ORNL/CASD/2026/SAR/R0

Chemical and Analytical Sciences Division

Safety Analysis Report
Radioactive Materials Analytical Laboratory
Building 2026

September 9, 1999

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6058
managed by
LOCKHEED MARTIN ENERGY RESEARCH CORP.
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ORNL/CASD/2026/SAR/R0

DOE APPROVALS

SAFETY ANALYSIS REPORT
FOR THE
RADIOACTIVE MATERIALS ANALYTICAL LABORATORY
BUILDING 2026

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ENERGY RESEARCH CONCURRENCES AND APPROVALS

SAFETY ANALYSIS REPORT
FOR THE
RADIOACTIVE MATERIALS ANALYTICAL LABORATORY
BUILDING 2026

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REVISION LOGS

SAFETY ANALYSIS REPORT
FOR THE
RADIOACTIVE MATERIALS ANALYTICAL LABORATORY
BUILDING 2026

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LIST OF ACRONYMS

Term	Definition
AGL	Above Ground Level
ALARA	As Low as Reasonably Achievable
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
CAM	Continuous Air Monitor
CASD	Chemical and Analytical Sciences Division
CEDE	Committee Effective Dose Equivalent
CFR	Code of Federal Regulations
CSO	Cognizant Secretarial Office
D&D	Decontamination and Decommissioning
DBFL	Design Basis Flood
DOE	Department of Energy
EH	Office of Environment, Safety and Health
Energy Research	Lockheed Martin Energy Research Corporation
Energy Systems (ES)	Lockheed Martin Energy Systems, Inc.
EPA	Environmental Protection Agency
ERPG	Emergency Response Planning Guideline
ETTP	East Tennessee Technology Park
FEM	Fissile Equivalent Mass
FMCL	Fissionable Material Control Limit
FRM	Facility Radiation Monitoring System
HEPA	High Efficiency Particulate Air
IEEE	Institute of Electrical and Electronics Engineers
IDLH	Immediately Dangerous to Life and Health
LCO	Limiting Condition for Operation
LCS	Limiting Control Setting
LEL	Lower Explosive Limit
LLLW	Liquid Low-level Waste
MCC	Motor Control Center
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards and Technology
NPH	Natural Phenomena Hazard
N&S	Necessary and Sufficient
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation

Term	Definition
OSHA	Occupational Safety and Health Administration
OSHP	Office of Safety and Health Protection
PC	Performance Category
PHA	Process Hazards Analysis
PMF	Probable Maximum Flood
QA	Quality Assurance
R&D	Research and Development
RCRA	Resource Conservation and Recovery Act
RQ	Reportable Quantity
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SL	Safety Limit
SR	Surveillance Requirement
SSCs	Structures, Systems, and Components
TNT	Trinitrotoluene
TQ	Threshold Quantity
TVA	Tennessee Valley Authority
RMAL	Radioactive Materials Analytical Laboratory
TSR	Technical Safety Requirement
USQ	Unreviewed Safety Question
USQD	Unreviewed Safety Question Determination
Valley	Tennessee Valley
WSS	Work Smart Standards

EXECUTIVE SUMMARY

E.1 Facility Background And Mission

The Radioactive Materials Analytical Laboratory (RMAL), Building 2026 , at Oak Ridge National Laboratory (ORNL) is operated by the Chemical and Analytical Sciences Division (CASD). The facility was designed for the chemical analysis and characterization of highly radioactive materials including alpha, beta and gamma emitting radionuclides. Present operations include general analytical chemistry measurements on radioactive materials, dissolution and dilution of samples, chemical separations, and other physical measurements.

E.2 Facility Overview

The RMAL facility is physically located in the 2000 area of the main plant complex of the Oak Ridge National Laboratory (ORNL) in Roane County, Tennessee. The ORNL is located on the U.S. Government-owned Oak Ridge Reservation (ORR), within the corporate limits of the city of Oak Ridge. The Laboratory is managed by Lockheed Martin Energy Research Corporation (Energy Research) for the U.S. Department of Energy (DOE).

The RMAL facility is located at the intersection of Hillside Avenue and Third Street. The Radiochemical Processing Pilot Plant, Building 3019, is to the east; the ORNL Cafeteria, Building 2012, is to the south; The Health Physics Calibration Laboratory, 2007, is to the west; and the Solid State Annex/Quality Complex, Building 2000 is to the North. Building 3019 is a non-reactor Category II nuclear facility. All of the other nearby facilities, except Building 3019, are non-nuclear facilities containing only standard industrial hazards. Activities and hazards at the adjacent or nearby facilities should not adversely affect RMAL.

The RMAL is operated by the Chemical and Analytical Sciences Division (CASD). The Facility receives, stores, assays, and disposes of radioactive materials. The RMAL provides a wide range of analytical chemistry support, including inorganic, organic, and radiochemical analyses to both the R&D divisions and plant operations. In addition, the RMAL staff performs in-house R&D activities involving a broad range of physical, chemical, and radiochemical measurements on radioactive materials.

E.3 Facility Hazard Classification

Hazards associated with the RMAL, Building 2026, were identified and screened in accordance with ES/CSET-2/R2[1] .The hazards of concern associated with operation of the RMAL are radioactive materials (including fissionable materials, radioactive surface contamination, radioactive waste, and toxic chemical materials).

The RMAL will be operated as a Category 3 nuclear facility by maintaining radioactive material inventories below Category 2 threshold quantities (TQs) provided in DOE-STD-1027-92[2]. Facility inventory limits required by Technical Safety Requirements[3] (TSRs) are used to maintain the total inventory in the facility below the Hazard Category 2 thresholds.

The airborne concentrations of toxic materials following worst-case accidents at the RMAL were determined to be below Emergency Response Planning Guideline 2 levels at on- and off-site boundaries. Therefore, the non-nuclear hazard classification for the facility is industrial in accordance with the guidelines of ES/CSET-2/R2[4].

E.4 Safety Analysis Overview

A Process Hazards Analysis (PHA) was performed to identify the hazards and accident scenarios to be evaluated; document the features that prevent, detect, or mitigate the accidents; estimate the frequency and consequences of the accidents; and determine the estimated risk of facility operations, the adequacy of the controls, and the need for further, more detailed, accident analysis.

The hazards that were not screened out in the hazard screening process and, thus, were considered unusual hazards, were further evaluated in the PHA. The PHA identified and qualitatively evaluated thirteen accident scenarios initiated by both external events (natural phenomena and man-made) and internal process-related events. The design and administrative features which act to prevent, detect, or mitigate these accidents were identified and documented in the PHA. The frequency and the on- and off-site consequences for each accident scenario were estimated. The general approach for the consequence estimates was to calculate (or reference similar facility conditions) the consequences for reasonable worst case accident scenarios and then estimate the consequences of lesser releases qualitatively by comparison to these scenarios. Relative risk rankings were assigned to each scenario by placing them on a three-by-three risk matrix consistent with the guidance provided in DOE-STD-3009-94[5]. Results showed there were no scenarios in which the relative risk is of concern.

No structures, systems, or components (SSCs) were designated safety-class or safety-significant.

The boundaries of safe operation, defined by administrative controls and the programs to implement the administrative controls, are included in the facility Technical Safety Requirements (TSRs). Operation in accordance with the TSRs ensures that the facility will be operated within the established risk evaluation guidelines.

E.5 Organizations

Energy Research is the prime contractor to DOE responsible for managing facilities at ORNL. The CASD has responsibility for the operation and maintenance for the RMAL facility. Lockheed Martin Energy Systems, Inc. (Energy Systems) provides engineering support services to Energy Research. This Safety Analysis Report (SAR) was prepared by a team of operating and technical staff from Chemical and Analytical Sciences.

E.6 Safety Analysis Conclusions

The operation of the RMAL facility will have minimal impact on operating personnel and members of the public during normal operations. No safety-class or safety-significant SSCs were identified by the hazard and accident analysis. Adherence to the TSRs ensures that the facility will be operated within the established risk evaluation guidelines.

E.7 SAR Organization

The structure and content of this SAR parallels the format delineated in DOE-STD-3009-94.

E.8 References

1. ES/CSET-2/R2, *Safety Analysis Report Update Program - Hazard Identification and Facility Classification Application Guide*, Lockheed Martin Energy Systems, Inc., Oak Ridge, TN, December 1995.

2. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report*, U.S. Department of Energy, Washington, D.C., Change Notice 1, September 1997.

3. ORNL/CASD/TSR, *Technical Safety Requirements for the Radioactive Materials Analytical Laboratory, Building 2026*, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, TN.

4. ES/CSET-2/R2, *Safety Analysis Report Update Program Hazard Identification and Facility Classification Application Guide*, Martin Marietta Systems, Inc., Oak Ridge, Tennessee, December 1995.

5. DOE-STD-3009-94. *Preparation guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D.C., July 1994.

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CHAPTER 1
SITE CHARACTERISTICS

1.1 Introduction

The objective of this chapter is to describe the characteristics of the site on which the Radioactive Materials Analytical Laboratory (RMAL) is located. This site information is necessary for identifying and evaluating potential external accident initiators and for identifying and analyzing accident consequences outside the facility. The following information is included.

- ! Description of the location of the site, the location of the facility within the site, and its proximity to the public and to other facilities.
- ! Identification of on-site workers and site boundaries.
- ! Specification of population sheltering, population location and density, and other aspects of the surrounding area to the site that relate to assessment of the protection of the health and safety of the public.
- ! Determination of the historical basis of site characteristics in meteorology, hydrology, geology, seismology, and other natural phenomena, to the extent needed for hazard and accident analysis.
- ! Identification of the design basis natural phenomena and sources of external accidents.
- ! Identification of nearby facilities impacting or impacted by the facility.

1.2 Requirements

Requirements for siting, external hazards to be evaluated, and evaluation of hazards are contained in U.S. Department of Energy (DOE) Orders 420.1[1] and 5480.23[2]. The RMAL has completed the Necessary and Sufficient (N&S) process and has established a set of Work Smart Standards (WSS) for Environment, Safety, and Health. Therefore, the degree of conformance of the RMAL with any referenced DOE Order throughout this Safety Analysis Report (SAR) will be as defined in the N&S set of standards.

1.3 Site Description

1.3.1 Geography

The RMAL is located in the 2000 area of the main laboratory complex of the Oak Ridge National Laboratory (ORNL) in Roane County, Tennessee. ORNL is located on the U.S. Government-owned Oak Ridge Reservation (ORR), within the corporate limits of the city of Oak Ridge. The ORR lies within the Tennessee Valley between the Cumberland and Southern Appalachian mountain ranges in the eastern part of the state of Tennessee, as shown in Fig. 1-1. The ORR (shown on Fig. 1-2) occupies about 37,000 acres and includes three major complexes with a total fenced area of about 2000 acres: the Y-12 Plant, ORNL, and the East Tennessee Technology Park (ETTP).

The eastern and southern boundaries of the ORR are defined by the Melton Hill Reservoir and the Clinch River. The western boundary is formed by the Clinch River backwaters of Watts Bar Reservoir on the Tennessee River. Black Oak Ridge forms the western portion of the ORR's northern boundary. The three complexes are located in separate but adjacent valleys on the ORR. The Y-12 Plant, situated in eastern Bear Creek Valley, is bounded on the south by Chestnut Ridge and on the north by Pine Ridge. The main ORNL facilities are located about eight miles southwest of the population center of the city of Oak Ridge in Bethel Valley between Haw Ridge and Chestnut Ridge, with ancillary facilities in Melton Valley to the south. The ETTP is located in East Fork Valley, about 10 miles west of the population center of the city of Oak Ridge.

The RMAL facility is located in the main complex area of ORNL. Figure 1-3 shows the location of the RMAL within the ORNL complex. The following paragraphs describe the location of and access to the RMAL facility.

The RMAL Facility is situated at a slight elevation in the north-west quadrant of the ORNL site. Third Street runs on the east side of the RMAL facility which is the location of the main entrance for the building. In emergency situations the RMAL facility can be accessed by either Third Street from the east side or by Second Street on the west side of the building. The point of nearest public access is approximately 200 m (656 ft.) to the north at Bethel Valley Road.

Bethel Valley Road, which runs east-west and is north of the main ORNL site, is the main access road into ORNL. Access roads onto the ORNL site from Bethel Valley Road are closed to the public. Bethel Valley Road connects the main ORNL site with the roads to Knoxville and the residential areas of Oak Ridge.

1.3.2 Demography

The western portion of ORNL (including the main laboratory area) is located in Roane County; the remaining area is in Anderson county. Roane County is adjacent to both Knox County and Loudon County across the Clinch River to the east and south, respectively. Morgan county borders Roane County to the north. The combined 1990 population of the above five counties was 499,781, with the majority in Knox County. The area immediately surrounding the ORR is predominantly rural with the exception of the populated areas of the city of Oak Ridge along the northeast border.

The city limits of Oak Ridge encompass ORNL, although no city residents live near ORNL. The Knox County area west of Knoxville has recently been the fastest-growing area near ORNL; however, the population density is less than 50 persons per square mile with five miles of the main laboratory complex. The demography of the area is not expected to change significantly.

Figure 1-1 Location of the Oak Ridge Reservation in the State of Tennessee

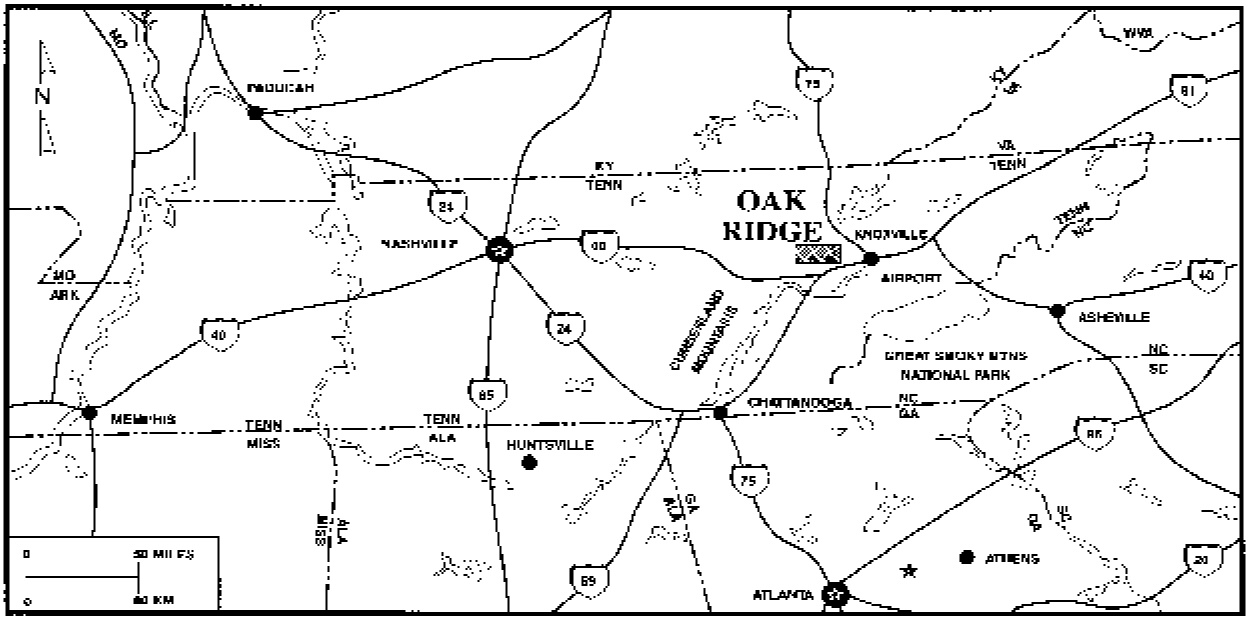


Figure 1-2 Oak Ridge Reservation Map

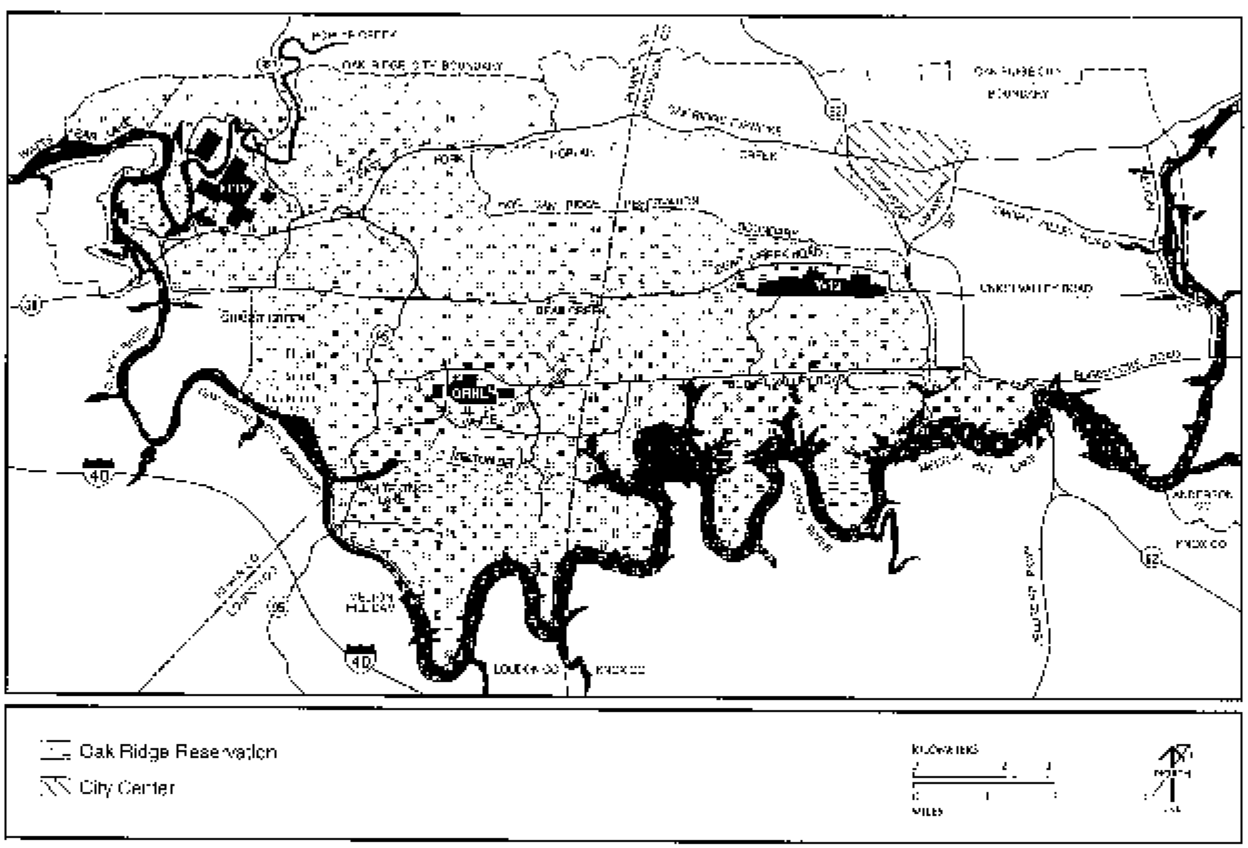
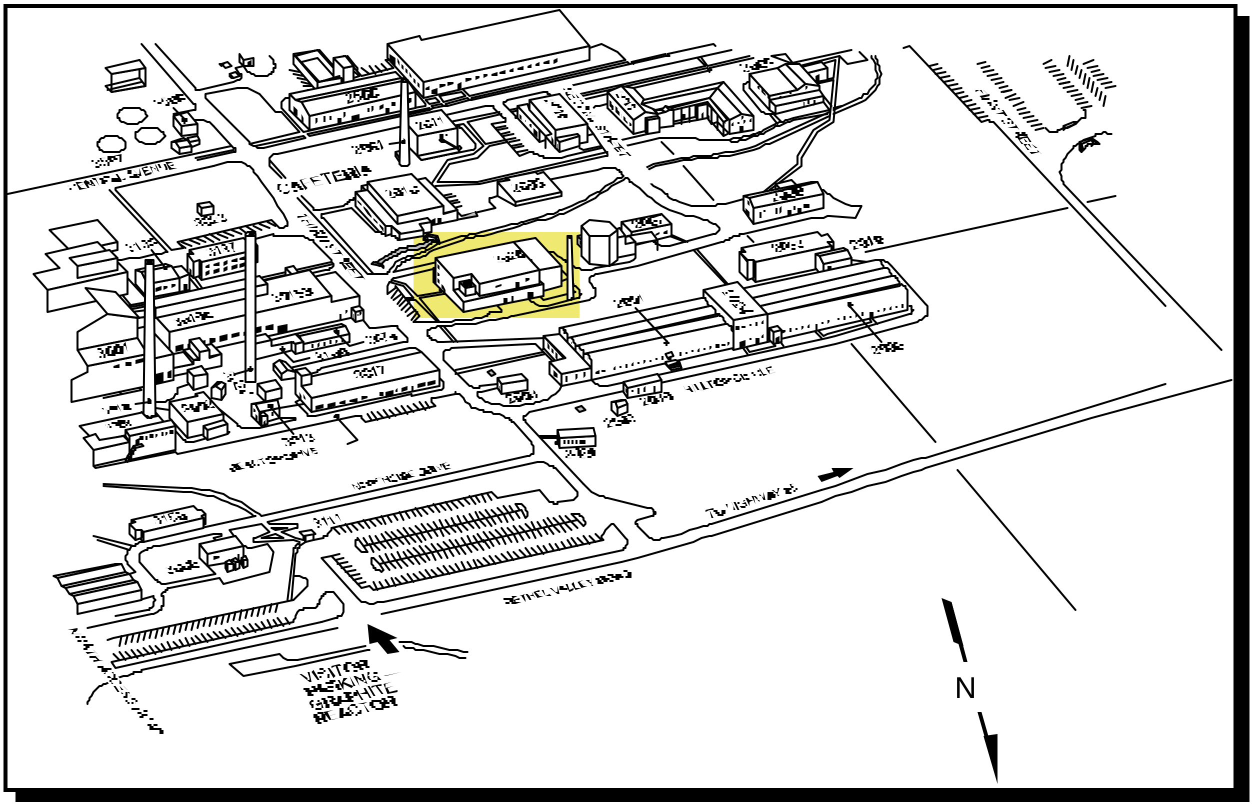


Figure 1-3 Location of RMAL Facility (Building 2026) on ORNL Site



Other than the roads within the ORR, the nearest major thoroughfare is Interstate 40, approximately 3.3 miles southwest of the RMAL. The Clinch River and Melton Hill Lake are components of the inland waterway system. Logs are kept of traffic locked through Melton Hill Dam, which is located approximately three miles south-southwest of the RMAL facility. ORNL is not served directly by railroads; however, both the ETTP and the Y-12 Plant have railroad spur lines within five miles of the main laboratory complex.

1.4 Environmental Description

1.4.1 Meteorology

1.4.1.1 Regional Climatology

ORNL is located in the Tennessee Valley (Valley), which is a broad funnel-shaped valley in the eastern part of Tennessee. The Valley, which contains the Tennessee River and its tributaries, is bordered to the northwest by the Cumberland Plateau with an average elevation of 2000 ft and to the southeast by the Great Smoky Mountains with peaks that rise as high as 6000 ft.

The Valley experiences extreme temperature drops less frequently than locations at the same latitude to the west of the Cumberland Plateau. The winter minimum monthly average temperature is around 38°F. The summer monthly average temperature is between 75 and 80°F. The temperature equals or exceeds 96°F an average of six days per year. The temperature falls below 10°F an average of four days per year. Low-level temperature inversions are frequent, occurring during approximately 57% of the hourly observations.

The average monthly precipitation during the winter gradually increases until it peaks in March, after which is decreases through June. Summer thunderstorm activity usually raises the average in July to near that of March. The average precipitation usually reaches a minimum in October. The annual precipitation averages between 50 and 60 inches and exceeds 65 inches about once in 10 years. Approximately once in 10 years, a thunderstorm will produce two in. of rain in an hour. The snowfall in the Valley averages between 6 and 12 in. Maximum snowfalls in a single storm recorded at Oak Ridge and Knoxville were 15 and 23 in., respectively. An average of one dry period each year will extend two weeks or longer. Once in 10 years, a drought may extend to four weeks or longer.

The lowest daily average humidity is found in the late winter and early spring, and the highest is in the summer and early fall. The Valley has a relatively high frequency of heavy fog. At the height of the fog season in October, heavy fog can be expected to occur on five or more days per month.
Damaging winds are relatively uncommon. Peak gusts recorded in the Valley are generally in the 60- to 70-mph range for the months of January through July and less during the other months. The Valley is infrequently subjected to tornadoes and hurricanes.

Eastern Tennessee has a relatively large number of forecast days of pollution potential (about seven per year). Data indicate an average 12 stagnation days per year. The region has a mild climate with warm humid summers and mild winters. Spring and fall are usually long, sunny, humid, and moderately warm. The Appalachian mountains generally divert hot southeasterly winds that develop along the South Atlantic coast; extreme temperatures, precipitation, and wind velocity are rare.

The annual mean air temperature in Oak Ridge is 58°F. Diurnal swings in temperature are relatively constant from month to month - about 20°F. Average annual precipitation is 53.5 inches water equivalent. Oak Ridge has one of the lowest average wind speed in the country and the winds are channeled through the ridge and valley topography.

1.4.1.2 Local Meteorology

Meteorological data and observations were obtained from five locations: the city of Oak Ridge, the Y-12 Plant area, the ETTP, ORNL in Bethel Valley, and the ORNL Tower Shielding Facility on Copper Ridge.

The station in the city of Oak Ridge operated from 1956 until 1979 and has the most complete data on meteorological parameters, including wind speed and direction, dry bulb temperature, dew point, precipitation, and sky cover. Starting in December 1958, the single wind sensor at the Oak Ridge station was 41 ft above ground level (AGL) at an elevation of 955 ft above mean sea level (MSL). Prior to that time it was at an elevation of 46 ft. Data presented from the Oak Ridge National Weather Service Office were obtained from ISSN 0198-4861[3].

Data on wind speed and direction, dry-bulb temperature, dew point, temperature difference, and precipitation were collected hourly at the ORNL Bethel Valley meteorological station from 1955 through 1972. The meteorological tower for this station was a 140 ft structure located in the main area of ORNL on top of a ridge with an elevation of 886 ft MSL. The lower temperature sensor was located four ft AGL, and the temperature difference measurements spanned 135 ft.

The monthly average of average daily temperatures vary from 37°F in January to 77° in July. Temperatures above 100°F (105°F maximum) have been experienced in each of the months from June through September, whereas temperatures below 0°F (-17°F minimum) have been experienced in December and January.

