PHASE I

CURRENT CHEMICAL HAZARD CHARACTERIZATION PRACTICES IN THE DOE COMPLEX

CSTC Project Team 2003-C

J. C. Laul, Chairman

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FINAL REPORT

PHASE I

CURRENT CHEMICAL HAZARD CHARACTERIZATION PRACTICES IN THE DOE COMPLEX

Prepared Under the Auspices of

The Chemical Safety Topical Committee (CSTC), a Joint Committee of the Department of Energy (DOE) and the Energy Facility Contractors Group (EFCOG) Safety Analysis Working Group (SAWG)

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ACRONYMS AND ABBREVIATIONS

AB	Authorization Basis
AC	Administrative Control
ACGIH	American Conference of Governmental Industrial Hygienists
AHA	Activity Hazard Analysis
AHE	Additional Hazard Evaluation
ALOHA	Areal Locations of Hazardous Atmospheres
AN	Anticipated
ANL-E	Argonne National Laboratory-East
ARCHIE	Automated Resource for Chemical Hazard Incident Evaluation
ARF	Airborne Release Fraction
ASA	Auditable Safety Analysis
BEU	Beyond Extremely Unlikely
BNL	Brookhaven National Laboratory
CC	Chemical Consequence
CFR	Code of Federal Regulations
CHC	Chemical Hazard Categorization
CHG	CH2MHILL Hanford Group, Inc
CIS	Chemical Information System
CMS	Chemical Management System
CSA	Chemical Safety Analysis
CSTC	Chemical Safety Topical Committee
D&D	Decontamination and Decommissioning
DiD	Defense in Depth
DOE	Department of Energy
DR	Damage Ratio
DSA	Documented Safety Analysis
EC	Engineering Control
EG	Evaluation Guideline
EPA	U.S. Environmental Protection Agency
EPICode	Emergency Prediction Information Code
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety and Health
ETA	Event Tree Analysis
EU	Extremely Unlikely
FC	Functional Classification
FEMP	Fernald Environmental Management Project
FHA	Fire Hazard Analysis
FMEA	Failure Modes and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FSA	Facility Safety Analysis
FSP	Facility Safety Plan
FTA	Fault Tree Analysis
FUA	Facility Use Agreement

HAR	Hazard Analysis Report
HAZOP	Hazard and Operability Study
HBM	Hazard Baseline Methodology
HC	Hazard Category
HCP	Hazards Control Plan
HER	Hazard Evaluation Report
HIT	Hazard Identification Tools
IDLH	Immediately Dangerous to Life or Health
IHA	Integrated Hazard Analysis
INEEL	Idaho National Engineering and Environmental Laboratory
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
IWS	Integrated Worksheet
JHA	Job Hazard Analysis
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MAR	Material at Risk
MCP	Miamisburg Closure Project
MEMP	Mound Environmental Management Project
NIOSH	National Institute for Occupational Safety and Health
NRASA	Not Requiring Additional Safety Analysis
ORNL	Oak Ridge National Laboratory
ORP	Hanford DOE Office of River Protection
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PHA	Process Hazard Analysis or Preliminary Hazard Analysis
PHC	Preliminary Hazard Classification
PHS	Preliminary Hazard Screening
PNNL	Pacific Northwest National Laboratory
PSM	Process Safety Management
RF	Release Fraction
RFETS	Rocky Flats Environmental Technology Site
RL	DOE Richland Operations Office
RMP	Risk Management Program
RQ	Reportable Quantity
SA	Safety Assessment
SAD	Safety Analysis Document
SAR	Safety Analysis Report
SARA	Safety Analysis Report Archives
SARAH	Safety Analysis Risk Assessment Handbook
SB	Safety Basis
SC	Screening Criteria
SCAPA	Subcommittee on Consequence Assessment and Protection Actions
SNL	Sandia National Laboratories
SRS	Savannah River Site
SS	Safety Significant

SSCs	Structure, System, and Components
TEEL	Temporary Emergency Exposure Limit
TLV	Threshold Limit Value
TPQ	Threshold Planning Quantity
TQ	Threshold Quantity
TWA	Time Weighted Average
UN	Unlikely
USQ	Unreviewed Safety Question
WSRC	Westinghouse Savannah River Company
WVDP	West Valley Demonstration Project

DEFINITIONS OF REGULATORY LIMITS AND GUIDELINES

Emergency Response Planning Guideline 1 (ERPG-1): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.

Emergency Response Planning Guideline 2 (ERPG-2): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective actions.

Emergency Response Planning Guideline 3 (ERPG-3): The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.

Immediately Dangerous to Life and Health (IDLH): The atmosphere of a work environment that poses an immediate hazard to life or poses an immediate irreversible debilitating effect on health. This term is defined within Occupational Safety and Health Administration regulation Title 29 of the Code of Federal Regulations 1910.120, Hazardous waste operations and emergency response.

Incident: An occupational injury or illness, release of a contaminant into the environment or damage to property. The cause of an incident is typically due to an unsafe act(s) or and unsafe condition(s) or a combination of the two.

Integrated Safety Management Systems (ISMS): A Safety Management System to systematically integrate safety into management and work practices at all levels of activity as required by Department of Energy P 450.4, Safety Management System Policy. An ISMS consists of five core functions, which are defined as: 1. Define work, 2. Identify and analyze hazards, 3. Develop and implement controls, 4. Perform work safely, and 5. Ensure performance and continuous improvement.

Occupational Safety and Health Administration (OSHA): Provides regulatory control on exposure limits to chemicals within the work environment quantified as a Permissible Exposure Limit. Regulates the type and quantity of certain listed chemicals to prevent or minimize the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. These releases may result in toxic, fire, or explosion hazards and are documented in Title 29 of the Code of Federal Regulations Part 1910, subpart 119, Process Safety Management of highly hazardous chemicals and also addressed in Title 29 of the Code of Federal Regulations 1910.120.

Permissible Exposure Limit (PEL): Are established by Occupational Safety and Health Administration to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. Some substances may also contain a skin designation. PELs are enforceable and are based on an 8-hour time weighted average exposure.

Temporary Emergency Exposure Limits 1, 2, and 3 (TEEL-1, 2, and 3): Where Emergency Response Planning Guideline - 1, 2, and 3 values are not available, TEEL values can be used. TEEL limits are listed for over 1,430 chemicals. These are alternate guideline limits based on comparisons between toxicity parameters and ERPGs.

Threshold Limit Value (TLV): Guidelines prepared by the American Council of Governmental Industrial Hygienists (ACGIH) designed for use in making determinations on the safe levels of exposure to various chemical substances and physical agents found in the workplace. These exposure limits are considered guidelines and are prepared by the ACGIH as best practices in preventing disease or injury.

U.S. Environmental Protection Agency (EPA): Provides for the protection of human health and safeguarding the natural environment. Regulations applicable to the release of hazardous chemicals is covered in Title 40 of the Code of Federal Regulations subpart 68, Chemical accident prevention provisions; 40 CFR 302, Designation, reportable quantities, and notification; and 40 CFR 355, Emergency planning and notification.

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- All participants listed in Table 1
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EXECUTIVE SUMMARY

This Phase I Report on Current Chemical Hazard Characterization Practices in the Department of Energy (DOE) Complex provides facts from 19 DOE contractors from 16 DOE sites. The DOE contractors provided information on their current Chemical Hazard Characterization practices that focused on three main topics: 1.0 Facility Chemical Hazard Category; 2.0 Hazard Baseline Methodology; and 3.0 Safety Document.

Based on the information gathered, there are wide variations in approaches to Chemical Safety Practices in chemical hazard categorization (CHC), hazard analysis methodology, and hazard document requirements among the various DOE sites. For example, in facility CHC, there are wide variations in hazard category terminology, in the screening criteria used to determine the hazard category such as regulation driven inventory quantities vs. evaluation guide (EG) values, and in the use of inventory vs. the consequence of a release to determine the hazard category.

Most of the sites have some form of hazard baseline methodology in place; however, the details vary depending on the complexity of their chemical safety analysis program. Hazard checklist category and hazard identification do not appear to correlate with the facility CHC level of High/Moderate/Low. Hazard evaluation tables (HET) for 10 sites list key features such as event description, hazards, root cause, unmitigated and mitigated frequency, consequence, risk, and engineering and administrative controls, although the format varies from site to site. In some cases, comparisons of unmitigated and mitigated frequency, consequence, and risk features are not provided in the HET.

In safety document requirements, there are also wide variations in the documented safety analysis/auditable safety analysis format, content and discussion of the CHC, unreviewed safety questions-like process and their criteria, and approval requirements by DOE/ NNSA.

Some variation in hazard categorization, analysis methodology, and document requirements are understandable and normal depending on the level of complexity of the Chemical Safety Analysis Program at each site. This is a Phase I report, which is mainly fact-finding. The Phase II report focuses on best practices or recommendations to mitigate wide variations, improve process quality, and reduce potential risk to the worker and public. Adoption of Phase II is voluntary.

INTRODUCTION

This Phase I Report summarizes the findings on Current Chemical Hazard Characterization Practices in the Department of Energy (DOE) Complex . Nineteen DOE contractors from 16 DOE sites provided information on their current Chemical Hazard Characterization practices that focused on three main topics: 1.0 Facility Chemical Hazard Category; 2.0 Hazard Baseline Methodology; and 3.0 Safety Document. Based on the information gathered, there are wide variations in approaches to Chemical Safety Practices among the various DOE sites.

There is no single DOE standard available for chemical safety analysis practices that describes chemical hazards, identification, screening, hazard analysis, accident analysis, consequences, and evaluation guide (EG) similar to DOE-STD-3009-94, "Preparation Guide for US Department of Energy Non-reactor Nuclear Facility Documented Safety Analysis", and Title 10 of the Code of Federal Regulations (CFR) 830, "Nuclear Safety Management" for nuclear facilities. For nuclear facilities that may also have chemical hazards, 10 CFR 830, Subpart B, 207(e)(4) states that "A documented safety analysis must address all hazards (that is, both radiological and non-radiological hazards) and the controls necessary to provide adequate protection to the public, workers, and the environment from these hazards." DOE-STD-3009-94 also requires chemical hazards to be analyzed and controls developed in the hazard analysis and provides guidance for selection of the safety-significant SSCs for workers safety from exposure to hazard materials including chemicals in nuclear facilities.

For non-nuclear facilities, there is no guidance on facility CHC, chemical hazard screening criteria (e.g. 29 CFR 1910.119, 40 CFR 355 or 302) and evaluation guide/criteria (ERPG-1, -2, -3) for the selection of controls. The DOE Order 5481.1B, "Safety Analysis and Review System", and DOE-EM-STD-5502-94, "DOE Limited Standard Hazard Baseline Documentation", provide some guidance for chemical safety practices and CHC. Though officially cancelled, DOE Order 5481.1B is still used by some sites such as the West Valley Demonstration Project (WVDP) for regulating their chemical safety practices. DOE-EM-STD-5502-94 is used by the Savannah River Site (SRS), Idaho National Engineering and Environmental Laboratory (INEEL), and WVDP. There are no EGs for chemical hazards for the protection of workers or the public in any DOE Order or Standard.

Over the years, various DOE sites have adopted chemical safety programs suitable to their needs. However, there is no consistency in the approaches to chemical safety practices by the various DOE sites. At the annual Chemical Safety Topical Committee (CSTC), joint Energy Facility Contractors Group/DOE topical "Chemical Management" Workshop, several working groups are formed to address various aspects of chemical safety programs. Subjects addressed by some of these working groups have included:

- Two-volume DOE Chemical Management Handbook
- Chemical User Safety and Health Requirements Roadmap that is being published as Volume 3 of the DOE Chemical Management Handbook
- DOE Handbook on Integration of Multiple Hazard Analysis Requirements and Activities
- Root Cause Identification and Analysis of DOE Chemical Incidents
- Hazards of Shock Sensitive, Time Sensitive and Reactive Chemicals
- Chemical Exposures During Closure Activities

In 2000, Ingle Paik at WSMS undertook the subject of this report but with a limited scope and a limited number of DOE sites. Since then, some DOE sites have significantly revised their Chemical Safety Analysis (CSA) Programs. This CSTC 2003-C project has significantly expanded the size and scope of original project to 19 contractors from 16 DOE sites. This report contains the current information from the participating contractors, however, some DOE contractors such as Lawrence Livermore National Laboratory (LLNL) and Pantex may change their procedures due to the evolving need and the nature of the chemical safety practices.

The CSTC Project 2003-C focuses on the "Current Chemical Hazard Characterization Practices" in the DOE complex. This Phase I report contains information from the participating DOE sites. The objective was to gather information on chemical hazard analysis practices from the various DOE sites to compare their similarities and differences and identify missing or undeveloped information. The Phase II report develops best practices or recommendations from the information collected in Phase 1. Adoption of the Phase II is voluntary.

The chemical hazard analysis/characterization practices information are organized in three main sections and their subsections of this report, which are inter related and listed in chronological order as shown in Figure 1. For example, Chemical Hazard Category (Section 1), using screening criteria, is used to determine the level of facility CHC (e.g., High/Moderate/Low), which determines the details of hazard analysis requirements (Section 2), and the safety document and approval requirements (Section 3). Under Section 1, consequence and frequency criteria are used for risk ranking that is used for the selection of safety controls in order to minimize the risk to a receptor (worker and public). Hazard Baseline Methodology (Section 2) describes how analyses are done using hazard check list criteria, hazard identification, screening criteria, hazard evaluation table, and accident analysis. Safety document (Section 3) is prepared as to how the results are utilized for facility authorization for safe operations. Each section/ subsection is built on the previous section/subsection to formulate a cohesive and unified picture for a safety basis document.

This report is presented in the following sections:

- Methods
- TQ and TPQ Inventory
- Results and Discussion (Sections 1, 2, and 3)
- Conclusions
- Bibliography

METHODS

For the CSTC 2003-C project, a report format was developed in a team effort to address three main topics: 1. Facility Chemical Hazard Category; 2. Hazard Baseline Methodology; and 3. Safety Document requirements including the Unreviewed Safety Question (USQ)-like process for non-nuclear facilities. The report format is shown in Figure 1.

Figure 1. Report Format

Table of Content

CHEMICAL SAFETY ANALYSIS PRACTICES

SITE NAME

Nineteen DOE contractors from 16 DOE sites participated voluntarily in the preparation of this report. Table 1 lists the DOE sites that participated and the authors who were responsible for contributing to this report. Their contributions and the DOE-HQ and Field/site (Operations) Offices, who were very helpful in influencing the contractors to participate in this project, are gratefully acknowledged.

Four participating sites are Decontamination and Decommissioning (D&D) and closure sites - Rocky Flats Environmental Technology Site (RFETS), WVDP, Mound (MCP - Miamisburg Closure Project), and Fernald (FEMP - Fernald Environmental Management Project). Their chemical safety programs are expected to decrease in scope over time.

Table 1. DOE Participating Sites

#	DOE Site	Point of Contact/Author
	DOE-HQ/EH, NNSA-SSO	Dan Marsick, Rob Vrooman
1	SRS	Michele Baker, J. C. Laul
2	Pantex+	Shawn Spivey, Ronald Frymoyer
3	INEEL	Larry Lee
	Hanford, RL	Joe Eizaguirre (DOE-RL)
4	Hanford, ERC	Jennifer Ollero, Mike Maxson
5	Hanford, Fluor	Craig Clairmont
6	Hanford, PNNL	Tonia Graham
7	Hanford, CHG (CH2MHILL)	Brad Evans
8	LANL	J. C. Laul
9	LLNL+	Charlotte Van Warmerdam, J. C. Laul
10	SNL	Sylvia J. Saltzstein, Stephen A. Coffing
11	ORNL, UT/Battelle	Ann Shirley Murphy, David Renfro
12	Oak Ridge, Bechtel Jacobs	Charlie Satterwhite
13	Y-12 National Security Complex (Y-12)	Jim Goss, H. F. Hartman
14	RFETS*	Mitchell Waller, Marco S. Colalancia
15	ANL-E	J. Woodring, G. Winner, G. Pierce
	WV, Mound, Fernald	Lydia Boada-Clista (DOE-OH)
16	WVDP*	Kelly Albamonti, Michele Baker
17	Mound (MCP)*	W. R. Henderson, Danny Punch, Larry Lee
18	Fernald (FEMP)*	Rich Lowery, Pat Fisk
19	BNL	Steve Hoey

* D&D and closure sites
+ Sites are revising their chemical safety procedures.

TQ AND TPQ INVENTORY

In gathering information for this report, two additional questions were asked of the contractors about the regulated chemicals. The answers to these questions are summarized in Table 2.

1. Does the site facility's chemical inventory exceede the 29 CFR 1910.119 (OSHA, PSM) Threshold Quantity (TQ)?

2. How many chemicals, if any, exceeded the 40 CFR 355 Threshold Planning Quantity (TPQ), Appendix A?

Table 2. Number of Regulated Chemicals by DOE Site

#	DOE Site	No. > 29 CFR 1910.119, TQ	No. >40 CFR 355, TPQ
1	SRS	0	3
2	Pantex	0	8
3	INEEL	0	10
4	Hanford, ERC	0	0
5	Hanford, Fluor	1, Chlorine	32
6	Hanford, PNNL	0	0
7	LANL	0	4
8	LLNL	0	7
9	SNL	0	4
10	ORNL, UT/Battelle	0	5, but 0 in a single location
11	Oak Ridge, Bechtel Jacobs	0	32
12	Y-12	0	59
13	RFETS*	0	3
14	ANL-E	0	0
15	West Valley*	0	3
16	Mound (MCP)*	0	0
17	Fernald (FEMP)*	0	0
18	BNL	0	23, but 0 in a single location

* D&D and closure sites

Among the DOE sites, only Hanford, Fluor has a process safety management (PSM) chemical that exceeds the 29 CFR 1910.119 threshold (Chlorine,1,500 pounds). The number of chemicals that exceed the 40 CFR 355 TPQs ranges from zero to 59. For example, the Y-12 National Security Complex (Y-12) has 59 chemicals, and Oak Ridge, Bechtel Jacobs and Hanford, Fluor each have 32 chemicals. Brookhaven National Laboratory (BNL) and Oak Ridge National Laboratory (ORNL)- UT/Battelle have 23 and 5 chemicals respectively site wide, but none in a single facility to exceed the TPQ limit. INEEL has 10 chemicals that exceed 40 CFR 355 TPQs. Pantex has 8 chemicals, LLNL has 7 chemicals, and LANL has 4 chemicals that exceed TPQs. Hanford ERC, Hanford PNNL, Argonne National Laboratory-East (ANL-E), Mound, and Fernald have zero TPQs. These sites have either D&D closure mission or have a limited Chemical Safety Analysis program.

