Discrete Radioactive Particle (DRP) Considerations in Decommissioning

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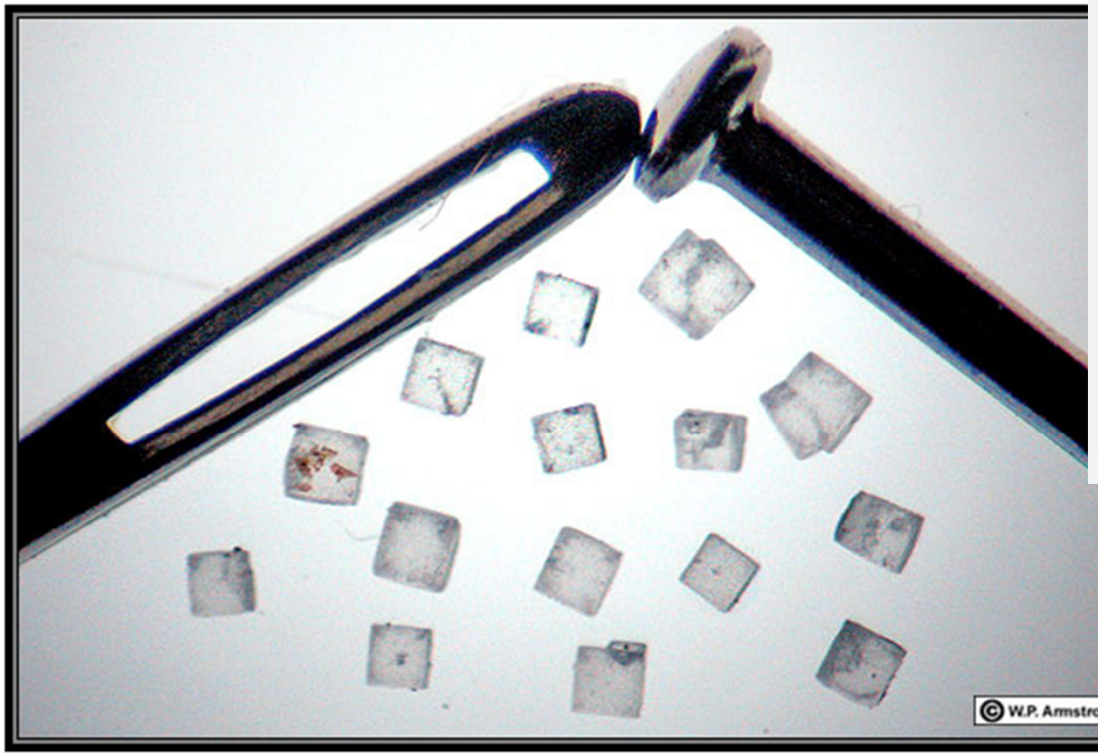
What is a DRP?

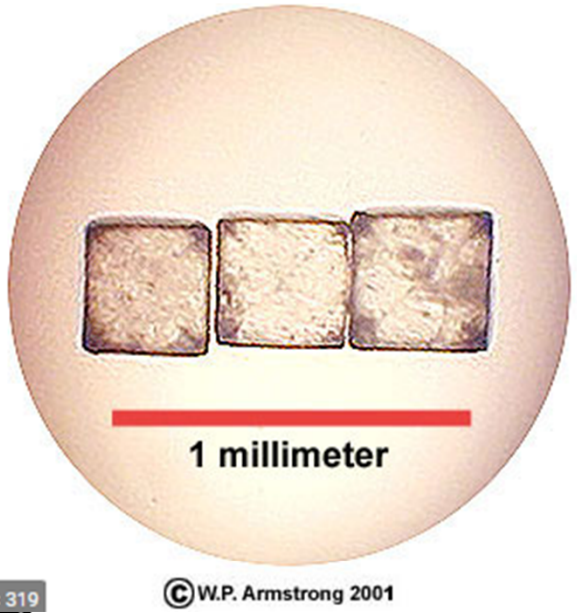
"Discrete Radioactive Particle" = Hot Particle

"Hot particle" means a discrete radioactive fragment that is insoluble in water and is less than 1 mm in any dimension.

Per IN 90-48, NCRP 106, etc.



