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Hot Cell Facility (HCF) Safety Analysis Report

G. W. Mitchell, R. E. Naegeli, J. A. Mahn, S. W. Longley, J. S. Philbin, N. F. Schwers, T. E. Vanderbeek, and D. T. Berry

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HOT CELL FACILITY (HCF)

SAFETY ANALYSIS REPORT

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Abstract

This Safety Analysis Report (SAR) is prepared in compliance with the requirements of DOE Order 5480.23, *Nuclear Safety Analysis Reports*, and has been written to the format and content guide of DOE-STD-3009-94 *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Safety Analysis Reports*. The Hot Cell Facility is a Hazard Category 2 nonreactor nuclear facility, and is operated by Sandia National Laboratories for the Department of Energy.

This SAR provides a description of the HCF and its operations, an assessment of the hazards and potential accidents which may occur in the facility. The potential consequences and likelihood of these accidents are analyzed and described. Using the process and criteria described in DOE-STD-3009-94, safety-related structures, systems and components are identified, and the important safety functions of each SSC are described. Additionally, information which describes the safety management programs at SNL are described in ancillary chapters of the SAR.

ACKNOWLEDGEMENTS

This SAR was the result of significant and enduring effort by a large number of people. The early efforts of S. Bourcier, D. Berry, and D. Talley to conscientiously apply sound principles of safety analysis are particularly acknowledged. Their initial work has greatly benefited and been carried through the entire report. The timely and thorough critical review accomplished by K. Reil and the SNL Radiological and Criticality Safety Committee contributed significantly to improving this document. Finally, the untiring and enthusiastic effort by C. Baca to prepare the report for review and publication was greatly appreciated.

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ACRONYMS AND ABBREVIATIONS

AC	Administrative Controls
ACL	Administrative Control Level
ACRR	Annular Core Research Reactor
ADPRO	Administrative Procedures
AFF	Aqueous Film Forming
AHCF	Auxiliary Hot Cell Facility
ALARA	As Low As Reasonably Achievable
ARAC	Atmospheric Release Advisory Code
ARF	Airborne Release Fraction
ATS	Automatic Transfer Switch
CAMS	Continuous Air Monitoring System
CAN	Clean Air Network
CEDE	Committed Effective Dose Equivalent
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CMU	Concrete Masonry Unit
COO	Conduct of Operations
COV	Change of Value
CSA	Criticality Safety Assessment
DAC	Derived Air Concentration
DBA	Design Basis Accident
DF	Design Feature
DI	Density Inches
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DPC	Differential Pressure Controller
DR	Damage Ratio
DU	Depleted Uranium
EBE	Evaluation Basis Earthquake
EG	Evaluation Guideline
EMCS	Energy Management and Control System
EPA	Environmental Protection Agency
EPP	Emergency Preparedness Plan
ERO	Emergency Response Organization
ES&H	Environment, Safety and Health
ET	Event Tree
FDA	U.S. Food and Drug Administration
FID	Field Interface Device
FMEA	Failure Mode and Effects Analysis
FRFV	Final Release Fraction Value
GB	Glovebox
GERT	General Employee Radiological Training
GIF	Gamma Irradiation Facility
GMP	Good Manufacturing Practices
HCF	Hot Cell Facility
HEPA	High Efficiency Particulate Absorber
HLW	High Level Waste
HQ	Headquarters

ACRONYMS AND ABBREVIATIONS (Continued)

HR	Hydrogeologic Regions
HVAC	Heating, Ventilation, and Air Conditioning
IC	Incident Commander
ILA	Internal Lease Agreement
ICS	Incident Command Structure
KAFB	Kirtland Air Force Base
KUMSC	KAFB Underground Munitions Storage Center
kV	Kilovolt
LCO	Limiting Condition for Operation
LCP	Local Control Panel
LCS	Limiting Control Settings
LECS	Liquid Effluent Control System
LLW	Low Level Waste
LMF	Large Melt Facility
LN	Liquid Nitrogen
LPF	Leakpath Factor
MACCS2	MELCOR Accident Consequence Code System (Version 2)
MAR	Material at Risk
MCC	Motor Control Center
MER	Mechanical Equipment Room
MOI	Maximally exposed offsite individual
MSDS	Material Safety Data Sheet
MSL	Melting and Solidification Laboratory, also Mean Sea Level
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NFSC	Nuclear Facilities Safety Committee
NWS	National Weather Service
NRC	Nuclear Regulatory Commission
NSR	Non-safety-related
OC	Operations Center
OJT	On the Job Training
OP	Operating Procedure
ORIGEN	Oak Ridge Isotope Generation Code
ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Act
PA	Public Address
PAB	Perimeter Access Building
PEL	Permissible Exposure Limits
PES	Product Exit System
PHA	Preliminary Hazards Analysis
PHC	Preliminary Hazard Checklist
PNM	Public Service Company of New Mexico
PPE	Personal Protective Equipment
PSAR	Preliminary Safety Analysis Report
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
RAMS	Remote Area Monitoring System
RCRA	Resource Conservation and Recovery Act
RCSC	Radiological and Criticality Safety Committee

ACRONYMS AND ABBREVIATIONS (Continued)

RCT	Radiological Control Technician
REM	Roentgen Equivalent Man
RMA	Radioactive Material Area
RML	Radiation Metrology Laboratory
RMMA	Radiological Material Management Area
RMWMF	Radioactive and Mixed Waste Management Facility
RPPM	Radiation Protection Procedures Manual
RWP	Radiological Work Permit
SAR	Safety analysis report
SCB	Steel Confinement Box
SGB	Shielded Glove Box
SIRAS	Sandia Independent Review and Appraisal System
SNCSC	Sandia Nuclear Criticality Safety Committee
SNFSC	Nuclear Facility Safety Committee
SOP	Standard Operating Procedure
SPR	Sandia Pulse Reactor
STB	Steel Transfer Box
SERF	Sandia Engineering Reactor Facility
SL	Safety Limit
SNL	Sandia National Laboratories
SPO	Security Police Officer
SR	Surveillance Requirements
SSC	Structure, System, or Component
STP	Standard Temperature and Pressure
TA-V	Technical Area V
TA	Technical Area
TEDE	Total Effective Dose Equivalent
TES	Target Entrance System
TIM	Training Implementation Matrix
TRU	Transuranic
TSR	Technical Safety Requirement
TWD	Technical Work Document
UPS	Uninterruptable Power System
USAF	U.S. Air Force
USQ	Unreviewed Safety Question
VOC	Volatile organic compound
WG	Water Gauge

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EXECUTIVE SUMMARY

E.1 Background and Mission

The mission of the Hot Cell Facility (HCF) is the chemical extraction of radioisotopes. Upgrades to the previous facility have been implemented to support this mission, which will contribute to providing radioisotopes essential to U.S. consumers. These upgrades include additional shielding, installation of additional processing stations, provisions for temporary storage of high activity waste, and minor modifications to the ventilation system to provide filtration appropriate to the isotope processing mission. Previously, the HCF conducted a variety of research and development activities that required the handling of highly activated and/or contaminated radiological materials, principally to support nuclear safety research projects and testing for Department of Energy (DOE) Defense Programs. While the primary mission of the facility is to produce radioisotopes as directed by the DOE, it is expected that research and process development activities will continue in the facility on a non-interference basis with the isotope processing operation.

E.2 Facility Overview

The HCF is operated by Sandia National Laboratories, New Mexico (SNL/NM) on Kirtland Air Force Base (KAFB) in Albuquerque. It is principally located in the basement of Building 6580 (B6580) of Technical Area V (TA-V) and consists of steel confinement boxes (SCBs); a glovebox (GB) line; fumehoods; support areas; and fissile and radioactive material storage areas. The HCF is a radiochemical-processing laboratory. Processing of high activity radioactive materials is performed remotely in the heavily shielded SCBs; quality sampling is done in the glovebox line; and packaging takes place in a nearby support area. A three zone exhaust ventilation system controls migration of radioactive contaminants. This ventilation system exhausts through the HCF stack located immediately north of B6580.

Additional support equipment exists in nearby buildings, including a Mechanical Equipment Room (B6580B), B6581, and a liquid-nitrogen storage tank located immediately east of B6580. Other portions of B6580 provide light laboratories and office space for HCF operations. Material storage areas within TAV (B6595, B6596, and B6597) support the HCF mission.

Other nuclear facilities within TAV include the Sandia Pulsed Reactor (SPR), the Annular Core Research Reactor (ACRR), the Gamma Irradiation Facility (GIF), and the Auxiliary Hot Cell Facility (AHCF). TAV is located at the northeast corner of a larger SNL testing site, Technical Area 3, which contains numerous non-nuclear test facilities, and is five miles south of the main SNL site. The maximally exposed offsite individual is located approximately 3000 meters from the facility, which corresponds to the nearest boundary of Kirtland AFB.

E.3 Facility Hazard Classification

The Facility has been classified as a hazard category 2 nuclear facility based upon the planned radioactive material inventory compared to the threshold levels identified in DOE-STD-1027-92.

E.4 Safety Analysis Overview

The facility produces radioisotopes by chemically processing the fission products of irradiated uranium dioxide. These processes involve the generation of liquid solutions, the evolution of volatile radioactive gases, and the generation of significant inventories of residual radioactive materials that are solidified for temporary storage in the facility. These processes must be conducted in shielded locations with adequate ventilation and appropriate filtration for the control of contamination and the prevention of unmitigated releases of hazardous materials to the environment.

A formal hazard analysis of the anticipated operations was conducted using Preliminary Hazard Assessment (PHA) and Failure Modes and Effects Analysis (FMEA) techniques to evaluate potential hazards associated with processing operations, waste handling and storage, quality control activities, and maintenance. This process included the identification of various features to control or mitigate the identified hazards. Based on the hazard analysis, a more limited set of accident scenarios was selected for quantitative evaluation, which bound the risks to the public. These scenarios included radioactive material spills and fires and considered the effects of equipment failure, human error, and the potential effects of natural phenomena and other external events. The hazard analysis process led to the selection of eight design basis accidents (DBA's), which are summarized in Table E.4-1.

The potential source term for each of the selected DBAs was conservatively derived based on the maximum potential radiological inventory and assuming that the entire inventory was available for release (i.e. the airborne release fraction was assumed to be 1.0).

Of the various scenarios evaluated, the most serious consequences resulted from the spill of volatile process materials or a fire in an SCB. Based on these evaluations, structures, systems and components with the potential to mitigate this hazard were identified. While many features in the HCF control or mitigate the hazards for both workers and the public, the most significant mitigative feature for the protection of the public is the filtered HCF exhaust ventilation system.

In addition to the DBAs, three beyond design basis accidents (BDBAs), summarized in Table E.4-2, were identified to provide a perspective of the residual risk associated with operation of the HCF. The potential consequences of BDBAs are not significantly different than those resulting from the previously identified DBAs.

E.5 Facility Organizations with Safety Functions

Operation of the HCF is the responsibility of the HCF Department at SNL/NM, which is in the Nuclear Energy Technology Center, a component of the Energy, Information, and Infrastructure Technology Division. Radiological Protection support is provided by a parallel safety organizational structure: the Environment, Safety, and Health (ES&H) Teams. Integrated Risk Management Department is in the Environment, Safety, and Health Center, a component of the Laboratory Services Division. The latter Division also provides maintenance support to the facility through the Facilities Operations and Engineering Center. Safety oversight of SNL nuclear facilities is formalized in the Sandia Independent Review and Appraisal System (SIRAS). This system, described in Chapter 17, provides independent oversight by both internal SNL and external subject matter experts. This SAR was developed by the above SNL organizations and has been reviewed in accordance with SNL safety policies.

Table E.4-1. Design Basis Accidents

DBA #	Accident Description	Type	Associated Hazard Events*
	Design Basis Accidents		
1	Operator error or mechanical failure releases volatile contents of the target and/or acid cocktail inside an SCB	Spill	CP-4, CP-10
2	Deflagration of hydrogen in the Zone 2A canyon elevator pit	Explosion, Fire	WE-4
3	Fire in an SCB releases volatile contents of the target, iodine trap, and/or acid cocktail	Fire	CP-7
4	Energetic fork lift accident which breaches target cask, breaches the target, and releases volatile radioactive components in the target; with and without a fork lift fire	Spill, (Exposure, Fire)	TT-1, TT-2, TT-3, TT-4, & CP-1
5	Combustion of hydrogen gas or flammable material in the Room 109 waste storage area	Fire,	WS109-2
6	Ventilation system failure (loss of off-site power)	External Event	CP-13
7	Fire in a HCF associated radioactive material storage area releasing radioactive material from the stored inventory	Fire	RS-1, MS-1
8	Design Basis Earthquake	Earthquake	CP-1, CP-3, CP-4, CP-5, CP-6, CP-8, CP-9, CP-10, CP-13, CP-14, WP-2, MS-1, RS-1, RS-2

* Hazard events are defined in Appendix 3C, Preliminary Hazards Analysis

Table E.4-2. Beyond Design Basis Accidents

BDBA #	Accident Description	Type	Associated Hazard Events
1	Multiple simultaneous errors or events that affect multiple SCBs, resulting in release of the contents of multiple targets	Spill	CP-6
2	BDBA Earthquake	Earthquake	n/a
3	Explosion	Explosion	n/a

E.6 Safety Analysis Conclusions

The DBAs identified above encompass the postulated events that pose the greatest risk to the public. Dose consequences and associated likelihood of occurrence for each of the DBAs were systematically evaluated using event tree methodology. For each accident, sequences of events that could result in the release of radiological material were developed. A source term, based on very conservative release assumptions, and an associated likelihood of occurrence were then calculated for each sequence of events. Finally, the dose consequences of the release were calculated.

Dose consequences and likelihoods of occurrence for each of the DBAs are summarized in Table E.6- 1.

Table E.6-1. Summary of Results of Accident Analysis

DBA	Sequence	Likelihood	Dose Consequences
Process Spill	Single target, filtered release	> 1/yr	3.2 mrem
	Single target, degraded filters	<1/yr	14 mrem
	Single target, unmitigated	<.0001/yr	300 mrem
	Multiple targets, filtered	<.1/yr <.01/yr	6 mrem 19 mrem
	Multiple targets, degraded filters	<.01/yr <.001/yr	28 mrem 90 mrem
	Multiple targets, unmitigated	$<10^{-5}$/yr $<10^{-6}$/yr	600 mrem 1.8 Rem
H2 Deflagration	All	$<10^{-4}$/yr	Negligible
SCB Fire	Filtered release	$<10^{-5}$/yr	3.5 mrem
	Unmitigated release	$<10^{-8}$/yr	2 rem
Forklift Accident	All	$<10^{-3}$/yr	< 1 mrem
Room 109 Fire	All	Not assessed	0.1 mrem
Ventilation Failure	Target, SCB intact	<.01/yr	Negligible
	Simultaneous loss of power and in-process target	$<10^{-5}$/yr	No off-site dose; Minor on-site contamination
Radioactive Material Storage Area Fire	Unmitigated Release	<0.01/yr	44 mrem
Design Basis Earthquake	Ventilation system operating, entire target source term released	$<10^{-8}$/yr	192 mrem

While the maximum potential consequences are similar for the process spill and the SCB fire DBAs, the process spill scenario dominates the overall risk to the public by several orders of magnitude as compared to all other DBAs. The maximum potential consequence at the exclusion area boundary (3000 m.) is calculated to be 2 Rem, and the sequence of events that results in this dose is assessed to be extremely unlikely. Accidents that are expected to occur within the lifetime of the facility are (conservatively) calculated to have dose consequences of up to several millirem at the exclusion area boundary. These DBAs bound all other potential accidents that have been postulated to occur in the facility.

E.7 SAR Organization

This safety analysis has been prepared in accordance with the guidelines of DOE-STD-3009-94, and is presented in the format described in that standard.

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CONTENTS

FIGURES

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1.0 SITE CHARACTERISTICS

1.1 Introduction

Chapter 1 provides information that will satisfy the requirements of U.S. Department of Energy (DOE) Order 5480.23, paragraph 8.b.(3)(c), as amplified in Attachment 1, paragraph 4.f.(3)(d)3, of the Order (Topic 3). This chapter also includes applicable information that will partially satisfy the requirements of DOE Order 5480.23, paragraphs 8.b.(3)(b), (f), and (u). This information is also discussed in the Introduction to DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports" (DOE 1994b). This chapter describes site characteristics that impact the safety basis of the facility. More specifically, information provided in Chapter 1 supports assumptions used in the hazard and accident analyses that consider potential accident initiators and accident consequences external to the Hot Cell Facility (HCF).

1.2 Requirements

Several DOE Orders establish the safety basis for the HCF. The following list describes and summarizes the major Orders pertinent to Chapter 1.

DOE Standard 3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, describes a Safety Analysis Report (SAR) preparation method that is acceptable to the DOE (DOE 1994b).

DOE Order 5480.23, Change 1, Nuclear Safety Analysis Reports, requires the documentation of the facility site characteristics that may impact the safety basis for the facility (DOE 1994a).

DOE Order 420.1, Change 2, Facility Safety requires the assessment of natural hazards for the facility (DOE 1995).

1.3 Site Description

Sandia National Laboratories (SNL) is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the DOE under contract DE-AC04-94AL85000. Sandia National Laboratories/New Mexico (SNL/NM) is located on the eastern portion of Kirtland Air Force Base (KAFB). Other installations located within KAFB include the DOE Albuquerque Operations Office, the Defense Nuclear Agency Field Command, the U.S. Air Force Operational Test and Evaluation Center, the KAFB Underground Munitions Storage Center (KUMSC), the KAFB administrative offices, and several small agencies.

1.3.1 Geography

Section 1.3.1 presents basic geographic information about SNL/NM and Technical Area V (TA-V), the area where the HCF is located.

1.3.1.1 SNL/NM Site Description

Sandia National Laboratories is situated south of Albuquerque, New Mexico, within the boundaries of KAFB, a U.S. Air Force (USAF) military reservation (Figure 1.3-1). SNL/NM facilities are located on DOE-leased land allocated within KAFB. KAFB covers approximately 52,000 acres.

Land use in the vicinity of SNL/NM and KAFB is urban to the northwest, north, and northeast. Isleta Pueblo lands, which are typically used for grazing, border the southern portion of KAFB. State-owned grazing land lies west and southwest of KAFB. The urbanized areas immediately northeast, north, and northwest of SNL/NM are predominantly residential, with commercial development along more heavily traveled streets. National Forest and rural residential areas are to the east. Military (Base) housing is located adjacent to the northern edge of SNL/NM TA-1. Albuquerque International Airport is located on the western portion of KAFB.

The general SNL/NM site consists of Coyote Canyon Test Field and five technical areas (TAs), which are shown in Figure 1.3-2. TA-I operations are dedicated primarily to research, development, and design of weapons systems; limited production of weapon system components; and energy programs. TA-II is a small area previously used for testing explosives. TA-IV contains several inertial confinement fusion research and pulsed power research facilities that house large accelerators. Various test activities take place on parcels of land scattered throughout Coyote Test Field.

The closest technical area to TA-V and the HCF is TA-III. TA-III facilities embrace extensive test facilities (sled tracks, centrifuges, and a radiant heat facility). TA-III also encompasses the inactive chemical, mixed, and low-level waste landfills, the Melting and Solidification Laboratory (MSL), and the Radioactive and Mixed Waste Management Facility (RMWMF).

1.3.1.2 TA-V Site Description

TA-V is located 5.4 km (3.4 mi) south of TA-I, which is the major SNL/NM installation. SNL/NM TA-III borders TA-V on the west and south (Figure 1.3-2).

The Auxiliary Hot Cell Facility (AHCF, Building 6597), Gamma Irradiation Facility (GIF, Building 6588), Annular Core Research Reactor (ACRR, Building 6588), and the Sandia Pulse Reactor (SPR, Buildings 6591, 6592, and 6593) are other major facilities in TA-V. Building 6580, the primary HCF structure, is generally centrally located within TA-V (Figure 1.3-3).

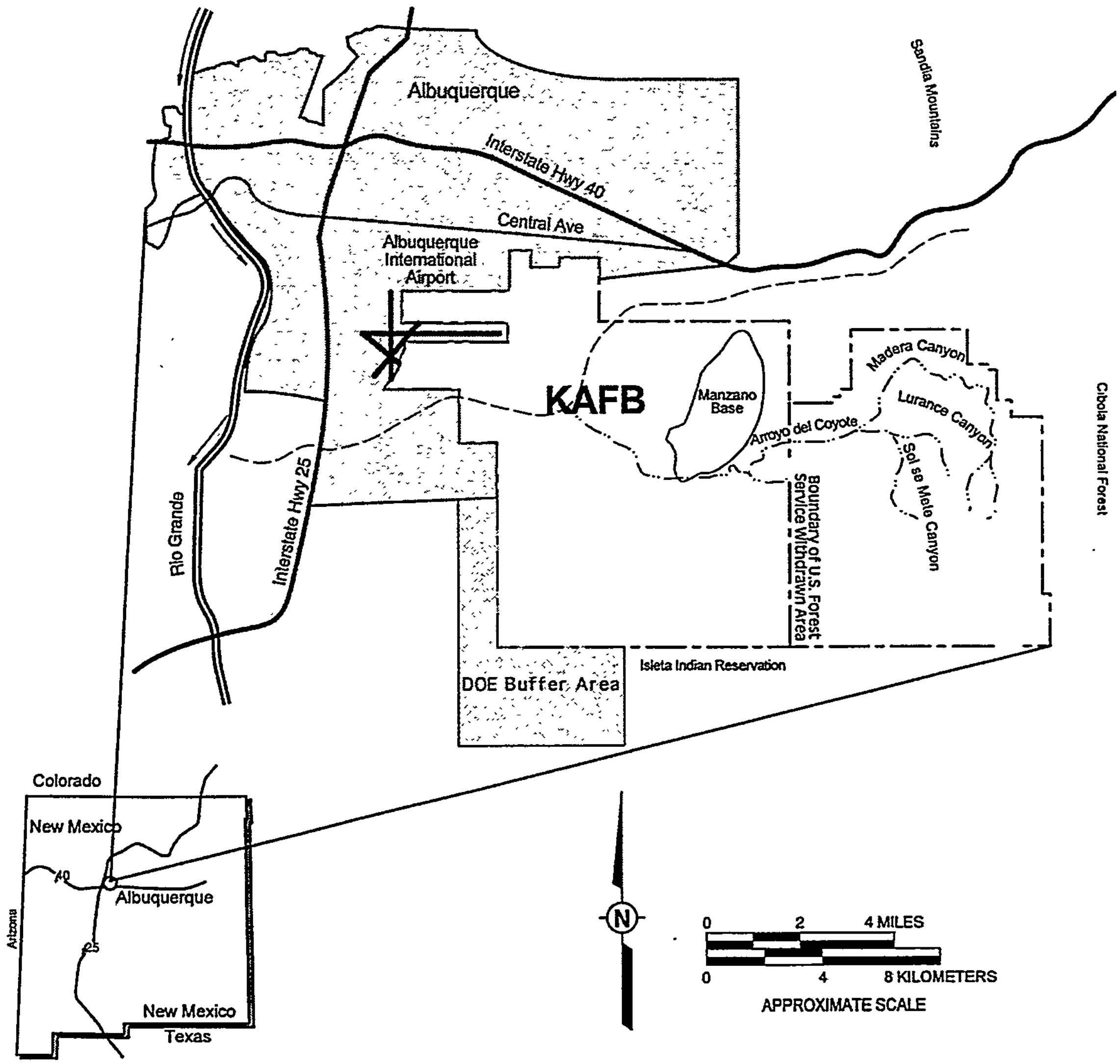
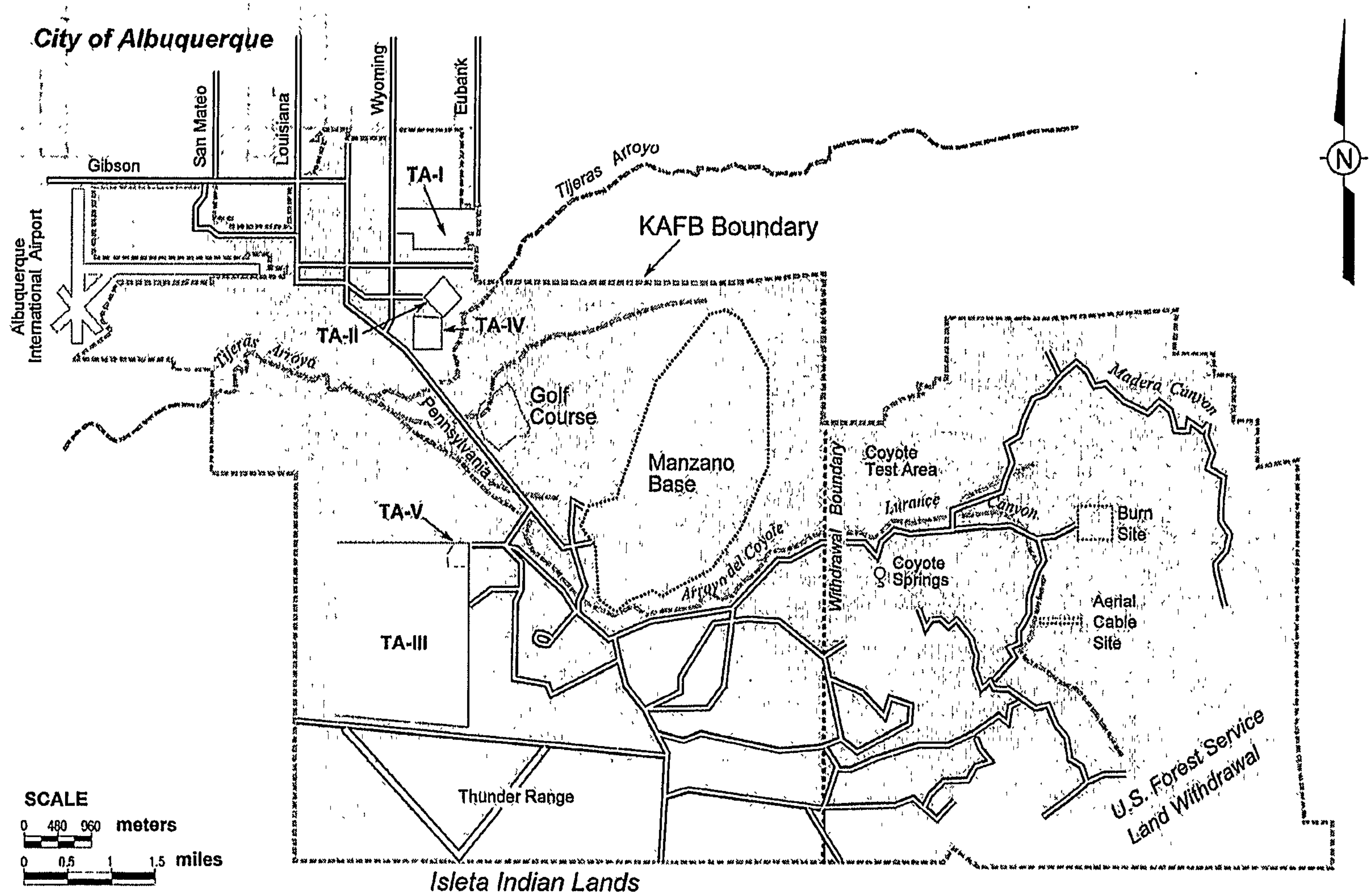


Figure 1.3-1. Albuquerque/KAFB



NOTE: The U.S. Forest Service land withdrawal area is 20,486 acres.

Figure 1.3-2 Sandia Technical Areas and Coyote Canyon Test Field

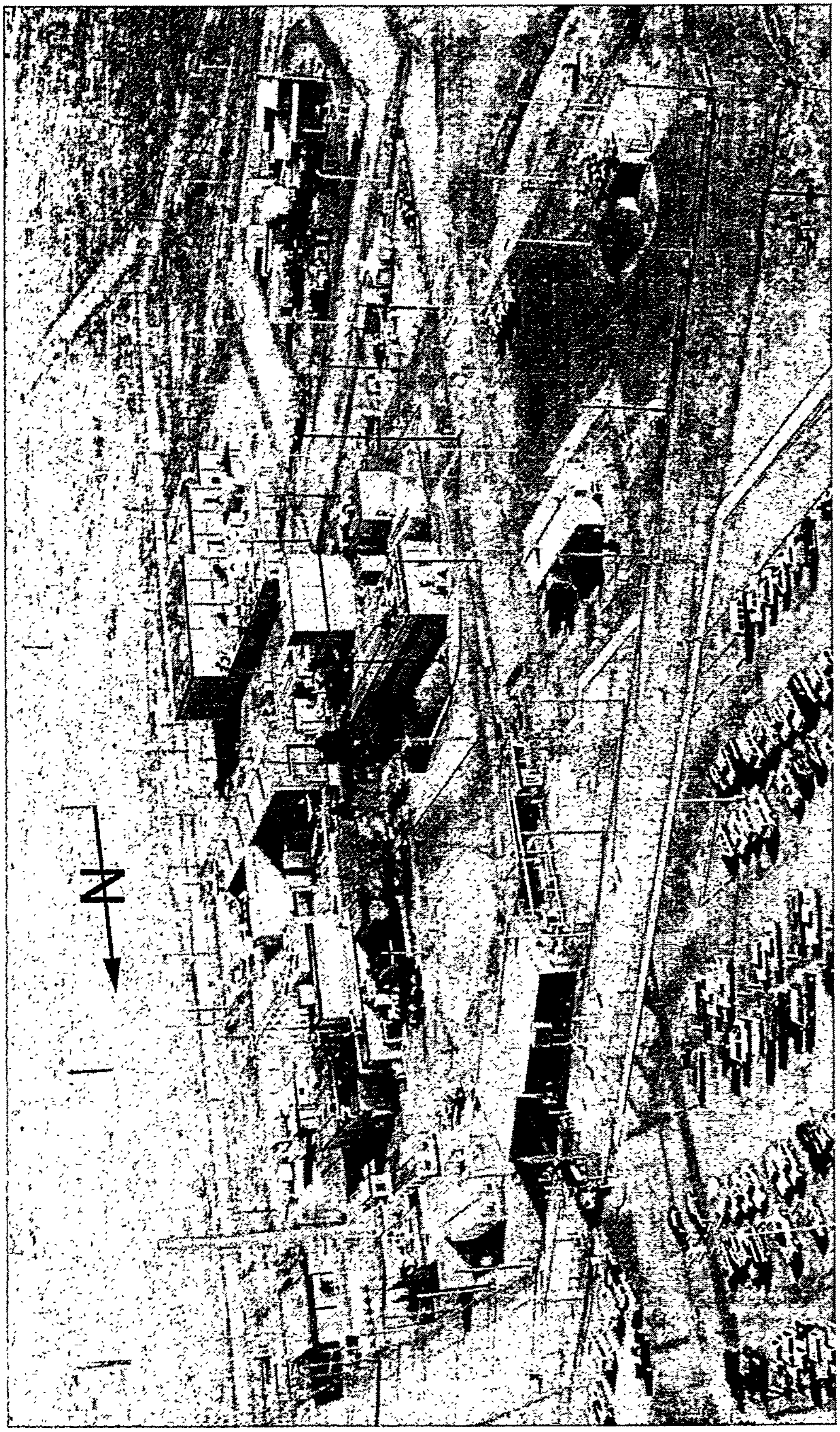


Figure 1.3-3. SNL Technical Area V

1.3.1.3 HCF Site Description

The HCF is located principally in Building 6580. The above grade portion of B6580, shown in Figure 1.3-4, houses office, storage, and light laboratory space. Hot cell operations are conducted in the below-grade basement, shown in Figure 1.3-5, of B6580. HCF support systems and equipment are located in several buildings within TA-V (including B6580B, B6580C, B6580D, B6595, B6596 and B6597). Adjacent and to the west of the fenced TA-V is B6585, which houses SNL staff and light laboratory space. The HCF and its systems are described in detail in Chapter 2, "Facilities Description."