RESULTS AND DISCUSSION

The extensive and important information provided by the 19 DOE contractors is summarized in three sections. 1.0 Facility Chemical Hazard Category, 2.0 Hazard Baseline Methodology, and 3.0 Safety Document. There are 24 tables that illustrate the wide variations and a few consistencies that exist across the DOE complex. Also, there are comparative discussions of the variations and consistencies to highlight potential issues .

The length of the chemical safety practices reports generated by the participating sites ranged from 3 to 18 pages depending on the complexity of the chemical safety analysis program of the reporting contractor. Results of these findings are presented in this report.

The DOE contractors that did not provide any information to the subsections of Sections 1, 2, and 3 of this report are shown by X in Table 3. These sites are either in developing stages or have limited chemical inventory or applications and thus have a limited Chemical Safety program. However, Hanford Tank Farms managed by CHG (CH2MHILL) and SRS have multi-million gallons of radioactive and hazardous wastes that were generated from 1940 to 1980 and are stored in underground tanks. These two sites have DSAs that address the radioactive and chemical hazards to provide the controls for safe and environmentally protective operations.

Table 3. Chemical Safety Practices Report Subsection Response

Section 1. Chemical Hazard Category

DOE Site	1.0 CHC	1.1 Screening Criteria	1.2 Frequency Ranking	1.3 Receptor	1.4 Chemical Consequence	1.5 Risk Binning	1.6 FC; Control Selection
Hanford, ERC			X		X	X	X
Hanford, Fluor							
Hanford, PNNL			X		X	X	X
Hanford, CHG			X	X	X	X	X
SNL			X			X	X
ORNL, UT/Battelle			X	X	X	X	X
ANL-E			X		X	X	X
BNL					X	X	X
X = information not provided.							

Section 2. Hazard Baseline Methodology
Section 3. Safety Document

DOE Site	2.1. Hazard Check list	2.2 Hazard Identi-fication	2.3 AHE	2.4 Common Hazard Screening Criteria	2.5 Example of HE Table	2.6 Consequence/ ST Method	3.1 Format & Content	3.2 USQ-Like Process
Hanford, ERC	X				X	X		
Hanford, Fluor					X			X
Hanford, PNNL					X	X		
Hanford, CHG	X	X	X	X	X	X		X
SNL						X		
ORNL UT/Battelle					X	X	X	X
ANL-E					X	X	X	X
BNL					X	X		
X = information not provided.								

Section 1.0 Facility Chemical Hazard Category

Determining how to safely manage hazardous chemicals in a cost-effective manner is addressed in six subsections:

- Section 1.1 Screening Criteria
- Section 1.2 Frequency Evaluation (Ranking)
- Section 1.3 Receptors (Dose Receivers)
- Section 1.4 Chemical Consequence Evaluation
- Section 1.5 Risk Binning Matrix
- Section 1.6 Safety Control Selection

These sections provide detailed insights into the various techniques and methods that are used to categorize the hazards, determine potential impacts of inadvertent incidents, and establish safety controls to protect the worker, the public, and the environment.

Section 1.1 Screening Criteria

This section presents the screening criteria used by the reporting sites to determine chemical hazard category (CHC). This section also discusses which sites use inventory or consequence to determine hazard category. Screening criteria are used to determine the CHC of the facility, typically early in the design. Some sites such as SRS, Hanford ERC, Hanford Fluor, Hanford PNNL, SNL, RFETS, Mound, Fernald, ORNL, ANL-E, and BNL use inventory criteria for CHC. Other sites such as Pantex, LANL, LLNL, Oak Ridge-Bechtel Jacobs, and WVDP use consequence-based criteria to determine CHC. The criterion basis used by each site to determine the hazard category is indicated by an "X" in Table 4. The screening criteria are colored coded to draw the distinction among the various CHC to a reader.

INEEL, LLNL, and Y-12 use both inventory and consequence-based criteria to determine CHC. For example, INEEL uses the consequence criterion immediately dangerous to life and health (IDLH) which is very close to ERPG-3 only for the high hazard category and inventory criteria for moderate and low categories. LLNL uses a hybrid approach of inventory criterion for initial CHC and consequence criterion for final CHC. Y-12 uses >1910 or >68 inventory criterion for **PSM/RMP** hazard category, and consequence criterion >ERPG-2 at 100m onsite for **Chemically hazardous** category. Currently, Y-12 does not have any **PSM/RMP** CHC.

Other variations noted are in the classification of CHC. For example, Pantex, INEEL, LANL, LLNL, Oak Ridge, Bechtel Jacob, and WVDP use **High/Moderate/Low** hazard category; SRS uses **High/Low** hazard category; Hanford Fluor and SNL use **Moderate/Low** hazard category; and Mound and Fernald use one category as **non-nuclear hazardous material** regardless of the inventory. Hanford ERC also uses one category as **non-nuclear** if chemical inventory is >302 but <1910 or 68. If chemical inventory would exceed 1910 or 68, then DOE would look into additional requirements of PSM and accidental release protection programs. Hanford PNNL calls one category as **Chemical**; ORNL-UT/Battelle, ANL-E, and BNL assign **no category** for chemicals under TQ <29 CFR 1910 or 40 CFR 68. BNL has currently no chemical hazard facility. Hanford CHG has also no chemical category as such and the hazardous chemicals are mixed with radioactive wastes in underground tanks. Pure chemical inventory information is managed by Handford-Fluor. RFETS also uses no category but classifies as **Chemical-AR** (accident analysis required, if the inventory is >1910 or 68) and **Chemical-NAR** (no AR, if the inventory is <1910 or 68).

Screening criteria used for inventory based CHC that vary considerably from site to site are:

- TQ (29 CFR 1910.119, 40 CFR 68)
- TPQ (40 CFR 355)
- RQ (40 CFR 302.4)

For example, SRS and INEEL use **Low** hazard category for SC of TQ <1910, while Pantex uses **Low** hazard category for SC of TQ >1910, which is the opposite. However, Pantex links 1910 criterion for **Low** CHC to consequence - >ERPG-2; minor onsite and negligible offsite. Likewise, Hanford ERC and Hanford Fluor use SCs of <302 for the **Industrial** category, while Hanford PNNL uses an SC of <1910 for the **Industrial** category. Sandia National Laboratory (SNL) uses an SC of >1910 or flammable liquid or gas >10,000 pounds for **Moderate** category; and >25% of 1910 or flammable liquid or gas >2,500 pounds <10,000 pounds or exceeds the Threshold Limit Value (TLV) and Permissable Exposure Limit (PEL) for the **Low** category; and <25% of 1910 for **Industrial** category.

There are also considerable variations in the consequences-based CHC. For example, LANL uses ERPG-3 as a SC guide for offsite as **High** category, onsite as **Moderate** category, and worker (local) as **Low** category. LLNL uses ERPG-3, -2, -1 for offsite and onsite as SC guide for **High/Moderate/Low** CHC:

- >ERPG-3 offsite for **High**
- <ERPG-3 >ERPG-2 offsite or >ERPG-3 onsite for **Moderate**
- <ERPG-2 >ERPG-1 offsite or <ERPG-3 >ERPG-2 onsite for **Low** CHC.

On the other hand, some sites such as Oak Ridge-Bechtel Jacobs, and WVDP use ERPG-2 for offsite and onsite as a SC for **High/Moderate/Low** hazard category:

- >ERPG-2 offsite for **High**
- >ERPG-2 onsite for **Moderate**
- >ERPG-2 for worker for **Low** CHC

Other variations and some consistencies used by the 19 contractors in hazard categorization are:

- 12 to 15 category titles are used, depending on title interpretation
- High is used by eight contractors
- Moderate is used by nine contractors
- Low is used by 10 contractors
- Industrial is used by nine contractors in four different ways
- Regulatory limits are used for screening criteria by 13 contractors
- ERPG's are used for screening criteria by five contractors
- Screening criteria vary significantly over hazard category titles

There appears to be a significant opportunity for achieving consistency, maintaining appropriate levels of safety for the workers and public and perhaps reducing cost across the DOE complex.

Overall, there are wide variations in the CHC approaches used from site to site based on inventory or consequence screening criteria.

Table 4. Facility Chemical Hazard Categorization and Screening Criteria

DOE Site	Hazard Category	Inventory	Consequence	Screening Criteria TQ, TPQ, RQ
SRS DOE-EM-STD-5502-94	• High • Low • Other Industrial	X		>1910 or 68 or 355 <1910 or 68 or 355> 302 <302
Pantex	• High, Class 1 • Moderate, Class 2 • Low, Class 3 • Class 4		X	>1910 or 302, major impact offsite/onsite, >ERPG-2 >1910 or 302, minor offsite & considerable onsite >1910 or 302, minor onsite & negligible offsite <1910 or 302
INEEL DOE-EM-STD-5502-94	• High • Moderate • Low • NRASA	 X X	X	Offsite, IDLH >1910 or 355 <1910 or 355 >302 <302
Hanford, ERC	• Non-nuclear • Industrial	X		<1910 or 68 >302 <302
Hanford, Fluor	• Moderate • Low • Industrial	X		>1910 or 355 > 302 <302
Hanford, PNNL	• Chemical • Industrial	X		>1910 <1910
LANL	• A (High) • B (Moderate) • C (Low)		X	Offsite, >ERPG-3; 1910, 68, 355 (lesser) Onsite, >ERPG-3 Worker, >ERPG-3
LLNL	• High • Moderate • Low • General Industry	X >1910, 68, 355 >355, 302 <355, 302	X	Offsite, >ERPG-3 Onsite, >ERPG-3 or Offsite <ERPG-3 >ERPG-2 Onsite, <ERPG-3 >ERPG-2 Offsite, <ERPG-2 >ERPG-1 Onsite, <ERPG-2 or Offsite <ERPG-1
SNL	• Moderate • Low • Std. Industrial	X		>1910 or Flammable liquid or gas >10,000 lbs >25% of 1910 or Flammable liquid or gas >2,500 lbs <10,000 lbs; Exceeds exposure limit (TLV, PEL) <25% of 1910

DOE Site	Hazard Category	Inventory	Consequence	Screening Criteria TQ, TPQ, RQ
Oak Ridge Ops, Bechtel Jacobs	• High • Moderate • Low • Other Industrial		X	Offsite/onsite, >ERPG-2 Onsite, >ERPG-2 Facility >RRPG-2 <302
Y-12 (National Security Complex)	• PSM/RMP • Chemically Hazardous	X	X	>1910 (PSM) or 68 (RMP) Onsite (100m), >ERPG-2
RFETS*	No Category • Chemical, AR • Chemical, NAR • Other Industrial	X		>1910 or 68 <1910 or 68 >355 or 302 <355 or 302
West Valley* DOE-STD-5502-94 DOE 5481.1B	• High • Moderate • Low • Industrial		X	Major impact offsite/onsite, >ERPG-2 Minor offsite & considerable onsite, >ERPG-2 Minor onsite, negligible offsite <302
Mound (MCP)* Fernald (FEMP)*	• One Category Non-nuclear hazardous material	X		1910, 355, 302 for DSA details
ORNL, UT/Battelle ANL-E BNL Hanford-CHG	No Category	X		<1910 or 68

* D&D and Closure
TQ = 29 CFR 1910.119 (PSM) ; TQ = 40 CFR 68.130 (Accidental Release) ;
TPQ = 40 CFR 355 (Emergency Planning); RQ = 40 CFR 302.4 (Spill, National Response Center)
PSM = Process Safety Management; RMP = Risk Management Program

Section 1.2 Frequency Evaluation (Ranking)

This section identifies the frequency levels used by the sites to assist in determining binning of hazards. DOE-STD-3009-94 cites four frequency levels:

Anticipated (AN) - $10^{-1} \geq f \geq 10^{-2}$, several times during lifetime of the facility;
Unlikely (UN) - $10^{-2} \geq f \geq 10^{-4}$, not anticipated during lifetime of the facility;
Extremely Unlikely (EU) - $10^{-4} \geq f \geq 10^{-6}$, probably not occur during life cycle of the facility;
Beyond Extremely Unlikely (BEU) -$10^{-6} \geq f$, not credible.

Many sites such as SRS, INEEL, Oak Ridge- Bechtel Jacobs, Hanford Fluor, RFETS, Y-12 , WVDP, Mound, and Fernald follow the DOE-STD-3009 four frequency levels format and terminology. Pantex also uses four levels (L4 to L1) of frequency except AN of DOE-STD-3009 is termed as “Frequent to Likely”.

However, LANL uses five levels of frequency (I to V). The frequency of UN, EU, and BEU of DOE-STD-3009 are the same except the terminology, while the AN is divided into two frequency levels – Frequent (expected, $>10^{0}$/yr) and Probable (likely, $<10^{0}$/yr to $>10^{-2}$/yr).

LLNL uses the following five levels of terminology:

- Very Likely (often)
- Likely (several times in life of facility)
- Unlikely (once during life cycle of facility)
- Extremely Unlikely - Decision Basis Accident (DBA)
- Less than credible - Beyond Design Basis (BDB)

However, there is no frequency ranking cited for these five levels of LLNL.

BNL uses six levels criteria, A to F (Frequent to Impossible) with three levels of overlap with DOE-STD-3009, but there is no frequency cited for the six levels.

- A, Frequent (occur repeatedly)
- B, Probable (several times in life of facility)
- C, Occasional (sometimes in life cycle)
- D, Remote (not likely to occur in life cycle)
- E, Extremely remote (probability is nearly zero)
- F, Impossible (impossible)

Table 5 summarizes the frequency evaluation criteria for the various sites.

There are some variations in the frequency criteria and terminology used by some sites.

Table 5. Frequency Evaluation (Binning)

DOE Site	Frequency Criteria	Comment
SRS, INEEL, Y-12 Oak Ridge-Bechtel Jacobs Hanford, Fluor RFETS*, West Valley* Mound*, Fernald*	• STD-3009	4 levels
Pantex	• Frequent to likely, L4 • STD-3009	L4 to L1 level: L3 (UN); L2 (EU); L1 (BEU), 4 levels
LANL	• I, (>10^0/yr) • II, (<10^0/yr to >10^{-2}/yr) • III, (<10^{-2}/yr to >10^{-4}/yr) • IV, (<10^{-4}/yr to >10^{-6}/yr) • V, (<10^{-6}/yr)	Frequent (Expected) Probable (Likely) Occasional (Unlikely) Improbable (EU) Remote (BEU) (5 levels)
LLNL (No frequency cited, 5 levels)	• Very Likely • Likely • UN • EU • Less than Credible	Often Several times in life of facility Once during life cycle of facility Design Basis Accident Beyond Design Basis
BNL (No frequency cited, 6 levels)	• A, Frequent • B, Probable • C, Occasional • D, Remote • E, Extremely remote • F, Impossible	Occur repeatedly Several times in life cycle Sometimes in life cycle Not likely to occur in life cycle Probability is nearly zero Impossible

* D&D and closure sites

Section 1.3 Receptors (Dose Receivers)

Table 6 lists the receptor locations for the worker and public, used by sites for hazard and consequence determination. Public location is well defined as maximally exposed offsite individual, offsite or site boundary, and the distance is quantitative meters or kilometers from the hazard release location. Most of the sites use site boundary as a criterion for public/offsite doses. Only Hanford Fluor and BNL have identified two locations for the public – onsite and offsite because of the public access to the site.

Worker locations have several definitions. Many sites have subdivided the worker location into two groups - onsite-1 and onsite-2 workers. For example, SRS and ANL-E consider onsite-1 as immediate or adjacent to the potential hazard inside the facility and onsite-2 as outside the occupied area of the potential hazard, which can be outside the facility. Oak Ridge-Bechtel Jacobs and BNL also use two groups for workers.

Hanford ERC and SNL use one group for workers as onsite-1 (inside facility) only. INEEL, RFETS, and Y-12 call for two groups for workers - onsite-1 (immediate), and onsite-2 is at 100 meters as co-located workers. Mound defines onsite-2 at 50 meters, while Fernald defines one group onsite-1 at 30 meters, which may be attributed to the fact that these are very small sites.

On the other hand, LANL and LLNL use only one onsite group both for immediate or co-located workers. Hanford, PNNL also assigns one onsite group for facility worker or worker at 100 meters. Pantex and WVDP assign one group as onsite worker.

There are wide variations in the definition of worker groups - Onsite-1 and Onsite-2 as receptors.

Table 6. Receptors (Dose Receivers)

DOE Site	Onsite 1 Worker	Onsite 2 Worker	Public/ Offsite	Comment
SRS	Immediate	Outside	X	Onsite-1; Inside facility Onsite-2; Outside facility
Pantex	X		X	
INEEL	Immediate	100 meters	X	
Hanford, ERC	X		X	
Hanford, Fluor	X	X	X onsite X offsite	Onsite-2; co-located at 100 meters
Hanford, PNNL	X or 100 meters		X	
LANL	X		X	Immediate or co-located
LLNL	X		X	Immediate or co-located at 100 meters
SNL	X		X	Inside facility
Oak Ridge, Bechtel Jacobs	X	X	X	Onsite-2; Onsite
Y-12	Immediate	100 meters	X	
RFETS*	Immediate	100 meters	X	
ANL-E	Immediate	Outside	X	
WVDP*	X		X	
Mound (MCP)*	Immediate	50 meters	X	Onsite-2 at 50 meters
Fernald (FEMP)*	X		X	Immediate or co-located at 30 meters
BNL	X	Outside	X onsite X offsite	

* D&D and closure sites

Section 1.4 Chemical Consequence Evaluation

Some sites evaluate workers at two locations- Onsite-1 and Onsite-2, and some sites evaluate them into one group – onsite. The consequence categories and their criteria vary widely from site to site for the workers and public. DOE-STD-3009-94 shows an example with the following four graded consequence levels:

High - Considerable onsite and offsite impacts on people or the environment
Moderate - Considerable onsite impact on people/environment, minor impact offsite
Low - Minor onsite and negligible offsite impact on people/ environment
No - Negligible onsite and offsite impact on people/ environment

Many sites use the DOE-STD-3009-94 four levels of graded consequences. Also, many sites use the same onsite worker exposure levels (ERPG-3,-2, etc) and the same public exposure levels (ERPG-2,-1, etc). Between sites there are some notable differences in exposure levels for public exposure for the same consequence such as IDLH, ERPG-3, -2, -1, TLV-time weighted average (TWA), or PEL-TWA. This is mainly due to the fact that there is no evaluation guide (EG) provided for chemicals by DOE. Examples are as follows.