The average annual precipitation of 54.76 in., with almost even monthly distribution. The months of lightest precipitation are August, September and October. An average of at least one thunderstorm per month occurs throughout the year. Hail generally occurs in the months of February through August and only about five days every two years. Snow can be expected from late fall through early spring. January has the highest probability of snowfall; however, the greatest total monthly snowfall, 21 in., occurred in March 1960 and the maximum snowfall in a 24-h period of 15 in. occurred in March 1993. The mean snowfall each season is about 10.2 in., and the maximum recorded snowfall in one season is 41.4 in.

Fifteen or more consecutive days without precipitation can be expected at ORNL on an average of once a year. Consecutive days without precipitation can be expected to extend to 31 days about once every 10 years and to 63 days about once every 100 years. The monthly average relative humidity at ORNL for the period of record (January 1951 through December 1964) ranged from 59.2% in April to 74.5% in August. The frequency of occurrence of fog is greatest during the late summer and fall with the average monthly occurrence at a maximum of eight days in October. Throughout the winter, spring, and early summer, fog can be expected on two days a month or less.

The wind direction above the ridge tops and within the Valley at ORNL tends to be aligned with the orientation of the Valley. The prevailing wind is from the southwest with a secondary maximum from the northeast during the winter, spring, and summer months. This situation is reversed in the fall, with the prevailing northeast wind. Wind speeds measured in the ORNL Bethel Valley area (about 4800 ft east of Building 2026) are provided in Table 1-1.

Dispersion is related closely to atmospheric stability. The vertical temperature gradients were used to define stability classes in accordance with the requirements of Regulatory Guide 1.23[4] (Safety Guide 23) at the ORNL Bethel Valley site. The annual frequency of occurrence of these stability classes is provided in Table 1-2.

Table 1-1 Wind Speeds

Wind Speed (mph)	Annual Frequency of Occurrence (%)
Calm	21
1 - 3	29
4 - 7	25
8 - 12	15
13 - 18	5
18 - 24	1
19 - 24	1
25 +	< 1
Unknown	3

Table 1-2 Atmospheric Stability Classes

Stability Class	Annual Frequency of Occurrence (%)
A - Extremely Unstable	24
B - Moderately Unstable	2
C - Slightly Unstable	2
D - Neutral	16
E - Slightly Stable	23
F - Moderately Stable	16
G - Extremely Stable	17

1.4.2 Hydrology

1.4.2.1 Surface Hydrology

Both Bethel Valley and Melton Valley are in the White Oak Creek drainage basin. Surface water flow in White Oak Creek is augmented by treated process wastewater, treated sanitary sewage effluent, and cooling tower discharges from various ORNL facilities. White Oak Creek is impounded by White Oak Dam about 0.5 miles above the confluence of White Oak Creek and the Clinch River. The impoundment, White Oak Lake, is used as a settling basin for waste effluent discharged from ORNL facilities. The Clinch River, the hydraulic sink for the Oak Ridge area, originates in southwest Virginia near the Kentucky border. Water flow on the Clinch River is extensively controlled by a series of Tennessee Valley Authority (TVA) dams.

1.4.2.2 Subsurface Hydrology

Groundwater flow on the ORR is primarily determined by water table conditions. Groundwater flow under water table conditions parallels closely the contours of the surface topography, and the water emerges to contribute to local stream flow. Recharge is derived primarily from precipitation, and groundwater discharge is through evapotranspiration, springs, and streams. The surface streams ultimately augment the water supply of the Clinch River, which is the hydraulic sink for the region. The riverbed lies at the base level of the zone of saturation, and groundwater from both sides of the channel enter the river. Because the river bed is a major topographic feature set down in bedrock, it is unlikely any groundwater flow can pass beneath the Clinic River.

1.4.3 Geology

The ORR is located in the folded and faulted Valley and Ridge Province of the Appalachians. Historic seismic activity in the vicinity of the ORR has occurred primarily in the Valley and Ridge Province in which Oak Ridge is located, although historically, some activity has occurred on the Cumberland Plateau to the west of Oak Ridge. The local geologic information is the basis for the ORR criteria developed in ES/CNPE-95/2[5], *Seismic Hazard Criteria for the Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio U. S. Department of Energy Reservations*, which is used to determine the Evaluation Basis Earthquake levels for ORNL facilities.

1.5 Natural Phenomena Threats

Natural phenomena are considered as accident initiators in Chap. 3, the Hazard and Accident Analysis. In accordance with the direction of DOE-STD-1021-93[6], a natural phenomena hazards (NPH) performance category (PC-0 through PC-4) and associated NPH design requirements are assigned to facility SSCs by evaluating the consequences of failure of the SSCs due to these NPH initiators. Per this standard, PC-4 applies only to those SSCs whose failure could result in accident consequences equivalent to severe accidents in large category A reactors, which is not the case for Building 2026. The PC-3 category is for accidents that exceed the safety-class SSC Evaluation Guidelines which is not possible for

Building 2026 since the facility is operated as a Hazard Category 3 facility. Therefore, the performance categories that may be applicable to Building 2026 are PC-0 (no NPH requirements), PC-1, and PC-2.

The Hazard and Accident Analysis in Chap. 3 evaluates the consequences of failure of facility SSCs due to the worst case NPH initiators (e.g., PC-2). The facility Description in Chap. 2 (1) documents the PC assigned to the facility based on the consequence evaluation and the guidance in DOE-STD-1021-93, and (2) evaluates the capability of the SSCs to withstand the effects of the NPH events associated with this PC.

The following sections summarize the design basis NPH associated with PC-1, PC-2 and PC-3 at the Building 2026 site per DOE-STD-1020-94[7]. The PC-3 category is included in the tables for the purpose of reference only and is not used in the safety analysis for the facility.

1.5.1 Flooding

The effects of flooding on structures, systems, and components (SSCs) must be considered per DOE Order 5480.28[8]. Flood design and evaluation criteria are specified in DOE-STD-1020-94. Evaluation of the flood design basis for SSCs consists of determining a Design Basis Flood (DBFL) for each flood hazard as defined by the hazard annual probability of exceedance and applicable combinations of flood hazards. The natural phenomena combinations applicable to Building 2026 are river flooding, dam failure, and local precipitation.

1.5.1.1 River Flooding

The potential for flooding from White Oak Creek was evaluated for Building 2026. The RMAL is located north of White Oak Creek Mile 2.74. Flood elevations at White Oak Creek Mile 2.74 from regional flooding have been determined in ES/CNPE-95/1[9], for various recurrence intervals, and those that are applicable to each PC are summarized in Table 1-3.

Table 1-3 Flood Elevation Criteria

Performance Category	1	2	3
Recurrence interval (years)	500	2000	10,000
Approximate flood elevation (feet)	784	787	791

1.5.1.2 Dam Failures

DOE-STD-1020-94 indicates that flooding due to upstream dam failures from overtopping during a DBFL, seismically induced failure, and random failure should be evaluated. These evaluations have been performed considering the Probable Maximum Flood (PMF) and are documented in ES/CNPE-95/1. The PMF is the most severe flood that can reasonable be predicted to occur at a site as a result of hydro meteorological conditions. These evaluations show that failure of Norris Dam during a PMF will not occur. Since the probability of the PMF occurrence is much smaller than the performance goal for PC-2 SSCs, overtopping is not a problem. A study conducted by Agbabian and Associates, R-7523-1-3717, *The Predicted Behavior of Norris Dam to Strong Earthquake Ground Motion*[10], shows that Norris Dam will not fail from the earthquake level associated with PC-3 SSCs; therefore, seismically induced dam failure is not an issue. The probability of a random failure of Norris Dam has been judged to be much less than the performance goal of PC-3 SSCs; therefore, a random failure is not an issue. The basis for this judgement is that TVA has a thorough inspection program to ensure random failures will not occur. Thus, it is concluded that dam failures are not a hazard of concern for Building 2026.

1.5.1.3 Local Precipitation

Local precipitation includes evaluation of snow and rain loads and effects of flooding due to local run-off.

DOE-STD-1020-94 requires consideration of rain and snow loads as specified in DOE 6430.1A which, in turn, requires rain and snow load design to be in accordance with ANSI A58.1, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*[11] (Superseded by ASCE 7, *Minimum Design Loads for Buildings and Other Structure*[12]). The criteria for snow loading in ASCE 7 is 10 lb/ft^2. ASCE 7 does not require drift loads to be considered for the Oak Ridge area. Roof ponding is not a concern for the RMAL Facility.

No quantitative hydrological analysis of the site runoff or storm water management system has been performed for Building 2026. Local flooding is qualitatively considered in hazard and accident analysis in Chapter 3.

1.5.2 High Winds/Tornados/Missiles

The criteria for high winds, tornados, and wind driven missiles, as specified in DOE-STD-1020-94, are summarized in Table 1-4 in terms of the performance categories.

1.5.3 Seismic Activity

The seismic studies performed in accordance with DOE Order 5480.28 and DOE-STD-1020-94 for the DOE ORR are documented in ES/CNPE-95/2[5]. The results of the seismic hazard studies for peak horizontal rock accelerations are provided in Table 1-5.

Building 2026 is supported on soil. There, the amplification of the above rock motions through the soil deposit to the foundation of the building will be considered to determine the soil ground motions. Specific soil amplification studies, however, have not been performed for Building 2026, but studies performed for other buildings supported on soil (≥ 10 ft deep) at the Y-12 Plant site (see ES/CNPE-95/2) indicate a soil amplification of 1.5. The results in the peak soil accelerations are provided in Table 1-6.

Table 1-4 High Wind, Tornado and Missile Criteria

Performance Category		1	2	3
Wind	Fastest-mile wind speed[1]	70 mph	70 mph	No value recommended by DOE-STD-1029-94 for straight wind speeds.
	Missiles	N/A[2]	N/A	2 x 4 timber plank, 15 lb @ 50 mph (horizontal.); max height 30 ft.
Tornado	Fastest-mile wind speed[1]	N/A	N/A	113 mph
	Atm. Pressure change	N/A	N/A	40 psf @ 20 psf/sec
	Missiles	N/A	N/A	2 x 4 timber plank, 15 lb @ 150 mph (horizontal); max height 150 ft; 70 nog (vertical) 3 in. diameter std. steel pipe, 75 lb @ 50 mph (horizontal); max. height 75 ft, 35 mph (vertical)

[1] Fastest-mile wind speed measured at a 10 meter height.
[2] N/A - not applicable to the performance category.

Table 1-5 Seismic Criteria

Performance Category		1	2	3
Recurrence Interval (years)		500	1,000	2,000
Peak Rock Acceleration (g)	Horizontal	0.06	0.08	0.12
	Vertical	0.04	0.05	0.08

Table 1-6 Modified Seismic Criteria

Performance Category		1	2	3
Recurrence Interval (years)		500	1,000	2,000
Peak Soil Acceleration (g)	Horizontal	0.15	0.20	0.30
	Vertical	0.10	0.13	0.20

1.6 External Man-made Threats

The following external man-made threats were evaluated as potential initiators in Chap. 3.

- Explosions/missiles - from natural gas pipelines or adjacent facilities
- Forced evacuation
- Loss of facility services

1.7 Nearby Facilities

The RMAL is located at Oak Ridge National Laboratory on Hillside Avenue and Third Street. The Radiochemical Processing Pilot Plant, Building 3019, is to the east; the ORNL Cafeteria, Building 2012, is to the south; The Health Physics Calibration Laboratory, 2007, is to the west; and the Solid State Annex/Quality Complex, Building 2000 is to the North. Building 3019 is a non-reactor Category II nuclear facility. All of the other nearby facilities, except Building 3019, are non-nuclear facilities containing only standard industrial hazards. Activities and hazards at the adjacent or nearby facilities should not adversely affect RMAL.

1.8 Validity of Existing Environmental Analyses

No significant discrepancies exist among any prior environmental analyses and impact statements for the RMAL facility and this current effort.

1.9 References

1. DOE Order 420.1, *Facility Safety*, Change 2, U.S. Department of Energy, Washington, D.C., October 24, 1996.

2. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, Change 1, U.S. Department of Energy, Washington, D.C., March 10, 1994.

3. ISSN 0198-4861, *1988 Local Climatological Data, Annual Summary with Comparative Data, Oak Ridge, Tennessee*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, N.C.

4. Directorate of Regulatory Standards, Regulatory Guide 1.23 (Safety Guide 23), *Onsite Meteorological Programs*, U.S. Atomic Energy Commission, February 17, 1972.

5. ES/CNPE-95/2, *Seismic Hazard Criteria for the Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio U.S. Department of Energy Reservations*, prepared by the Center for Natural Phenomena Engineering, Lockheed Martin Energy Systems, Inc., December 1995.

6. DOE-STD-1021-93, *Natural Phenomena Hazards performance Categorization Guidelines for Structures, Systems, and Components,* Change Notice #1, U.S. Department of Energy, Washington, D.C., January 1996.

7. DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities,* Change Notice #1, U.S. Department of Energy, Washington, D.C., January 1996.

8. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, U.S. Department of energy, Washington, D.C., January 15, 1993.

9. ES/CNPE-95/1, *Flood Analyses for Department of Energy Y-12, ORNL, and K-25 Plants*, prepared for the Center for Natural Phenomena Engineering at the Oak Ridge Y-12 Plant, Lockheed Martin Energy Systems, Inc., prepared by the Water Resources Division of the Tennessee Valley Authority, May 1995.

10. R-7523-1-3717, *The Predicted Behavior of Norris Dam to Strong Earthquake Ground Motion*, prepared by Agbabian and Associates, prepared for the project Management Corporation, Chicago, Illinois, July 1975.

11. American National Standards Institute, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*, ANSI A58.1.

12. American Society of Civil Engineers, *Minimum Design Loads for Buildings and Other Structures*, ASCE 7.

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CHAPTER 2
FACILITY DESCRIPTION

2.1 Introduction

The objective of this chapter is to describe the facility, its designed mission, processes, and SSCs. The following information is included:

- Overview of the facility, its inputs and its outputs, including mission and history.
- Description of the facility structure and design basis.
- Description of the facility process systems and constituent components, instrumentation, controls, operating parameters, and relationships of SSCs.
- Description of confinement systems.
- Description of the facility safety support systems.
- Description of the facility utilities.
- Description of facility auxiliary systems and support facilities.

2.2 Requirements

DOE Orders 420.1[1] and 5820.2A[2] are required for establishing the safety basis of the facility. The nuclear hazard category is designated Category 3. The non-nuclear category is designated Industrial.

2.3 Facility Overview

The Radioactive Materials Analytical Laboratory (RMAL), Building 2026, located at Oak Ridge National Laboratory (ORNL) and operated by the Chemical and Analytical Sciences Division (CASD). The RMAL facility receives, stores, assays, and disposes of a wide variety of radioactive materials. Assay operations include dissolutions, dilutions, separations, followed by physical, chemical, and radiochemical examinations of individual samples. The RMAL provides a wide range of analytical chemistry support, including inorganic, organic, and radiochemical analyses to both the R&D divisions and plant operations. In addition, the RMAL staff performs in-house research and development (R&D) activities involving a broad range of physical, chemical, and radiochemical measurements on radioactive materials.

The RMAL facility was constructed in 1964 (additions added in 1966 and 1985) and provides 22,600 sq. ft. of laboratory and office space dedicated to the application of general analytical chemistry to radioactive materials. The facility is equipped with special containment and ventilation systems to handle high levels of radioactivity in hot cells (high gamma dose) and in glovebox systems (high levels of alpha). To mitigate cross contamination, the facility is designed to handle lower levels of radioactivity in laboratories segregated from higher contamination levels. The facility was recently upgraded to include a new radioactive liquid waste system that meets current regulatory requirements; the facility is fully equipped to handle the packaging and disposal of radioactive solid waste.

The RMAL was originally designed to support the processing and examination of spent reactor fuel, the current missions of the RMAL only include low hazard operations. Over the past fifteen years the type of work supported by the RMAL has changed from handling high dose spent fuel to mostly radioactive waste characterization in support of waste management, environmental management, environmental restoration, and decontamination activities. Therefore, based on the current and near future (10 years) types of operations performed in the RMAL, the scope of this safety analysis is only intended to support low hazard (Category 3) operations. The low hazard operations provide the basis for a broad application of the graded approach to the safety and hazard analysis discussed in this document.

2.4 Facility Structure

The RMAL facility (Building 2026) is physically located at the Oak Ridge National Laboratory at the intersection of Hillside Avenue and Third Street. The Radiochemical Processing Pilot Plant (Building 3019) is located to the east; the Cafeteria (Building 2010) is to the south; the Health Physics Calibration Laboratory (Building 2007) is to the west; and the Health and Safety Research Annex (Building 2001) is located to the north.

The RMAL facility is a two story block structure. Simple floor plans of the first and second floor are shown in Figure 2-1. The construction of the facility consists of steel framing for all load bearing walls with 12" concrete blocks used for exterior walls and 8" concrete blocks for most interior walls. High density concrete was used in areas around the cell windows which is where workers would spend most of their time performing routine activities.

The Hazard and Accident Analysis in Chapter 3 does not take credit for facility design to prevent or mitigate accidents initiated by natural phenomena. Also, based on application of graded approach as provided in DOE-STD-3009-94; "*....for Hazard Category 3 facilities, onsite meteorological conditions, hydrology, population information, and off-site accident pathways are not typically required, since consequences are limited to the facility itself*." Therefore, no safety-related natural phenomena performance criteria are established for SSCs in Building 2026, and the facility structure is designated a PC-1 structure per DOE-STD-1021-93[3]. The design of Building 2026 was completed and approved prior to issue of DOE Order 5480.28[4], DOE-STD-1021-93, and DOE-STD-1020-94[5]. The following gives some comparison of the Building 2026 natural phenomena design information and the current natural phenomena criteria in DOE-STD-1020-94.

PC-1 facilities are not required to be designed to withstand tornados or wind driven missiles. Due to the lack of verifiable design information for the building, the Hazard and Accident Analysis in Chapter 3 does not take credit for wind or seismic resistance of the structure.

The building site was graded to divert rainwater flow away from Building 2026 to prevent local flooding. No quantitative analysis of storm-water runoff has been performed, however, the site grading is considered sufficient to prevent local flooding based on a qualitative evaluation.

The RMAL facility can generally be divided into six sections: (1) hot cell structures, (2) glovebox laboratories, (3) radiochemical laboratories, (4) operating areas, (5) utility areas, and (6) office areas. Most of the office space and utility areas are located on the second floor of the facility.

2.4.1 Hot Cells

The hot cell bank includes six working cells (6' x 7' x 11') with 51" thick windows filled with concentrated zinc bromide which provides shielding for up to 1400 Ci of ^{60}Co equivalent activity. One unloading cell located in the center of the cell bank is equipped with a 2-ton hoist and a 5-ton pneumatic lift for handling shielded carriers used to transport radioactive samples. In addition, a large storage cell (8' x 12' x 8') is located next to the loading cell and is designed to handle up to 25,000 Ci of ^{60}Co equivalent activity of sample storage.

2.4.2 Glovebox Laboratories

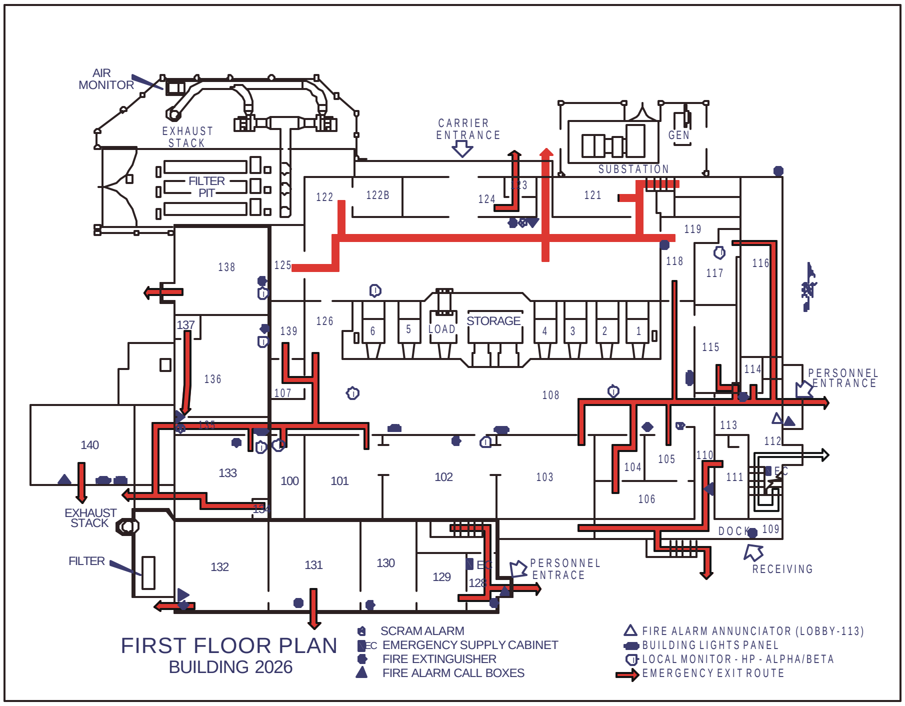
Two glovebox laboratories are currently available for work involving high levels of alpha activity. One glovebox laboratory is setup for the preparation of samples for inorganic and radiochemical measurements. The second laboratory is currently used for the preparation of samples requiring organic measurements.

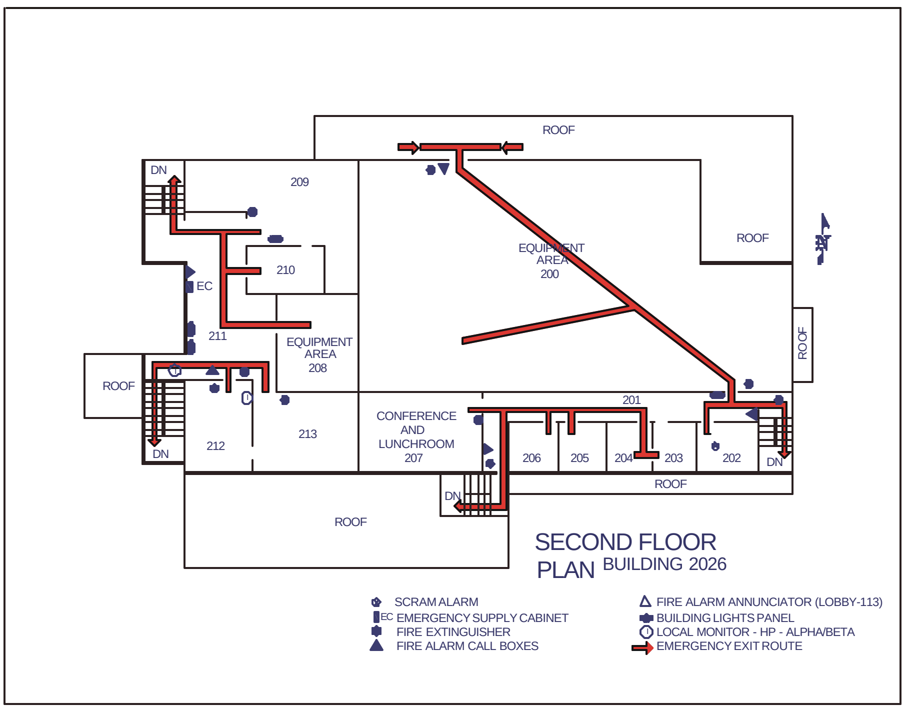
The preparation of samples can involve many standard laboratory operations such as sample dissolution, sample dilution, liquid-liquid extractions, column separations, etc. All of these operations are routine functions performed in any analytical laboratory, but the glovebox containment is required for higher levels of alpha activity.

2.4.3 Radiochemical Laboratories

The RMAL analytical laboratory capabilities support a broad range of analytical methodologies required for testing and characterizing a wide range of samples from mixed-radioactive sludge from underground storage tanks to spent fuel from a nuclear reactor. The facility is equipped with a variety of modern analytical instrumentation for the determination of metals, anions, organic compounds, radionuclides, and physical properties.

Figure 2-1 First and Second Floor Plans for the RMAL Facility





2.4.4 Operating Areas

Along with the laboratories, the operating areas are where the personnel are located most of the time. Testing and analytical processes performed in the hot cells are conducted by personnel located in the cell operating area using master-slave manipulators. Various testing equipment and computers are located in the operating area to support analytical tests conducted in the hot cells.

2.4.5 Utility Areas

The main utility area is located on the second floor of the building in Room 200. This area contains the main power distribution panels for the facility, water and steam supply headers, hot water heater, ventilation control equipment, and various pumps and motors for the cooling tower and cooling systems. The air supply fans for the containment areas are also in the equipment area along with the ventilation fans for the office and change room areas (non-containment areas). A second utility area is located in the west addition in Room 208 and a third utility area is located in the South addition in Room 130.

2.4.6 Office Areas

Most of the facility office areas and the lunchroom are located on the second floor, well away from the radiological and chemical hazards.

2.5 Process Description

2.5.1 Hot Cells Operations

The hot cell bank includes six working cells (6' x 7' x 11') with 51" thick windows filled with concentrated zinc bromide which provides shielding for up to 1400 Ci of ^{60}Co equivalent activity. One unloading cell located in the center of the cell bank is equipped with a 2-ton hoist and a 5-ton pneumatic lift for handling shielded carriers used to transport radioactive samples. In addition, a large storage cell (8' x 12' x 8') is located next to the loading cell and is designed to handle up to 25,000 Ci of ^{60}Co equivalent activity of sample storage.

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Two glovebox laboratories are currently available for work involving high levels of alpha activity. One glovebox laboratory is setup for the preparation of samples for inorganic and radiochemical measurements. The second laboratory is currently used for the preparation of samples requiring organic measurements. The preparation of samples can involve many standard laboratory operations such as sample dissolution, sample dilution, liquid-liquid extractions, column separations, etc. All of these operations are routine functions performed in any analytical laboratory, but the glovebox containment is required for higher levels of alpha activity.

2.5.3 Laboratory Operations

The RMAL analytical laboratory capabilities support a broad range of physical, inorganic, organic, and radiochemical methodologies required for testing and characterizing a wide range of samples from mixed-radioactive sludge from underground storage tanks to spent fuel from a nuclear reactor. The RMAL also provides analytical support to many projects and programs involved with environmental levels of radionuclides and trace inorganic and organic contaminates. The facility is equipped with a variety of modern analytical instrumentation for the determination of metals, anions, organic compounds, radionuclides, and physical properties.