The Hot Cell Facility Department has direct operational and safety responsibility for the HCF.

1.3.1.4 Public Exclusion Areas

The boundary of KAFB defines the extent of the area under KAFB/SNL jurisdiction. In addition, the DOE leases two parcels of land abutting the south west corner of KAFB as a buffer zone for the SNL/NM sled track operations (SNL 1998c). Outside that boundary, depending on the jurisdiction, control is exercised by the city of Albuquerque, Bernalillo County, Isleta Pueblo, the state of New Mexico, and the U.S. Forest Service.

Routine access to TA-V is over a paved access road connecting TA-V to the main paved road, Pennsylvania Avenue (Figure 1.3-2). This access road crosses one small arroyo, Arroyo del Coyote. The arroyo is normally dry, although during the rainy season the water may run deep enough to briefly affect traffic.

1.3.1.5 Access Control

Access to TA-V is controlled first at the main street entrances to KAFB (the Eubank, Wyoming, Gibson, Carlisle, Truman, and South Valley "gates"). No other vehicle or pedestrian entrances are authorized for public entry onto the Base. Access to KAFB is monitored by Air Force personnel at the main entrances.

In addition to the main gate access controls, TA-V has an additional set of access controls. TA-V is completely enclosed by two standard security chain-link fences. All regular entries into and exits from TA-V are through Building 6577, the Perimeter Access Building (PAB), or through the adjoining vehicle gate.

SNL Protective Force personnel operate the PAB during business hours. The number of personnel on site is monitored and provides an accurate count of the total number of persons within TA-V at any given time. Ingress into and egress from TA-V are normally through the PAB. There is, however, a second vehicle gate in the west fence and a personnel gate in the north fence that are normally locked but which may be opened if the PAB is unusable or inaccessible. Use of these alternate gates must be coordinated with the on-site protective force and health physics personnel.

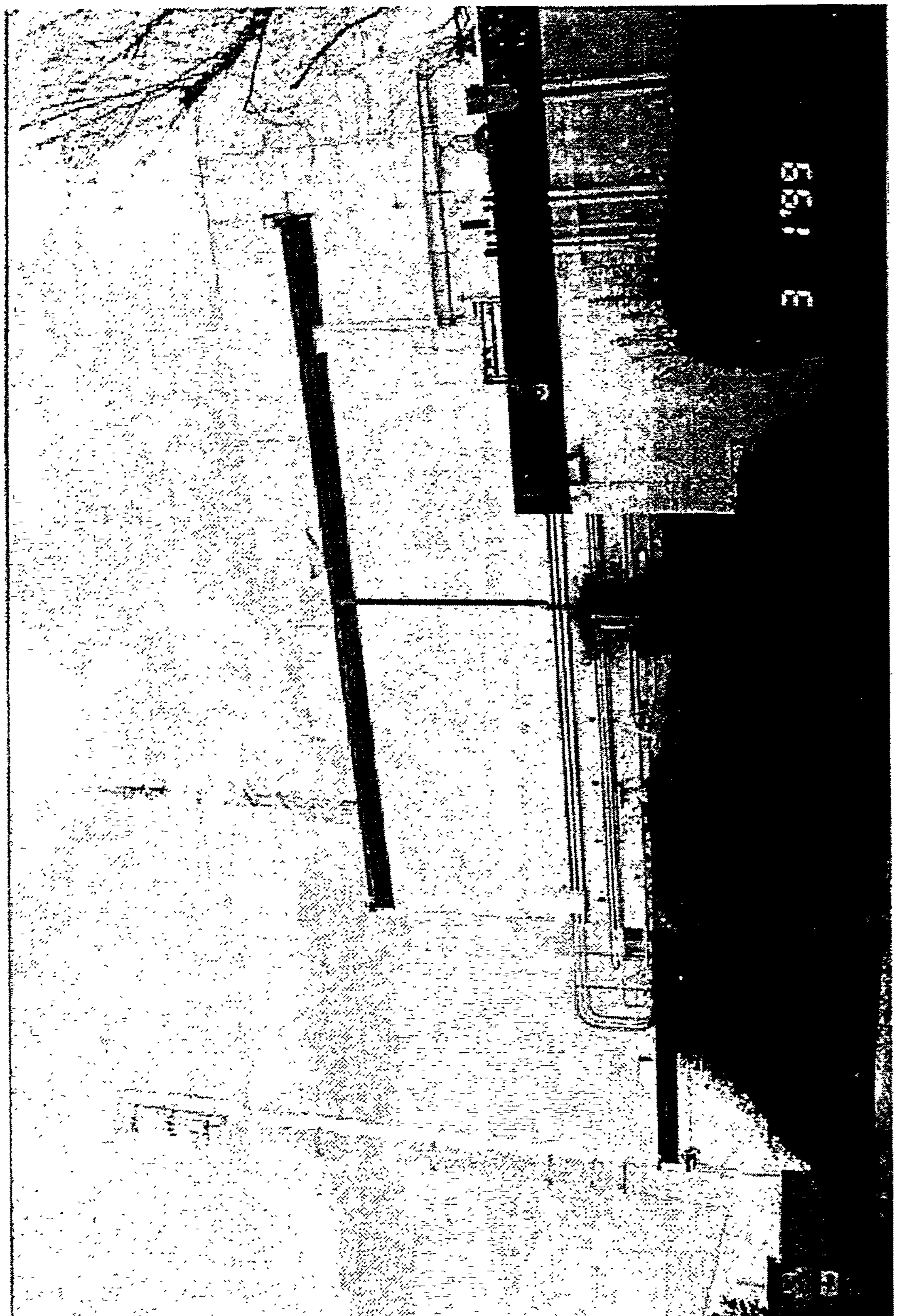


Figure 1.3-4. Building 6580

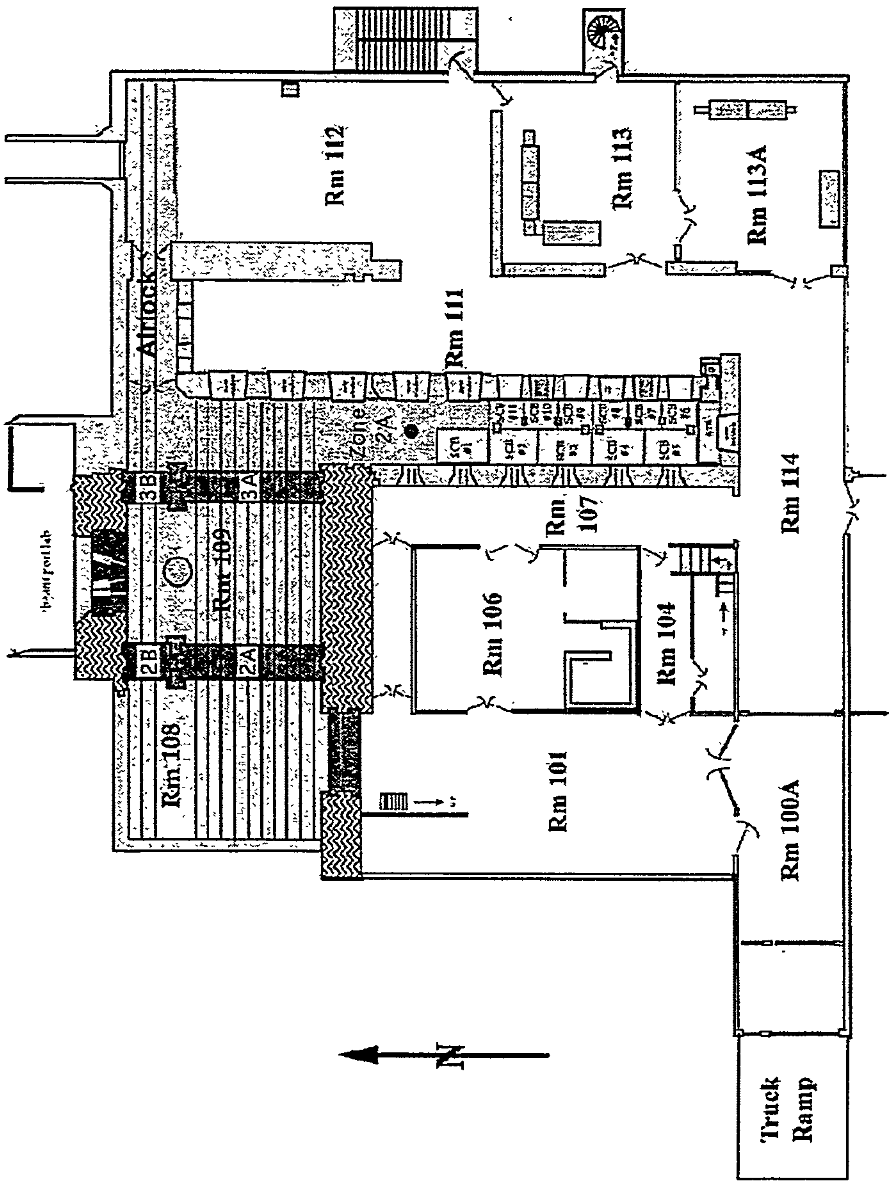


Figure 1.3-5. Building 6580 Basement

During an emergency, physical access to the site by emergency vehicles, such as fire trucks and ambulances, is coordinated through the Incident Commander or Emergency Supervisor (Chapter 15). Organizations that are authorized to enter TA-V in case of emergencies are the SNL/NM Environmental and Emergency Management Department Incident Commanders, SNL/NM Medical Department, KAFB Fire Department, and USAF Security Police.

The protective force provides emergency-response vehicles unimpeded access to the facility through the TA-V gate. In addition, the protective force provides emergency assistance as required by the SNL/NM Incident Commanders. Additional emergency response information is presented in Chapter 15.

1.3.1.6 Point Where Evaluation Guidelines Are Applied

The HCF is located approximately 3000 m (1.9 mi), from the western boundary of KAFB. The point where evaluation guidelines are applied is the closest point along the western boundary of KAFB to the HCF. All personnel and vehicular access into the area delineated by a 3000 m (1.9 mi) radius center on TA-V is controlled by the normal KAFB control points (i.e., KAFB vehicle/pedestrian entrance gates). In the event of an emergency, SNL/NM security forces, in conjunction with the KAFB security forces, have the authority to control access on all other roads within KAFB. There are no permanent residences inside this area; however, other SNL/NM and KAFB organizations conduct business within this area. Procedures for evacuating or sheltering personnel from these organizations is discussed in the TA-V Emergency Plan (see Chapter 15).

The location of the maximally exposed off-site individual (MOI), which is the point along the boundary where Evaluation Guidelines are applied, is taken to be at a distance of not less than 3000 m (1.9 mi) (Figure 1.3-6).

1.3.2 Demography

Population and demographic information based on 1990 census data are included in this section to show the population distribution as a function of distance and direction from the HCF. The demographics described here are inclusive of all areas potentially affected by the accidents analyzed in Chapter 3, "Hazard and Accident Analysis."

1.3.2.1 Albuquerque and Surrounding Area Demography

Albuquerque is the largest population center in Bernalillo County and the state and the closest population center to KAFB. Within the general area, the population centers of major concern are metropolitan Albuquerque and Santa Fe (Figure 1.3-1). Albuquerque is adjacent to KAFB, occupying all land from the southwest quadrant clockwise through the northeast quadrant. The metropolitan area (excluding suburban communities) extends out to a maximum radius of about 15 miles from TA-V. The 1990 census showed 384,736 people living within the city limits and more than 480,577 in Bernalillo County. An estimated total population of 571,677 people live within a 50 mile radius of KAFB (DOC 1990). This population includes permanent residents of KAFB living in the KAFB housing areas.

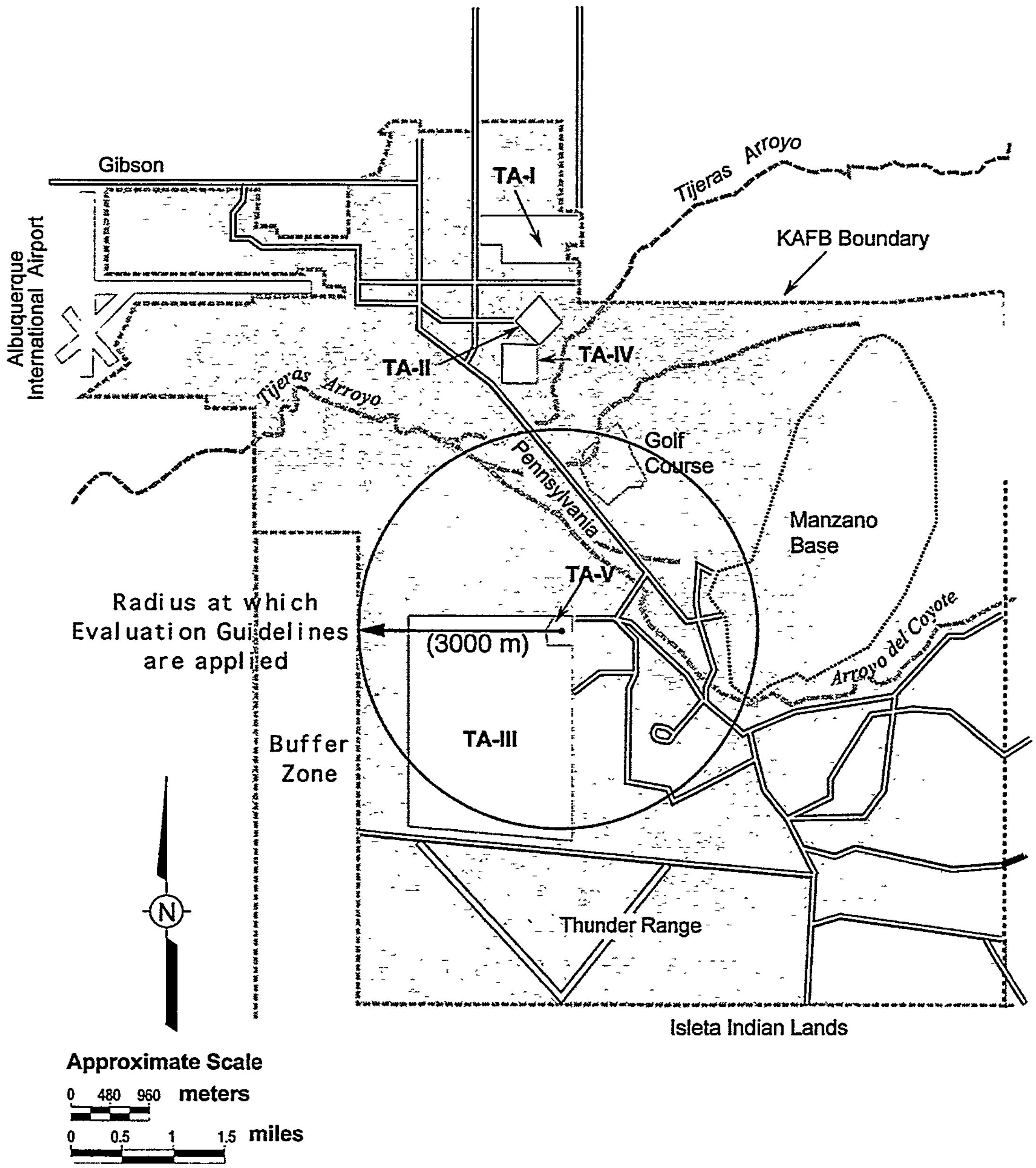


Figure 1.3.6 Application of Evaluation Guidelines (HCF Exclusion Area)

Rio Rancho, located 19 km (12 mi) northwest of the complex, had a population of 32,505 in 1990. Santa Fe, located 90 km (56 mi) northeast of the complex, had a population of 56,557 at that time. Other population concentrations of concern are the Los Alamos area 100 km (62 mi) north, with a 1990 population of 18,115; and the Los Lunas-Belen-Socorro areas, 30 to 110 km (19 to 68 mi) south of Albuquerque on Interstate 25. In 1990, Los Lunas had a population of 6,013; Belen, 6,547; and Socorro, 8,159 (DOC 1990).

The KAFB/Isleta Indian land-grant boundary is 6.1 km (3.8 mi) south of TA-V; there are no permanent residences along the boundary. A private cattle company occupies the land bordering the western boundary of KAFB, 3000 m (1.9 mi) from TA-V. All areas within a radius of 3000 m (1.9 mi) of a point centered on TA-V are under the control of SNL/NM or KAFB.

The Albuquerque International Airport terminal and maintenance facilities are located 9.3 km (5.8 mi) northwest of TA-V. The airport shares runways and other flight facilities with KAFB, forming an integral unit. All the private and commercial facilities at the airport are located at the westernmost part of the airfield. The number of persons in the terminal and surrounding facilities varies, but peak occupancy may be several thousand people.

1.3.2.2 Demography for KAFB and TAs Surrounding TA-V

The four major locations whose populations would be of immediate interest are the SNL/NM TAs I, III, and IV, and the KAFB Headquarters. The TA-I/KAFB Headquarters complex is located about 5.4 km (3.4 mi) north of the HCF in TA-V. This complex has a total population of about 12,000 persons during normal business hours, which is the largest population group in the SNL/NM/USAF complex on KAFB. Of this number, about 8000 are SNL/NM employees and contractors. The remainder are associated with or attached to the various military and civilian government organizations.

TA-IV is located 4.0 km (2.5 mi) north of TA-V and had an assigned occupancy in January 1999 of 722 persons, most of whom are SNL/NM employees. TA-III, adjacent to TA-V on the west and south sides, has an assigned occupancy of 278 persons. The number of persons on site may vary because of the transient nature of the diverse testing operations that occur in this area (SNL 1995d).

Several organizations have installations in and near the Manzano Administration Area, located about 2.7 km (1.7 mi) northeast of TA-V. Few or no Sandians are normally present at the Manzano Waste Storage Facilities. The Nonproliferation and National Security Institute (NNSI; formerly the DOE Central Training Academy) has a population of about 150 staff, with an additional 150 students during spring, summer, and fall. A few times a year, the population rises above 300 for a few days at a time. There is no regular after-hours staff. The Lovelace Respiratory Research Institute (formerly Inhalation Toxicology Research Institute) lies to the southeast, with a combined population of about 250. A fire station, USAF dog kennels, and Phillips Laboratory have a combined population of about 50 persons.

The nearest USAF facility with a significant population is KUMSC, which is situated 1.7 km (1.1 mi) northwest of TA-V. The KUMSC has a population during normal business hours of about 150 persons and is equipped with its own environmental control system. Operations at this installation have no impact on TA-V (SNL 1995d). All other special areas or zones within KAFB (including military facilities) either have small populations or are located in a low meteorological probability zone (that is, a zone in which winds from TA-V have a very low frequency of occurrence).

1.3.2.3 TA-V Demography

The population in and immediately adjacent to TA-V is somewhat fluid over time, rises during construction or other short-term projects, and changes dramatically between business and non-business hours. In January 1999, 204 occupants were assigned to the buildings in and near TA-V (Table 1.3-1). The temporary work force rarely exceeds 40 persons. All personnel are required to receive a briefing on emergency procedures before being allowed unescorted access into TA-V.

Table 1.3-1. Assigned Occupancy, TA-V and Vicinity, January 1999.
Buildings not enumerated had no assigned occupants in January 1999.

Building Number	Building Description	Number of Assigned Occupants
6577	Perimeter Control	1
6578	Communications & Defense	1
6580	Hot Cell Facility	15
6581	Security Services	1
6585	Technology Support Center	163
6588	ACRR	15
6591	Reactor Control	5
6594	Low level Counting Lab	1
6597	Radiation Simulation	1
T52	Transportable Building	1
	TOTAL	204

1.4 Environmental Description

This section describes meteorological, hydrologic, and geologic characteristics of the site.

1.4.1 Meteorology

The Department of Energy (DOE 1995) requires that at least one year of valid meteorological data shall be used to develop estimated joint frequency distributions of wind speed and stability conditions. These data will be used to establish the bases for the dispersion calculations conducted to support accident analysis.

1.4.1.1 General Regional Climatology and Local Meteorology

The general weather patterns for Albuquerque and its vicinity are characteristic of high-altitude, dry continental climates, with maximum monthly rainfall occurring during the summer months. The presence of the Sandia and Manzano Mountains has a significant influence on the climate, producing inversion conditions and localized perturbations in wind patterns. Normally, sunshine is recorded for 75% or more of the daylight hours for the entire year. In other words, adverse weather conditions in this area are atypical and can be forecast with a reasonable degree of confidence.

1.4.1.2 Temperature, Humidity, and Precipitation

Normal daily minimum temperatures for winter months are about –5°C to –3°C (23°F to 27°F) and for the summer months, 14°C to 19°C (57°F to 66°F). Normal daily maximum temperatures are 8°C to 11°C (46°F to 52°F) in winter and 28°C to 33°C (82°F to 91°F) in summer. Thus, the approximate diurnal temperature range for both winter and summer is 14C° to 16C° (25F° to 29F°). Temperatures above 38°C (100°F) and below –18°C (0°F) are rare. Average values for relative humidity vary from lows of 10% to 20% to highs of 60% to 70%, and these ranges can occur during any day of the year.

For the long-term record, the National Weather Service (NWS) data taken at the Albuquerque International Airport is used to determine temperature and relative humidity. The average annual rainfall for the Albuquerque area is 8.4 inches. The lowest monthly precipitation typically occurs in the winter, with less than 0.5 inches. The highest average monthly precipitation occurs from July to September and accounts for about half of the annual amount. Summer precipitation is usually the result of highly localized heavy thundershowers that typically last an hour or less at any given location. The maximum recorded precipitation within a 24-hour period occurred in September 1955, when 49 mm 1.9 inches was recorded at the Albuquerque International Airport. Because thundershowers move with the prevailing winds aloft, thundershower activity can result in considerable precipitation. Localized flooding may result from this concentrated activity, and water may run high in arroyos in the area.

SNL/NM precipitation and wind information varies from NWS data. Topographic features such as mountains, canyons, and arroyos influence local wind patterns across SNL/NM. Canyons and arroyos tend to channel or funnel wind, whereas mountains create upslope-downslope diurnal wind flows. A more detailed climatic description for the TA-V site is given in the following section.

1.4.1.3 Meteorological Measurement and Monitoring Program

To postulate the dispersion of contaminants from accidental releases, climatic conditions throughout the SNL/NM area must be taken into consideration. The current eight-tower meteorological monitoring network at SNL/NM consists of six 10-meter towers, one 60-meter tower and one 50-meter tower. Four of the towers occur within a 3000 m radius of TA-V (Figure 1.4-1). The closest tower to TA-V (A36) is located in TA-III, just outside the southwest corner of TA-V (SNL 1998a). This network has been in operation since 1994. The meteorological variables measured at A36 include wind speed and direction, temperature, relative humidity, precipitation, and barometric pressure. The standard deviation of the horizontal wind direction (sigma theta) is calculated from the one-second variations of wind direction for use in Pasquill-Gifford atmospheric stability calculations. Meteorological parameters are measured once per second, averaged, and stored as 15-minute averages. The data are continuously downloaded to a central facility computer that controls data retrieval, validation, and management. The real-time data are available in the SNL/NM Emergency Operations Center.

Meteorological information from a rooftop monitor is also available in the TA-V Emergency Operations Room. If a release were to occur, information from this monitor may be used initially to determine dispersion patterns. Chapter 15 describes the emergency preparedness program and plans.

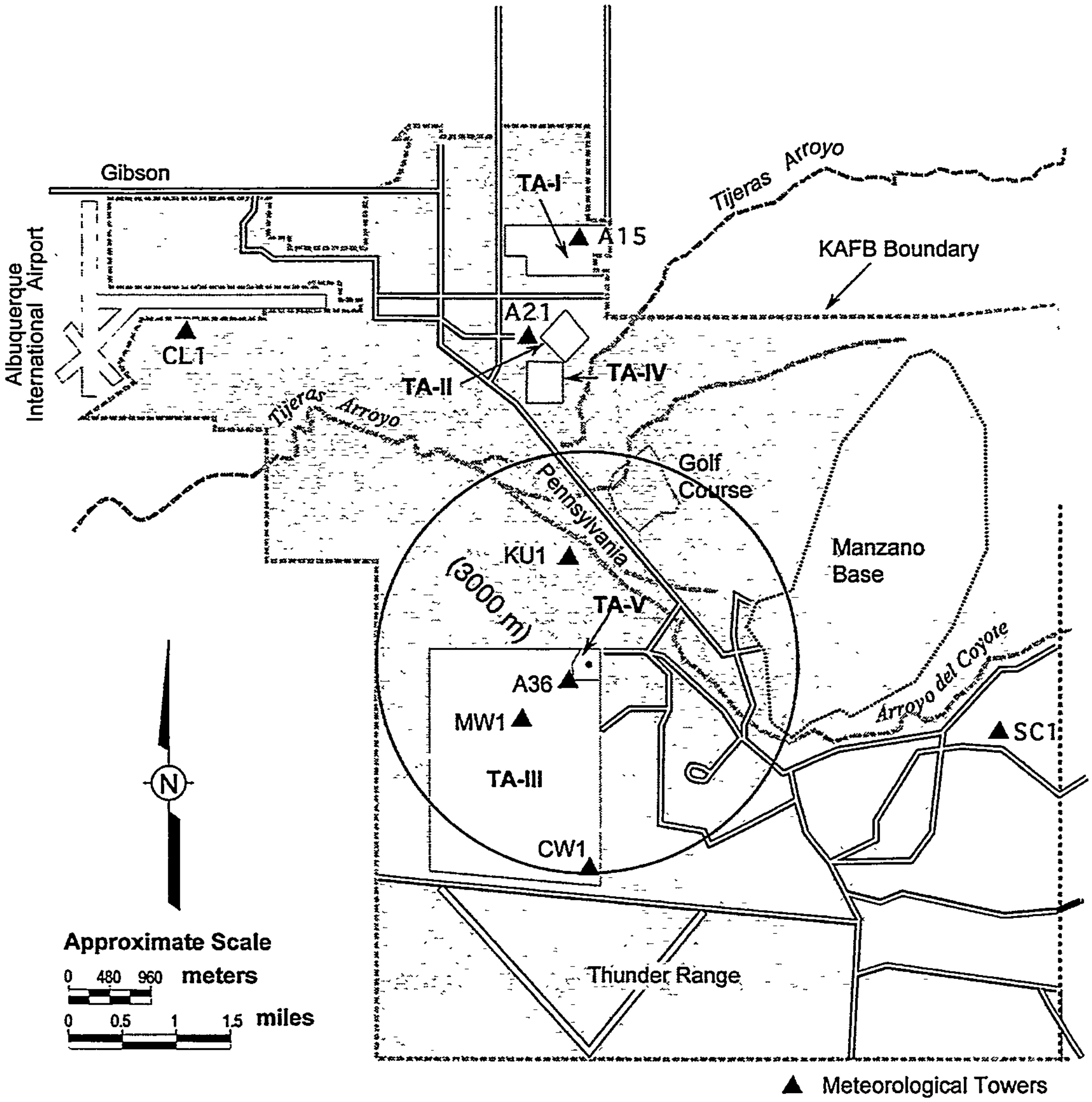


Figure 1-4-1 Meteorological Monitoring Stations Within a 3000-m Radius of TA-V

Table 1.4-1 presents three-year climatic data from the A36 meteorological tower. The data were recorded 10 m (33 ft) above ground surface. The general trends to note include the large average daily temperature range as shown by the daily maximum and minimum temperatures, the windy season that produces low relative humidity between April and June, and the warm-season precipitation pattern.

The most important implication of meteorological variation across SNL/NM is that wind variability may affect the transport and dispersion of pollutants.

Pasquill-Gifford atmospheric stability classes are calculated using the standard deviations of the horizontal wind direction. The stability stratification for the TA-V tower is given using the three-year database. Table 1.4-2 identifies the frequency of stability and wind speed conditions that could be expected in general at TA-V.

Table 1.4-1 Three-Year Climatological Data for the A36 Tower.

Parameters	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)												
Daily Maximum	9.5	13.5	16.1	20.0	27.8	31.6	32.9	31.5	26.2	20.6	14.3	10.3
Daily Minimum	-2.4	0.5	2.2	5.5	11.3	16.7	18.5	18.2	13.1	6.8	1.1	-1.3
Average	3.7	7.2	9.3	13.0	19.6	24.3	25.5	24.4	19.8	14.7	8.6	4.8
Extremes (°C)												
Record High	19.8	20.8	25.0	29.8	34.4	39.3	38.4	36.0	34.1	28.3	22.5	19.5
Record Low	-10.1	-11.2	-6.1	-2.6	3.1	7.8	11.5	14.8	3.5	-4.5	-7.6	-13.6
Relative Humidity (%)												
Relative	46.1	43.4	39.6	30.1	27.9	28.7	35.8	47.6	48.4	42.2	48.9	50.6
Precipitation (Centimeters)												
Average	0.7	0.9	0.7	0.4	2.5	1.6	2.1	7.3	3.3	4.0	1.9	0.8
Maximum	1.3	1.5	1.5	1.2	7.2	3.7	2.5	11.6	4.4	7.6	3.8	2.1
Minimum	0.00	0.5	0.1	0.00	0.00	0.1	1.5	3.0	2.0	0.00	0.2	0.00
24-hour Maximu	1.0	1.1	0.4	0.6	1.7	1.6	2.4	3.5	1.7	2.8	1.9	1.1
Wind (Meters per Second)												
Monthly Average	3.3	3.6	4.1	4.4	4.5	4.1	3.9	3.5	3.3	3.6	3.3	2.9
24-hour Maximu	8.5	8.1	11.2	9.7	10.6	9.1	6.6	6.4	9.1	11.6	7.5	7.1
Maximum Gust	25.3	22.1	25.3	23.7	25.3	26.9	26.9	27.7	19.7	25.3	23.7	26.9
Barometric Pressure												
Pressure	838.2	836.9	834.8	832.4	830.7	832.2	833.7	834.5	835.4	835.2	837.0	837.6

Table 1.4-2 Average Wind Speeds for Each Stability Class and Frequencies of Stability for TA-V.

Stability Class	Ave WS	WS<1	WS 1-2	WS 2-3	WS 3-4	WS 4-5	WS 5-6	WS >.6	Total %
A (1) Extremely Unstable	2.11 m/s	0.43%	4.02%	7.05%	0	0	0	0	11.5
B (2) Moderately Unstable	2.00 m/s	0.09%	0.92%	1.72%	5.40%	0	0	0	8.13
C (3) Slightly Unstable	3.83 m/s	0.07%	0.84%	1.52%	1.89%	3.29%	1.68%	0	9.28
D (4) Neutral	5.10 m/s	0.25%	4.09%	7.30%	6.28%	3.84%	4.59%	14.25%	40.59
E (5) Slightly Stable	3.01 m/s	0.45%	4.24%	5.76%	6.88%	4.85%	0	0	22.18
F(6) Moderately Stable	1.59 m/s	1.22%	4.97%	2.13%	0	0	0	0	8.32

1.4.1.4 Local Transport and Dispersion

Wind patterns differ noticeably across the SNL site, depending on the strength and location of synoptic systems and the individual site's proximity to the mountains and foothills. The Manzano Mountains and Tijeras Canyon are two topographic features that influence transport and dispersion at SNL/NM. Tijeras Canyon acts as a funnel for east winds, while the mountains create upslope-downslope diurnal wind patterns. Daytime winds blow from the valley upslope to the mountains, and winds at night blow downslope from the mountains toward the valley. Day and night windroses for 1997 are shown in Figure 1.4-2.

