Use of Plutonium Equivalent Curies for Measuring Risk

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Acronyms

ARF: Airborne Release Fraction
DCF: Dose Conversion Factor
DOE-SR: Department of Energy, Savannah River
DR: Damage Ratio
LPF: Leak Path Factor
MAR: Material at Risk
PEC: Plutonium Equivalent Curies
Question

Should Plutonium Equivalent Curies (PEC) be used as a Measure of Relative Risk Between Nuclear Facilities at SRS?

DOE-SR Perspective

PEC does not Adequately Describe or Represent Risk.
Definition of Risk

- Risk is Defined as the Possibility of Suffering Harm or Loss
  - Definition implies a probability in conjunction with a consequence
  - Mathematically:
    - $Risk = \text{probability of a bad thing happening} \times \text{consequences of a bad thing}$
Risk Management and the Safety Based Design Process

• **Start with a Conceptual Design for a Facility or Process**
  – For example, a facility to neutralize waste and turn it into glass

• **Risk Determination Begins with Hazard Analysis**
  – Identifies potential hazards present within a facility or process

• **Risk Determination Matures with Accident Analysis**
  – Indication of potential bounding consequences (dose) without measures to prevent or reduce hazards

• **Controls are Selected to Manage Risks (Prevent/Mitigate)**
• **Controls are then Classified According to Safety Function**
  – *Safety Class* to prevent/mitigate offsite consequences
  – *Safety Significant* to prevent/mitigate worker consequences
  – *Safety Significant* to provide significant defense-in-depth

• **Design Requirements Based upon Safety Function**
**Hazard Analysis & Control Selection Process**

**Conceptual Design**
- Initial Design

**Hazard Analysis**
- Hazard Analysis

**Accident Analysis**
- Accident Analysis
  - Unmitigated Release Doses:
    - Public
    - Co-located Worker
    - Facility Worker

**Control Selection**
- Select Controls and Assign Safety Related Classification
- Results Acceptable?
  - No
  - Yes
    - Incorporate Controls into Design

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**Key DOE Directives and Standards:**

- **DOE O 420.1**
  - DOE STD 3009
  - DOE STD 1189
  - DOE STD 1027
  - DOE G 420.1-1

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- **DOE STD 1027**
- **DOE G 420.1-1**
Accident Analysis Consequences

• Define a Scenario from Hazard Analysis Results
  – May combine several events into a single event

• Determine Unmitigated Dose (Consequences) to Maximally Exposed Offsite Individual
  – Highest dose to hypothetical member of public closest to the site

• Compare to Offsite Evaluation Guideline
  – Results drive the need for design features

• Identify Controls to Prevent or Mitigate Offsite Consequences
  – Assures public and worker protection
Calculating Dose Consequences

• **Unmitigated Dose Consequences must be Reasonably Conservative**
  – **Material at Risk (MAR)** – This is the quantity of radiological material susceptible to a release. Form (liquid, powder, etc.) and quantity (e.g., PEC) should be reasonably bounding
  – **Damage Ratio (DR)** – Amount of MAR actually impacted by event; again, should be reasonably bounding
  – **Airborne Release Fraction (ARF)** – This is the fraction of MAR that, once released, can go into the air. Bounding estimates are established in DOE handbook
  – **Leak Path Factor (LPF)** – Amount of airborne MAR released from the facility
  – **Dispersion** – Based upon bounding meteorology
  – **Dose Conversion Factor (DCF)** – Converts quantity inhaled to radiological dose

\[
\text{Dose} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{LPF} \times \text{Dispersion} \times \text{DCF}
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Plutonium Equivalent Curies and Risk

- Plutonium Equivalent Curies does not Adequately Describe or Represent Risk
- Plutonium Equivalent Curies is an Expression of “Material at Risk”
  - One of six terms used to calculate radiological consequences
    - Plutonium Equivalent Curies is one Component of a Component of Risk
- Plutonium Equivalent Curies used as a Risk Surrogate Neglects Several Important Factors in Determining Risk
  - Equipment malfunction/damage allowing some material to be released
    - Very few events have the potential to release all of the material at risk
  - Is it dispersible?
    - Powder versus glass logs
  - Energy available for dispersion
  - Leakage from the facility
  - Likelihood of event occurrence
QUESTIONS?