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Spent Nuclear Fuel & Plutonium Storage Risk

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SRS Citizens Advisory Board

Hilton Savannah DeSoto, Savannah, GA

Purpose

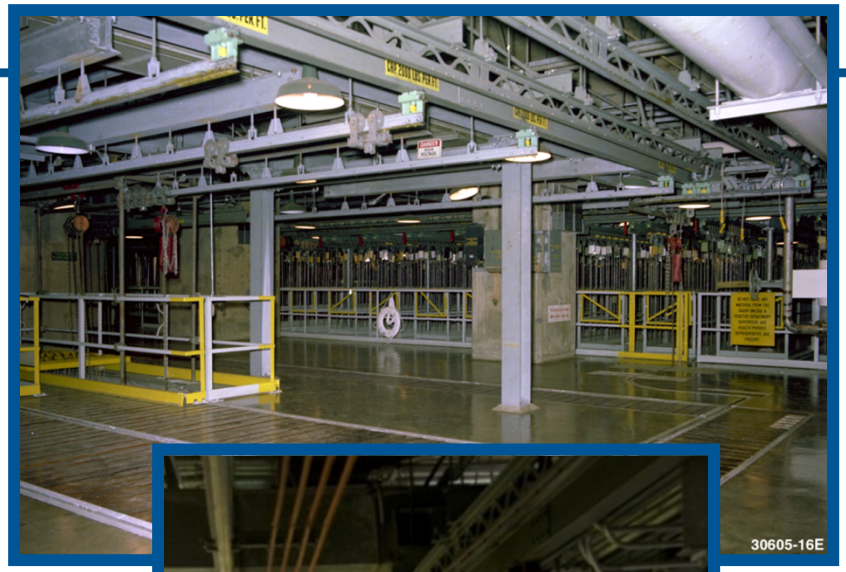
- To fulfill the Nuclear Materials Committee Work Plan topic
- Address a request from the Nuclear Materials Committee / CAB

Risk Analysis

- **Documented Safety Analysis (DSA)**
  - Facility Hazard Categorization
  - Hazard Analysis
    - *Scenario development / event progression*
    - *Material–at-risk / source term analysis*
    - *Prevention features*
    - *Frequency binning*
    - *Mitigation features*
    - *Consequence analysis*
  - Identification of controls to prevent occurrences and mitigate consequences
  - Defines risk and ensures within established evaluation guidelines

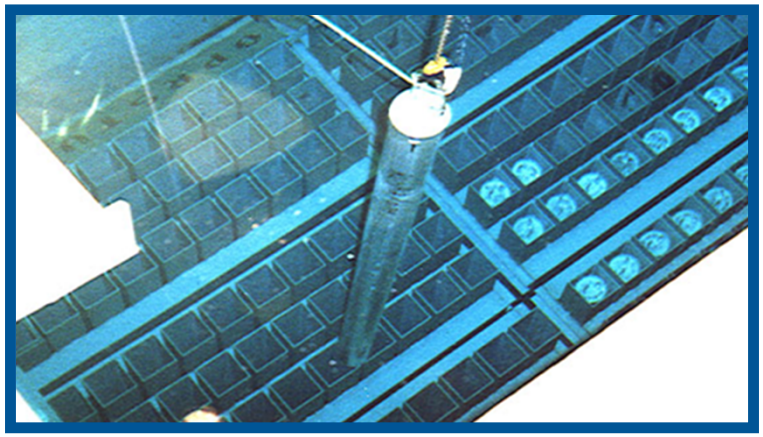
Potential Initiating Events

- Fire
- Explosion
- Loss of Containment / Confinement
- Direct Radiation Exposure
- Nuclear Criticality
- External Events
- Natural Phenomena (e.g., seismic, tornado, wind)



Accident Prevention - Examples

- **Engineered Controls**
  - Building structure
  - Storage rack and fuel bundle designs
  - Cask design
  - Fuel & cask handling equipment



- **Administrative Controls**
  - Combustible / flammable / explosive control programs
  - Hoisting & rigging program
  - Highly structured procedures
  - Personnel training & qualification

