

Marrying Characterization Results and Burial Model Configuration Calculations

(K-25 and EMWMF)

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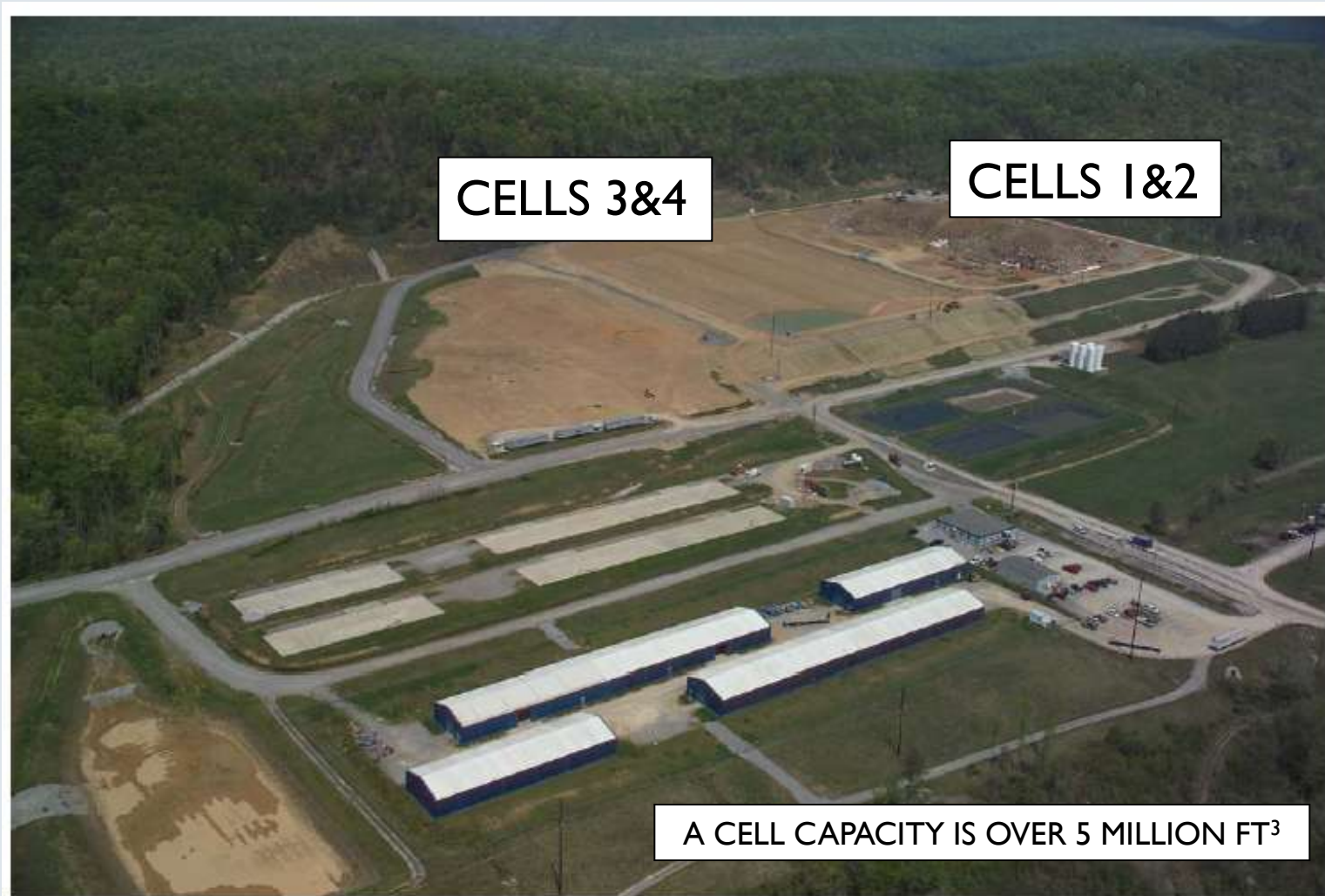
Roy W. Rathbun



ETTP Site (1989) K-25 is the U shape



Environmental Management Waste Management Facility (EMWMF) Burial Ground



➤ Normal Condition Calculation Models

- Every item is modeled containing the ^{235}U mass limit of ^{235}U in a very reactive geometry/shape
- Infinite array of tightly packed items in all directions
- The ^{235}U mass within each item is optimally moderated
- The worst credible soil, water condition, or void space is modeled surrounding each item (space not occupied by the adjacent waste items)
- Only minimal credit is taken for neutron absorption of steel and other elements that comprise the structure of the waste item

