UK Health Security Agency

Updating the Exemption Methodology for the Transport of NORM in Bulk Quantities

Iain Brown

Exemption and Transport Regulations

- Transport regulations adopted the exemption values in the 1994 version of the Basic Safety standards (IAEA Safety Series No. 115)
- However the transport regulations allow for a factor of 10 to be applied to the exemption values of radionuclides of natural origin (both moderate and bulk quantities) as BSS values thought to be too restrictive
- IAEA GSR Part 3 (BSS) published in 2014 introduced new concepts

Exemption of NORM in Bulk Quantities - IAEA

- IAEA GSR part 3 “For radionuclides of natural origin, exemption of bulk amounts of material is necessarily considered on a case by case basis by using a dose criterion of the order of 1 mSv in a year”
- IAEA GSR part 3 on exemption values (activity concentrations) : “The calculated values apply to practices involving small scale usage of activity where the quantities involved are at the most of the order of a tonne.” – hence bulk quantities over a tonne.

Exemption Transport Exposure Scenarios

- The methodology in RP 65 (CEC, 1995) did not include transport specific scenarios. However Carey et al. (1995) studied transport scenarios and showed the general exemption values where satisfactory
- Carey et al. (1995) consider four scenarios:
  a) Postman/Courier delivering to laboratory or hospital
  b) Driver transports bulk material or packages
  c) Loading bulk material or packages onto truck or van
  d) Member of public exposed to material in aircraft hold

Transport for Bulk Quantities

- The assumption of bulk quantities changes possible scenarios
- Of the scenarios (b) a driver and (c) a loader are the most applicable to the transport of bulk materials. However transport is possible by aircraft
- Note that for bulk material the dose criterion is 1 mSv y^{-1} not 10 µSv y^{-1}
- There is no dose criterion for accidents for bulk material

Exemption Pathways

- An assessment to a driver/transport worker would need to consider
  - External irradiation
  - Inhalation of dust
  - Inadvertent ingestion of dust
  - Skin contamination

- There are key parameters that need to be agreed for these calculations such as the exposure time, dust loading factor, rate of inadvertent ingestion and area of the skin contaminated
- External dose rate also needs to be calculated. We propose to use Monte-Carlo codes to do this. There are several possible scenarios to investigate

Preliminary Calculations

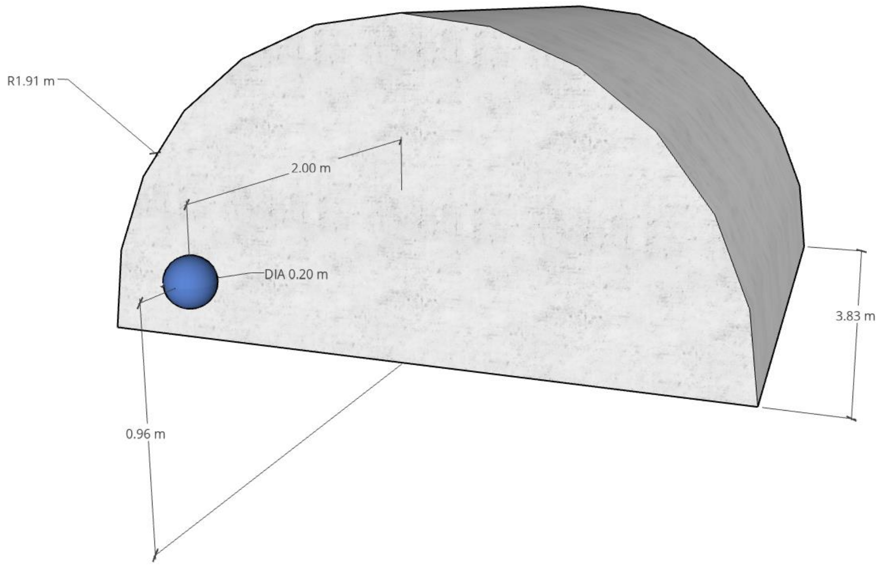
- Plan to update the pathway calculations for Carey et al. scenarios with updated dose criterion and dose coefficients
- Calculate activity concentrations for NORM
- The external irradiation calculation will instead use MCNP
- The skin contamination calculation will use VARSKIN+

Radionuclides in Bulk Materials

- Ra-226 and its progeny chosen for this preliminary calculation as includes different emission types and can compare against Carey et al.
- Also consider Pb-210 as likely to have different dominant pathways