351 × 319



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Examples of DRPs

- Neutron activated metal (legacy wearing particles, cuttings from reactor vessel (RV)/RV internals/rebar in bioshield, etc.)
- Legacy fuel flea (spent fuel)
- Neutron activated bioshield concrete (primarily Europium (Eu) isotopes)
- Others (e.g., natural Thorium from welding/cutting, damaged sources, etc.)

What are the issues?

- Understanding contamination events and risk of DRPs being released to the environment
- Ability to scan for/identify DRPs in soil
- DRP dosimetry
- Potential exposures to average member of the critical group (exposure scenarios?)

What can be left behind? What is the risk of that material? What is acceptable?

Current Regulatory Requirements

- Decommissioning/Unrestricted Release Requirement: 25 mrem/y Total Effective Dose Equivalent (TEDE)
- Public Dose Limit: 100 mrem/y TEDE
- No deterministic effect limits for public in 10 CFR 20
- Deterministic Effect Limits:
  - 15 rem/y to lens of eye
  - 50 rem/10 cm^2 shallow dose equivalent (SDE) for skin
  - 50 rem/y Committed Dose Equivalent (CDE) to organ
    - Basis: ICRP 26/30
- SDE/local DE is not a contributor to TEDE so it can be problematic
  - area averaging could be 1 cm^2 or 10 cm^2 for skin, 1 cm^2 for internal organs

Previous Regulatory Evaluations

- 2002 – Occupational Dose Limit for SDE established (10 CFR 20.1201(a)(2)(ii) and (c))
  - 50 rem over 10 cm^2

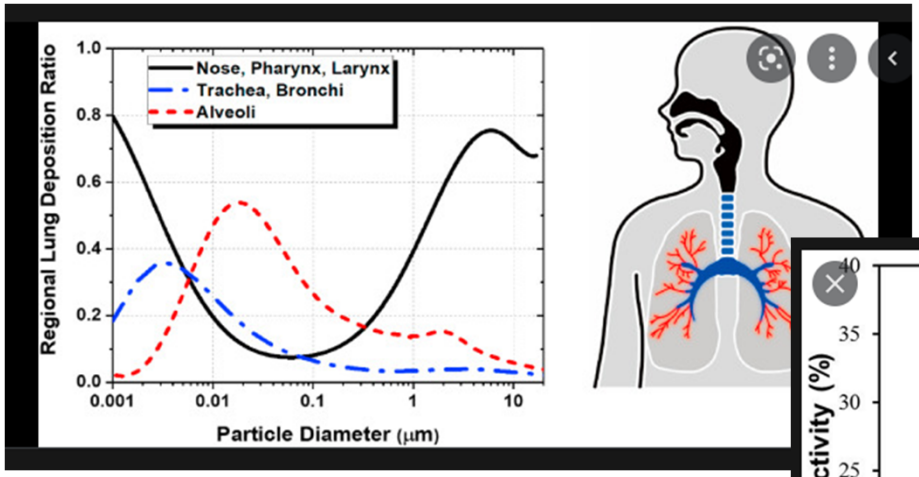
…the worst-case deterministic effects are a 5-percent probability of erythema if all of the dose (500 rem) were delivered to an area of 2.5 square centimeters, and a 50-percent probability that measurable dermal thinning would be observable if all of the dose were delivered to an area of <0.5 square centimeters. At this dose, no acute cell killing or skin ulceration was predicted for DRPs 3 or more millimeters off the skin because the dose is distributed over too large an area. The worst case probability of producing a barely detectable scab as a result of acute cell killing was estimated to be 10 percent for ^{60}Co or activated fuel DRPs located about 0.4 mm off the skin. Additional discussion of implications of the health effects associated with the proposed unified skin dose limit can be found in the regulatory analysis developed for this rulemaking.