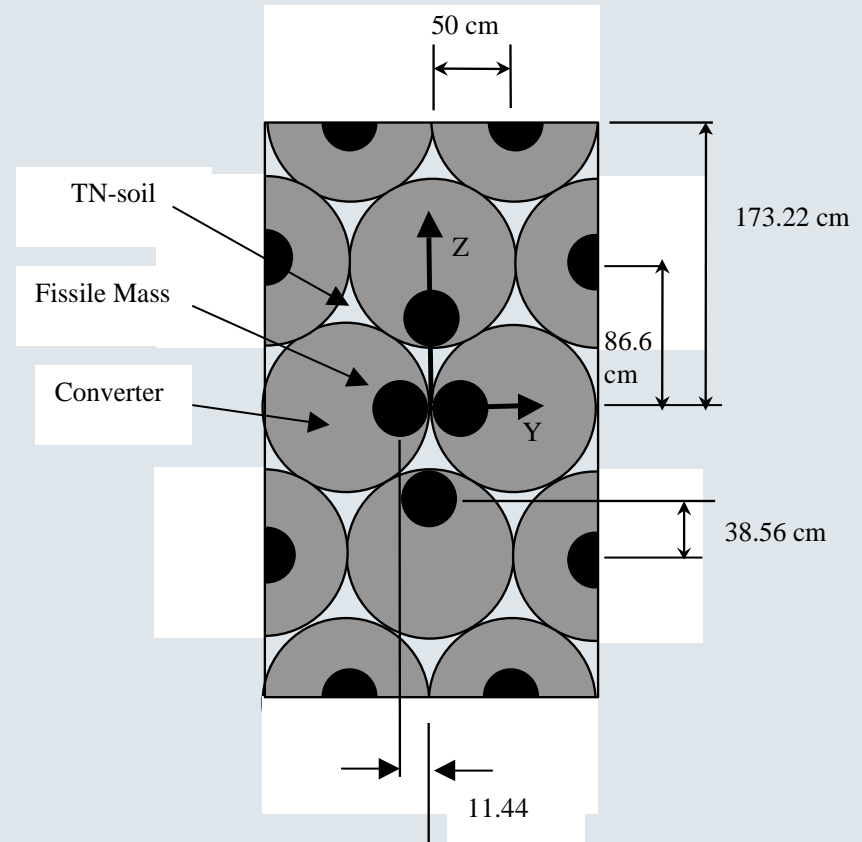
EMWMF Mass Limit Examples

Selected Components	Subcritical Mass Limit per Item
Converter or Compressor	350 g ²³⁵U
Process Gas Piping; 4" up to 6" diameter	10 g ²³⁵U per ft
Process Gas G-17 Valves: 4" up to 6" diameter	50 g ²³⁵U
Process Gas Piping; 10" diameter or greater	22 g ²³⁵U per ft
Process Gas G-17 Valves: 10" diameter or greater	75 g ²³⁵U

EMWMF Calculation Model Example

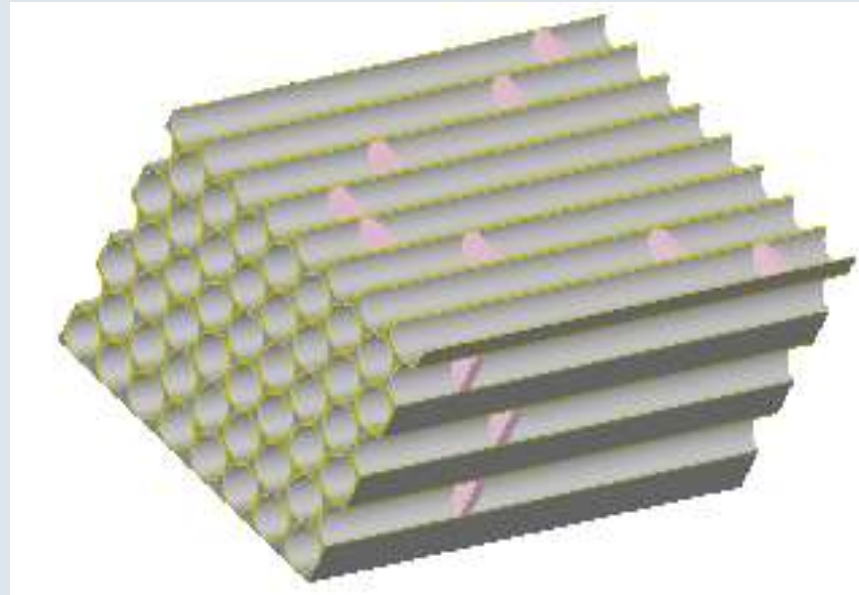
➤ Converters

- 350 g ^{235}U in the form of an H/D=1 cylinder
- Fissile masses as close together as physically possible
- Optimally moderated
- Model used smallest converters for tightest credible packing