Major analytical instrumentation located in the facility includes Inductively Coupled Plasma - Atomic Emission Spectroscopy, Graphite Furnace - Atomic Absorption, Inductively Coupled Plasma - Mass Spectrometry, Ion Chromatography, and various Gas Chromatography (GC) systems for organic measurements such as GC-mass spectrometry, GC-flame ionization detector and GC-electron capture detector. Also, general analytical laboratory equipment such as carbon analyzers, microwave dissolution systems, pH meters, pipetting and titration equipment, instrumentation for the measurement of rheological properties on highly radioactive sludge and sediment samples, particle size analysis, and instruments used for the determination of the bulk density of solid and semi-solid materials are located in the facility.

The RMAL facility includes a state-of-the-art counting room with advanced instrumentation for the measurement of gamma, alpha, beta, and neutron emitters. The counting room instruments include computer systems for the operation of multichannel analyzers, High Performance Germanium detectors for gamma spectrometry, gas-flow proportional counters for alpha/beta measurements, and liquid scintillation counting systems for low energy beta measurements such as tritium. In addition to the counting equipment, a significant amount of lead shielding is present in the counting laboratory.

2.6 Confinement Systems

Two levels of containment/confinement are provided to prevent the escape of radioactive and/or hazardous materials. The primary containment areas can be either hot cells, gloveboxes, or radiochemical hoods, depending upon the level of radioactivity and the associated dose rates present. The hot cells provide heavy shielding for high dose materials and the highest negative pressure for containment of higher levels of contamination. The glovebox systems provide containment for high levels of pure beta and alpha contaminated materials with lower levels of penetrating gamma dose.
The containment areas are maintained under a negative pressure with respect to surrounding areas by the exhaust system, and the air flow moves towards the areas of highest contamination. All air flowing from the contamination areas, and adjacent buffer areas, is exhausted through HEPA filters to the facility off-gas stack.

Secondary confinement is effectively the outer shell of the building and the inner walls surrounding the containment areas. Normally (i.e., with all doors closed), a small negative pressure relative to the atmosphere (about -0.05 in. water) is maintained in the secondary containment areas by air exhaust through the hot cells, gloveboxes, and radiochemical hoods. Filtered outside air is provided through supply fans located in the equipment room (Room 200) and building in-leakage. All air from the containment areas is exhausted from the building through tested High Efficiency Particulate Air (HEPA) filters.

During abnormal conditions (e.g., with airborne radioactivity in the secondary containment areas), the building can be put into containment by activating the scram or fire alarm systems. The "scram" system reduces the supply air provided, and the fire system shuts the supply fans down resulting in increased negative pressure in the containment areas.

2.7 Safety Support Systems

The RMAL Facility employs a standard complement of protective features including wet and dry standpipe sprinkler system, emergency showers, radiation monitoring instruments for detecting beta-gamma radiation, and continuous air monitors (CAMs) for detecting airborne contamination. Radiation monitors and CAMs provide warning of radiological hazards for personnel protection. These radiation monitoring instruments have locally audible alarms. Personnel radiation detection instrumentation (visual dosimeters, etc.) is provided where required and/or mandated by the ORNL Radiation Protection Procedures.

2.8 Utility Distribution Systems

Three phase electrical power for Building 2026 is provided from a 500-kVA transformer located at Transformer Station 6-2, on the north side of the RMAL Facility. The electrical distribution equipment is located in the second floor equipment room (Room 200). Electrical power (480-V, three phase) is provided to four motor control centers (MCC-1 through MCC-4) where it feeds various pumps, fans, hoists and miscellaneous 480 volt loads as well as four 480 to 208/120 volt transformers and distribution panels which provide normal lighting and standard 208/120 volt outlet power. The control center, MCC-3, is the emergency load center which powers the main (K-2) exhaust fans, emergency lighting, alarms and instrumentation through an automatic bus transfer system to a standby diesel generator on loss of normal power. The equipment room also contains the main water header, steam header, and plant air headers connected to the ORNL utility systems.

The facility is supplied plant steam at 110 psi (designed for 125 psi) which is immediately lowered to 50 psi (designed for 60 psi) next to the main shut-off valve. The 50 psi steam is lowered to 15 psi to provide the supply for the facility heating coils and hot water heaters. These heating coils and hot-water systems make-up 99% of the steam distribution in the facility. The 50 psi steam is used on a single system for distillation of water in an industrial still. None of the steam lines pass through any of the areas designed for nuclear/radiochemical work.

Plant air is supplied to the facility at 85-90 psi which is dropped to approximately 20 psi for the instrument air distribution system. The instrument air is not required for safe operation of the ventilation system (all systems fail to a maximum containment configuration). Process water is supplied to the facility at approximately 50 psi which is dropped to 30 psi for distribution throughout the facility. The facility is also supplied with natural gas which is distributed to the laboratories for the operation of laboratory scale bunsen burners and small torch systems for melting laboratory glassware (simple glass blowing operations).

2.9 Auxiliary Systems and Support Facilities

2.9.1 Facility Ventilation System

Filtered air is supplied to the containment areas of the building through the K-1 supply fans located in room 200. Also, since the containment areas of the facility are maintained at a negative pressure there is some air available through building in-leakage. The K-2 fans exhaust air from the containment areas through the hot cells, radiochemical hoods, or glovebox systems, to the facility HEPA filter system and out the 2026 stack. The non-regulated areas, (offices, equipment and change rooms), have separate ventilation systems (K-3 and K-4).

Under abnormal conditions, the building ventilation system is automatically changed to help prevent the release or spread of radioactive particles. Basically, this is done by reducing the amount of supply air to the containment areas and thereby increasing the negative pressure in those areas. More specifically, if there is a failure of both of the K-2 fans, indicated by a decrease in K-2 exhaust header vacuum below 0.16 in/H_2O for greater than three minutes, the K-1, K-3 and K-4 system fans are shut down. If the condition persists beyond five minutes, the building scram/evacuation system is activated. The building scram alarm system can also be activated manually at all exits from the main containment areas.

2.9.2 Facility Liquid Low Level Waste (LLLW) System

The RMAL operations may generate LLLW in the laboratories, gloveboxes, or hot cells. All LLLW generated in the facility is transferred to a waste management facility for further processing.

Low-level compactible solid radioactive waste, such as wipes used in decontamination activities, blotter paper, small glass and plastic laboratory supplies are packaged in accordance with applicable ORNL procedures and placed in a dumpster for compactible radioactive waste. When the dumpster is full, the waste is transferred to an ORNL solid waste are for compaction and disposal.

Low-level non-compactible solid radioactive waste, such as larger components of contaminated laboratory equipment, old glovebox systems, etc., are packaged in accordance with applicable ORNL procedures and placed in B-25 metal storage boxes for disposal in an ORNL solid waste area.

Any high dose solid waste is decontaminated to satisfy the waste acceptance criteria for the low-level forms of solid waste. The liquid waste generated during the decontamination process is transferred to the LLLW system as specified above.

2.10 References

1. DOE Order 420.1, *Facility Safety*, Change 2, U.S. Department of Energy, Washington, D.C., October 24, 1996.

2. DOE Order 5820.2A, Radioactive Waste Management, U.S. Department of Energy, Washington, D.C., September 26, 1988.

3. DOE-STD-1021-93, *Natural Phenomena Hazards performance Categorization Guidelines for Structures, Systems, and Components*, Change Notice #1, U.S. Department of Energy, Washington, D.C., January 1996.

4. DOE Order 5480.28, *Natural Phenomena Hazards Mitigation*, U.S. Department of energy, Washington, D.C., January 15, 1993.

5. DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, Change Notice #1, U.S. Department of Energy, Washington, D.C., January 1996.

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CHAPTER 3
HAZARD AND ACCIDENT ANALYSES

3.1 Introduction

The objective of this chapter is to systematically identify and evaluate the hazards present in the Radioactive Materials Analytical Laboratory, Building 2026. The results of the hazard analysis are then used to evaluate the potential internal and external events that can cause the identified hazards to develop into accidents.

This chapter contains the following information:

- Description of the methodology for and the approach to hazard and accident analysis.
- Identification of the hazardous materials and energy sources present by type, quantity, form, and location.
- Nuclear hazard classification in accordance with DOE-STD-1027-92[1].
- Non-nuclear classification in accordance with ES/CSET-2/R2[2].
- Identification in the hazard analysis of the spectrum of potential accidents at the facility in terms of qualitative consequence and frequency estimates.

3.2 Requirements

The requirements for accident analysis are contained in DOE Order 5480.23[3]. Recommended practices for hazard screening, accident selection, and accident analysis are included in DOE-STD-1027-92, DOE-STD-3009-94[4], and ES/CSET-2/R2.

3.3 Hazard Analysis

This section describes the hazard identification, classification, and evaluation performed for the RMAL facility. <u>Hazard identification</u> involves the systematic identification of the hazardous materials and/or energy sources associated with the facility that can affect the public and/or workers. <u>Hazard classification</u> provides a relative ranking of the facility in terms of unmitigated consequences of accidents involving the unusual hazards identified. The <u>hazard evaluation</u> process results in identification of potential accidents involving the identified hazards and their consequences. These accidents can be binned according to predefined consequences and the likelihood ranking thresholds to determine the need for detailed accident analysis. The basic flowchart for hazard/accident analysis used for the RMAL is provided in Figure 3-1.

3.3.1 Methodology

This section presents the methodology used to identify and characterize hazards and to perform a systematic evaluation of basic accidents. The basic accidents are identified by type (fire, explosion, spill, etc.) and by category (operational, natural phenomena, and external).

3.3.1.1 Hazard Identification Methodology

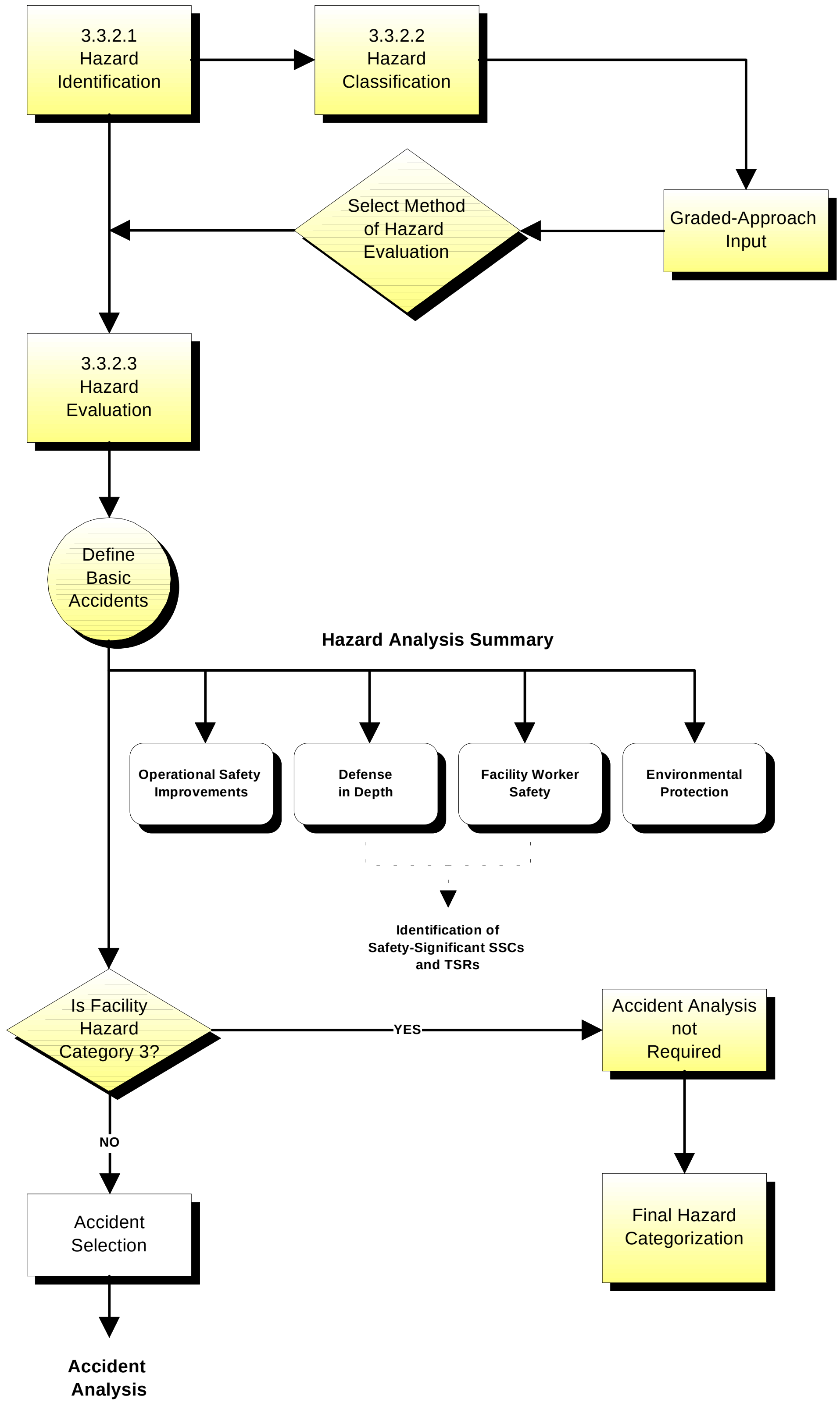
Hazardous materials and energy sources associated with RMAL operations were identified in terms of quantity, form, and location. To facilitate the hazard identification process the overall facility structures and processes were divided into smaller discrete systems (i.e. glovebox laboratories, hot cell operations, and radiochemical laboratory operations). The hazards in the individual systems were identified by using a checklist provided in ES/CSET-2/R2. Hazards were identified by reviewing facility documentation, drawings, and by conducting discussions with experienced operations staff. The hazards are grouped into the following 19 general hazard types:

! Radiological Hazards Associated with Ionizing Radiation
- Radioactive materials (including fissionable material)
- Radioactive surface contamination
- Radioactive waste

! Non-radiological Hazards Associated with Dangerous Properties of Materials
- Toxic materials (including combustion products)
- Carcinogens
- Biohazards
- Asphyxiants
- Flammable materials
- Reactive materials
- Explosive materials
- Incompatible chemical reaction products

! Non-radiological Hazards Associated with Energy Sources
- Electrical energy sources
- Kinetic energy sources
- Thermal energy sources
- High pressure sources
- Potential energy sources
- Lasers
- X-ray machines

Figure 3-1 Flowchart for Performing RMAL Hazard Analysis



The hazards identified were analyzed and screened in accordance with the criteria in ES/CSET-2/R2, 40 CFR 302.4[5], and DOE-STD-1027-92 to eliminate from further consideration the insignificant, routine, and standard industrial hazards.

Insignificant and routine hazards were considered to be those of the type and magnitude routinely encountered by the public and workers in everyday life and the workplace (equal to or lower in magnitude than the preliminary hazard screening criteria in ES/CSET-2/R2). Standard industrial hazards were considered to be those hazards that are not insignificant or routine, but are encountered in general industry in appropriate applications that are adequately controlled by the Occupational Safety and Health Administration (OSHA) regulations or one or more national consensus standards [e.g., American Society of Mechanical Engineers (ASME), American National Standards Institute (ANSI), National Fire Protection Association (NFPA), Institute of Electrical and Electronics Engineers (IEEE), National Institute of Standards and Technology (NIST)]. These standards are adequate to define special safety requirements, unless the hazards are in quantities or situations that can significantly impact large numbers of people.

The hazards that were not screened out as insignificant and routine hazards were evaluated to determine if they could be considered standard industrial hazards. For hazards screened out as standard industrial hazards, the regulations and standards used to control the hazards are stated in the DOE approved (September 1996) set of ORNL Work Smart Standards (WSS) for Radiochemical Research Facilities.

3.3.1.2 Hazard Classification Methodology

Operations in the RMAL can involve both nuclear and non-nuclear hazards. Therefore, both nuclear and non-nuclear hazard classifications are specified for the RMAL operations performed in the facility. The categorization logic for the preliminary nuclear facility classification is shown in Fig. 3-2, and the similar logic used for the non-nuclear operations is shown in Fig. 3-3.

DOE Order 5480.23 states that "*...contractors shall be required to perform a hazards analysis of their nuclear activities and classify their processes, operations, or activities... The consequences of unmitigated releases of radioactive and/or hazardous material shall be evaluated and classified by the following categories:*"

- Category 1: The hazard analysis shows the potential for significant off-site consequences.
- Category 2: The hazard analysis shows the potential for significant on-site consequences.
- Category 3: The hazard analysis shows the potential for only significant localized consequences.

Facilities which are shown to pose no "*significant localized consequences*" are assumed to be "*Radiological*" facilities.

Nuclear Classification Methodology

The RMAL will be operated as a Category 3 facility per DOE Order 5480.23 as further clarified in DOE-STD-1027-92. Therefore, the nuclear material inventory at the RMAL will be restricted such that the total facility inventory remains below the Category 2 threshold quantities (TQs) listed in DOE-STD-1027-92.

Non-nuclear Classification Methodology

The preliminary non-nuclear classification for chemical hazards is determined by comparing the identified inventories with Reportable Quantity (RQ) values in 40 CFR 302.4 and TQ in 29 CFR 1910.119[6] or 40 CFR 355[7]. The non-nuclear facility hazard classifications based on chemical inventory are summarized in Table 3-1. Significant chemical hazards (greater than 40 CFR 302.4 RQs) are evaluated for the consequential health effects using the methodology from ES/CSET-2/R2.

Based upon ES/CSET-2/R2 (Section 3.6, *Material Excluded from Hazard Identification*), small quantities of hazardous materials may be excluded if a laboratory meets requirements of 29 CFR 1910.1450[8] (OSHA Laboratory Standard). Laboratory use of these chemicals must not involve "production" and testing should be on a scale smaller than pilot-plant operations. The RMAL is a analytical chemistry laboratory that meets the conditions stated above and all operations meet the requirements of 29 CFR 1910.1450. Therefore, all laboratory chemicals are excluded from the hazard identification process for this analysis.

Table 3-1 Non-nuclear Hazard Classification Criteria

Hazard Classification	Classification Criteria
Industrial	Chemical inventory less than RQ values in 40 CFR 302.4
Low	Chemical inventory is greater than "**Industrial**" but less than TQs listed in 29 CFR 1910.119 and 40 CFR 355
Moderate	Chemical inventory is greater than "**Low**"
High	Reserved for extremely hazardous materials with the potential to cause serious consequences to large numbers of people, both on-site and off-site

[a] If the inventory exceeds the "Industrial" criteria but it can be shown that the hazardous materials are routine or the consequences resulting from accidents involving the hazardous materials are negligible to on-site and off-site receptors, a "Low" classification can be downgraded to "Industrial".

Figure 3-2 Logic Flow Diagram for Preliminary Nuclear Facility Classification

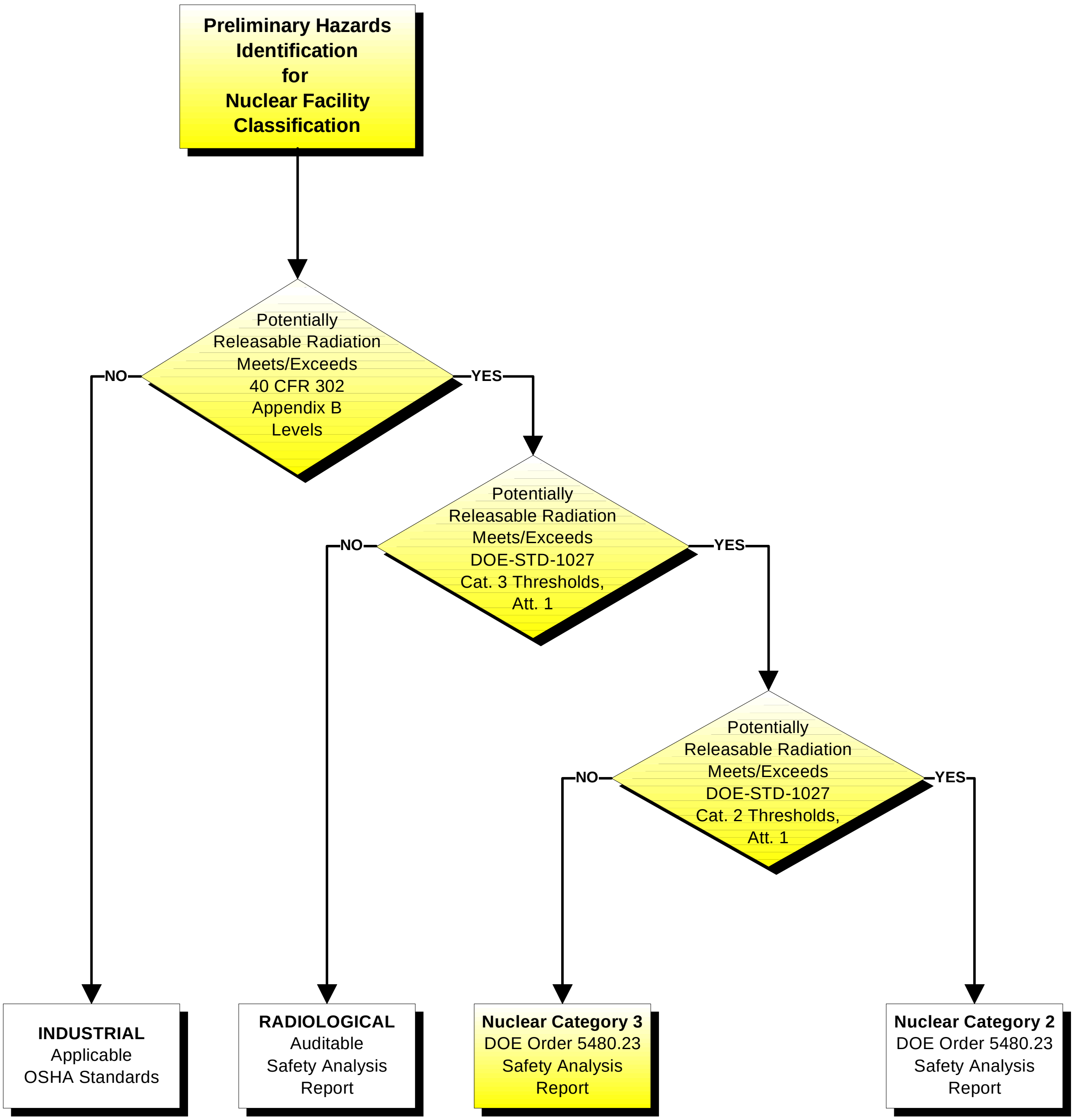
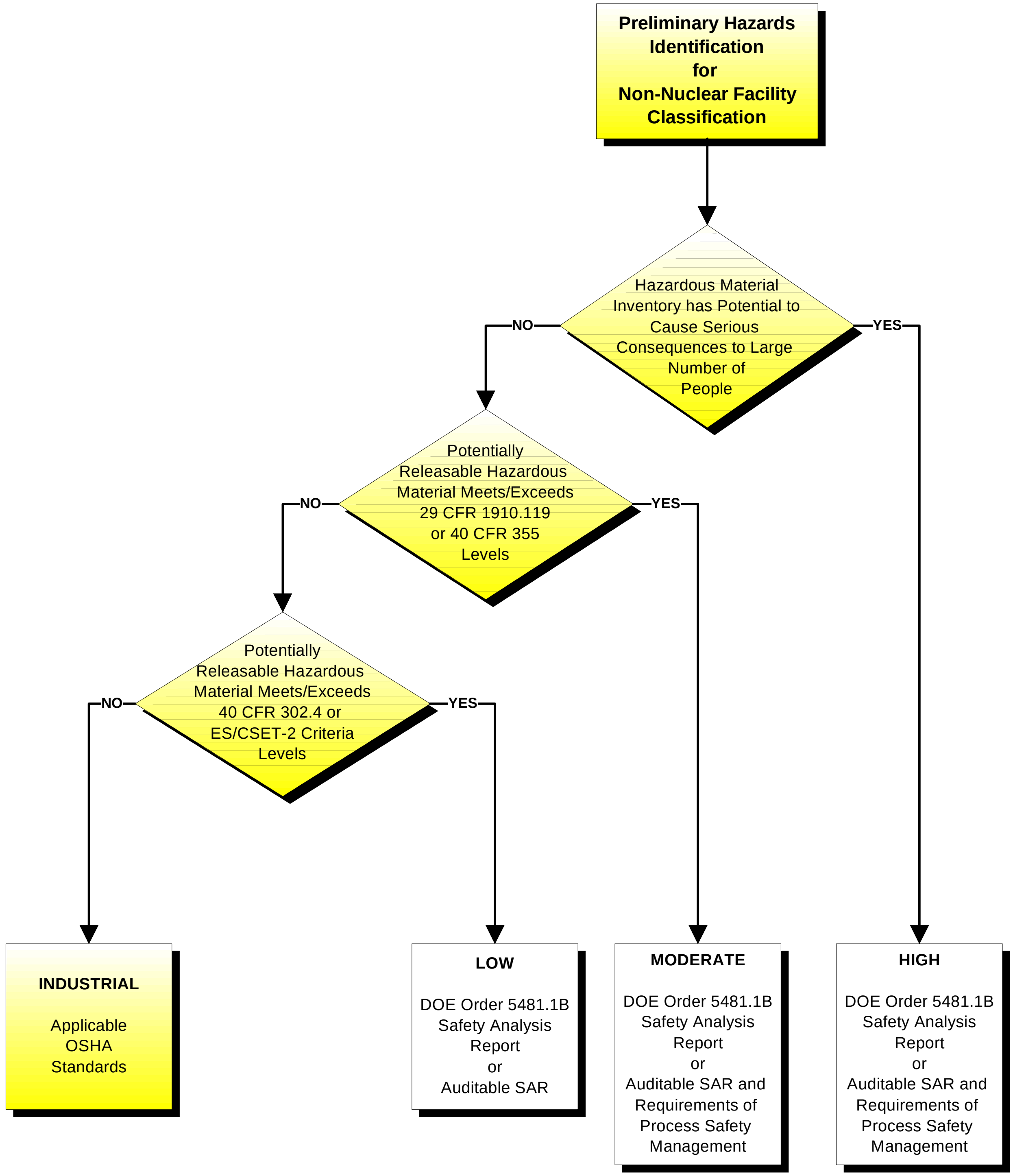


Figure 3-3 Logic Flow Diagram for Preliminary Non-nuclear Facility Classification



3.3.1.3 Hazard Evaluation Methodology

The purpose of the hazard evaluation is to identify possible accident scenarios that could result from failure to control the unusual hazards that were identified. These accident scenarios are then qualitatively evaluated to determine possible consequences, frequency, and associated risk in order to determine if more detailed accident analysis is needed. A Process Hazards Analysis (PHA) was used as the hazard evaluation method for the RMAL facility. The PHA technique is appropriate for the RMAL facility since there are no complex systems or operations.