SRS and INEEL use the following four consequence levels- **High/Moderate/Low/Negligible**.

- High category, consequence criterion (CC) is >ERPG-3 for onsite-1 & onsite-2 workers , and >ERPG-2 for the public
- Moderate consequence, CC is between ERPG-3 to ERPG-2 for workers, and between ERPG-2 and ERPG-1 for the public
- Low consequence, CC is between ERPG-2 and ERPG-1 for workers, and <ERPG-1 for the public
- Negligible, CC is <ERPG-1 for workers, and SRS uses <PEL-TWA while INEEL uses <TLV-TWA for the public

Pantex uses a different set of consequence criteria (CC) defined as **Bodily injury/Loss of equipment or facilities/ Loss of production/Other**. The CC for bodily injury is permanent injury or death to workers and the public. The CC for release of toxic material is IDLH for onsite workers and ERPG-2 for the offsite public. Loss of equipment/facilities is tied to a $1-million value. Loss of production is tied to 6 months duration, and “Other” consequence decision is at the discretion of division manager.

Hanford Fluor uses the following 3 consequence levels - **High/Moderate/Low** .

- High consequence, the CC is >ERPG-3 for both onsite-1 and onsite-2 workers, and >ERPG-2 for the public
- Moderate consequence, CC is >ERPG-2 for onsite-1 and onsite-2 workers, and >ERPG-1 for the public
- Low consequence, CC is less than moderate consequence for workers, and also less than moderate consequence for the public

LANL has the following five consequence levels, **A/B/C/D/E** (A>B>C….), and the CC is descriptive and qualitative for onsite workers and quantitative for the public:

- A - CC is immediate health effect or loss of life for workers, and >ERPG-2 for the public
- B - CC is long-term health effect, disability, sever injury (no permanent health effects), and CC is between ERPG-2 and ERPG-1 for the public
- C - CC is loss-time injury, no disability, and <ERPG-1 for the public
- D - CC is minor injury with no disability and no work restriction, and less than measurable dose for the public
- E - there is no measurable consequence to workers and none to the public

LLNL, similar to SRS and INEEL, has four consequence levels of **High/Moderate/Low/ Negligible**, but the CC is descriptive and qualitative for both onsite workers and the public, and there is no ERPG criterion used for both workers and the public:

- High consequence, - CC can result in death, severe environmental impact, and destruction of building for both onsite workers and the public
- Moderate consequence, - CC is severe injury, illness, major damage to building, and minor environmental impact for workers, and minor injury and illness for the offsite
- Low consequence, - CC is minor injury, illness or environmental impact to workers and, no harm to the public
- Negligible consequence, - There is no harm to workers and the public

SNL has assigned no consequence level or **category**, however, the CC can vary from death to minor injury to onsite-1workers and the public, depending on the performance of hazard analysis for consequences for the accident scenarios.

Oak Ridge-Bechtel Jacobs uses the following three consequence levels **High/Moderate/Low**, based on ERPG-2 criterion:

- High consequence - CC is >ERPG-2 for onsite-1 and onsite-2 workers and the public
- Moderate consequence - CC is >ERPG-2 for onsite workers and <ERPG-2 for the public
- Low CHC - CC is >ERPG-2 for onsite-1 worker inside the facility, <ERPG-2 for onsite-2 workers and the public

Y-12 also has the following three consequence levels of **High/Moderate/Low**, but the criteria are descriptive for onsite-1 workers and quantitative – ERPG-2 for onsite-2 workers and the public (site boundary):

- High consequence - CC is >ERPG-2 for the public
- Moderate consequence - CC is >ERPG-2 for collocated workers at 100 meters (Onsite-2)
- Low consequence - CC is serious injury or other serious health effects for immediate workers (Onsite-1)

RFETS and WVDP have also three consequence levels **High/Moderate/Low**. WVDP uses first three levels of STD-3009-94, using ERPG-2 criterion for onsite and offsite workers. RFETS uses descriptive and qualitative CC for onsite-1 (immediate) workers for hazard and quantitative for onsite-2 workers (100 meters) and the public. For High consequence, CC is prompt death for onsite-1 worker and >ERPG-3 for onsite-2 worker, and >ERPG-2 for public. For Moderate consequence, CC is serious injury for onsite-1 worker, and no criteria (N/A) used for onsite-2 and the offsite public. For Low consequence, CC is less than serious for onsite-1 worker, <ERPG-3 for onsite-2 worker, and <ERPG-2 for the public.

Mound has the following consequence levels **High/Moderate/Low/Negligible**, but the CC is same for both onsite-1 workers in immediate contact with hazards and onsite-2 workers within 50 meters of hazard:

- High consequence - CC is >IDLH for workers and >ERPG-2 for the public
- Moderate consequence - no CC (N/A) is cited for workers and the public
- Low consequence - CC is <IDLH for workers and <ERPG-2 for the public

- Negligible consequence - CC is only 10% of IDLH and ERPG-2; <0.1xIDLH for workers and <0.1xERPG-2 for the public

Fernald also has the following four similar levels **High/Moderate/Low/Below Concern**, but the CC is quantitative for onsite (immediate and at 30m) workers and the public:

- High consequence - CC is >ERPG-3 for workers and >ERPG-2 for the public
- Moderate consequence - CC is >ERPG-2 for workers and >ERPG-1 for the public
- Low consequence - CC is >ERPG-1 for workers and >PEL-TWA for the public
- Below Concern, CC is <ERPG-1 for workers and EPA and other legal limits that are applicable for public

Table 7 summarizes the CC evaluation for the workers and the public identified as located at the site boundary for the various sites. Where ERPG-1, 2, and 3 values are not available, TEEL (Temporary Emergency Exposure Limit) values can be used. TEEL limits are listed for over 1,430 chemicals. The Subcommittee on Consequence Assessment and Protection Actions (SCAPA) – approved methodology published in the American Industrial Hygiene Association was used to obtain hierarchy derived TEELs (Craig et al, Amer. Ind. Hyg. Assoc. J, 56, 919-925, 1995). The methodology used to determine these exposure limits is also documented in Westinghouse Savannah River Company Technical Reports by Douglas K. Craig -WSRC-TR-98-0080, 1998; WSMS-SAE-02-0171, July 2003.

These are alternate guideline limits based on comparisons between toxicity parameters and ERPGs. TEEL values can be obtained from SCAPA's home page - http://www.sep.bnl.gov/scapa/ and can also be found on the DOE's Environment Health Chemical Safety Home page -http://tis.eh.doe.gov/web/chem_safety/ doe_reg.html or tis-hq.eh.doe.gov/web/chem_safety/teel.html.

There are some important variations in the CC criteria used for onsite-1 and onsite-2 workers and the public by the various sites. DOE standardized EGs could be helpful in mitigating these variations.

Table 7. Chemical Consequence Evaluation

<table>
<tr><th>DOE Site</th><th>Consequence</th><th>Onsite-1 Worker</th><th>Onsite-2 Worker</th><th>Public</th><th>Consequence Criteria</th></tr>
<tr><td>SRS</td><td>• High
• Moderate
• Low
• Negligible</td><td>≥ ERPG-3
ERPG-2 ≤ to <ERPG-3
ERPG-1 ≤ to <ERPG-2
<ERPG-1</td><td>≥ ERPG-3 or 1910
ERPG-2 ≤ to <ERPG-3
ERPG-1 ≤ to <ERPG-2
<ERPG-1</td><td>≥ ERPG-2
ERPG-1 ≤ to <ERPG-2
PEL-TWA ≤ to <ERPG-1
<PEL-TWA</td><td>Onsite-1; Inside facility
Onsite-2; Outside facility</td></tr>
<tr><td>Pantex</td><td>• Bodily Injury
• Loss of equipment or facilities
• Loss of production
• Other</td><td colspan="2">Bodily Injury
Toxic Material
(IDLH for onsite)</td><td>Bodily Injury
Toxic Material
(ERPG-2 offsite)</td><td>Permanent injury, death
IDLH for onsite
ERPG-2 offsite
$1,000,000
6 months
At the discretion of Div. manager</td></tr>
<tr><td>INEEL</td><td>• High
• Moderate
• Low
• Negligible</td><td>>ERPG-3 or >Δ10 psi
ERPG-2 to ERPG-3
ERPG-1 to ERPG-2
<ERPG-1</td><td>>ERPG-3 or >Δ10 psi
ERPG-2 to ERPG-3
ERPG-1 to ERPG-2
<ERPG-1</td><td>>ERPG-2
ERPG-1 to ERPG-2
TLV-TWA to ERPG-1
<TLV-TWA</td><td>Onsite-1; Facility worker
Onsite-2; Collocated worker at 100 meters</td></tr>
<tr><td>Hanford, Fluor</td><td>• High
• Moderate
• Low</td><td>> ERPG-3
>ERPG-2
<Moderate Consequence</td><td>> ERPG-3
>ERPG-2
<Moderate Consequence</td><td>> ERPG-2
>ERPG-1
<Moderate Consequence</td><td>Onsite-1; Facility worker
Onsite-2; Co-located worker at 100 meters</td></tr>
<tr><td>LANL</td><td>• A
• B
• C
• D
• E</td><td colspan="2">Immediate health effect or loss of life
Long-term health effect, disability, sever injury
Loss-time injury, no disability
Minor injury with no disability & no work restriction
No measurable consequence</td><td>>ERPG-2
>ERPG-1 to <ERPG-2
Measurable to <ERPG-1
<Measurable
None</td><td>Pot. for long term health effects
No permanent health effects
No sig. offsite impact
No offsite impact</td></tr>
<tr><td>LLNL</td><td>• High
• Moderate
• Low
• Negligible</td><td colspan="2">Result in death, sever environ. Impact, destruction of bldg.
Severe injury, illness, major damage to bldg., minor env. Impact.
Minor injury, illness or env. Impact
No harm</td><td>Same impact as onsite
Minor injury, illness, &env. Impact.
No harm
No harm</td><td>No ERPG criteria is used.</td></tr>
<tr><td>SNL</td><td>• No Category</td><td>Death to minor injury</td><td></td><td>Death to minor injury</td><td>HA is performed for consequence.</td></tr>
</table>

Current Chemical Hazard Characterization Practices in the DOE Complex.

DOE Site	Consequence	Onsite-1 Worker	Onsite-2 Worker	Public	Consequence Criteria
Oak Ridge, Bechtel Jacobs	• High • Moderate • Low	≥ ERPG-2 ≥ ERPG-2 >ERPG-2	≥ ERPG-2 ≥ ERPG-2 <ERPG-2	≥ ERPG-2 <ERPG-2 <ERPG-2	Onsite-1; Inside facility Onsite-2; Onsite
Y-12 Plant	• High • Moderate • Low	Serious injury or serious health effects	>ERPG-2 at 100m	>ERPG-2	
RFETS*	• High • Moderate • Low	Prompt death Serious injury <Serious injury	>ERPG-3 N/A ≤ERPG-3	>ERPG-2 N/A ≤ERPG-2	
WVDP*	• High • Moderate • Low	STD-3009		STD-3009	ERPG-2
Mound (MCP)*	• High • Moderate • Low • Negligible	>IDLH N/A ≤IDLH ≤0.1x IDLH	>IDLH N/A ≤IDLH ≤0.1x IDLH	>ERPG-2 N/A ≤ERPG-2 ≤0.1x ERPG-2	Considerable offsite impact Minor offsite impact Neg. offsite impact No offsite impact
Fernald (FEMP)*	• High • Moderate • Low • Below Concern	>ERPG-3 >ERPG-2 >ERPG-1 ≤ERPG-1		>ERPG-2 >ERPG-1 >PEL-TWA EPA & other legal limits	Onsite-2; Worker at 30m

* D&D and closure sites
If ERPG-1, -2, -3 values are not available, TEEL-1, -2, -3 can be used.

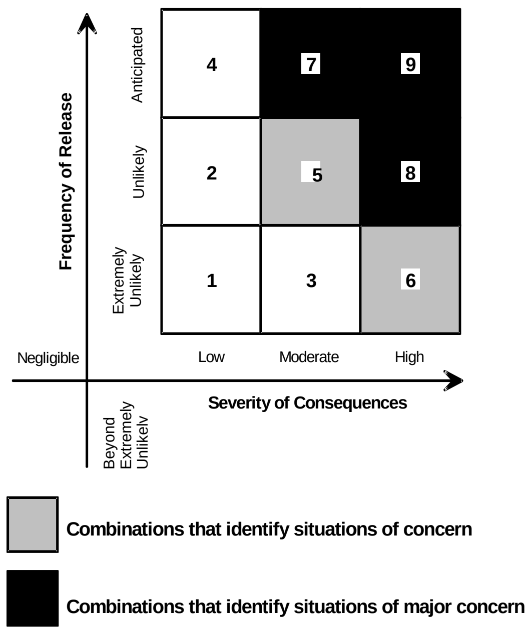
DOE-STD-3009-94

High	Considerable onsite and offsite impacts on people or the environment
Moderate	Considerable onsite impact on people/environment, minor offsite impact
Low	Minor onsite and negligible offsite impact on people/environment
No	Negligible onsite and offsite impact on people/environment

Section 1.5 Risk Binning Matrix

This section discusses how the various sites use frequency and consequence to establish risk bins. DOE-STD-3009-94 uses a 3x3 risk-binning matrix for hazard evaluation as shown in Figure 2. Risk is the product of frequency listed in Table 5 and consequence listed in Table 7. Table 8 summarizes the risk-binning classification for both onsite-1 and onsite-2 workers and for the public for the various sites.

Figure 2. DOE-STD-3009-94 Consequence Binning Matrix



This 3x3 matrix has risk bins with rankings of 1 to 9, where 9>8>7…..>2>1. Risk bins 9, 8, and 7 are of major concern and risk bins 6 and 5 are of concern. These risk bins are identified as: H-AN, H-UN, H-EU, M-AN, and M-UN for onsite workers and the public. Events that fall into these five bins require controls to reduce risk. The binning schemes are designed to separate the lower risk accidents that are adequately assessed by hazard evaluation from higher risk accidents that may warrant additional quantitative analysis if the phenomena involved are not simplistic. A limited number of moderate risk accidents between the two extremes may also be identified for assessment.

WVDP, Y-12, and Mound use the 3x3 risk matrix of DOE-STD-3009-94 and safety controls criteria, except these sites provide added controls for Low-Anticipated (L-AN) bins for both the workers and the public. Y-12 will also identify controls for low consequence category events for all but BEU frequency category events if feasible. RFETS also uses a 3x3 risk matrix with a risk binning of I through IV where (I>II>III>IV and controls are required for the five risk categories (H-AN, H-UN, H-EU, M-AN, M-UN) identified in STD-3009-94 for workers and the public. Hanford Fluor uses a 4x4 risk matrix with a risk binning of I through IV where (I>II>III>IV, but controls are required for only five risk categories (H-AN, H-UN, H-EU, M-AN, M-UN) similar to RFETS for workers and public.

Fernald uses a risk matrix of 4x4, however, lists no risk binning, and instead identifies risk as "significant" for the six risk bins (H-AN, H-UN, H-EU, M-AN, M-UN, L-AN) used by WVDP and Mound.

SRS also uses a 4x4 risk matrix with a risk binning of 1 to 11, where 1>2>3 ….11. However, safety controls are required for five risk categories (H-AN, H-UN, H-EU, M-AN, M-UN) as that of DOE-STD-3009 for onsite workers, and six risk categories for the public (the five risk bins plus L-AN).

Pantex uses a 4x4 risk matrix, but does not use any risk binning. Instead, it lists the following consequence severity criterion:

- S4 (>ERPG-2 for offsite)
- S3 (death/onsite release >IDLH, loss of equipment/ facilities> $1 million)
- S2 (disabling injury, loss of production for >6 months)
- S1 (minor injury)

The frequency criteria are L4 (Frequent to Likely), L3 (UN), L2 (EU), and L1 (BEU). The site uses Defense in Depth controls for six categories. S3-L1, S2-L2, S2-L1, S1-L3, S1-L2, and S1-L1; and safety item controls for 6 different categories, S4-L2, S4-L3, S4-L4, S3-L3, S3-L4, and S2-L4. These control requirements are the same for both onsite workers and the public.

INEEL uses a 4x4 risk matrix with a risk matrix of 1 to 16 (16>15>….>1). However, control requirements are for 5 risk category for onsite-1 workers with immediate contact with hazards, which are different from six risk categories for onsite-2 workers co-located within 100 meters of hazards. Onsite-2 worker controls for six risk categories are the same as for six risk categories for the public, which has an additional L-AN classification from DOE-STD-3009.

LLNL also uses a 4x4 risk binning with a risk binning of 1 to 16 where 1>2>3 …..>16, which has the **reverse binning** from INEEL. The six risk categories similar for both the workers and the public are: H-Very likely, H-Likely, H-UN, M-Very likely, M-Likely, L-Very likely. These categories are somewhat different from those used by INEEL and provided by DOE-STD-3009-94.

LANL uses a 5x5 risk matrix with a risk binning of 1 through 4 where 1>2>3>4. For risk 1, work is not performed. Risk 2 requires an approval from division director. Risks 1 and 2 require additional safety controls to reduce the risk to 3 or 4, which is an acceptable level. There are 10 risk categories for onsite workers; A-Expected, A-Likely, A-UN, A-EU, B-Expected, B-Likely, B-UN, C-Expected, C-Likely, and D-Expected and the same 9 risk categories for the public except D-Expected. These risk categories differ from some other sites but , they overlap with the five risk categories provided by DOE-STD-3009.

There are additional differences across the sites in terms of the implementation of safety controls or the hierarchy of safety controls for workers and the public.

There are wide variations in the design of risk matrices, risk-binning criteria, and risk categories where safety controls are required. In some cases, risk classification importance is different for onsite-1 and onsite-2 workers and the public. Terminology varies across the sites.

