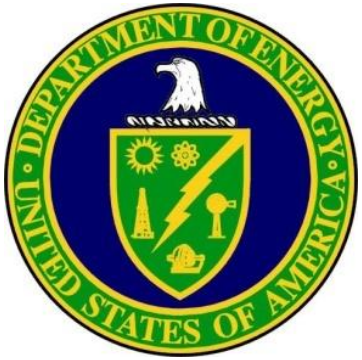

EHSS
Office of Environment, Health, Safety and Security

Session II – Hazard Analysis

Session II Overview

- **DOE-STD-3009-2014, Section 3 provides detailed criteria and guidance for performing Hazard Analysis, Accident Analysis, and Hazard Control Selection**
- **Clarifies requirements, adding "shalls" to CN3 guidance**
  - See handout "DOE-STD-3009-2014 Requirements Table"
  - Red font on slides highlight requirements if not already obvious
- **Session II Hazard Analysis Topics:**
  - Hazard Identification
  - Hazard Evaluation

Hazard Analysis Major Changes

- **No significant change in philosophy**
- **"Hazard Analysis" is:**
  - Hazard Identification,
  - Hazard Categorization, and
  - Hazard Evaluation.
- **Clarifies methods for unmitigated and mitigated hazard evaluations and control selection**
- NEW **Includes Co-located Worker receptor @ 100 m**
- **Clarifies treatment of standard industrial hazards**
- NEW **Includes screening & evaluation of chemical hazards**

Note: STD-3009-2014 Section number in upper right box.

Hazard Analysis Key Requirements

- **No significant changes, other than addition of clear "shall" statements**
  - Systematic Identification & Evaluation of Hazards
  - Nuclear and Nonnuclear Hazards
  - Complete Spectrum of Events ("hazard scenarios")
  - Largely Qualitative
  - Hazard Analysis Forms Basis for Entire Safety Analysis

Hazard Identification Major Changes

- **Clarifies Exclusion of Standard Industrial Hazards (SIH) and Chemical Screening**
  - Appendix, Section A.1 clarifies SIH screening
  - Appendix, Section A.2 clarifies chemical screening
- **Document Basis for Exclusions**
  - Examples: 10 C.F.R. 851.23, Safety & Health Standards; other codes
- **Use bounding inventories (radiological and hazardous materials)**
  - May use SACs to establish inventory limits
- **DSA Section [3.3.2.1] hazard ID summary tables or text**

Note: use of brackets [ ] refers to DOE-STD-3009-2014, Section 4

Appendix, Section A.1 Standard Industrial Hazards

- **Standard Industrial Hazards (SIHs) are hazards that are routinely encountered in general industry and construction.**
  - SIHs are addressed by 10 C.F.R. 851, *Worker Safety and Health Program* (issued 2006).
  - 10 C.F.R. 851 requires identification and assessment of worker hazards and compliance with safety and health standards that provide specific safe practices and controls.

Appendix, Section A.1 SIH Screening

- **SIH included in DSA Hazard Evaluation if:**
  - Initiate radiological or hazardous material (hazmat) accident
  - Worsen consequences of radiological or hazmat accident
  - Result from chemical or radiological hazards (e.g., shrapnel from explosion due to radiolysis in tank)
  - NEW Prevent Safety SSCs from providing its safety function
- **Unique Hazards not Excluded as SIH**
  - Unique to DOE applications or operations
  - Larger quantities than typically used in general industry
  - NEW Affect entire work area or impact safe operations of facility (prevent implementing SAC)

Appendix, Section A.2 Chemical Screening

- **DSA not intended to deal extensively with chemicals that can be safely handled by Hazardous Material Protection Program**
- **<u>Example</u> chemical screening:**
  - No known or suspected toxic properties (listed by OSHA or EPA, has PAC-2 or PAC-3 value established)
  - NFPA 704 health hazard rating of 0 or 1
  - Commonly available and used by general public
  - Small-scale use quantities similar to intent of 29 C.F.R. 1910.1450
  - May exclude fire smoke but not process decomposition products

Appendix, Section A.2 Chemical Screening (Cont.)

- Extraordinary toxic hazard not excluded
- Chemicals included if:
  - Initiate or contribute to radiological or hazmat accidents, or
  - Prevent operators to safely manage facility

Hazard Evaluation Major Changes

- **Methodology**
  - Standardizes frequency, consequences, and risk tables
  - Appendix, Section A.3 clarifies initial conditions
  - Appendix, Section A.4 clarifies risk ranking
- **Mitigated Hazard Evaluation**
  - Effectiveness of Controls
  - Safety Functions
- **Facility Worker Hazard Evaluation**
- **Inadvertent Criticality Hazard Evaluation**
- **Chemical Hazard Evaluation**

Hazard Evaluation General

- **The hazard evaluation shall provide:**

  (a) Assessment of the facility hazards associated with the full scope of planned operations

  - Normal ops (startup/shutdown, maintenance), abnormal conditions, accident conditions

  (b) Identification of controls that can prevent or mitigate these hazards or hazardous conditions.

