LA-UR-19-22336
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Title: Addressing Design Basis Events and the Concurrent Loss of Multiple Parameters

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Intended for: Classroom presentation

Issued: 2019-03-14

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Addressing Design Basis Events and the Concurrent Loss of Multiple Parameters

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03/06/19

National Nuclear Security Administration

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

Agenda

3/4/2019

- **What is a DSA?**
  - Hazard Categorization
  - Regulatory Drivers
  - DOE Requirements
  - Developing a DSA and TSRs
- **How Does Crit. Safety Relate to the DSA**
  - Design Basis Events (DBEs)
  - NCS Control Elevation to the DSA
  - Concurrent Loss of Multiple Parameters
  - DSA Crit. Controls at LANL
- **Example of Evaluating a DBE**
  - Example Evaluation
  - Scenario
  - Hazards
  - Parameters Affected and Controls to Mitigate

What is a DSA?

Unclassified

Hazard Categories for DOE Nuclear Facilities

- HC-1: Potential for significant offsite consequences.
- HC-2: Potential for significant onsite consequences.
  - Includes facilities with the potential for nuclear criticality events (unless precluded by nature of process or segmentation argumentation)
- HC-3: Potential for only significant localized consequences.
- < HC-3: Inventories below HC 3 threshold quantity
  - Colloquially known as ‘Radiological Facilities’

Hazard Categories for DOE Nuclear Facilities

- Facility Hazard Categorization (HC) drives the method of safety analysis
- Lower HC (higher number) reflects lower consequences – less rigorous (but still sufficient) safety analysis
  - (Qualitative) Hazard Analysis for HC-3
- Higher HC (lower number) reflects higher consequences – more rigorous safety analysis
  - (Quantitative) Accident Analysis for HC-2

Regulatory Drivers

10 CFR 830 § 830.202 Safety Basis

(a) The contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must establish and maintain the safety basis for the facility.

(b) In establishing the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must:

- (1) Define the scope of the work to be performed;
- (2) Identify and analyze the hazards associated with the work;
- (3) Categorize the facility *consistent with DOE-STD-1027-92 ("Hazard Categorization and Accident Analysis Techniques for compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports," Change Notice 1, September 1997*);
- (4) Prepare a documented safety analysis for the facility;
- (5) Establish the hazard controls upon which the contractor will rely to ensure adequate protection of workers, the public, and the environment.

Regulatory Drivers

10 CFR 830 § 830.202 Safety Basis

(c) In maintaining the safety basis for a hazard category 1, 2, or 3 DOE nuclear facility, the contractor responsible for the facility must:

- (1) Update the safety basis to keep it current and to reflect changes in the facility, the work and the hazards as they are analyzed in the documented safety analysis;
- (2) Annually submit to DOE either the updated documented safety analysis for approval or a letter stating that there have been no changes in the documented safety analysis since the prior submission; and
- (3) Incorporate in the safety basis any changes, conditions, or hazard controls directed by DOE

Regulatory Drivers

10 CFR 830 § 830.204 Documented Safety Analysis

(a) The contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must obtain approval from DOE for the methodology used to prepare the documented safety analysis for the facility unless the contractor uses a methodology set forth in Table 2 of appendix A to this part.

(b) The documented safety analysis for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility:

- (1) Describe the facility (including the design of safety structures, systems and components) and the work to be performed;
- (2) Provide a systematic identification of both natural and man-made hazards associated with the facility;
- (3) Evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility;