Current and historical meteorological monitoring-network data confirm that under night-time conditions, cold air from the mountains typically flows downward into the canyons and arroyos and fans onto the flat terrain. These cold-air-drainage winds can be very shallow, with depths occasionally less than 50 or 100 m (164 to 328 ft). In addition, nocturnal cooling complicates the area's temperature-inversion profile.

The result is that pollutants are trapped below the inversion and transported generally towards Tijeras Arroyo, which acts as a confluence zone for air on each side of the arroyo. Results from two smoke tests conducted in March 1957 also confirm that transport winds from TA-V will generally blow towards, but not across, Tijeras Arroyo prior to temperature-inversion breakup (Olson et al. 1979). Under average conditions at night, when general worst-case dispersion exists, Tijeras Arroyo acts as confluence zone where transported material would flow towards, then be trapped in down-canyon transport, away from populated areas. Tijeras Arroyo acts as an effective barrier at night to limit northward or southward transport across the arroyo.

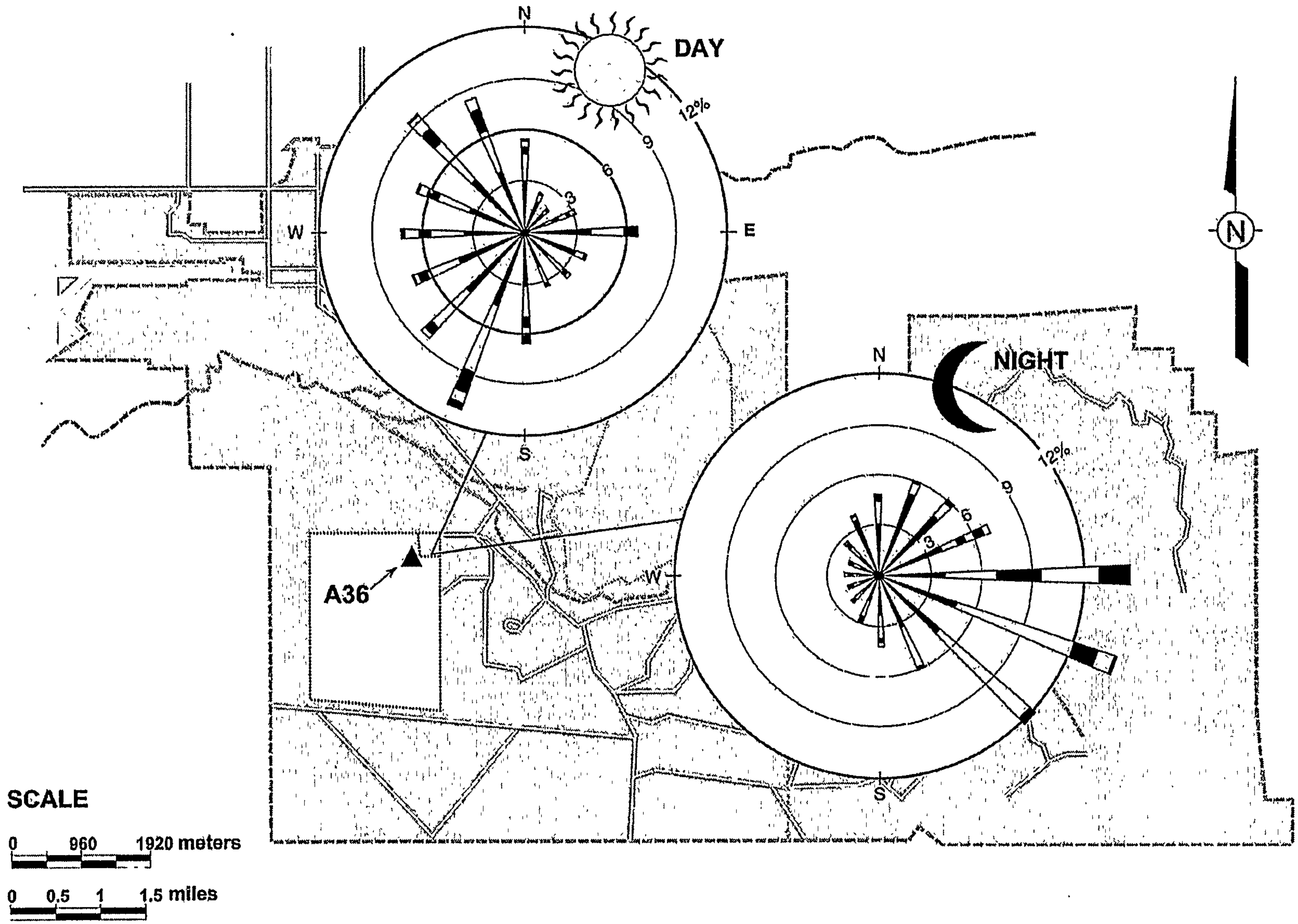


Figure 1.4-2 Day and Night Windrose for the A36 Tower (1997)

1.4.1.5 Meteorological Data for Accident Release

For routine air emissions releases, CAP88-PC (EPA 1995) is used to evaluate dose to the public in accordance with 40 CFR Part 61. Wind information from the existing meteorological monitoring network is compiled and tabulated as STARDECKS (Doty 1976) for direct input into CAP88-PC. Average temperature and precipitation for the evaluated year are also taken from the network.

For accidental releases, real-time meteorology would be used to calculate transport and dispersion. The HOTSPOT Health Physics code (Homann 1994) is used initially in the SNL/NM Emergency Operations Center. The Atmospheric Release Advisory Code (ARAC) may be consulted for larger source-term releases (Sullivan 1993). In addition, hand calculation of dispersion factors (X/Q) can also be performed using the *Workbook of Atmospheric Dispersion Estimates* (Turner 1969).

For postulated accident releases, the MELCOR Accident Consequence Code System (MACCS2) computer code is used (Chanin and Young 1997). MACCS2 incorporates site-specific meteorological data that have been compiled and extracted from the meteorological data recorded by the Clean Air Network (CAN) system (SNL 1998a). MACCS2 has been used to calculate dispersion patterns for this SAR. The MACCS2 Radiological Consequence Modeling Results are presented in Appendix F and discussed in Chapter 3.

1.4.2 Hydrology

Since KAFB has been in operation, surface water in the KAFB region has generally flowed southwest, through several major and many small unnamed arroyos, to the Rio Grande. However, groundwater flow directions have recently changed considerably from the southwesterly flow direction reported for KAFB (Bjorklund and Maxwell 1961). This change in flow direction to the north and northwest is believed to be the result of groundwater pumping in excess of recharge by KAFB and by nearby city of Albuquerque supply wells. Pumping from these well fields has created a groundwater depression along the western and northern boundaries of KAFB. This depression, extending as far south as Isleta Pueblo, is probably a result of preferential flow through highly conductive ancestral Rio Grande deposits that are the primary aquifer material in this area (SNL 1998a).

1.4.2.1 Surface Drainage

On the western side of the Rio Grande, the ground surface slopes generally to the southeast and toward the river at about 9.4 to 18.9 m/km (50 to 100 ft/mi). The west drainage area is described by a zone extending westward from the river about 4.8 km (3 mi) and confined by a north-south trending terrace that rises about 183 m (600 ft). Beyond this zone, drainage essentially follows cut terraces that parallel the river. The eastern side of the river, referred to as the East Mesa, where SNL/KAFB is located, has a generally westerly-southwesterly ground-surface slope ranging from about 47.4 m/km (250 ft/mi) near the mountains to 3.8 m/km (20 ft/mi) near the river. The distance between the base of the mountains and the river varies, but is roughly 17 km (11 mi).

TA-V sits on a mesa bounded on the east by the Manzano Mountains, on the west by the Rio Grande, on the north by Tijeras Arroyo, and on the south by Hell's Canyon Wash. The slope of the mesa declines gradually towards the Rio Grande. The terrain is characterized by numerous small canyons that have been cut through the mesa by drainage from the mountains. Topography near TA-V is dominated by Tijeras Arroyo, about 3 km (1.9 mi) to the north.

Arroyo del Coyote, of particular importance to TA-V during precipitation events, is about 0.8 km (0.5 mi) east of the complex, running southeast to northwest and emptying into Tijeras Arroyo (Figure 1.3-2). During heavy precipitation events east of TA-V, Arroyo del Coyote effectively collects runoff from the mountains and diverts surface flow away from TA-V. Therefore, surface flows that could affect TA-V are limited to the amount of runoff that collects between TA-V and the arroyo. The heaviest precipitation to date in this area has not produced flooding in TA-V. All precipitation occurring in areas to the north, south, and west of TA-V is drained away from the complex by the natural surface slope and, therefore, does not constitute a threat. General flooding of the site is extremely unlikely, and, on the basis of historical evidence, is not apt to result from natural phenomena.

Most runoff from TA-V flows west onto TA-III as overland flow and in natural and manmade surface drainage features. The remainder flows into two storm sewers in the northern portion of TA-V. Both storm sewers discharge to open channels within, and just north of, TA-III. Drainage from TA-III is to the west onto undeveloped portions of KAFB and then into playas on undeveloped state land. At present there is no requirement for monitoring runoff from TA-V because the runoff flowing from that area is not discharged to "Waters of the United States" (SNL 1998c).

1.4.2.2 Soil Characteristics

TA-V falls within the Upper Llano de Manzano geomorphic subprovince, and Arroyo del Coyote, at least the part that drains TA-V, falls within the Tijeras Arroyo geomorphic subprovince. Soils associated with the Arroyo del Coyote valley floor and embankments and the northeast section of TA-V are of the Embudo and Tijeras Series. These soils are generally well drained, have moderate permeability, and have high potential for surface erosion. Water percolates rapidly through the fine sandy loam associated with the Arroyo del Coyote valley floor (SNL 1998b). In addition to the Embudo and Tijeras Series, TA-V has soils of the Madurez Series (SNL 1997b). Water percolates very rapidly through MaB-Madurez loamy fine sand and MWA-Madurez Wink association soils. The moderate to rapid percolation in these soils reduces excess runoff that creates flooding. Major soil classifications for TA-V are described in Table 1.4-3.

1.4.2.3 Subsurface Characteristics

Groundwater in the KAFB area occurs within saturated, unconsolidated geologic material and fractured and porous bedrock. The groundwater beneath KAFB is part of an interconnected series of water-bearing geologic units within the Albuquerque Basin that form the Albuquerque-Belen Basin aquifer. The principal sedimentary fill of the Albuquerque-Belen Basin is the Santa Fe Group, consisting of gravel, sand, silt, and clay (Thorne et al. 1993). The potentiometric surface and direction of groundwater flow for the regional groundwater system is shown in Figure 1.4-3 (SNL 1998a).

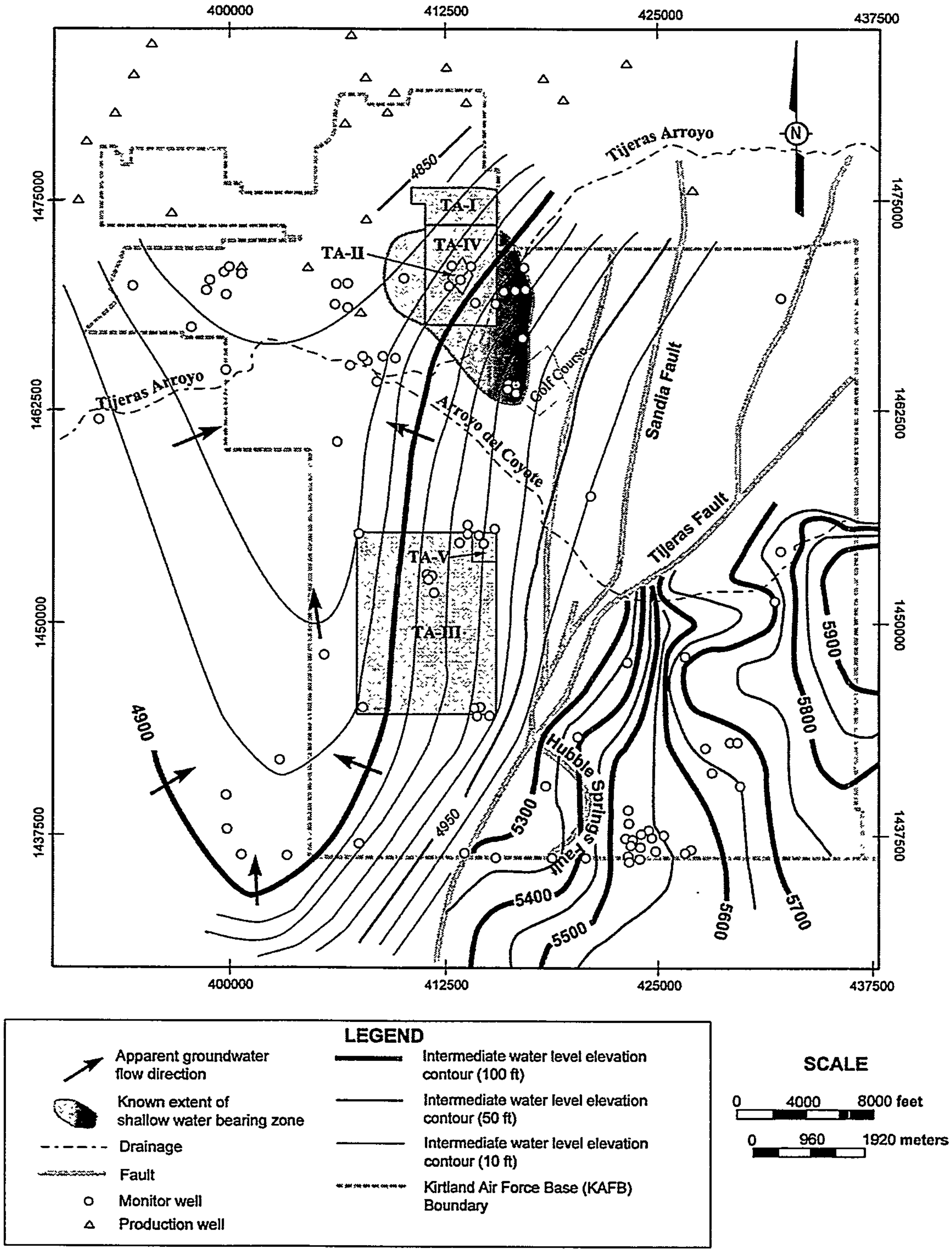


Figure 1.4-3 Potentiometric Surface and Groundwater Flow Directions for the Regional Groundwater System.

The local (SNL/NM) groundwater system has three hydrogeologic regions (HRs), whose locations are delineated by the geologic fault system that bisects KAFB (Fault systems are discussed in detail in Section 1.5.2.3).

The first hydrogeologic area underlies all the SNL/NM TAs and lies generally west of the fault system. Groundwater flow is generally north to northwest. Groundwater levels have been declining at rates of 0.06 to 0.91 m (0.2 to 3.0 ft) per year in this area. Hydraulic conductivities range from less than 0.03 m/d (0.1 ft/d) to more than 30.5 m/d (100 ft/d). The depth of the unsaturated zone ranges between 149 m (488 ft) and 162 m (530 ft) in TA-V, depending on the location of the well measured.

Table 1.4-3. Major Soil Classifications for TA-V and Arroyo del Coyote Drainage Area

Series	Type	Subprovince *	Percent Slope	Runoff f	Soil and Water Erosion Hazard
Embudo	EmB-Embudo gravely fine sandy loam	1, 3	0 to 5	Medium	Water erosion—moderate
	EtC-Embudo Tijeras Complex	1	0 to 9	Medium	Water erosion—moderate
Tijeras	TgB-Tijeras gravely fine sandy loam	1, 3	1 to 5	Moderate	Water erosion—moderate
Madurez	Madurez loamy fine sand	1, 3	1 to 5	Slow	Soil blowing—severe
	Madurez-Wink association	1, 3	1 to 5	Slow	Soil blowing— moderate to severe

U.S. Department of Agriculture (USDA), 1997, "Soil Survey of Bernalillo County and Parts of Sandoval and Valencia Counties, New Mexico," Soil Conservation Service, U.S. Department of the Interior, Bureau of Indian Affairs and Bureau of Land Management. Source: USDA 1977. Subprovinces: * 1-Tijeras Arroyo; 3-Upper Llano de Manzano.

Hydraulic conductivities are highly variable in areas of the fault systems, the hydrogeologic region just east of TA-III and TA-V. These conductivities range from 0.0009 m/d (0.003 ft/d) in the bedrock to nearly 46 m/d (150 ft/d) in the alluvial material. Depth to groundwater also varies greatly, from zero feet along the Arroyo del Coyote south of Manzano Base, to 152 m (500 ft) near the southeast corner of TA-III (SNL 1998b).

A third hydrogeologic area is characterized by bedrock aquifers east of the faulted zone, although in some places a thin layer of groundwater-containing alluvial material overlies the bedrock. Depth to groundwater varies 46 m/d (150 ft/d) near the Hubbell Springs Fault to near zero ft along portions of Arroyo del Coyote.

Monitor wells located in TA-V and in the area defined by the 3000-m radius centered on TA-V are shown in Figure 1.4-4. Water levels are measured monthly, and water quality is measured quarterly for volatile organic compounds (VOCs) and nitrate plus nitrite. In addition, samples taken during some quarters are analyzed for the full suite of analytes, including VOCs, nitrate plus nitrite, semivolatile organic compounds, Resource Conservation and Recovery Act (RCRA) metals plus beryllium, major anions and cations, tritium, gross alpha and beta, and gamma spectroscopy (SNL 1997a).

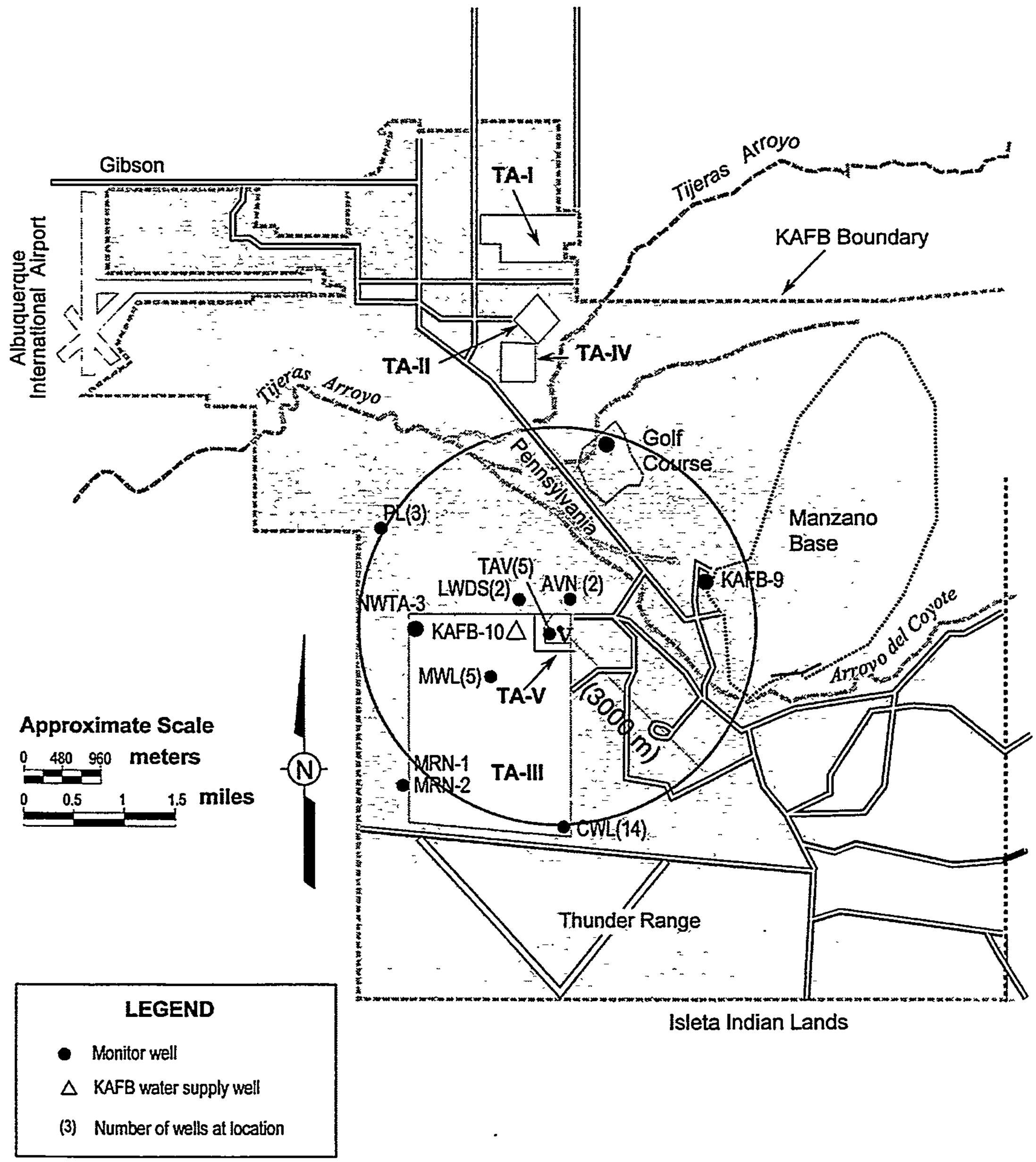


Figure 1.4-4 Monitor Well Locations Within the Vicinity of TA-V.

1.4.2.4 TA-V Water Supply

The groundwater beneath SNL/NM and adjacent areas is the source of drinking water for SNL/NM, KAFB, and portions of the city of Albuquerque. Several water-supply wells for the city of Albuquerque and KAFB are near the northern boundary of KAFB.

Water from the main KAFB water system supplies the TA-III/TA-V water distribution system. The primary water sources are a 1-million gallon storage tank and a 3.5-million gallon storage tank located approximately 5.6 m (3.5 mi) north of TA-III/TA-V. Water is conveyed from these tanks to TA-III/TA-V through 0.254-m (10-in) and 0.356-m (14-in) water lines that are cross-connected within these two Technical Areas. In addition, a 700,000-gallon storage tank located east of TA-III provides temporary backup to the TA-III/TA-V water distribution systems in the event that the supply from the primary water sources is disrupted.

1.4.3 Geology

This section provides the general geologic information concerning the site.

1.4.3.1 General Data

SNL/NM is situated in the eastern portion of the Albuquerque-Belen Basin. This basin, one of the largest in a series of basins that trend to the north in the Rio Grande trough, is about 145 km (90 mi) long and 48 km (30 mi) wide. The basin is bounded by the Sandia-Manzanita-Manzano Mountains on the east, the Lucero uplift and Puerco plateau on the west, and the Nacimiento uplift on the north. The southern boundary is defined by the Socorro channel. The basin is widest in the Albuquerque area and constricted to the south by the San Acacia channel and to the north by the Cerrillos trend.

Large-scale faulting, deepening of the basin, and tilting of the mountain zones occurred in late Miocene time. Since then, basin deposits have been laid down in a sequence of complex layers (SNL 1995d).

1.4.3.2 Basin and Range Structures

The majority of the basin is composed of poorly consolidated sediments eroded from the surrounding mountain areas following the faulting and structural changes that occurred in late Miocene time. The upper part of the basin is a complex sequence of gravel, sand, silt, clay, and caliche deposits known as the Santa Fe Group. Underlying these deposits are sedimentary rocks indicated by gravity and aeromagnetic mapping to extend down to about 3050 m (10,000 ft) below sea level, or about 4570 m (15,000 ft) below ground level. These sedimentary rocks rest on a bed of Precambrian rocks that underlie the entire basin and then lift up to form the western plateaus and eastern mountains.

The Sandia Mountains rise about 1,524 m (5,000 ft) above the land surface of the basin, giving a total difference of elevation between the Precambrian rocks in the basin and mountains of roughly 6,100 m (20,000 ft). On the west side, Precambrian rocks lie at about sea level, with sedimentary rock overlying them to a depth of about 1524 m (5,000 ft) above sea level (SNL 1995b).

1.4.3.3 Site Geology

TA-V is underlain by formations of the Santa Fe Group of Quaternary and Tertiary age. The Santa Fe Group is in turn underlain by formations of Permian, Pennsylvanian, and Precambrian age. These older rocks crop out in the horst about 800 m (0.5 mi) east of the site and also in the mountains farther east. Thin deposits of recent alluvium occur in the arroyos in the area.

The alluvium consists of unconsolidated sand, gravel, and silt with a maximum thickness of 5 to 6 m (15 to 20 ft). This material is largely derived from the granite and metamorphosed rocks of Precambrian age that are exposed to the east. Generally, the porosity and permeability of this alluvial material are high, allowing relatively free movement of water. The Santa Fe Group comprises material similar to the alluvium, but much of the material has come into the area from the north, and there is a slightly greater degree of consolidation of some beds.

The Santa Fe Group was deposited by streams and, consequently, there are rapid lateral and vertical changes in the character of the sediments. Individual beds are generally lenticular, but some extend for considerable distances as channel deposits. These long, narrow channel deposits are generally oriented in a northeast-southwest direction. The thickness of the Santa Fe Group beneath the site is not known, but is probably more than 150 m (500 ft). The porosity and permeability of the Santa Fe Group as a unit in this general area are generally high; however, the permeability of individual beds or lenses of silt or clay is quite low.

The pre-Tertiary rocks that underlie the Santa Fe Group consist of sandstones, siltstones, limestones, and metamorphosed sediments lying on top of granite. These rocks are well consolidated and less porous and permeable than the rocks of the Santa Fe Group. The thickness of these rocks appears to be at least 6700 m (22,000 ft).

Rocks of Precambrian age are exposed about 800 m (0.5 mi) east of the site in a northeast-southwest upfaulted block or horst about 300 m (980 ft) wide. The fault bordering the west side of the horst has a displacement of at least 180 m (590 ft) and probably much more, as indicated by the 200 m (650 ft) of clay, sand, and gravel penetrated by the Sandia well in the northwest quadrant of the southwest quarter of Section 15, Township 9 North, about 3200 m (2 mi) northeast of TA-V.

The small hills east of the horst are deformed beds of the Santa Fe Group along the west side of a downfaulted block, or graben. Any faults that may be present at TA-V are masked by an alluvial fan.

Table 1.4-4 summarizes the stratigraphy of TA-V.

Table 1.4-4 Stratigraphy of TA-V.

Age	Formation or Group	Thickness (m)	Character	Water-Bearing Characteristics
Recent	Alluvium	4 to 6	Sand and gravel	Unsaturated, but generally highly porous and permeable
Quaternary and Tertiary	Santa Fe Group	0 to 3000	Sand, gravel, and silt; generally unconsolidated	Permeable and porous; the only important aquifer in the area
Permian	San Andres Formation, Glorieta Sandstone, Yeso Formation, Abo Formation	850	Sandstone, siltstone, and limestone	Low permeability and porosity, but some water occurs in Glorieta sandstone; most water in these formations occurs in cracks and joints
Pennsylvanian	Magdalena Group	240 to 270	Siltstone, limestone, and sandstone	Low permeability and porosity; most, if not all, water occurs in cracks and joints
Precambrian	Seviletta Formation, Upper Metaclastic Series, Lower Metaclastic Series, Greenstone complex intrusives	5500+	Metamorphosed sedimentary and pyroclastic rock and intrusives, and granites and pegmatites	Low permeability, very low porosity; all water in these formations occurs in cracks and joints

1.5 Natural Hazards

This section identifies natural phenomena events and the likelihood that they will affect operations at TA-V.

1.5.1 Wind and Tornadoes

The portions of the HCF that are below grade are not subject to winds or tornadoes, with the exception of the roll up door entrance at the southwest corner of the facility, which faces west. This entrance performs no safety function and has no performance requirement. The above grade HCF structures would be subjected to winds. Recommended wind speeds for performance category 1 or 2 structures are specified in DOE-STD-1020-94 as 78 miles per hour for Albuquerque.

The mean annual frequency of tornado occurrences in New Mexico ranged from a minimum of 0.2 to a maximum of 1.1 between 1953 and 1962, depending on the location (Thom 1963). Statistically, the highest frequency has been observed in the eastern half of the state. For the western half of the state, generally demarcated by the Rio Grande and the mountain ranges that parallel it on the east side, tornado frequencies are 0.3 or less. In the Albuquerque area, which lies west of the Sandia and Manzano Mountains, only one tornado was recorded in 1985. Damage was very light and no official wind readings were denoted.

In addition, one funnel cloud has been observed in the same 20-year period. This cloud was reported in the Four Hills area of Albuquerque about 6 km (3.7 mi) to the north of the TA-V site on KAFB. Based on the climatological records available, Albuquerque can be classified as a region of low tornado occurrence with an annual frequency of 0.1 or less. Tornado severity within the Albuquerque area would be expected to be significantly less than that in the Midwest because the meteorological conditions required to produce a severe tornado rarely occur.

1.5.2 Earthquakes

This section covers the seismicity in the Albuquerque vicinity.

1.5.2.1 Seismic History

There are ten absolute-gravity stations in the vicinity of SNL/KAFB that are maintained by the National Geodetic Survey and the Defense Mapping Agency. The Albuquerque area is located in Seismic Zone 2B (Figure 1.5-1), which is defined as a region that can be expected to receive moderate damage from earthquakes. Seismically, the Albuquerque area is characterized as a region of high activity but relatively low magnitude and intensity.

Based on available information, most earthquakes recorded in New Mexico have occurred along the Rio Grande trough, with the region between Albuquerque and Socorro [100 km (62 mi) apart] exhibiting the highest concentration, accounting for about 90% of the recorded earthquakes between 1890 and 1960. Instrumented seismic records for New Mexico beginning in 1960 indicate that the pattern of seismic activity for earthquakes of Richter magnitude 2.7 or greater has shifted, such that the center of activity is in the northeast quadrant of the state. As far as can be determined from geologic data, there have been no intensive earthquakes in the Albuquerque area within recent geologic history. However, several earthquakes centered near Albuquerque during the past 20 years have recorded Richter magnitudes of 2.7 or greater (Sanford et al. 1972). Earthquakes with magnitudes of 3.0 or greater for the period 1986 through 1994 are shown in Figure 1.5-2.

Perhaps the strongest shock of the century in the Albuquerque area was that of January 4, 1971, which registered a magnitude 4.7 on the Richter scale. The largest shock predicted in New Mexico in a 100-year time period is of magnitude 6.0 on the Richter scale (SNL 1995a).

1.5.2.2 Albuquerque Fault Zones

The entire length of the Rio Grande trough is characterized by complex fault zones along the trough boundaries. The faults are generally characterized by major lines of discontinuity that define large blocks of substructure that have shifted with respect to each other, primarily vertically. Most of the faults lie along the base of the mountains on each side of the trough.

In general, the characteristics of the trough within the Albuquerque-Belen Basin are essentially the same as for the Rio Grande trough. The basin is bounded on both sides by a complex fault structure characterized by large vertical displacements between adjacent blocks; in some areas, evidence can be found indicating horizontal displacement. Faulting has been determined to exist at subsurface levels, and on the east side at least four zones of subsurface faults have been identified.