Table 8. Risk Binning Matrix

<u>DOE-STD-3009-94</u>: 3 x 3 Matrix = Risk 1 → 9 ; 9> 8>7> ….2>1. Controls are required for Risk Bins# 9 to 5.
H-AN, H-UN, H-EU; M-AN, M-UN

DOE Site	*F* x C	Onsite/Public Bins	Onsite-1 Controls	Onsite-2 Controls	Public/Controls
SRS	4 x 4	1 → 11; 1>2>3…11	H-AN, H-UN, H-EU M-AN, M-UN		H-AN, H-UN, H-EU M-AN, M-UN L-AN
Pantex	4 x 4	No Risk ranking	Safety items as controls are required in high-risk events.		Safety items as controls are required in high-risk events.
INEEL	4 x 4	16 → 1 ; 16>15>…>1	H-AN, H-UN M-AN, M-UN L-AN	H-AN, H-UN, H-EU M-AN, M-UN L-AN	H-AN, H-UN, H-EU M-AN, M-UN L-AN
LANL	5 x 5	1 → 4; 1>2>3>4 For Risk 1, work will not be performed.	A-Expected, A-Likely, A-UN, A-EU B-Expected, B-Likely, B-UN C-Expected, C-Likely D-Expected		A-Expected, A-Likely, A-UN, A-EU B-Expected, B-Likely, B-UN C-Expected, C-Likely
LLNL	4 x 4	1 → 16 ; 1>2>3……>16	Risk ranking is reverse from INEEL. H-Very likely, H-Likely, H-UN, M-Very likely, M-Likely L-Very likely		
Oak Ridge, Bechtel Jacobs	4 x 4	A → D ; A>B>C>D	H-AN, H-UN, H-EU M-AN, M-UN		H-AN, H-UN, H-EU, H-BEU M-AN, M-UN, M-EU L-AN, L-UN, L-EU
Y-12	3 x 3	STD-3009; 1 → 9; 9>8>…1	H-AN, H-UN, H-EU M-AN, M-UN, M-EU L-AN, L-UN, L-EU		
RFETS* Hanford, Fluor	3 x 3 4 x 4	I → IV; I>II>III>1V	H-AN, H-UN, H-EU M-AN, M-UN		
WVDP*	3 x 3	STD-3009; 1 → 9; 9>8>…1	H-AN, H-UN, H-EU M-AN, M-UN L-AN		
Mound (MCP)*	3 x 3	STD-3009; 1 → 9; 9>8>…1	H-AN, H-UN, H-EU M-AN, M-UN L-AN		
Fernald (FEMP)*	4 x 4	Significant No Risk #	H-AN, H-UN, H-EU M-AN, M-UN L-AN		

* D&D and Closure sites
F- Frequency; C - Consequence

Section 1.6 Safety Control Selection

This section identifies whether sites use consequence or risk to determine safety controls. There are no chemical EGs, similar to nuclear EGs, provided by DOE and none are used by DOE site contractors to give a Safety Class Classification, except INEEL (DOE-ID O 420.D).

Some sites have developed their own EGs such as ERPG-1,-2, and -3 for consequences but use different EG criteria for safety controls - safety significant (SS), DiD, and administrative controls (ACs). For example, SRS; Hanford, Fluor; and RFETS use PEL-TWA and ERPG-1,-2,-3 as EGs. However, the safety controls are based on **consequence** by SRS and RFETS, while Hanford Fluor, uses safety controls based on **risk** criterion. INEEL uses TLV-TWA and ERPG-1,-2,-3 as EGs and safety controls are based on **risk** criterion for offsite based safety controls. Table 9 summarizes basis safety control selection for the various sites.

Table 9. Safety Control Selection

DOE Site	Hazard Category		EG Criteria**	Safety Controls (SS, DiD, and AC)	
	Inventory	Consequence		Consequence	Risk
SRS	X		• PEL-TWA • ERPG-1, -2, -3	X	
Pantex		X	• IDLH • ERPG-2		X
INEEL	X (M, L)	X (H)	• TLV-TWA • ERPG-1, -2, -3	X Onsite >ERPG-3	X Offsite
Hanford, Fluor	X		• PEL-TWA • ERPG-1, -2, -3		X
LANL		X	• ERPG-1, -2, -3	X	
LLNL	X	X	• ERPG-1, -2, -3	X	
Oak Ridge, Bechtel Jacobs		X	• ERPG-2		X
Y-12	X	X	• ERPG-2, -3	X	X
RFETS*	X		• PEL-TWA • ERPG-1, -2, -3	X	
WVDP*		X	• ERPG-1, -2, -3	X	
Mound (MCP)*	X		• IDLH • ERPG-2	X	
Fernald (FEMP)*	X		• ERPG-2 • ERPG-3	X	

* D&D and closure sites

** If ERPG-1, -2, and -3 values are not available, Temporary Emergency Exposure Limit (TEEL)-1, -2, and -3 can be used.

On the other hand, LANL, LLNL, and WVDP use ERPG-1,-2,and -3 for EGs and safety controls are based on **consequence** criterion. Oak Ridge- Bechtel Jacobs uses only ERPG-2 as an EG, but controls are based on **risk**. On the other hand, Y-12 uses ERPG-2, -3 for EG and controls are based on both consequence and risk criteria.

Mound (MCP) and Pantex both use IDLH and ERPG-2 as EGs. However, Mound uses **consequence** criterion for safety controls while Pantex uses **risk** criterion. Fernald (FEMP) uses both ERPG-2 and ERPG-3 as EGs and **consequence** criterion for the selection of safety controls.

There are wide variations among the sites in the selection of IDLH, ERPGs or Temporary Emergency Exposure Limits (TEELs), and PEL-TW or TLV-TWA for the EGs for safety controls. Also, there are variations across the sites between using consequence or risk criterion to select safety controls. There is no correlation between the inventory or consequence based facility CHCs to the consequence or risk criterion for EGs for the selection of safety controls.

Section 2.0 Hazard Baseline Methodology

Hazard baseline methodology (HBM) is usually qualitative and includes:

- Hazards Checklist
- Hazard Identification
- Additional Hazard Evaluation (AHE) such as chemical mixing hazards and chemical incompatibility
- Common Hazards Screening Criteria
- Hazard Evaluation Table
- Consequence/Source Term Determination Method

Most of the HBM information is presented in a tabular form in each Chemical Safety Analysis (CSA) report. Hazard analysis can be qualitative or quantitative depending on the facility CHC. Most of the sites have some form of HBM in place but the details vary depending on the complexity of their chemical safety program. The sites HBM is presented in the following sections:

- Section 2.1 Hazard Checklist Category
- Section 2.2 Hazard Identification
- Section 2.3 Additional Hazard Evaluation
- Section 2.4 Common Hazard Screening Criteria
- Section 2.5 Example of Hazard Evaluation Table
- Section 2.6 Consequence/Source Term Definition Method

Section 2.1 Hazard Checklist Category
Section 2.2 Hazard Identification

Due to the interrelated nature of hazard checklist categories and the hazard identification process, the HBM summary combine the hazard checklist categories and the identification process in a single comprehensive table, Table 10.

These sections discuss the HBM used by the various sites. The facility CHCs (e.g., High/Moderate/Low) and its screening criteria (TQ, TPQ, RQ, or ERPG-1, -2, and -3) from Table 4 are included in Table 10 to compare the details from each site. The discussions on hazard checklist category and hazard identification do not appear to correlate with the facility CHC level. The details of hazard identification at the sites are as follows.

SRS's **High/Low** CHC lists hazards checklist categories as pyrophoric, spontaneous combustion, flammable, combustibles, chemical reactions, potential (pressure), explosive/pyrophoric, and hazardous material. Hazard energy sources and examples are then listed under each category. For example, Pu and U metals are pyrophoric, while alkali metals, acetone, oxidizers, ammonia, beryllium, and chlorine compounds are hazardous materials. Under Hazard Identification, these hazardous chemicals are identified by location in a facility per the WSRC-IM-97-9 manual.

Pantex's **High/Moderate/Low** CHC for chemical facilities are mostly explosive facilities and require Process Hazard Analysis (PHAs) according to the following documents:

- DOE M 440.1-1 “DOE Explosive Safety Manual”
- 29CFR 1910.109 “Explosive and Blasting Agent”
- 29CFR 1910.119 “Process Safety Management of Highly Hazardous Chemicals”

PHAs focus on the processes that are conducted in the facility using What If, FMEA, and Hazard and Operability Study (HAZOP) techniques. Hazards are identified through PHAs.

INEEL’s **High/Moderate/Low** CHC lists various hazard checklist categories such as explosive, flammable, combustibles, and hazardous material and also lists other potential nonchemical hazard sources such as pressure, kinetic energy, thermal energy, and natural phenomena, and then lists various hazards under each category. OSHA type hazards (nonchemical) are also listed. Four main requirement documents are:

- DOE-ID 420.C“Safety Basis Review and Approval Process”
- DOE-ID Order 420.D, “Requirements and Guidance for Safety Analysis” INEEL Program Requirements Documents
- PRD-164, “Safety Analysis for Other than Nuclear Facilities”
- INEEL Management Control Procedure; MCP-2451, “Safety Analysis for other than Nuclear Facilities”

Hanford ERC’s **Non-nuclear** CHC include hazards identification and evaluation. Potential chemical hazards are classified as flammable, reactive, explosive, and toxic materials. Hazards are identified under each category in a worksheet that includes information such as hazard type, location, form, quantity, remarks, and reference (EDPI-4.28-01, Hazard classification procedure).

Hanford Fluor’s **Moderate/Low** CHC includes hazard identification and evaluation against the screening criteria of TQ, TPQ, and RQ. Potential chemical hazards identified are: oxidizer, pyrophoric, flammable, reactive, explosive, toxic, and organic peroxide materials. Hazard identification information for a facility is typically compiled in a database known as the Chemical Inventory Tracking System that contains the hazard type, location, form, quantity, remarks, and references such as HNF-PRO 10468, “Chemical Management Process”, and HNF-PRO-700, “Safety Basis Development. These are further evaluated for the workers and public.

PNNL’s **Chemical** CHC includes hazards identification and evaluation. Potential chemical hazards are flammable, reactive, explosive, and toxic materials. Hazards are identified under each category and information for a facility is managed via FUA (facility use agreement) and CMS (chemical management system), which include hazard type, location, form, and quantity in accordance PNNL-MA-440, Safety Analysis Manual. Chemical safety practices, which are a part of ISM, consist of the following five core steps:

- Define work
- Identify and analyze hazards
- Develop and implement controls
- Perform work safely
- Ensure performance and continuous improvement

LANL's **High/Moderate/Low** CHC categories include chemical reaction, toxicity, flammability and fires, explosions, and hazardous materials, and nonchemical hazards as pressure, electrical, heat and temperature, leak of material, and equipment failure. Various hazards are identified under each category by location and process activity in a facility. Chemical safety program, which is a part of Integrated Safety Management (ISM), consists of the following five core steps:

- Define work
- Identify and analyze hazards
- Develop and implement controls
- Perform work safely
- Ensure performance and continuous improvement

The chemical safety program is in accordance with LIR-300-00-07, Non-nuclear Facility Safety Authorization; FWO-OAB-501, Hazard Analysis Methodology Handbook.

LLNL's **High/Moderate/Low** CHC categories consist of chemical, electrical, thermal, radiant, kinetic, pressure, potential, and biological energy. Under chemical, subcategories are corrosive, flammable, toxic, reactive, oxygen deficiency, and carcinogens. Hazards are identified under each category by location and process activity. Occupational Safety and Health Administration (OSHA) type hazards are screened out. Reference documents are:

- SARA #2006, Rev. 2, Facility CHC Methodology
- ES&H manual 3.1, Safety Analysis Program
- ES&H Manual 3.2, Safety Basis Thresholds

SNL's **Moderate/Low** CHC contains information on chemicals, CAS number, quantity, location, owner, Material Safety Data Sheets, pressure, and NFPA code, which is maintained in a Chemical Information System (CIS). Potential chemical hazards in CIS are identified as flammable, reactive, explosive, and toxic materials. Primary hazard screening module of the Integrated Safety Management System (ISMS) identifies all hazards associated with the operations. Chemical safety program consists of the following five safety management functions:

- Define work scope
- Identify and analyze hazards
- Develop and implement hazard controls
- Perform work with controls
- Provide feedback on adequacy of controls and continue to improve safety management

The reference document is the ES&H manual, CPR400.1.1.

ORNL-UT/Battelle's **No Category** CHC is prepared from work control subject area using a work planning checklist for operations, maintenance and service and a Research & Development hazard identification and control checklist for Research & Development activities. Potential chemical hazards are flammable, reactive, explosive, and toxic. Hazards are identified at work activity level through standard based management system such as chemical safety and work control. The reference document is the ORNL/LPD-EP/HS-103, Hazards survey for maintenance and operations contractor non-nuclear facilities.

Oak Ridge-Bechtel Jacobs' **High/Moderate/Low** CHC is made for preliminary hazard screening (PHS) and activity hazard analysis (AHA), and job hazard analysis (JHA). Checklist also includes chemical hazards as toxic, flammable, reactive materials and asphyxiants, and non-chemical hazards as pressure, electrical, kinetic energy, and laser energy. Various hazards are identified under each category by job specific activity and facility specific chemical analysis. The reference documents are:

- BJC/NS-1009, Safety documentation for radiological and non-nuclear facilities
- BJC/OR-112, Hazard categorization /classification and HA application guide

Y-12 's **PSM/RMP and Chemically Hazardous** categories contains facility/process hazards that are identified using a facility-specific Hazardous Material Identification document, process description, and a hazard checklist. Hazards are screened to determine which are carried forward to the Hazard Evaluation Study. The Hazard Evaluation Study is performed using appropriate techniques (What-If, HAZOP, etc). As necessary, accident analysis is performed to identify controls that will be credited in the safety basis. Safe work practices (SWP) consists of the following five steps of the ISMS:

- Define work
- Identify and analyze hazards
- Develop and implement controls
- Perform work safely
- Ensure performance and continuous improvement

Reference documents are:

- Y74-801INS, Hazardous material identification;
- Y74-48-007INS, Hazard screening
- Y74-48-009INS, Accident Analysis
- Y74-802, Safety Basis Documents for Nuclear, PSM/RMP, and Chemically Hazardous Facilities
- Y74-48-008INS, Hazards Evaluation Study

RFETS' **Chemical AR/ Chemical NAR** CHC consists of various categories such as hazardous chemicals as corrosive, explosive-pyrophorics, flammable, and toxic or pathogenic materials, and non-chemical hazards as thermal, pressure, electrical, and external events. Various hazards are then identified under each category by specific activity, quantity, location, and facility. OSHA type hazards are eliminated. The reference document "Safety Analysis and Risk Assessment Handbook (SARAH-RFETS 2001b), Chapters 2, 4, 5, and 9, and Appendices D & I.

ANL-E (**No category** CHC) does not have a facility that exceeds TQ (29 CFR 1910.119). Onsite chemicals are tracked through CMS, which identifies chemicals as carcinogens and sensitive chemicals such as peroxide. Other potential chemical exposure are also identified. The checklist also involves nonchemical hazards. Hazards are identified under each activity. PHA involves the hazard checklist, What If analysis, HAZOP, Failure Modes Effects and Criticality Analysis , Fault Tree Analysis (FTA), and Event Tree Analysis (ETA). Reference documents are:

- ANL-Environment, Safety and Health (ES&H) manual
- Comprehensive Emergency Management Plan

- Waste Handling Procedural Manual

WVDP's **High/Moderate/Low** CHC uses a hazard screen checklist form (WV-3909) and area hazard survey checklist forms (WVDP-273) are used to identify different chemical category and other related hazard nonchemical categories. Chemical hazards involve toxic, carcinogen, flammable, reactive, corrosive materials. Various hazards are identified under each category by activity, location, and facility. Reference documents are:

- WVNS-SAR-001, Safety analysis report for waste processing and support activities
- WVDP-193, Hazards assessment
- WV-921, Hazards identification and analysis

Mound's **one category** CHC uses a hazard survey checklist that is prepared from inventory, interviews and process operations, and is an integral part of PHA. It is documented by activity in a facility hazards and accident analysis matrix . Under chemical, hazards are identified as toxic, noxious, explosive, and compressed gases. Various nonchemical hazard categories are pressure, temperature, potential energy, kinetic energy, laser, external events, etc. Various hazards are identified by activity, location, and facility. Reference documents are:

- PP-1059C, Authorization Basis manual of practices
- MD-10414, Safety basis methodology
- PP-1049, Integrated safety management system

Fernald's **one-category** CHC currently has no non-nuclear hazard facility. In general, chemicals are tracked through CMS in accordance with CMS, EP-0012. Chemical hazards are noted as caustic/acidic, acute toxic, and chronic toxic. Other non-chemical categories are identified as pressure, thermal, kinetic, electrical, laser, etc. Various hazards are identified by activity, location, and facility in a checklist format. Integrated hazard analysis (IHA) is prepared from inventory, interviews, and process operations, as part of the PHA in accordance with SA-DPT-07, Safety assessment/auditable safety record methodology, EP-0012, Chemical management, and PL-2352, FEMP Hazard survey and hazard assessment.

BNL's **No category** CHC has no non-nuclear hazard facility. As a checklist criteria, the hazard identification tools (HIT) is used to identify hazards with each activity in a facility. For potential chemical hazards, the categories are flammable, reactive, explosive, and toxic materials. Based on hazards, HIT calculates hazard rating 0, 1, 2, 3 with 3 being the highest, which is used for evaluation in technical hazard analysis. Hazards are documented in the FUA as hazard type, location, form, quantity, and controls. The FUA is the vehicle for and documentation of the authorization basis (AB). Reference documents are HIT, Hazard identification tools, and FUA, Facility use agreement manual.

Most of the sites have some form of HBM in place, however, the details vary depending on the complexity of their chemical safety analysis program. Some sites use the ISM five core steps as part of Chemical Safety practices. Discussions on hazard checklist category and hazard identification do not appear to correlate with the facility CHC level of High/Moderate/Low.