Regulatory Drivers

10 CFR 830 § 830.204 Documented Safety Analysis

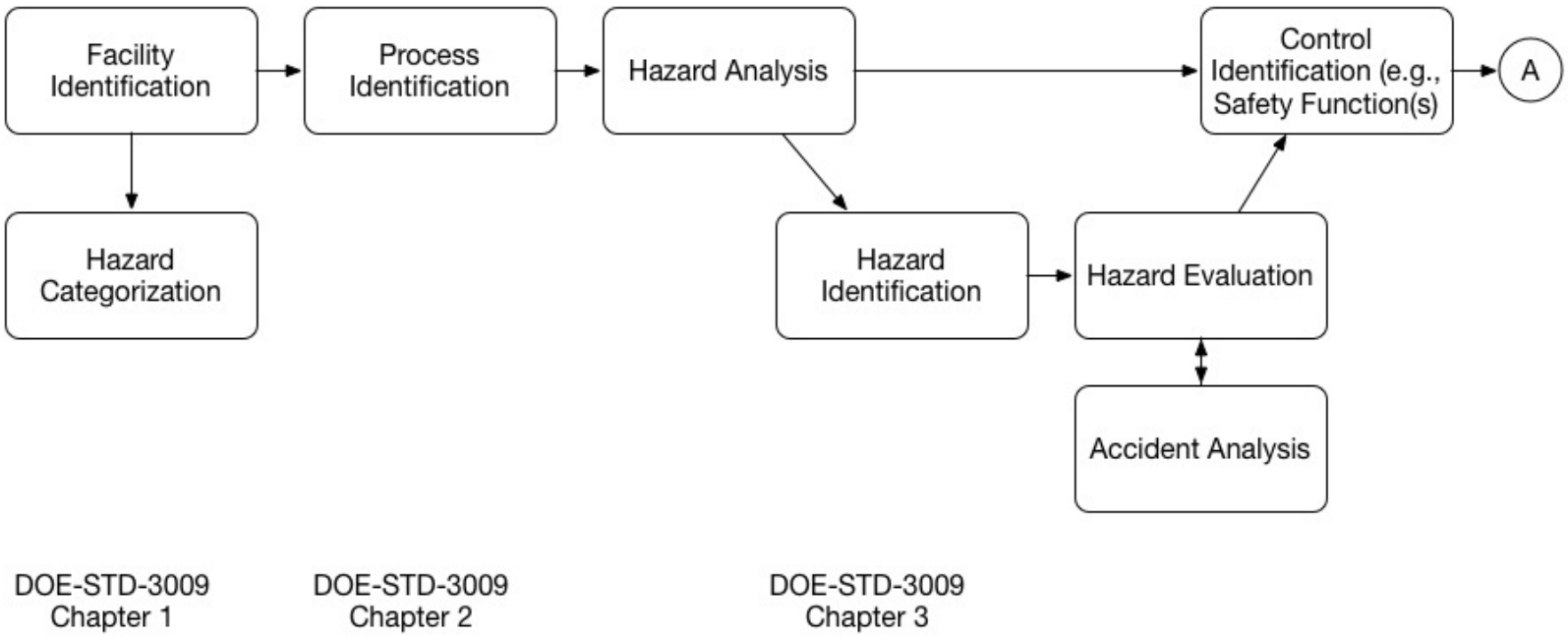
- (4) Derive the hazard controls necessary to ensure adequate protection of workers, the public, and the environment, demonstrate the adequacy of these controls to eliminate, limit, or mitigate identified hazards, and define the process for maintaining the hazard controls current at all times and controlling their use;
- (5) Define the characteristics of the safety management programs necessary to ensure the safe operation of the facility, including (where applicable) quality assurance, procedures, maintenance, personnel training, conduct of operations, emergency preparedness, fire protection, waste management, and radiation protection; and
- (6) With respect to a nonreactor nuclear facility with fissionable material in a form and amount sufficient to pose a potential for criticality, define a criticality safety program that:
  - (i) Ensures that operations with fissionable material remain subcritical under all normal and credible abnormal conditions,
  - (ii) Identifies applicable nuclear criticality safety standards, and
  - (iii) Describes how the program meets applicable nuclear criticality safety standards.

DOE Requirements and Guidance

DOE Order 420.1C, *Facility Safety*

- DOE-STD-3009-14, *Preparation of Nonreactor Nuclear Facility DSA*
- DOE-STD-5506, *Preparation of Safety Basis Documents for TRU Waste Facilities*
- DOE-STD-1189, *Integration of Safety into the Design Process*
- DOE-STD-1186, *Specific Administrative Controls*
- DOE G 420.1-1A, *Nonreactor Nuclear Safety Design Criterial for Use with DOE O 420.1C*
- DOE G 423.1-1B, *Implementation Guide for Use in Developing TSRs*

Development of DSA and TSR Documents



Development of DSA and TSR Documents

- Chapters 3 and 4 (Hazard and Accident Analyses and SSCs) of the DSA provide input for preparation of DSA chapter 5 and the TSR.

- Chapter 5 (Derivation of TSRs) provides the bridge between the DSA and the TSR document.