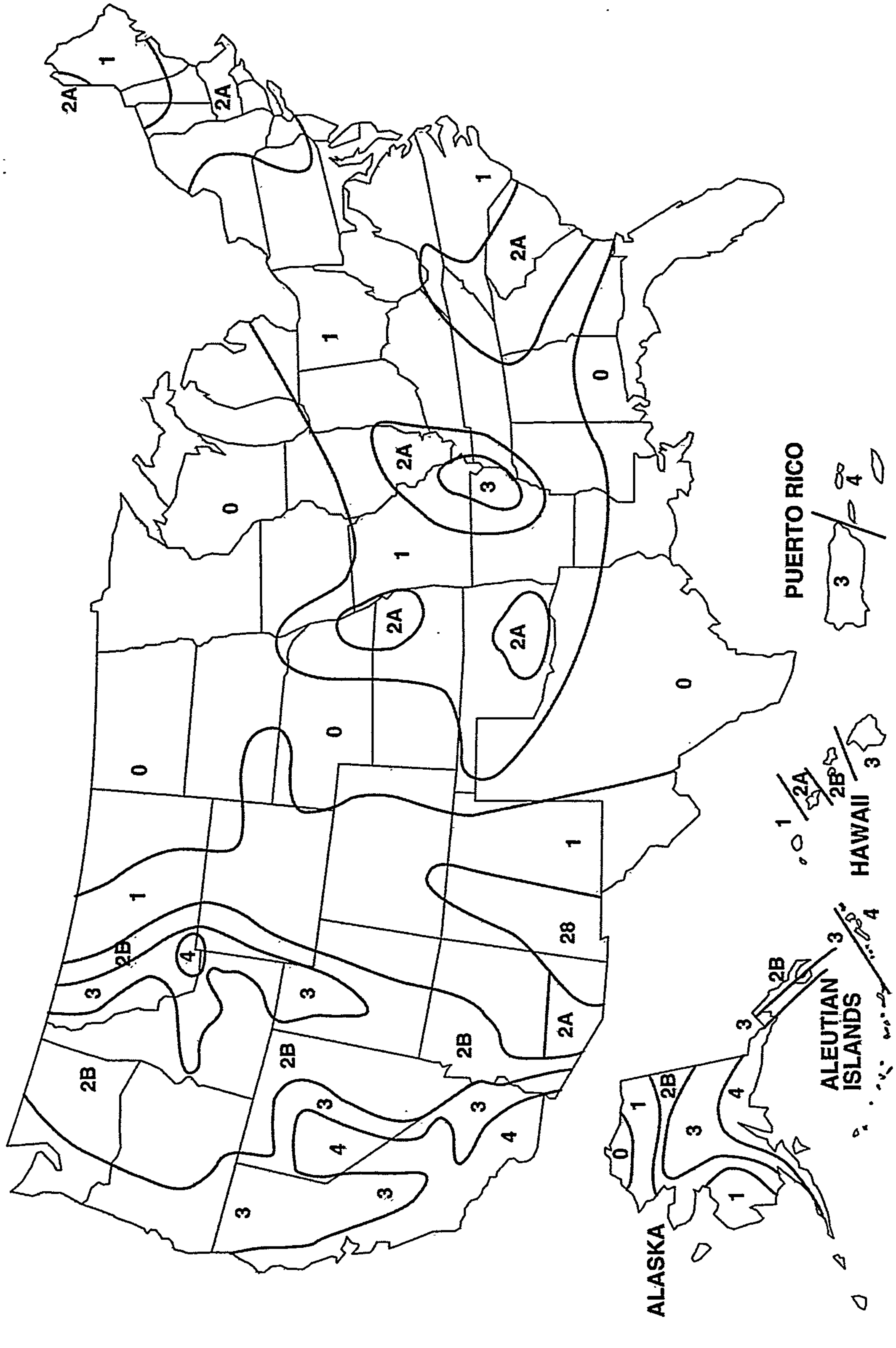
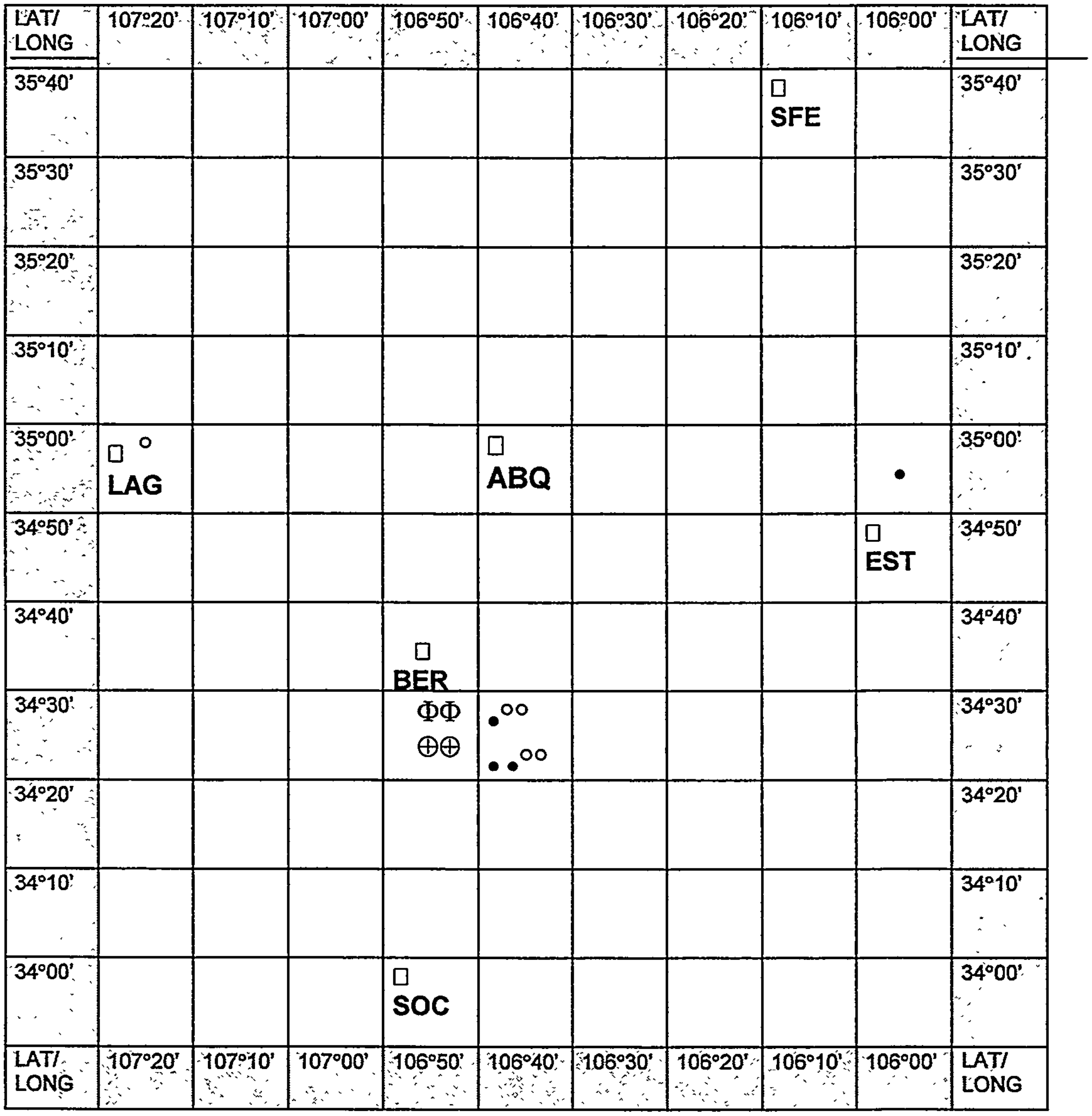


Figure 1.5-1 Seismic Risk Map of the United States (ICBO 1994)



MAGNITUDE
(RICHTER)

∘	3.0 - 3.4
•	3.5 - 3.9
⊕	4.0 - 4.4
Φ	4.5 - 4.9

CITY/TOWN KEY ☐

ABQ	Albuquerque	SFE	Santa Fe
BER	Bernardo	SOC	Socorro
EST	Estancia		
LAG	Laguna (Pueblo)		

Figure 1.5-2 Map of Central Rio Grande Region of New Mexico, Showing Locations of Magnitude ≥ 3.0.
Earthquakes Detected by NM Institute of Mining and Technology Seismographs for the Period 1986 – 1994 (SNL 1995c).

1.5.2.3 Fault Zones in the Vicinity of TA-V

Three zones of faulting on the west slope of the Sandia and Manzano Mountains have been identified in the vicinity of Manzano Base and the SNL TAs: the Tijeras Fault, the Sandia Fault, and the Hubbell Springs Fault. The Tijeras and Sandia Faults converge near the south end of TA-III into the Hubbell Springs Fault (Figure 1.5-3).

The Tijeras Fault is a strike-slip fault of Paleozoic age expressed by southwesterly movement of the northern block (left lateral). The fault has been traced as far north as Madrid, New Mexico, and trends southwesterly through Tijeras Canyon and along Four Hills just north of KAFB. The two other faults on KAFB are the Tertiary age Hubbell Springs and Sandia Faults. These faults are north-south trending, down-to-the-west, enechelon normal faults (Lozinsky and Teford 1991).

The Sandia Fault is thought to be the primary boundary between the Sandia Mountains and the Albuquerque Basin. The Hubbell Springs Fault extends northward from Socorro County, New Mexico, into the southern portion of KAFB. The Hubbell Springs Fault is particularly important to the HCF and other facilities in TA-V/TA-III because this fault has been active as recently as 1931-35, when earth movement along the fault shut off the water flow from nearby springs.

1.5.2.4 Design Basis Earthquake

The design basis earthquake (DBE) for NPH performance category 2 (PC2) systems, structures and components (SSCs) is specified in accordance with DOE-STD-1020-94 as follows:

- Seismic Zone 2B
- An annual probability of exceedance of 1×10^{-3}
- A maximum horizontal peak ground acceleration (Z) of 0.22 g
- Importance factor (I) of 1.25

1.5.3 Flooding

Flooding at the site is extremely unlikely and, on the basis of historical evidence, is not apt to result from natural phenomena. TA-V is located on a mesa that slopes gently from the mountains westward to the river valley. The altitude of the site is 1657 m (5436 ft). The river valley is about 14,000 m (8.7 mi) west of the site at an altitude of 1500 m (4920 ft). Because of the difference in elevation of 157 m (515 ft) and the distance from the river, flooding from the river does not present a threat to the HCF.

As discussed in Section 1.4.1.2, precipitation that falls to the east and north of TA-V is carried by natural and artificial flow paths into two primary surface channels: the Tijeras Arroyo and the smaller Arroyo del Coyote. Floods in these arroyos are characterized by high peak flows, small volumes, and short durations. Because TA-V facilities are higher than these surface channels, and because they have been built outside the 500-year and 100-year floodplains of the arroyos, the facilities are not threatened by flooding from these sources (SNL 1993a). No man-made structures in TA-V/TA-III store sufficient quantities of water to flood the site and cause structural failure.

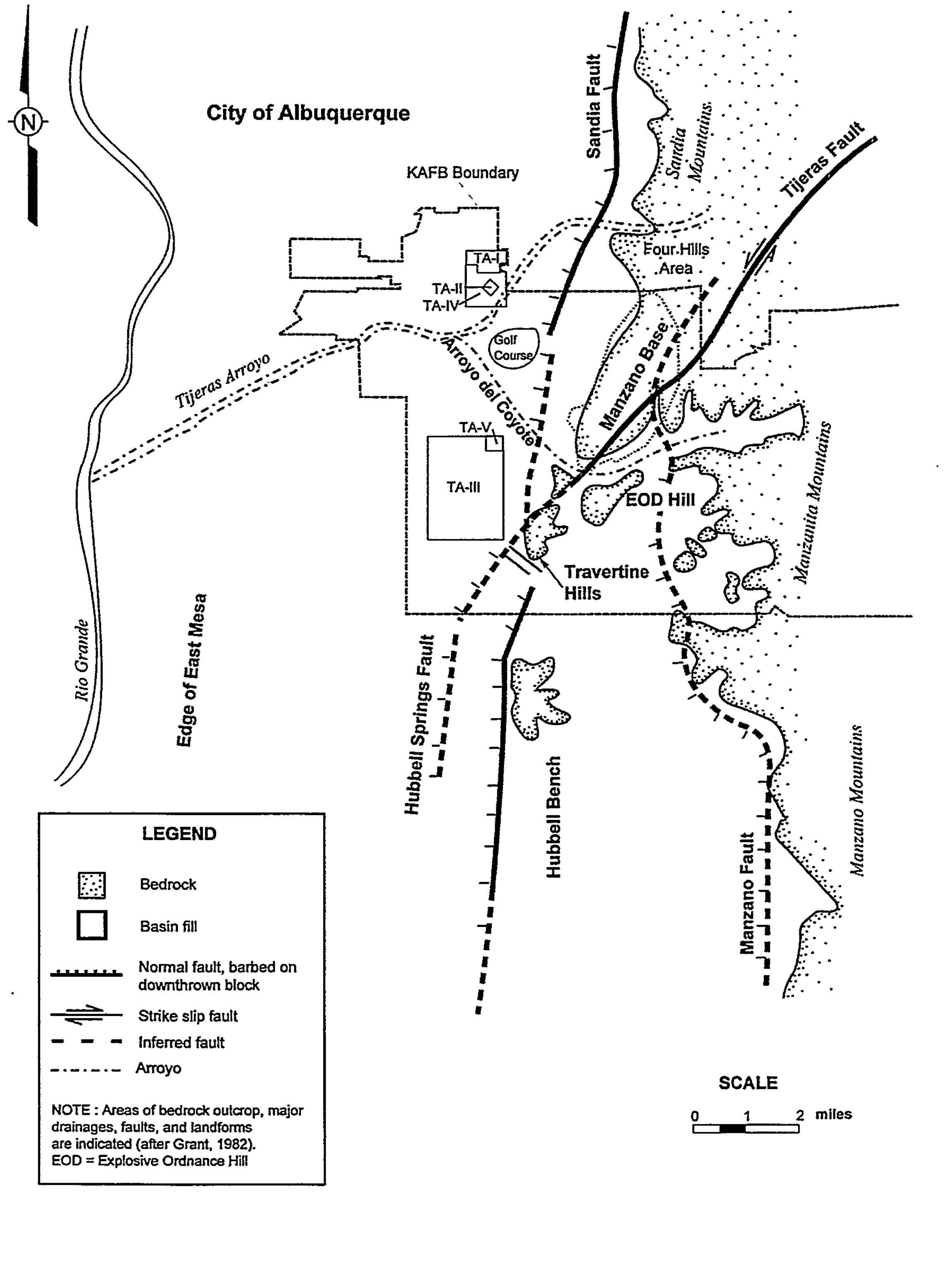


Figure 1.5-3 Fault Zones Near TA-V

An analysis of the potential for extreme flooding scenario for the Sandia Pulsed Reactor (SPR) was accomplished in 1999 (Pickard 1999). This analysis concluded that the likelihood of rainfall sufficient to completely flood a facility, such as the HCF, was of the order of once per million years.

The evaluation above constitutes the flood screening analysis for the HCF, which defines the HCF as a flood-dry site. Flooding is not a design basis event for the HCF.

1.6 External Man-Made Threats

Potential man-made threats include aircraft crashes, chemical/toxic gas releases, forest fires, loss of electrical power, soil erosion, criticality events, explosions, missiles, pipeline accidents, structural interactions, and transportation accidents. These events and their potential effects on the HCF are discussed in Chapter 3.

1.7 Nearby Facilities

This section identifies both nearby facilities that could be affected by accidents within TA-V and hazardous operations or facilities onsite or off site that could adversely affect operations at the HCF.

TA-V installations that could potentially affect or be affected by the HCF include the Annular Core Research Reactor (ACRR), Gamma Irradiation Facility (GIF), Auxiliary Hot Cell Facility (AHCF), Radiation Metrology Laboratory (RML), and the Sandia Pulse Reactor III (SPR III). The GIF provides two cobalt cells for total dose irradiation environments. A new GIF is under construction in the northeast quadrant of TA-V. SPR III provides intense neutron bursts for effects testing of materials and electronics. The RML provides radiation measurement services to Sandia's reactors, isotopic sources, and accelerator facilities. The AHCF provides a capability to handle limited quantities of radioactive material in a shielded cell. These facilities have separate SARs that describe potential accidents. The most severe accidents for all of these facilities involve the release of radiological materials which could necessitate a site evacuation. No physical damage to the HCF could be induced by any of the postulated accidents, nor could any of the HCF accidents physically affect any of the other facilities.

KAFB includes all of the SNL TAs and the USAF installations. Adjacent to and physically combined with the USAF installations is the Albuquerque International Airport, a large joint military/commercial transportation complex. No other commercial, industrial, or transportation facilities are within 6 km (4 mi) of the HCF. Landing and takeoff patterns for the various runways at the airport facilities do not affect operations. The runway of most concern relative to operations is the east-west runway. Aircraft using the east end of this runway for landing or take off could possibly fly over the HCF if approaching or leaving the airport in a southeasterly direction; however, any aircraft that fly over the area during take off are already fully airborne.

Military and SNL test ranges are all 1.0 km (0.63 mi) or more from TA-V; any accidents at these sites would not directly affect HCF operations.

Accidents involving the transport of hazardous materials on routes near TA-V would not affect access to TA-V, since the area surrounding TA-V is crossed by numerous improved dirt roads. If an accident were to occur on the main route, emergency vehicles could still gain access to the area using one of the improved dirt roads.

A comprehensive group of probable accident types has been reviewed, and appropriate procedures have been incorporated into the Emergency Preparedness Master Plan for SNL/NM (SNL 1993b).

1.8 Validity Of Existing Environmental Analyses

The hydrology of the site has changed significantly from the conditions reported in earlier Safety Analysis reports (SARs) and environmental reports for TA-V. These changes (groundwater flow direction, depth to groundwater, and so forth) are related to the increased withdrawal of groundwater from pumping wells in the Albuquerque and KAFB areas. As dramatic as these changes are to the Albuquerque area, they do not affect the design basis of the HCF. No other significant discrepancies exist between the effects of site characteristics identified in this study and those identified in previous studies of the site.

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FIGURES

TABLES

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2.0 FACILITY DESCRIPTION

2.1 Introduction

This chapter provides a description of the Hot Cell Facility (HCF), its mission, and its history. It also provides a description of the facility and processes and their relationship to safety and support systems. Other topics covered in this chapter include:

- Facility structure and design basis.
- Facility processes, systems, equipment, and instrumentation.
- Confinement and ventilation systems.
- Safety support and utility systems.
- Other support facilities.

2.2 Requirements

This section identifies the codes, standards, regulations, and Department of Energy (DOE) Orders that are required for establishing the safety basis for the HCF. Only those requirements that are pertinent to the safety analysis and scope of this chapter are provided.

DOE Order 420.1, Facility Safety, requires the detailed application of that order's requirements to be guided by safety analyses that establish the identification and functions of safety (safety class and safety significant) structures, systems, and components (SSCs) for a facility and establish the significance of safety functions performed by those SSCs. It specifies that nuclear facilities shall be designed with the objective of providing multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment. The safety analyses must consider facility hazards, natural phenomena hazards, and external man-induced hazards. Paragraph 4.4.1 requires safety analyses for hazardous facilities to include the ability of SSCs and personnel to perform their intended safety functions under the effects of natural phenomena. DOE O 420.1 (DOE 1995) incorporates requirements from the cancelled DOE Orders 5480.28, 5480.7A, and 6430.1A (DOE 1993).

DOE Order 5480.21, Unreviewed Safety Questions, defines the basis for determining the existence of an Unreviewed Safety Question (USQ). The order establishes the process for implementing physical and procedural changes to the facility and to conduct tests and experiments without prior DOE approval as long as the changes do not affect the authorization basis. It is thus implicitly embodied in the definition of the configuration of the facility, which is the focus of Chapter 2 of the SAR.

DOE Order 5480.23, Chg. I, Nuclear Safety Analysis Reports, Paragraph 8.b.(3)(d), as amplified in paragraph 4.f.(3)(d)4 of Attachment 1 to the Order, requires a description of the facility and operations conducted in the facility, including design of principal structures, components, systems, engineered safety features, and processes. (DOE 1994a).

DOE-STD-1027-92, Change Notice 1, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, provides guidance for performing hazard categorization and accident analysis for SARs (DOE 1992).

DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, describes a SAR preparation method that is acceptable to the DOE. Chapter 2 of the Standard presents the format and content required for the facility description contained in the SAR. (DOE 1994b).

DOE-STD-1020-94, Chg. 1 (1/96), Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities, specifies natural phenomena requirements and NPH design and evaluation criteria for DOE facilities and supports DOE Order 420.1.

DOE-STD-1021-93, Chg.1 (1/96), Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components, provides criteria for selecting NPH performance categories (PCs) for nuclear facility structures, systems and components (SSCs) in accordance with DOE Order 420.1, and recommends general procedures for consistent application of the categorization criteria.

SNL ES&H Manual, MN471001, implements a number of requirements, including those contained in 10CFR835, Occupational Radiation Protection (SNL 1998).

Structures, systems, and components (SSCs) that are important to safety and that are identified as Safety SSCs are based on criteria contained in DOE-STD-3009 (p. xix) and the results of safety analyses, which determine the safety contributions of specific SSCs. The degree of consequence mitigation is the basis for identification of Safety SSCs and associated "Safety Functions". These "Safety Functions" are the essential performance requirements that are imposed on Safety SSC's which maintain the consequences of accident scenarios within bounds that are described in the SAR accident analysis. The use of the term "Safety Function" will be limited to these essential performance requirements in this SAR. While many SSCs provide a material safety benefit and could be considered to perform a safety function, SSCs that are not relied upon to effect an acceptable outcome will not have an associated Safety Function as the term is used in this SAR. Safety SSCs and associated Safety Functions are based on the results of hazard evaluation and accident analysis described in Chapter 3, and are specifically identified in Section 3.3.2.3. The specific safety functions important to safety are described in Chapter 4, and form the basis of the derivation of Technical Safety Requirements presented in Chapter 5.

2.3 Facility Overview

The primary mission of the HCF is currently that of chemical processing of radioisotopes which are generated in uranium targets by the fission process at the nearby Annular Core Research Reactor (ACRR). Modifications to the existing facility have been implemented to support this mission, which will contribute to providing radioisotopes essential to the U.S. medical community. Previously, the HCF conducted a variety of research and development activities which required the handling of highly activated and/or contaminated radiological materials, principally to support nuclear safety research projects and testing for DOE Defense Programs. While the primary mission of the facility is to produce radioisotopes as directed by the DOE, it is expected that research and process development activities will continue in the facility on a non-interference basis with the isotope processing operation.

HCF operations are accomplished in several buildings within SNL TAV, including Building 6580 (B6580), B6580B, B6580C, B6580D, B6581, B6595, B6596, and B6597. The locations of these buildings in TAV are depicted in Figure 2.3-1.

Processing of high activity radioactive materials are accomplished in that portion of the facility which occupies the basement of B6580. In this area, the facility provides shielded process stations for remote handling of high activity radiological material and various support areas in rooms adjacent to the processing areas. A three zone confinement and filtered ventilation system is used to control migration of radioactive contaminants in the basement processing areas. Major elements of this ventilation system are contained in the Mechanical Equipment Room (MER, B6580B), located above grade, directly over the southeast portion of the basement area. This ventilation system exhausts filtered contaminants through the HCF stack located immediately north of B6580. Other portions of B6580, principally on the ground floor, are used for radiological protection activities, light laboratories, and as office space to support HCF operations.

B6580B, B6580C, B6580D, and B6581 contain HCF support systems and equipment, including ventilation system components, vacuum system components, hydraulic system components, compressed gas supplies, standby power, and electrical distribution systems which directly support operations in B6580. A liquid-nitrogen dewar, which supplies cryogenic systems in the HCF, is located to the east of the MER. B6595, B6596, the south half of B6597, and the monorail storage holes located to the east of B6581 are locations at which materials (including radiological materials) are stored or used to support HCF operations. B6597 is used for HCF supporting operations such as maintenance activities and storage of DOT shipping containers.

2.4 Facility Structures

The major portion of the Hot Cell Facility is located in the basement of B6580 in Technical Area V of Sandia National Laboratories. Auxiliary support equipment is located in B6580B (MER) 6580C, 6580D, and 6581. The building was constructed in the early 1960s to house the Sandia Engineering Reactor (SER) Facility. Material storage and handling operations occur in B6595, B6596 and B6597.

2.4.1 Building 6580

The basement floor plan for the facility is depicted in Figure 2.4-1. A three zone confinement and filtered ventilation system is used to control migration of radioactive contaminants in the basement processing areas. These zones are defined as follows:

- Zone 1 - Innermost confinement zone, consisting of the 11 steel confinement boxes (SCBs) and associated ventilation ducting.
- Zone 2A - Secondary confinement zone which surrounds all of the SCBs.
- Zone 2 - Occupied working area of the HCF, consisting of rooms 107 and rooms 111 through 114.

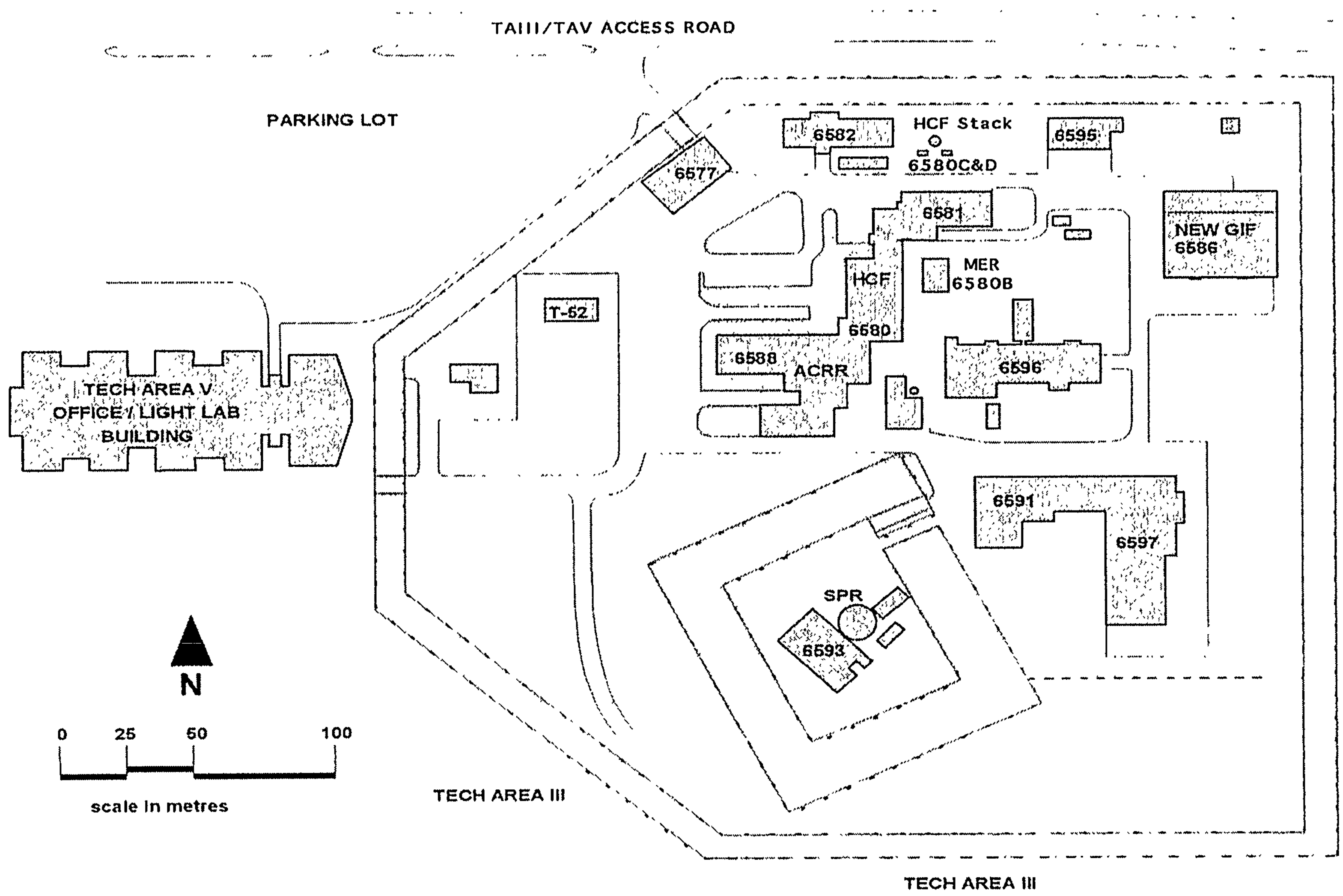


Figure 2.3-1 SNL Technical Area V

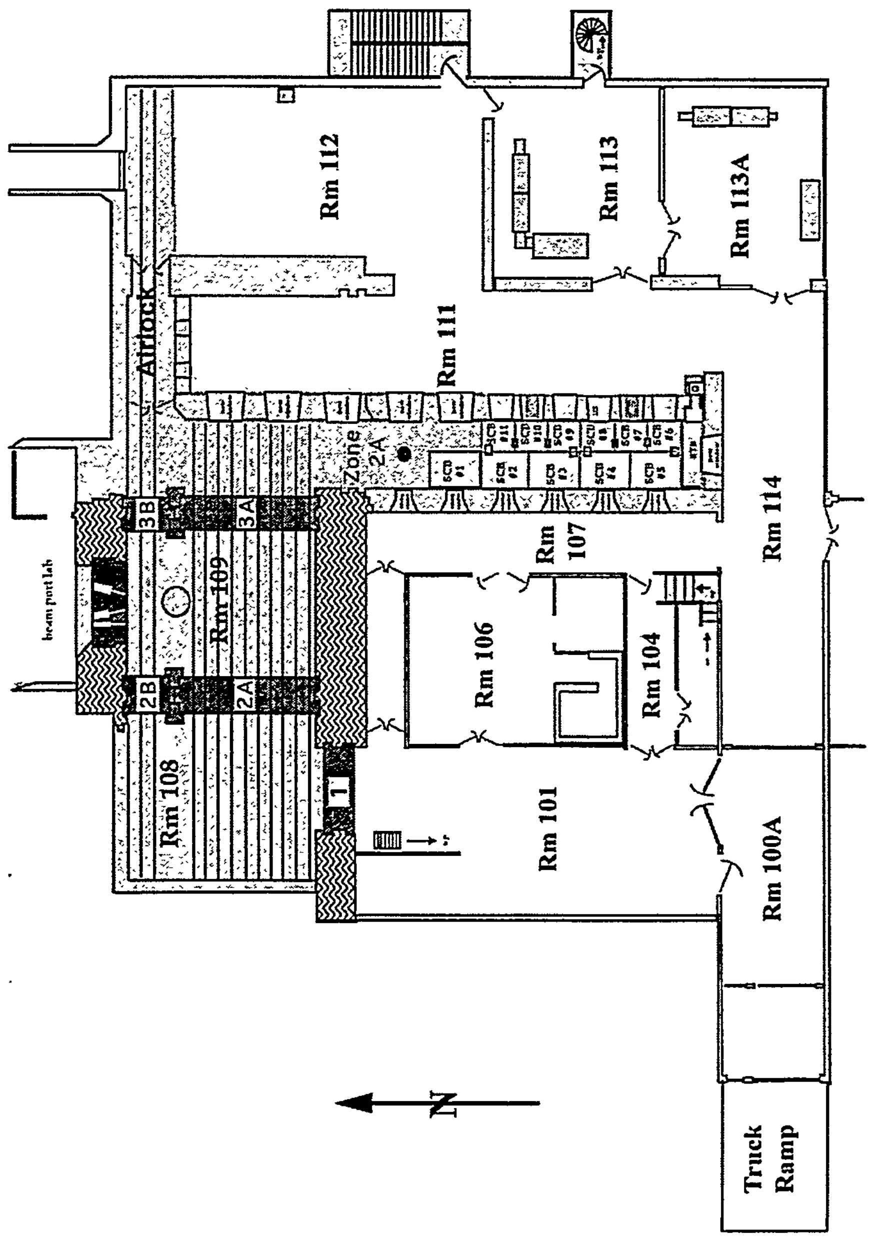


Figure 2.4-1 HCF Floor Plan

The eleven SCBs provide enclosed stations for radiochemical processing of high activity radiological material. SCB1 is used for remote packaging of solidified waste. SCBs 2 through 5 are used for radiochemical processing of high activity materials and/or materials which could evolve halogens or noble gases. These stations will exhibit the highest levels of residual contamination. SCBs 6 through 11 are used for radiochemical processing for moderate activity materials which do not evolve significant halogens or noble gases. Thus, they will exhibit lower levels of volatile contamination as compared to SCBs 2 through 5. A steel transfer box (STB) at the south end of The Zone 2A canyon is the preferred path for bringing both irradiated and unirradiated materials to the processing stations. A conveyer system which travels underneath the SCBs provides a path to transport materials from the STB to each of the SCBs. A hatch cover exists on the opening of each SCB to the conveyer. This cover is in place when materials are not being removed from or placed into the conveyer.