External Irradiation using MCNP

Half cylinder of concrete

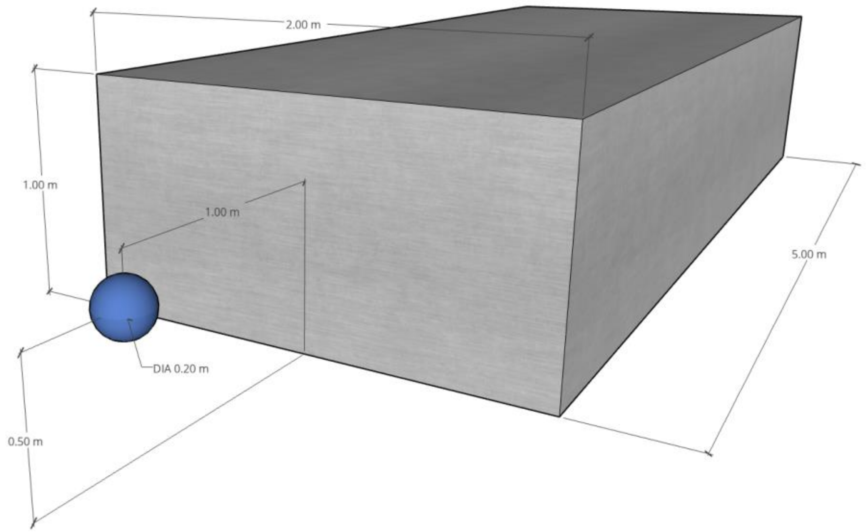


Notes

- Carey et al (1995) describe a half cylinder of volume 22 m^3
- Radius 1.91 m, length 3.83 m
- The material is concrete of density 2.3 g cm^{-3} = 50 tonnes
- The cell for the driver is 2 m away

External Irradiation using MCNP (2)

Based on scenario in RP 122, cuboid with 10 m^3 volume

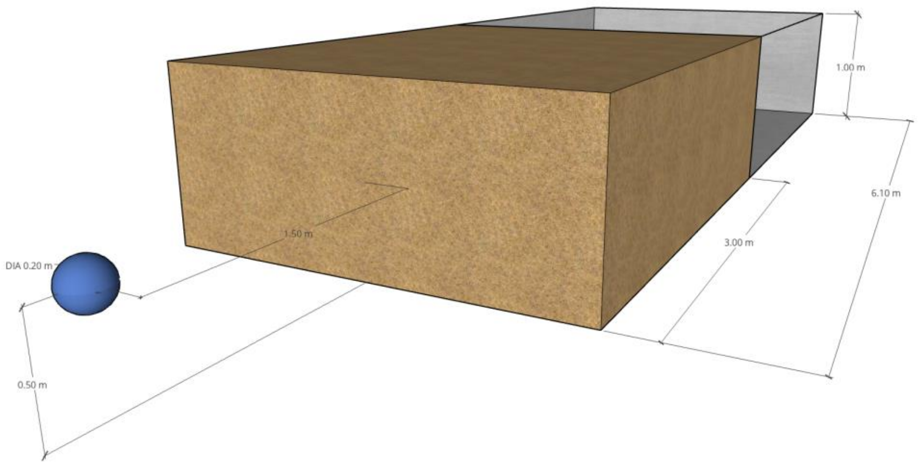


Notes

- Based on scenario in IAEA SRS 44 and EC RP 122
- 5 x 2 x 1 = 10 m^3 volume
- Material is steel but density is 1.5 g cm^{-3}
- Driver 1 m away

External irradiation using MCNP (3)

More realistic scenario with 3 mm steel shielding and weight ~ 15 tonnes



Notes

- whole container is 2.4 x 1 x 6.1 m
- Source material 2.4 x 1 x 3 m at front made of Tantalum oxide
- 3 mm steel shielding surrounding
- Driver 1.5 m away
- Material within container may be distributed differently
- Steel shielding could be applied to other scenarios

Questions on External Irradiation for Future Work

- What scenario should be used?
  - Need to balance detail and computing time
  - Should not be specific to one transport arrangement
  - Consultation with industry needed

- Parameters of calculations need to be confirmed with industry, such as position and exposure time of the driver
- Need to compare with measured dose rates from RPAs

Updated Dose Coefficients and Parameters

- Updated dose coefficients for occupational intakes have been produced by the ICRP in Publications 134, 137, 141 and 151.
- Dust loading factor is a key parameter for inhalation dose calculations. The current assumption is a 1 mg m^{-3} but could change in future work
- Rate of inadvertent ingestion could also change after review of literature

Skin Contamination Doses

- Skin contamination doses are from material in contact with skin, occurring during the loading and unloading of material
- Carey et al. (1995) involves the sum of gamma and beta dose rates
- Used VARSKIN+1.0 program which includes alpha, beta and gamma dose rates

Dose to Driver

Radionuclide	Carey et al. (mSv y^{-1})	New calculation (mSv y^{-1})		
		Rectangular cuboid	Half-Cylinder	Steel Container
^{226}Ra	20	22	24	11

New dose rate similar to that calculated by Carey et al. (1995)

Preliminary Results –Activity Concentrations

Radionuclide	RP-65 (Bq g^{-1})	Carey et al. (Bq g^{-1})	New Scenario	New exemption values (Bq g^{-1})		
				Rectangular cuboid	Half-Cylinder	Steel Container
^{226}Ra	4.7	0.5	Driver	45	43	89
^{210}Pb	5.2	-	Loader	958	958	958

Future work

- The most significant pathway was external irradiation (Driver) for Ra-226 and inhalation (Loader) for Pb-210. However other naturally occurring radionuclides will have other dominant pathways
- Other scenarios for all modes of transport, such as air and sea, will be considered with industry
- The external irradiation scenarios will be improved by better reflecting current practices and being quicker to compute

Conclusions

- These are preliminary results of the calculation of exemption limits for the transport of radionuclides of natural origin in bulk quantities
- The values were calculated using an effective dose criterion for bulk material set at 1 mSv y^{-1} instead of 10 µSv y^{-1} and updated coefficients
- Other exposure scenarios, such as bulk material in aircraft holds, will be considered in future work
- The calculation of external dose rates with MCNP will be further refined based on information on working practices from the industry.
- Will present work at PATRAM 2023