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## **Radiation Safety Quantities, Units, and Terms**



ENVIRONMENTAL MANAGEMENT SAFETY \* EFFICIENCY \* TRANSPARENCY

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#### **Metric**

<u>PRE</u>	FIX	<u>SYMBOL</u>	MULTIPLE	DECIMAL
•	tera	т	1012	1,000,000,000,000
•	giga	G	10 <sup>9</sup>	1,000,000,000
•	mega	Μ	<b>10</b> <sup>6</sup>	1,000,000
•	kilo	k	10 <sup>3</sup>	1,000
•	Base Unit		10 <sup>0</sup>	1
•	milli	m	10-3	0.001
•	micro	μ	10-6	0.000001
•	nano	n	10 <sup>-9</sup>	0.00000001
•	pico	р	10-12	0.00000000001

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## Activity

- curie (Ci)
  - The activity of 1 gram of <sup>226</sup>Ra

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- 3.7 x 10<sup>10</sup> disintegrations per second (dps)
- Becquerel (Bq)
  - One disintegration per second (dps)
- One dps is <u>NOT</u> synonymous with the number of particles emitted by the isotope in one second







#### Activity

1 Ci = 3.7 x 10<sup>10</sup> Bq 1 Bq = 2.7027 x 10<sup>-11</sup> Ci

## 3.7 x 10<sup>10</sup> dps x 60 sec/min = 2.22 x 10<sup>12</sup> dpm



1 Ci = 2.22 x 10<sup>12</sup> dpm 1 μCi = 2.22 10<sup>6</sup> dpm 1 pCi = 2.22 dpm





#### Activity

• 1 dps = 1 Bq = 27 pCi = 2.7027 x 10<sup>-11</sup> Ci

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- 1 dpm = 60 Bq = 1.622 pCi = 1.622 x 10<sup>-9</sup> Ci
  - 1μCi = 37,000 Bq : 1 MBq = 27μCi
  - 1 mCi = 37 MBq : 1 MBq = 0.027 mCi
    - 1 GBq = 0.027 Ci : 1 Ci = 37 GBq
    - 1 TBq = 27 Ci : 1 Ci = 0.037 TBq





## **Decay Methods**

- Alpha ( $\alpha$ )
- Beta minus ( $\beta^{-}$ )



- Beta positive ( $\beta^+$ ) (positron) and Electron Capture
- Gamma (associated with other types of decay)

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## Exposure

• Roentgen (R)

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- The measure of the number of ion-pairs produced by X or gamma radiation in a certain volume of air
- One statcoulomb of charge per cm<sup>3</sup> of air at 0° and 760 mm Hg
- Not a U.S. Nuclear Regulatory Commission defined term of exposure



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#### Dose

RAD (Radiation Absorbed Dose)

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- An absorbed radiation dose of 100 ergs per gram
- Energy deposited by any ionizing radiation in a unit mass of any absorber
- Gray (Gy)
  - 1 Gy = Absorbed Dose of 1 Joule/kg
  - 1 Gy = 100 rads
  - 1 rad = 0.01 Gy or 1cGy







#### Dose

- Sievert (Sv)
  - 1 Sv = 100 rems
- REM (Roentgen Equivalent Man)

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- The absorbed dose (RAD) multiplied by a quality factor to equalize biological consequences

<u>Radiation</u>	Quality Factor	
x-ray	1	
gamma	1	
beta	1	
alpha	20	
neutron (unknown energy)	5-20	





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### **Internal Dose**

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 Dose Equivalent (H<sub>T</sub>) - the product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest. Expressed in rem or Sv

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• Effective Dose Equivalent  $(H_E)$  - the sum of the products of the dose equivalent to the organ or tissue  $(H_T)$  and the weighting factors  $(W_T)$  applicable to each of the body organs or tissues that are irradiated  $(H_E = SW_T H_T)$ 





#### **Organ Dose Weighting Factors**

Organ or Tissue	WT
Gonads	0.25
Breast	0.15
Red Bone Marrow	0.12
Lung	0.12
Thyroid	0.03
Bone Surfaces	0.03
Remainder	<sup>1</sup> 0.30
Whole Body	1.00

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<sup>1</sup> 0.30 results from 0.06 for each of the "remainder" organs (excluding the skin and the lens of the eye) that receive the highest dose.



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## **Internal Dose**

- Committed Dose Equivalent (H<sub>T,50</sub>) the dose equivalent to organs or tissues of reference (T) that will be received from an intake of radioactive material by an individual during the 50year period following the intake
- Committed Effective Dose Equivalent  $(H_{E,50})$  {CEDE} the sum of the products of the weighting factors applicable to each of the body organs or tissues that are irradiated and the committed dose equivalent to these organs or tissues ( $H_{E,50} =$  $SW_T H_{T,50}$ )





#### **DOE Dose Reporting**

 Total Effective Dose Equivalent (TEDE) - the sum of the deepdose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures)
TEDE - Deep Dose + CEDE

TEDE = Deep Dose + CEDE

EBAN

 Total Effective Dose (TED) - the sum of the effective dose (for external exposures) and the committed effective dose
TED = Deep Dose + CED





#### **Dose vs Dose Rate**

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- Dose generic term that means absorbed dose, dose equivalent, effective dose equivalent or total effective dose equivalent (mrem)
- Dose Rate the rate at which a dose is being delivered per a time interval (mrem per hour)







#### **Radiation Exposure vs Radioactive Contamination**

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- Exposure the delivery of radiation to an individual that results in the receipt of a radiation dose
- Contamination radioactive material distributed in an unwanted place or location







## **QUESTIONS?**