Consequence Mitigation - Examples

- **Engineered Controls**
  - Area radiation monitoring system
  - Basin water level
  - Shielding
  - Fire water supply
- **Administrative Controls**
  - Fuel receipt & shipping program
  - Emergency response
  - Fire department and manual fire fighting
  - Procedures & training

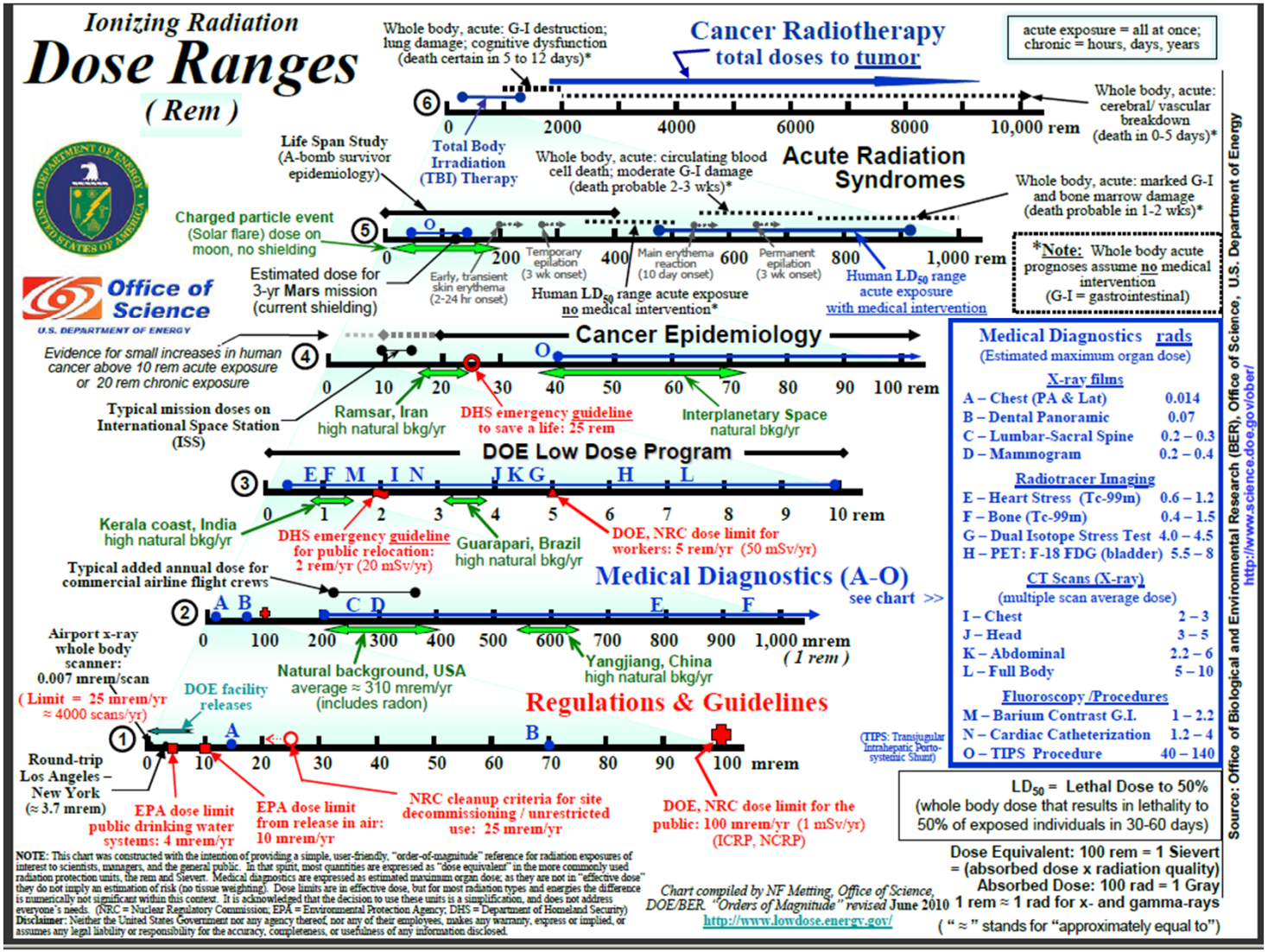
Results of Postulated Accident Scenarios – L Area