The Zone 2A canyon, shown in Figure 2.4-2, surrounds all of the SCBs and the STB, and also contains a below grade pit to the north of SCB1. This pit is used for the temporary staging of barrels containing solid radioactive waste, which moderates the ambient radiation levels in the Zone 2A canyon, desirable both from equipment as well as personnel dose perspectives. Five pairs of rails exist in the floor at the north end of the canyon and provide tracks for movement of waste barrels from the canyon into the waste storage area, Room 109. An airlock exists along the north wall of the canyon to permit movement of material into and out of the canyon while maintaining the zone differential pressure.

Shielding windows are located at each operating station in the HCF, and are numbered from 1 to 20 starting from the northernmost station in Room 107 and proceeding counterclockwise around the processing canyon. Station 7 is located at the south end of the canyon, with the operator station in Room 114, and Station 18 is the northernmost station in the east shield wall in Room 111. While the windows are not building structural elements, they are an integral contributor to the shielding capability provided by the concrete walls.

Zone 2, which is the occupied region of the HCF, includes Rooms 107, 111, 112, 113, 113A and 114. In addition to manipulator operations at each of the processing stations, these areas are used for cask and material handling, quality control activities, packaging and shipping, and maintenance.

The Building 6580 basement HCF-support areas in Zone 3 consist of all areas not part of Zones 1, 2A, or 2, including Rooms 100A, 101, 102, 104, 105 and 106. A small machine shop, a manipulator training station, an operations center, and non-radioactive material storage occupy these areas. Room 108 will eventually be used for preparing waste for off-site shipment, although that capability does not currently exist and is not described in this SAR.

2.4.1.1 Building 6580 Construction

The basement of B6580 is a poured reinforced concrete construction. Drawings relevant to the building structure are identified in Appendix 2A. Some of the walls and ceilings of the basement of B6580, in addition to being major load bearing structural elements of the building, also perform shielding functions for operations personnel. These walls include:

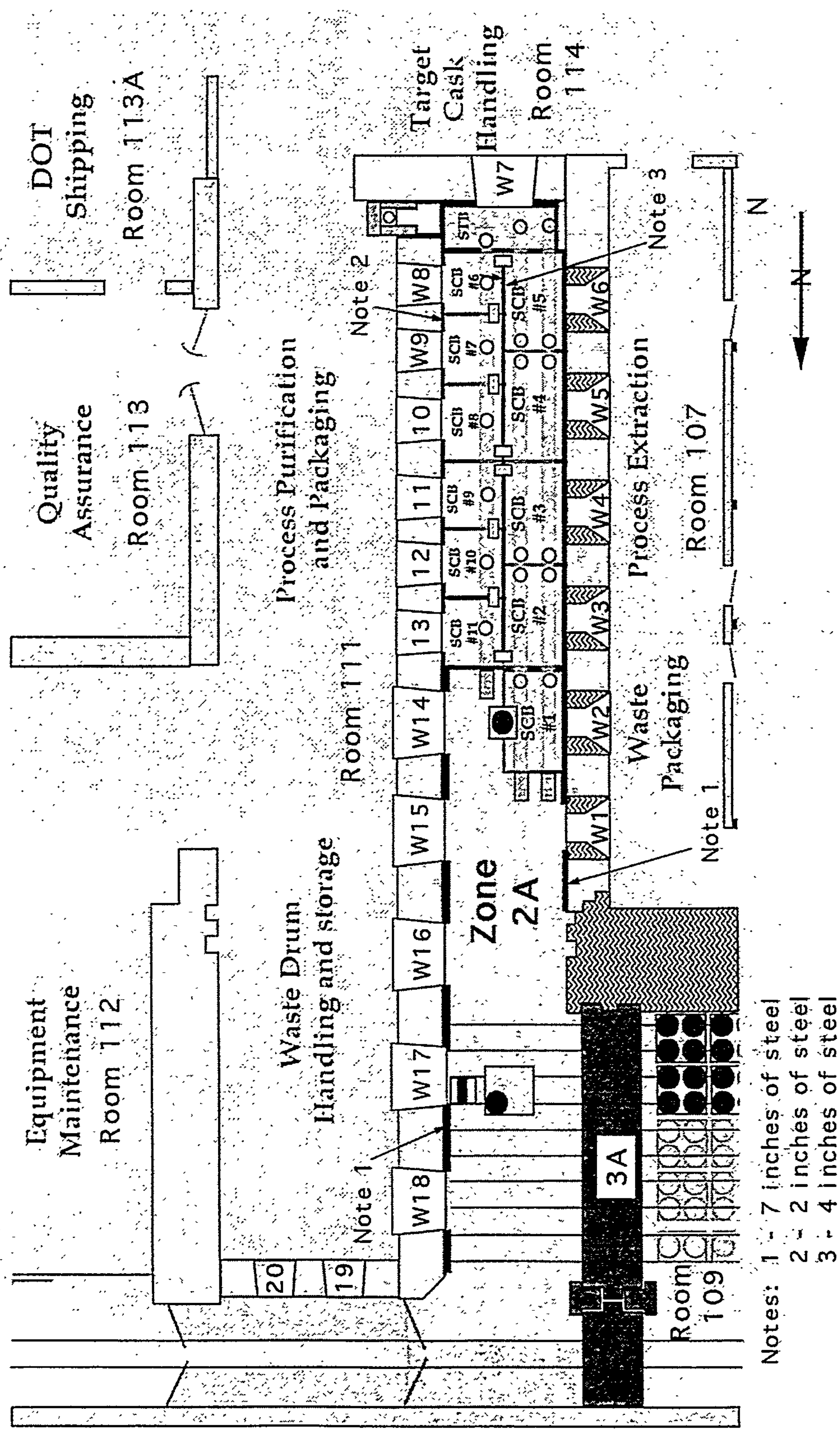


Figure 2.4-2 HCF Zone 2A Canyon and Associated Areas

- The west shield wall of the Hot Cell - 3.5-ft thick reinforced concrete with 7 inches of supplemental steel shielding
- The south shield wall of the Hot Cell - 3.5-ft thick by 15-ft high reinforced concrete with 6 inches of supplemental steel shielding
- The ceiling of the Hot Cell – 2 ft reinforced concrete topped with a minimum of 5 ft of soil overburden.
- Room 108 ceiling - 7-ft thick normal concrete or concrete-and-earth equivalent.
- Room 108 south wall - 8-ft(east of shield door 1) and 6-ft (west of shield door 1), 3.2 g/cc magnetite concrete.
- Room 108 north and west walls - concrete and compacted earth equivalent to 7 ft of normal concrete.
- Room 109 ceiling - 8.5-ft normal concrete, with 3.2-g/cm^3 density magnetite concrete around the reactor tank. The SERF core barrel is located at the north end of this room and the reactor tank penetrates the ceiling.
- Room 109 north and south walls - 8-ft, 3.2-g/cm^3 magnetite concrete.
- Room 111/112/113 ceiling - concrete and compacted earth equivalent to 7 ft of concrete.
- HCF north wall - concrete and compacted earth equivalent to 7 ft of concrete.
- Room 111/112 separation wall - 5.5-ft concrete.

Other elements of the HCF are not structural elements of the building, but do provide shielding for radioactive material. These include:

- The east shield wall of the Hot Cell - 3.5-ft thick concrete with 2 inches of supplemental steel shielding at SCBs 6 through 11, 7 inches of steel shielding north of SCB 11; this wall was poured as an addition to the HCF in the mid 1970's and is not load bearing.
- Mobile shield door 1 between Room 101 and 108 - 4.75-ft thick, 4.7-g/cm^3 density magnetite concrete with steel punchings.
- Mobile shield doors 2A and 2B between Rooms 108 and 109 - 5.42-ft thick, 4.7-g/cm^3 density magnetite concrete with steel punchings.
- Mobile shield doors 3A and 3B between Rooms 109 and the Zone 2A canyon - 4.83-ft thick, 4.7-g/cm^3 density magnetite concrete with steel punchings.
- North shield wall in Room 111. 3 ft thick reinforced concrete; this wall was poured as part of the HCF modifications in 1998 and is not load bearing.

The boundary of the processing canyon (Zone 2A), is defined by the west, south, and east shield walls, the facility structural wall at the north end of the zone, the mobile shield doors 3A and 3B, the inner airlock door, and the ceiling and floor contained within these walls. The boundary also includes components, such as shielding windows, lighting plugs, and piping, which either form an integral part of the wall pressure boundary or which penetrate the wall. This boundary provides confinement for control of contamination. The thickness and density of the walls provide shielding for handling and storage of high activity materials.

When used without a clarifying adjective or phrase and when not specifically associated with the HCF ventilation system, the term "Zone 2A" identifies the hot cell canyon as described above and does not include Room 109. When the term "Zone 2A ventilation system" is used, it is understood that this system exhausts air from Room 109 as well as from the canyon itself.

The waste storage area in Room 109 is bounded by the permanent and mobile walls, ceiling and floor. The walls, doors, and ceiling provide significant shielding for the very high inventory of radioactive waste which will be stored in this room. They also provide a confinement boundary to control the migration of contamination.

The thick concrete walls which surround processing and waste storage areas provide significant attenuation of radiation to reduce dose to operational personnel in the HCF, however, the shielding capability of the walls as they existed in 1996 was not sufficient to perform routine processing operations to support the new HCF mission and maintain operator dose at acceptable levels. Steel plate shielding was added to the inner wall of the Zone 2A canyon in 1998 and 1999 to provide adequate attenuation capability. The thickness of the steel varies from two to seven inches along the perimeter of the canyon, appropriate to the level of shielding required at each process station. A shielding analyses of the HCF modifications has been accomplished (Mitchell and Vernon 1999) to document the adequacy of the modifications with respect to shielding. Table 2.4-1 summarizes the approximate attenuation capability (based on the expected inventory, with an average gamma energy of about 0.4 Mev) of each of the shield walls in the HCF.

Table 2.4-1 HCF Shielding Capability

Structure	Material	Thickness	Approximate Attenuation
Zone 2A Canyon West Wall	Concrete w/ 7 in. steel	49 in.	3E6
Zone 2A Canyon South Wall	Concrete w/ 6 in. steel	48 in.	2E6
Zone 2A Canyon East Wall (Stations 8-13)	Concrete w/ 2 in. steel	44 in.	1E5
Zone 2A Canyon East Wall (Stations 14-18)	Concrete w/ 7 in. steel	49 in.	3E6
Rm 111 North Wall	Concrete	3 ft	5E3
Shield Door 2A&B	Magnetite Concrete w/Punchings	5.4 ft	1E12
Shield Door 3A&B	Magnetite Concrete w/Punchings	4.8 ft	1E11
Rm 109 South Wall	Magnetite Concrete	8 ft	1E12

There are several penetrations through the walls and ceiling of Room 109 which had been provided for operations associated with the SER. Removable shield plugs that exist in the north wall of Room 109 have been secured in place to prevent inadvertent removal. Shield plugs in the ceiling of Room 109 (floor of Rm 212) will be rendered non-movable or the crane required to move them will be locked out. A potential for radiation streaming through the SER reactor vessel also exists, which could result in undesirable radiation levels at the mezzanine elevation in Room 212. The shielding characteristics of this potential path will be evaluated in pre-operational testing. If required, additional shielding and/or administrative controls will be implemented to maintain personnel exposure acceptably low.

The walls and windows surrounding the hot cell canyon provide gamma shielding for operations with very high activity levels expected for the processes to be implemented at each shielded station in the HCF. The hot cell shield windows installed in the canyon walls were selected to provide gamma shielding equivalent to the concrete walls in which they are placed.

The dry windows (windows 1 through 6) installed in the canyon west shield wall provide shielding for the waste handling at window 1 and for high activity SCB processing stations 1 through 5. These windows consist of multiple layers of glass of various compositions and densities as tabulated in Table 2.4-2 to provide sufficient shielding within the radiation exposure capabilities of the glass. The inner panes of glass on these windows are low density (2.5 and 3.2 g/cc) to avoid window browning which would occur more rapidly in glass of higher density.

Table 2.4-2 HCF Window Composition

Window	Glass Thickness 2.5 g/cc	Glass Thickness 3.2 g/cc	Glass Thickness 5.6 g/cc	Glass Thickness 6.2 g/cc	Oil Thickness 0.86 g/cc	Density Product
W 1-5	2	8	4	16	0	152
W 6	2	8	16	3	0	139
Type "A"	9	0	21	0	14	152
Type "A-1"	9	0	6	13	15	150
Type "C"	3.5	0	0	14	14	108
W19, 20	4	0	0	12	0	85

Note: Numerical values indicate thickness in inches, although the total may comprise several panes of glass at varying locations in the window
Density Product refers to the summation of the density products of the window layers in units of density inches, or inch-grams/cc

2.4.1.2 HCF Support Functions

Several buildings other than B6580 support essential HCF operations, including B6580B, B6580C, and B6581.

B6580B houses the HCF Mechanical Equipment Room (MER, B6580B, Figure 2.4-3) located directly above Rooms 112 and 113 at ground level just east of the above grade portion of B6580. The MER houses the HCF Zone 1 and Zone 2A ventilation-system fans, charcoal filter housings, and other ventilation-system equipment. A layout of equipment in the MER is depicted in Figure 2.4-4. Zone 1 exhaust filters and fans, and the process vacuum system are contained in an enclosed room that occupies the southwest portion of the MER. This room is separately ventilated by a fan that discharges into the hot exhaust system. A 1500-gallon liquid-nitrogen dewar located to the east of the MER supplies liquid nitrogen to the process vacuum system cold traps and also provides a facility gaseous nitrogen supply.

B6580C, located at the base and to the west of the HCF stack, houses ventilation system HEPA filters and exhaust fans 4 and 5. This building and the stack are located directly north of B6580.

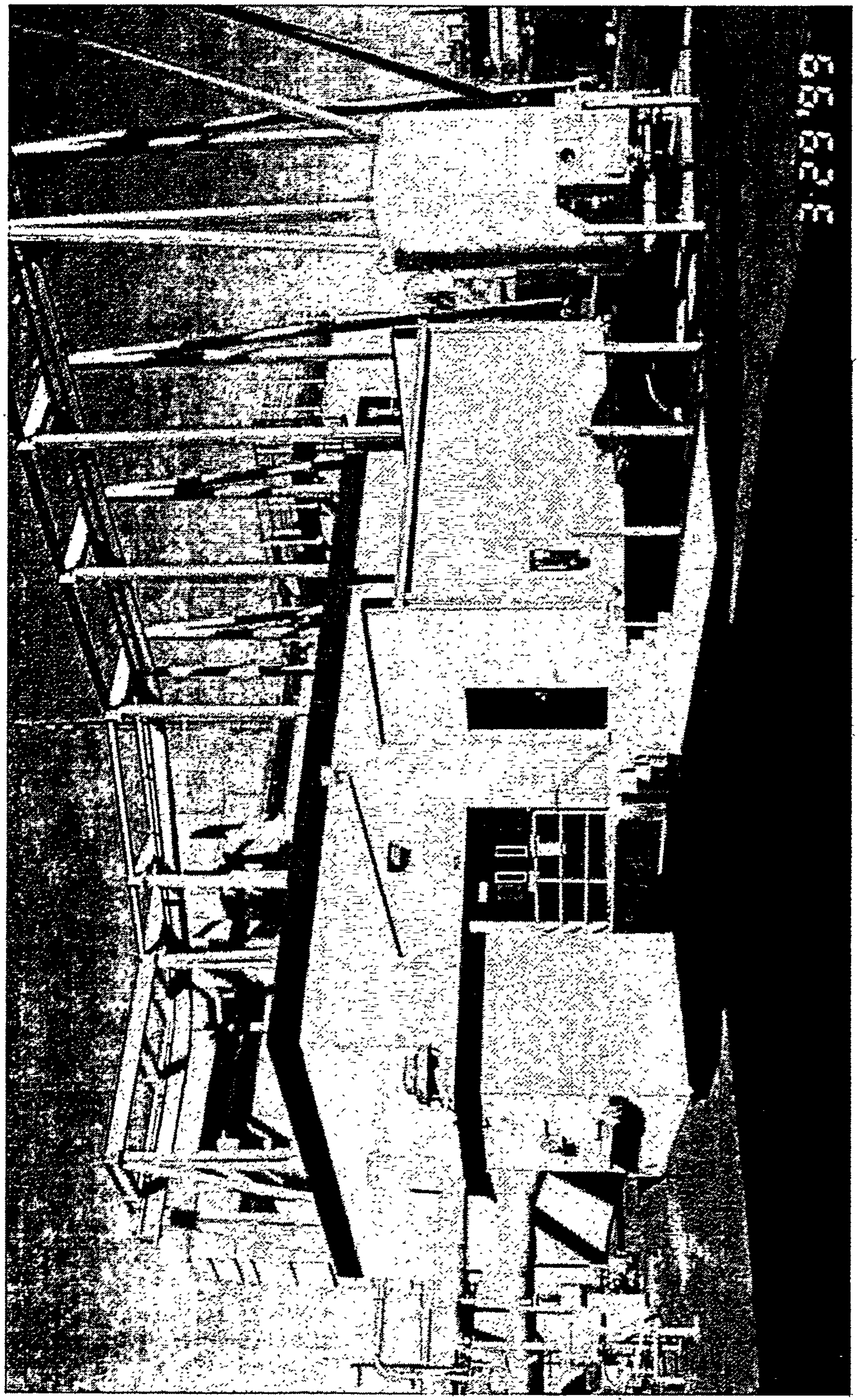


Figure 2.4-3 HCF Mechanical Equipment Room and LN Tank

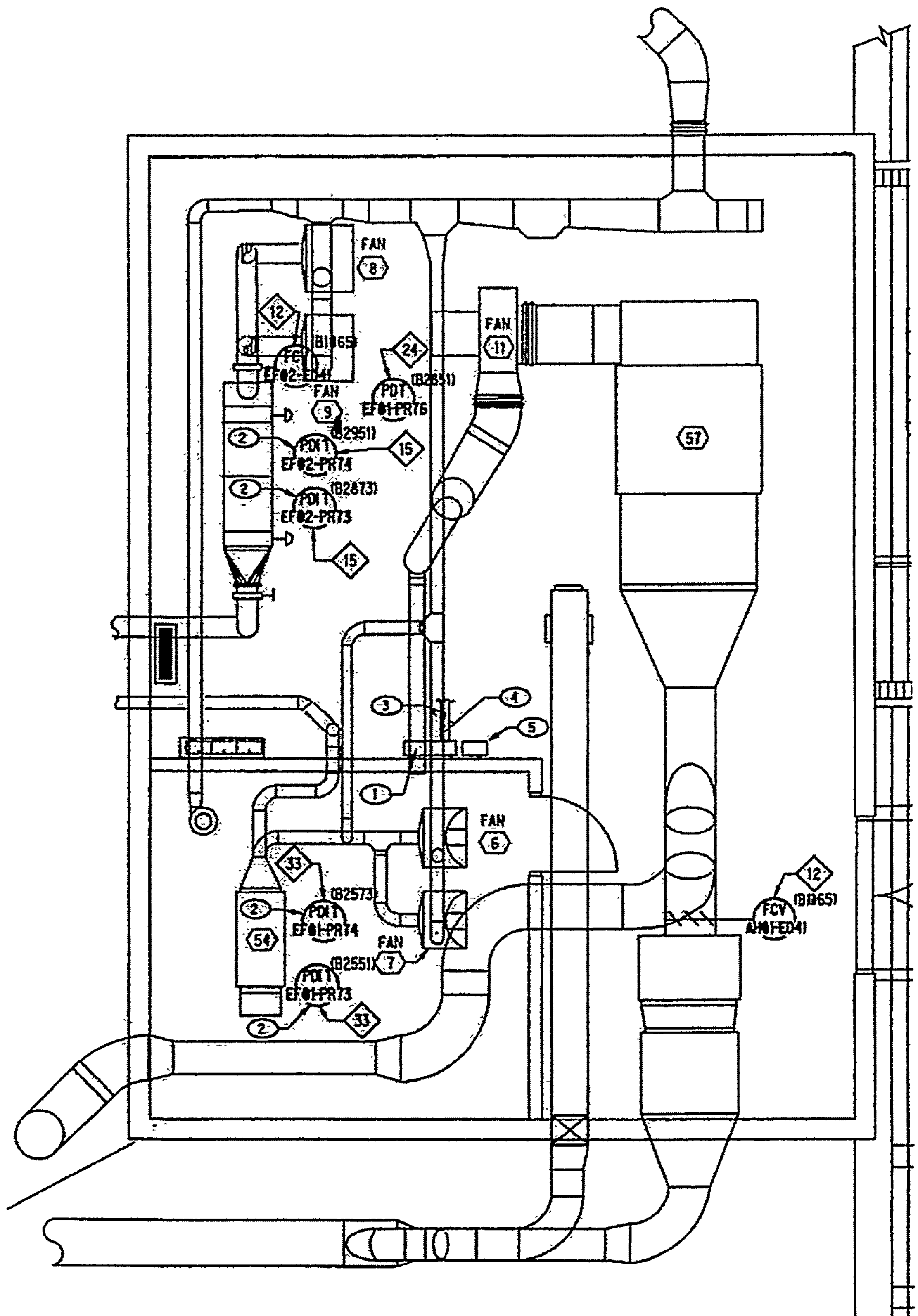


Figure 2.4-4 MER Layout

B6581 contains several HCF support systems, including the standby diesel generator and air compressors. The 560-gallon fuel tank for the diesel standby generator is located outside and immediately east of B6581. This building also houses major parts of the hydraulic system for the Room 108 and 109 shield doors and parts of the fire-protection-system plumbing. The ventilation system exhaust ducting, including Zone 1 and 2A hot exhaust ducting, Zone 2 exhaust ducting, as well as filter housings for the hoods and gloveboxes in Rooms 113 and 113A, is routed along the roof of B6581, down the north wall of the building, and underneath a road along the north side of the building to fans 4 and 5 at the base of the stack.

2.4.1.3 Other HCF Activities

Areas which surround the main HCF processing areas include an Operations Center in Room 106, a maintenance area in Room 112, a Quality Control Laboratory in Room 113, a product packaging area in Room 113A, and a machine shop in Room 101. Rooms 112, 113 and 113A are contained in ventilation Zone 2, while Rooms 101 and 106 are in Zone 3. Other areas of B6580 contain offices and light laboratories, principally on the first floor and the mezzanine elevation. Rooms 203 and 218 contain chemistry laboratories and may contain small quantities of radiological material, including unirradiated isotope targets.

2.4.2 Monorail Storage Area

The monorail storage area includes 12 below grade cylindrical cavities located east of B6580 and between B6581 and B6580B (MER). Ten of the storage holes are 10 inches in diameter and 21 feet deep, and two of the holes are 24 inches in diameter and 30 feet deep. Each hole is equipped with an environmental cover to exclude rainwater from these holes. An overhead monorail crane services the storage holes and truck loading pad. Power for the crane comes from a locked junction box near the monorail. All power can be locked out when the crane is not in operation.

2.4.3 Building 6595

B6595 is a concrete masonry unit (CMU) structure with a concrete-reinforced column and steel joist frame on a concrete slab and a built-up flat roof. The building is used to store non-radioactive materials and supplies that are used in the HCF.

2.4.4 Building 6596

B6596 consists of an east-west oriented high bay, an addition (called the Chapel) on the north side of the structure, a small storage addition on the north side of the building and west of the Chapel, and offices, restrooms, and a mechanical equipment room located on the southwest portion of the building. A concrete shield wall extending only up to the lower roof line separates the east and west portions of the high bay. The main building and Chapel are pre-engineered structures consisting of a rigid steel frame with galvanized steel wall and roof panels on a concrete slab. A low profile passageway connects the Chapel to the high bay. The office/restroom addition consists of CMU walls and a built-up-asphalt flat roof. Four metal roll-up doors of various sizes, each with an associated fork lift ramp, are located on the east, west, and south side of the building and on the east side of the Chapel.

The east west high bay has a 2-ton bridge crane that spans the north-south dimension of the building and travels east to west. A 1/2-ton jib crane is located outside of the east door to the facility. The Chapel has a 6-ton bridge crane that spans the east-west dimension of the building and travels north to south.

2.4.5 Building 6597

B6597 is a CMU structure with a concrete-reinforced column and steel joist frame on a concrete slab and a built-up flat roof. The floor is an 8-inch thick concrete [3000 pound per square inch (psi)] slab reinforced with #4 bars at 12-inch on center each way. The interior ceiling/roof height is approximately 35 ft.-0 in. Built in 1971, the entire building occupies almost 14,000 ft^2 of floor space. A mechanical equipment room is located on the east side of the building. Metal roll-up doors are located on the north and south ends of the high-bay. The opening dimensions of the high-bay roll-up doors are approximately 20 ft.-0 in. wide by 18 ft.-0 in. high.

The high-bay has a floor trench system around the building perimeter and down the center in both the east-west and north-south directions that contains electrical conduit and pipes. In addition, the south portion of the high bay contains subsurface equipment pits. Two double-girder bridge cranes, each with a capacity of six tons, span the east-west dimension of the high-bay and travel north to south. Additional description of B6597 and of systems and equipment installed in B6597 can be found in the AHCF SAR.

2.4.6 HCF NPH Assessment

An evaluation of Natural Phenomena Hazard (NPH) effects has been accomplished for HCF SSCs (Mitchell & Naegeli, 1999). This evaluation was accomplished in accordance with the 8-step process described in DOE-STD-1021, and included evaluations of both safety SSCs and other SSCs in the HCF. The functions of these SSCs were evaluated in NPH environments, and specifically in a DBE scenario, which is the only NPH hazard that significantly challenges HCF SSCs. Many HCF SSCs, including CMU building structures, have been assessed to not withstand the DBE and significant damage to SSCs contained in above grade CMU structures would be expected to occur in seismic events. The accident analysis results support the conclusion that despite this damage, the only SSCs in the HCF with an identified NPH radiological safety function are the shield walls (and associated shielding windows) surrounding the hot cell canyon (Zone 2A). An NPH Performance Category 2 (PC2) assignment is made for this structure, based on its radiation attenuation function. Other building structures (e.g., walls, and ceilings), the Zone 1 ventilation exhaust piping, and the HCF stack are assigned NPH Performance Category 1 on the basis of life safety considerations, while all other HCF SSCs are assigned NPH Performance Category 0.

2.5 Process Description

In general, the HFC is a radioactive material and radiochemical processing laboratory. Highly radioactive materials are handled and chemically processed, and these activities must be conducted in appropriately shielded areas with adequate control of contamination. A representative isotope separation process flow diagram is depicted in Figure 2.5-1. Isotope processing will generally be accomplished by acidic dissolution of uranium dioxide containing mixed fission products. The uranium dioxide is typically coated on substrates or internally coated on stainless steel containers that are irradiated in the ACRR and transferred to the HCF for processing. The types of operations conducted in the HCF are identified primarily by the locations where they are conducted. The envelope for the operations that can be conducted in the facility is described in this SAR. Some operations are limited to specific locations in the facility. When this is the case, the operations and the specific locations are identified.

For the purposes of this section, HCF activities are broken down into the following groups:

- Operations at shielded high and low activity SCB process stations.
- Irradiated target and process material transfers.
- Product and material transfers.
- Process waste handling and storage operations.
- Operations in hoods and gloveboxes.
- Support activities in Zone 2 and Zone 3.
- Radioactive material storage in B6596 (Chapel and East High Bay), B6597 (south high bay), and in the monorail storage holes.
- Operational support activities in B6595, B6596 and B6597.

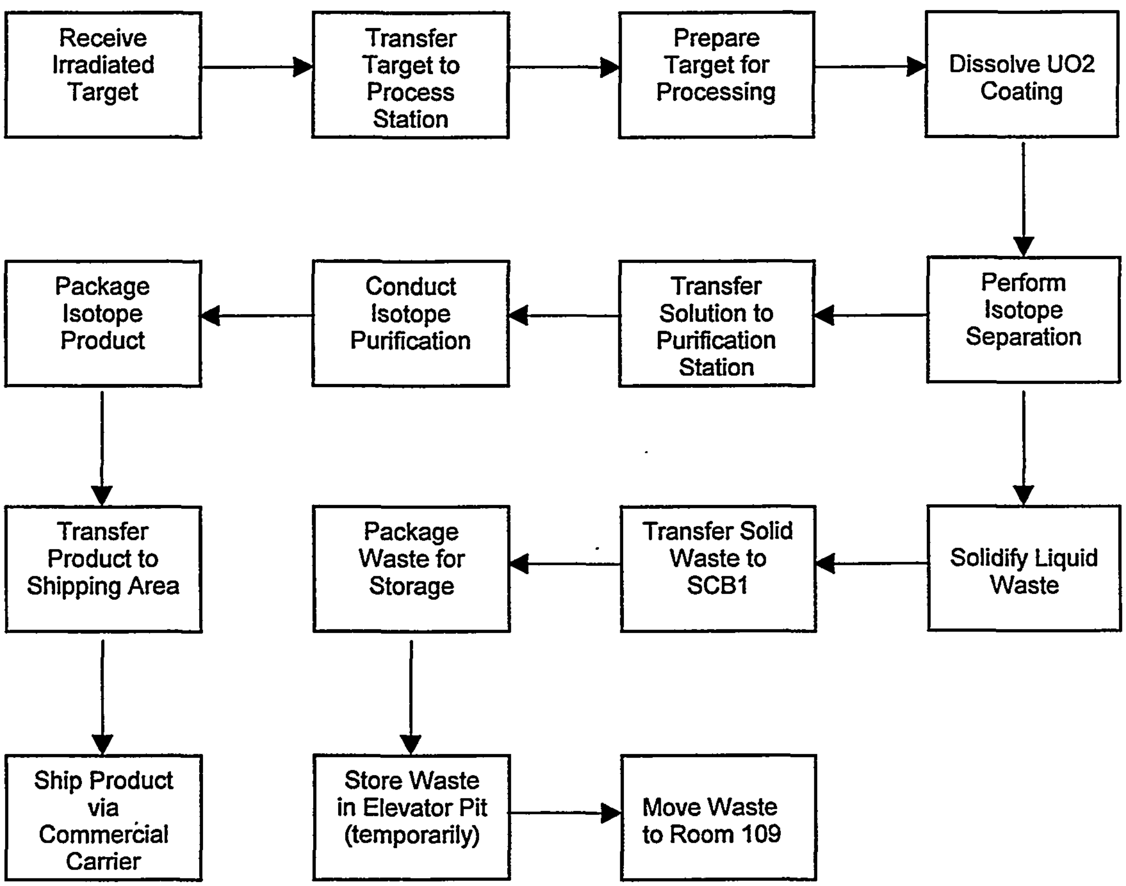


Figure 2.5-1 – Isotope Separation Process Flow Diagram

Normal personnel access to HCF processing areas in Zone 2 is through the Operations Center in Room 106. The Operations Center serves as an access control point for the facility and will contain operations information pertinent to the operations in progress on a daily basis. The Center houses the ventilation control system that displays real-time operating information. Personnel contamination monitoring systems are also provided at the Operations Center.