The RMAL will be operated as a Nuclear Hazard Category 3 Facility and by definition cannot release the quantities of materials which could threaten workers at adjacent facilities, the public, or the environment. The Hazard Analysis alone should be sufficient to identify important release mechanisms for the level of hazard present in a Category 3 facility. The focus of the analysis is to identify unique or non-routine scenarios which could have significant adverse effect on workers in the facility and to demonstrate that there are sufficient preventative or mitigative features to protect them.

In the PHA, the hazards and accidents scenarios were described, frequency and consequence were estimated for each scenario, and the scenarios were binned into qualitative risk categories consistent with the guidelines provided in DOE-STD-3009-94 and DOE-STD-1027-92. Key features or controls which act to prevent, detect, or mitigate the accidents were also identified. The last step of the PHA was to address the adequacy of the existing hazard controls and need for more detailed accident analysis. Each step in the PHA process is described in more detail in the following sections.

<u>Scenario Development</u>

Accident initiators were identified that can lead to a failure to control the hazards in each of the facility operating modes. These operating modes do not apply to the non-containment areas of the facility (office areas and south addition). The following modes of operation were considered: |

OPERATIONAL A mode in which the affected process area of the facility is performing intended mission activities (e.g. analysis and testing of samples/specimens that contain less than the Category 2 threshold quantities of radioactive material). Decontamination, maintenance and/or repair activities may be performed during this mode of operation. Radiological work is authorized throughout the facility and performed under a routine Radiological Work Permit (RWP), as applicable

STANDBY Radioactive materials are present and limited to below category 2 threshold quantities. Activities involving radioactive materials may not be performed without a job specific RWP and/or approval by the Facility Manager following an evaluation of the area(s) affected by the STANDBY mode. The STANDBY mode is mostly used for maintenance activities where one or more of the containment systems, such as the exhaust side of the ventilation system, are temporarily taken out of service for repair or maintenance. |

For the purpose of this process hazard analysis, accidents were evaluated for both modes of operation because the same hazards are present in each mode.

A checklist of potential internal and external initiating events was developed through a review of industry standards, the facility design, physical construction, expected processes, and discussions with facility personnel. These potential initiating events were reviewed to identify accidents that could involve the unusual hazards identified in the hazard identification. Events which could not occur in the facility, had an annual probability of less than 10^{-6}, or were of obvious insignificant consequence were screened from further consideration. Scenarios to be evaluated in the PHA were developed by grouping together accident initiators of similar frequency that result in the same accident.

Frequency Estimates

The frequencies of accidents leading to a release were based on a semi-quantitative evaluation of general accident initiator multiplied by an approximate number of operations multiplied by a conditional probability of release, given the initiator.

Table 3-2 Qualitative Accident Frequency Ranges

Frequency category	Estimated frequency of occurrence	Description
Anticipated	$10^{-1} \$ p > 10^{-2}$	Incidents that may occur during the lifetime of the facility (common occurrences).
Unlikely	$10^{-2} \$ p > 10^{-4}$	Accidents that are not anticipated to but could occur during the lifetime of the facility.
Extremely Unlikely	$10^{-4} \$ p > 10^{-6}$	Accidents not expected to occur during the lifetime of the facility.

Consequence Estimates

The general approach for the consequence estimates was to calculate (or reference similar facility conditions) the consequences for reasonable worst case accident scenarios and then estimate the consequences of lesser releases qualitatively by comparison to these scenarios. Low, moderate, and high consequence ranges were established using the evaluation guidelines in Table 3-3 and Table 3-4. The resulting consequence ranges are listed in Table 3-5. The Analysis Guidelines for identification of Safety-Significant SSCs are summarized in Table 3-6. All hazards related to chemicals were determined to have low or negligible consequences because of the limited inventory of chemicals in the facility (i.e. laboratory quantities).

Table 3-3 Evaluation Guidelines for Internal/External Manmade Accidents

Accident Frequency (per year)	On-site		Off-site	
	Radiological Guidelines	Toxicological Guidelines	Radiological Guidelines	Toxicological Guidelines
10^{-2} # $f < 10^{-1}$	5 rem	ERPG-3 dosage	0.5 rem	ERPG-2 dosage
10^{-4} # $f < 10^{-2}$	25 rem	ERPG-3 dosage	5 rem	ERPG-2 dosage
10^{-6} # $f < 10^{-4}$	100 rem	ERPG-3 dosage	25 rem	ERPG-2 dosage

Note: If Emergency Response Planning Guideline (ERPG) information is not available, the Evaluation Guideline shall be the Immediately Dangerous to Life and Health (IDLH) concentration for ERPG-3 or one-tenth of the IDLH concentration for ERPG-2 or any better toxicological information available to indicate estimated dosages do not represent a potential health threat in excess of the ERPG-2 or ERPG-3 definition.

Table 3-4 Evaluation Guidelines for Natural Phenomenon Accidents

Accident Frequency (per year)	On-site		Off-site	
	Radiological Guidelines	Toxicological Guidelines	Radiological Guidelines	Toxicological Guidelines
Initiating frequency defined by DOE Order 5480.28	None	None	25 rem	ERPG-2 dosage

Table 3-5 Accident Scenario Consequence Ranges

Description	Range				
	Nuclear Hazard Committed Effective Dose Equivalent (CEDE) (d in rem)			Non-nuclear Hazard Airborne concentration (c)	
	On-site[1,2]	Public[3]		On-site[1,2]	Public[3]
		Man-made Events	Natural Phenomena		
Low	d < 5	d < 0.5	d < 25	c # ERPG-3	c # ERPG-2
Moderate	5 # d < 25	0.5 # d < 5	n/a	n/a	n/a
High	25 # d < 100	5 # d < 25	25 # d	ERPG-3 < c	ERPG-2 < c

1. Per DOE-STD-3009-94, no quantitative numerical guidelines for evaluation of consequences to facility workers have been established. Detailed analysis for facility workers is considered for accidents involving a prompt death or multiple serious injuries depending on the accident, hazard involved, and worker safety program applicable.
2. Not applicable to natural phenomena events. On-site natural phenomena evaluation guidelines are not required for safety assurance.
3. Consequences to the public are evaluated at the nearest point at which the public may not be controlled in time of an emergency.

Table 3-6 Analysis Guidelines for Safety-Class and Safety-Significant SSCs

Consequence Threshold Criteria	Consequence	Analysis Guideline: Extremely Unlikely Event	Analysis Guideline: Unlikely Event	Analysis Guideline: Anticipated Event
Radiological Offsite - > 25 rem at 200 m (offsite boundary)	High Consequence	SAFETY-CLASS SSCs REQUIRED	SAFETY-CLASS SSCs REQUIRED	SAFETY-CLASS SSCs REQUIRED
Radiological Onsite - > 100 rem at 200 m Worker - prompt death **Chemical** Offsite - > ERPG 2 at 200 m Onsite - > ERPG 3 at 30 m Worker - prompt death	High Consequence	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs
Radiological Offsite - > 5 rem at 200 m Onsite - > 25 rem at 30 m Worker - serious injury **Chemical** Offsite - N/A Onsite - N/A Worker - N/A	Moderate Consequence	NO SAFETY-SIGNIFICANT SSCs REQUIRED	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs
Radiological Offsite - > 0.5 rem at 200 m Onsite - > 5 rem at 30 m Worker - significant injury **Chemical** Offsite - > ERPG 1 Onsite - > ERPG 2 at 30 m Worker - significant injury	Low Consequence	NO SAFETY-SIGNIFICANT SSCs REQUIRED	NO SAFETY-SIGNIFICANT SSCs REQUIRED	EVALUATE THE NEED FOR SAFETY-SIGNIFICANT SSCs
Radiological Offsite - < 0.5 rem at 200 m Onsite - < 5 rem at 30 m Worker - no significant injury **Chemical** Offsite - < ERPG 1 Onsite - < ERPG 2 at 30 m Worker - no significant injury	Negligible Consequence	NO SAFETY-SIGNIFICANT SSCs REQUIRED	NO SAFETY-SIGNIFICANT SSCs REQUIRED	NO SAFETY-SIGNIFICANT SSCs REQUIRED

Accident Frequency Range

The calculations for the non-nuclear consequences are shown in Attachment E. A bounding accident was evaluated and it was assumed that the accident involved a release of hazardous chemicals used at the RMAL Facility. The on-site and off-site consequences were estimated using a Gaussian plume dispersion model. A conservative airborne concentration was determined for the accident and the consequences were compared to the ERPG concentration to determine if the severity of the consequence was "Low", "Moderate", or "High". All the remaining accidents were qualitatively compared to the bounding accident (i.e., if another accident involved one-half of the hazardous chemicals used in the RMAL Facility, the consequences were estimated to be equal to one-half of the bounding consequences).

The bounding conditions for the nuclear consequences are based on the model used in DOE-STD-1027-92, Appendix A, *Calculation of Category 2 Radiological Thresholds*. Since the RMAL Facility will operate as a Category 3 facility per DOE Order 5480.23, the nuclear material inventory will be restricted and controlled by facility procedures such that the total facility inventory remains below the Category 2 threshold quantities listed in DOE-STD-1027-92.

Risk Matrix

Using the accident frequency and consequence ranges discussed above, a three-by-three risk matrix was constructed to assign risk categories, evaluate the adequacy of existing controls, and/or determine the need for more detailed accident analysis. An example of the risk matrix is provided in Fig. 3-4. Additional analysis and controls were not considered necessary if the PHA did not identify any scenarios in risk categories of major concern.

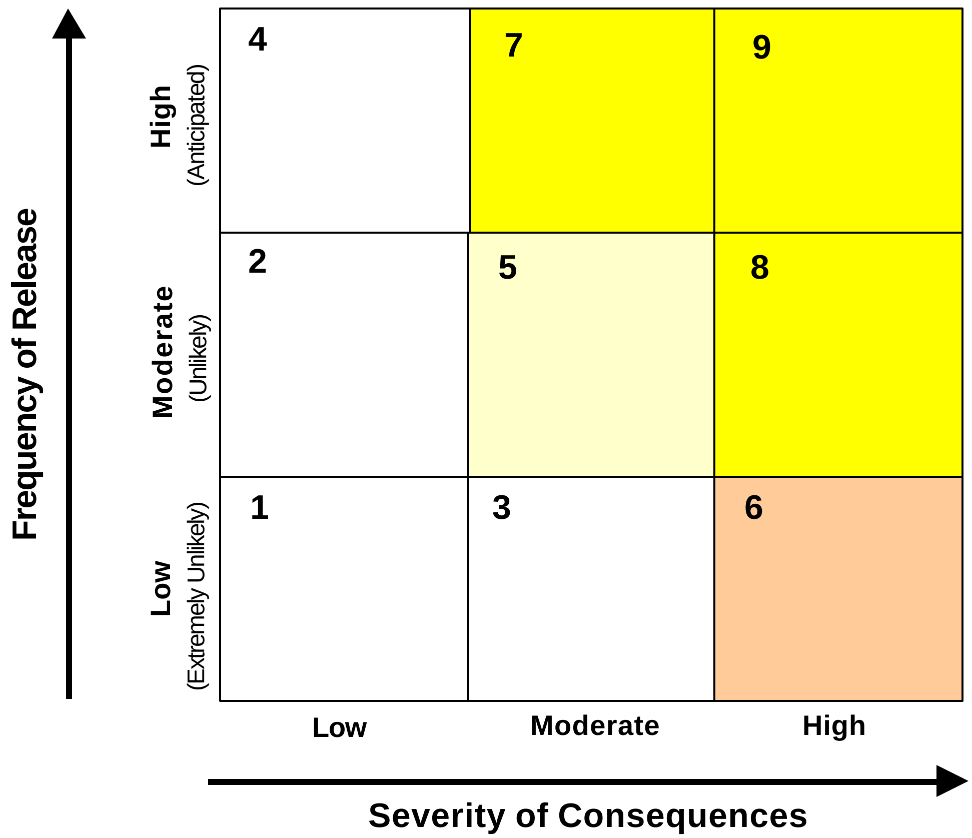
3.3.2 Hazard Analysis Results

This section contains results of the hazard analysis including hazard identification, hazard classification, and hazard evaluation.

3.3.2.1 Hazard Identification

In order to facilitate the hazard identification process, and to ensure complete identification of possible hazards, the facility is divided into five segments. The following segments were used for hazard identification: (1) Non-Radiological Areas, (2) Equipment and Utility Areas, (3) Filter Bank and Stack Area, (4) Radiological Laboratory Areas (both hood and glovebox laboratories), and (5) Hot Cell Containment Area.

Figure 3-4 Example of Three-by-Three Risk Matrix



RISK

Very High	Combinations of conclusions from risk analysis that identify situations of major concern.
High	Combinations of conclusions from risk analysis that identify situations that may be of major concern for some accidents.
Moderate	Combinations of conclusions from risk analysis that identify situations of concern.
Low	Combinations of conclusions from risk analysis that identify situations that require qualitative analysis only.

The identified facility hazards and the comparison of these hazards to the selection criteria are given in the Preliminary Hazard Screening, Attachment A. The hazards that exceeded the selection criteria were retained for further characterization as insignificant, routine, standard industrial, or unusual. These characterizations are given in Attachment B, Hazard Identification Matrix. Only those hazards identified as unusual were retained for further evaluation. The hazards identified as unusual for the RMAL Facility are radioactive material (including fissionable materials), radioactive surface contamination, radioactive waste, and toxic materials. Each of these unusual hazards is discussed in further detail in the following paragraphs. It should be noted that any hazards screened out in Attachment A or Attachment B were considered as potential initiating events for accidents involving the identified unusual hazards.

The facility is an analytical chemistry operation which involves the handling of a large variety of materials and chemicals. Since this is a laboratory operation all of these materials would be classified as a limited quantity process materials since all analytical samples are typically small in volume or mass and there is very low potential for explosions in hot cells or gloveboxes.

Over the years large quantities of acids were used to dissolve or process samples and there was some condensed material build-up in the ventilation system. Because some of these past operations used perchloric acid the facility duct work was steam cleaned and inspected to ensure no high levels of perchlorate salts were present. This duct cleaning was performed a few years ago and there has been no use of "hot" perchloric acid since the work was completed. Current requirements restrict the use of "hot" perchloric acid in radiochemical hoods, gloveboxes, and cells to prevent this problem from occurring again. The only materials currently used in large enough quantities to result in a significant build-up are the mineral acids used to dissolve samples. These type of acids do not result in explosive salts.

Radioactive Material (including fissionable material)

Radiological hazards include both fissionable and radioactive material hazards. The facility is an analytical chemistry operation that supports a wide variety of work including: R&D activities, actinide production, reactor operations, nuclear fuel processing, and waste characterization. Therefore, the radionuclide inventory can be very broad including thorium, uranium, transuranium elements such as neptunium, plutonium, americium, curium, and californium, and both fission and activation products such as cobalt, cesium, strontium, iodine, and europium, among others. In addition to the radionuclide inventory from samples and standards, radioactive material hazards are also present in the form of surface contamination within containment enclosures, ventilation ducts, and HEPA filters. Typical amounts of radioactive material handled by the RMAL Facility are listed in Table 3-7.

The inventory control for the facility is based on the combinations of radioactive materials that are present. The sum of the ratios of the quantity of each radioactive nuclide to the corresponding Category 2 thresholds must not exceed one (1.0) as follows:

$$\sum_{i}^{n} \left[\frac{Isotope\ A_i}{Cat.\ 2\ Threshold\ for\ A_i} \right] < 1.0$$

Trace levels of fissionable radionuclides (uranium, neptunium, plutonium, americium, and curium) are typically present in analytical samples and radiochemical standards. Due to airborne particulate emissions from analytical operations, residues from these fissile radionuclides have been deposited in very low quantities in the gloveboxes, hot cells, in ventilation duct work, on HEPA filters, and as surface contamination on equipment and other containment enclosures. The total of these residues and traces is so small and so widely dispersed that it can be and is not included in the calculation of the fissile material inventory for the RMAL facility.

A list of fissionable materials are included in the procedure ORNL/NS-P02[9], *Nuclear Criticality Safety Program*. Typical amounts of fissionable material found in analytical samples are well below the Fissile Material Control Limits (FMCL) as listed in Table 3-8. The ORNL Nuclear Criticality Safety Program requires additional levels of control, review, and approvals when either a fissile isotope exceeds the FMCL value listed in Table 3-8 or if the sum of the fissile isotopes divided by the FMCL exceeds one (1). Additional review and approval is required if the quantity of fissile material exceeds the Significant Amounts of Fissionable Material (SAFM) limits listed in Table 3-8. All operations with fissile material in the RMAL will be in compliance with the ORNL Nuclear Criticality Program.. The inventory of fissile isotopes permitted in the facility will not exceed the SAFM limits listed in Table 3-8.

Radioactive Surface Contamination

The internal surface areas of the hot cells, gloveboxes, and radiochemical hoods contain various quantities of radioactive surface contamination. The contamination is on the walls, floor, equipment, and materials located in these areas. Additional general comments concerning surface contamination areas are provided above in the section on Radioactive Materials. There is potential for direct external radiation exposure and internal/external exposure due to an airborne release following an accident. Therefore, these hazards must be evaluated further.

Radioactive Waste

Radioactive waste is generated in various locations in the RMAL Facility. Some operations generate solid waste, and other processes involve washing contaminated samples and/or equipment with various chemicals. These various processes generate small quantities of liquid radioactive waste which is transferred to the LLLW system. Additional general comments on radioactive waste are provided in the section above under Radioactive Materials. There is potential for direct external radiation exposure and internal/external exposure due to an airborne release following an accident. Therefore, these hazards must be evaluated further.

Toxic Material

The RQ values listed in 40 CFR 302.4 are intended to identify facilities and processes with toxic material hazards that can have significant toxic consequences to on-site and off-site personnel during and following accidents. Most RQs are based on a pure chemical form that is susceptible to airborne release when spilled, heated, or ignited. The lowest listed RQ for hazardous chemicals is one pound. None of the hazardous chemicals on the RMAL laboratory inventory exceed the RQ values. However, two sources of hazardous material required for facility operations include lead shielding and concentrated zinc bromide solution used for shielding in the hot cell windows. Therefore, the toxic materials hazard is retained for further evaluation of the lead and zinc bromide.

Hazard Identification Summary

Radioactive materials (including fissionable materials), radioactive surface contamination, radioactive waste, and toxic materials lead and zinc bromide were the only unusual hazards identified that are associated with the RMAL Facility. These hazards require further evaluation. All of the other hazards were determined to be insignificant, routine, or standard industrial hazards.

Occupational Hazards. Other occupational hazards not discussed above include: flammable materials, explosive and pyrophoric materials, electrical energy, thermal energy, kinetic energy, potential energy, lasers, and x-ray machines.

Flammable materials. The flammable material hazards discussed in the section are limited materials with flash points of less than 100ºF. All other materials are considered as combustible materials and are not discussed in this section. Flammable materials, if they spill or leak and are subsequently ignited, can result in burns and/or the inhalation of smoke/toxic vapors. In addition, flammable materials can result in a fire that may be an initiating event for a release of radioactive materials from confinement.

There are no significant sources of flammable materials used in the RMAL operations. There are flammable materials present in small amounts that are common to general laboratory operations in the industry. Therefore, flammable materials are not considered an unusual hazard and are not evaluated further.

Explosive/pyrophoric materials. Small quantities of explosive material may be handled in the facility as analytical samples or standards. The total amount of explosive material will not exceed the limits of 49 CFR Division 1.1 and 1.2 (Class A Explosives), 1.3 (Class B Explosives); or 10 oz. of Division 1.4 (Class C Explosives). Therefore, no further evaluation of explosive material is required.

Small quantities of pyrophoric material are handled as analytical samples or as analytical reagents or standards. The total amount of pyrophoric materials present in the facility are typical for laboratory operations and would not be a significant hazard. Therefore, no further evaluation of pyrophoric materials is required.

Electrical energy sources. Electrical power is used throughout the facility for instrumentation and equipment. The maximum voltage used by the facility is 480 volts. No unusual sources of electrical hazards are present, and the risk to operating personnel is controlled by adhering to national codes and standards used in industry. The electrical energy source is a routine hazard encountered in general industrial and public facilities and is not considered for further evaluation. Potential fires from shorts in the electrical power system are the only accidents identified that may be initiated by the identified electrical energy hazard sources.

Thermal energy sources. There are no significant thermal energy sources beyond what is routinely encountered in general industrial and public facilities. Therefore, thermal energy source hazards are not evaluated further.

Kinetic and potential energy sources. There are numerous sources of rotational kinetic energy which may include facility equipment such as the ventilation fans, fan belts, and pulleys, among others. Failure of rotating equipment can result in operator injury and/or damage to equipment if projectiles are generated and operating personnel are nearby. Rotational kinetic energy is a routine hazard encountered in general industrial and public facilities and is not considered for further evaluation.

There are several overhead cranes located within the facility that are a source of potential energy hazards. Structural failure due to inadequate support can cause equipment to fall on or hit personnel. These sources of potential energy are common to general industrial and public facilities and are not considered for further evaluation from the perspective of their own intrinsic hazard. The potential energy sources can initiate accidents involving other hazard sources in the facility (i.e. dropping a shielded carrier). These potential energy sources are evaluated further as accident initiators.

The potential energy sources associated with high pressure systems are industrial hazards such as the rupture of a line, valve, or pressure relief device when pumps are operating. ORNL has a program to provide special review and approval for these high pressure systems. The ORNL Office of Safety and Health Protection administers the safety review program. Therefore, the potential energy hazard is screened out and is not considered for further evaluation.

Table 3-7 Typical RMAL Inventory of Radioactive Material

Isotope	Half-life (yr)	Specific Activity (Ci/g)	DOE-STD-1027-92 Threshold Quantity		Radionuclide Inventory		Percent of Cat. 2 (%)
			Cat. 2 (g)	Cat. 2 (Ci)	RMAL (g)	RMAL (Ci)	
H-3, water	1.23E+01	9.666E+03	3.00E+01	2.90E+05	1.03E-04	1.00E+00	0.000%
C-14	5.73E+03	4.457E+00	3.10E+05	1.38E+06	2.24E-02	1.00E-01	0.000%
Co-60	5.27E+00	1.131E+03	1.70E+02	1.92E+05	8.85E-05	1.00E-01	0.000%
Ni-63	1.00E+02	5.675E+01	8.00E+04	4.54E+06	1.76E-08	1.00E-06	0.000%
Sr-90	2.88E+01	1.379E+02	1.60E+02	2.21E+04	7.25E-02	1.00E+01	0.045%
Cs-134	2.06E+00	1.294E+03	4.60E+01	5.95E+04	7.73E-05	1.00E-01	0.000%
Cs-137	3.02E+01	8.650E+01	1.00E+03	8.65E+04	1.16E-03	1.00E-01	0.000%
Eu-152	1.30E+01	1.809E+02	7.50E+02	1.36E+05	5.53E-06	1.00E-03	0.000%
Eu-154	8.50E+00	2.731E+02	4.20E+02	1.15E+05	3.66E-06	1.00E-03	0.000%
Eu-155	4.90E+00	4.708E+02	1.60E+03	7.53E+05	2.12E-06	1.00E-03	0.000%
Th-228	1.91E+00	8.198E+02	1.10E-01	9.02E+01	1.22E-09	1.00E-06	0.000%
Th-229	7.34E+03	2.127E-01	1.10E-01	5.50E+01	4.70E-06	1.00E-06	0.000%
Th-232	1.41E+10	1.093E-07	1.60E+08	1.75E+01	5.00E+02	5.47E-05	0.000%
U-233[b]	1.59E+05	9.639E-03	2.30E+04	2.22E+02	5.00E+00	4.82E-02	0.022%
U-234	2.45E+05	6.237E-03	3.50E+04	2.18E+02	5.00E-01	3.12E-03	0.001%
U-235[b]	7.04E+08	2.162E-06	1.10E+08	2.38E+02	1.40E+01	3.03E-05	0.000%
U-238	4.47E+09	3.362E-07	7.10E+08	2.39E+02	2.00E+03	6.72E-04	0.000%
Np-237	2.14E+06	7.050E-04	8.30E+04	5.85E+01	1.42E-02	1.00E-05	0.000%
Pu-238	8.77E+01	1.712E+01	3.60E+00	6.16E+01	2.92E-02	5.00E-01	0.811%
Pu-239[b]	2.44E+04	6.131E-02	9.00E+02	5.52E+01	4.05E+01	2.48E+00	4.500%
Pu-240	6.57E+03	2.268E-01	2.47E+02	5.60E+01	2.21E+00	5.00E-01	0.893%
Pu-241	1.44E+01	1.030E+02	2.80E+01	2.88E+03	4.85E-03	5.00E-01	0.017%
Pu-242	3.76E+05	3.929E-03	1.51E+04	5.93E+01	2.54E-03	1.00E-05	0.000%
Am-241	4.33E+02	3.426E+00	1.60E+01	5.48E+01	2.19E-01	7.50E-01	1.368%
Am-243	7.37E+03	1.996E-01	2.80E+02	5.59E+01	2.00E-02	4.00E-03	0.007%
Cm-243	2.85E+01	5.163E+01	1.07E+00	5.50E+01	3.87E-03	2.00E-01	0.364%
Cm-244	1.81E+01	8.096E+01	6.79E-01	5.50E+01	6.18E-02	5.00E+00	9.091%
Cm-245	8.50E+03	1.717E-01	3.10E+02	5.32E+01	5.82E-06	1.00E-06	0.000%
Cm-246	4.73E+03	3.073E-01	1.79E+02	5.50E+01	3.25E-04	1.00E-04	0.000%
Percent of Category 2 Total TQ Limit:							**17.121%**

[a] The quantities listed in this table are only provided to give the reader an approximation of the amount of radioactive material typically handled in the facility.

[b] The limits for these fissionable isotopes can only be used if segmentation or nature of process precludes potential for criticality. Otherwise, use the criticality limits for ^{233}U, ^{235}U, and ^{239}Pu of 500, 700, and 450 grams, respectively.