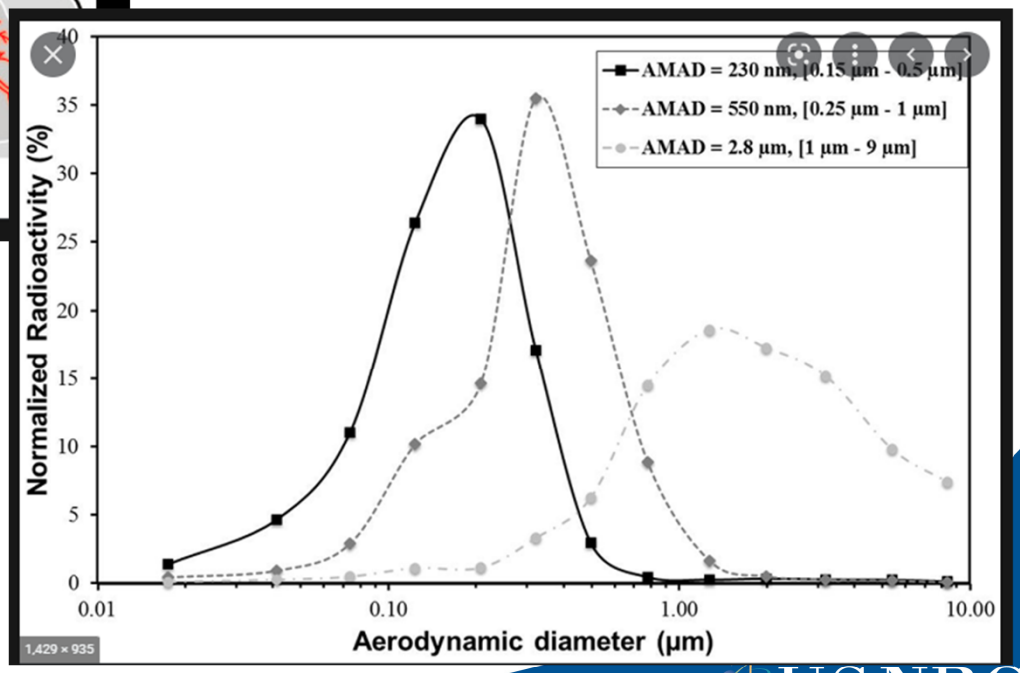
Aerodynamic Diameter ≠ AMAD

AMAD: Activity Median Aerodynamic Diameter

10 µm generally considered “largest” respirable particle size (aerodynamic equivalent *not* AMAD).

Size matters, volume/radioactivity increase by power of 3 as size increases





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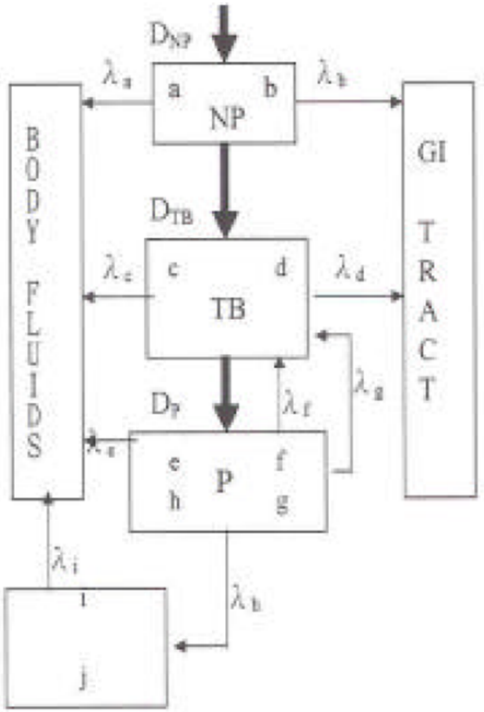
ICRP 26/30 Biokinetic Models not Ideal for Assessing Dose from DRPs