TSR Structure

- Section 1 Use and Application
- Section 2 Safety Limits
- Section 3/4 Operating Limits and Surveillance Requirements
- Section 5 Administrative Controls
- Section 6 Design Features
- Appendix Bases for the TSRs (Why)

TSRs are One of Two Types

1. Engineered Controls (Active or Passive)
   - Limiting Conditions of Operations (LCOs) and Surveillance Requirements (SR)
   - Design Features (DFs)
2. Administrative Controls
   - Specific (SACs) (DOE-STD-1186)
   - Programmatic (ACs) (NCS, Radcon, etc.)

TSR/LCO Example

3.6.1 HS-Pu Dissolution

LCO: The dissolution vessel SHALL:
1. have continuous inert gas flow (>0 scfm) into the vessel

OR

2. be vented

APPLICABILITY: MODE 1

PROCESS APPLICABILITY: Full Scale and Bench Scale HS-Pu Aqueous Scrap Recovery, during HS-Pu Dissolution

ACTIONS:

Condition	Required ACTION	COMPLETION TIME
A. Loss of inert gas flow into dissolution vessel **AND** vessel not vented.	A.1 Restore inert gas flow **OR** vent dissolution vessel	30 minutes
B. Required ACTIONS and associated COMPLETION TIMES of condition A not met	B.1 TRANSFER solution to vented vessel.	IMMEDIATELY

SURVEILLANCE REQUIREMENTS:

SR #	Surveillance	FREQUENCY
4.6.1.1	VERIFY inert gas flow (>0 scfm) into dissolution vessel	Within 24 hours prior to start-up **AND** Every 60 minutes during dissolution
	OR	
	VERIFY dissolution vessel is vented.	Once, within 60 minutes of starting dissolution

How does Crit. Safety Relate to the DSA?

Unclassified

Design Basis Events

- DOE Order 420.1C requires that entire processes involving fissionable material remain subcritical under normal and credible abnormal conditions including those initiated by design basis events

- DOE-STD-1027 states design basis natural phenomena events that should be considered

Design Basis Events

- Ensure fissionable materials are stored in such a way that accidental nuclear criticality resulting from the following is not a concern:
  - Fire
  - Flood
  - Earthquake
  - Explosion
  - Aircraft Crash
  - Other natural calamity

Excerpt from one of the Crit. Safety procedures at LANL

Design Basis Events

- The DBE frequency is usually binned into credible or not credible (BEU is generally considered not credible)
- The DBE frequency is usually taken from the DSA and is considered defensible (it has been approved by DOE after all!)

NCS Control Elevation to DSA

- SD 130 provides criteria for considering elevation of controls to the safety basis:
  - If a single process upset (e.g., loss of structural integrity of a glovebox from a seismic event), leads to a condition that is not definable for analysis or not known to be clearly subcritical
  - Extra controls judged to be required because the parametric (e.g., mass, volume, geometry) safety margin is relatively small under normal conditions, must be considered for elevation

NCS Control Elevation to DSA

- Extra controls judged to be required to preclude (make incredible) the loss of control of a single parameter (when loss of that parameter could result in criticality)
- Active engineered controls relied on for subcriticality that require calibration and possibly surveillance
- Baseline initial conditions required for tractability of programmatic implementation (e.g., if a facility is limited to the processing of U-235 only, this limitation must be considered for elevation to protect this baseline conditions that affect all the aspects of the criticality safety program implementation)

NCS Control Elevation to DSA

- If a single process upset (e.g., loss of structural integrity of a glovebox from a seismic event), leads to a condition that is not definable for analysis or not known to be clearly subcritical
- *Example: An earthquake causes a safe to fall, spilling contents onto floor*
  - Control relies on spacing provided by safe
  - Loss of interaction control is an un-analyzed process upset
  - **Resulting control:** Safe must be seismically braced in order to withstand a predetermined level of earthquake

Control must be elevated to DSA

Concurrent Loss of Multiple Parameters

- If any process conditions are identified that result in the loss of two independent parameters, and is not caused by a design basis event
- *For Example: a forklift knocks over an aqueous processing GB, rupturing multiple tanks inside*
  - *Releases fissionable solution from geometrically safe tanks*
  - *Fissionable solution from multiple tanks is comingled together*
  - *Loss of geometry and interaction controls*

Are additional controls needed? Is this scenario credible?