Table 3-8 Fissionable Material Administrative Control Limits and Typical RMAL Inventory

Nuclide	FMCL[a] (g)	SAFM[b] (g)	^{235}U fissile mass equiv. f_{35}	RMAL[c] Inventory (g)	$^{235}U_{eq}$ $m \times f_{35}$ (g)
U-233	185	500	1.4	5.00E+00	7.00E+00
U-235	250	700	1	1.40E+01	1.40E+01
Np-236	1.8	5	140	0.00E+00	0.00E+00
Np-237	7100	20000	0.035	1.42E-02	4.96E-04
Pu-238	1100	3000	0.23	2.92E-02	6.72E-03
Pu-239	160	450	1.56	4.05E+01	6.32E+01
Pu-240	5300	15000	0.047	2.21E+00	1.04E-01
Pu-241	70	200	3.5	4.85E-03	1.70E-02
Pu-242	14000	40000	0.018	2.54E-03	4.58E-05
Am-241	5700	16000	0.044	2.19E-01	9.63E-03
Am-242m	4.6	13	54	0.00E+00	0.00E+00
Am-243	8900	25000	0.028	2.00E-02	5.61E-04
Cm-243	32	90	7.8	3.87E-03	3.02E-02
Cm-244	1100	3000	0.23	6.18E-02	1.42E-02
Cm-245	11	30	23	5.82E-06	1.34E-04
Cm-247	320	900	0.78	0.00E+00	0.00E+00
Cf-249	3.6	10	70	2.44E-07	1.71E-05
Cf-251	1.8	5	140	6.30E-07	8.83E-05
				Total:	**84.1**
				Control Limit Criteria:	**< 700.0**

[a] Fissionable Material Control Limits as defined by ORNL procedure.
[b] Significant Amount of Fissionable Material as defined by ORNL procedure.
[c] The fissile material quantities listed are only provided here to give the reader an idea of the nominal amount of material typically handled in the facility.

Lasers. The "ORNL Laser Safety Program" applies to all laser usage above Class 1 lasers. The program requires hazard analysis for each Class 3b and/or Class 4 laser/laser system operation. The direct consequences from lasers are not included within the scope of the SAR since they are being evaluated and controlled by the Laser Safety Program.

X-ray machines. Any x-ray machines meeting ANSI N43.3[10] (*Non-Medical X-Ray and Sealed Gamma Ray Sources*), ANSI N43.2[11] (*X-Ray Diffraction and Fluorescence Analysis Equipment*), and/or ANSI 43.5[12] (*Radiographic and Fluoroscopic X-Ray Equipment*) requirements are considered standard industrial hazards and are screened out and not considered for further evaluation.

3.3.2.2 Hazard Classification

In order to facilitate the consequence based non-nuclear hazard classification process, the potential external and internal accident initiators were identified. Attachment C documents the checklist of initiating events, and those events that were retained for further evaluation. As discussed before, the RMAL Facility will be operated as a Category 3 facility and the nuclear material inventory will be restricted such that the total facility inventory remains below the Category 2 threshold quantities listed in DOE-STD-1027-92. After the hazards were identified and screened, the facility was assigned a nuclear and a non-nuclear hazard categorization based on the types and amounts of hazardous materials present in the facility. According to the criteria in section 3.3.1.2, the RMAL Facility is classified as a Nuclear Category 3 and a non-nuclear Industrial Hazard facility

Preliminary Non-nuclear Hazard Categorization

Small laboratory quantities of toxic, corrosive and reactive materials are routinely used in research and sample analysis at RMAL. These hazardous chemicals are defined by 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*, as substances for which there is evidence, from at least one scientific study, that health effects may occur in exposed persons. The requirements of 29 CFR 1910.1450 are implemented through site wide and divisional procedures. A site-wide Hazardous Material Protection Program provides for identification and control of hazardous materials and training of personnel to minimize occupational exposure to hazardous materials. The program has the following objectives:

- Minimize the potential for chemically related damage, illnesses, and/or injuries in the workplace.
- Informing employees of hazards that may be encountered in their work area.
- Maintaining exposure to hazardous materials As-Low-As-Reasonably-Achievable (ALARA).

The CASD Chemical Hygiene Plan, written in accordance with 29 CFR 1910.1450, covers all laboratory work areas in which hazardous chemicals are used. This plan sets general principles for work with laboratory chemicals and sets specific precautions for work with materials considered to be extremely hazardous. Engineering and administrative controls minimize the potential for ingestion of and inhalation exposure to hazardous materials. The plan documents performance required for the protection of employees against potential health hazards in the CASD laboratories.

Preliminary Nuclear Hazard Categorization

The RMAL operations consists of the following activities:

1. Sampling and analysis of radioactive materials.
2. Transferring radioactive material in/out of hot cells.
3. Transferring radioactive material in/out of glove box containment.
4. Transferring radioactive material between laboratories and radiochemical hoods.
5. Maintenance/testing/modifications of facility.
6. Operating support systems (ventilation system, etc.)

The preliminary nuclear hazard categorization for the facility was determined by comparing the radionuclide inventory with the corresponding Category 3 and Category 2 TQ values in DOE-STD-1027-92. Since the radionuclide inventory for the RMAL is constantly changing with sample load, the summary in Table 3-6 provides conservative estimates of major radionuclides handled compared by ratio to the Category 3 and Category 2 TQ values. In general, the sum of the Category 3 ratios exceeds one and the sum of the Category 2 ratios is significantly less than one.

3.3.2.3 Hazard Evaluation

This section presents the results of the hazard evaluation performed to: identify the accident scenarios to be evaluated; estimate of the frequency, consequences, and risk due to these scenarios; describe and evaluate the adequacy of the controls available to prevent, detect, or mitigate the accidents; and determine the need for more detailed accident analysis.

Scenario Development

The potential internal and external initiating events identified in Attachment C as retained for further evaluation remain applicable to scenario development for hazard evaluation. For simplicity, the initiating events were grouped together and evaluated as one accident scenario where they were in the same frequency range and resulted in the same accident. Table 3-9 lists the identified accident scenarios and shows which initiating events could lead to each accident. The accident scenarios were examined qualitatively in the PHA summary sheets, Attachment D. The accident scenarios are listed below:

Accident 1: External event causes damage to the facility and its systems resulting in loss of containment.

Accident 2: Contaminated solid waste stored in the facility is released to the environment.

Accident 3: Additional radioactive material is placed in the storage areas producing excessive dose rates in adjacent working areas.

Accident 4: Failure of glovebox containment releases radioactive material into the laboratory spaces.

Accident 5: Building ventilation systems fails to maintain negative pressure in the containment areas or fails to properly filter exhaust air prior to discharge from the facility.

Accident 6: Radioactive material relocated within the facility is left improperly shielded resulting in external exposure to personnel working in the area.

Accident 7: Loss of containment control of material results in personnel contamination and internal/external exposure.

Accident 8: Fire within a laboratory causes loss of containment and airborne dispersion of radioactive material into the immediate area.

Accident 9: Failure of hot cell window results in loss of zinc bromide and loss of shielding of radioactive materials.

Accident 10: Zinc bromide solution storage containers receive damage resulting in loss of chemical confinement.

Accident 11: Hot cell access is opened in error resulting in exposure to operating personnel.

Accident 12: Loss of carrier/cask control results in personnel exposure.

Accident 13: Liquid waste line is breached or sample container is dropped resulting in the introduction of radioactive liquid into the facility.

Frequency Estimates

A qualitative estimate of the annual probability of occurrence for each accident scenario is provided in the PHA summary sheets. These values are based upon the guidance in Table 3-2 and are considered to be conservative estimates of the frequency for a release of the magnitude specified.

Table 3-9 Initiating Events Leading to Identified Accidents

Initiating Event	Accident Scenarios												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Earthquake	U												
Tornado/High Winds/Missiles	U												
Lightning	U												
Extreme Cold													
Equipment Failure				U	U		U	U	U			U	U
Fire (internal)		U		U			U	U	U	U			
Explosions	U	U		U			U	U	U	U			U
Uncontrolled Chemical Reaction		U		U			U	U	U	U			
Flooding (internal)		U					U						

Initiating Event	Accident Scenarios												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Loss of Power													
Containment Failure				U			U		U	U			
Operator Error		U	U	U		U	U	U	U		U	U	U
Loss of Facility Services					U								

Consequence Estimates

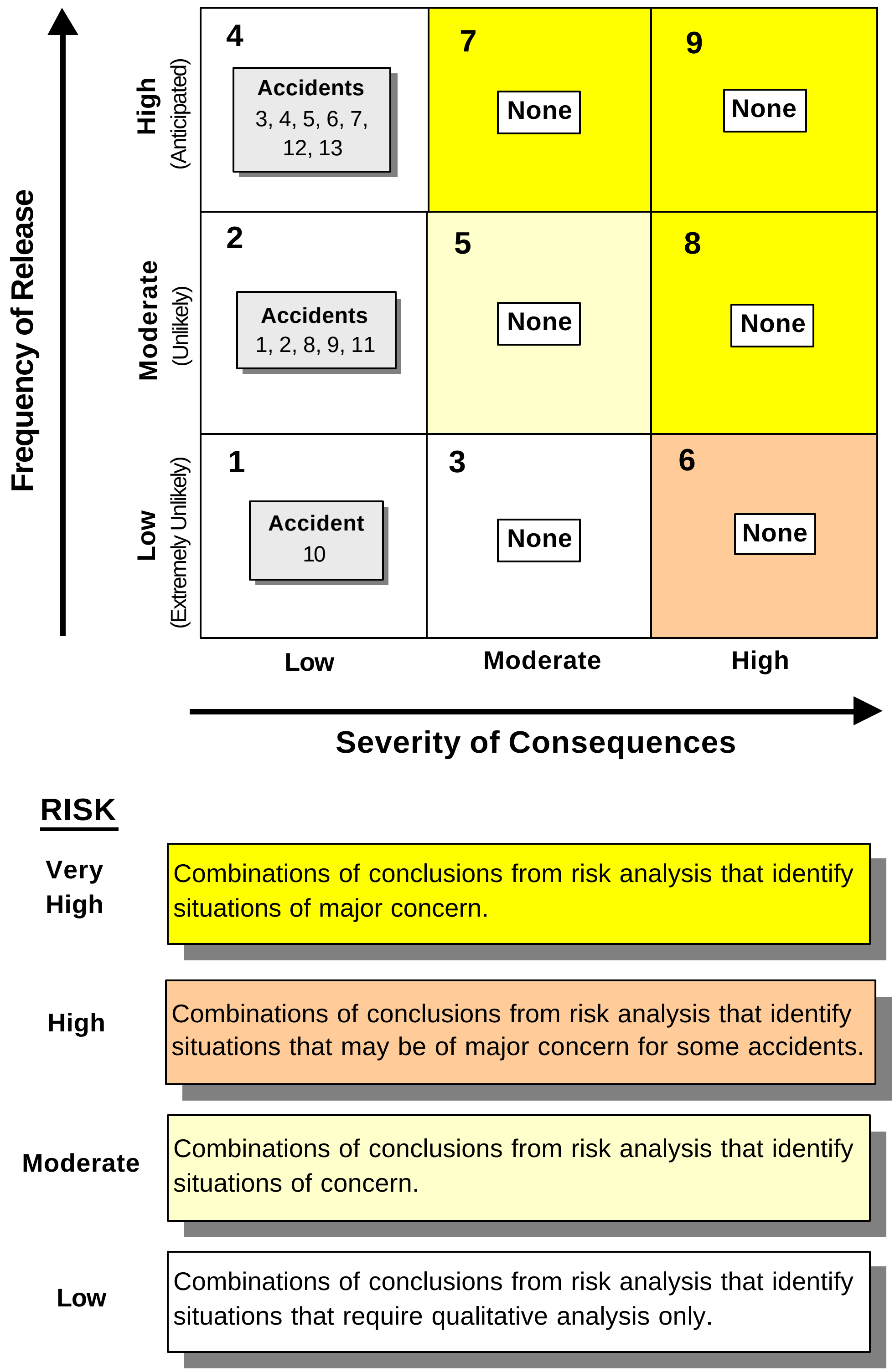
A bounding accident involving the zinc bromide located in the RMAL Facility will not cause airborne concentrations greater than ERPG-2 concentrations at on-site and off-site locations. Therefore the consequences from hazardous chemicals for every accident scenario are determined to be "Low."

The bounding accident involving radioactive material is based upon the model used in DOE-STD-1027-92, Appendix A, *Calculation of Category 2 Radiological Thresholds*. Since the RMAL Facility will operate as a Category 3 facility, the nuclear material inventory will be restricted such that the total facility inventory remains below the Category 2 threshold quantities listed in DOE-STD-1027-92. The Category 2 threshold quantities are based upon a dose of 1 Rem which is the sum of the 50-year Committed Effective Dose Equivalent (CEDE) and the Cloud Shine Dose Equivalent (CSDE)] at 100 meters using standard air dispersion/dose calculations. Since the actual distance to the site boundary is approximately 200 meters, the worst case dose from radioactive materials for every accident scenario is estimated to result in consequence levels evaluated as "Low" for both on-site and off-site locations.

Risk Assessment

Figure 3-5 summarizes the combinations of conclusions (frequency and consequence estimates) from the hazard evaluation as documented in the PHA summary sheets in Attachment D. There were no accident scenarios of major concern identified in the analysis that would require safety class or safety significant SSCs to be defined to protect the public or worker. Various controls were identified which act to prevent, detect, or mitigate an accident. Only the administrative controls were taken credit for in the risk assessment. Credit was taken for administrative controls placed on the types and amounts of radioactive material that may be present in the RMAL Facility and the institutional safety programs such as radiation protection and ALARA programs. Credit was taken for performing routine radiation surveys of the various facility areas in accordance with the radiation protection program to ensure workers are well informed about local contamination and radiation dose areas. Credit was taken for effective implementation of the emergency preparedness program so that facility personnel could quickly evacuate following an accident. Based on DOE-STD-3009-94 no further representative or quantitative analyses are required for Hazard Category 3 Non-reactor Nuclear Facility.

Figure 3-5 Risk Assessment Matrix for RMAL, Building 2026



3.3.2.4 Hazards Analysis Summary

Planned Design and Operational Safety Improvements

This SAR does not make a commitment to planned design or operational safety improvements.

Defense in Depth

Administrative controls on the inventory of radioactive material present at the RMAL Facility and effective implementation of the radiation protection and emergency preparedness programs provide the necessary and sufficient means of ensuring acceptable risk at the facility. The inventory control and radiation protection program are the major/primary controls for defense-in-depth. However, as noted in the PHA summary sheets, additional controls are available which act to prevent, detect, or mitigate an accident involving hazardous materials. These controls, both hardware and administrative, provide additional defense-in-depth against the accidental release of hazardous and radioactive materials from confinement areas to the environment. The following summarizes some of the controls providing defense-in-depth and the contribution to reducing risk at the facility.

Control	Defense-in-depth Role
Hot cells and Cell window design	High dose (typically > 1 R/hr) radioactive material is handled in the six analytical working cells and the loading/unloading cell. The storage cell is only used to store radioactive material. The cell walls and the viewing windows are the primary means of radiation protection during these operations.
Glovebox systems	High levels (typically > 10^6 Bq) of alpha or "pure" beta emitting materials are handled in glovebox containment systems. For low gamma dose material the glovebox systems are the primary means of containment and radiation protection during these operations.
Radiochemical hood design	After radioactive samples are prepared for analysis the resulting solution can be diluted to lower the level of radioactivity to a level where the samples can be safely handled in a laboratory hood system. The upper limit of activity allowed in the hoods is controlled by administrative procedures. For diluted samples and lower level samples the radiochemical hoods are a primary means of containment and protection.
Building design	Although no credit is taken for the building's ability to withstand an accident, the building provides significant protection of the radioactive and hazardous materials for many external events and secondary containment in the event of a loss of shielding or spill.
Building inspection	The building is periodically inspected to verify the building systems are operable and structurally sound. These inspections help ensure the structure will perform as anticipated in response to events which may challenge secondary containment.

Control	Defense-in-depth Role
Facility ventilation system	The ventilation system exhausts airborne radioactive and/or hazardous material through HEPA filtration to the Building 2026 stack. This limits the particulate material released and causes a greater dispersion of that material, resulting in reduced consequences for the receptors. Also, within the facility the ventilation system maintains the negative pressures in areas such that the air always flows to the highest level of containment, which reduces the risk to workers handling the radioactive or hazardous materials.
Fire detection & suppression systems	Limits the possibility for a release due to a fire by providing quick detection and alarm to the fire department so that fire can be quickly suppressed. Automatic suppression limits the possibility for releases due to fire by quick suppression.
Monitrons	Limits facility worker exposure to elevated radiation levels in facility by providing quick detection and alarm.
CAMs	Limits facility worker exposure to airborne radioactive materials in facility by providing quick detection and alarm.

For example, in a typical RMAL glovebox operation the following layers of protection are in place:

Physical Barriers
- facility access restrictions
- primary, secondary, tertiary, etc. packaging
- glovebox
- laboratory confinement
- adjacent space (facility inner walls)
- facility outer walls
- ventilation system
- backup power supply

Administrative
- access control
- experienced personnel
- glovebox operating procedure
- training program
- radiological protection procedures
- inventory limits
- emergency preparedness
- inspections/surveillance

All of these layers are contributors to defense-in-depth yet no single component is a major contributor. In the event of a breach of one layer the material is contained by another layer. No one layer is considered more important than the others for the prevention of an uncontrolled material release. Commitment to the administrative control components provide for an acceptable margin for safety for a

Hazard Category 3 facility with radioactive material inventory limits below the Hazard Category 2 Thresholds.

Safety Management Programs

The safety management programs described in Chapters 6 through 17 provide additional defense-in-depth by establishing programmatic and facility specific requirements which directly and/or indirectly help to ensure an acceptable level of safety at the facility. These programs and requirements directly influence facility safety by ensuring the facility and systems are designed, constructed, and maintained to acceptable standards, facility hazards are understood and controlled to protect workers, measures are taken to prevent accidents, and properly qualified and trained personnel are responsible for the facility operation. Facility safety is indirectly, but significantly, enhanced by safety management programs which act to establish an overall safety culture responsible for maintenance of the safety basis.

Worker Safety

The same administrative controls that limit the inventory of radioactive material in the RMAL facility to protect the public and environment also provides protection for the facility workers. The primary controls for worker safety include experienced and trained workers, facility access training, radiation worker training, and the Radiation Protection Program, which are all administrative controls. The numerous features listed in the defense-in-depth section also provide supplementary protection to the facility worker from chemical and radiological hazards. The Industrial Hygiene Program and the Division Chemical Hygiene Plans provide additional control for chemical hazards.

Worker safety is an important aspect of all RMAL operations. Radiation shielding, containment of loose contamination (gloveboxes and hoods), remote operations (hot cells), and ventilation exhaust flows provide air flow away from workers which helps to reduce exposure to both chemical and radioactive materials to as low as reasonably achievable (ALARA). When it is necessary for RMAL staff to work in contamination or radiation areas, appropriate radiation protection support is provided and protective clothing is worn. All of the primary containment systems are surrounded by secondary containment which protects both workers in adjacent areas and the environment outside the facility.

Although the Category 2 Threshold inventory quantities would most likely never be located in a single hot cell, these values were used to estimate the dose to a worker in the area of a cell window during a generic accident where the window shielding and containment was lost. The dose estimates for this evaluation were all below a 50 year Committed Effective Dose Equivalent (CEDE) of 50 rem for each radionuclide listed in DOE-STD-1027-92. This CEDE dose level is well below the guidelines for prompt death or serious injury. This evaluation did not include long-term health effects which are included in the radiation protection program for worker safety.

The ORNL site, CASD division, and RMAL facility safety programs also contribute to worker safety by ensuring that workers are trained to do their jobs, are provided with necessary protective clothing and equipment, are provided radiation protection and industrial hygiene oversight when needed, and that records of radiation exposure are maintained. Descriptions of the safety programs are included in subsequent chapters of this SAR.

Environmental Protection

No accidents which would cause widespread environmental damage have been identified. The same administrative controls that limit the inventory of radioactive material in the RMAL facility to protect the public also serve to protect the environment. The numerous controls listed in the defense-in-depth section also provide protection to the environment from non-standard industrial hazards.

The primary containment areas for all major sources of radioactive materials used in the RMAL are enclosed in secondary containment structures (e.g. hot cells are surrounded by cell access area, glovebox and hood operations are performed in laboratories, radioactive liquid waste doubly contained). The use of secondary containment is an example of the defense in depth approach to engineering safety features. All the containment areas are exhausted through a once-through ventilation system equipped with HEPA filtration. The filtration minimizes airborne release of radioactive material to the environment. In addition to the physical features that protect the environment, administrative controls and site programs help prevent and respond to environmental releases.

3.4 References

1. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U. S. Department of Energy, Washington, D. C., Change Notice 1, September 1997.

2. ES/CSET-2/R2, *Safety Analysis Report Update Program Hazard Identification and Facility Classification Application Guide*, Martin Marietta Systems, Inc., Oak Ridge, Tennessee, December 1995.

3. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, Change 1, U. S. Department of Energy, Washington, D. C., March 10, 1994.

4. DOE-STD-3009-94, *Preparation Guide for U. S. Department of Energy Non-reactor Nuclear Facility Safety Analysis Reports*, U. S. Department of Energy, Washington, D. C., July 1994.

5. 40 CFR 302, *Designation, Reportable Quantities, and Notification*, Section 4, "Designations of hazardous substances," Code of Federal Regulations.

6. 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*.

7. 40 CFR 355, *Emergency Planning and Notification*.

8. 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*.

9. ORNL Nuclear Criticality Safety (NCS) Program, ORNL/NS-P02, current revision.

10. ANSI N43.3, *American National Standard For General Radiation Safety - Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies Up to 10 MeV* (Which updates ANSI N543-1974) (ANSI, 1993).

11. ANSI N43.2, *Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment* (ANSI, 1989a).

12. ANSI N43.5, *Radiological Safety Standard for the Design of Radiographic and Fluoroscopic Industrial X-Ray Equipment* (Formerly called N537) (ANSI, 1989b).

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CHAPTER 4
SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

This chapter provides details on facility SSCs that are necessary for the facility to satisfy Evaluation Guidelines for consequences to off-site personnel or provide significant protection to on-site workers. Descriptions are provided of the attributes required to support the safety functions identified in the hazard and accident analyses and to support subsequent derivation of TSRs. The contents of this chapter, as applicable to the graded approach, include:

- Description of safety SSCs, including safety functions
- Identification of the support systems safety SSCs depend upon to carry out safety functions
- Identification of the functional requirements necessary for the safety SSCs to perform their safety functions, and the general conditions caused by postulated accidents under which the safety SSCs must operate
- Identification of the performance criteria necessary to provide reasonable assurance that the functional requirements will be satisfied
- Identification of assumptions needing TSR coverage

4.2 Requirements

The requirements for the designation of safety SSCs, their functional requirements, and their performance criteria are listed in DOE Order 5280.23[1] and DOE-STD-3009-94[2]. TSR requirements are contained in DOE Order 5480.22[3].

4.3 Safety-class And Safety-significant SSCs

The hazard evaluation and analysis discussed in Chapter 3 did not identify any SSCs that require safety-class or safety-significant designation. Based on DOE-STD-3009-94 the radioactive material inventory limits for a Hazard Category 3 non-reactor nuclear facility cannot have a significant impact on off-site personnel, therefore, there are no safety class SSCs identified. The analysis guidelines used for identification of safety significant SSCs are summarized in Table 3-6 of Chapter 3. All hazards related to chemicals were determined to have low or negligible consequences because of the limited inventory of chemicals in the facility (i.e. laboratory quantities). Again, based upon the hazard and accident analysis there were no safety significant SSCs identified for the facility.

4.4 References

1. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, Change 1, U.S. Department of Energy, Washington, DC, March 10, 1994.

2. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, DC, July 1994.

3. DOE Order 5480.22, *Technical Safety Requirements*, Change 2, U.S. Department of Energy, Washington, DC, January 23, 1996.

CHAPTER 5
DERIVATION OF
TECHNICAL SAFETY REQUIREMENTS

5.1 Introduction

The purpose of this chapter is to build upon the control functions determined to be essential in Chap. 3, “Hazards and Accident Analyses,” and Chap. 4, “Safety Structures, Systems, and Components” to derive TSRs. This chapter supports and provides the information necessary for the separate TSR document required by DOE Order 5480.22[1]. Derivation of TSRs consists of summaries and references to pertinent sections of the SAR in which design (i.e., SSCs) and administrative features (i.e., non-SSCs) are needed to prevent or mitigate the consequences of accidents. Design and administrative features addressed include ones which: (1) provide significant defense-in-depth in accordance with the screening criteria of DOE Order 5480.22, (2) provide significant worker safety, or (3) maintain consequences of facility operations below Evaluation Guidelines. This chapter contains the following information as applicable to RMAL Facility operations:

- Information with sufficient basis from which to derive, as appropriate, any of the following TSR parameters for individual TSRs:
  - Safety Limits (SLs)
  - Limiting Control Settings (LCSs)
  - Limiting Conditions for Operation (LCOs)
  - Surveillance Requirements (SRs)
- Information with sufficient basis from which to derive TSR administrative controls for specific control features or to specify programs necessary to perform institutional safety functions
- Identification of passive design features addressed in the SAR
- Identification of TSRs from other facilities that affect the facility’s safety basis

No SSCs were identified in Chap. 4 that require designation as safety-class or safety-significant items. Facility inventory controls were identified that provide protection for on-site workers from the consequences of accident scenarios and maintain facility operations within the “envelope” bounded by this Safety Analysis Report. Effective implementation of the radiation protection and emergency preparedness programs is also necessary to protect RMAL personnel and other on-site workers.

5.2 Requirements

The requirements for TSRs are included in DOE Order 5480.22. Guidance for selection of TSRs is provided in DOE-STD-3009-94[2].

5.3 Technical Safety Requirement Coverage

This section provides assurance that TSR coverage for the RMAL Facility is complete.

5.3.1 Criteria

The following criteria for items which require TSR coverage were developed from interpretations of the guidance in DOE Order 5480.22 and DOE-STD-3009-94. TSR coverage is necessary for:

- SSCs which have been designated safety-significant
- SSCs which have been designated safety-class
- Administrative controls, including safety management programs, which are required to ensure safe operation of the facility.
- The following administrative control topics are required to be addressed in TSRs by DOE Order 5480.22:

  - Administrative control provisions relating to organization and management, procedures, recordkeeping, reviews, and audits necessary to ensure safe operation of the facility.

  - Requirements associated with administrative controls for reporting deviations from Technical Safety Requirements. (i.e., violation of TSR).

  - Staffing requirements for facility positions important to safe operation of the facility shall be provided.

  - Physical and administrative controls of the criticality safety program shall also be addressed.

5.3.2 Identification of Items Requiring TSR Coverage

The first and second criteria in Sect. 5.3.1 apply to safety-class and safety-significant SSCs. There were no SSCs designated safety-class or safety-significant in Chap. 4. The third criteria in Sect. 5.3.1 applies to administrative controls and safety management programs. Table 5-1 lists the unusual hazards present at the RMAL Facility and the administrative controls which were specifically taken credit for in the hazard evaluation. These administrative controls require TSR coverage. Table 5-2 lists the safety management programs and discusses the need for TSR coverage of the programs. The topics listed in the fourth criterion in Sect. 5.3.1 will be addressed in the TSRs for the RMAL Facility.