Table 10. Hazard Baseline Methodology: Hazards Checklist Category and Hazard Identification

DOE Site	Hazard Category	Criteria for HA	Hazard Checklist Category	Hazards Identification	Comment/References
SRS	High Low	>TQ, TPQ >RQ	Pyrophoric material Flammables Combustibles Chemical reaction Explosive/Pyrophoric material Hazardous material, etc	Various hazards are identified under each category.	WSRC-IM-97-9 manual
Pantex	High Moderate Low	Offsite >ERPG-2 Major impact onsite Minor onsite	PHA consists of What If, FMEA, and HAZOP.	Hazards are identified through PHA.	PHA and Facility Hazard classification manual. DOE M440.1-1, 29 CFR 1910.109, 29 CFR 1910.119 for PHA
INEEL	High Moderate Low	Offsite, IDLH >TQ, TPQ >RQ	Explosive material Flammables Hazardous materials Kinetic energy Pressure Thermal energy, etc	Various hazards are identified under each category.	MCP-2451; PRD-164, Safety analysis for other than nuclear facilities, DOE-ID O 420D, Requirement and guidance for safety analysis
Hanford, ERC	Non-nuclear	>RQ , <TQ	Flammable material Reactive material Explosive material Toxic material	Hazard identification worksheet is used under each category.	EDPI-4.28-01, Hazard classification procedure
Hanford, Fluor	Moderate Low	TQ, TPQ RQ	Oxidizer materials Pyrophoric materials Flammable materials Reactive materials Explosive materials Toxic materials, or Organic peroxide	Hazard identification information is compiled in a database, the CITS, which contains hazard type, location, form, quantity, remarks, and references.	The identified hazards are evaluated to the events and controls necessary to provide adequate protection from the identified hazards. HNF-PRO 10468, "Chemical Management Process," Revision 1 HNF-PRO-700, "Safety Basis Development" DOE 0223, RLEP 3.22
Hanford, PNNL	Chemical	FUA 4 elements of PSM	Flammable material Reactive material Explosive material Toxic material	Hazard identification information for a facility is managed via FUA and CMS, which include hazard type, location, form and quantity.	Chemical Safety practices consists of 5 core steps: • Define work • Identify and analyze hazards • Develop and implement controls • Perform work safely • Ensure performance & continuous improvement • PNNL-MA-440, Safety analysis manual
LANL	High Moderate Low	Offsite >ERPG-3 Onsite >ERPG-3 Worker >ERPG-3	Chemical reaction Toxicity Flammability and fires Explosions Hazardous material, etc	Various hazards are identified under each category by location and process activity.	Chemical Safety program is via LIRs, which are part of ISM, Safe Work Practices, and FWC. Safe Work Practices consists of 5 core steps: • Define work • Identify and analyze hazards • Develop and implement controls

DOE Site	Hazard Category	Criteria for HA	Hazard Checklist Category	Hazards Identification	Comment/References
					• Perform work safely • Ensure performance & continuous improvement. LIR-300-00-07, Non-nuclear facility safety authorization FWO-OAB-501, Hazard analysis methodology handbook
LLNL	High Moderate Low	Offsite >ERPG-3 Onsite >ERPG-3 or Offsite >ERPG-2 Onsite >ERPG-2 Offsite >ERPG-1	Chemical energy Electrical energy Thermal energy Radiant energy Kinetic energy Pressure energy etc	Various hazards are identified under each category by location and process activity for workers and public.	SARA #2006, Rev. 2, Facility CHC methodology ES&H manual 3.1, safety analysis program ES&H manual 3.2, Safety basis thresholds
SNL	Moderate Low	>1910 >25% of 1910	CIS contains needed information on chemicals. Hazards are identified as Flammable material Reactive materials Explosive materials Toxic material	Primary hazard screening module of ISMS identifies all hazards associated with operations	CS program has 5 safety management functions: • Define work scope • Identify and analyze hazards • Develop and implement hazard controls • Perform work with controls • Provide feedback on adequacy of controls and continue to improve safety management ES&H manual CPR400.1.1
ORNL, UT/Battelle	No Category CHC	<TQ If >TQ	Chemical hazards are - Flammable material Reactive materials Explosive materials Toxic material	Checklist is prepared from Work Control using Work Planning checklist for operations, maintenance and service.	Hazards are identified at activity level through standard based management System – Chemical Safety and Work Control ORNL/LPD-EP/HS-103, Hazards survey for M&O contractor non-nuclear facilities
Oak Ridge, Bechtel Jacobs	High Moderate Low	Offsite >ERPG-2 Onsite >ERPG-2 Facility >ERPG-2	Chemical hazards Toxic material Flammable Reactive Electrical Kinetic energy Pressure, etc	Various hazards are identified under each category by job specific activity and facility specific chemical analysis.	Checklist is made for PHS and AHA, and JHA. BJC/NS-1009, Safety documentation for radiological and non-nuclear facilities BJC/OR-112, Hazard categorization /classification and HA application guide
Y-12	PSM/RMP Chemically Hazardous	>1910 or 68 Onsite >ERPG-2	All facility/process hazards are identified using Hazardous Material Identification document, process description, and a hazards checklist.	Information from the sources listed under Hazard Checklist Category are screened to determine which hazards are carried forward to the Hazards Evaluation Study.	SWP consists of 5 steps of the ISMS: • Define work • Identify and analyze hazards • Develop and implement controls • Perform work safely • Ensure performance and continuous improvement Y74-801INS, Hazardous material identification Y74-48-007INS, Hazard screening

DOE Site	Hazard Category	Criteria for HA	Hazard Checklist Category	Hazards Identification	Comment/References
					Y74-802, Safety Basis Documents for Nuclear, PSM/RMP, and Chemically Hazardous Facilities
RFETS*	No Category Chemical, AR Chemical, NAR	 >TQ >TPQ or RQ	Corrosive Explosive-pyrophorics Flammable materials Toxic or pathogenic Thermal, etc	Various hazards are identified under each category by specific activity, quantity, location, and facility.	Safety analysis and risk assessment handbook (SARAH-RFETS 2001b), Chapters 2, 4, 5, 9, and Appendices D and I.
ANL	No Category CHC	<TQ If >TQ	PHA involves hazard checklist, What-If analysis, HAZOP, FMECA, FTA, ETA	Hazards are identified under each activity. Other hazards are identified under construction project, design review, NEPA, etc.	ANL-ES&H manual Comprehensive emergency management plan Waste procedural manual
WVDP*	High Moderate Low	Offsite>ERPG-2 Onsite >ERPG-2 Minor onsite	A hazard screen checklist form (WV-3909) and area hazard survey checklist form (WVDP-273) are used to identify different chemical category and other related hazard category.	Various hazards are identified under each category by activity, location, and facility.	WVNS-SAR-001, Safety analysis report for waste processing and support activities WVDP-193, hazards assessment WV-921, Hazards identification and analysis
Mound (MCP)*	One Category Non-nuclear hazardous material	TQ, TPQ, RQ	Hazard survey checklist is prepared from inventory, interviews and process operations, and is an integral part of PHA.	Various hazards are identified by activity, location, and facility.	PP-1059C, Authorization Basis manual of practices MD-10414, Safety basis methodology PP-1049, Integrated safety management system
Fernald (FEMP)*	One Category Non-nuclear hazardous material	TQ, TPQ, RQ Currently non	IHA is prepared from inventory, interviews, and process operations, as part of PHA.	Various hazards are identified by activity, location, and facility.	SA-DPT-07, safety assessment/auditable safety record methodology EP-0012, Chemical management PL-2352, "FEMP Hazard Survey and Hazard Assessment"
BNL	No Category Non-nuclear hazardous	TQ, TPQ, RQ Currently non	HIT is used to identify hazards with each activity. Some categories are: Flammable materials Reactive materials Explosive materials Toxic materials	Based on hazards, HIT calculates hazard rating 0, 1, 2, 3 (highest), which is used for evaluation in technical hazard analysis.	A FUA is the vehicle for and documentation of the AB consisting of: Hazard analysis subject area Facility AB program description FUA subject area HIT, "Hazard Identification Tools" FUA, "Facility Use Agreement" Manual

* D&D and closure sites
TQ = 29 CFR 1910.119 (PSM) ; TQ = 40 CFR 68.130 (Accidental Release) ;
TPQ = 40 CFR 355 (Emergency Planning); RQ = 40 CFR 302.4 (Spill, National Response Center)
PSM = Process Safety Management; RMP = Risk Management Program

Section 2.3 Additional Hazard Evaluation

This section discusses additional hazard evaluations (AHEs) performed for site-specific hazards. Table 11 displays summaries of AHEs from the various sites. Nine contractors from eight DOE sites – SRS, INEEL, Hanford Fluor, LANL, LLNL, Y-12 , ORNL-UT/Battelle, Mound, and Fernald point out AHE as mixing of chemicals or incompatible chemicals that can cause violent reaction. Process knowledge should be used to assess the hazards when mixing chemicals.

SRS in its WSRC-IM-97-9 manual cites a comprehensive listing of numerous incompatible chemicals, mixing of which can lead to heat generation, fire, explosion, violent reaction, and toxic fumes. LLNL requires that an IWS (integrated worksheet) be developed and signed by management and Environment Safety and Health prior to starting new work, to safeguard against any potential additional hazards.

In Pantex, deviations resulting from the inadvertent mixing of chemicals are analyzed in a PHA. A chemical hazard table is formulated during the PHA for each chemical process. The PHA includes a compilation of the chemical properties for evaluation. Hanford ERC calls AHE other hazards such as rotating mechanical equipment or unique hazards that are evaluated during the preparation of an ASA. An additional hazard analysis is recommended for work that involves complex processes or unique hazards. At PNNL, FUAs (facility use agreement) are prepared for all facilities. For an AHE, additional documents may be prepared based on specific hazards associated with the facility (e.g., ASA, PSM).

SNL uses a graded approach for AHE for Moderate vs Low hazard operation. For Low hazard operation, a hazard analysis document is prepared using ISMS software. An HA involves a modified FMEA. For moderate hazard operation, a safety assessment (SA) is prepared which is a more rigorous risk assessment of the identified hazards often using more advanced risk management approaches. Oak Ridge-Bechtel Jacobs evaluates additional hazards by chemical vulnerabilities, which can be as a result of facility or operational transition, physical deficiencies, large/bulk quantities of hazardous materials, and any unique characteristics.

RFETS, in addition to incompatible chemicals, evaluates other hazards through the What If method including the following questions:

- What if raw material is the wrong concentration?
- What if a leak in a system occurs?; What if the instrument air system fails?
- What if a common mode failure occurs, causing multiple spills?

These hazards can be evaluated qualitatively and quantitatively. ANL-E indicates that AHEs are conducted as the need is identified through other review and hazard screening activities.

WVDP through Hazard Identification Analysis (WV-921) identifies hazards and establishes controls. Chemical hazards are identified through process knowledge, periodic walk through surveys, review of documents and reports about chemical inventory, injury/illness, etc. These are reviewed annually or as needed to identify any new or additional hazards and control measures. In BNL, if a facility has a hazard rating of 3, given by the HIT, technical hazard analysis is needed. If the hazard rating is 2 and the facility involves complex processes, rotating mechanical equipment, or unique hazards, then limited technical hazard analysis is recommended.

Most sites emphasize mixing of chemicals or incompatible chemicals as AHE, while other sites focus on other hazards as AHE.

Table 11. Additional Hazards Evaluation

DOE Site	Additional Hazards Evaluation
SRS	Mixing of chemicals or incompatible chemicals can cause violent reaction. Process knowledge should be used in mixing chemicals and assessing hazards. WSRC-IM-97-9 manual cites a comprehensive listing of incompatible chemicals, mixing of which can lead to heat generation, fire, explosion, violent reaction, and toxic fumes.
Pantex	Deviation concerning the inadvertent mixing of chemicals are analyzed in PHA. A chemical hazard table is formulated during the PHA for each chemical process.
INEEL Hanford, Fluor LANL LLNL Y-12 ORNL,UT/Battelle Mound* Fernald*	Mixing of chemicals or incompatible chemicals can cause violent reaction. Process knowledge should be used in mixing chemicals and assessing hazards. For LLNL, IWS are required to be developed and signed by management and ESH prior to starting a new work.
Hanford, ERC	Other hazards such as rotating mechanical equipment or unique hazards are evaluated during the preparation of an ASA. An additional hazard analysis is recommended for work that involves complex processes or unique hazards.
Hanford, PNNL	Additional documents may be prepared based on specific hazards associated with the facility such as ASA, PSM, and FUAs for all operating facilities.
SNL	For Low hazard operation, an HA document is prepared using ISMS software. HA involves modified FMEA. For moderate hazard operation, SA is prepared which is more rigorous risk assessment of the identified hazards often using more advanced risk management approaches.
Oak Ridge, Bechtel Jacobs	Additional hazards are evaluated by chemical vulnerabilities, which can be as a result of facility or operational transition, physical deficiencies, large/bulk quantities of hazardous materials, and any unique characteristics.
RFETS*	In addition to incompatible chemicals, other hazards are evaluated through What-If method. e.g., What if raw material is the wrong concentration?; What if a leak in a system occurs?; What if the instrument air system fails? What if a common mode failure occurs, causing multiple spills?
ANL	AHEs are conducted as the need is identified through other review and hazard screening activities.
WVDP*	Hazard Identification Analysis (WV-921) identifies hazards and establishes controls. Chemical hazards are identified through process knowledge, periodic walk through surveys, review of documents and reports about chemical inventory, injury/illness, etc. These are reviewed annually or as needed to identify any new or additional hazards and control measures.
BNL	If a facility has a hazard rating of 3, given by the HI tool, technical hazard analysis is needed. If hazard rating is 2 and the facility involves complex processes, rotating mechanical equipment, or unique hazards, then limited technical HA is recommended.

* D&D and closure sites

Section 2.4 Common Hazards Screening Criteria

Table 12 summarizes common hazards screening criteria with the emphasis on characteristics properties of hazardous chemicals (NPFA ratings; toxic, corrosive, reactive, ignitable, and incompatible). All DOE sites except Pantex use RQ in accordance with 40 CFR 302, TPQ in accordance with 40 CFR 355, and TQ in accordance with 29 CFR 1910.119 and 40 CFR 68 (individually or in combination) as a screening criteria. The chemicals that are not eliminated through the screening process are evaluated for hazard level and perform qualitatively or quantitatively accident analysis and select safety controls.

There are other OSHA type common hazards such as pressure, temperature, and voltage, which can be eliminated through the screening process. However, they can serve as initiators for accidents involving hazards. Flammable materials, leak of materials, and equipment failure are other examples of common hazards, which can serve as initiators for accidents.

SRS uses RQ, TPQ, and TQ for chemicals, and Class A, B, C in 40 CFR 173 for high and low explosive materials, oxygen <18% for asphyxiants, and >3,000 psig for pressure for further evaluation of hazards. Pantex has no screening criteria, but uses the approach if the process requires a process hazard analyses or it does not. If it does, all hazards of the process are required to be addressed. INEEL uses the following screening criteria:

- RQ, TPQ, and TQ for chemicals
- 29 CFR 1910.109 and DOE M 440.1-1 for explosive materials
- 29 CFR 1910. 144, 1200 and 29 CFR 1926.152 for volatile flammable, or reactive gases or liquids

Hanford ERC use RQ and TQ for chemicals, while PNNL uses only TQ for chemicals screening for further evaluation of hazards. Hanford Fluor, LANL, Y-12 , ORNL-UT/Battelle, WVDP, Mound, and Fernald use RQ, TPQ, and TQ as a screening criteria for chemicals for further evaluation of hazards. LLNL, in addition to RQ, TPQ, and TQ, uses ChemTrack inventory, facility or operational safety plan, and IWS to identify hazards.

Y-12 screens chemical hazards by looking at whether ERPG-2 could be exceeded at 100 meters from a release point assuming all Materials at Risk (MAR) is released. SNL uses TPQ and TQ for chemicals screening. Chemical inventory is maintained within CIS (chemical information system) when answering PHS (preliminary hazard screening) questions that are often TQ- or exposure-based.

Oak Ridge-Bechtel Jacobs, like SRS, uses RQ, TPQ, and TQ for chemicals, oxygen <18% for asphyxiants, and >3,000 psig pressure for further evaluation of hazards. RFETS uses TPQ and TQ for chemicals, however, when more than one chemical is involved, their combined effect is considered by calculating a hazard index per SARAH Chapter 2 and summing.

ANL-E uses only TQ for chemicals for further evaluation of hazards. Work place exposure potential is evaluated against recommended exposure limits by OSHA, American Conference of Governmental Industrial Hygienists (ACGIH), and National Institute for Occupational Safety and Health (NIOSH). BNL uses RQ and TQ for chemicals and a HIT (hazard identification tool) provides further guidance on incompatible chemicals, toxic, sensitizers, etc.

Table 12. Common Hazards Screening Criteria

DOE Site	Hazards	Screening Criteria	Comment
SRS	Chemical hazards (toxic, reactive, compatibility) Explosive Flammable Asphyxiants Pressure Temperature	RQ, TPQ, TQ Class A, B, C in 49 CFR 173 Considered as a initiator for fire Oxygen <18% >3,000 psig Can act as an initiator	WSRC-IM-97-9 manual Flammable materials can act as an initiator for fire that can release toxic or hazardous materials. It is an example of common hazard.
Pantex	N/A	No screening criteria	Process requires a process hazard analyses or it does not. If it does, all hazards of the process are required to be addressed.
INEEL	Chemical hazards (toxic, reactive, corrosive) Explosive Volatile flammable or reactive gases or liquids Fire Voltage (<600 or >600 V)	RQ, TPQ, TQ 29 CFR 1910.109, DOE M 440.1-1 29 CFR 1910.144, 1200, 29 CFR 1926.152 Fire protection program, DOE O 420.1 29 CFR 1910, S, NEC 70	Table in INEEL report lists various occupational hazards analysis checklist.
Hanford, ERC	Chemical hazards	RQ, TQ	If chemical inventory exceeds these thresholds, it will require further hazard analysis.
Hanford, PNNL	Chemical hazards	TQ	Uniform building fire codes and NFPA also apply.
Hanford, Fluor LANL Y-12 ORNL UT/ Battelle WVDP* Mound (MCP)* Fernald (FEMP)*	Chemical hazards (corrosivity, reactivity, ignitability, toxicity) NPFA rating	RQ, TPQ, TQ	Common hazards are considered as initiators for accidents involving hazards. such as flammable material, leak of material, equipment failure are examples of common hazards.
LLNL	Chemical hazards Other hazards	RQ, TPQ, TQ ChemTrack inventory Facility or operational safety plan, integration work sheets (IWS)	ES&H manual 3.1, safety analysis program. ES&H manual 3.2, Safety basis thresholds.
SNL	Chemical hazards	TPQ, TQ	ES&H manual Chemical inventory is maintained within CIS when answering PHS questions that are often TQ or exposure based such as TLV and PEL.
Oak Ridge, Bechtel Jacobs	Chemical hazards (toxic, reactive, compatibility) Flammable Asphyxiants Pressure Temperature	RQ, TPQ, TQ Considered as a initiator for fire Oxygen <18% >3,000 psig Can act as an initiator	Flammable materials can act as an initiator for fire that can release toxic or hazardous materials. It is an example of common hazard.
RFETS*	Chemical hazards (corrosivity, reactivity, ignitability, toxicity)	TPQ, TQ	When more than one chemical is involved, their combined effect is considered by calculating hazard Index (per SARAH Chapter 2) and summing.
ANL	Chemical hazards	TQ	Workplace exposure potential is evaluated against recommended exposure limits by OSHA, ACGIH, and NIOSH.
BNL	Chemical hazards	RQ, TQ	HIT provides guidance on incompatible chemicals, toxic, sensitizers, etc.

