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:
    - \( \text{Risk} = \text{probability of a bad thing happening} \times \text{consequences of a bad thing} \)
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 | Hazard Analysis | Accident Analysis | Control Selection

Initial Design → Hazard Analysis → Accident Analysis

Unmitigated Release Doses:
- Public
- Co-located Worker
- Facility Worker

Select Controls and Assign Safety Related Classification

Reanalyze Accident

Results Acceptable?

No → Yes

Incorporate Controls into Design

Key DOE Directives and Standards:

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<th>Hazard Analysis</th>
<th>Accident Analysis</th>
<th>Unmitigated Release Doses:</th>
<th>Select Controls and Assign Safety Related Classification</th>
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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

\[
\text{Dose} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{LPF} \times \text{Dispersion} \times \text{DCF}
\]
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?