EMWMF Calculation Model Example

- Piping and G-17 Valve representation
- ^{235}U mass limit in each foot of pipe and ^{235}U mass limit in each G-17 valve
- Optimal moderation; Tightly packed array of pipes
- Reality versus model i.e., # of valves per foot of pipe
 - Reality = 1 valve for every 43 feet of pipe (on average)
 - Model = 1 valve for every 10 feet of pipe



➤ **Process knowledge review**

- Personnel sorted through thousands of historical documents including logbooks and nuclear safety related reports
- Included conversations with personnel who worked at K-25 during building operation
- Identified characterization activities performed during operation or prior to 1980s NDA program

➤ **Results: Created a database of process upsets for K-25**

➤ **Results: Identified systems normally exposed to process gas and systems potentially exposed to process gas**

➤ Visual Inspections {Vent, Purge, Drain, & Inspect (VPDI) Program}

- Performed on all process gas piping \geq 3 inch diameter and on process gas components
- Performed under a work package with NCS controls
- Results documented on VPDI Registers

➤ **Results: All deposits and liquids in inspected items were identified for further consideration through the NCS Discovery Process**

- Graded documented approach specified within work package for VPDI crew to follow
- NaI detector surveys at location at same time as visual deposition was encountered

➤ **Non-Destructive Assay (NDA) Measurements**

- Significant use of 1980s ‘historical’ NDA values verified through new ‘contemporary’ NDA measurements
 - Contemporary NDA measurements on a graded approach using statistical methods
- Over 170,000 contemporary NDA measurements made in West Wing, North End, and East Wing
- Department of Energy (DOE) reviewed and approved NDA program
- Graded approach employed using a systematic characterization on those systems with little to no potential for uranium deposition

➤ Foaming

- Applied to piping \geq 3 inch diameter and to certain process gas components
- Ensures that equipment is buried with the same ^{235}U mass quantity and distribution as it was characterized to contain in the building
 - If a 10 ft long pipe contains 5 g $^{235}\text{U}/\text{ft}$ in each foot, it does not arrive at the burial cell with 50 g in a single foot due to either water entry and migration, or just the demolition and hauling process shaking things around
- Foaming Cards clearly document the piping and components that received foam

➤ Equipment Removal

- All high risk equipment (HRE) > 350 g ^{235}U
- All items exceeding EMWMF NCS limits established in NCSE-ET-K25-1600

➤ Equipment Removal Process

- Identified through characterization processes (VPDI and/or NDA)
- Tracked by Data Management group through the Criticality Incredible Data Management System (CIDMS)
- Identified for removal by a procedure process that creates an Engineering Transmittal to convey specific information to Operations group to perform the removal
- Independently verified as removed through NCS Engineer walkdowns

➤ Converters

- 1980s NDA Program In-situ measured 2667 (average mass < 200g ²³⁵U)
- Identified 125 HRE (i.e., exceed EMWMF mass limit of 350 g ²³⁵U)
- Of those 125, after ex-situ measurements only 11 were actually HRE

➤ Piping

- Contemporary NDA measurement on over 150,000 feet
- ~90% with less than 2 g ²³⁵U/foot
- Only 8 were HRE, and comprised less than a total of 100 feet of pipe

➤ G-17 Valves

- Contemporary NDA measurement on all ~5000 valves
- Over 85% with less than 25 g ²³⁵U
- Only 2 were HRE after ex-situ measurement were performed

- **Each of the project activities that was performed has some potential for failure**
- **Upset scenarios and potential magnitudes were defined and/or discussed for each of the project activities**
- **For each characterization activity it is concluded that it was at least unlikely for the activity to have missed an HRE deposit**
- **Each of the items normally exposed to process gas had multiple project activities performed on it**
 - Including at least two independent characterization techniques
- **Therefore, it becomes extremely unlikely or not credible depending upon the item type for the item to contain an HRE deposit**