Example of Evaluating a DBE

Unclassified

Example Seismic Evaluation

As described in Section 4.11.1, a seismic event could cause comingling of the XX tanks with YY tanks as described in the seismic memo from operations, along with the activation of the sprinkler system from a fire. Per the seismic memo, the two tank banks will fall onto one another while maintaining their integrity within their own structures which will also prevent the tank banks from coming in direct contact with one another. This could potentially result in the closer interaction of YY, ten 6-in tanks containing a total of 520 g, and XX, three 8-in tanks containing a total of 520 g.

Figure 8 shows the configuration modeled in MCNP, Tank XX interacting with one 6”, schedule 10, 304 stainless steel tank, modeled at an outer diameter of 6.625”, fully flooded with full density water. Fully flooded and full density water greatly increased the reflection of the center units which contain the greatest mass. The one 6” tank is representative of the YY tank bank and is bounding of multiple tanks containing 520 g spaced out. While the seismic memo describes spacing being maintained by the tank structures, no spacing was modeled for conservatism. Figure 9 demonstrates the configuration maintaining subcriticality.

Example Seismic Evaluation Cont'd

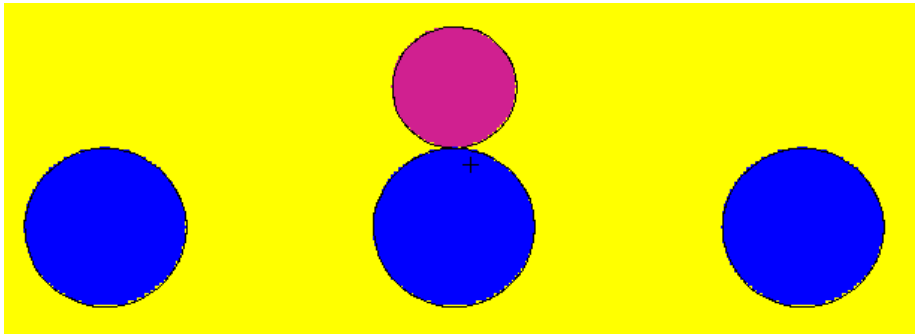


Figure 8. Tank XX Comingled with a 6" Tank with 520 g, BLUE Being XX, PINK being the 6" Tank, YELLOW Being Water

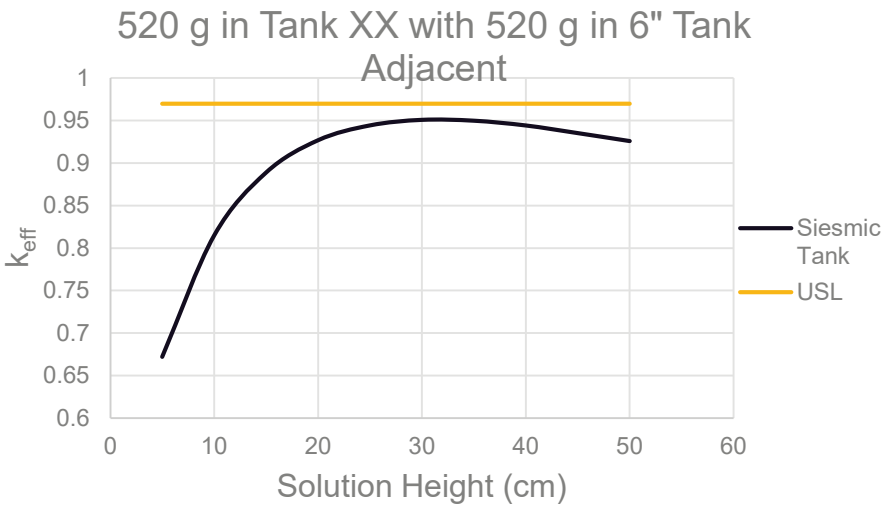


Figure 9. Tank XX Interaction with 520g 6" Tank

Example DBE Scenario

- There is a fire inside of a vault room
- Vault contains array of fissionable material
- Fire is large enough to cause activation of sprinkler system

Hazards?

- Safety Basis Concerns
  - Fire could cause release of radioactive material
  - HEPA filters may become compromised releasing material outside facility
- NCS Concerns:
  - Sprinkler activation introduces moderation causing system to go critical
    - Control must be elevated to DSA due to single process upset condition causing criticality
  - Potential for fire to manipulate material forms

Parameters Affected: Moderation & Mass/Material Form

Controls to Prevent/Mitigate Criticality

- Combustible loading is minimized to prevent fire
- Water fire suppression system is cut off or manually operated
- Fire suppression system uses another material
  - This material would still need to be evaluated
- Material is containerized in fire resistant containers