The normal entry and exit for material and equipment into the HCF is through the truck ramp extending westward from the southwest corner of the building. Irradiated targets will be brought into the facility, and product shipments will be removed via this ramp. Access requires passing through a series of three roll up doors into Room 114, which allows ventilation integrity to be maintained during movements of material. Fire exits for personnel working in the HCF are provided by a stairwell with a personnel door exit located on the east wall of Room 112, a spiral staircase in Room 113, and personnel exits in the Room 114 truck ramp.

Materials and equipment access to the Zone 2A canyon is provided through two airlock doors accessible at the north end of Room 112, and through an engineered shielded transfer station at the south end of the canyon. Normal access to bring process materials into the process stations is through the steel transfer box (STB) at the south end of the canyon. Isotope products are removed from the processing stations along the east side of the canyon through two engineered transfer systems.

2.5.1 Operations at Shielded SCB Process Stations

The shielded SCBs include low and high activity radiochemical processing stations. High activity processing stations, comprised of SCBs 2 through 5, are located on the west side of the Zone 2A canyon, with operator stations located in Room 107. Significant shielding is provided around these stations to mitigate the high radiation fields associated with initial isotope process extraction operations. This shielding provides attenuation of more than six orders of magnitude for the radiation emanating from the source term associated with a maximally irradiated isotope target. (Mitchell, 1999, pp. 14-18) Operations at these stations include initial acidic dissolution, evolution of the noble gases, distillation and trapping of the halogens, and initial isotope separation processes.

Initial process dissolution is accomplished by either immersing a uranium-coated substrate in acid or by injecting acid into an internally coated container. The process container is usually heated to moderate temperatures (less than 200 C) to facilitate the dissolution process. The resultant solution, containing both uranium and fission products is then subjected to a wet chemistry process specific to the isotope of interest. Wet chemistry processes are generally accomplished in metallic and glass containers. Glassware is typically coated with plastic to reduce the potential for breakage. Fixtures, stands, and tools are used at each process station to facilitate remote manipulator handling of the process containers. The Mo-99 process uses a total of about 400 ml of liquid solutions per target processed, which amounts to less than 2.5 liters per day. Other isotope separation processes may use greater or lesser quantities of process chemicals. The potential hazard created by the presence of process chemicals is minor compared to the radiological hazard, and will be mitigated by remote handling in the SCBs and by the sealed process hardware and glassware.

Once the desired isotope has been separated from the balance of the fission product stream, the solution containing the isotope is transferred from the high activity SCB to a low activity

SCB for further processing. The residual process solution, containing the bulk of the fission product activity as well as the uranium, is solidified each day, prior to being transferred to SCB1 for packaging and eventual disposal as waste. This solidification renders the radiological inventory into a state of extremely low volatility.

The low activity stations, SCBs 6 through 11, have operator stations in Room 111. Wet chemistry operations similar to those accomplished in the high activity SCBs, with appropriate fixtures, tools and equipment, are accomplished at these stations. Specifically, these stations are used for processing, purification, and packaging of individual isotopes and for processes not involving significant quantities of noble gases or halogens. The shielding around these stations provides appropriate attenuation for the inventory that will be present. (Mitchell, 1999, pp. 14-18)

Processing of many isotopes will use materials and equipment similar to that already described, for which hazards can be readily characterized using chemical flow sheets. The principal hazard associated with the HCF results from having highly radioactive materials in liquid and gaseous form, as well as significant quantities of solid radioactive waste. These materials produce both a direct radiation hazard and a potential contamination hazard. The type and quantity of radionuclides that will be located in the HCF are based on maximum anticipated processing rates of thirty irradiated targets per week. The total fission product activity of an irradiated production target will vary from a few thousand to approximately 18,000 curies at the time of processing.

Process materials are brought into each SCB through a hatch in the floor of the SCB, using one of three under-box conveyor systems. The conveyor systems can move irradiated materials as well as other process materials from the entry point at the south end of the Zone 2A canyon to each of the SCB's. There are three conveyor systems that service the SCB's. Redundant conveyors "A" and "B" are used to move materials to and between SCB's 1 through 5, and conveyor "C" is used to move materials to and between SCB's 6 through 11. The conveyor consists of a stainless steel transfer container suspended from trolleys that ride along Unistrut channels within enclosed rectangular ducts. The container is magnetically coupled to a chain drive system that is used to control the movement of material.

The eleven SCBs in which processing operations are accomplished are exhausted to the ventilation system to provide control of contamination within the facility. The ventilation system, which provides this important function, is described in Section 2.6.2. SCB local control panels (LCPs) are located at each process station, and indicate SCB pressure differential and flow rate. Operators can manually adjust the flow rate of air through the SCB. Red and green lights on the panel provide indications when either differential pressure or flow rate is outside predetermined limits. Normal operating parameters are described in Section 2.6.

Each SCB incorporates a water washdown system to periodically clean inner SCB surfaces that become contaminated. This is accomplished to maintain the working environment as clean as possible to maintain product purity. The system consists of a supply manifold located in Room 114, water supply piping inside of the Zone 2A canyon, nozzles on the top of each SCB, and a drain system that will allow injected water to drain out of the SCB into a collection tank. The system is not permanently connected to a water supply and would only be activated when all process materials, including radioactive targets, have been removed from the SCB which is to be cleaned. To effect cleaning of the SCB, a pressurized water filled container is connected to the system each time a cleaning operation is desired. The supply of water to a specific SCB is controlled by valves in the supply header.

2.5.2 Irradiated Target and Process Material Transfer Operations

Process materials, including irradiated targets and process kits, are normally brought into the processing canyon through the STB (Figure 2.5-2) at Station 7. At this station, process materials and targets are removed from an engineered transfer system, the target entrance system (TES), through an opening in the bottom of the STB using remote manipulators. After removing the materials, closing the transfer system opening, and removing one of three north-south conveyor system covers, materials are placed into the conveyor to be moved to the appropriate processing station. Only simple material transfers (i.e., no chemical processing) are permitted at this station in order to keep the STB environment as clean as possible. This is necessary so as not to contaminate containers or other materials being returned to Zone 2. The STB is not connected directly to the active ventilation system, however, appropriate pressure differentials are maintained during material transfers by closures on each opening in the STB. No two closures would be simultaneously opened, so the STB will equilibrate with whichever volume it is open to. This maintains an exchange of air from Zone 2 to Zone 2A each time the transfer system is operated.

Transfers of irradiated targets requires removal of the target from a shielded cask (Figure 2.5-3) which is translated through the shielding wall using the TES (Figure 2.5-4) housed in the east shield wall at the south end of the Zone 2A canyon. This system is designed to translate the 5000 pound target transfer cask from Zone 2 into the STB so that the target can be removed for processing. The system contains external shielding to attenuate radiation from materials inside the canyon. A shield cover is designed to remove the cask shield lid so that the cask and target can be translated after the lid is removed. A mechanical interlock (a metal pin) is physically pushed by the shield cask lid when it is removed from the cask. This pin extends into the shielding wall to prevent the removal of the cover with the cask lid removed, thus assuring that irradiated targets will always be shielded.

Alternatively, irradiated targets can be brought into the Zone 2A canyon in a shielded cask through the airlock at the north end of the canyon. The target would be removed from the cask once it is positioned in the shielded area of the canyon. Appropriate cask and target handling equipment will be required to effect this alternative entry.

2.5.3 Radioactive Material Transfer Operations

Material removal systems, identified as Product Exit Systems (PES) and depicted in Figure 2.5-5, exist at processing stations 9 and 12. These systems will be used to remove QC samples and isotope products from the processing areas in Zone 1. Appropriate shielded containers will be used to attenuate radiation emanating from materials removed using this system. In the case of isotope product, this shielding is in the form of the inner shield of the appropriate DOT container being used to ship the product. The PES has been designed to translate the container from Zone 2 into position under an opening in the floor of the process SCB, and then to raise the container up into the process station. A gliding rail system is used to translate the container out into Zone 2 when material is being removed, so that the container is accessible for transfer to a portable dolly. The system is designed to attenuate radiation emanating from materials inside the Zone 2A canyon to reduce operator radiation exposure. This is accomplished with a depleted uranium "shutter" and a shield block which are integrated into the transfer system. An interlock exists such that the external shield doors must be closed to open the shutter, and they cannot be opened if the shutter is open. This PLC interlock, actuated by appropriate limit switches on the moving components, captures the external shield doors with an electromagnetic latch.

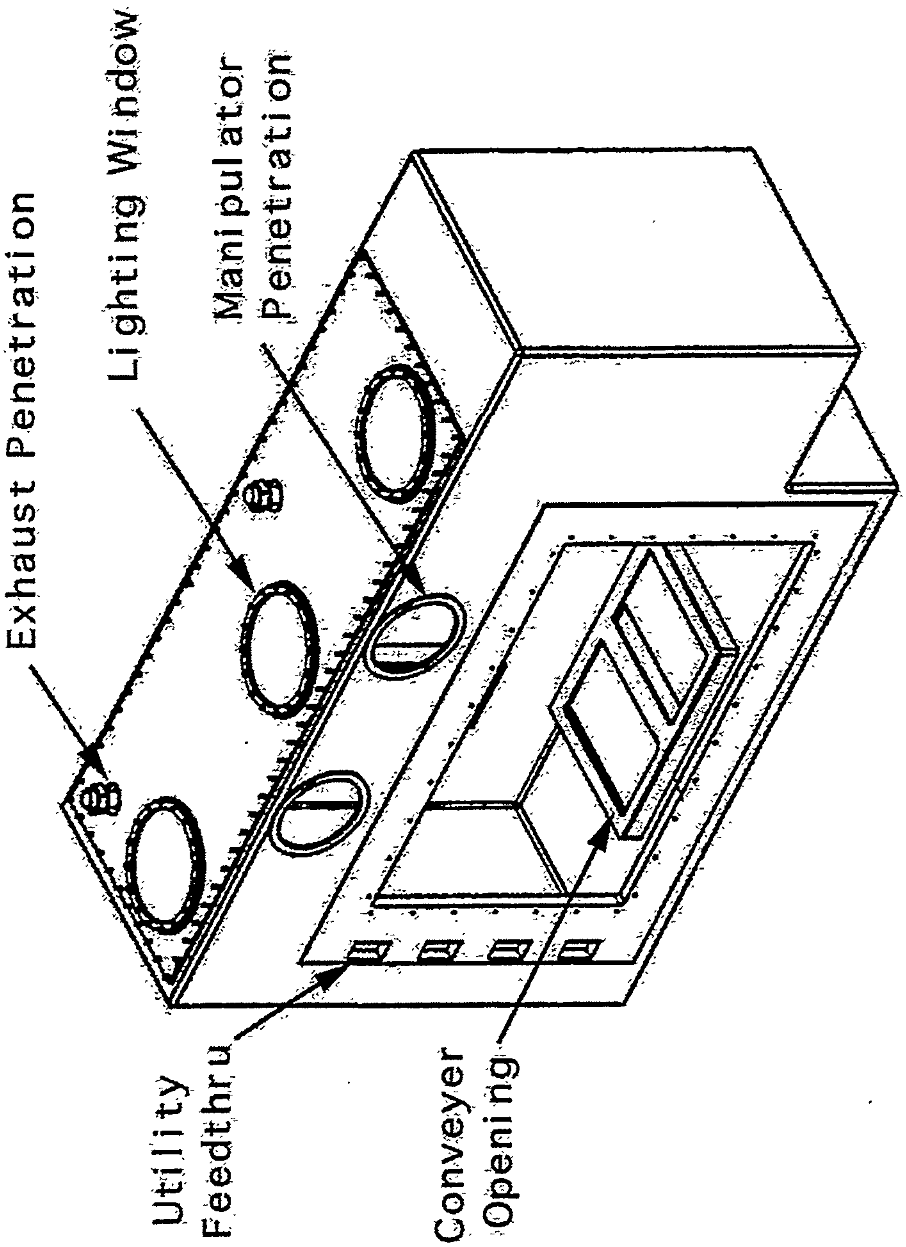


Figure 2.5-2 Steel Transfer Box

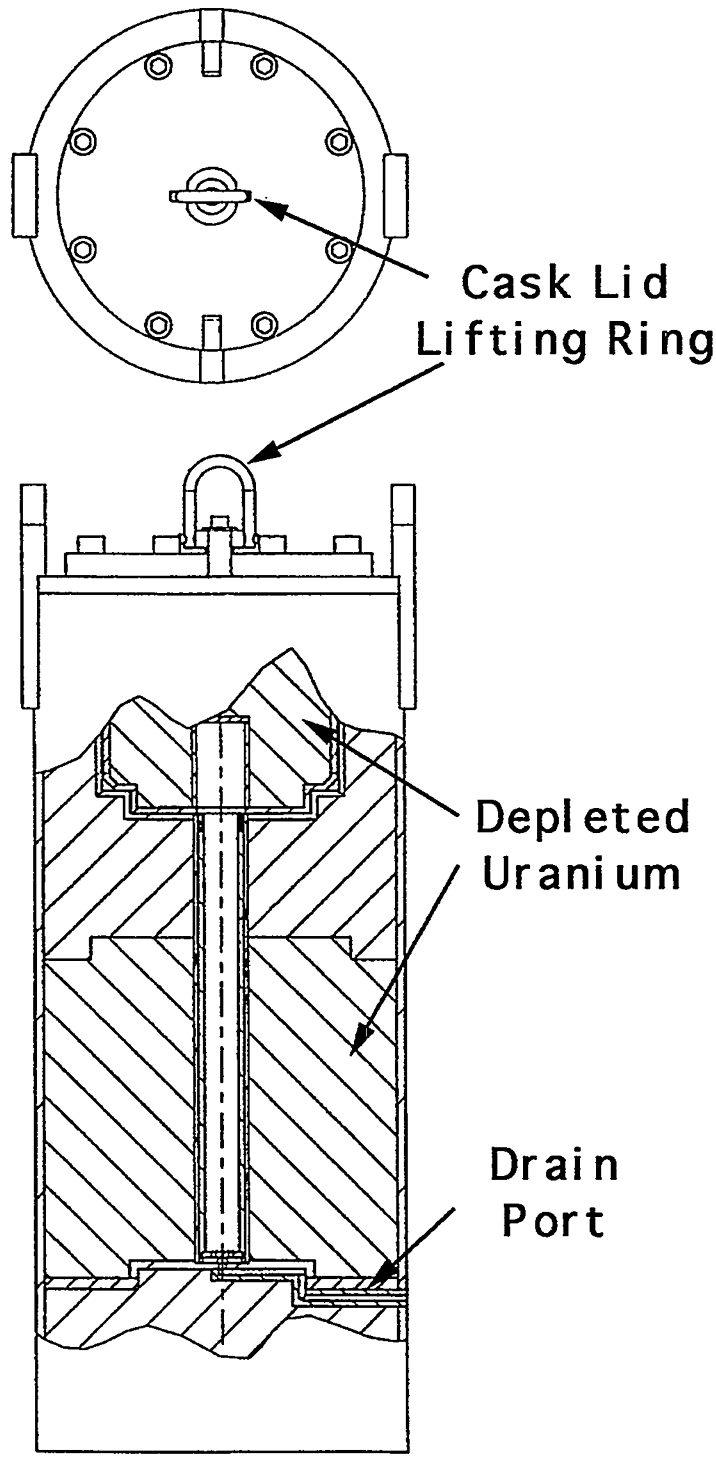


Figure 2.5-3 Target Transfer Cask

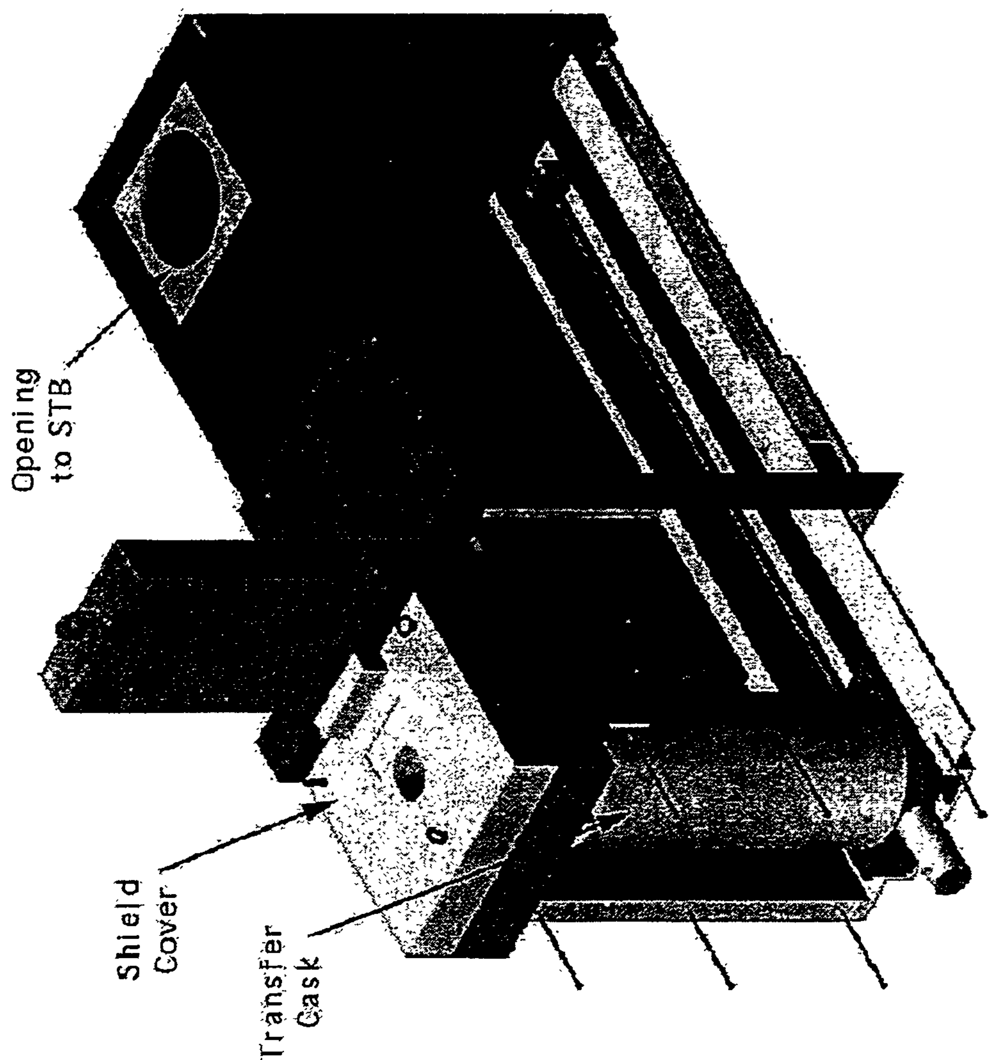


Figure 2.5-4 Target Entrance System

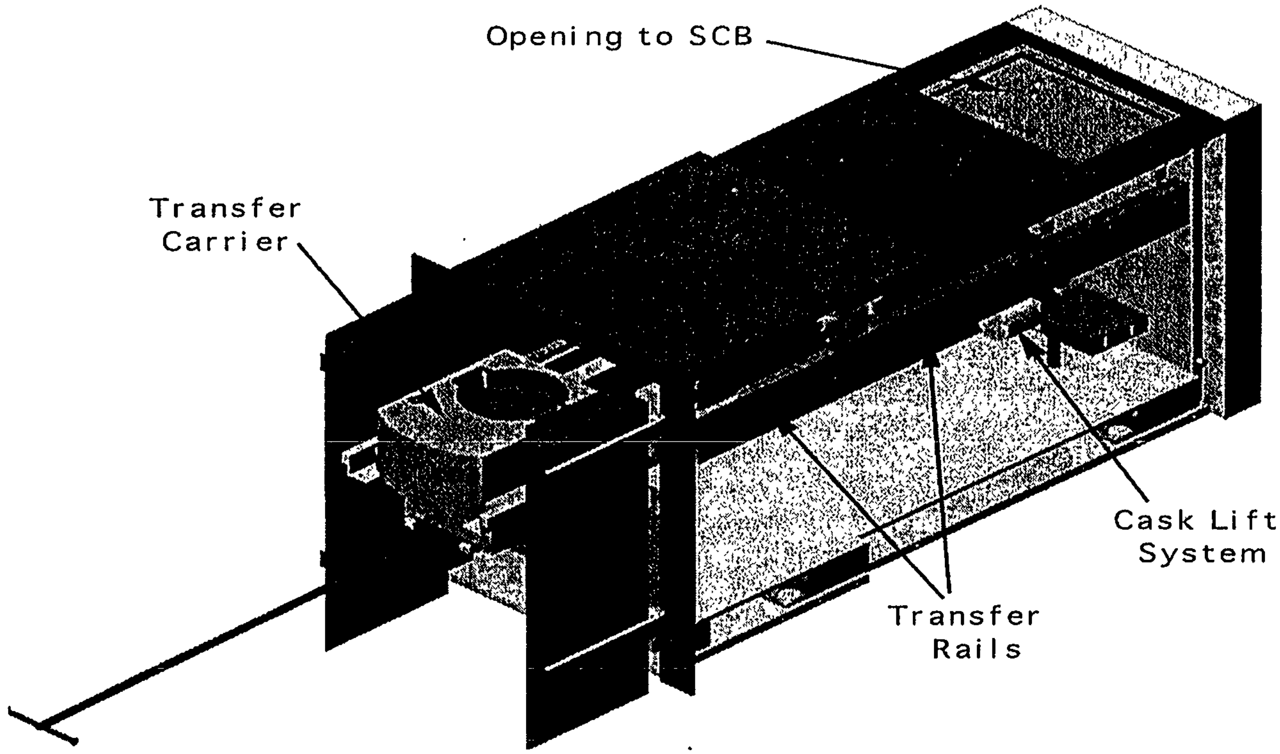


Figure 2.5-5 Product Exit System

2.5.4 Process Waste Handling & Storage

Process waste operations include the initial solidification of the liquid process residuals, packaging the solidified waste and other solid process residuals in waste barrels, loading of waste barrels on storage carts, and emplacement of waste barrels in shielded interim storage in Room 109. A complete description of the types and expected quantities of waste that will be generated in the HCF is contained in Chapter 9, Radioactive and Hazardous Waste Management.

2.5.4.1 Waste Generation and Packaging

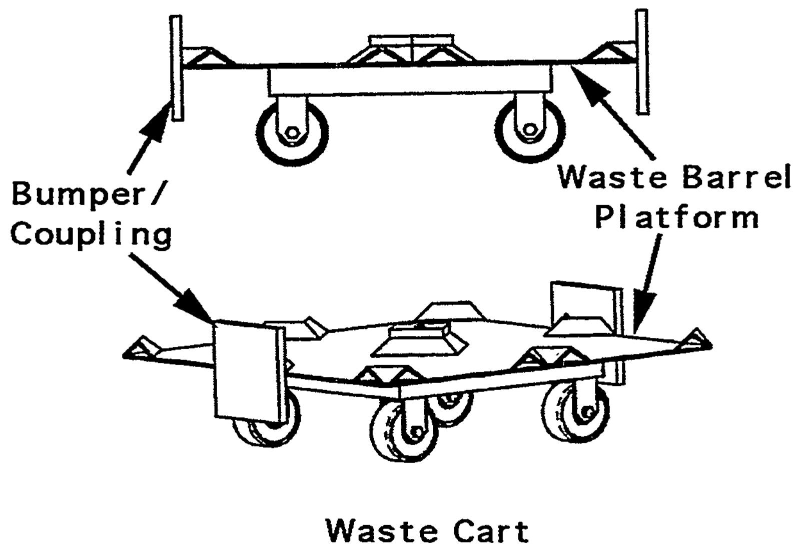
Liquid process residuals that contain the residual fission product and uranium inventory are solidified as part of the isotope extraction process by mixing the liquid with a solidification agent in a stainless steel container. This solidification is accomplished at each isotope extraction station (Stations 3 through 6). After solidification, the waste container as well as other solid process residuals (glassware, syringes, etc), are removed from the SCB and transferred to the waste packaging station (SCB1) using either conveyor "A" or "B". In SCB1, the waste materials will be placed in a waste barrel that has been mated to the SCB. Empty barrels are mated to SCB1 when required and remain attached to SCB1 during filling to mitigate the migration of contaminants. Once filled, the barrels are removed and a vented cover is installed. The filled barrels will normally be placed in a 36-inch diameter, 17-foot deep cylindrical well in the floor of the Zone 2A canyon (identified as the "elevator pit") to mitigate both operator and equipment radiation exposure, until sufficient barrels have been accumulated for movement into Room 109. Each barrel may contain the process waste from up to 12 processed targets, with a total inventory of up to 100,000 curies when initially filled. The fission product inventory in waste barrels will decay to about 35,000 curies within one week, to 18,000 curies within two weeks, and to about 1000 curies within 6 months.

An elevator platform in the pit is raised and lowered using a hydraulic ram. The elevator hydraulic system includes a tank and a pump located in the MER, and hydraulic system controls located in Room 111. Hydraulic fluid piping, which descends through the ceiling in Room 112 and then penetrates the Zone 2A canyon wall, connects the hydraulic tank and pump to the elevator. There are no valves in the hydraulic-fluid line. A single line is used in this system; that is, hydraulic fluid is supplied to the elevator and returned to the storage tank through the same piping.

2.5.4.2 Waste Barrel Handling Operations

Normally, when 4 barrels have been accumulated in the elevator pit, they are all removed from the pit and placed on a waste cart for movement into Room 109. This operation will require lowering of the east shield door (Door 3A) of Room 109. Five shielded stations (14, 15, 16, 17, and 18) in the east shield wall at the north end of the Zone 2A canyon, and one station (1) in the west shield wall, each with remote manipulators, are provided for handling barrels of process waste. Manipulator and crane operations are used to handle empty barrels, move filled barrels into the elevator pit for temporary storage and to place filled barrels on carts for emplacement in Room 109. An electromagnet is used to lift barrels using the crane.

Waste carts shown in Figure 2.5-6, used to move the waste into Room 109, hold either 4 or 8 barrels, stacked two high on platforms designed to accommodate the barrels. A drive "mule" is used to push the cart along recessed tracks in the floor into Room 109 or to retrieve the cart



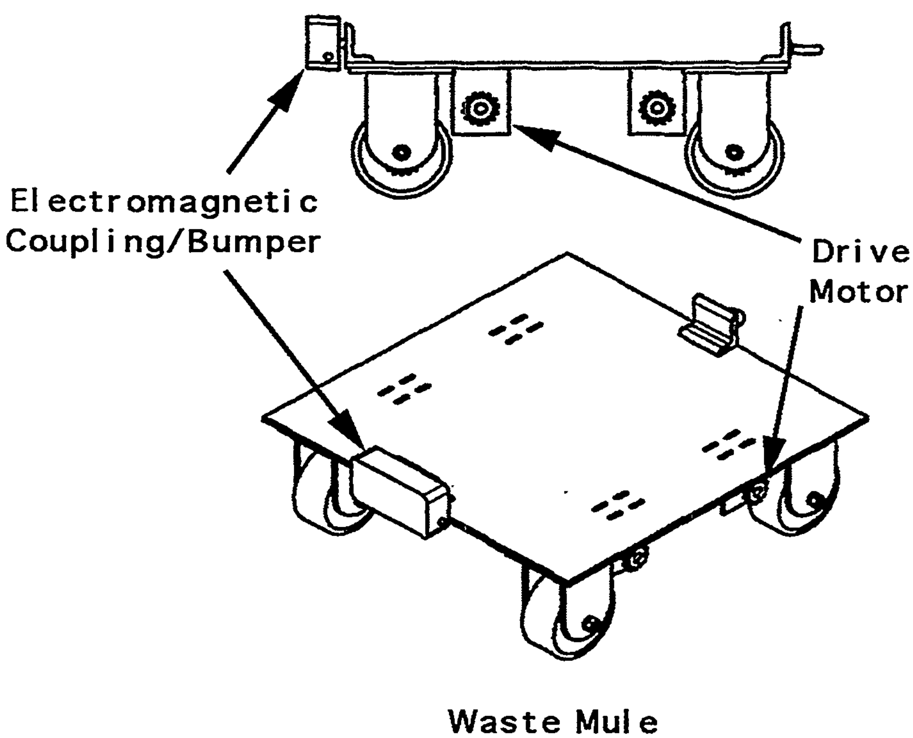


Figure 2.5-6 Waste Cart and Waste Mule

from 109 to place additional barrels on the cart. The barrel configuration in Room 109 is depicted in Figure 2.5-7. If filled at maximum rates of processing, the accumulated 180 waste barrels of decayed radioactive waste in the Room 109 waste storage area will contain fission product activity of approximately 500,000 curies.

Storage in Room 109 allows for significant decay of fission products prior to off-site shipment, which significantly reduces the hazard associated with such shipment. No capability currently exists to remove high activity waste from Room 109 for the purpose of off-site shipment. This capability is anticipated in the future and will be described and incorporated into this SAR at that time.

2.5.4.3 Moveable Shield Door Operations

The hydraulically actuated shield doors for Room 109 provide shielding for the high activity waste when they are in the up position. When required, the doors are lowered to place waste into the room. These waste handling operations will result in significant radiation areas in the north portion of Room 112, so appropriate procedures and radiological protection support will be required to effect these operations. The doors are moved by operation of the hydraulic system, which is used to raise and lower the doors. This system is operated from a control panel at the north end of Room 107. Each of the shield doors, which weigh from 157,000 to 471,000 pounds, rest on four spring-loaded latches when in the up position. These latches allow the hydraulic system to be depressurized when not required for door operation, and preclude lowering the shield doors if the hydraulic system is not pressurized. Operation of the hydraulic system is required to raise the door slightly in order to disengage the latches and subsequently lower the door.

In addition to the hydraulic cylinders, the shield-door hydraulic system includes a 300-gallon hydraulic fluid tank, an electric pump, associated piping, valves and filters. All of these system components are installed in B6581. Figure 2.5-8 is a schematic of the shield door hydraulic system. Emanating from the piping manifold/valve panel located in B6581, Room 222, are six sets of lines that connect the hydraulic-fluid supply to each shield-door jack and each set of shield-door latches, respectively. When a door is to be closed (raised), hydraulic fluid is supplied (via the electric pump) through the piping manifold/valve panel to the appropriate hydraulic jack and door latches. When a door is to be opened (lowered), the weight of the door forces the hydraulic fluid back through the supply lines, into the piping manifold/valve panel, and finally back to the storage tank through separate return lines.