* D&D and Closure

Section 2.5 Example of Hazard Evaluation Table

This section lists examples of hazard evaluation tables from 10 contractors from nine DOE sites – SRS, Pantex, INEEL, LANL, SNL, Oak Ridge-Bechtel Jacobs, Y-12 Plant, RFETS, WVDP, and Mound. The examples are shown in Tables 13 to 22. The tables vary in format but addresses the hazard events, consequence, preventative and mitigative features as controls, and in most cases show the reduced risk to a receptor. Tables vary somewhat from site to site, however, the key features such as event description, hazards, root cause, unmitigated and mitigated frequency, consequence, and risk, and controls are summarized.

Controls can be engineering controls (ECs) or AC and they can act as a preventor or mitigator. A preventor control reduces the potential event's frequency (likelihood), and a mitigitor control reduces the potential event's consequence. However, the controls must reduce the risk or consequence of an incident to an acceptable level for workers and public. SRS captures these features in Table 13 with a fire and flammable gas detonation scenarios.

Pantex in Table 14 uses a What If scenario, response (result), root cause, and EC and AC safeguards. Identified controls are linked to the hazard analysis in different categories. For example, release of toxic material on site can be evaluated through different What If accident scenarios (fumes/vapor) and controls (preventive or mitigative), can be hazardous vapor monitoring/warning system, particulate scrubbers, and an exhaust system.

In Table 15 INEEL lists the hazard, hazardous event, cause, and unmitigated (without controls) likelihood (frequency), consequence, and risk binning, and then lists EC design and preventive or mitigative ACs. Table 15 does not list mitigated likelihood, consequence, and risk but these are discussed in an INEEL accident analysis document. Accident scenario discussions are used to explain the effectiveness of controls and the reduction in risk to an acceptable level.

LANL displays two examples of hazard evaluations in Table 16. Some facilities use an example of a potential event using the What If scenario, cause, consequence, hazard, control, and any comment or action taken to reduce the risk for immediate workers. This example does not utilize likelihood (frequency) and quantify consequence and risk. The emphasis is mostly on workers. The second example is recommended by the Office of Safety Basis (OSB), which recommends institutional policy. This example is similar to the SRS example in Table 13. Table 16 lists hazard, accident type, scenario, uncontrolled likelihood and consequence, existing controls, controlled likelihood and consequence, uncontrolled and controlled risk for both workers and the public. Risk levels of 1 and 2 require additional controls. Controlled risk needs to be an acceptable level of 3 and 4.

SNL uses an ISMS software program to display features of hazard analysis. Table 17 shows an example of low hazard operation. It documents the following information:

- Hazard source (caustic/corrosive chemical)
- Conditions (injury/burn/spill/property damage)
- Cause (initiating event), unmitigated consequence
- Controls (personal protective equipment, procedure)
- Adequacy assessment

For moderate hazard operation, safety assessment is more rigorous than for low hazards.

Oak Ridge-Bechtel Jacob's hazard evaluation in Table 18 is similar to hazard evaluation examples in SRS and LANL tables except the format is different. For example, unmitigated frequency, consequence, and risk binning are grouped separately from the mitigated frequency, consequence and risk binning group. Preventive and mitigative features such as EC and AC are clearly identified. Events of large fire and flammable gas detonation scenarios are described in Table 18.

Y-12 hazard evaluation in Table 19 is identical to the one example shown by LANL in Table 16. Table 19 lists an example of a potential event in a What If scenario, cause, consequence, hazard, control, and justification or action, to reduce the risk for immediate workers and public. This example does not utilize likelihood (frequency) and quantify consequence and risk. The emphasis is mostly on workers.

RFETS hazard evaluation in Table 20 contains essentially the same information as provided by SRS, LANL, and Oak Ridge-Bechtel Jacob, except for format. In Table 20, hazard, accident type, and cause or energy source are presented in row format, while the remaining formation is presented in column format. Receptors are public, collocated workers, and immediate workers. Prevention and mitigation controls such as EC and AC are identified. Frequency is compared with and without prevention. Likewise, consequence is compared with and without mitigation. Risk class is also compared with and without control. Any specific mitigation features are also identified.

WVDP displays its example of hazard evaluation in Table 21. Table lists the name, location, volume, and construction of the facility being analyzed in a row format. The column lists the hazard, event, initiator, preventative features, mitigative features, consequence, frequency, and risk factor. The table shows only unmitigated consequence, frequency, and risk, and not mitigated. Examples of a major and minor spills are cited in Table 21.

Mound's example of hazard evaluation in Table 22 lists in column format - activities, hazards, scenario, receptors (immediate, co-located, public), unmitigated frequency and consequence, safety controls (EC and AC), and any physical limitation and they are identified as a preventor or mitigator, and mitigated frequency and consequence. The table does not list any risk ranking - unmitigated or mitigated. A large fire involving multiple containers is cited in Table 22.

A hazard evaluation table lists key features such as event description, hazards, root cause, unmitigated and mitigated frequency, consequence, and risk, and controls (EC and AC), although format varies from site to site. Some information such as comparison of unmitigated and mitigated features is not provided in some tables.

Tables 13-22. Examples of Completed Hazard Evaluation Tables

Table 13. SRS Completed Hazard Evaluation Table

Event No.	Event Cat.	Event Description	Causes	Preventive Features	Freq. Level		Meth. of Detection	Mitigative Features	Consequence Level		Risk Rank	
					Init.	Prev.			Unmitigated	Mitigated	Unmit.	Mit.
BC-1	E-1	Injuries due to localized fire. Location: Backpulse Chamber Areas Hazard Source: Combustion products; toxic smoke or gases	Electrical short; Thermal energy from electrical equipment; Friction from belts, bearings, etc.; Human error; unknown ignition source	Design: Electrical equipment design code; NFPA standards. Administrative: Combustible material control; Trained personnel; SOPs	A	TBD		Design: Fire detection and suppression system; Building design; Building ventilation system. Administrative: Fire Department response, Emergency Operating Procedures, trained personnel.	Onsite 1: Negligible Onsite 2: Negligible Offsite: Negligible [Potential for Moderate worker consequences due to physical nature of event]	Standard Industrial Hazard. NFPA Standards provide protection against this event.	11 11 11	NA
BC-2	E-2	Flammable gas detonation Location: Backpulse Chamber Areas Hazard Source: Filtrate solution (100 gal)	Oxygen diffuses into vapor space and mixes with flammable gas (e.g., benzene) to form an explosive mixture in the presence of an ignition source.	Design: Backpulse chamber design; nitrogen supply (positive pressure on backpulse chamber); backup nitrogen system Administrative: Limited ignition sources in room	U IC3 IC4	U		Design: Building design; fire detection and suppression system; Building ventilation system. Administrative: **<u>Personnel Access Restrictions</u>**; Emergency Operating Procedures; Trained personnel.	Onsite 1: Low Onsite 2: Negligible Offsite: Negligible [Potential for High worker consequences due to physical nature of event]	Onsite 1: Low Onsite 2: Negligible Offsite: Negligible [Access Restrictions will protect worker from serious injury]	6 11 11	6 11 11

This table was taken from Hazard Analysis Methodology Manual, Revision 1, WSRC-IM-97-9.

E1	Fire – consequences typically due to inhalation/ingestion of released hazardous material.
E2	Explosion – consequences typically due to inhalation/ingestion of released hazardous material.
IC3	Initial condition #3
A	Anticipated, expected
U	Unlikely
Risk	6>11

Table 14. Pantex Completed Hazard Evaluation Table

Below is an example of one type of hazard analysis performed for chemical operations.

Item No.	What-If?	Response	Root Cause	Safeguards	Action Items
1	Personnel are exposed to the chemicals of the process?	Minor injury to Death	Incorrect Procedure, Procedure Violation, Equipment Failure, *Etc.*	Vapor Monitor-EC, HVAC/ Ventilation System-EC, Approved Procedures-AC, Equipment Design-EC, Procedural Approval Process-AC, Management of Change Program-AC, *Etc*.	
45	*Reactor Vessel Section:* The vessel is over pressurized?	See item no. 1, this section	Incorrect Procedure, Procedure Violation, Equipment Failure, Incorrect Valve Lineup, *Etc.*	Vessel Rupture Disks-EC, Vessel Pressure Testing-AC, Pre-op Inspection-AC, Vessel Surge Tank-EC, *Etc.*	
101	*Solvent Transfer Section:* The transfer line leaks?	See item no. 1, this section	Incorrect Connection, Equipment Failure, *Etc.*	Training/Qualification-AC, Approved Procedures-AC, *Etc.*	

Example List of Identified Controls (linked to the Hazards Analysis)

Category	PHA Reference	Identified Accident	Mitigative or Preventive Control
1. Bodily Injury	WHAT IF # 1, 3, 9, 10 REDBOOK - Unit Siting & Layout # 4; Instrumentation #1, 6 WHAT IF # 2, 4, 7, 8, 11 WHAT IF # 12, 13, 14, 15 WHAT IF # 37, 79, 92, 124 REDBOOK - Pressure & Vacuum Relief #1; Vessels #10	Explosion Fire Hazardous Concentrations of Chemical Fumes/vapors Vessel Overpressure	Blast Door Interlocks Communications Emergency Reactor Cooling Explosives Heating Controller Facility Structure Fire Detection & Alarm System Fire Suppression System Hazardous Vapor Monitor/Warning System Lightning Protection Process Vessel Overpressure Protection Reactor Process Alarms Task Exhaust
2. Toxic Material On-Site	WHAT IF # 12, 13, 14, 15 REDBOOK - Materials and Flow sheet # 60; Environmental Protection #3; Unit Siting & Layout #4; Vessels #19; Instrumentation #1; Environmental Protection #41	Hazardous Concentrations of Chemical Fumes/Vapors	Hazardous Vapor Monitor/Warning system Particulate Scrubbers Task Exhausts
4. Loss of Equipment or Facilities	WHAT IF # 1, 3, 9, 10 REDBOOK - Unit Siting & Layout #1; Instrumentation #1, 6 WHAT IF # 2, 4, 7, 8 , 11 WHAT IF # 37, 79, 92, 124 REDBOOK - Pressure & Vacuum Relief #1; Vessels #10	Explosion Fire Vessel Overpressure	Blast Door Interlocks Emergency Reactor Cooling Explosives Heating Controller Facility Structure Fire Detection and Alarm System Fire Suppression System Lightning Protection Process Vessel Overpressure Protection Reactor Process Alarms
5. Loss of Production	WHAT IF # 1, 3, 9, 10 REDBOOK - Unit Siting & Layout #1; Instrumentation #1 WHAT IF # 37, 79, 92, 124 REDBOOK - Pressure & Vacuum Relief #1; Vessels #10	Explosion Vessel Overpressure	Blast Door Interlocks Emergency Reactor Cooling Explosives Heating Controller Facility Structure Fire Detection and Alarm System Fire Suppression System Lightning Protection Process Vessel Overpressure Protection Reactor Process Alarms

Table 15. INEEL Hazard Evaluation Table Results Section

Hazard	Hazardous Event	Cause	Likelihood, Consequence, and Risk without controls				Preventive and Mitigative Features*	
			Likelihood Rank[a]	Consequence Rank[b]		Risk Bin Number[c]	Design[d]	Administrative[e]
1. Hazardous materials	Bulk chemical tank spill inside a building	Overfilling tank	Anticipated	Public: Co-located Worker: Facility Worker: Environment:	N N ***H*** N	7 7 ***16*** 7	***Catch pan for spills***	***Monitoring of tank during filling***

a. The likelihood categories are listed and described in Figures 2-1, 2-2, 2-3.

b. N = Negligible, L = Low, M = Moderate, H = High

c. Risk bin numbers are highlighted in ***bold italics*** if they indicate that safety SSCs, OSRs, and/or safety requirements should be identified to manage risk (see Figures 2-1, 2-2, 2-3).

d. Structures, systems, and components (SSCs) designated as safety-class or safety-significant SSCs are highlighted in ***bold italics***. See Chapter 3, "Hazard Controls," for additional information on these safety SSCs.

e. Operational safety requirement (OSR) and safety requirement level controls are highlighted in ***bold italics***. See Chapter 3., "Hazard Controls," for additional information on OSRs and safety requirements.

f. Natural phenomena risk. (The risk of natural phenomena hazards are discussed in Section 2.5.1.3.)

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* The table does not list mitigated likelihood, consequence, and risk but these are discussed in an INEEL accident analysis document. Accident scenario discussions are used to explain the effectiveness of controls and the reduction in risk to an acceptable level.

Table 16. LANL Example of Completed Hazard Evaluation Table

Some facilities use the following table as an example of a potential event ("What If scenario"), cause, consequence, hazard, control and any comment or action taken to reduce the risk for immediate workers. This example does not utilize likelihood (frequency) and quantify consequence and risk. Implementation of controls can minimizes or prevents any potential accident from happening.

Hazard Evaluation Table (Worker)

Item	Event (What If..)	Cause	Consequence	Hazard	Control	Comment or Action
1	Chemical Reaction	Pyrophoric (strong oxidizer)	Explosion	Chemical (reagent)	Inert atmosphere	Provide shield or hood
2	Acid Spill	Glass bottle crack	Floor damage	Chemical (acid)	Double container	Store in acid cabinet
3						

The OSB recommends the following format for HA.

Completed HA Results**

(linked to process flowchart, scenarios listed are for example purposes)

#	Hazard	Accident type	Scenario	Uncontrolled		Controls		Controlled		Qualitative Risk		Notes
				Likelihood Bin	Consequence Bin	Existing	Recommended	Likelihood Bin	Consequenc e Bin	Uncontrolled	Controlled	
1	Chemical (reagent)	Chemical reaction	Ammonium nitrate mixed with organic matter forms explosive mixture by heat. Worker injury	II	W = A P = D	1. Inert atmosphere 2. No heat source 3. Hood or shield 4. PPE 5. Work instructions		III	W = C P = E	W = 1 P = 3	W = 3 P = 4	
2	Chemical (acid)	Acid spill	Nitric acid spills when glass bottle cracks by human error. Worker injury and floor damaged.	I	W = B P = E	1. Double container 2. PPE 3. Store in acid cabinet 4. Work instructions	Perform operation in hood	III	W = D P = E	W = 1 P = 4	W = 4 P = 4	
3	Be (powder)	Be release	Used wrong gas (H_2 vs O_2), mixture exploded and caught fire. Be release inhaled & worker injury	I	W = B P = D	1. Check gas cylinder & valve 2. Two persons verify gas 3. PPE 4. Work instructions	Limit # of gas cylinder	III	W = C P = E	W = 1 P = 3	W = 3 P = 4	

** Modified from a format taken from Hazard Analysis Technical Handbook, FWO-OAB-501. W = Worker; P = Public
Risk to immediate workers will be of great concern in most scenarios. Risk = 1> 2 > 3 > 4. Risks 3 and 4 are acceptable.
Control are preventors (P), when there is a change in frequency (likelihood); Mitigators (M) are when there is a change in consequence.

