, Hf 181, Re 181, Hf 182, Os 182, Re 182, Ta 182, Ta 183,
 Hf 184, Re 184, Ta 184, Ir 185, Os 185, W 185, Ir 186s, Ir 186,
 Re 186, W 187, Ir 188, Pt 188, Re 188, Ir 189, Pt 189, Re 189,
 Ir 190, Os 191, Pt 191, Ir 192, Os 193, Pt 193, Au 194, Ir 194,
 Au 195, Hg 197, Pt 197, Au 198, Au 199, Pb 200, Pt 200, Tl 200,
 Tl 202, Bi 203, Hg 203, Pb 203, Tl 204, Bi 205, Pb 205, Bi 206,
 At 207, Bi 207, Bi 210, Bi 212, Ac 224, Ac 228, Pa 228, Pa 230,
 Th 231, U 231, Pa 232, Pa 233, Np 234, Pa 234, Np 236, U 237,
 Am 239, U 240, Am 240, Cm 241, Am 244, Pu 245, Bk 245, Bk 246,
 Bk 249, Fm 253, Cf 253, Fm 254,
 Zn 69m, Tc 95m, Nb 95m, Tc 97m, Tc 99m, Rh 102m, Ag 106m,
 Ag 108m, Ag 110m, In 115m, Cd 117m, Sn 117m, Sb 118m, Sn 119m,
 Sn 121m, Te 121m, Te 123m, Ba 133m, Ba 135m, Ce 137m, Nd 139m,
 Ho 166m, Lu 174m, Hf 179m, Re 184m, Re 186m, Pt 193m, Hg 193m,
 Pt 195m, Hg 197m, Au 198m, Au 200m

Category V < 0,01 % :

H 3, Be 7, F 18, Si 31, S 35, Sc 43, Ti 45, Cr 48,
 V 49, Cr 51, Mn 53, Fe 55, Ni 59, Co 61, Cu 61, Ni 63,
 Cu 64, Ge 66, Ga 67, Ga 68, Ge 69, Ge 71, As 73, Br 75,
 Ge 75, Ge 77, Br 77, As 78, Ge 78, Sr 80, Rb 81, Br 83,
 Nb 89, Tc 93, Zr 93, Tc 94, Tc 95, Ru 97, Nb 97, Pd 101,
 Ag 103, Ag 104, Cd 107, In 109, In 110, Te 116, Sb 117, I 120,
 I 121, I 123, Sn 127, Cs 127, Sb 128, Cs 129, Cs 131, La 135,
 Ce 137, Pr 137, La 137, Pr 139, Nd 141, Sm 142, Pm 143, Pm 145,
 Tb 147, Nd 149, Eu 149, Sm 151, Gd 151, Tb 155, Dy 155, Tb 157,
 Dy 157, Dy 159, Er 161, Ho 161, Dy 165, Er 165, Ho 167, Tm 171,
 Ta 173, Hf 173, Ta 174, Ta 175, W 176, Yb 177, Ta 177, W 177,
 Yb 178, Ta 178, Ta 179, W 181, Os 181, Re 182, Hf 183, Ir 184,
 Pt 186, Ir 187, Re 187, Au 193, Hg 193, Ir 195, Hg 195, Tl 195,
 Tl 197, Pb 198, Tl 198, Pb 199, Tl 199, Tl 201, Bi 201, Pb 201,
 Bi 202, Po 205, Po 207, Pb 209, Pu 234, Np 235, Pu 237, Am 237,
 Cm 238, Am 238, Np 240, Pu 243, Am 245, Cm 249, Bk 250, Es 250,
 Es 251, Md 257
 Co 58m, Zn 71m, Br 80m, Rb 82m, Sr 85m, Sr 87m, Y 90m,
 Nb 93m, Mo 93m, Rh 99m, Rh 101m, In 113m, Sb 116m, In 117m,
 I 132m, Pr 138m, Tb 156ms, Tb 156m, Ho 162m, Lu 176m, Ta 180m,
 Hf 180m, Hf 182m, Os 189m, Ir 190ms, Ir 190m, Os 191m, Ir 195m,
 Hg 195m, Pt 197m, Tl 198m, Pb 202m

LITERATURE

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