Transportation Safety Aspects of Ore and Related Material – Inconsistencies in Current Exemption Values

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BACKGROUND

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IAEA Transport Regulations Prior to 1996

- Exempted material based on uniform threshold activity concentration -- 70 Bq/g
- Use of a single activity concentration threshold is not justifiable from the standpoint of radiation protection because dose depends strongly on the particular radionuclide(s) in the material

Dose-Based Approach to Exemption Values Introduced in CEC Report RP-65

- Describes principles and methods for dose-based exemption system
- Exemption values tabulated for ~300 radionuclides
- Exemption values based on maximum allowable effective dose of 10 μSv/y and maximum skin dose of 50 mSv/y

Principles and exemption values of RP-65 adopted by IAEA

- Used in Basic Safety Standards (BSS, 1994)
- BSS values carried over to updated Transport Regulations (TS-R-1, 1996)
- List of radionuclides extended in TS-R-1 based on RP-65 methods

The problem of naturally occurring radioactive materials (NORMs)

- BSS exemption values often much lower than previous guideline of 70 Bq/g
- This would bring into scope of regulations many previously unregulated NORMs handled in large quantities in industry

Current and previous exemption values for natural U and Th

Nuclide	Current value (Bq/g)		Pre-1996 value (Bq/g)
	Parent	Implied value for full chain	
U-238+ progeny	1	14	70
Th-232+ progeny	1	10	70

Example: Typical levels of U and Th in commercial zircon (Selby et al. 2002)

Nuclide	Typical activity (Bg/g)	
	Parent	Full chain
U-232+ Progeny	3.1-4.4	43-61
Th-232+ Progeny	0.4-0.8	4-8
Total	3.5-5.2	45-70

Special provision for NORMs

- To minimize economic impact for NORMs, special provision made in TS-R-1
- If material not intended for processing for use of radionuclides, exemption value increased 10-fold

Inconsistencies in dose-based exemption values for transport

- Special provision for NORMs introduced inconsistencies from standpoint of radiation protection
- Inconsistencies compounded in some cases by more subtle factors in the method of derivation of exemption values

METHOD OF DERIVATION OF EXEMPTION VALUES

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Scenarios used in RP-65

- Investigators faced with unlimited possibilities for exposure to sources
- Problem made manageable by confining attention to 2 environments -- workers at a fixed installation and members of public exposed to discarded sources at a landfill
- Total of 24 exposure scenarios considered

Critical (limiting) RP-65 scenarios for activity concentration

- External from nearby source -- limiting for 77% of the ~300 radionuclides addressed
- Chronic inhalation by worker – limiting in 18% of cases
- Ingestion by member of public – limiting in 5% of cases

Additional considerations for updated IAEA Transport Regulations

- Specific transport scenarios developed (Casey et al., 1995)
- Exemption values re-derived for 20 nuclides and checked against BSS values
- Transport-specific values higher in most cases but differences judged not to warrant alternate values for transport

Comparison of BSS exemption values (activity concentrations) with values based on transport scenarios

Radionuclide	Ratio of BSS value to transport-specific value
C-14	0.55
K-40	19
Ra-226 + progeny	9.4
Th-232 + progeny	2.7
U-238 + progeny	3.7

Critical (limiting) transport-specific scenarios for activity concentration

- External dose to truck driver hauling bulk material – 60% (12/20) of cases
- External + inhalation + ingestion doses to truck cleaner – 20% (4/20)
- External dose from handling or being near small sources (packages) – 20% (4/20)

Important scenarios for NORMs

- Truck driver scenario often dominant
- Truck cleaner scenario also important because of multiple modes of exposure
- Ship crew can receive relatively high doses, but this scenario often not pertinent

Illustration of inconsistencies in exemption values

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Hypothetical case

- Company A transports natural material containing Ra-226+ (Ra-226 in equilibrium with progeny) to be dumped in landfill
- Company B transports natural material containing U-238N (U-238 in equilibrium with progeny) to be processed for recovery of radionuclides

Analysis based on transport scenarios of Casey et al. (1995)

- External dose to truck driver is dominant scenario for both materials
- Dose rate to driver virtually the same for Company A and Company B because it arises almost entirely from Ra-226+ in both cases
- Exemption values based on transport scenarios would be 0.50 Bq/g in both cases

Analysis based on TS-R-1 and its underlying methods (RP-65)

- Derived exemption value in RP-65 for Ra-226+ is 4.67 Bq/g
- Derived value for U-238N is 1.83 Bg/g
- Limiting scenario for Ra-226+ is ingestion by member of public and for U-238N is chronic inhalation by worker, neither of which is particularly relevant for transport

Analysis based on TS-R-1 and its underlying methods -- continued

- Rounding rule in RP-65: Derived values between 3×10^{n} and $3 \times 10^{n+1}$ are rounded to 10^{n+1}
- Value for Ra-226+ (4.67 Bq/g) rounds to 10 Bq/g
- Value for U-238N (1.83 Bq/g) rounds to 1 Bq/g

Analysis based on TS-R-1 and its underlying methods -- continued

- Due to the intended use of material hauled by Company A, the exemption value for Ra-226+ is increased 10-fold to 100 Bq/g
- Due to the intended use of material hauled by Company B, the exemption value remains at 1 Bq/g

Conclusions

- TS-R-1 exemption values may differ by at least two orders of magnitude for materials posing the same doses from transport
- The special 10x provision in TS-R-1 for NORMs introduces inconsistencies in the dose-based system
- Transport-specific scenarios would provide an improved technical basis for exemption values

Suggestions for improving transport exemption values

- Apply the special provision of a 10-fold increase in exemption values to all NORMs, regardless of their intended use
- Use transport-specific scenarios to derive exemption values
- Round derived exemption values to one significant digit