5.3.3 Summary of Items Requiring TSR Coverage

Items requiring TSR coverage per the criteria in Sect. 5.3.1 are:

- Organization and management

- Procedures
- Record keeping
- Reviews and Audits
- Deviation reporting
- Staffing requirements
- Criticality safety program
- Radioactive material inventory controls
- Radiation protection program
- Quality assurance program
- Emergency preparedness program
- Fire Protection

Table 5-1 Hazard evaluation administrative controls

Hazard	Administrative control
Radioactive material	The total quantity of radioactive materials in the RMAL Facility must remain below the Category 2 TQs specified in Ref. 3.
Radioactive surface contamination	The administrative controls for radioactive material are applicable here.
Radioactive waste	The administrative controls for radioactive waste are applicable here.
Toxic material	The quantity of toxic material (zinc bromide) at the RMAL Facility is much less than what could be kept in the facility before Evaluation Guidelines would be exceeded. It was assumed that future quantities of toxic material would be similar to the present quantities evaluated.

Table 5-2 Evaluation of safety management programs for TSRs

Program	TSR coverage required	Justification/Basis
Prevention of inadvertent criticality	Yes	The quantity of fissile material present in the RMAL Facility is limited by administrative control to below the Significant Amounts of Fissionable Material (SAFM) as defined in Table 3-8. Section 3.3.2.1 provides the fissionable material limiting criteria that must be met to satisfy assumptions made in this SAR.
Radiation protection	Yes	The quantity of radioactive materials allowed to be transported or processed at any one time is directly related to the radiation levels that are received by the worker. The radiation protection program ensures the necessary radiation measuring devices are available for worker safety.

Program	TSR coverage required	Justification/Basis
Hazardous material protection	No	The hazardous material protection program applies to occupational exposure during normal operations and safe working practices to help prevent accidental exposure. The hazard evaluation is concerned only with post-accident exposures and does not take credit for any initial condition established by the hazardous material protection program.
Radioactive and hazardous waste management	No	The hazard evaluation does not take credit for waste stream management.
Initial testing, in-service surveillance, and maintenance	No	The hazard evaluation does not take credit for any instrumentation of other equipment that requires testing, in-service surveillance, or maintenance
Operational safety	Partial	Several aspects of operational safety that require TSR coverage are addressed by other programs discussed in this table, or are required to be included in TSRs as discussed in Sect. 5.3.1. These aspects include organization and management, operating procedures, and control of hazardous material, among others. An element not covered elsewhere, however, is fire protection. Chap. 11 discusses a fire protection program applicable to the RMAL Facility. The hazard evaluation, however, takes no credit for proper functioning of any facility SSCs or other controls which act to prevent, detect, or mitigate a fire. Therefore, fire protection cannot affect the conclusions of the hazard evaluation and TSR coverage is not required.
Procedures and training	Yes	The safety of the facility is ensured primarily by administrative controls on the types and amounts of radioactive material that may be handled and stored in the facility. Approved procedures establish the administrative controls and training is required to ensure proper implementation.
Human factors	No	Human factors are normally applied to complex facility equipment and instrumentation designs. No such equipment or instrumentation was identified as safety-class or safety-significant in the hazard evaluation. Thus, detailed human factors design considerations are not necessary to ensure safe facility operation.
Quality assurance	Yes	No equipment or instrumentation was taken credit for in the hazard evaluation. The remaining QA program elements related to operations are required to ensure acceptable level of quality for facility safety analysis and other required safety management programs.

Program	TSR coverage required	Justification/Basis
Emergency preparedness	Yes	The hazard evaluation takes credit for emergency response capabilities. Facility workers are assumed to evacuate the immediate area of an accident consistent with anticipated response of any individual when confronted with a known hazard. However, other personnel may be unaware of the accident and must be notified in order to minimize their exposure to the hazard. Evacuation of other personnel within a specified time is assumed in the hazard evaluation.
Fire protection program	Yes	A site-wide Fire Protection Program is implemented and maintained at ORNL to meet contractual obligations; state and federal laws; and necessary and sufficient elements of DOE orders, policies, and guides. No elements of the fire protection program are taken credit for in the hazard evaluation, but, is included in the TSR coverage as a best management practice to ensure worker safety.
Provisions for decontamination and decommissioning	No	Decontamination and decommissioning are not related to accident consequences.
Management, organization, and institutional safety provisions	Yes	Elements of this program, as described in Chap. 17, are topics that require TSR coverage per DOE Order 5480.22.

5.4 Derivation of Facility Modes

The following modes defined for operation of the RMAL Facility do not apply to the non-containment areas of the facility (office areas and south addition): |

OPERATIONAL A mode in which the affected process area of the facility is performing intended mission activities (e.g. analysis and testing of samples/specimens that contain less than the Category 2 threshold quantities of radioactive material). Decontamination, maintenance and/or repair activities may be performed during this mode of operation.

STANDBY Radioactive materials are present and limited to below category 2 threshold quantities. Activities involving radioactive materials may not be performed without a job specific RWP and/or approval by the Facility Manager following an evaluation of the area(s) affected by the STANDBY mode. The STANDBY mode is mostly used for maintenance activities where one or more of the containment systems, such as the exhaust side of the ventilation system, are temporarily taken out of service for repair or maintenance. |

5.5 Technical Safety Requirement Derivation

5.5.1 Safety Limits, LCSs, and LCOs

Building 2026 has no safety-significant or safety class SSCs. Therefore, there are no Safety Limits (SLs), Limiting Control Settings (LCSs), or Limiting Conditions for Operation (LCOs), as defined in 5480.22, required for safe operation of the RMAL Facility.

5.5.2 Surveillance Requirements

Building 2026 has no safety-significant or safety class SSCs. Therefore, there are no SRs related to the operability of SSCs, as defined in 5480.22, required for safe operation of the RMAL Facility.

5.5.3 Administrative Controls

For the purposes of organizing the TSR and deriving the individual administrative controls, the topics requiring coverage have been divided into three groups that are major subsections of the TSR administrative controls: Organization and Oversight, Operations, and Programs. This grouping is not required or suggested by orders or standards, but merely provides a convenient framework to assemble the administrative controls. The placement of a control in a group is subjective and is not intended to imply a limited scope of application. For example, elements of the programs requiring TSR coverage certainly apply to organization, oversight, and facility operations. Each of the subsections and the derivation of the administrative controls in each are discussed in the following sections.

5.5.3.1 Organization and oversight

Contractor organization

Per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.a, lines of authority, responsibility, and communication within the operating organization must be defined. Personnel from other contractor organizations or other contractors (not assigned to the RMAL) performing work at the facility shall be under the control of personnel from the RMAL operating staff.

Contractor responsibility

Per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.b, the TSRs must require the facility supervisor or his designee to be responsible for the safe operation of the facility. The RMAL Facility TSRs require this and include examples of typical duties related to safe operations.

Reviews and audits

Per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.j, the methods established to conduct independent reviews and audits require TSR coverage. The RMAL Facility TSRs include a description of the independent reviews and audits associated with the RMAL Facility operations. The descriptions were developed by consensus review and approval.

5.5.3.2 Operations

This subsection includes staffing requirements, procedures, hazardous material inventory control, record keeping, and reporting.

Staffing requirements

The minimum operations shift complement requires TSR coverage per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.e. The Hazards and Accident Analysis in Chap. 3 did not take credit for any personnel actions which would require more than a single individual to perform. Therefore, the minimum staff requirement while the facility is in the Operation Mode is one qualified operator on site. There is no minimum staff requirement while the facility is in the Standby Mode.

Operating support provisions require TSR coverage per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.f, including the requirement that a list of required support contacts be maintained. The RMAL Facility TSRs include controls for support personnel, such as radiation protection personnel, fire protection personnel, or plant and equipment personnel.

Per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.g, minimum staff qualifications and staff training and training replacement require TSR coverage. A description of these controls, developed by consensus review and approval, has been included in the RMAL Facility TSRs.

Procedures

DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.c specify that TSRs should require that procedures be established, implemented, and maintained for activities in support of the TSRs. The RMAL Facility TSRs include this control.

Radioactive material inventory controls

The inventory controls included in the RMAL Facility TSRs are derived from the hazard evaluation. The accident scenarios selected and the resultant consequences are directly dependent on the materials assumed to be at risk. Therefore, these controls, as summarized below, require TSR coverage to ensure the results of the hazard evaluation remain correct:

- Facility limited to less than Category 2 TQs per Ref. 3
- Facility radioactive material inventory must meet criteria specified in section 3.3.2.1

Record keeping

The administrative controls section of the TSRs must include record keeping requirements per DOE Order 5480.22, 9.e.(5). The required records and retention periods, identified by consensus review and approval, are included in the RMAL Facility TSRs.

Reporting

Per DOE Order 5480.22, 9.e.(5) and Attachment 1, 2.4.k, the administrative controls section of the TSRs must include reporting requirements. The RMAL Facility TSRs include this control.

5.5.3.3 Programs

The programs identified for inclusion in the TSRs are Radiation Protection; Quality Assurance; Emergency Preparedness; and Fire Protection. The elements of these programs to be included in the RMAL Facility TSRs were developed by consensus review and approval.

Radiation protection

The Radiation Protection Program was identified in Sect. 5.3.3 as essential since the program ensures the availability of radiation monitoring and measuring equipment.

Quality assurance

The QA Program was identified in Sect. 5.3.3 as required to ensure acceptable quality of facility safety analysis and the other safety management programs.

Criticality Safety

The Criticality Safety Program was identified in Section 5.3.3 as essential since the program ensures that operations involving fissionable materials are addressed and reviewed if there are fissionable nuclide quantities that exceed threshold limits.

Emergency preparedness

The Emergency Preparedness Program was identified in Sect. 5.3.3 as essential to ensure notification and evacuation, if necessary, of facility personnel within specified times assumed in the hazard evaluation following an accident in which personnel could receive significant external radiation doses.

Fire Protection

The ORNL Fire Protection Program was identified in Sect. 5.3.3 as a best management practice required to ensure worker safety.

5.6 Design Features

No design features associated with RMAL Facility operations have been designated as safety-class or safety-significant. The hot cells provide significant protection to facility personnel from external radiation exposure during normal operations. A description of the hot cells is provided in Chap. 2.

5.7 Interface with Technical Safety Requirements from Other Facilities

There are no identified TSRs at other facilities that affect operations at the RMAL Facility.

5.8 References

1. DOE Order 5480.22, *Technical Safety Requirements*, Change 2, U.S. Department of Energy, Washington, D. C., January 23, 1996.

2. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Non-reactor Nuclear Facility Safety Analysis Reports*, U.S. Department of Energy, Washington, D. C., July 1994.

3. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, U.S. Department of Energy, Washington, D. C., Change Notice 1, September 1997..

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CHAPTER 6
PREVENTION OF INADVERTENT CRITICALITY

6.1 Introduction

The TSRs for the RMAL facility[1] contain an administrative control limiting the quantity of fissionable material that may be present at the facility to below the Significant Amounts of Fissionable Material (SAFM). Typical amounts of fissionable material found in analytical samples are well below the Fissile Material Control Limits (FMCL) as listed in Table 3-8. The ORNL Nuclear Criticality Safety Program requires additional levels of control, review, and approvals when either a fissile isotope exceeds the FMCL value listed in Table 3-8 or if the sum of the fissile isotopes divided by the FMCL exceeds one (1). All operations with fissile material in the RMAL will be in compliance with the ORNL Nuclear Criticality Program. The inventory of fissile isotopes permitted in the facility will not exceed the SAFM limits listed in Table 3-8. Because the facility is limited to less than the SAFM, criticality is precluded by nature of process. Therefore, with adherence to the TSRs, criticality safety concerns are not an issue.

6.2 References

1. ORNL/CASD/2026/TSR, Technical Safety Requirements for the Radioactive Materials Analytical Laboratory, Building 2026, Lockheed Martin Energy Research Corp., Oak Ridge National Laboratory, Oak Ridge, TN.

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CHAPTER 7
RADIATION PROTECTION

7.1 Introduction

This chapter describes features/provisions for the Radiation Protection Program, radiological protection training, radiation exposure control, radiological monitoring, and radiation protection instrumentation.

7.2 Requirements

Radiation protection standards and program requirements for DOE and DOE contractor operations with respect to the protection of the worker from ionizing radiation are contained in DOE Notice 441.1[1] and 10 Code of Federal Regulations (CFR) 835[2].

7.3 Radiation Protection Program

7.3.1 Occupational Radiation Protection Program

A site-wide, DOE-approved Radiation Protection program based on the requirements of DOE Notice 441.1 and 10 CFR 835 is maintained. The program is designed to protect workers from the harmful effects of radiation. The program has the following objectives:

- maintaining radiation exposure ALARA
- limiting internal and external radiation exposure of occupational workers
- monitoring and recording occupational exposure
- radioactive materials are identified
- posting and establishing entry control points for areas with elevated radiation fields
- providing periodic radiation safety training

7.3.2 Public and Environmental Radiological Protection Program

ORNL site-wide programs to provide radiological protection of the public and environment are established, implemented, and maintained. The public and environmental radiation protection programs are implemented through ORNL site-wide procedures and procedures of the ORNL organization responsible for the program. The public and environmental radiological protection program include provisions for (1) obtaining the necessary regulatory permits for routine releases of radionuclides to the environment from ORNL operations and facilities, (2) conducting air, water, and environmental radiological monitoring on the ORNL site and Oak Ridge Reservation, (3) assessing monitoring results to demonstrate compliance with applicable regulations and standards, and (4) assessing ORNL planned actions prior to implementation to ensure compliance with regulatory requirements. The public and environmental radiological protection program includes the following objectives:

- Airborne and liquid releases are monitored in accordance with the applicable regulatory requirements;
- Regulatory limits on routine discharges of radionuclides are met;
- Doses to members of the public are periodically assessed; and
- Protection of the environment from contamination is provided to the degree practical.

The management structure at ORNL is organized into major programmatic areas each led by an Associate Director who reports to the ORNL Laboratory Director. The Director of the ORNL Office of Environmental Protection has overall responsibility for the public and environmental radiological protection program and reports to the ORNL Associate Director for Operations, Environment, Safety, and Health. The office of Environmental Protection consists of groups that (1) provide guidance, evaluations, interpretation, and oversight of regulatory requirements, (2) prepare and issue regulatory-mandated submissions (permit applications, permit modifications, reports, and other documentation) for ORNL operations and facilities, and (3) perform air and water surveillance monitoring of releases of radionuclides to the environment from ORNL operations and facilities and perform environmental surveillance monitoring for the ORNL site and Oak Ridge Reservation to support compliance with permits, compliance agreements, and regulatory requirements.

7.4 Radiological Protection Training

General plans and procedures for training personnel are discussed in Chapter 12, Procedures and Training. Periodic radiation safety training is provided through implementation of the site-wide Radiation Protection Program.

Procedures for response to accidents involving radioactive materials are discussed in Chapter 15, Emergency Preparedness Program.

7.5 Radiation Exposure Control

Some operations at the RMAL facility have the potential for low-level radiation exposure to personnel, contamination of clothing, and the spreading of contamination outside intended areas. Strict adherence to ORNL and facility procedures, however, ensures that activities comply with the concept of ALARA.

Radiological areas and restrictions for these areas have been identified and are posted in agreement with ORNL Radiological procedures.

Radiological work permits (RWPs) are utilized when facility management deems it necessary or when required by ORNL radiological protection procedures.

Personnel radiation monitoring devices are provided where required and as mandated by the ORNL Radiation Protection Manual. Additional monitoring devices are provided by facility management for facility personnel who work directly with radioactive materials.

Respiratory protection is provided for activities that may subject personnel to radioactive airborne activity, or any operation where respiratory protection is deemed advisable by the person performing the work, the facility radiological control technician, or by facility management.

7.6 Radiation Protection Instrumentation

Office of Radiation Protection procedures describe the ORNL program for providing, maintaining, and calibrating radiation detection instruments for personnel protection. Individual ORNL organizational responsibilities related to radiation detection instruments used in the ORNL program are also described.

7.7 References

1. DOE Notice 441.1, *Radiation Protection for DOE Activities,* U.S. Department of Energy, Washington, DC, September 19, 1996.

2. Title 10, Code of Federal Regulations, Part 835, *Occupational Radiation Protection.*

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CHAPTER 8
HAZARDOUS MATERIAL PROTECTION

8.1 Introduction

This chapter describes the essential features of the Hazardous Materials Protection Program.

8.2 Requirements

Hazardous material protection requirements are contained in 29 CFR 1910.1450[1].

8.3 Hazardous Material Protection Program

A site-wide Hazardous Material Protection Program provides for identification and control of hazardous materials and training of personnel to minimize occupational exposure to hazardous materials. The program has the following objectives.

- Minimize the potential for chemically related damage, illnesses, and/or injuries in the workplace.
- Informing employees of hazards that may be encountered in their work area.
- Maintaining exposure to hazardous materials ALARA.

The Hazardous Material Protection Program is implemented by approved divisional and ORNL procedures. The procedures establish hazardous material protection requirements for conduct of operations and activities and assigns the responsibilities of ORNL organizations for implementing the requirements.

Engineering and administrative controls minimize the potential for ingestion of and inhalation exposure to hazardous materials.

Procedures for response to accidents involving hazardous materials are discussed in Chapter 15, Emergency Preparedness Program.

8.4 References

1. Title 29, Code of Federal Regulations, 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories.*

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CHAPTER 9
RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 Introduction

This chapter describes the provisions for radioactive and hazardous waste management.

9.2 Requirements

The policies, guidelines, and requirements by which DOE manages its radioactive and mixed waste and contaminated facilities are contained in DOE Order 5820.2A[1].

9.3 Radioactive and Hazardous Waste Management Program

The site-wide Radioactive and Hazardous Materials Waste Management Program provides controls and procedures for the safe management of radioactive and hazardous waste material at ORNL. The program addresses:

- Segregating and packaging of radioactive and hazardous waste materials
- Minimizing waste
- Storing and disposing of waste

9.4 Radioactive And Hazardous Waste Streams And Sources

The RMAL generates various liquid and solid waste streams. Hazardous wastes are stored in a designated temporary storage area until they are turned over to waste management personnel.

> All waste is characterized and managed in agreement with approved ORNL procedures, including waste acceptance criteria. Radioactive waste is segregated and stored in “B-25" metal storage boxes and/or 55 gal. drums for disposal in an ORNL solid waste area.

9.5 References

1. DOE Order 5820.2A, *Radioactive Waste Management,* U.S. Department of Energy, Washington, DC, September 26, 1988.

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CHAPTER 10
INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

10.1 Introduction

This chapter describes the essential features of the initial testing, in-service surveillance, and maintenance programs. There are no safety-class or safety-significant SSCs in the RMAL facility. As such, there are no programs related to initial testing, in-service surveillance, or maintenance of safety-class or safety-significant items.

10.2 Requirements

Requirements pertinent to initial testing, in-service surveillance, and/or maintenance include 10 CFR 830.120[1], as implemented by ORNL.

10.3 Initial Testing, Surveillance, and Maintenance Programs

The testing program includes both initial testing of new equipment and surveillance testing of equipment following installation. The maintenance program ensures that DOE property is maintained in a manner that promotes operational safety, worker health, environmental protection and compliance, property preservation, and cost effectiveness while meeting the programmatic mission. Primary responsibility, authority, and accountability for the direction and management of these programs resides with the line management assigned direct programmatic responsibility.

10.4 References

1. Title 10, Code of Federal Regulations, Part 830, Section 830.120, *Quality Assurance Rule*.

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CHAPTER 11
OPERATIONAL SAFETY

11.1 Introduction

The purpose of this chapter is to discuss general aspects of operational safety. Because many aspects of operational safety are discussed in other chapters of this SAR, this chapter will specifically focus on the bases for the conduct of operations program and the fire protection program.

11.2 Requirements

Requirements pertinent to Conduct of Operations are specified in facility Work Smart Standards[1]. Fire protection is addressed by the National Fire Protection Association (NFPA) Life Safety Code and by NFPA standards.

11.3 Conduct of Operations

The full conduct of operations program was originally developed for nuclear reactors and DOE Order 5480.19[2] acknowledges that the guidelines are written so as to allow flexibility. Because the Order contains numerous elements inappropriate for strict compliance in the RMAL facility, the principles of the Order have been incorporated into the RMAL facility conduct of operations matrix using a graded approach and best management practice. This implementation strategy allows for elimination of overly restrictive requirements for RMAL facility research and operations while ensuring the appropriate principles of conduct of operations are properly applied to activities.

11.4 Fire Protection

A site-wide Fire Protection Program is planned, implemented, and maintained at ORNL to meet contractual obligations; state and federal laws; and necessary and sufficient elements of DOE orders, policies, and guides. The Director of the Office of Laboratory Protection administers the program, including identification of the organizations responsible for implementation of major program elements. Program responsibilities include the following.

- Maintaining an emergency response firefighting crew on a 24-hour basis.
- Investigating and reporting fires.
- Inspecting, testing, and maintaining fire protection equipment at ORNL.
- Providing fire protection engineering services.
- Conducting required training/education for emergency responders and general employee population.

- Conducting facility fire safety/prevention inspections.
- Controlling combustible loading.

Fire exit or evacuation drills at ORNL are conducted periodically as determined necessary by the Emergency Preparedness Department or facility manager.

11.5 References

1. Oak Ridge National Laboratory, *Final Report: ORNL Necessary and Sufficient Process; Work Smart Standards for Environment, Safety and Health; Report of the Identification Team for the Radiochemical Research Facilities*, Lockheed Martin Energy Research Corp., August 19, 1997.

2. DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, Change 1, U.S. Department of Energy, Washington, DC, May 18, 1992.

CHAPTER 12
PROCEDURES AND TRAINING

12.1 Introduction

This chapter describes the control and use of procedures and the essential elements of the training program.

12.2 Requirements

The requirements for procedures and training of personnel are included in DOE Order 5480.20A[1] and 10 CFR 830.120[2] .

12.3 Procedures

Activities at the RMAL facility are conducted in accordance with applicable corporate, site-wide, and divisional requirements and/or approved facility-specific operating procedures.

The elements of the safety management programs described in Chapters 6 through 17 are typically implemented by site-wide, corporate, or divisional procedures, manuals, plans, etc. Certain elements/topical areas from the safety management programs are also specifically addressed in facility operating procedures as discussed in the following.

Activities at the RMAL facility are controlled by facility command media made up of operating procedures/guidelines/policies which provide instructions for assuring compliance with requirements which are specific to the facility.

12.4 Training

The ORNL training program provides general safety training for site employees with the following objectives.

- General employee training of on-site personnel to acquaint them with emergency response, alarms, and responsibilities.
- Periodic training of personnel to maintain a level of proficiency consistent with assigned tasks.
- Assuring that personnel are qualified to carry out their assigned responsibilities.
- The RMAL training program was developed under guidance in DOE Order 5480.20A and is implemented by divisional procedures. As such, identified RMAL facility personnel must acceptably complete various facility and activity-specific related training modules. Untrained

personnel assigned to perform work in the RMAL facility must be supervised until training requirements are satisfied.

12.5 References

1. DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities,* U.S. Department of Energy, Washington, DC, November 15, 1994.

2. Title 10, Code of Federal Regulations, Part 830, Section 830.120, *Quality Assurance Rule*.

CHAPTER 13
HUMAN FACTORS

13.1 Introduction

The purpose of this chapter is to demonstrate that human factors are considered in facility operations where humans are relied upon for preventive action (e.g., surveillance and maintenance activities during normal operations), and for operator mitigative actions during abnormal and emergency operations.

13.2 Requirements

DOE Order 5480.23[1] requires review of the importance to safety of reliable, correct, and effective human-machine interactions.

13.3 Human Factors

The requirements places emphasis on human-machine interfaces required for ensuring the safe function of safety-related SSCs and on the provisions made for optimizing the design of those human-machine interfaces to enhance reliable human performance. Human factors are normally applied to complex facility equipment and instrumentation designs. No instrumentation or equipment associated with RMAL facility operations was designated safety-class or safety-significant. Thus, detailed human factors design considerations are not necessary to ensure safe facility operation. Personnel receive general site and facility-specific training for awareness of potential safety risks and proper conduct of operations as discussed in Chapter 12, Procedures and Training. Therefore, human factors considerations are not discussed further.

13.4 References

1. DOE Order 5480.23, *Nuclear Safety Analysis Reports*, Change 1, U.S. Department of Energy, Washington, DC, March 10, 1994.

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CHAPTER 14
QUALITY ASSURANCE

14.1 Introduction

This chapter describes the essential features of the QA Program and document control/records management.

14.2 Requirements

Requirements for QA are contained in 10 CFR 830.120[1].

14.3 Quality Assurance Program

The QA Program documentation describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing adequacy of work. The QA Program is implemented by division plans, procedures, and guidance, as well as site-wide procedures and standards. The program has the following objectives.

- Ensuring that personnel are trained and qualified to perform their assigned work and are provided continuing training to ensure that job proficiency is maintained.
- Establishing and implementing processes to detect and prevent quality problems and ensuring quality improvement.
- Preparing, reviewing, approving, issuing, using, and revising documents that prescribe processes, specify requirements, or establish design.
- Performing work to established technical standards and administrative controls.
- Designing items and processes using sound engineering/scientific principles and appropriate standards.
- Ensuring that procured items and services meet established requirements and perform as specified.
- Inspecting and acceptance-testing specified items and processes using established acceptance and performance criteria.
- Management at all levels periodically assessing the integrated QA program and its performance.
- Performing planned and periodic independent assessments to measure items quality and process effectiveness and to promote improvement.

14.5 References

1. Title 10, Code of Federal Regulations, Part 830, Section 830.120, *Quality Assurance Rule*.

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CHAPTER 15
EMERGENCY PREPAREDNESS PROGRAM

15.1 Introduction

This chapter describes the Emergency Preparedness Program.

15.2 Requirements

Emergency Preparedness Program requirements are contained in the DOE Order 151.1[1].

15.3 Emergency Preparedness Program

An emergency preparedness program is provided to ensure the safety and health of workers and members of the general public, as well as protect the environment. The Emergency Management Program is implemented by site-wide plans and procedures and accomplishes the following minimum objectives.

- Developing and maintaining emergency planning, preparedness, and response capabilities, as well as effective public and interagency communications, in order to minimize the consequence to workers, national security, the public, and the environment from incidents involving DOE operations.

- Responding to emergencies in an effective and timely manner to mitigate the consequences and bring the emergency situation under control.