2.5.5 Process Vacuum System

A process vacuum system is installed in the HCF to draw off gases evolved during chemical processing and to evacuate containers used in isotope extraction processes. These gaseous effluents will contain radioactive isotopes, including noble gases and iodine. Therefore, appropriate measures must be implemented to retain these elements and prevent unmitigated release to the environment. It is also important to prevent accumulation of radioisotopes in potentially occupied areas of the HCF. The process vacuum system used to accomplish these functions, shown in Figure 2.5-9, has constituent elements distributed throughout the facility, and consists of dual vacuum pumps located in the MER, a vacuum tank, associated piping, in-box filters, a cryogenic cold trap in the Zone 2A canyon, and a liquid nitrogen (LN) supply system for the cold trap. The process vacuum from SCBs 1 through 5 are routed through a cold trap to retain noble gases and to trap iodine and other volatile elements which are not retained by the in-box filters. The effluent from SCBs 6 through 11, since significant quantities

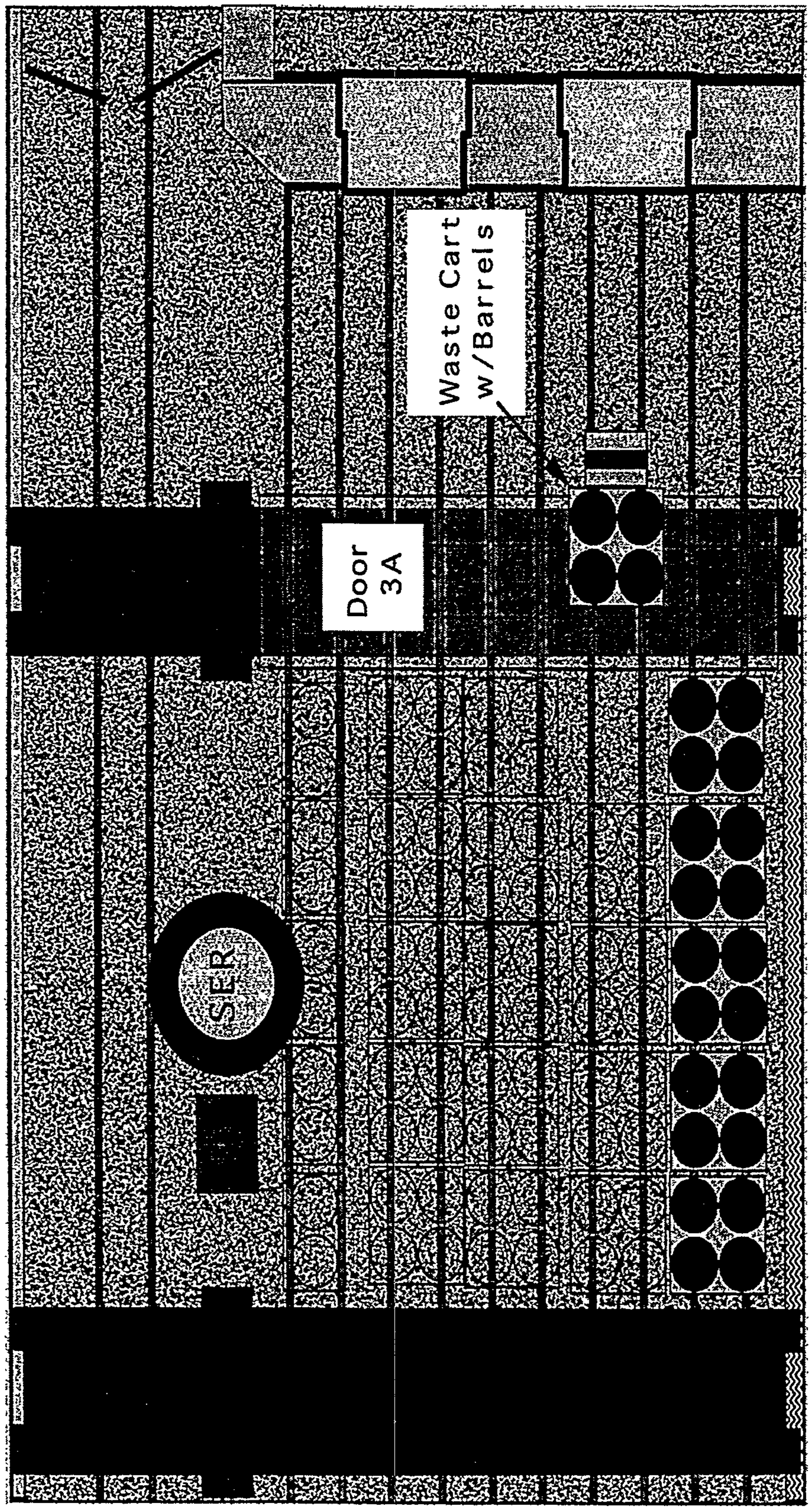


Figure 2.5-7 Waste Storage Configuration, Room 109

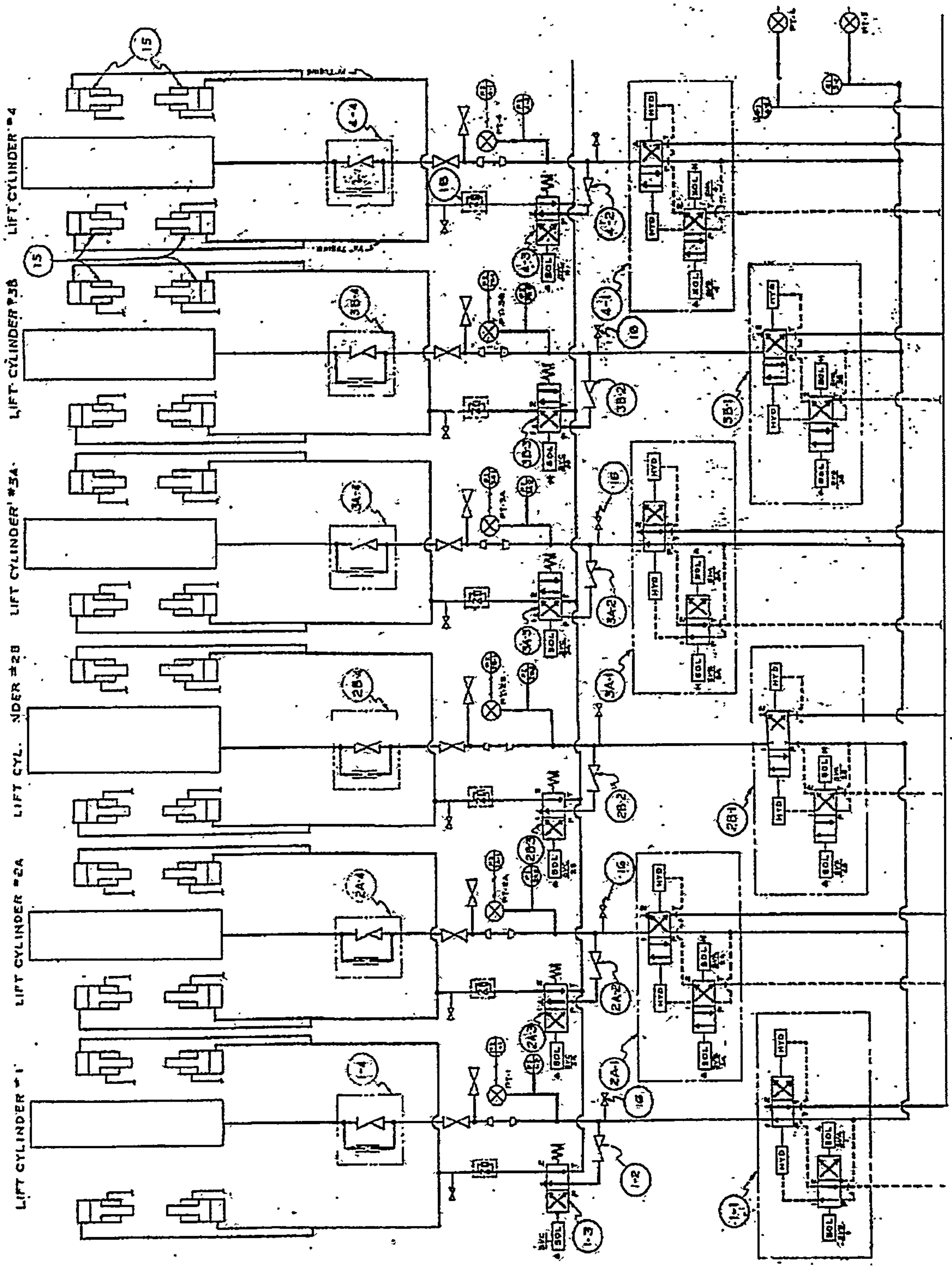


Figure 2.5-8 Shield Door Hydraulic System

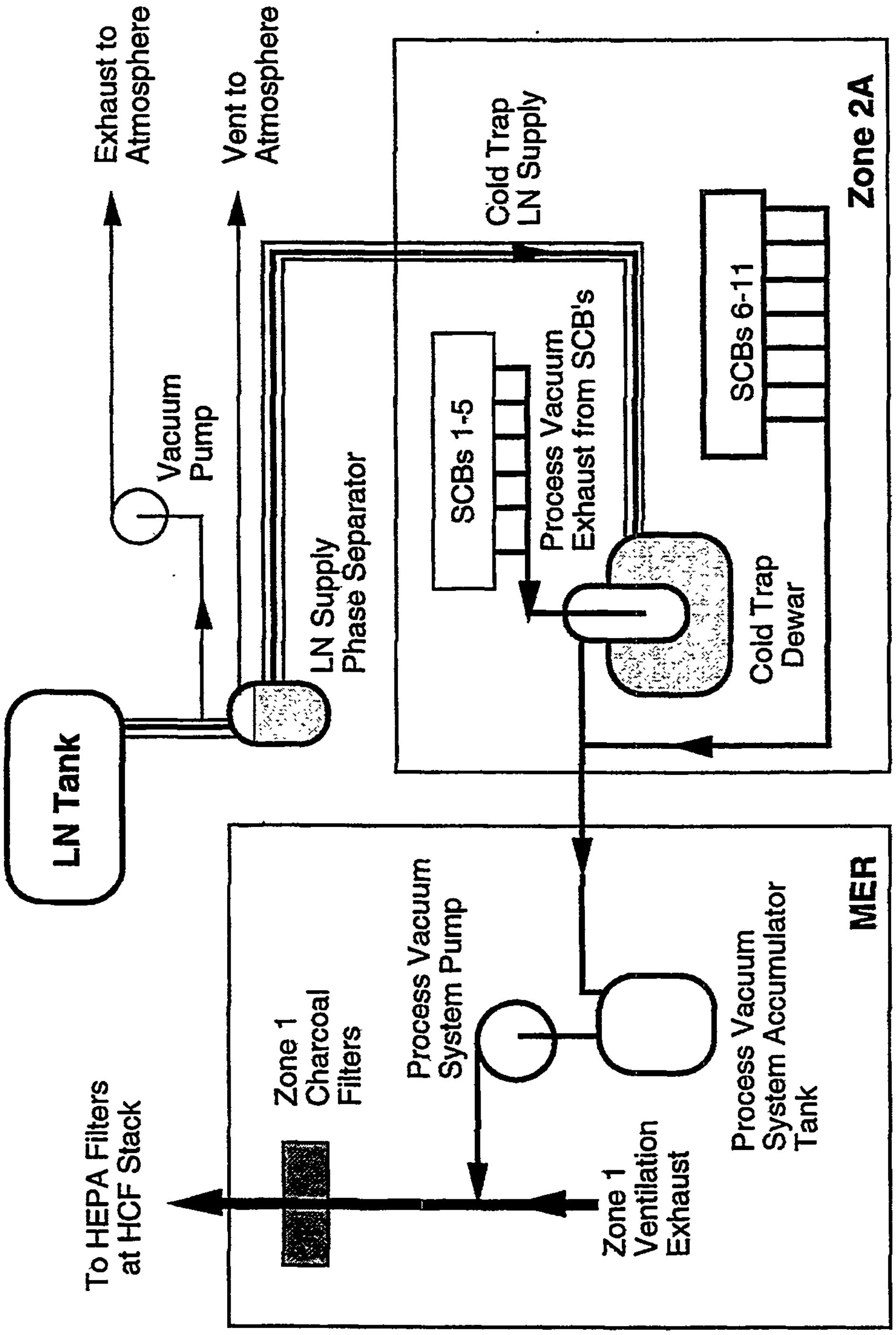


Figure 2.5-9 Process Vacuum and Liquid Nitrogen Systems

of noble gases or halogens will not be evolved at these stations, bypass the cold trap to minimize condensate buildup in the trap. Valves in the system allow separate evacuation of SCBs 1 through 5 from SCBs 6 through 11, and also allow remote selection and/or isolation of the in-service cold trap.

2.5.5.1 Process Vacuum Supply

Redundant 28 cfm vacuum pumps located in the Zone 1 filter room of the MER, shown in Figure 2.5-10, evacuate a 80-gallon (10.7-cubic feet) tank to supply system vacuum. The pumps are configured to automatically start to maintain system vacuum at a prescribed level. The exhaust from the pumps is routed into the Zone 1 exhaust upstream of the Zone 1 charcoal filters. Two-inch welded stainless steel piping is routed from the vacuum tank in the MER through the overhead in Rooms 112 and 111 into the Zone 2A canyon. In the canyon, the vacuum line is routed to a cold trap that will condense radioactive effluents that are drawn into the vacuum system. Two-inch welded stainless steel tubing is used to route process vacuum to each SCB. While the pumps themselves are not identified as important to safety, the routing of the pump exhaust to the Zone 1 exhaust is so identified, because it assures appropriate filtration of the effluent in the event that hazardous constituents are drawn into the system.

2.5.5.2 In-Box Filters

In each SCB a multi-stage filter will be installed on the process vacuum line. The filter will be configured appropriately for specific process operations. For Mo-99 processing, the filter will consist of an iodine pre-filter, a moisture trap, followed by a charcoal filter. The effluent from the process vacuum is exhausted to the ventilation system, which contains appropriate filters to mitigate releases.

2.5.5.3 Cold Traps and Liquid Nitrogen Supply

A cryogenic cold trap, located in the Zone 2A canyon near SCB1, is incorporated in the process vacuum system to retain radioactive noble gases liberated during processing operations and to capture radioisotopes which are not captured by the in-box filters. Redundant traps and appropriate valving are provided so that a backup trap can be placed in service in the event that capture efficiency of a trap is degraded or fails. Additionally, redundancy exists so that the traps can be isolated periodically to allow the radiological inventory to decay and eventually be vented into the ventilation system.

LN is supplied to the cold trap from an above grade tank located east of B6580. The LN is routed through vacuum-jacketed piping to a phase separator shown in Figure 2.5-11, located above window 3 in Room 107. From the phase separator, which steps down the supply pressure of 100 psi gauge (psig) to one atmosphere, vacuum jacketed supply lines penetrate the west shield wall of the Zone 2A canyon and are routed to the cold trap. The vacuum for the LN supply piping from the LN tank to the phase separator is provided by a pump located Room 212 (SER high-bay). The exhaust from this pump is vented to the atmosphere. The static vacuum jacket between the phase separator and the cold trap is not evacuated through the vacuum pump.

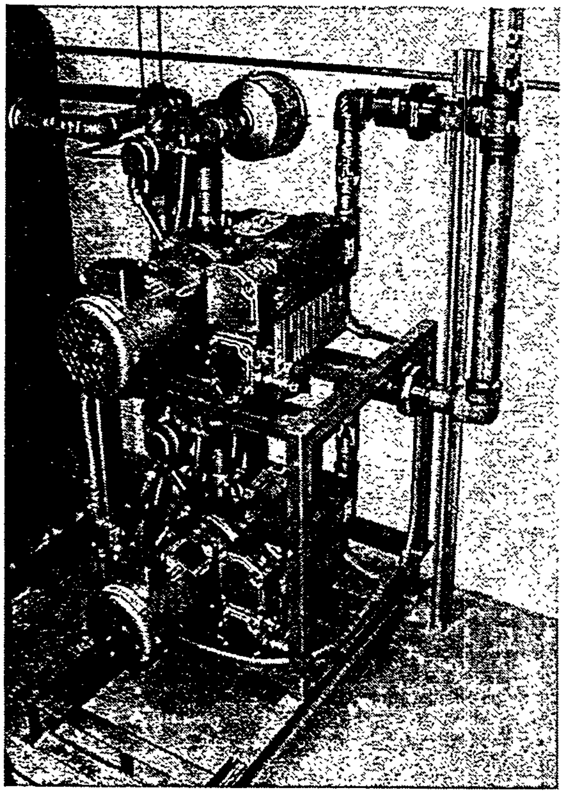


Figure 2.5-10 Process Vacuum Pumps

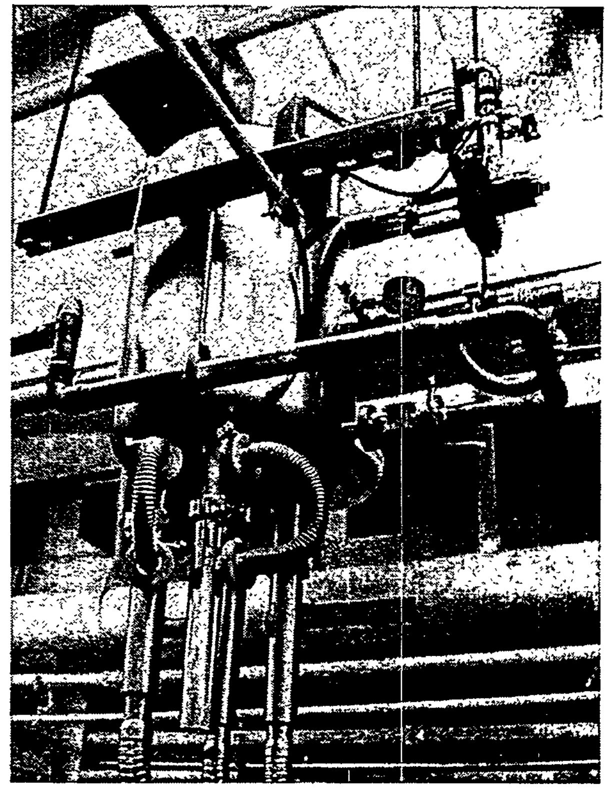


Figure 2.5-11 LN Phase Separator

2.5.6 Operations in Hoods and Gloveboxes

Hoods and shielded gloveboxes are used in Rooms 113 and 113A to accomplish isotope production quality control that consists of simple chemical processing steps and other light laboratory operations with limited quantities of radioactive materials. The shielded glovebox is exhausted through HEPA filters by fans 15 or 16, while the hoods are exhausted through a HEPA filter by fan 17.

Chemicals used in the quality control analyses in the shielded glove box (SGB) and ventilation hoods of the Quality Control Laboratory involve small (less than a liter) quantities of some acidic and basic chemicals, including ammonium thiocyanate, stannous chloride, sulfuric, nitric, and hydrochloric acids, ferric sulfate, carrier solutions, ethyl acetate, sodium nitrite, chloroform, sodium hydroxide, and potassium iodide. Material Safety Data Sheets for any processes implemented in the HCF are reviewed in accordance with the SNL ES&H Manual to identify any carcinogens or other hazardous materials. Operations in the SGB for preparation of various Mo-99 product dilution samples would require a small bulk supply of sodium hydroxide (0.1N NaOH). Quality control analysis sample preparation operations require small bulk supplies of the above chemicals. Workers performing quality control analysis use chemical handling procedures as required by the Sandia ES&H Manual.

2.5.7 Support activities in Zone 2 and Zone 3

Activities, exclusive of processing operations, in occupied areas of the HCF, identified as Zone 2 and Zone 3, include process material handling, product packaging, manipulator maintenance, and material storage, including storage of isotope targets. Small quantities of radioactive materials, including targets containing ^{235}U and residual materials resulting from the quality control process, may be stored at various locations in the HCF. When these activities involve the handling of radioactive and/or contaminated materials, the activity will be conducted in accordance with prescribed radiological practices and approved technical work documents generated in accordance with SNL's ES&H manual.

2.5.8 Radioactive Material Storage

The capability to store radioactive materials exists at several locations in TAV, including the monorail storage holes, B6596, and B6597.

2.5.8.1 Monorail storage holes

The twelve monorail storage holes are below grade cylindrical cavities located east of B6580 and between B6581 and B6580B (MER), and oriented east to west. Ten 10-inch diameter storage holes are 21 feet deep, and two 24-inch diameter holes are 30 feet deep. Each hole is equipped with an environmental cover to exclude rainwater from the holes. An overhead monorail crane services the storage holes and truck loading pad. The crane is controlled from a pendant attached to the trolley. There is sufficient cable to allow the operator to be as much as 45 feet from the cask. Power for the crane comes from a locked junction box near the monorail. All power can be locked out when the crane is not in operation.

2.5.8.2 Building 6596

B6596 is used for the temporary storage of radioactive material and equipment. There are *no daily operational activities conducted within this building. The east wing of the building* and the chapel are used for the storage of HCF radioactive material, including solid radioactive waste, irradiated experiments and ACRR components, under the ownership of the Hot Cell Facility Department. Other users store radioactive material in the B6596 High Bay. The total allowable radionuclide inventory in B6596 will be maintained below the Hazard Category 2 inventory thresholds as given in DOE-STD-1027-92, and will be administratively controlled. Waste containers are inspected prior to being accepted for storage. Containers that are damaged or suspect are rejected. Incoming waste is checked against accompanying documentation for accuracy and completeness.

2.5.8.3 Building 6597

The B6597 high-bay is used for the temporary storage of radioactive material, shipping containers (containing depleted uranium shields and contaminated or potentially contaminated inner containers), some low level waste, and equipment. The building is also used to perform maintenance activities associated with the hot cell facility. The Auxiliary Hot Cell Facility (AHCF), a Category 3 nuclear facility, also conducts operations in this building.

2.6 Confinement Systems

Portions of the HCF structure, along with the steel confinement boxes (SCBs), gloveboxes, fume hoods, and the ventilation systems perform confinement functions. These confinement systems provide defense in depth by ensuring that hazardous materials are retained in specific designated areas within the HCF. They accomplish this function by maintaining an air pressure differential hierarchy from regions of greater contamination to those of lesser contamination within the facility. These differentials are described later in this section. This pressure differential controls the movement of contamination by diffusion and by adverse airflows. The identified contamination zones in the HCF are as follows:

- Zone 1 - Normally contaminated area; Process boxes and associated ventilation ducting
- Zone 2A - Potentially contaminated but normally a minimally contaminated area
- Zone 2 - Normally uncontaminated and occupied area; includes Rooms 107, and Rooms 111 through 114.
- Zone 3 - Normal building and outside environment

Additionally, to limit the buildup of contamination in the above designated areas, airflow is established to continually remove airborne contaminants. Airflows in the system are established at prescribed flowrates such that they are adequately filtered prior to being discharged to the environment. All air drawn from Zone 1 is exhausted through charcoal and HEPA filters to remove halogens and particulate contaminants from the exhaust air prior to release to the atmosphere. These ventilation filter systems are equipped with test ports and are periodically checked for operating efficiency. In addition to the ventilation system filters, in-box filters are used to reduce the levels of airborne contaminants that are drawn into the Zone 1 ducting.

Air from Zone 2A is drawn from a vent located north of the SCB's through charcoal and HEPA filters. In addition, a remotely maintainable HEPA filter is provided at the inlet to reduce buildup of contaminants in the ducting. Air is drawn from Zone 2 at the north end of Room 112 and is exhausted through one HEPA filter at the HCF stack.

Motor-control circuits have been designed to provide sequential startup of the main HCF ventilation fans in a manner that ensures that the zone differential pressure hierarchy is maintained. Interlocks are employed to shut down the necessary fans to avoid adverse pressure differentials in the event of fan failures.

2.6.1 Steel Confinement Boxes (SCBs)

Two basic types of confinement boxes are provided in the Zone 2A canyon. High activity extraction processing SCB's, shown in Figure 2.6-1, located along the west side of the canyon, are nominally 8 feet wide, 5 feet deep and 7.5 feet high. Low activity SCB's, depicted in Figure 2.6-2 and located along the east side of the canyon, are 5 feet wide, 3.5 feet deep and 5.5 feet high. The waste packaging station (SCB 1) is similar to the extraction SCB except that it has a 14-inch by 50-inch extension on the left side of the box to accommodate attachment of a waste barrel. Each SCB is constructed of 3/16-inch thick stainless steel to provide resistance to attack by acids used in isotope separation processes.

Each process SCB has a one inch thick cerium oxide glass window to permit viewing into the box, and three cerium oxide glass windows in the top of the box to facilitate illumination using any of three external lights. Replaceable utility plugs penetrate the front surface of each box. The plugs are designed to be readily replaceable from the cold side and can be configured to provide any desired utility. The boxes are mounted on a steel decking within the Zone 2A canyon which provides a support surface to position the SCB at the proper elevation relative to the shielding window's. A. covered hatch internal to each SCB provides access to material conveyor systems and an in-box crane is installed to effect removals from the system. Additionally, box-to-box transfers can be accomplished using airlocks between boxes.

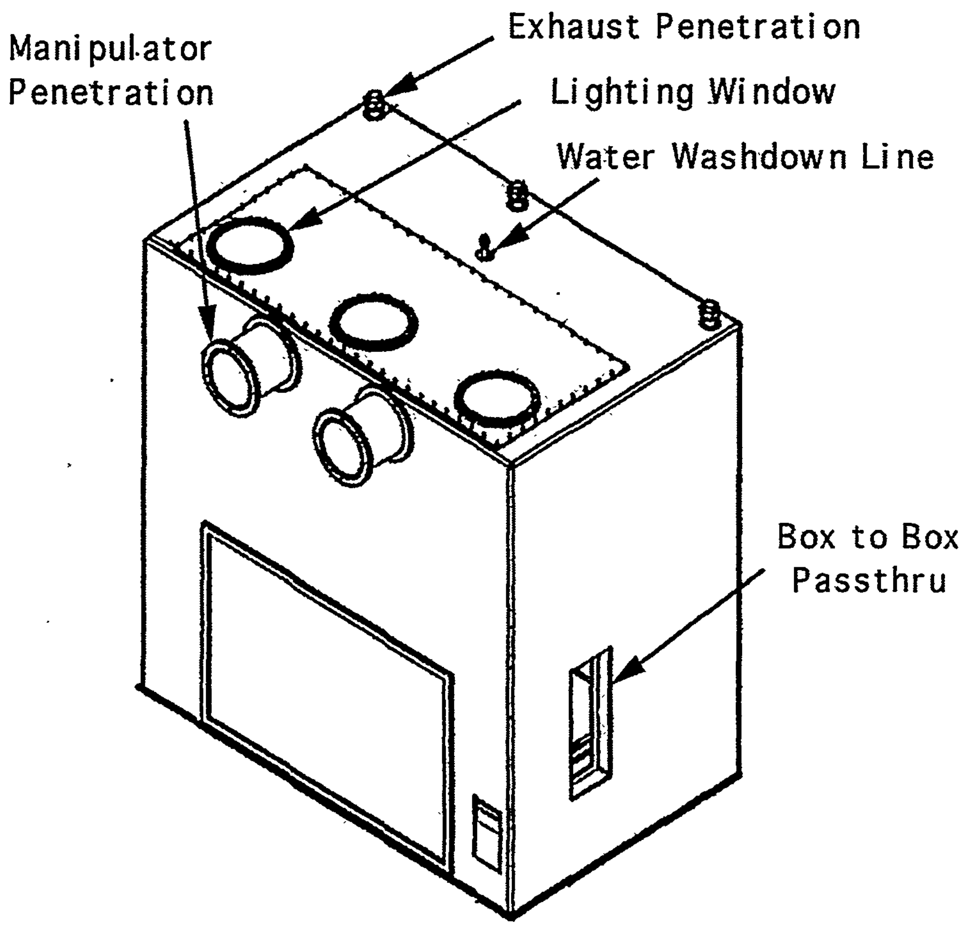


Figure 2.6-1 Extraction Process SCB

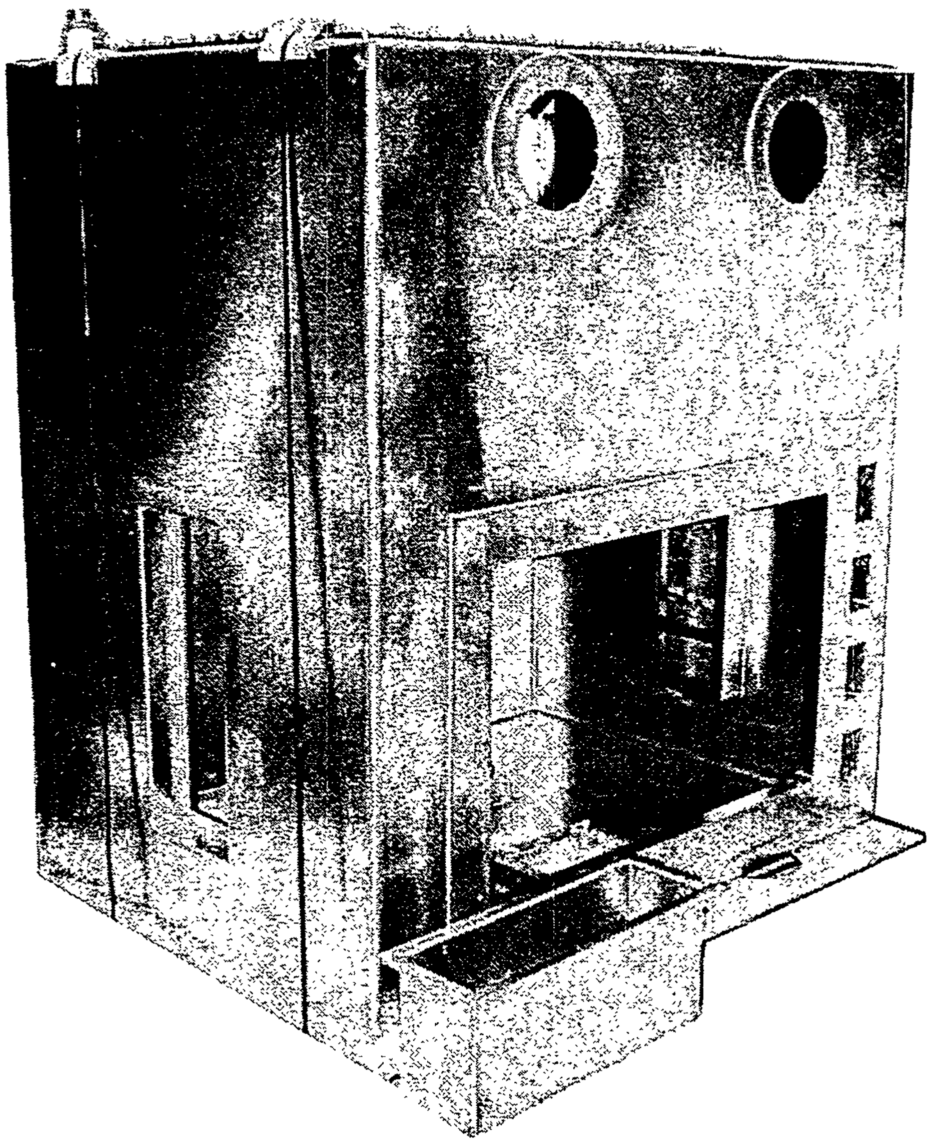


Figure 2.6-2 Low Activity SCB

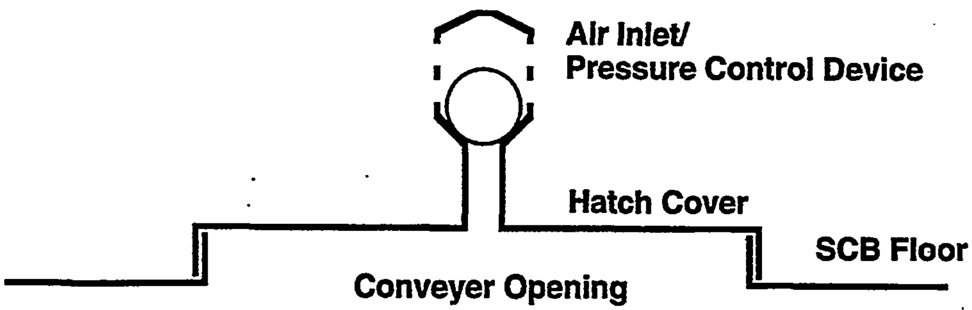


Figure 2.6-3 Hatch Cover

Airborne leakage from Zone 1 to Zone 2A is prevented by maintaining a nominal negative pressure differential of 0.25 in. water gauge (WG) between the two zones. Air is drawn into the SCB through an engineered opening in the conveyer hatch cover, which maintains the pressure differential between the two volumes. The pressure control feature, shown in Figure 2.6-3, uses a simple ball check valve that opens at a differential pressure of 0.25 in. WG, allowing air to flow from the conveyor duct into the SCB, and it closes if the differential pressure falls below this value. Air is drawn into the conveyor duct from Zone 2A through filters located at the north end of each duct. Manipulator penetrations also provide potential leakage paths between Zone 1 and Zone 2. Normally, boots on each manipulator arm form the physical barrier between the two zones to maintain the appropriate pressure differential. Alternatively, plugs will be installed in manipulator ports if necessary for shielding or contamination control when manipulators are removed for maintenance.