Accident	Offsite Dose (mrem)
Fire on -40' Level	6.5
Bounding Facility Fire	22.5
Fire-Induced Criticality	41
Process-Induced Criticality in Disassembly Area	8.3
Wildland or Post-Seismic Initiated Fire	22.5

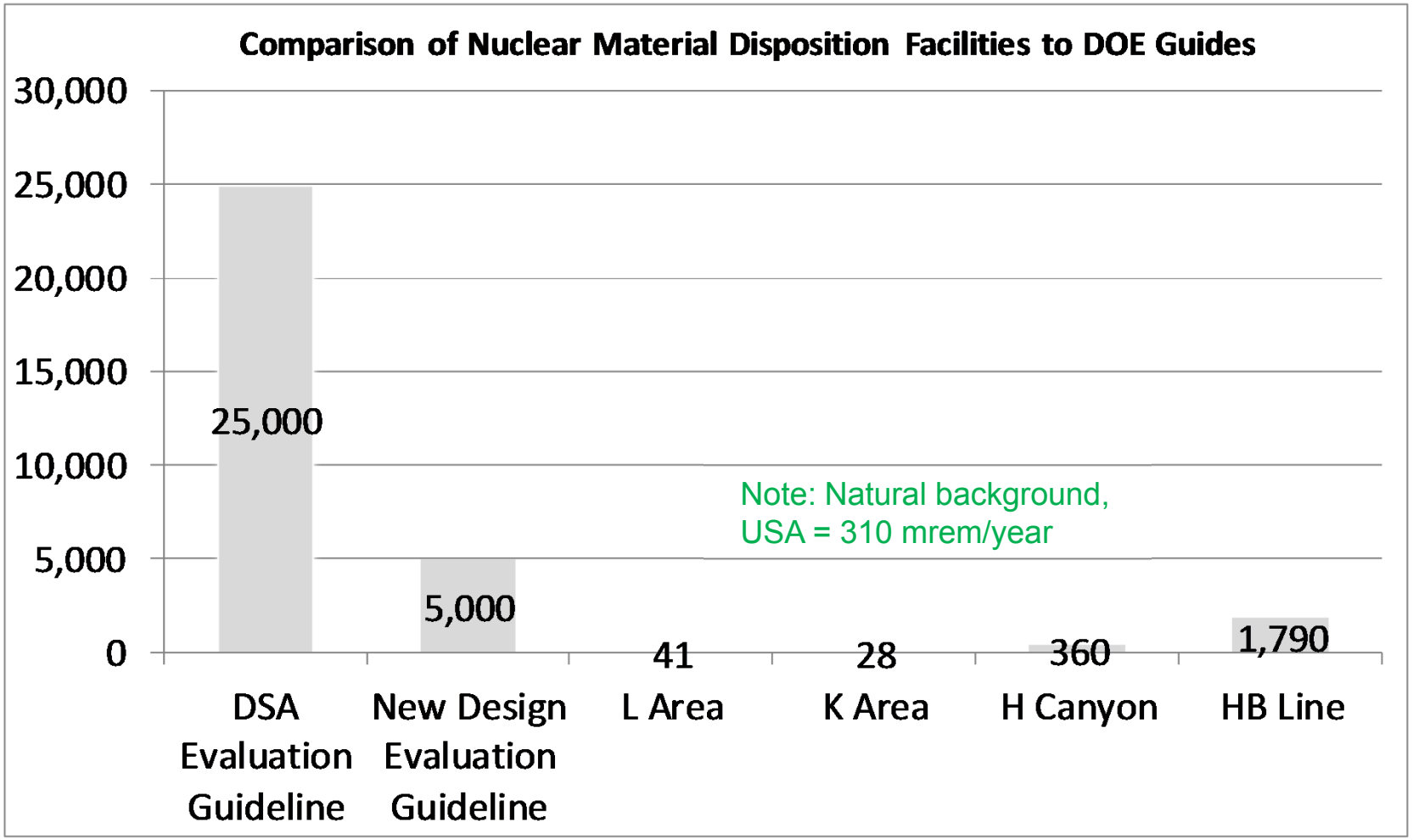
Contributors to postulated fire-induced criticality accident (mrem):