- Providing support, within resource constraints, to other local, state, and federal agencies and international organizations, as requested, and in accordance with pertinent federal regulations and plans, appropriate interagency agreements, and international conventions.

A local emergency manual is maintained by RMAL management. A copy is maintained in the ORNL Shift Superintendent's office to assist in emergency response. The local emergency manual provides the directions for responding to and mitigating foreseeable emergency conditions that may develop at the RMAL facility. The local emergency manual provides direction in the following areas.

- Notification criteria
- Suggested responses to various types of emergency conditions
- Profile of the facility including description, population, process description, and a description of potential major emergency conditions and procedures for handling them.
- Guidelines for rescue operations.

- Guidelines for handling injured and/or contaminated persons.
- Guidelines for building and/or area reentry.
- Required post-emergency documentation.
- Equipment testing and drills.
- Incident command system.

Credible major emergencies that may develop at the RMAL include fires, radioactive material releases, and medical illness or emergencies. In the event of an emergency, personnel are instructed to notify the appropriate authority (i.e., local emergency supervisor, shift superintendent, Emergency Control Center), sound the evacuation alarm, proceed to combat the emergency if it can be done safely, and/or meet and orient the emergency service units. The facility is equipped with a public address system and fire alarm.

15.4 References

1. DOE Order 151.1, *Comprehensive Emergency Management System*, Change 2, U.S. Department of Energy, Washington, DC, August 21, 1996.

CHAPTER 16
PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

A detailed decontamination and decommissioning (D&D) plan has not been established for the RMAL in its current uses by the CASD. The facility is not in the D&D phases of its life cycle. D&D plans are not required until the facility is designated for D&D. Safety programs associated with these activities therefore do not apply. However, provisions were made in the facility design and construction that will facilitate future D&D activities. When appropriate, a D&D plan will be prepared for the facility.

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CHAPTER 17
MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 Introduction

This chapter describes the overall structure of the organizations and personnel at ORNL with responsibilities for facility safety and programs that promote safety consciousness and morale. These programs address safety culture, performance assessment, configuration and document control, occurrence reporting, staffing, and qualification.

17.2 Requirements

The basic requirements for management, organization, and institutional safety provisions are included in DOE Order 5480.20A[1], DOE Order 232.1[2], and in 10 CFR 830.120[3].

17.3 Description of Provisions

17.3.1 Organizational Structure

The CASD has responsibility for the operation and maintenance of the RMAL facility. Direct responsibility for the maintenance and operation of the RMAL is vested in the facility manager. Technical and operational support services are provided by the CASD personnel and other ORNL organizations. The CASD Safety Officer and Radiation Control Officer represent the division director in matters of industrial and radiation safety, performing, at the division level, the responsibilities that are designated by the division director. The QA Specialist for the CASD represent the ORNL Quality organization director and has the responsibility for reviewing and reporting on the QA systems for the division.

The ORNL disciplines for operations, environment, safety, and health furnish the expertise to deal with environmental monitoring, industrial hygiene, radiation monitoring, radiation protection, and compliance with Environmental protection Agency (EPA), Resource Conservation Recovery Act (RCRA), and DOE regulations.

17.3.2 Operational Readiness Reviews

New activities at the RMAL facility are subject to readiness assessments, internal management assessments, or other management reviews as determined by the facility manager. The scope and extent of reviews are graded commensurate with the hazards and complexity of the new activity. By identifying and minimizing the risks associated with mission success, the review process ensures that each new activity is ready to proceed to the next increment of work.

17.3.3 Safety Review Program

Various programs have been established for reviewing the safety of ORNL facilities, including the RMAL facility. These programs verify safety in the areas of radiation protection, criticality safety, industrial hygiene, industrial safety, fire protection, environmental monitoring, emergency preparedness, and facility safety analysis. For each of these areas, safety reviews are performed by the line organization at the ORNL facility. Periodic independent safety reviews are initiated by ORNL.

An Unreviewed Safety Question Determination (USQD) program applicable to the RMAL is established, implemented, and maintained. The USQD program is implemented by site-wide policies and procedures and assures the following objectives are met.

- Evaluating proposed changes, tests, experiments, and as-found conditions to determine if they can result in the facility being outside its authorization basis.
- Documenting safety evaluations by completing screening work sheets or USQD reports in accordance with approved procedures.
- Reporting Unreviewed Safety Questions (USQs) to the original authorizing body.
- Approving, by the original authorizing body, appropriate safety analysis prior to implementation/commencement of changes, tests, or experiments found to constitute a USQ.

17.3.4 Audit Appraisals and Reviews

Periodic audits and reviews of operations at the RMAL are performed by several organizations to ensure facility safety. The organizations involved include the CASD, ORNL Quality Division, and DOE/OR Environmental Safety and Health, among others.

17.3.5 Facility Records

Records and logs shall be prepared and retained for the RMAL, Building 2026, for at least the following items and retained as a minimum for the period of time specified in parentheses:

- Facility operating logs (1 year);
- Principal maintenance activities (1 year);
- Training records (2 year); and
- Unreviewed Safety Question Determinations (operating lifetime of facility);
- Occurrence reports applicable to the RMAL facility (1 year).

17.3.6 Configuration and Safety Document Control

The RMAL applies a graded approach to implement the site-wide Configuration Management Program by ensuring the initial conditions assumed in the hazard evaluations remain correct and that any changes within the safety envelope as established by the SAR are documented.

17.4 References

1. DOE Order 5480.20A, *Personnel Selection, Qualification, and Training requirements for DOE Nuclear Facilities*, U.S. Department of Energy, Washington, DC, November 15, 1994.

2. DOE Order O 232.1, *Occurrence Reporting and Processing of Operations*, U.S. Department of Energy, Washington, DC, August 1, 1997.

3. Title 10, Code of Federal Regulations, Part 830, *Nuclear Safety Management*, Section 120, *Quality Assurance Requirements.*

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ATTACHMENT A

PRELIMINARY HAZARD SCREENING WORKSHEETS

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PRELIMINARY HAZARD SCREENING WORKSHEET

Facility: Radioactive Materials Analytical Laboratory
System, subsystem: **(1) Non-Radiological Areas** Date: 4/1/98

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Radioactive Material	Any radioisotope meeting or exceeding the table A1, DOE-STD-1027-92 TQ criteria; or exceeding the Appendix B, 40 CFR 302 RQ criteria. The inventory / RQ or inventory / TQ ratios should be added when making this evaluation.	N/A	None identified.
Radioactive Surface Contamination	Measurements of fixed, removable, or both exceed values in Attachment 2 of DOE 5480.11 (reproduced in Appendix C of ES/CSET-2A.	N/A	None identified.
Radioactive Waste	> 0.002 FCi per gram of waste.	N/A	None identified.
Toxic Material (include combustion products)	Any toxic chemical or combustion products $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	Screen Out	Maintained below RQ values. Standard "laboratory use" quantities of chemicals are under ORNL (OSHA) Laboratory Standard OSHP-003.
Carcinogen	Any known carcinogen > RQ from Table 302.4, 40 CFR 302 or any other known carcinogen if not treated as toxic material (e.g., a substance listed in ES Chemical Carcinogen Report which is available on System Select 69).	Screen Out	Maintained below RQ values. Standard "laboratory use" quantities of chemicals are under ORNL (OSHA) Laboratory Standard OSHP-003.
Biohazard	Any known biohazard where special controls are required (see Section 4.2.5.2 of CSET2/R2).	N/A	None identified.
Asphyxiant	Any asphyxiant (i.e., gas at ambient temperature that is denser than air) that could either affect a large number of people or any unsuspecting people.	Screen Out	

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Flammable Material	> 500 lb of a liquid with a flash point , 100EF or > 3000 standard ft^3 of a gas with an established lower explosive limit (LEL).	Screen Out	
Reactive Material	> 10 lb of a substance with an NFPA reactivity hazard level $ 2.	Screen Out	
Explosive Material	Any 49 CFR 173 Division 1.1, 1.2, or 1.3; or >10 oz. of Division 1.4.	N/A	None identified.
Incompatible Material	Presence of > 1 kg of two or more incompatible chemicals listed in Appendix G of "Analysis References for Hazard Identification and Facility Classification" in same area.	N/A	None identified.
Electrical Energy	Unusual application not adequately controlled by OSHA (e.g.; soil vitrification); $ 800 volts and 24 ma output; or stored energy $ 50 joules at 600 volts.	N/A	None identified.
Kinetic Energy	High energy (e.g., flywheel or centrifuge type equipment).	N/A	None identified.
Thermal Energy	Unacceptable situation or by-product.	N/A	None identified.
High Pressure	$ 3,000 psig or $ 0.1 lb. TNT (1.4 x 10^5 ft-lb$_f$) equivalent energy.	Keep	20,000 lbs hydraulic press is utilized for mass spec target fabrication.
Lasers	Any Class IV, any Class III with non-enclosed beam per ANSI Z-136.1.	N/A	None identified
Potential Energy	Elevated mass with "high" potential energy.	N/A	None identified
Accelerators	Keep (Classify based on DOE Order 5480.25).	N/A	None identified
X-ray Machines	Any not meeting ANSI N43.2, N43.3, or N43.5 requirements.	N/A	None identified
RF Generating Equipment	Equipment operating between 4kHz and 6GHz.	Keep	Plasma spectroscopy systems.
High Magnetic Field	Fields in excess of 100 gauss.	Keep	Mass spectrometers generate high magnetic fields in excess of criteria.

[1] Action decision is "keep" if criterion is exceeded or "screen out" if: a) criterion not exceeded, b) criterion is not applicable, or c) criterion is exceeded but justification as "Other Industrial" hazard requiring no further evaluation is attached and approved.

PRELIMINARY HAZARD SCREENING WORKSHEET

Facility: Radioactive Materials Analytical Laboratory

System, subsystem: **(2) Equipment and Utility Areas** Date: 4/1/98

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	**ACTION** "keep" or "screen out"	**ACTION BASIS** include inventory and form of all materials
Radioactive Material	Any radioisotope meeting or exceeding the table A1, DOE-STD-1027-92 TQ criteria; or exceeding the Appendix B, 40 CFR 302 RQ criteria. The inventory / RQ or inventory / TQ ratios should be added when making this evaluation.	N/A	None identified.
Radioactive Surface Contamination	Measurements of fixed, removable, or both exceed values in Attachment 2 of DOE 5480.11 (reproduced in Appendix C of ES/CSET-2A.	N/A	None identified.
Radioactive Waste	> 0.002 FCi per gram of waste.	N/A	None identified.
Toxic Material (include combustion products)	Any toxic chemical or combustion products $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	N/A	None identified.
Carcinogen	Any known carcinogen > RQ from Table 302.4, 40 CFR 302 or any other known carcinogen if not treated as toxic material (e.g., a substance listed in ES Chemical Carcinogen Report which is available on System Select 69).	N/A	None identified.
Biohazard	Any known biohazard where special controls are required (see Section 4.2.5.2 of CSET2/R2).	N/A	None identified.
Asphyxiant	Any asphyxiant (i.e., gas at ambient temperature that is denser than air) that could either affect a large number of people or any unsuspecting people.	N/A	None identified.
Flammable Material	> 500 lb of a liquid with a flash point , 100EF or > 3000 standard ft^3 of a gas with an established lower explosive limit (LEL).	N/A	None identified.
Reactive Material	> 10 lb of a substance with an NFPA reactivity hazard level $ 2.	N/A	None identified.
Explosive Material	Any 49 CFR 173 Division 1.1, 1.2, or 1.3; or >10 oz. of Division 1.4.	N/A	None identified.
Incompatible Material	Presence of > 1 kg of two or more incompatible chemicals listed in Appendix G of "Analysis References for Hazard Identification and Facility Classification" in same area.	N/A	None identified.
Electrical Energy	Unusual application not adequately controlled by OSHA (e.g.; soil vitrification); $ 800 volts and 24 ma output; or stored energy $ 50 joules at 600 volts.	Screen Out	Standard building service <600 volts.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Kinetic Energy	High energy (e.g., flywheel or centrifuge type equipment).	Keep	Equipment room contains support equipment (e.g., fans, motors, switchgear).
Thermal Energy	Unacceptable situation or by-product.	Screen Out	Equipment room contains support equipment (e.g., hot water heater, distiller). No unacceptable situation or by-products.
High Pressure	$\geq$ 3,000 psig or $\geq$ 0.1 lb. TNT (1.4×10^5 ft-lb_f) equivalent energy.	N/A	None identified.
Lasers	Any Class IV, any Class III with non-enclosed beam per American National Standards Institute Z-136.1.	N/A	None identified.
Potential Energy	Elevated mass with "high" potential energy.	N/A	None identified.
Accelerators	Keep (Classify based on DOE Order 5480.25).	N/A	None identified.
X-ray Machines	Any not meeting ANSI N43.2, N43.3, or N43.5 requirements.	N/A	None identified.
Other	None	N/A	None identified

[1] Action decision is "keep" if criterion is exceeded or "screen out" if: a) criterion not exceeded, b) criterion is not applicable, or c) criterion is exceeded but justification as "Other Industrial" hazard requiring no further evaluation is attached and approved.

PRELIMINARY HAZARD SCREENING WORKSHEET

Facility: Radioactive Materials Analytical Laboratory
System, subsystem: **(3) Filter and Stack Area** Date: 4/1/98

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Radioactive Material	Any radioisotope meeting or exceeding the table A1, DOE-STD-1027-92 TQ criteria; or exceeding the Appendix B, 40 CFR 302 RQ criteria. The inventory / RQ or inventory / TQ ratios should be added when making this evaluation.	N/A	None present
Radioactive Surface Contamination	Measurements of fixed, removable, or both exceed values in Attachment 2 of DOE 5480.11 (reproduced in Appendix C of ES/CSET-2A.	Keep	Removable and fixed contamination typically present in filter pit containment. Enclosure is maintained smear-clean but fixed contamination may be present.
Radioactive Waste	> 0.002 FCi per gram of waste.	Keep	SLLW and TRU Wastes generated during filter change activities may be stored in order to minimize background in labs. Activity may exceed >0.002 µCi/gm
Toxic Material (include combustion products)	Any toxic chemical or combustion products $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	N/A	None identified.
Carcinogen	Any known carcinogen > RQ from Table 302.4, 40 CFR 302 or any other known carcinogen if not treated as toxic material (e.g., a substance listed in ES Chemical Carcinogen Report which is available on System Select 69).	N/A	None identified
Biohazard	Any known biohazard where special controls are required (see Section 4.2.5.2 of CSET2/R2).	N/A	None identified.
Asphyxiant	Any asphyxiant (i.e., gas at ambient temperature that is denser than air) that could either affect a large number of people or any unsuspecting people.	N/A	None identified.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Flammable Material	> 500 lb of a liquid with a flash point , 100EF or > 3000 standard ft^3 of a gas with an established lower explosive limit (LEL).	N/A	None identified.
Reactive Material	> 10 lb of a substance with an NFPA reactivity hazard level $ 2.	N/A	None identified
Explosive Material	Any 49 CFR 173 Division 1.1, 1.2, or 1.3; or >10 oz. of Division 1.4.	N/A	None identified.
Incompatible Material	Presence of > 1 kg of two or more incompatible chemicals listed in Appendix G of "Analysis References for Hazard Identification and Facility Classification" in same area.	N/A	None identified
Electrical Energy	Unusual application not adequately controlled by OSHA (e.g.; soil vitrification); $ 800 volts and 24 ma output; or stored energy $ 50 joules at 600 volts.	N/A	None identified
Kinetic Energy	High energy (e.g., flywheel or centrifuge type equipment).	N/A	None identified.
Thermal Energy	Unacceptable situation or by-product.	N/A	None identified.
High Pressure	$ 3,000 psig or $ 0.1 lb. TNT (1.4 x 10^5 ft-lb_f) equivalent energy.	N/A	None identified
Lasers	Any Class IV, any Class III with non-enclosed beam per American National Standards Institute Z-136.1.	N/A	None identified
Potential Energy	Elevated mass with "high" potential energy.	Keep	Filters, plugs, and equipment are elevated by crane.
Accelerators	Keep (Classify based on DOE Order 5480.25).	N/A	None identified
X-ray Machines	Any not meeting ANSI N43.2, N43.3, or N43.5 requirements.	N/A	None identified
Other	None	N/A	None identified

[1] Action decision is "keep" if criterion is exceeded or "screen out" if: a) criterion not exceeded, b) criterion is not applicable, or c) criterion is exceeded but justification as "Other Industrial" hazard requiring no further evaluation is attached and approved.

PRELIMINARY HAZARD SCREENING WORKSHEET

Facility: Radioactive Materials Analytical Laboratory
System, subsystem: **(4) Radiological Laboratory Areas** Date: 4/1/98

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Radioactive Material	Any radioisotope meeting or exceeding the table A1, DOE-STD-1027-92 TQ criteria; or exceeding the Appendix B, 40 CFR 302 RQ criteria. The inventory / RQ or inventory / TQ ratios should be added when making this evaluation.	Keep	Various transuranics are utilized for research purposes, see nuclear inventory.
Radioactive Surface Contamination	Measurements of fixed, removable, or both exceed values in Attachment 2 of DOE 5480.11 (reproduced in Appendix C of ES/CSET-2A.	Keep	Fixed and/or removable contamination is present in glove boxes and hoods. Quantities may exceed DOE 5480.11 Att. 2 values.
Radioactive Waste	> 0.002 FCi per gram of waste.	Keep	SLLW and TRU Wastes are generated during research activities in very small quantities. Activity may exceed >0.002 µCi/gm
Toxic Material (Lead only)	Lead products $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	Keep	Lead shielding
Toxic Material (include combustion products)	Any toxic chemical or combustion products (except for lead) $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	Screen Out	Maintained below RQ values. Standard "laboratory use" quantities of chemicals are under ORNL (OSHA) Laboratory Standard OSHP-003.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION “keep” or “screen out”	ACTION BASIS include inventory and form of all materials
Carcinogen	Any known carcinogen > RQ from Table 302.4, 40 CFR 302 or any other known carcinogen if not treated as toxic material (e.g., a substance listed in ES Chemical Carcinogen Report which is available on System Select 69).	Screen Out	Maintained below RQ values. Standard “laboratory use” quantities of chemicals are under ORNL (OSHA) Laboratory Standard OSHP-003.
Biohazard	Any known biohazard where special controls are required (see Section 4.2.5.2 of CSET2/R2).	N/A	None identified.
Asphyxiant	Any asphyxiant (i.e., gas at ambient temperature that is denser than air) that could either affect a large number of people or any unsuspecting people.	Screen Out	Cylinders of various compressed gases are utilized throughout lab operations. Argon and P10 are piped into the facility from cylinders maintained outside the facility. Criteria is not exceeded.
Flammable Material	> 500 lb of a liquid with a flash point , 100EF or > 3000 standard ft^3 of a gas with an established lower explosive limit (LEL).	Screen Out.	Standard laboratory solvents and quantities. Below criteria.
Reactive Material	> 10 lb of a substance with an NFPA reactivity hazard level $ 2.	Screen Out	Maximum quantities are not exceeded
Explosive Material	Any 49 CFR 173 Division 1.1, 1.2, or 1.3; or >10 oz. of Division 1.4.	N/A	None identified.
Incompatible Material	Presence of > 1 kg of two or more incompatible chemicals listed in Appendix G of “Analysis References for Hazard Identification and Facility Classification” in same area.	N/A	No chemicals are present above referenced quantity. Incompatible materials (of < quantities) are maintained IAW OSHA Lab Std.
Electrical Energy	Unusual application not adequately controlled by OSHA (e.g.; soil vitrification); $ 800 volts and 24 ma output; or stored energy $ 50 joules at 600 volts.	Screen out	Various lab equipment
Kinetic Energy	High energy (e.g., flywheel or centrifuge type equipment).	N/A	None identified.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Thermal Energy	Unacceptable situation or by-product.	Keep	
High Pressure	$ 3,000 psig or $ 0.1 lb. TNT (1.4 x 10^5 ft-lb_f) equivalent energy.	Screen out	Compressed gas cylinders are <3000 psi.
Lasers	Any Class IV, any Class III with non-enclosed beam per American National Standards Institute Z-136.1.	Keep	CASD follows the guidelines of ANSI Z-136.1. All variances are addressed in CASD-OP-000-SH01.
Potential Energy	Elevated mass with "high" potential energy.	N/A	None identified
Accelerators	Keep (Classify based on DOE Order 5480.25).	N/A	None identified
X-ray Machines	Any not meeting ANSI N43.2, N43.3, or N43.5 requirements.	Keep	X-ray machine complies with applicable sections of ANSI N43.2 and 43.3, and N43.5.
Other	None	N/A	None identified

[1] Action decision is "keep" if criterion is exceeded or "screen out" if: a) criterion not exceeded, b) criterion is not applicable, or c) criterion is exceeded but justification as "Other Industrial" hazard requiring no further evaluation is attached and approved.

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PRELIMINARY HAZARD SCREENING WORKSHEET

Facility: Radioactive Materials Analytical Laboratory
System, subsystem: **(5) Hot Cell Containment Area** Date: 4/1/98

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Radioactive Material	Any radioisotope meeting or exceeding the table A1, DOE-STD-1027-92 TQ criteria; or exceeding the Appendix B, 40 CFR 302 RQ criteria. The inventory / RQ or inventory / TQ ratios should be added when making this evaluation.	Keep	Various isotopes are maintained for analytical and research purposes. See nuclear inventory. Materials are maintained in shielded containers, storage cabinets, or within the cells. Small quantities of fissionable materials may be present.
Radioactive Surface Contamination	Measurements of fixed, removable, or both exceed values in Attachment 2 of DOE 5480.11 (reproduced in Appendix C of ES/CSET-2A.	Keep	Removable and fixed contamination typically present on cell floor, walls and ceiling. Cell access area is maintained smear-clean but fixed contamination may be present.
Radioactive Waste	> 0.002 FCi per gram of waste.	Keep	SLLW and TRU Wastes generated during research activities may be stored in order to minimize background in labs. Activity may exceed >0.002 µCi/g.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Toxic Material (include combustion products)	Any toxic chemical or combustion products $ RQ from Table 302.4, 40 CFR 302; or any other known toxic material (e.g., NIOSH Pocket Guide to Chemical Hazards lists an IDLH).	Keep	Zinc bromide solution used for shielding in the cell window was identified as exceeding the RQ limit.
Carcinogen	Any known carcinogen > RQ from Table 302.4, 40 CFR 302 or any other known carcinogen if not treated as toxic material (e.g., a substance listed in ES Chemical Carcinogen Report which is available on System Select 69).	N/A	None identified
Biohazard	Any known bio-hazard where special controls are required (see Section 4.2.5.2 of CSET2/R2).	N/A	None identified.
Asphyxiant	Any asphyxiant (i.e., gas at ambient temperature that is denser than air) that could either affect a large number of people or any unsuspecting people.	N/A	None identified.
Flammable Material	> 500 lb of a liquid with a flash point , 100EF or > 3000 standard ft^{3} of a gas with an established lower explosive limit (LEL).	N/A	None identified.
Reactive Material	> 10 lb of a substance with an NFPA reactivity hazard level $ 2.	N/A	None identified
Explosive Material	Any 49 CFR 173 Division 1.1, 1.2, or 1.3; or >10 oz. of Division 1.4.	N/A	None identified.
Incompatible Material	Presence of > 1 kg of two or more incompatible chemicals listed in Appendix G of "Analysis References for Hazard Identification and Facility Classification" in same area.	N/A	None identified
Electrical Energy	Unusual application not adequately controlled by OSHA (e.g.; soil vitrification); $ 800 volts and 24 ma output; or stored energy $ 50 joules at 600 volts.	N/A	None identified
Kinetic Energy	High energy (e.g., flywheel or centrifuge type equipment).	N/A	None identified.
Thermal Energy	Unacceptable situation or by-product.	N/A	None identified.
High Pressure	$ 3,000 psig or $ 0.1 lb. TNT (1.4 x 10^{5} ft-lb_{f}) equivalent energy.	N/A	None identified
Lasers	Any Class IV, any Class III with non-enclosed beam per American National Standards Institute Z-136.1.	N/A	None identified
Potential Energy	Elevated mass with "high" potential energy.	Keep	Shielded casks and equipment are elevated by crane.

TYPE HAZARD	KEEP IF CRITERIA ARE EXCEEDED	ACTION "keep" or "screen out"	ACTION BASIS include inventory and form of all materials
Accelerators	Keep (Classify based on DOE Order 5480.25).	N/A	None identified
X-ray Machines	Any not meeting ANSI N537/NBS123 requirements.	N/A	None identified.
Other	None	N/A	None identified.

[1] Action decision is "keep" if criterion is exceeded or "screen out" if: a) criterion not exceeded, b) criterion is not applicable, or c) criterion is exceeded but justification as "Other Industrial" hazard requiring no further evaluation is attached and approved.

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ATTACHMENT B

HAZARD IDENTIFICATION MATRIX

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HAZARD IDENTIFICATION MATRIX

Facility: 2026 - Radioactive Materials Analytical Laboratory
Segment: Balance of Facility — Date: 4/1/98

Hazard Type	Hazard Description	Location	Dispo.[a]	Justification for Hazard Disposition of Insignificant, Routine, or Standard Industrial Hazards
Radioactive Material	Various physical forms of radionuclides are prepared and utilized for experiments in the radiological laboratories.	Rad Labs	U	
	Radioactive samples (both solid and liquid form) are maintained, stored in shielded container, as source materials for experimental use.	Hot Cell Areas	U	
Radioactive Surface Contamination	Fixed and/or removable surface contamination in glove boxes and fume hoods. Laboratories are maintained smear-clean and are regulated as Radiological Buffer Areas.	Rad Labs	U	
	Fixed and/or removable surface contamination present in excess of criteria.	Hot Cell Areas	U	
	Fixed and/or removable surface contamination present in excess of criteria.	Filter and Stack Area	U	

Hazard Type	Hazard Description	Location	Dispo.[a]	Justification for Hazard Disposition of Insignificant, Routine, or Standard Industrial Hazards
Radioactive Waste	All radiological laboratories have potential for the generation of radioactive waste. Waste may be collected in the laboratories until container volume or background radiation requires disposal.	Rad Labs	U	
	All radiological areas have potential for the generation of radioactive waste.	Filter & Stack Area	U	
	Hot Cells my be utilized for the interim storage of high radiation wastes in order to minimize background in the individual laboratories in accordance with ALARA principles.	Hot Cell Areas	U	
Toxic Material	Lead bricks and lead sheeting are used for shielding purposes.	Rad Labs	U	
	Lead bricks and lead sheeting are used for shielding purposes.	Hot Cell Areas	U	
	Zinc bromide solution used for shielding in cell windows.	Hot Cell Areas	U	
Kinetic Energy	Electric motors and fans associated with ventilation system. Various support equipment.	Equip. And Utility Areas	SIH	Use of electric motors and fans are common to industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
Thermal Energy	Various laboratories are equipped with high temperature furnaces and drying ovens for sample preparation.	Rad Labs	SIH	Use of high temperature furnaces and ovens are common in laboratory applications and industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.