Lung Model

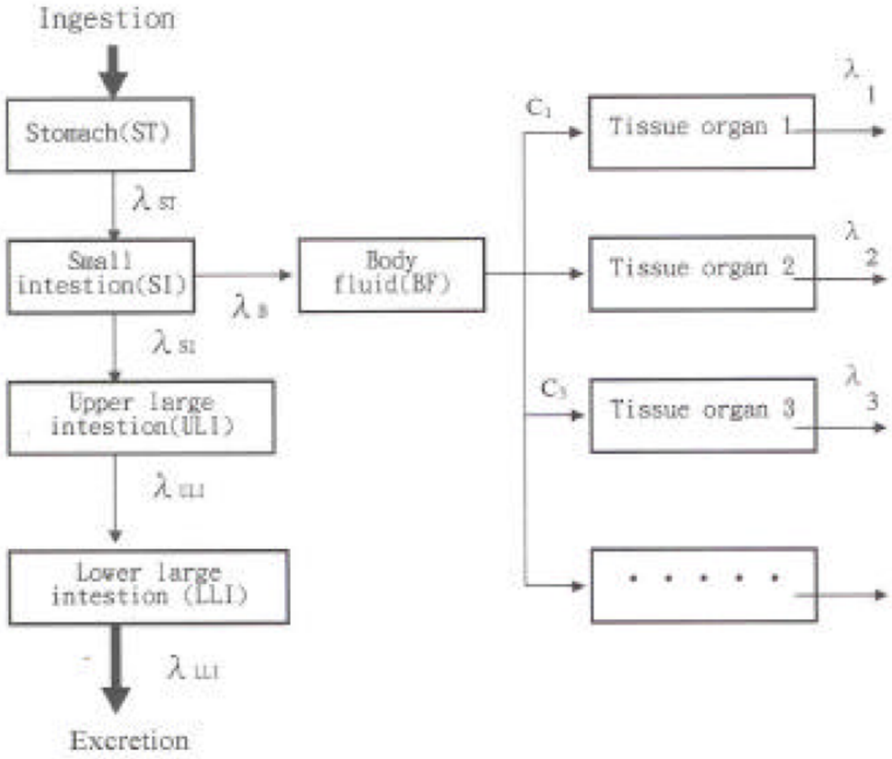


Region	Compart-ment	D		W		Y	
		T	F	T	F	T	F
NP (D_{NP}=0.30)	a	0.01	0.5	0.01	0.1	0.01	0.01
	b	0.01	0.5	0.40	0.9	0.40	0.99
TB (D_{TB}=0.08)	c	0.01	0.95	0.01	0.5	0.01	0.01
	d	0.2	0.05	0.2	0.5	0.2	0.99
P (D_P=0.25)	e	0.5	0.8	50	0.15	500	0.05
	f	--	--	1.0	0.4	1.0	0.4
	g	--	--	50	0.4	500	0.4
	h	0.5	0.2	50	0.05	500	0.15
	i	0.5	1.0	50	1.0	1000	0.9
	j	--	--	--	--	∞	0.1

AMAD = 1 μm ; T(d)

FIG. 2. Mathematical model used to describe clearence from the respiratory system

Alimentary Tract Model



Compartment	λ(天$^{-1}$)
Stomach(ST)	24
Small intestion(SI)	6
Upper large intestion(ULI)	1.8
Lower large intestion (LLI)	1

FIG. 1. Structure of the gastrointestinal tract of the ICRP 30 model

Potential Public DRP Exposures Outside of 10 CFR 20?

- Skin dose (SDE using VARSKIN)
- Ingestion/Inhalation of “an” insoluble particle
  - “local" DE dose to respiratory and alimentary track lining (using VARSKIN [SDE])

Research Assistance

- Renaissance Code Development (RCD)– Developing "a" particle appropriate inhalation/ingestion "localized" DE/EDE/CDE Dose Conversion Factors (DCFs) and skin SDE/EDE DCFs for most significant radioisotopes
  - To make it relatively easy to estimate potential exposures to DRPs
- ORISE – Developing methodology/examples for determining a "scan minimum detectable activity (MDA)" similiar to MARSSIM methods
  - Expected to potentially have multiple applications (e.g., discrete source materials)
- Draft reports are being made publicly available

General Considerations for DRPs

- DRP management should be continued from operations through decommissioning
- DRPs generated through decommissioning activities should be controlled at the source
- If a release to environment occurs, licensees should take corrective action to identify the extent of release, remediate as appropriate, and document surveys to support potential license termination reviews
  - The quicker the better to avoid secondary environmental transport
- If DRPs are anticipated to be present in the environment, it should be discussed in the license termination plan (LTP) or decommissioning plan (DP)

Decommissioning DRP Experience

- Connecticut Yankee
- Maine Yankee
- Yankee Rowe
- Rancho Seco
- Shelwell*

NRC efforts to address DRPs

- Developing methods and/or guidance for
  - Acceptable dosimetry methods for DRPs
  - Scanning for detection of DRPs
    - Survey methods/scan MDAs eventually placed in NUREG-1507; NUREG-1757, Volume 2; and MARSSIM
- Potential Generic Communications in 2023
  - Preventing/documenting release of DRPs during decommissioning

Questions

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