- Bounding disassembly area fire 31
  - ✓ Dry fuel storage
  - ✓ Deionizers and filters
  - ✓ Radioactive waste
  - ❖ No contribution from underwater fuel
- Evaporated basin water 1.6
- Criticality 8.3

41

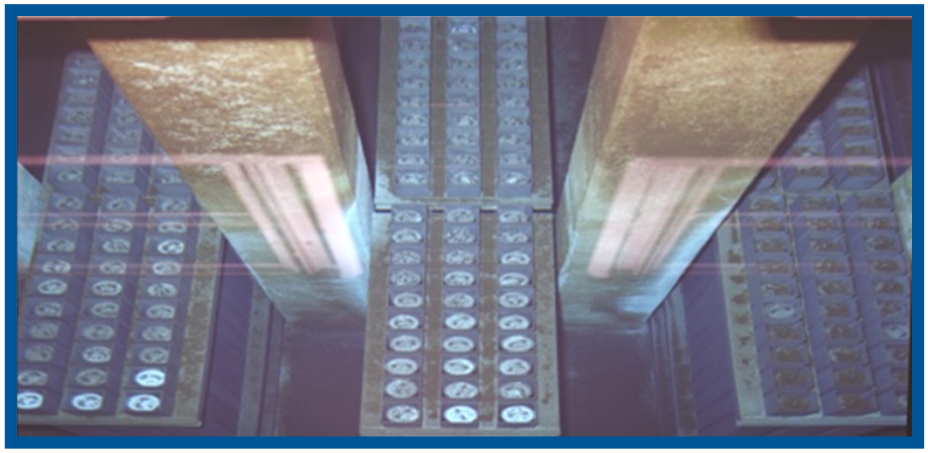

Ionizing Radiation
Dose Ranges
(Rem)
Office of Science
U.S. DEPARTMENT OF ENERGY
Cancer Radiotherapy
total doses to tumor
acute exposure = all at once; chronic = hours, days, years
Whole body, acute: G-I destruction; lung damage; cognitive dysfunction (death certain in 5 to 12 days)*
Whole body, acute: cerebral/ vascular breakdown (death in 0-5 days)*
0 2000 4000 6000 8000 10,000 rem
Total Body Irradiation (TBI) Therapy
Acute Radiation Syndromes
Life Span Study (A-bomb survivor epidemiology)
Whole body, acute: circulating blood cell death; moderate G-I damage (death probable 2-3 wks)*
Whole body, acute: marked G-I and bone marrow damage (death probable in 1-2 wks)*
Charged particle event (Solar flare) dose on moon, no shielding
0 200 400 600 800 1,000 rem
Temporary epilation (3 wk onset)
Main erythema reaction (10 day onset)
Permanent epilation (3 wk onset)
Early, transient skin erythema (2-24 hr onset)
Estimated dose for 3-yr Mars mission (current shielding)
Human LD50 range acute exposure no medical intervention*
Human LD50 range acute exposure with medical intervention
*Note: Whole body acute prognoses assume no medical intervention (G-I = gastrointestinal)
Cancer Epidemiology
Evidence for small increases in human cancer above 10 rem acute exposure or 20 rem chronic exposure
0 10 20 30 40 50 60 70 80 90 100 rem
Typical mission doses on International Space Station (ISS)
Ramsar, Iran high natural bkg/yr
DHS emergency guideline to save a life: 25 rem
Interplanetary Space natural bkg/yr
DOE Low Dose Program
E F M I N J K G H L
0 1 2 3 4 5 6 7 8 9 10 rem
Kerala coast, India high natural bkg/yr
DHS emergency guideline for public relocation: 2 rem/yr (20 mSv/yr)
Guarapari, Brazil high natural bkg/yr
DOE, NRC dose limit for workers: 5 rem/yr (50 mSv/yr)
Typical added annual dose for commercial airline flight crews
Medical Diagnostics (A-O)
see chart >>
A B C D E F
0 100 200 300 400 500 600 700 800 900 1,000 mrem
(1 rem)
Airport x-ray whole body scanner: 0.007 mrem/scan
(Limit = 25 mrem/yr ≈ 4000 scans/yr)
Natural background, USA average ≈ 310 mrem/yr (includes radon)
Yangjiang, China high natural bkg/yr
DOE facility releases
Regulations & Guidelines
A B
0 10 20 30 40 50 60 70 80 90 100 mrem
Round-trip Los Angeles – New York (≈ 3.7 mrem)
EPA dose limit public drinking water systems: 4 mrem/yr
EPA dose limit from release in air: 10 mrem/yr
NRC cleanup criteria for site decommissioning / unrestricted use: 25 mrem/yr
DOE, NRC dose limit for the public: 100 mrem/yr (1 mSv/yr) (ICRP, NCRP)