Hazard Type	Hazard Description	Location	Dispo.[a]	Justification for Hazard Disposition of Insignificant, Routine, or Standard Industrial Hazards
High Pressure	Carver laboratory press capable of 20,000 lbs hydraulic pressure is utilized for pellet (target) fabrication.	Non-Rad Areas	SIH	Press is commonly found in industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
Lasers	Class 3b and Class 4 lasers may be utilized in optical spectroscopy, fluorescence spectroscopy, and laser spectrometry.	Rad Labs	SIH	Operations of laser are in accordance with CASD Laser Operating Procedure as per applicable sections of ANSI standards. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
Potential Energy	Heavy loads may be elevated by various overhead cranes in the filter pit areas. It should be noted that overhead lifts are not normally used in these areas.	Filter and Stack Area	SIH	The use of a crane to elevate heavy loads is common to industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
	Heavy loads may be elevated by various overhead cranes in the operating and cell access areas. It should be noted that overhead lifts are not normally used in these areas.	Hot Cell Areas	SIH	The use of a crane to elevate heavy loads is common to industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
Accelerators	Not applicable			
X-ray Machines	X-ray generators may be utilized for various experiments and R&D applications.	Rad Labs	SIH	X-ray generator are common to industry. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.
Microwave/ RF Generators	Microwave digestion unit utilized for sample preparation. RF Generator is power source for emission and mass spectrometer systems. RF systems operate at 27.12 MHZ at 1000-1400 Watts (capable of 2000 Watts).	Rad Labs	SIH	Microwave digestion unit and RF generator are both common to industry and particularly the analytical environment. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.

Hazard Type	Hazard Description	Location	Dispo.[a]	Justification for Hazard Disposition of Insignificant, Routine, or Standard Industrial Hazards
High Magnetic Field	Mass spectrometers, which may be used in the facility, generate high magnetic fields (>100 gauss).	Rad Labs	SIH	Mass spectrometers are common to industry and particularly in the area of analytical techniques. Common precautions regarding the installation and operation of this equipment are sufficient to provide an acceptable margin of safety.

[a] Hazard disposition - identify whether the hazard is Insignificant (I), Routine (R), Standard Industrial (SIH) or Unusual (U).

ATTACHMENT C

INITIATING EVENT SELECTION

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INITIATING EVENT SELECTION

No.	Initiating Event	Event Description	Retained (Y/N)	Justification for Events not Retained
1	Earthquake	Seismic event causes collapse of building structure resulting in loss of containment.	Yes	
2	Tornado/High Wind	Tornado/high winds and associated flying debris causes collapse of building structure resulting in loss of containment.	Yes	
3	Snow/Ice Loads	Snow/ice load on building causes roof to collapse resulting in loss of containment.	No	Roof is capable of 30 lbs/ft^2 loading.
4	Lightning	Direct lightning strike causes fire.	Yes	
5	Extreme Cold	Extreme cold causes ventilation system freeze-stat trip resulting in shift of system to reduced flow.	Yes	
6	Flooding (external)	Heavy rainfall and/or failure of river dams causes flood that exceeds site grade.	No	Building is above 100 year flood plain.
7	Fire (external)	Fire in surrounding vegetation causes damage to building.	No	RMAL is constructed of non-combustible materials. Localized area contains few trees and is maintained clear of tall vegetation. A fire in the vicinity is not considered credible.
8	Equipment Failure	Electrical and/or mechanical equipment/device failure/malfunction results in loss of containment.	Yes	
9	Fire (internal)	Flammable materials ignite or electrical equipment malfunction causes fire resulting in loss of containment and dispersion of material.	Yes	
10	Explosion	Explosion causes fire and loss of containment resulting in the dispersion of material.	Yes	

No.	Initiating Event	Event Description	Retained (Y/N)	Justification for Events not Retained
11	Uncontrolled Chemical Reaction	Uncontrolled chemical reaction results in 9 and/or 10 above.	Yes	
12	Flooding (internal)	Introduction of water into the laboratory spaces causes the spread of contamination.	Yes	
13	Power Failure	Power to the building is lost due to events beyond facility personnel control.	Yes	
14	Containment Failure	Containment failure causes loss of control of material.	Yes	
15	Operator Error	Operator error results in loss of containment and/or loss of shielding.	Yes	
16	Aircraft Crash	Aircraft crashes into the building causing structural damage and loss of containment.	No	The estimated frequency of an aircraft crash into building 2026 is less than 10^{-6} per year. This event is not considered credible.
17	Forced Evacuation	Facility personnel are forced to evacuate the facility due to fire, smoke, chemical release, of lab-wide evacuation.	Yes	
18	Criticality Accident	Sufficient quantities of fissionable material is introduced into the facility resulting in an uncontrolled criticality.	No	Administrative controls limit the amount of fissile material to less than the SAFM.
19	Transportation Accident	Transportation accident involving trains, trucks, tankers, cranes, or automobiles causes damage to the facility structure.	No	Location of the facility is in proximity to the following: No rail lines, no major transportation route. Accident involving movement of trucks and forklifts are addressed under operator error.
20	ORNL Adjacent Facility Interaction	Accidents or activities at adjacent facilities impact operations.	No	Adjacent facilities pose no credible threat to operations.

ATTACHMENT D

PROCESS HAZARD ANALYSIS SUMMARY SHEETS

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Process Hazard Analysis Summary Sheets

Accident 1 Scenario		
Description		**External event causes damage to the facility and its systems resulting in loss of containment and subsequent exposure to personnel.**
Initiating Events		Earthquake, Tornado/High Wind, Lightning
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, radioactive surface contamination, radioactive waste, and toxic material.
Controls		
Prevention	**Design**	! Facility designed to withstand certain external loads. ! Hot cells provide additional wall thickness for shielding.
	Administrative	N/A
Detection	**Design**	Regional and local weather/seismic monitoring.
	Administrative	Operations personnel observation.
Mitigation	**Design**	Building structure will provide some secondary containment if not destroyed.
	Administrative	! Restrictions on total nuclear material inventory. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **Moderate**
Consequence Level: **Low**
Risk Level: **Low (2)**

Process Hazard Analysis Summary Sheets

Accident 2 Scenario		
Description		**Contaminated solid waste stored in the facility is released to the environment.**
Initiating Events		Fire, explosions, uncontrolled chemical reaction, flooding
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive waste.
Controls		
Prevention	**Design**	Facility designed to withstand certain external loads.
	Administrative	Limit on amount of waste staged for disposal.
Detection	**Design**	Continuous air monitor.
	Administrative	Operations personnel observation.
Mitigation	**Design**	Building structure will provide some secondary containment if not destroyed.
	Administrative	! Restrictions on total nuclear material inventory. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **Moderate**
Consequence Level: **Low**
Risk Level: **Low (2)**

Process Hazard Analysis Summary Sheets

Accident 3 Scenario		
Description		**Additional radioactive material is placed in the storage areas producing excessive dose rates in adjacent working areas.**
Initiating Events		Operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	Storage area equipped with additional shielding.
	Administrative	! Sample login and/or material inventory. ! Monitoring by radiological protection personnel.
Detection	**Design**	None.
	Administrative	Routine radiation survey.
Mitigation	**Design**	None.
	Administrative	! Evacuation of area. ! Emergency preparedness program

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 4 Scenario		
Description		**Failure of glovebox containment releases radioactive material into the laboratory spaces.**
Initiating Events		Equipment failure, fire, explosion, uncontrolled chemical reaction.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination.
Controls		
Prevention	**Design**	! Rugged construction of glovebox. ! Ventilation system maintains box negative with respect to laboratory.
	Administrative	Pre-operational glovebox checks.
Detection	**Design**	Continuous air monitors.
	Administrative	Operator observation.
Mitigation	**Design**	Building ventilation system.
	Administrative	! Glovebox training - abnormal conditions. ! Evacuation of laboratory/facility.

<u>RISK DETERMINATION</u>

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 5 Scenario		
Description		**Building ventilation systems fails to maintain negative pressure in the containment areas or fails to properly filter exhaust air prior to discharge from the facility.**
Initiating Events		Equipment failure, loss of facility services.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	! Redundant components in ventilation system. ! Facility is inherently safe in stagnant flow condition.
	Administrative	! Periodic maintenance. ! Daily operational checks.
Detection	**Design**	! Differential pressure and flow indicators. ! Ventilation system alarms.
	Administrative	! Daily operational checks. ! Alarms associated with ventilation system.
Mitigation	**Design**	Automatic configuration change and shift to backup (standby) components.
	Administrative	! Operational restrictions on facility. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 6 Scenario		
Description		**Radioactive material relocated within the facility is left improperly shielded resulting in external exposure to personnel working in the area.**
Initiating Events		Operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	None.
	Administrative	Radiological protection coverage.
Detection	**Design**	None.
	Administrative	Routine radiation surveys.
Mitigation	**Design**	Building structure and storage area provides some shielded.
	Administrative	! Radiological protection coverage. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 7 Scenario		
Description		**Loss of containment control of material results in personnel contamination and internal/external exposure.**
Initiating Events		Equipment failure, fire, explosion, uncontrolled chemical reaction, containment failure, operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	Redundant layers of containment.
	Administrative	Limits on material quantities within certain containment areas.
Detection	**Design**	! Continuous air monitors. ! Fire protection system.
	Administrative	! Operator observation. ! Radiological area exit detection instrumentation.
Mitigation	**Design**	! Redundant layers of containment. ! Ventilation system. ! Fire protection system.
	Administrative	! Restriction of the inventory of radioactive materials. ! Standard operating procedures.

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 8 Scenario		
Description		**Fire within a laboratory causes loss of containment and airborne dispersion of radioactive material into the immediate area.**
Initiating Events		Equipment failure, fire, explosion, uncontrolled chemical reaction.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	! Facility is constructed mainly of non-combustible materials such as concrete, cinder block, and steel. ! Hot cells are constructed of concrete, metal, and glass.
	Administrative	Quantities of flammable material allowed in the facility are limited to amounts normally used in laboratory operations.
Detection	**Design**	! Automatic fire alarms ! CAMS
	Administrative	Operator observation.
Mitigation	**Design**	! Automatic fire protection system ! Hand-held extinguishers. ! Fire department.
	Administrative	! Restriction of the inventory of radioactive materials. ! Fire protection program. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **Moderate**
Consequence Level: **Low**
Risk Level: **Low (2)**

Process Hazard Analysis Summary Sheets

Accident 9 Scenario		
Description		**Failure of hot cell window results in loss of zinc bromide and loss of shielding of radioactive materials.**
Initiating Events		Equipment failure, fire, explosion, uncontrolled chemical reaction, containment failure, operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, toxic material.
Controls		
Prevention	**Design**	Rugged structural design.
	Administrative	Periodic inspection of hot cells.
Detection	**Design**	! Differential pressure. ! Monitron and continuous air monitors.
	Administrative	Operator observation.
Mitigation	**Design**	Ventilation system maintains negative pressure.
	Administrative	! Radionuclide inventory restrictions. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: Moderate
Consequence Level: Low
Risk Level: Low (2)

Process Hazard Analysis Summary Sheets

Accident 10 Scenario		
Description		**Zinc bromide solution storage containers receive damage resulting in loss of chemical confinement.**
Initiating Events		Fire, explosion, uncontrolled chemical reaction, containment failure.
Applicable Operating Mode		Operation, Standby
Hazards		Toxic material.
Controls		
Prevention	**Design**	Containers are double lined.
	Administrative	Inspection of building equipment and containers.
Detection	**Design**	None.
	Administrative	Operator observation.
Mitigation	**Design**	Containers are double lined.
	Administrative	! Spill response. ! Emergency preparedness.

RISK DETERMINATION

Frequency Level: **Low**
Consequence Level: **Low**
Risk Level: **Low (1)**

Process Hazard Analysis Summary Sheets

Accident 11 Scenario		
Description		**Hot cell access is opened in error resulting in exposure to operating personnel.**
Initiating Events		Operator error
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	! Cell doors are locked. ! Sequence must be followed.
	Administrative	Standard operating procedure is in place.
Detection	**Design**	! Differential pressure. ! Monitron and continuous air monitors.
	Administrative	Operator observation.
Mitigation	**Design**	! Building structure provides some shielding. ! Ventilation system maintains flow into the cell.
	Administrative	! Radionuclide inventory is controlled. ! Access area/building evacuation as necessary. ! Emergency preparedness program.

RISK DETERMINATION

Frequency Level: **Moderate**
Consequence Level: **Low**
Risk Level: **Low (2)**

Process Hazard Analysis Summary Sheets

Accident 12 Scenario		
Description		**Loss of carrier/cask control results in personnel exposure.**
Initiating Events		Equipment failure, operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	! Structural design of carrier/cask. ! Hoist rated sufficiently to lift range of carriers/casks. ! Building structure provides for some shielding.
	Administrative	! Inspection of hoisting equipment. ! Standard operating procedures are adhered to.
Detection	**Design**	Monitrons and continuous air monitors in cell access area.
	Administrative	Operator observation.
Mitigation	**Design**	Building ventilation system provides containment to within access area.
	Administrative	Standard operating procedures.

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

Process Hazard Analysis Summary Sheets

Accident 13 Scenario		
Description		**Liquid waste line is breached or sample container is dropped resulting in the introduction of radioactive liquid into the facility.**
Initiating Events		Equipment failure, operator error.
Applicable Operating Mode		Operation, Standby
Hazards		Radioactive material, surface contamination, and waste.
Controls		
Prevention	**Design**	LLLW piping is double lined with failure detection. Pipe is protected by facility structure.
	Administrative	Procedures are in place for proper operation of the LLLW system.
Detection	**Design**	Pressure gauges and alarms associated with annulus pressure detect abnormal conditions.
	Administrative	Operational checks performed on system.
Mitigation	**Design**	Majority of piping is installed underground.
	Administrative	Procedure dictates proper response to abnormal operating condition.

RISK DETERMINATION

Frequency Level: **High**
Consequence Level: **Low**
Risk Level: **Low (4)**

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ATTACHMENT E

NON-NUCLEAR HAZARD CLASSIFICATION

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Non-Nuclear Hazard Classification for the RMAL, Building 2026

1 INTRODUCTION

Various quantities of laboratory chemicals are used in the analytical chemistry and test processes conducted in the RMAL Facility. Based upon ES/CSET-2/R2[1] (Section 3.6, *Material Excluded from Hazard Identification*), small quantities of hazardous materials may be excluded if a laboratory meets requirements of 29 CFR 1910.1450[2] (OSHA Laboratory Standard). Laboratory use of these chemicals must not involve "production" and testing should be on a scale smaller than pilot-plant operations. The RMAL is an analytical chemistry laboratory that meets the conditions stated above and all operations meet the requirements of 29 CFR 1910.1450. Therefore, all laboratory chemicals are excluded from the hazard identification process for this analysis. Although the majority of the chemicals used in the facility are small quantities, a few chemicals (lead and zinc bromide) are present in large quantities for shielding purposes.

The purpose of this attachment is to provide analysis of an unmitigated bounding accident at the RMAL Facility in support of the non-nuclear hazard classification process. Specifically, the maximum airborne concentrations of toxic materials at on-site and off-site locations following the given events are calculated and compared to the estimated Emergency Response Planning Guideline (ERPG-2) concentrations for the released materials. The facility non-nuclear hazard classification will be based upon this analysis.

2 BASIS

2.1 Assumptions

- All of the containers of hazardous chemicals located in the RMAL Facility are breached due to the bounding accident. All the material stored in the containers is subsequently released from the containers.

- The respirable airborne fraction is 0.001 for all hazardous materials. This release fraction is based on the assumption that there are not significant quantities of hazardous gases or volatile hazardous materials present in the RMAL Facility.

- The quantities and types of hazardous materials listed in the Hazardous Materials Information System will not change significantly over time.

- The lead (Pb) in the RMAL Facility is not in a dispersible form, the zinc bromide ($ZnBr_2$) is in an aqueous solution which would not be easily dispersed (conservatively assumed < 10%).

- Atmospheric stability category "D" and windspeed of 3.0 m/sec are conservative for hazard classification purposes.

2.2 Methodology

According to ES/CSET-2/R2, any toxic material limit that is present in quantities less than the 40 CFR 302.4[3] final Reportable Quantities (RQ) can be eliminated from further analysis. In addition, ES/CSET-2/R2 (Section 3.6, *Material Excluded from Hazard Identification*), states that small quantities of hazardous materials may be excluded if a laboratory meets requirements of 29 CFR 1910.1450 (OSHA Laboratory Standard). However, those chemicals that are present in quantities greater than the final RQ must be retained for a consequence-based evaluation. The consequence-based evaluation is described in the following paragraphs.

The centerline concentrations downwind at the receptor site following an accidental release of toxic materials are calculated using a simple Gaussian dispersion model in accordance with ES/CSET-2A[4]. For the purpose of hazard classification, an on-site receptor distance of 200 m is used. Both the on-site and off-site receptor distance is taken to be 200 m for the purpose of this hazard classification. A windspeed of 3.0 m/sec and an atmospheric stability category "D" are assumed for the Gaussian dispersion model as recommended in Appendix E of ES/CSET-2A.

Given the quantity of toxic material at risk, the time-weighted average airborne concentration of toxic material is determined. The following equations apply for instantaneous ground-level releases such as an earthquake scenario:

$$C = \frac{I}{t_A} \tag{1}$$

where,

- C = time-weighted average airborne concentration, g/m^3
- I = concentration-time integral close to a point source, g-sec/m^3
- t_A = averaging time, sec.

$$I = \left(\frac{Q}{\pi U A_y A_z} \right) \sum_{j=0}^{j=1} \left[\frac{1}{S_j (1 + S_j)} \exp\left(- \frac{H_j}{(1 + S_j)} \right) \right] \tag{2}$$

where,

- Q = amount of material release to the air, g
- U = velocity of the air carrying material from the source in the X direction, m/sec
- A_y = dispersion parameter in the Y direction, m
- A_z = dispersion parameter in the Z direction, m
- j = a counting variable with values 0 and 1.

$$H_j = \left(\frac{Y}{A_y}\right)^2 + \left[\frac{(Z - H)^2 + 4jZH}{A_z^{\,2}}\right] \qquad \textbf{(3)}$$

where,

Y = horizontal distance of the receptor measured from the X axis (all values), m
Z = vertical distance of the receptor measured from the X axis ("+" values), m
H = vertical position ("+" values) of the point source measured from the X axis, m.

$$S_j = \sqrt{1 + \frac{H_j}{X_A}} \qquad \textbf{(4)}$$

$$X_A = \left(\frac{X}{A_y}\right)^2 \qquad \textbf{(5)}$$

where, X = distance from point of release to receptor, m.

The dispersion parameters A_y and A_z are calculated in one of two ways. The method that gives the larger parameter should be used for the Gaussian dispersion model:

$$A_y = \left(\frac{0.08X}{\sqrt{1 + 0.0001X}}\right) \text{, and} \qquad A_z = \left(\frac{0.06X}{\sqrt{1 + 0.0015X}}\right) \qquad \textbf{(6)}$$

or,

$$A_y = A_z = 0.175\sqrt{X} \qquad \textbf{(7)}$$

The equations for A_y and A_z in Eq. 6 are taken from Table 2, Appendix E, ES/CSET-2A, and are the formulas for estimating dispersion coefficient for Stability category "D" as recommended by DOE-STD-1027-92. The dispersion coefficients given by Eq. 7 are for small values of X and are not used here.

3 ANALYSIS AND CALCULATIONS

3.1 Toxic Material Release Calculations

The types and quantities of hazardous chemicals located in the RMAL Facility are maintained on an internal inventory system. An initial screening was conducted to determine which toxic chemicals must be retained for further analysis. The initial screen was based on identifying chemicals that exceeded laboratory quantities as defined in 29 CFR 1910.1450 and 40 CFR 302.4 RQ limits. If the quantity was greater than laboratory quantities or the RQ values, the material required additional evaluation based upon a consequence analysis. Only two materials were identified that required further evaluation, which included the lead used for shielding and the zinc bromide solution used in the hot cell window, also for shielding. The following table lists the quantity of theses materials.

Table 1 Comparison of Hazardous Material Quantities to 40 CFR 302.4 RQs

Material	Total Volume/Weight	Total Weight (lbs)	302.4 RQ (lbs)
Lead shielding	87,500 lbs.	87,500	10*
Zinc bromide solution	2400 gal.	50,064	1,000

* No reporting required if the diameter of the pieces of the solid metal released is equal to or exceed 100 micrometers (0.004 in.).

The lead is in the form of shielding bricks, lead sheets, and lead glass and it is not possible to release the lead in forms smaller than 0.004 inches. Therefore, the lead is not reportable per 40 CFR 302.4 and is screened from further analysis. The zinc bromide solution must be examined further to determine the effect to the on-site and off-site population.

In accordance with DOE Order 5481.1B[5], the non-nuclear classification is established by estimating the consequences of unmitigated, bounding accident scenarios involving the unusual non-nuclear hazard. The criteria in Table 2 are used for determining the non-nuclear classification.

Table 2 Criteria for Determining the Non-nuclear Hazard Classification

Hazard Classification	Consequence Criteria
Industrial	Reversible health effects or less onsite and off site
Low	Greater than reversible health effects on-site
Moderate	Greater than reversible health effects off-site
High	As designated by CSO

To determine if the zinc bromide solution will cause irreversible health effects at 200 m, a Gaussian dispersion model is used to estimate the maximum airborne concentration of zinc bromide at on-site and off-site locations following a bounding release. The airborne concentration is compared to the ERPG-2 concentration to determine a facility hazard classification. Airborne concentrations exceeding the ERPG-2 concentrations are conservatively assumed to result in irreversible effects. Therefore, applying the criteria summarized above, if the concentration exceeds the ERPG-2 value on-site, the facility is considered a Low Hazard Facility. If the concentration is less than the ERPG-2 value on-site, the facility is considered an Industrial Hazard Facility.

Very few ERPG-2 values are established for hazardous materials. Based on information from the Material Safety Data Sheet (MSDS) for the zinc bromide solution, the ERPG concentration was estimated from Ref. 6. The ERPG-2 concentration was estimated to be 90 mg/m^3. As an initial consequence analysis, the airborne concentration of zinc bromide as a result of a bounding accident is compared to the ERPG-2 concentration of 90 mg/m^3.

The Gaussian dispersion model from ES/CSET-2A is used to determine the airborne concentration due to 1 gram release of respirable material. The zinc bromide solution is a high density (>2.5 g/mL) aqueous solution with a high viscosity that would be resistant to dispersion as an aerosol. The on-site distance of 200 m, windspeed of 3.0 m/sec, and atmospheric stability category “D” are also assumed for the model. The consequences from an airborne release of 1 gram of hazardous material are calculated as follows for the on-site location of 200 m:

$$A_y = A_z = 0.175\sqrt{200} = 2.47\ m$$

$$A_y = \left(\frac{0.08 \cdot 200}{\sqrt{1 + 0.0001 \cdot 200}} \right) = 15.84\ m$$

$$A_z = \left(\frac{0.06 \cdot 200}{\sqrt{1 + 0.0015 \cdot 200}} \right) = 10.52\ m$$

Therefore, the parameters A_y = 15.84 m and A_z = 10.52 m will be used for the Gaussian dispersion model. Since the parameters Y, Z, and H, as defined in Eq. 3 are set to zero for this model because of the large distance (200 m) to the receptor, all possible values for H_j and S_j will result in the following constants, H_j = 0 and S_j =1.

Then from Eq. 2,

$$I = \left[\frac{1g}{\pi \times 3.0\,m/\text{sec} \times 15.84 \times 10.52}\right]\left[\frac{1}{1 \times (1 + 1)} + \frac{1}{1 \times (1 + 1)}\right] = 0.00064\ g \cdot \text{sec}/m^3$$

and Eq. 1, the time-weighted average airborne concentration can be calculated as follows:

$$C = \left[\frac{0.64\ mg \cdot \text{sec}/m^3}{15\,min \times 60\,sec/\text{min}}\right] = 0.00071\,mg/m^3$$

Therefore, an airborne release of 1 gram of dispersible zinc bromide solution from the RMAL Facility would cause an airborne concentration of 0.00071 mg/m^3 at the on-site location (200 m away). In order for the estimated ERPG-2 concentration of 90 mg/m^3 to be achieved, an airborne release of 126,760 grams (279.4 lb.) of dispersible zinc bromide solution is required. It is assumed that a conservative respirable release fraction for the bounding accident is applicable to the zinc bromide solution and is equal to 0.001. Therefore, the RMAL Facility must contain more than 279,400 lb. of zinc bromide solution before the estimated ERPG-2 concentration is exceeded. Currently the RMAL Facility contains approximately 50,064 lb. of zinc bromide solution, of which about 78% (39,050 lb.) is zinc bromide. Therefore, it is concluded that the quantities of hazardous materials used and stored in the RMAL Facility are not enough to cause the ERPG-2 concentration to be exceeded on-site or off-site.

4 CONCLUSIONS

Based on the results in section 3.1, the RMAL Facility does not contain enough hazardous material to cause significant on-site or off-site consequences. Therefore, the RMAL Facility is classified as a non-nuclear Industrial Hazard facility.

5 REFERENCES

1. ES/CSET-2/R2, *Safety Analysis Report Update Program Hazard Identification and Facility Classification Application Guide*, Martin Marietta Systems, Inc., Oak Ridge, Tennessee, December 1995.

2. 29 CFR 1910.1450, *Occupational Exposure to Hazardous Chemicals in Laboratories*.

3. 40 CFR 302, *Designation, Reportable Quantities, and Notification*, Section 4, “Designations of hazardous substances,” Code of Federal Regulations.

4. ES/CSET-2A, Analysis References for Hazard Identification and Facility Classification, Martin Marietta Systems, Inc., Oak Ridge, Tennessee, January 1996.

5. DOE Order 5481.1B, Safety Analysis and Review System, Change 1, U. S. Department of Energy, Washington, D. C., May 19, 1987.

6. JBFA-233-03-92, *Sensitivity and Toxic Equivalency Analysis for the WMRAD Hazardous Waste Storage Facilities*, JBF Associates, Inc., Knoxville, Tennessee, July 1994.

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