Development of Consistent Hazard Controls for DOE Transuranic Waste Operations

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DOE is responsible for the safe conduct of transuranic (TRU) waste operations from generation to disposal . . .

Generation

Storage

Retrieval and Handling

Characterization and Packaging

Transportation

Disposal

A large portion of these operations occurs at TRU waste generator and storage sites located across the country . . .

These sites share similarities in terms of the hazards and scope of TRU waste operations . . .

Similar Hazards

Fires

Lightning

Tornadoes

Similar Scope

Storage

Handling

Characterization

Despite these similarities, a wide range of safety controls have been historically applied to TRU waste operations . . .

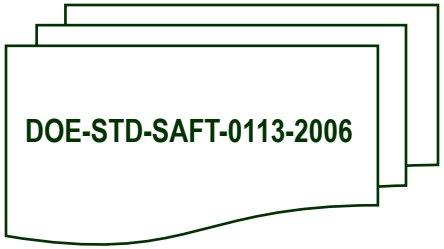
TRU Sites	Similar Hazards	Different Assumptions	Different Safety Controls
 Site A		Overly Optimistic	
 Site B		Overly Conservative	

In 2006, DOE's Office of Environmental Management (EM) launched a reengineering effort to address these inconsistencies. . .

Reengineering Objective

Standardize hazard analysis assumptions and methods and resulting safety controls applied to multiple TRU waste operations located across the U.S.

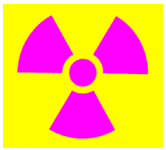
New DOE Technical Standard



"Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities"

The reengineering effort faced two key challenges . . .

1



- TRU wastes are located at both large and small sites
- Range from very low levels of radioactivity to those with significant radiological hazards

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- A one-size-fits-all approach could be:
  - Overly costly for smaller sites
  - Not necessarily in line with relative lower actual risks

2

- TRU waste operations are conducted in both newly designed structures and older buildings
- Older buildings typically don't meet current facility design requirements

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- Protective features designed into new structures are not always available in older buildings
- May be cost prohibitive for retro-fitting into older buildings

The reengineering process . . .

1. Working group collected hazard analysis and control data
2. Established a baseline of minimum accidents that should be included with DSAs at TRU waste operations
3. Examined container behavior tests/studies to establish reasonably conservative assumptions to support hazard and accident analyses
4. Conducted a series of meetings during which hazardous TRU waste events, necessary control functions, and proposed preferred and alternate controls were established
5. Led to a consensus approach to support the development of the new DOE technical standard

DOE-STD-SAFT-0113-2006

Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities

Key Technical Standard content . . .

Hazard and Accident Analysis

- Factors and Assumptions
- Material at Risk (MAR)
- Damage Ratios (DR)
- Airborne Release Fractions and Respirable Fractions (ARF*RF)
- Minimum Set of TRU Waste Accidents

Hazard Control Selection

- Risk Binning Guidelines
- Safety Controls

Factors and Assumptions: Receptor Doses

Receptor doses can be estimated by the following equation:

$$\text{Dose (rem)} = ST \cdot \chi/Q \cdot DCF \cdot BR$$

Where:

ST	=	respirable source term (Ci)
χ/Q	=	atmospheric dilution factor (s/m^3)
BR	=	breathing rate (m^3/s).
DCF	=	inhalation dose conversion factor (rem/Ci)

Factors and Assumptions: Respirable Source Term

Respirable source term is dependent on certain accident stresses and assumptions given in the following equation:

$$ST = MAR \cdot DR \cdot ARF \cdot RF \cdot LPF$$

Where,

- **MAR = material-at-risk is the amount of radionuclides available to be acted on by a given physical stress**
- **DR = damage ratio or fraction of the MAR that is impacted by the postulated accident scenario, unitless**
- **ARF = airborne release fraction, unitless**
- **RF = respirable fraction, unitless**
- **LPF = leak-path factor, unitless**

Hazard and Accident Analysis

Minimum Set of TRU Waste Accidents: Fires and Explosions

Hazard Evaluation Event	Characterization	Container Handling	Venting and/or Abating/Purging	Staging and Storage	Retrieval and Excavation	Waste Repackaging	Type B Container Loading/Unloading
Fire Events							
Fuel Pool Fire (Event 1)		X		X	X		X
Small Fire (Event 2)	X	X	X	X	X	X	X
Enclosure Fire (Event 3)						X	
Large Fire (Event 4)	X	X	X	X	X	X	X
Explosion Events							
Ignition of Fumes Results in an Deflagration/Detonation (external to container) (Event 5)		X			X	X	X
Waste Container Deflagration (Event 6)	X	X	X	X	X		
Multiple Waste Container Deflagration (Event 7)	X	X	X	X	X		
Enclosure Deflagration (Event 8)						X	