Medical Diagnostics rads
(Estimated maximum organ dose)
X-ray films
A – Chest (PA & Lat) 0.014
B – Dental Panoramic 0.07
C – Lumbar-Sacral Spine 0.2 – 0.3
D – Mammogram 0.2 – 0.4
Radiotracer Imaging
E – Heart Stress (Tc-99m) 0.6 – 1.2
F – Bone (Tc-99m) 0.4 – 1.5
G – Dual Isotope Stress Test 4.0 – 4.5
H – PET: F-18 FDG (bladder) 5.5 – 8
CT Scans (X-ray)
(multiple scan average dose)
I – Chest 2 – 3
J – Head 3 – 5
K – Abdominal 2.2 – 6
L – Full Body 5 – 10
Fluoroscopy /Procedures
M – Barium Contrast G.I. 1 – 2.2
N – Cardiac Catheterization 1.2 – 4
O – TIPS Procedure 40 – 140
(TIPS: Transjugular Intrahepatic Porto-systemic Shunt)
LD50 = Lethal Dose to 50% (whole body dose that results in lethality to 50% of exposed individuals in 30-60 days)
Dose Equivalent: 100 rem = 1 Sievert = (absorbed dose x radiation quality)
Absorbed Dose: 100 rad = 1 Gray
1 rem ≈ 1 rad for x- and gamma-rays
(" ≈ " stands for "approximately equal to")
NOTE: This chart was constructed with the intention of providing a simple, user-friendly, "order-of-magnitude" reference for radiation exposures of interest to scientists, managers, and the general public. In that spirit, most quantities are expressed as "dose equivalent" in the more commonly used radiation protection units, the rem and Sievert. Medical diagnostics are expressed as estimated maximum organ dose; as they are not in "effective dose" they do not imply an estimation of risk (no tissue weighting). Dose limits are in effective dose, but for most radiation types and energies the difference is numerically not significant within this context. It is acknowledged that the decision to use these units is a simplification, and does not address everyone's needs. (NRC = Nuclear Regulatory Commission; EPA = Environmental Protection Agency; DHS = Department of Homeland Security)
Disclaimer: Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information disclosed.
Chart compiled by NF Metting, Office of Science, DOE/BER. "Orders of Magnitude" revised June 2010
http://www.lowdose.energy.gov/
Source: Office of Biological and Environmental Research (BER), Office of Science, U.S. Department of Energy
http://www.science.doe.gov/ober/

Mitigated Offsite Consequence (mrem)



Risk from Spent Nuclear Fuel & Plutonium Storage

- None of the analyzed accident scenarios result in damage to or release of radioactive material from the entire inventory of stored nuclear material, thus
- Results of consequence analyses are not affected by the total inventory of stored nuclear material
- Offsite consequences for bounding accidents are categorized as "negligible" (SCD-11) and are unaffected by quantity of stored nuclear material



Nuclear Materials Management