Table 17. SNL Completed Hazard Evaluation Table

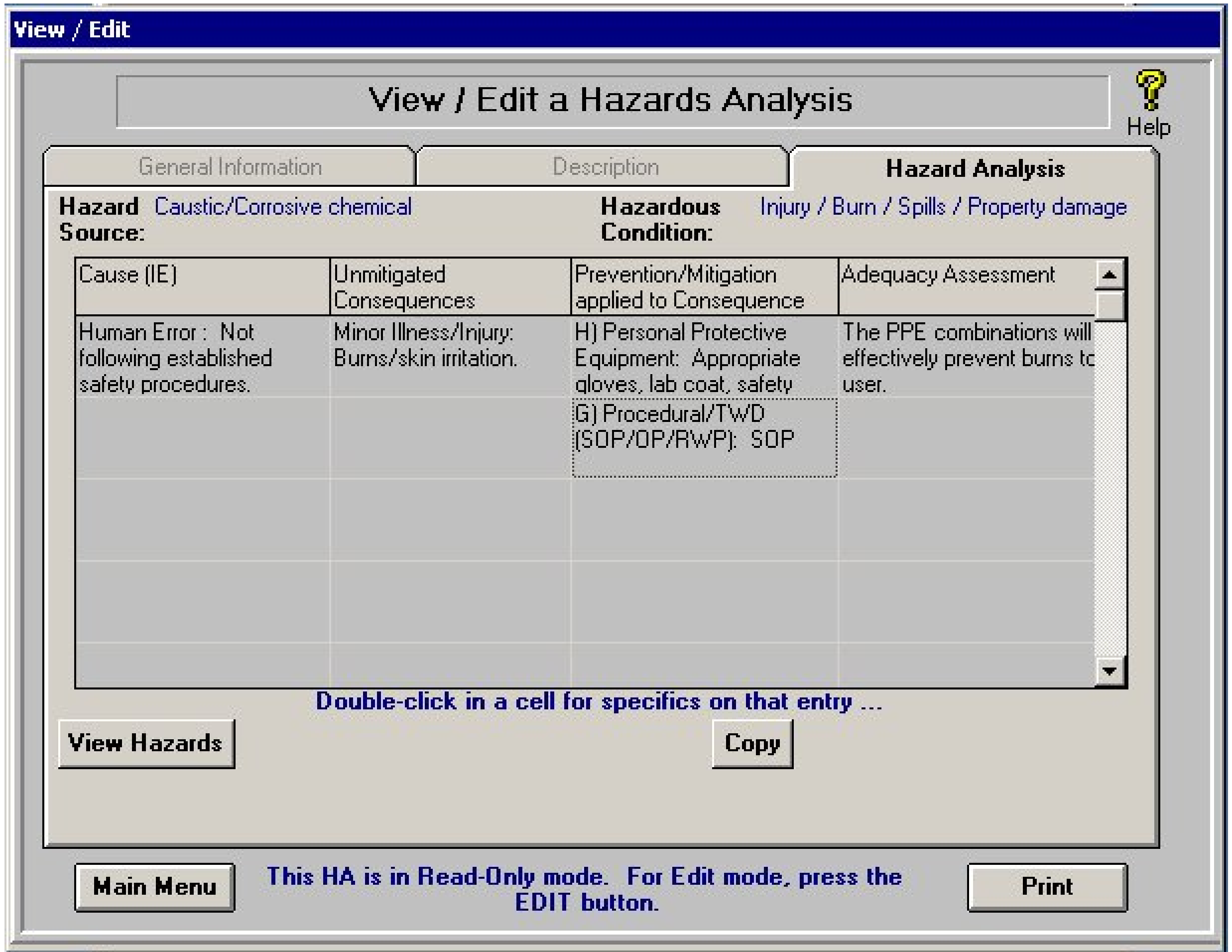

Table 18. Oak Ridge, Bechtel Jacob Completed Hazard Evaluation Table

Event No.	Event Cat.	Event Description	Causes	Unmitigated			Method of Detection	Preventive Features	Mitigative Features	Mitigated		
				Freq. Level	**Consequence Level**	**Risk Rank**				**Freq. Level**	**Consequence Level**	**Risk Rank**
BC-3	E-1	Large fire Location: Backpulse Chamber Areas Release Mechanism: Thermal (fire) Hazard Source: Combustion products; toxic smoke or gases	Combustible/ flammable material: • Miscellaneous combustibles • Hydrogen from Uninterrupted Power Source battery AND Ignition sources • Electrical short • Thermal energy from electrical equipment, friction from belts, bearings.	A 1,2	Chemical FW: High Co-located: Mod. Offsite: Low Physical High facility worker consequences due to physical nature of event Other Impacts: Combustion products may plug High Efficiency Particulate Air filter causing loss of filtration	C A C B P A		Design: Electrical equipment design code; NFPA standards. Administrative: Combustible material control; Trained personnel; Standard Operating Procedures	Design: **Fire detection and suppression system**; Building design; Building ventilation system. Administrative: Fire Department response, Emergency Operating Procedures, **Trained personnel**.	A	Chemical FW: Mod. Co-located: Low Offsite: Neg. Physical Low. Workers are trained to recognize obvious hazards and evacuate	C C D D P D
BC-4	E-2	Flammable gas detonation Location: Backpulse Chamber Areas Release Mechanism: Explosion Hazard Source: Filtrate solution (100 gal)	Explosive material: • Oxygen diffuses into vapor space and mixes with flammable gas (e.g., benzene) AND Ignition sources • Electrical short • Thermal energy from electrical equipment, friction from belts, bearings, etc.	U 1 IC3 IC4	Radiological FW: Low Co-located: Neg. Offsite: Neg. Chemical FW: Moderate Co-Located: Neg. Offsite: Neg. Physical High Worker consequences due to physical nature of event	R D D D C C D D P A		Design: **Backpulse chamber design; nitrogen supply (positive pressure on backpulse chamber)**; backup nitrogen system Administrative: Limited ignition sources in room	Design: Building design; fire detection and suppression system; Building ventilation system. Administrative: **Personnel Access Restrictions**; Emergency Operating Procedures; Trained personnel.	EU	Radiological FW: Low Co-located: Neg. Offsite: Neg. Chemical FW: Moderate Co-located: Neg. Offsite: Neg. Physical Negligible. Access Restrictions will protect worker from serious injury	R D D D C D D D P D

1. Engineering judgment; 2. Equipment failure rate database (Ref. XX); 3. ICs are identified in the document text

Table 19. Y-12 - Example of Hazard Analysis Evaluation Table

Hazard Evaluation Table (Worker)

Item	Event (What If..)	Cause	Consequence	Hazard	Control	

Table 20. RFETS Hazard Analysis Evaluation Table

Hazard	Chemical Hazard: Inside HNO_3 tanks
Accident Type	Catastrophic rupture of two (2) 2,200 gallon capacity, 12N HNO_3 recovery tanks.
Cause or Energy Source	Maintenance error, piping failure, falling objects

Receptor	**Prevention** (Features that Lower Scenario Frequency)	**Mitigation** (Features that Lower Scenario Consequences)	**Scenario Frequency**		**Consequences**		**Risk Class**		**Specific Credited Features**
			Without Prevention	**With Prevention**	**Without Mitigation**	**With Mitigation**	**Without Prevention or Mitigation**	**With Prevention & Mitigation**	
Public	**Engineered Features** Tank and ancillary piping **Admin Controls** Tank inspection	**Admin Controls** Emergency response Personnel protection	Unlikely	Unlikely	Low (<ERPG-2)	Low (<ERPG-2)	III	III	None
Collocated Workers	Same as Public	Same as Public **Engineered Features** Secondary/tertiary confinement	Unlikely	Unlikely	Low (<ERPG-3)	Low (<ERPG-3)	III	III	None
Immediate Workers	Same as Public	Same as Collocated Workers	Unlikely	Unlikely	High	Low (1)	I	III	Emergency response – Personnel protection

(1) High consequences to attending workers cannot be precluded.

Table 21. WVDP Hazard Evaluation Table

Hazard (1)	Event	Initiator	Preventative Features	Mitigative Features	Conseq (2)	Freq (3)	Risk Factor (4)
	Tanker Truck Volume: 19,000 gallons Name: Caustic Addition System Location: Tank Farm Yard Construction: N/A						
NaOH	1) Major Spill 2) Minor Spill	- Tornado - Seismic event - corrosion - operator error (misalignment of transfer lines - mechanical error / malfunction - fire/explosion - vehicle crash into truck	- ACs and procedures for tanker truck operations - Time that NaOH is within tanker will be limited - Established procedures and training for personnel	- Portable berm - Inflatable berm - Hazmat response - West Valley Volunteer Hose Company	1) Neg 2) Neg	1)A 2) U	1) 0 2) 0

Table 22. Mound Hazard Evaluation Table

Example Facility Chemical Hazards and Accident Analysis Matrix

Activities	Hazards	Scenario	Receptors	Unmit.[1]		Safety-Related Features and Controls[2]			Mit.[1]	
				F	C	Engineered	Physical Limitation	Administrative	F	C
1.1 Storage	Fire	Large fire involving multiple containers	Immediate Co-located Public	U	M M M	Fire detection, suppression, and alarm system (M)	**Hazardous wastes limited to RCRA Permit (M)**	**Fire protection inspections (P)** **Emergency response procedures for evacuation (M)**	U	N N L

[1] Unmitigated frequency is the frequency of the initiating event; unmitigated consequences are the maximum theoretical. Mitigated frequency is the frequency of the consequences as modified by the prevention controls; mitigated consequences are the expected consequences assuming the functioning of listed controls.
F=Frequency, A=Anticipated, U=Unlikely, EU=Extremely Unlikely, BEU=Beyond Extremely Unlikely
C=Consequences, H=High, M=Moderate, L=Low, N=Negligible, N/A=Not Applicable
[2] Safety-related features and controls become OCs if required to reduce frequency and/or mitigate consequences based on results of accident analysis. Controls are identified in BOLD.
D=Detection, P=Prevention, M=Mitigation

Section 2.6 Consequence/Source Term Determination Method

This section discusses the dispersion models used by the sites to establish source terms and the consequence of a release to the atmosphere. When the qualitative HA indicates that threshold criteria may be exceeded, quantitative source terms are needed to calculate receptor doses for workers and the public. Table 23 summarizes consequence/source term determination methods being used by the DOE contractors at the 12 reporting sites for this subject. In some cases, chemical consequence is calculated to evaluate the facility CHC shown in Table 4. Similar to radiological dose, chemical dose is calculated as follows.

Concentration (mg/m^3) = [X/Q x MAR x ARF x RF x DR x LPF]1/T …………………(1)

where:

X/Q (sec/m^3)	Atmospheric dispersion coefficient for assumed weather conditions, median and 95% meteorology and exposure associated with the postulated release.
MAR (mg)	Material at risk available for release.
ARF	Airborne release fraction suspended in air as an aerosol and available for transport.
RF	Respirable fraction of airborne of 10 µm or less particles (RF= 1).
DR	Damage ratio of the total MAR that could be impacted by the accident. For conservative assumption, DR is 1.
LPF	Building leakpath factor, For breach confinement, LPF is 1.
T (sec)	Release duration.

ARF and RF values can be taken from DOE-HDBK-3010-94 and DOE-STD-1027-92. Release duration is typically 10 or 15 minutes, although a short duration is possible for puff release or small MAR release (small gas cylinder). X/Q value is a very important meteorological parameter that can vary significantly (1 to 3 orders of magnitude) depending on the weather conditions (stability class A to F). Thus, its accurate determination is crucial and the X/Q value is normally obtained through cumbersome computer code such as MACCS2 (MELCOR Accident Consequence Code System) by providing historical meteorological onsite data or simple hand calculations. RSAC (Radiological Safety Analysis Computer) is another code that also provides X/Q value using the historical meteorological onsite data. Many sites use a F stability class and 1 m/s wind speed for initial consequence calculations as being conservative with weather conditions. These codes use a centerline Gaussian dispersion plume model. Once an X/Q value is obtained, then using other parameters listed in Equation (1), chemical dose or concentration (mg/m^3 or ppm) at a receptor (worker or public) can be calculated. The X/Q value is usually not reliable below 100 meters, mainly because of the theoretical model and great uncertainty in the modeling: Therefore, a dose value for immediate distance workers (~30 meters) is viewed as an qualitative estimate.

There are other well developed chemical dispersion computer codes such as ALOHA (Areal Locations of Hazardous Atmospheres) and EPICode (Emergency Prediction Information Code) that can calculate X/Q values with the weather conditions input provided, such as stability class (A-F), temperature, wind direction, and distance from release. These codes also use a centerline Gaussian dispersion plume model and are user friendly.

With the other information provided as input (e.g., MAR, temporary, time), codes calculate concentration (mg/m^3 or ppm) at a given distance (immediate worker, co-located worker, public). These values are then usually compared with the ERPG-1, -2, and -3 values, which are based on up to 1-hour exposure . However, a sampling (exposure) time of 15 min time-weighted average (TWA) is recommended to compare with the guideline, which is conservative estimate for dose assessment to a receptor (Craig et al, WSRC-MS-92-206, 2000). If ERPG-1, -2 ,and - 3 values are not available for a chemical, TEEL-1, -2, and -3 values can be used. The X/Q method, ALOHA, and EPICode are approved models by DOE-HQ (Chung and O'Kula, June 2002). Different approaches used are as follows.

SRS uses both X/Q method and ALOHA computer code, although there is no standard methodology site wide. ARF and RF are taken from DOE-HDBK-3010-94 and DOE-STD-1027. In the X/Q method, the chemical concentration (mg/m^3) is given as follows.

C = X/Q x RR ………………………………………………………………….. …(2)

where:

RR Release rate as mg/s

RR = ST/RT

where:

ST Source term

RT Release time, RT varies from 3 to 15 minutes.

Pantex performs quantitative hazard analysis when a chemical exceeds TPQ or TQ. The hazard analysis involves accident scenario and consequence analysis using airborne dispersion modeling, but the dispersion modeling approach is not specified.

INEEL also uses both X/Q method and ALOHA, code, but the X/Q value is taken from RSAC code. RF and ARF are taken from DOE-HDBK-3010-94. Release time is typically 15 minutes. Consequence may be determined qualitatively for low hazard and quantitatively for moderate and high hazards accident scenarios.

LANL uses X/Q method, ALOHA, and EPICode for chemical dispersion modeling, although there is no standard methodology sitewide. X/Q value is calculated from MACCS2 code. Different analysts use different models. The ARF and RF are taken from DOE-HDBK-3010-94. Release time is typically 10 to 15 minutes and 1 minute for puff release.

LLNL and Hanford, Fluor use two common models: ALOHA and EPICode for gas and chemical releases. Release time is typically 15 minutes and 1 minute for puff release. Oak Ridge, Bechtel Jacobs uses X/Q method and ALOHA code to calculate chemical doses. Based on consequence-high, moderate and low, offsite and onsite, hazard analysis is performed. EPICode was developed at LLNL.

Y-12 uses three computer codes:

- HG SYSTEM
- HG SYSTEM/UF6-WAKE
- SCREEN3

HG SYSTEM can model heavy gases such as anhydrous hydrogen fluoride. WAKE is a preferred code and is normally used because it allows modeling of wake effect, elevated releases/receptors, and terrain effects. SCREEN3 cannot model heavy gases. These codes yield comparable results when conditions modeled are consistent.

RFETS uses ALOHA and ARCHIE (Automated Resource for Chemical Hazard Incident Evaluation) models. ARCHIE was developed by the United States Environmental Protection Agency (EPA)in 1987 and is capable of modeling fires and explosion, although the material involved in the fire or explosion must be combustible or flammable. Whereas, ALOHA is suitable for gases that disperse directly and liquids that must evaporate before dispersion.

WVDP and Fernald both use EPICode for chemical releases. EPICode can model chemical releases as one of five different types of releases and allows the user to choose the meteorological and environmental conditions. Typically hazardous materials can be in the form of solids including powders, liquids including dissolved solids or gases, and gases including vapors and aerosols.

Mound uses X/Q method. However, the X/Q value is not taken from MACCS2 code, but is calculated from approaches outlined in MD-10414 manual (Safety Basis Methodology). The ARF and RF are taken from DOE-HDBK-3010-94. Typically hazardous materials can be in the form of solids including powders, liquids including dissolved solids or gases, and gases including vapors and aerosols.

Chemical dispersion models X/Q method, ALOHA, and EPICode are commonly used for dose calculations and appear reliable, although other models are also used for specific purpose.

Table 23. Consequence/Source Term Determination Method

DOE Site	Dispersion Model	Approach	Comment
SRS	X/Q method ALOHA	Chemical Concentration (mg/m^3) = X/Q x RR (release rate as mg/s) RR = ST/RT ST = source term RT = release time	No standard methodology site wide. ARF & RF are taken from DOE-HDBK-3010-94 and DOE-STD-1027. RT varies from 3 to 15 minutes
Pantex	ALOHA EPICode	Quantitative HA is performed when a chemical exceeds TPQ or TQ	HA involves accident scenario and consequence analysis using airborne dispersion modeling.
INEEL	X/Q method (RSAC code) ALOHA	X/Q is taken from RSAC code. RF and ARF are taken from DOE-HDBK-3010-94. Release time is typically 15 minutes.	Consequence may be determined qualitatively for low hazard and quantitatively for moderate and high hazards.
LANL	X/Q method (MACCS2) ALOHA EPICode	X/Q is taken from MACCS2 code. RF and ARF are taken from DOE-HDBK-3010-94.	No std methodology site wide. Release time is typically 15 minutes and 1 minute for puff release.
LLNL Hanford, Fluor	ALOHA EPICode	Release time is typically 15 minutes and 1 minute for puff release.	EPICode is developed at LLNL.
Oak Ridge, Bechtel Jacobs	X/Q method ALOHA	Based on consequence-high, moderate and low, offsite and onsite, hazard analysis is performed.	Analyst is responsible for demonstrating adequacy of the code.
Y-12	HG SYSTEM HG SYSTEM/UF6-WAKE SCREEN3	WAKE is a preferred code because it allows modeling of wake effect, elevated releases/receptors, and terrain effects.	SCREEN3 can not model heavy gases.
RFETS*	ALOHA ARCHIE (EPA) X/Q method	ALOHA is suitable for gases that disperse directly and liquids that must evaporate before dispersion.	ARCHIE is capable of modeling fires and explosion, although the material involved in the fire or explosion must be combustible or flammable.
WVDP*	EPICode	It can model chemical releases as one of five different types of releases and allows the user to choose the meteorological and environmental conditions.	EPICode is used for toxic chemicals.
Mound (MCP)	X/Q method	X/Q is calculated from approaches outlined in MD-10414 manual. RF and ARF are taken from DOE-HDBK-3010-94.	MD-10414-Safety Basis Methodology. FEMA- Handbook of Chemical hazard Analysis Procedures
Fernald (FEMP)	EPICode	Typically hazardous materials can be in the form of solids (including powders), liquids (including dissolved solids or gases), and gases (including vapors and aerosols).	PL-2352, FEMP Hazard Survey and Hazard Assessment

*D&D and closure sites

Section 3.0 Safety Document

This section addresses the last key item in chemical safety management, the safety document that contains the results of screening, hazard categorization, potential consequence and risk assessments, and establishment of appropriate safety controls. The safety document is a vehicle to obtain contractor and DOE management approval for safe and environmentally protective operation of DOE facilities. The safety documents are presented in the following sections:

Section 3.1 Format and Contents of Safety Document
Section 3.2 USQ-Like Process for Non-Nuclear Facilities

The summary of format and content of safety documents for the sites is combined in Table 24 with the summary USQ – like process for non-nuclear facilities. For facilities that have both nuclear and non-nuclear hazards, the nuclear hazard category has precedence (HC-1, 2, or 3) over the non-nuclear hazard category, and non-nuclear hazards are analyzed as part of the nuclear facility safety basis (SB) documents such as SAR, Basis for Interim Operations (BIO), and document safety analysis (DSA) using DOE-STD-3009-94 and the 10 CFR 830 rule. For pure non-nuclear facilities, the 10 CFR 830 rule does not apply and approaches are different for non-nuclear hazard category, safety documents, and the USQ-like process.