- **Operational Accidents, Natural Phenomena Hazards (NPH), Man-made External Events**
- **Graded Approach to select Haz. Eval. Technique**
  - Rationale justified

Hazard Evaluation General (Cont.)

- **Unmitigated hazard evaluation of "hazard scenarios"**
  - Each initiating event by assuming absence of preventive or mitigative controls
  - Initial Conditions covered in Section 3.2.2 unmitigated analysis
- **Estimate Consequences**
  - Qualitative and/or semi-quantitative techniques
  - Shall address potential effects on Facility Workers (FW), Co-located Workers (CLW), and Public (Maximally-exposed Offsite Individual [MOI])
    - CLW is new requirement
  - Shall use Table 1 consequence levels

Hazard Evaluation General (Cont.)

- **Estimate Likelihoods Qualitatively**
  - NEW • Shall use Table 2 likelihood bins
- **Use of risk binning optional**
  - NEW • If risk rankings used, Tables 1 and 2 shall be used
  - Appendix, Section A.4, Hazard Evaluation and Risk Ranking & Table A-1
- **Section 3.2.2 provides additional considerations**

Hazard Evaluation
Table 1 Consequence Thresholds

Consequence Level	Public	Co-located Worker	Facility Worker
High	≥25 rem TED or ≥PAC-2	≥100 rem TED or ≥PAC-3	Prompt death, serious injury, or significant radiological and chemical exposure
Moderate	≥5 rem TED or ≥PAC-1	≥25 rem TED or ≥PAC-2	No distinguishable threshold
Low	<5 rem TED or <PAC-1	<25 rem TED or <PAC-2	No distinguishable threshold

Hazard Evaluation
Table 2 Qualitative Likelihood Bins

Description	Likelihood Range (/year)	Definition
Anticipated	Likelihood $>10^{-2}$	Events that may occur several times during the lifetime of the facility (incidents that commonly occur).
Unlikely	10^{-2}> likelihood $>10^{-4}$	Events that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this likelihood class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
Extremely Unlikely	10^{-4}> likelihood $>10^{-6}$	Events that will probably not occur during the lifetime of the facility.
Beyond Extremely Unlikely	Likelihood $<10^{-6}$	All other accidents.

Hazard Evaluation Table 2 (Cont.)

- **May quantify frequency of occurrence to assign qualitative likelihood**
  - Probabilistic calculations not required to inform likelihood estimates
  - May use probabilistic risk assessment (PRA) per DOE-STD-1628-2013 to inform qualitative likelihood estimates
  - Use DOE-STD-3014-2006 for aircraft crash frequencies
- **Use of <1E-6/yr (BEU) threshold not appropriate for Haz Eval**
  - Should not be used as an absolute cutoff for dismissing physically possible low probability operational accidents such as “red oil” explosions.
  - NEW Hazard scenarios of operational accidents that are deemed not plausible per the criteria in Section 3.2.1 may be excluded from the hazard evaluation also.

Hazard Evaluation
Table A-1: 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 Above 10^{-2}/yr
High Consequence	III	II	I	I
Moderate Consequence	IV	III	II	II
Low Consequence	IV	IV	III	III

Hazard Evaluation Facility Worker

- **FW unmitigated consequences should be based on combination of the following:**
  - **(1) Magnitude, type, and form of radioactive and hazardous materials involved in a hazard scenario;**
  - **(2) Type and magnitude of energy sources involved in scenario;**
  - **(3) Characteristics of hazard scenario such as duration and location where it may occur (e.g., in unmanned areas, such as tank vaults); and,**
  - **(4) Potential for a hazard to impact workers' mobility or ability to react to hazardous conditions.**

- Mobility or ability to react to hazardous conditions <u>should not</u> be used as the sole or primary basis for determining FW impacts

Hazard Evaluation Facility Worker (Cont.)