Hazard and Accident Analysis

Minimum Set of TRU Waste Accidents: Loss of Confinement/Containment

Hazard Evaluation Event	Characterization	Container Handling	Venting and/or Abating/Purging	Staging and Storage	Retrieval and Excavation	Waste Repackaging	Type B Container Loading/Unloading
Loss of Confinement/Containment							
Vehicle/Equipment Impacts Waste/Waste Containers (Event 9)		X	X	X	X	X	X
Drop/Impact/Spill Due to Improperly Handled Container, etc. (Event 10)		X			X	X	X
Collapse of Stacked Containers (Event 11)		X	X	X			
Waste Container Over-Pressurization (Event 12)	X	X	X	X	X		
Direct Exposure to Radiation Events (Event 13)	X	X	X	X	X	X	X
Criticality Events (Event 14)	X	X	X	X	X	X	
Externally Initiated Events							
Aircraft Impact with Fire (Event 15)	X	X	X	X	X	X	X
External Vehicle Accident (Event 16)	X	X	X	X	X	X	X
External Vehicle Accident with Fire (Combustible or Pool) (Event 17)	X	X	X	X	X	X	X
External Explosion (Event 18)	X	X	X	X	X	X	X
External Fire (Event 19)	X	X	X	X	X	X	X

Hazard and Accident Analysis

Minimum Set of TRU Waste Accidents: NPH Initiated Events

Hazard Evaluation Event	Characterization	Container Handling	Venting and/or Abating/Purging	Staging and Storage	Retrieval and Excavation	Waste Repackaging	Type B Container Loading/Unloading
NPH Initiated Events							
Lightning (Event 20)	X	X	X	X	X	X	X
High Wind (Event 21)	X	X	X	X	X	X	X
Tornado (Event 22)	X	X	X	X	X	X	X
Snow/Ice/Volcanic Ash Build-up (Event 23)	X	X	X	X	X	X	X
Seismic Event (Impact Only) (Event 24)	X	X	X	X	X	X	X
Seismic Event with Fire (Event 25)	X	X	X	X	X	X	X

Consequence Levels and Evaluation Guidelines

Consequence Level	Maximally Exposed Offsite Individual	Collocated Worker (at 100 meters)	Facility Worker Involved worker within facility boundary
High	Considerable offsite impact on people or the environs. CHALLENGE 25 rem TEDE or > AEGL-2/TEEL-2	Significant onsite impact on people or the environs. > 100 rem TEDE or > AEGL-3/TEEL-3	For Safety Significant designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, shall be considered.
Moderate	Only minor off-site impact on people or the environs. ≥ 1 rem TEDE or > AEGL-1/TEEL-1	Considerable on-site impact on people or the environs. ≥ 25 rem TEDE or > AEGL-2/TEEL-2	No distinguishable threshold
Low	Negligible off-site impact on people or the environs. < 1 rem TEDE or < AEGL-1/TEEL-1	Minor on-site impact on people or the environs. < 25 rem TEDE or < AEGL-2/TEEL-2	No distinguishable threshold

Qualitative Risk Ranking Bins

Consequence Level	Beyond Extremely Unlikely Below 10^{-6}/yr	Extremely Unlikely 10^{-4} to 10^{-6}/yr	Unlikely 10^{-2} to 10^{-4}/yr	Anticipated 10^{-1} to 10^{-2}/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	I
Low Consequence	IV	IV	III	III

Designation of TRU Waste Controls

- ✓ Standard designates specific controls for accident events mandated by the standard and that are Risk Class I or II
- ✓ Controls designated for each event includes Minimum Control Functions and associated Preferred and Alternate Controls
  - Control Functions must be met (e.g., minimize material release, limit fire growth, etc.)
  - Preferred controls represent highest level of protection
  - Alternative controls permitted when Preferred control are not available or not appropriate to the given facility situation

MAR Effects on Hazard Control Selection

- ✓ Preferred controls may not be warranted for entire container population when a facility's TRU waste inventory is dominated by a small percentage of containers
- ✓ Standard's provision for dealing with this situation
  - Apply preferred control set to entire operation if practical
  - If not practical and high MAR containers can be identified, apply preferred controls to subpopulation of concern
  - If highest MAR containers can't be differentiated (e.g., retrieval from burial ground), then separate control of this population should not be applied

Control Strategy for Hydrogen Deflagration Accidents

- ✓ Define controls for handling “suspect” containers, defined as a container with no vent, obvious pressurization, waste stream with potential for generating hydrogen, or vented but above 8% H2 concentration by volume
- ✓ Until vented and H2 concentration is less than 8%, containers are considered “suspect” and must handled accordingly
- ✓ Containers with H2 levels >4% can’t be opened or repackaged

Hazard Control Selection

Example of Safety Controls for Hydrogen Deflagration Accident

Accident	Minimum Control Functions	Preferred Controls	Alternative Controls
Waste Container Deflagration (Event 6) Multiple Waste Container Deflagration (Event 7) During Characterization (non-intrusive) AND Container Handling	Minimize Releases	Container integrity that meets WIPP acceptance criteria	See *Minimize Worker Exposure* control for this event
	Reduce Explosive Atmosphere	Vent *Suspect* containers (Treat as *Suspect* until H2 concentration verified below 8%)	
	Minimize Worker Exposure	Lid restraints on suspect containers (e.g., nylon straps, netting, overpack etc) OR Impact resistant shielding	Minimize worker contact with suspect container; Prevent unnecessary personnel within affected area

Summary

- The DOE reengineering effort standardizes hazard analysis assumptions and methods and resulting safety controls for TRU waste operations located across the U.S.
- The reengineering effort recognized key differences between sites, avoiding a “one-size-fits-all approach”
- The new technical standard provides sites with the information/guidelines necessary to develop consistent safety controls for TRU waste operations
- This reengineering process can serve as a model for the development of a new technical standard in a high quality and timely manner