Each site has developed safety documents (SAR/DSA, ASA, FUA, and Hazard Control Plan) suitable to its needs. For example, SRS, Hanford Fluor, Pantex, RFETS, WVDP, and BNL have no standard format, but content requirements are defined. INEEL, Hanford ERC, SNL, Oak Ridge-Bechtel Jacobs, Y-12 , Mound, and Fernald have a well defined format and contents. The details of format and contents differ from site to site, however, the following key features are discussed in safety documents such as SAR/DSA and ASA:

- Facility description
- Process operation
- Hazard analysis and accident analysis
- Safety control (EC and AC) implementation

LANL, LLNL, INEEL, Hanford Fluor, SNL, and Y-12 use a graded approach in the DSA, and some sites such as SRS and RFETS use an ASA (auditable safety analysis) regardless of the hazard category. Some sites require DOE approval of the SAR or DSA/ASA and some sites do not require DOE approval. The same situation applies to the USQD-like process.

Over all, there are wide variations in the SAR or DSA/ASA format and content with regard to CHC (High/Moderate/Low), USQ-like process and their criteria, and approval requirements by DOE/NNSA.

Table 24 summarizes the CHC, safety documents (DSA/ASA), DOE approval for safety documents, and USQ-like process for the various sites. The lowest category of industrial from Table 4 is not included here because no DSA/ASA is required by most sites. Only the Hazard Control Plan is used for industrial facilities and no DOE approval is needed. A summary from each site follows.

SRS uses ASA for both **High/Low** CHC. There is no standard format for the ASA, but the contents are defined. The ASA is written in accordance with guidance in DOE- STD-EM- -5502-94. The ASA does not require DOE approval. The facility manager and level 1 manger are responsible for the ASA. A USQ-like procedure is through "Management of Safety Basis (MSB) Change Process" and does not require DOE approval.

Pantex uses DSA with a graded approach for **High/Moderate/Low** CHC. There is no standard format, but the contents are defined. Safety controls are identified from the PHA for each CHC, to minimize established risk thresholds. The site has a formal Management of Change program, per 29 CFR 1910.119, which is similar to the USQ-like process. DOE approval is not required for DSA for any CHC or USQ-like process.

INEEL uses a safety analysis document (SAD) for **High/Moderate** CHC and ASA for **Low** CHC. The SAD/ASA has a three-chapters format that include facility description, qualitative hazard and accident analysis, and safety – Structure Safety and Component or operational safety requirements (OSR) as safety controls. Format and contents are defined. SAD requires approval from DOE-ID for High/Moderate CHC, but not for ASA for Low hazard category. The ASA is written in accordance with guidance in DOE-EM-STD-5502-94. A USQ-like process is similar to nuclear USQ process and requires approval from DOE for High/Moderate CHC. A USQ-like process is not required for Low CHC ASA.

Hanford-ERC has only **Non-nuclear** CHC and the ASA is used for this purpose. If a facility involves complex processes or unique hazards, additional hazard analysis is recommended. The format and contents of the ASA involving facility description, operations, HA, and controls are defined. USQ-like process is through Management of Change. DOE approval is not required for ASA or USQ process.

Hanford-Fluor has **Moderate/Low** CHC and uses a graded approach for DSA. There is no standard format, but contents are defined to include facility description, hazards identification, hazards screening, hazards analysis, consequences, and controls to reduce the risk to the workers and the public. DOE approval is required for a DSA for Moderate hazard facility, but not for Low hazard facility. The USQ-like process presumably follows the same protocol.

PNNL has one CHC "**Chemical**," and the safety document is a FUA and is based on four elements of PSM. These four elements are:

- Management leadership (commitment, accountability, etc)
- Safety technology (design, process hazards, PHA, etc)
- Facilities (siting, codes and standard, inspection, etc)
- Personnel (job skills, Safe Work Practices, training, etc)

A USQ-like process is through change control and is implemented via "Chemical hazard facility maintaining safety analyses" that can modify the FUA. The FUA does not require DOE approval, but the USQ-like process requires DOE approval.

LANL uses a graded approach for DSA for **High/Moderate/Low C**HC. For the High category, the safety basis consists of extensive FSA (facility safety analysis) and OSRs . The FSA includes the hazard analysis and AA and identification of important safety controls.

The Moderate CHC does not require AA. The Low CHC consists of Facility Safety Plan (FSP) and Facility Tenant Agreements (FTA) and is germane to workers in the local area. A USQ-like process is performed through the SB change control program. DOE approval is required for the High/Moderate DSA and their USQ-like processes, and not for the Low CHC. Management performs a Safety (SB) review every 2 years for any SB change control program.

LLNL also uses a graded approach for DSA for the **High/Moderate/Low** CHC. For the High and Moderate categories, a complete SAR is required. Format and contents are defined. For the Low category, only Hazard Analysis Report is required. DOE approval is required for the SAR, but not for the Hazard Analysis Report. A USQ-like process is performed through IWS. For positive USQ, DOE approval is required for the High/Moderate CHC, but not for the Low category. Management performs a SB review every 5 years to update any change management process.

SNL has the Moderate/Low CHC. For the Moderate category, SB document consists of a safety assessment (SA), Primary Hazard Screening (PHS), and hazard analysis. Format and contents for the SA, PHS, and hazard analysis are defined. For the Low category, only the hazard analysis is required. DOE approval is required for the Moderate category, but not for the Low CHC. A USQ-like process outside the SB document or start/restart operation requires DOE approval for a Moderate CHC.

Oak Ridge-Bechtel Jacobs lists **High/Moderate/Low** CHCs and safety documents are prepared with a graded approach. For Moderate and Low CHCs, an ASA is written that also includes a PHS Primary Hazard Screening. Format and contents are defined. DOE approval is not required for DSA/ASA. A USQ-like process, similar to nuclear USQ, outside the approved SB is through unreviewed changes determination for management approval prior to implementation. DOE approval is not required for USQ-like process unless specifically requested.

Y-12 prepares SB documents using a graded approach for **PSM/RMP and Chemically Hazardous** categories. A Hazard Evaluation Report (HER) is written for both hazard categories unless preparation of a SAR is specified by management. Format and contents of the HER are defined, and the HER (or SAR) reflects the results of the Hazards Evaluation Study and accident analysis. A USQD-like process outside the approved HER is implemented through a Change Evaluation Worksheet (CEW) process; the equivalent of a USQ is called a Major Change. DOE approval of SB documents and Major Changes is required for all hazard categories .

RFETS uses ASA for **High/Low** CHCs. There is no standard format for ASA, but the contents are defined to include facility hazards, process hazards, hazard analysis, and HCP. A USQ-like process outside the approved ASA is through change control and JHA. The facility manager and level 1 manager are responsible for the ASA or Facility Safety Analysis. DOE approval is required for initial facility CHC, but no approval is needed for subsequent re-categorization or USQ-like process.

WVDP uses SB documents with a graded approach for High/Moderate/Low CHCs. For the High category, a complete SAR is written per DOE Order 5481.1B, where as a HASP is written in according with guidance in DOE-EM-STD-5502-94. There is no standard format, but contents are defined. A USQ-like process is similar to nuclear process, and implemented through the "Unreviewed Safety Question Process" form. There is DOE approval required for safety documents for High/Moderate/Low categories and also for the USQ-like process.

Mound and Fernald have only **one category** for non-nuclear hazardous material with chemical inventory threshold <29 CFR 1910 to >40 CFR 302. Both sites use safety document as an ASA for this category. Format and contents are defined. A USQ-like process outside the approved ASA scope is performed through change control process. DOE approval is not required for the ASA and USQ-like process. The Safety Analysis Program Manager reviews ASA and USQ-like documents annually.

BNL has no chemical hazard facility, thus **no category**. If a chemical hazard were present, the facility will be assigned a HR (hazard rating) by the HIT (hazard identification tool). If the HR is 3, it requires a "Technical Hazard Analysis". If the HR is 2 or below the FUA, and the use of appropriate institutional safety programs (ISP) serves as the facility AB and provides the authorization to proceed with the work. There is no standard format but contents are defined. A USQ-like process for change control is utilized and documented through the work planning and control management system. DOE approval is not required for safety document or USQ-like process.

Table 24. Safety Document: Format, Content, and USQ-Like Process

DOE Site	Hazard Category	SAR/DSA or ASA	DOE Approval	USQ-Like Process, DOE Approval	Comment+
SRS DOE-STD-5502	High/Low	ASA (Auditable safety analysis)	No	No	No std. format, but contents are defined. ASA guidance is from STD-EM-5502-94.
Pantex	High/Moderate/ Low	DSA is with graded approach	No	No	No std. format, but contents are defined.
INEEL DOE-STD-5502	High/Moderate/ Low	DSA ASA	Yes No	Yes No	Format & content are defined.
Hanford, ERC	Non-nuclear	ASA	No	No	Format & content are defined.
Hanford, Fluor	Moderate/ Low	DSA, graded approach.	Yes for Moderate No for Low	Yes for Moderate No for Low	No std. format, but contents are defined.
Hanford, PNNL	Chemical	FUA (Facility use agreement) 4 elements of PSM	No	Yes	4 element of PSM: Management leadership, Safety technology, Facilities, Personnel.
LANL	High/Moderate/ Low	DSA is with graded approach	Yes No	Yes No	Management perform a SB review every 2 yrs.
LLNL	High/Moderate/ Low	SAR HAR	Yes No	Yes No	Management perform a SB review every 5 yrs.
SNL	Moderate Low	SA+ PHS+ HA HA	Yes No	Yes No	Format & content defined
Oak Ridge, Bechtel Jacobs	High/Moderate/ Low	DSA, graded approach. ASA is used for Moderate & Low	No	No	Format & content are defined.
Y-12	PSM/RMP Chemically Hazardous	HER for both categories, unless SAR is specified.	Yes	Yes	Format & content are defined.
RFETS*	No Category Chemical, AR Chemical, NAR	ASA for High or Low	No	No	No std. format, but contents are defined.
West Valley* DOE-STD-5502	High/Moderate/ Low	DSA, graded approach.	Yes for all category	Yes for all category	No std. format, but contents are defined.
Mound (MCP)* Fernald*	One Category Non-nuclear hazardous material	ASA <1910 to >302	No	No	Format & content are defined.
BNL	No Category Non-nuclear hazardous	FUA (Facility use agreement)	No	No	No std. Format, but contents are defined.

* D&D and closure sites
+Format and contents somewhat vary from site to site, but facility description, process operations, hazard and accident analysis, and controls are included in contents.

CONCLUSIONS

There are wide variations in approaches to chemical safety practices among the various DOE sites as described in Sections 1, 2, and 3. These identified variations are as follows.

1. Overall, there are wide variations in CS practices from site to site. In facility CHC, there are wide variations in hazard category terminology, in the screening criteria used to determine the hazard category such as regulation driven inventory quantities vs EG values, and in the use of inventory or consequence of a release to determine the hazard category.
2. There are some important variations in the chemical consequence criteria used for onsite-1 and onsite-2 workers and the public by the various sites. DOE standardized EGs should be helpful to mitigate these variations.
3. There are wide variations in the definition of worker groups (Onsite-1 and Onsite-2) as receptors.
4. There are wide variations in the design of risk matrices, risk-binning criteria, and risk categories where safety controls are required. In some cases, risk classification importance is different for onsite-1 and onsite-2 workers and the public. Terminology varies across the sites.
5. There are wide variations among the sites in the selection of IDLH, ERPGs or TEELs, and PEL-TWA or TLV-TWA for the EGs for safety controls. Also, there are variations across the sites between using consequence or risk criterion to select safety controls.
6. Most of the sites have some form of HBM in place; however, the details vary depending on the complexity of their CSA program. Some sites use the ISM five core steps as part of CS practices. Discussions on hazard checklist category and hazard identification do not appear to correlate with the facility CHC level of High/Moderate/Low.
7. The sites hazard evaluation tables list key features such as event description, hazards, root cause, unmitigated and mitigated frequency, consequence, and risk, and controls (engineering, administrative), although format varies from site to site. In some cases, comparisons of unmitigated and mitigated features are not provided in the evaluation tables.
8. There are wide variations in the SAR or DSA/ASA format or content with regard to CHC, the USQ-like process and their criteria. The approval requirements by DOE/NNSA also vary significantly with respect to the CHC and USQ-like process from site to site.
9. Some variation in hazard characterization, analysis methodology and documentation requirements are understandable and normal depending on the level of complexity of the chemical safety program across the DOE site.

The Phase II report focuses on best practices/recommendations of the CSA program including facility CHC, screening criteria for CHCs, and EGs for controls in order to mitigate wide variations, improve process quality, and reduce potential risk for the onsite workers and the public. Adoption of Phase II by DOE contractors is voluntary.

BIBLIOGRAPHY

Federal Government

DOE-STD-3009-94, "Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports", July 1994, Change Notice No. 1, January 2001.

DOE-STD-1027-92, "*Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice No. 1, September 1997.

DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*, Change Notice No. 1, March 2000.

10 CFR 830 Rule, "Nuclear Safety Management," Vol. 66, No. 7, 1810-1827, January 2001.

DOE-EM-STD-5502-94, "Hazard Baseline Documentation," U.S. Department of Energy, Washington, DC, August 1994. (Cancelled).

DOE Order 5481.1B, "Safety Analysis and Review System," U.S. Department of Energy, Washington, DC, May 19, 1987. (Cancelled).

DOE-ID Order 420C, "Safety Basis Review and Approval Process."

DOE-ID Order 420D, " Requirement and Guidance for Safety Analysis."

OSHA 29 CFR, Part 1910.119, Process Safety Management Of Highly Hazardous Chemicals, U.S. Department of Labor, Washington, DC, May 26, 1992.

40 CFR, Part 68, Accidental Release Prevention Requirements: Risk Management Programs Under Clean Air Act, U.S. Environmental Protection Agency, March 1995.

40 CFR, Part 355, Emergency Planning and Notification, U.S. Environmental Protection Agency, Washington, DC, July 1992.

40 CFR, Part 302.4, Designation, Reportable Quantities, and Notification, U.S. Environmental Protection Agency, Washington, DC July 1992.

Ingle Paik, Project 2000-E, "Current Chemical Safety Analysis Practices in the DOE Complex", Draft Report, WSMS, October 2000.

Dae Y. Chung and Kevin R. O'Kula, "Accident Analysis Guidance for Completion of 10 CFR830 Compliance DSAs, EFCOG, Oak Ridge, TN, June 22-27, 2002.

Douglas K. Craig, J.S. Davis, R. Devore, D.J. Hansen, A.J. Petrocchi, and J.T. Powell, "Alternative Guideline Limits for Chemicals without ERPGs, Amer. Ind. Hyg. Assoc. J, 56, 919-925, 1995.

Douglas K. Craig and C. Ray Lux, "Methodology for Deriving Temporary Emergency Exposure Limits (TEELs), WSRC-TR-98-00080. Westinghouse Savannah River Company, Aiken, SC, 1998.

Douglas K. Craig, Janet S. Davis, Larry G. Lee, Jamie Prowse, and Paul W. Hoffman, "Toxic Chemical Hazard Classification and Safety Evaluation Guidelines for Use in DOE Facilities", WSRC-MS-92-206, Rev. 3, December 2000.

Douglas K. Craig, "SCAPA ERPG Working List", WSMS-SAE-02-0171, July 2003.

<u>DOE Sites</u>

SRS:
WSRC-IM-97-9 Manual.

Pantex:
DOE M 440.1-1 "DOE Explosive Safety Manual."
29 CFR 1910.109 "Explosive and Blasting Agent."
29 CFR 1910.119 "Process Safety management of Highly Hazardous Chemicals"

INEEL:
DOE-ID Order 420C, "Safety Basis Review and Approval Process."
DOE-ID Order 420D, " Requirement and Guidance for Safety Analysis."
MCP-2451, "Safety Analysis for Other Than Nuclear Facilities."
PRD-164, "Safety Analysis for Other Than Nuclear Facilities."

Hanford, ERC:
EDPI-4.28-01, "Hazard Classification Procedure."

Hanford, Fluor:
HNF-PRO-700, "Safety Basis Development."
HNF-PRO 10468, "Chemical Management Process," Revision 1.
DOE 0223, RLEP 3.22.

Hanford, PNNL:
PNNL-MA-440, "Safety Analysis Manual."

LANL:
LIR-300-00-07, "Non-nuclear Facility Safety Authorization."
FWO-OAB-501, "Hazard Analysis Methodology Handbook."
OST-300-00-06H, "LANL Guidelines for Performing Atm. Dispersion Analysis", August 2001.

LLNL:
SARA #2006, Rev. 2, "Facility Hazard Characterization Methodology."
ES&H manual 3.1, "Safety Analysis Program."
ES&H manual 3.2, "Safety Basis Thresholds."

SNL:
CPR400.1.1, “ES&H Manual”.

ORNL-UT/Battelle:
ORNL/LPD-EP/HS-103, “Hazards survey for M&O contractor non-nuclear facilities.”

Oak Ridge-Bechtel Jacobs:
BJC/NS-1009, Safety documentation for radiological and non-nuclear facilities
BJC/OR-112, “Hazard Categorization /Classification and HA Application Guide.”

Y-12 :
Y74-801INS, “Hazardous Material Identification.”
Y74-48-007INS, “Hazard Screening.”
Y74-48-009INS, Accident Analysis
Y74-802, “Safety Basis Documents for Nuclear, PSM/RMP, and Chemically Hazardous Facilities.”
Y74-48-008INS, Hazards Evaluation Study

RFETS:
SARAH-RFETS 2001b, “Safety Analysis and Risk Assessment Handbook,” Chapters 2, 4, 5, 9, Appendix D & I.

ANL:
ANL-ES&H Manual, “Comprehensive Emergency Management Plan.”
Waste Procedural Manual.

WVDP:
WVNS-SAR-001, “Safety Analysis Report for Waste Processing and Support Activities.”
WVDP-193, “Hazards Assessment.”
WV-921, “Hazards Identification and Analysis.”

Mound:
PP-1059C, “Authorization Basis Manual of Practices.”
MD-10414, “Safety Basis Methodology.”
PP-1049, “Integrated Safety Management System.”

Fernald:
SA-DPT-07, “Safety Assessment/Auditable Safety Record Methodology.”
EP-0012, “Chemical Management.”
PL-2352, “FEMP Hazard Survey and Hazard Assessment.”

BNL:
HIT, “Hazard Identification Tools.” Manual
FUA, “Facility Use Agreement” Manual.