➤ Converters

- 1 out of every 8 modeled containing 700 g ^{235}U , other 7 at 350 g

➤ Pipes and G-17 Valves

- 3 out of every 52 ten foot lengths of pipe modeled containing a 'double batch' lump
 - For example, 10 inch diameter pipe with an mass limit of 22 g/ft;
One lump in each of three pipes with 440 g ^{235}U
- 1 out of every 52 ten foot lengths of pipe modeled containing a lump of 700 g ^{235}U

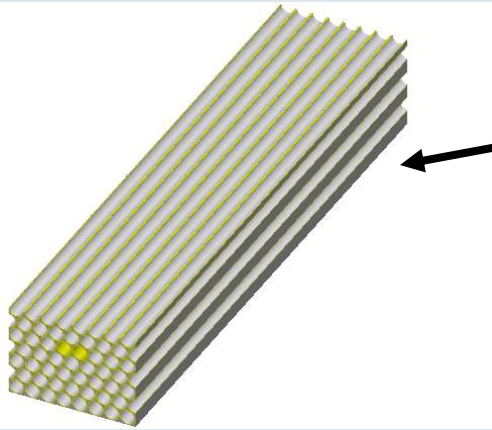
➤ Each upset configuration remains subcritical

EMWMF Calculation Upset Condition Example

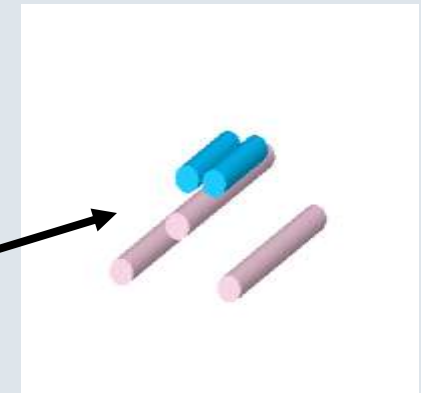
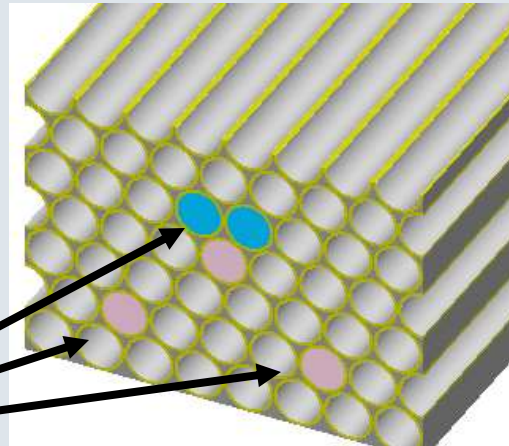
blue = expected mass lumps; pink = 2 × mass lumps in ~5% of pipes

52-pipe Array of 10-foot Long Pipes Buried in TN-Soil

Fissile Lumps Centered



Cut-away View
of Fissile Lumps



View with Pipes Removed & Only Lumps Shown

All credible heterogeneous configurations must be shown to be subcritical

➤ Converter Example

- 1980s NDA Program measured each converter with Gamma based technique, if result was greater than 300 g ^{235}U , an independent neutron measurement was performed
- Visual inspections performed to verify NDA modeling assumptions, i.e., no visible chunks or deposits
- Ex-situ measurements on removed converters confirm in-situ measurements are conservative
- All converters greater than EMWMF mass limit 350 g ^{235}U confirmed removed prior to demolition
- Based on the amount of characterization performed and its results, 1 in 8 converters remaining in the building having 700 g ^{235}U while the other 7 contain 350 g ^{235}U is not credible

➤ Piping Example

- Typical K-25 Building unit contains ~3000 feet of pipe
- EMWMF upset model ~500 feet of pipe and 3 mass upsets (modeled at 20x the ^{235}U mass limit)
 - So for example to exceed EMWMF upset model, each unit of the building would have to contain 18 mass upset conditions,
OR
 - Each unit of the building would have to contain 6 pipe sections with 700 g ^{235}U
- Based on visual inspection results and NDA characterization, such a large quantity of mass upset conditions is not credible for any unit, or in all units

Conclusion

- **Over 90% of the massive K-25 Building has been demolished and disposed at EMWMF using this process**
- **6 Units remain (3 of which are ^{99}Tc Contaminated) but will use a similar process with some minor tweaks**

ETTP Site (May 2013)