- **May exclude FW consequences if solely due to SIH**
  - Include serious injury/fatality from SIH if due to the rad. or chemical hazard being evaluated (e.g., explosion, chemical burn)
- **May use scoping calculations, engineering judgment, historical experience**
  - Not expected to quantify FW rad. / hazmat inhalation consequences

Hazard Evaluation
Co-located Worker

- **Consequence determinations shall be supported by an adequate technical basis**
  - Such as scoping calculations consistent with Section 3.2.4.
- **Alternately, the quantitative evaluation CLW consequences used to compare to Table 1 thresholds may be performed in the accident analysis and reported in the DSA Section [3.4]**

Hazard Evaluation
Hazard Controls

- **For each of the unmitigated hazard scenarios, the controls (SSCs, administrative and/or programmatic) that can prevent or mitigate the hazard scenario shall be identified.**
- **A mitigated hazard evaluation shall be performed to determine the effectiveness of safety significant (SS) controls by estimating hazard scenario likelihood with preventive controls and consequences with mitigative controls.**
  - Following the preferred hierarchy described in Section 3.3

NEW

Hazard Evaluation
Hazard Controls (Cont.)

- **Evaluation of control effectiveness may be accomplished using <u>one</u> of the following two options:**
  - **(1) Perform mitigated analysis and include results for hazard scenarios directly in hazard evaluation tables; <u>or</u>,**
  - **(2) Perform mitigated analysis and include as a summary evaluation in DSA Section [3.3.2.3].**
- **In either case, include SS controls for hazard scenarios having:**
  - **high estimated chemical consequences to the public, or**
  - **high radiological or chemical consequences to workers**
- **Control effectiveness, along with safety functions for these controls, shall be included in the hazard evaluation,**
  - unless determined as part of the Section 3.2 accident analysis

Hazard Evaluation
Hazard Controls (Cont.)

- **Additional considerations for mitigated hazard evaluation are provided in:**
  - Section 3.2.3, Mitigated Analysis
  - Section 3.3, Hazard Control Classification
- **DSA hazard evaluation shall also examine the potential for large-scale environmental contamination and identify preventive and mitigative controls to protect the environment**
  - Section 3.3 criteria for safety control selection are not based on environmental contamination
    - unless a significant spill to the environment outside the facility can contribute to radiological exposures as discussed in Sect. 3.2.4.2.

NEW

Hazard Evaluation Criticality Hazards

- **Inadvertent criticality accident represents a special case for hazard evaluation**
- **Criticality safety evaluations per ANSI/ANS-8 series**
- **DSA hazard evaluation shall include:**
  - NEW **Events where consequences exceed the high rad. thresholds for either the co-located workers or the MOI, and**
    - Unless unmitigated criticality accident is not credible
  - NEW **Situations where an active engineered control(s) is required by the Nuclear Criticality Safety (NCS) analysis to ensure subcriticality**

Hazard Evaluation Criticality Hazards (Cont.)

- **If the NCS program requires a criticality accident alarm system, then the criticality accident alarm system shall be discussed in the hazard evaluation and carried forward to evaluation in accordance with Section 3.3.**
- **Chapter 6 of the DSA will provide:**
  - General discussion of criticality control strategies
  - General discussion of the parameters used for the prevention of inadvertent criticality

Hazard Evaluation
Chemical Hazards

- **Chemicals not screened (e.g., A.2) need to be considered for their possible impact on:**
  - **radiological or other chemical accident initiation or progression, or**
  - **potential adverse impact on safety systems**
- **<u>Qualitative</u> evaluation of chemical consequences is generally sufficient for comparison to Table 1**
- **<u>Quantitative</u> analysis should be performed to determine impacts to CLW and MOI (based on guidance in 3.2.4.3)**

Hazard Evaluation Chemical Hazards (Cont.)

- **Determination of chemical quantities sufficient to challenge the criteria may be supported by:**
  - Scoping calculations using the methods presented in Section 3.2.4.3, or by
  - Engineering judgment based on previous safety basis calculations, emergency planning calculations, or consensus standards.
- **Appendix, Section A.2 provides guidance on chemical exposure calculations**
  - Topic to be addressed in more detail in the DOE Accident Analysis Handbook

Hazard Evaluation Documentation

- **Section [3.3.2.3] Provides Expectations of Summaries**
- **Provide Hazard Evaluation tables or data sheets - either as a DSA appendix or supporting document(s).**
  - Note that hazard evaluation data are part of the DSA, whether included directly or by reference.
- **For each hazard scenario table or data sheets:**
  - Brief scenario summary, unmitigated likelihood and consequences, preventive and mitigative controls
  - Optional: unmitigated risk binning; mitigated likelihood, consequence, risk binning; and operational safety enhancements

Hazard Evaluation Documentation (Cont.)

- **Provide summaries if large number of hazard scenarios by distilling from Hazard Evaluation tables or data sheets**
- **Present mitigated hazard evaluation if not included in DSA Section 3.4, Accident Analysis**
- **Other DSA Sections:**
  - **[3.3.2.4] Defense-in-Depth**
    - Appendix, Section A.9 provides background on defense-in-depth philosophy
  - **[3.3.2.5] Facility Worker Safety**
  - **[3.3.2.6] Environmental Protection**