2.6.2 Ventilation Systems

The ventilation system is designed to exhaust air from contaminated areas through appropriate filters prior to discharging the air to the environment through the HCF stack. The system is also designed to maintain appropriate zone-to-zone pressure differentials to control the migration of contamination in the facility. An overall schematic of the ventilation system is shown in Figure 2.6-4. There are 5 basic elements or "legs" of the overall system: Zone 1 exhaust, Zone 2A exhaust, Zone 2 exhaust, hood exhaust and glovebox exhaust. Each of these legs, with the exception of Zone 1 exhaust, has a specified nominal flow rate which the system will automatically attempt to maintain. The flowrates from Zone 1 and 2A are important due to the desire to maximize the capture of radioiodine on ventilation system charcoal filters. Excessive flowrate is undesirable for this reason, and the intentional lowering of system flowrates would be desirable in some scenarios. Desired pressure differentials are maintained by controlling the rate of air inflow into each zone.

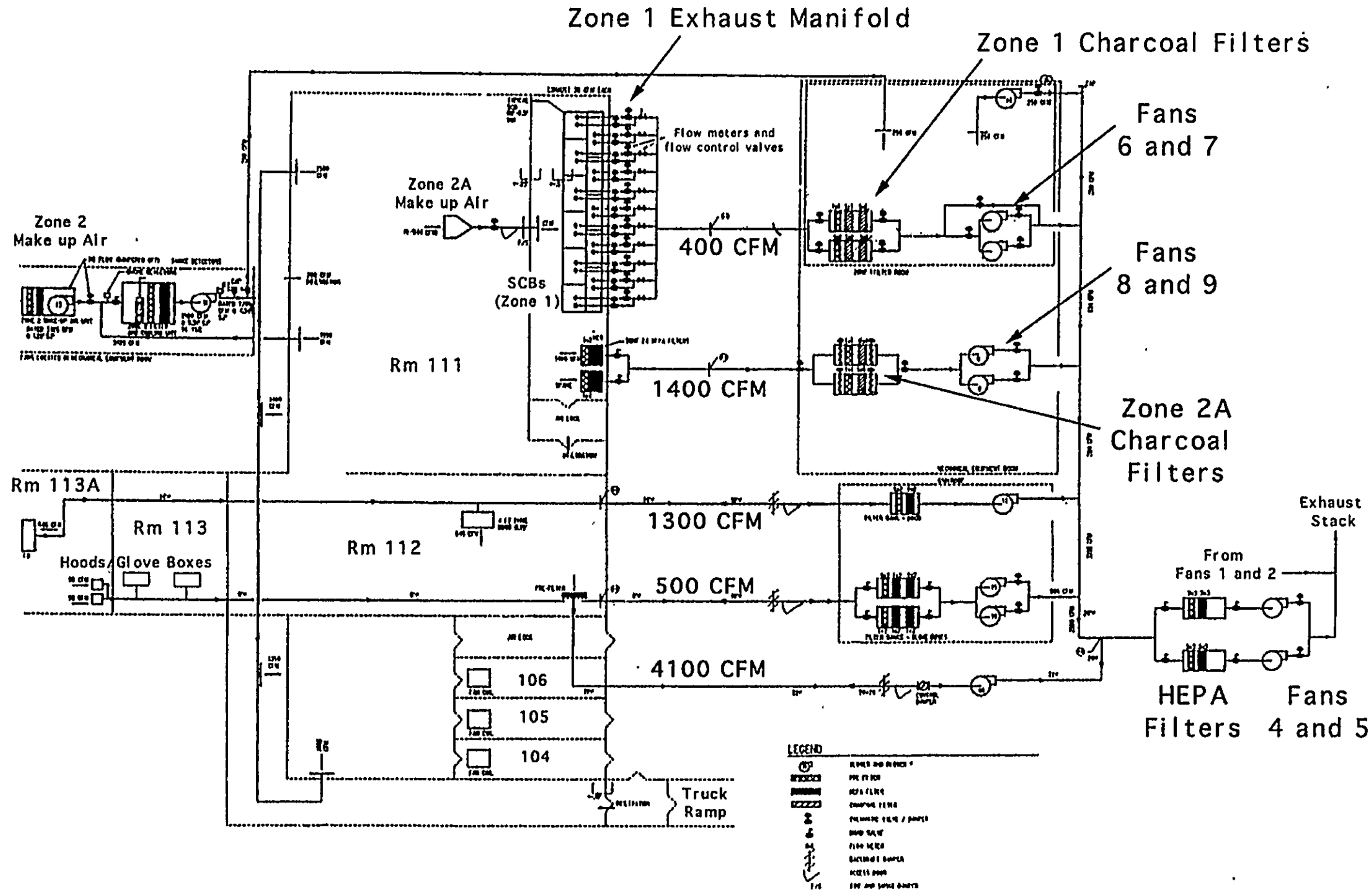


Figure 2.6-4 HCF Ventilation System

The ventilation system is monitored and controlled from the Operations Center by means of a computer-based Energy Management and Control System (EMCS), running Insight™ software (Landis and Staefa, Inc.). This software is a commercial product that is widely used at Sandia for operating building ventilation systems. It monitors, records, and displays system equipment status as well as normal operating and alarm conditions. System hardware consists of two field interface devices (FID-A & FID-B) located on the south wall of Room 112, and the computer (man-machine interface) located in Room 106. Normal power to each of the FIDs and the computer is backed up by a dedicated uninterruptible power supply having a 10-minute capacity. The standby electrical power system automatically picks up these loads in the event of a loss of normal electrical power. By design, there are no capabilities for dial-up or remote modem operation of this system.

The EMCS (FIDs A and B) receives pressure and fan current information from transducers throughout the ventilation system and displays the data on the operations center computer; it also uses the information in calculations of flow rate which are displayed on the computer and at the LCPs. Differential pressures (e.g. Zone 1 to Zone 2A, Zone 2A to 2) are calculated and displayed. The alarms which annunciate at the computer and the LCPs are generated in the FIDs from comparisons with predetermined alarm setpoints.

The Insight™ software is a graphics-based software package that operates in a Windows environment and provides the HCF operations staff with the capability for remotely commanding fans on or off, assessing system performance, and solving system problems at the Operations Center work station. The EMCS is a tool for operating the ventilation system fans and displaying system operational data. However, it is not required to operate the ventilation system. Although system fans can be turned on or off using the EMCS, these fans can also be turned on and off using the Hand-Off-Auto (HOA) switches in Field Interface Device Cabinet B. More specifically, SCB exhaust valves, filter bank isolation dampers, and system control dampers cannot be operated using the EMCS. Thus, the EMCS is primarily a monitoring (display) system. It consists of a graphical representation of ventilation system fans, dampers, filter banks, ducting, sensors, etc., and selected displays of operating information, including alarm conditions. This information is partitioned for display among approximately 25 graphics screens. An example of these screens is shown in Figure 2.6-5. The software is Y2K compliant.

Four to twenty milliamp analog signals for selected system operating parameters and binary signals associated with ventilation fan status are input to the FIDs. These signals are then conditioned and displayed by the software on the computer video display terminal. For data trending, FID inputs are sampled on a percent change-of-value (COV) basis rather than using time interval sampling. Sampled data is stored by the FIDs for only short time periods. Longer term storage requires that this data be downloaded to the computer hard drive.

The EMCS provides controls for designated exhaust and supply fans. The controls, embedded in FIDs A and B, assure an automatic and orderly shutdown and re-start of facility fans according to a prescribed hierarchy as shown in Figure 2.6-6. The control logic, coupled with automatic operation of associated isolation dampers, reduces the likelihood of back flow in the hot exhaust or of positive pressures in hot exhaust ducting with respect to pressure outside the duct, minimizing the spread of contamination to surrounding spaces. The controls are established as follows:

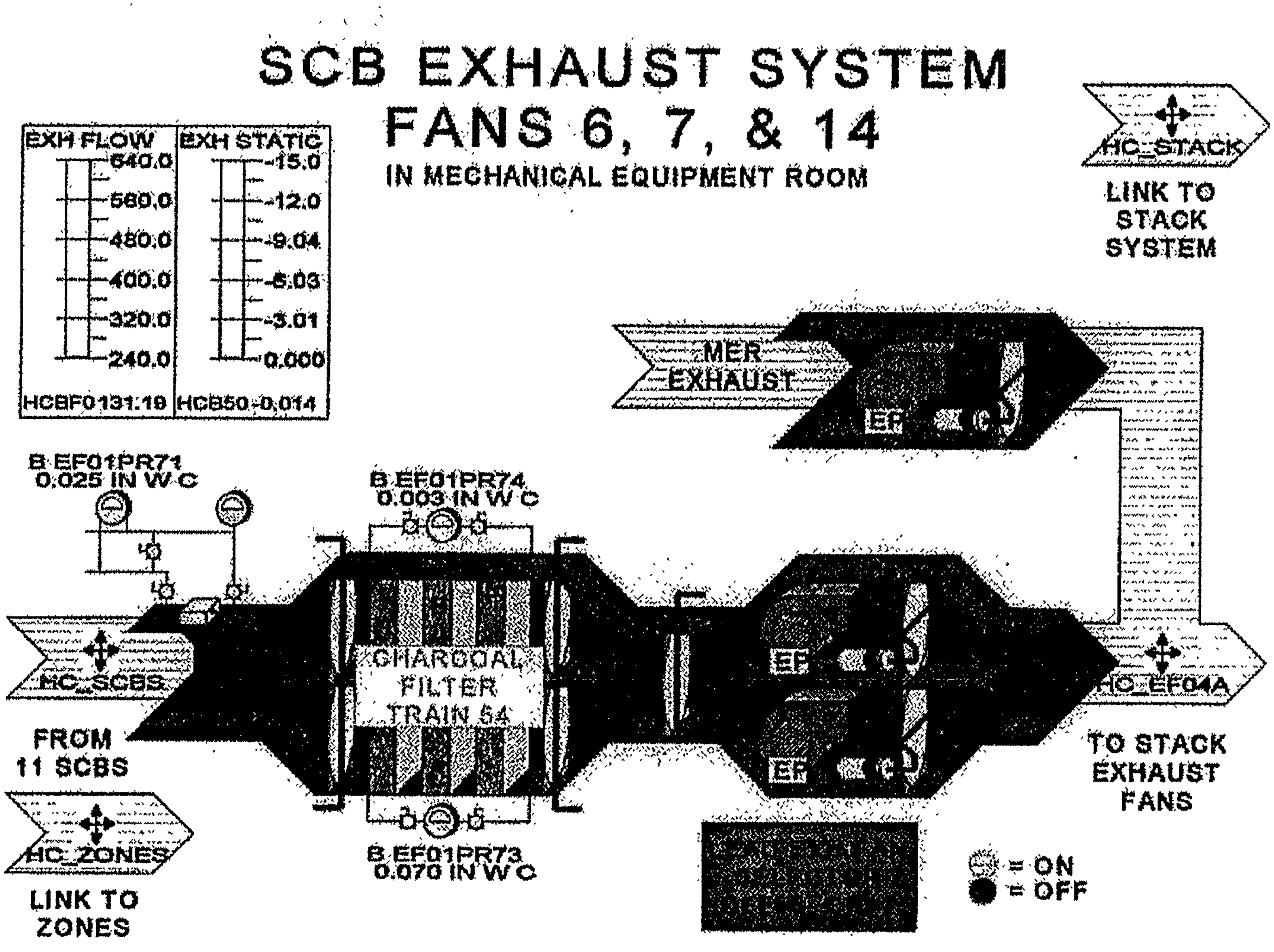


Figure 2.6-5 Ventilation Control System Data Display

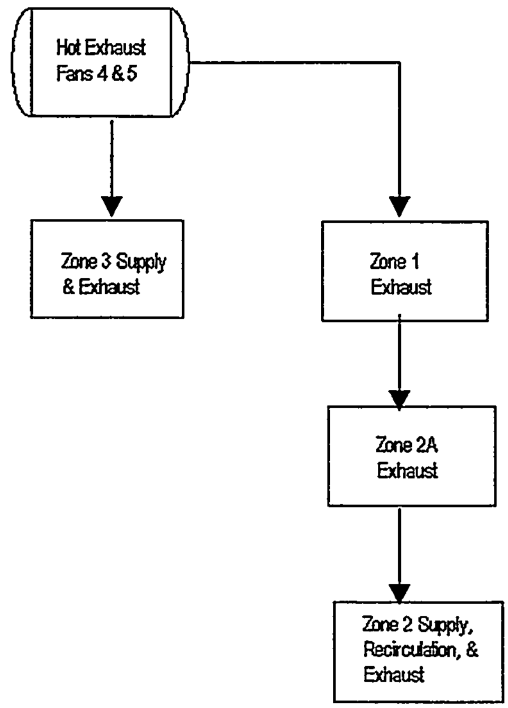


Figure 2.6-6 Ventilation System Hierarchy for Cascade Shutdown

- If both stack exhaust fans remain off for a predetermined time interval, the Zone1 exhaust fan(s), the Zone 2A exhaust fan(s), the Zone 2 supply, recirculating, and exhaust fans, and the Zone 3 supply and exhaust fans shutdown until upstream exhaust flow is restored.
- If Zone 1 or Zone 2A exhaust fans remain off for a predetermined time interval, their respective subordinate fans shutdown until upstream exhaust flow is restored.
- If both cold exhaust fans remain off for a predetermined time interval, the Zone 3 supply fan shuts down until exhaust flow is restored.

2.6.2.1 Zone 1 Ventilation System

Zone 1 consists of the eleven SCBs located within the Zone 2A canyon and the associated ventilation ducting. These SCBs will have the highest contamination levels, and are maintained at a negative pressure relative to Zone 2A to control the migration of contaminants. Airflow is drawn from Zone 2A into each SCB from the conveyor duct through a pressure control device and then exhausted through the Zone 1 ventilation ducting. The conveyer volume draws filtered air from Zone 2A at the north end of the duct. When the conveyer hatch cover is opened to move materials into or out of the SCB, the pressure differential between the SCB and the conveyer volume will approach zero, however, the airflow into the SCB, which acts to prevent the undesired migration of contamination out of the SCB, will be maintained. The SCB exhaust pipes penetrate the east wall of the Zone 2A canyon at an elevation of 12 feet and enter a common plenum located below the ceiling of Room 111 in Zone 2. A plan view of the ventilation duct routing in the basement is shown in Figure 2.6-7. The Zone 1 exhaust plenum exhausts through a 6-inch duct that penetrates the ceiling of the HCF in Room 112 into the MER.

Each processing SCB has an internal charcoal and HEPA filter to retain the majority of the volatile halogens and particulate within the shielded processing region of the HCF. This filter reduces the buildup of contaminants in the ventilation ducting which would produce undesirable radiation fields around the ducting, since this ducting passes through normally occupied areas (Zone 2) of the HCF. Dual, operator selectable, in-box filters are provided in the event one filter set is damaged, blocked, or otherwise rendered ineffective. These filters provide a safety benefit for occupational radiation exposure by capturing radioactive contamination, which reduces radiation levels in occupied areas of the HCF.

Dual 3-inch diameter exhaust ducts connect each SCB to a common Zone 1 exhaust plenum. An operator controlled, electrically actuated stainless steel ball valve in each exhaust line is used to establish the normal flowrate of approximately 30 cfm through each extraction SCB and 15 cfm through each purification and packaging SCB. Flow rate is measured downstream of the ball valve and displayed to the operator at each process station. The operational display and control functions are incorporated in a local control panel (Figure 2.6-8), located at each processing station to provide SCB status information for the operator. The operator can select the desired in-service exhaust leg and filter and establish or change flow and differential pressures at each station by manually positioning the selected exhaust valve. Operator actions to change the flow drawn from any single SCB do not significantly affect the other SCBs, since the flow from one SCB is a small fraction of the overall total flow from Zone 1, and the pressure in the Zone 1 exhaust plenum is established at an adequately negative pressure with maximum flow. In other words, the principal pressure drop in this portion of the system occurs across the SCB flow control valves. Thus, the operational status of each processing station can be independently maintained. This allows maintenance of individual SCBs (filter removal/replacement, SCB cleanup, etc.) while operations continue at other process stations.

The flow and pressure measurement instrumentation is physically located in each exhaust duct east of the Zone 2A canyon east shield wall. This exhaust manifold configuration is shown in Figure 2.6-8. Fan 6 or 7 draws air from all process SCB's through the Zone 1 exhaust plenum to which each of the individual exhaust lines are connected. In addition to the in-box filters, the Zone 1 exhaust is filtered through two stages of charcoal filters, shown in Figure 2.6-9, prior to being combined with the flow from Zone 2A in the MER. All exhaust flow also passes through a HEPA filter located upstream of stack fans 4 & 5 in B6580D prior to being discharged to the environment through the HCF stack.

In the MER, a separate fan exhausts 400 cfm from the Zone 1 Filter Room and discharges it into the ventilation exhaust. The purpose of this system is to exhaust any airborne contamination that could result from Zone 1 ventilation system filter replacements or fan maintenance to the HCF stack.

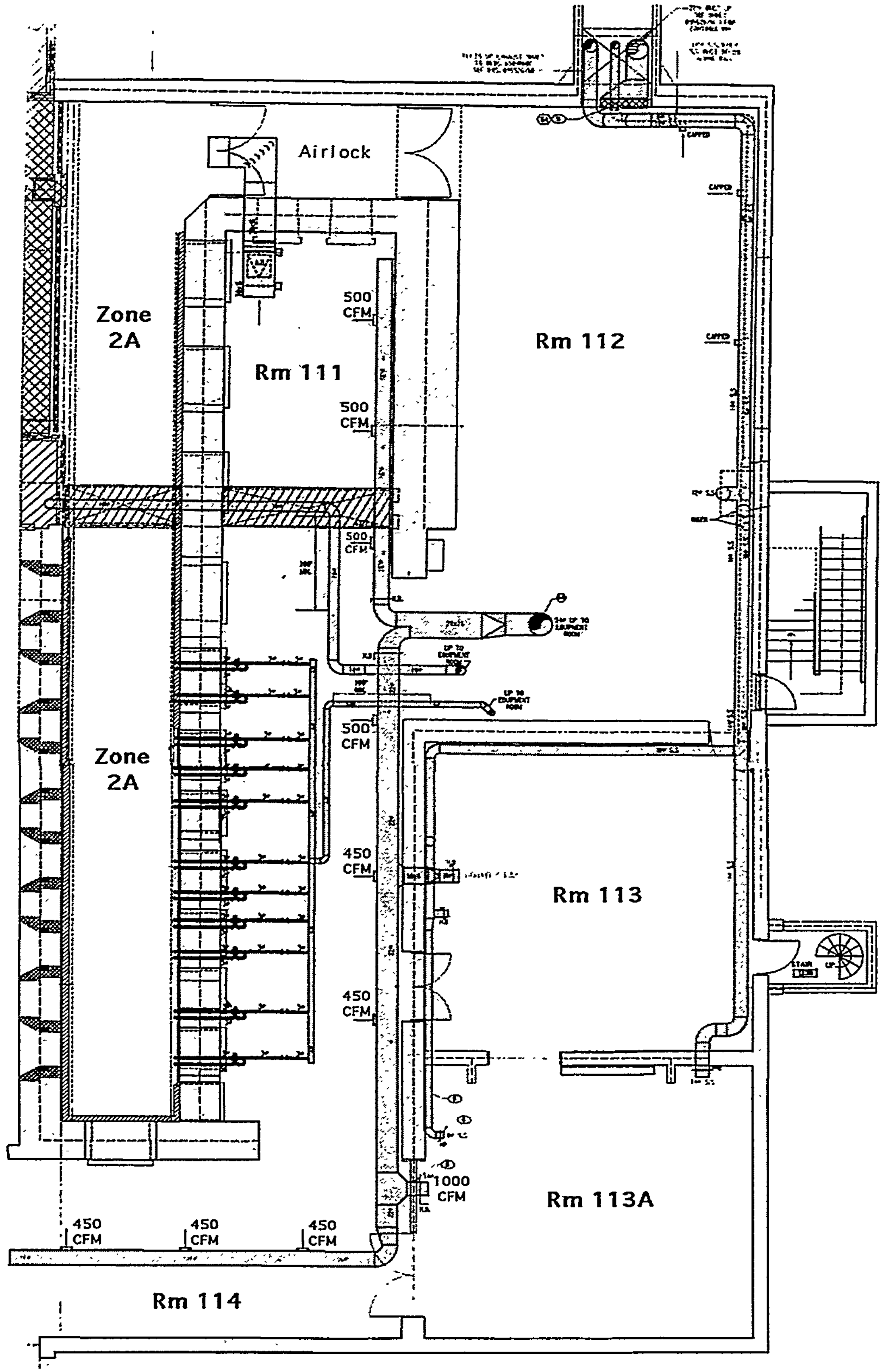
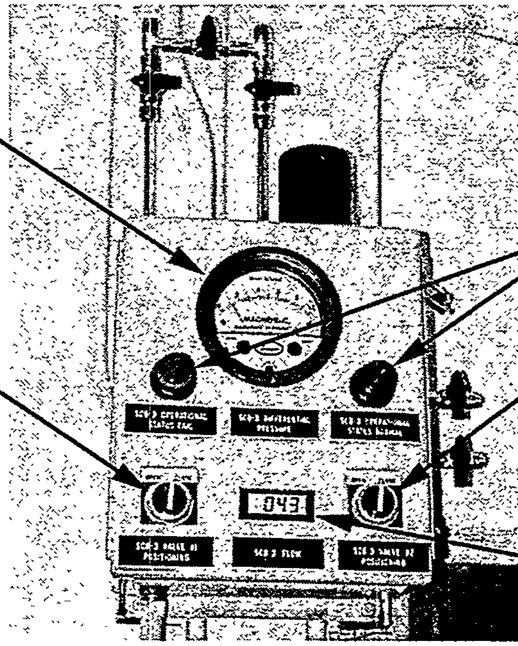
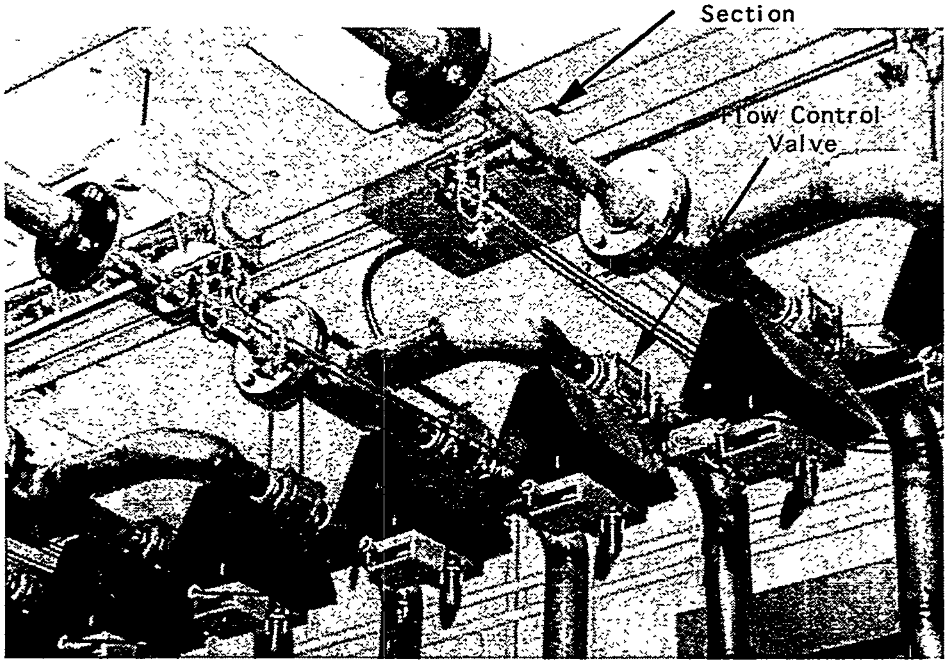


Figure 2.6-7 Ventilation System Ducting

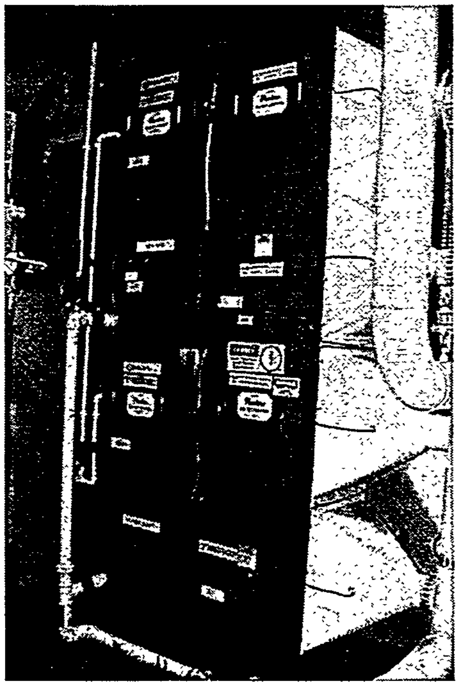


SCB Local Control Panel

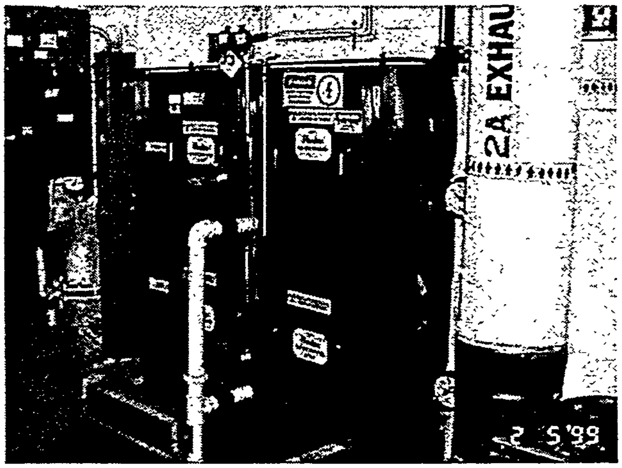


SCB Flow Control Manifold

Figure 2.6-8 SCB Local Control Panel and SCB Flow Control Manifold



Zone 1 Charcoal Filter Housings



Zone 2A Charcoal Filter Housings

Figure 2.6-9 Zone 1 and Zone 2A Charcoal Filters

2.6.2.2 Zone 2A Ventilation System

The Zone 2A canyon boundary serves as a secondary confinement area that surrounds the SCBs (Zone 1). This secondary confinement volume is exhausted by a separate ventilation system. The Zone 2A ventilation system also draws on Room 109 so that any potential contamination from waste is appropriately controlled. When both moveable shield walls are in the up position, a negative pressure differential will exist between Room 109 and the Zone 2A canyon. When either of these shield doors are lowered, this pressure differential will approach zero. However, the airflow through Room 109 into the Zone 2A canyon, which acts to mitigate the undesired migration of contamination, will be maintained. All exhaust from Zone 2A is filtered through a HEPA filter located in the Zone 2A canyon and a charcoal filter located in the MER prior to being combined with the Zone 1 exhaust flow in the MER.

The Zone 2A exhaust inlet and HEPA filter housing is located on the west shield wall, across from window 16 (see Figure 2.6-7 for ducting layout), which allows for remote maintenance of the filter. From this housing, the ten-inch exhaust duct penetrates the east shield wall through the (inactivated) shield door 4 recess and is routed to the MER along the ceiling of Rooms 111 and 112. The Zone 2A exhaust damper, located in the MER on the exhaust duct upstream of the exhaust fans, is set to establish the desired flow rate of 1400 cfm. Redundant exhaust fans 8 and 9 are controlled such that the alternative fan is started in the event of failure of the primary fan. The pressure differential between Zone 2 and Zone 2A is maintained at a nominal -0.25-inch WG with respect to Zone 2 by modulating the supply damper. This damper is automatically controlled based on the pressure differential. The supply duct draws air from Room 111 at a location above window 19 and introduces it into the Zone 2A canyon above the inner airlock door.

2.6.2.3 Zone 2 Ventilation System

Zone 2 of the HCF consists of Rooms 107, 111, 112, 113, 113A and 114. Approximately 4100 cfm is exhausted from Zone 2 through an inlet at the north end of Room 112 by fan 18, located on the roof of B6581. An additional 1800 cfm is drawn from Zone 2 into Zone 2A through the Zone 2A supply duct at the north end of Room 111, and approximately 2000 cfm is drawn from Zone 2 through hoods and gloveboxes by fans 15/16 and 17. Zone 2 is maintained at a pressure differential of -0.1 in. WG with respect to Zone 3 by modulating a makeup damper. A differential pressure controller (DPC) provides an input to modulate the makeup damper located on the discharge side of fan 11. The west section of Zone 2 is maintained using the output of a DPC to modulate the damper located in the return-air duct downstream of the return-air fan.

The makeup-air unit supplying Zone 2 receives its air from the building distribution system, the Zone 3 ventilation system (fan 3), boosted by fan 13 and recirculated by fan 11. The volume of makeup air is determined by the amount of air exhausted from the east and west Zone 2 sections, the amount of makeup air supplied to Zone 2A (which includes the Zone 1 supply air), less the amount of infiltration air into Zone 2. In addition to maintaining the correct pressure differential, the Zone 2 system provides at least four air changes per hour in Zone 2 and provides necessary environmental conditioning. The volume of recirculated air is regulated by a manual intake damper located in the intake duct of the Zone 2 filter and cooling coil.

Zone 2 air (supplied by the Zone 3 ventilation system) is cooled by the existing building air chiller and preheated if necessary by a hot-water coil in the system. The temperature of Zone 2 is controlled by a thermostat located in Room 107. This thermostat controls the cooling coil located in the Zone 2 filter and cooling unit and the reheat coil located in the Zone 3 ventilation system. The system maintains Zone 2 at 22°C (72°F) under both full load and no load conditions. The thermostat also prevents the Zone 2 temperature from dropping below 20°C (68°F) during operating hours.

2.6.2.4 Building 6580 (Zone 3) Ventilation System

The B6580 Zone 3 ventilation system serves all general work areas (i.e., Rooms 100A, 101, 102, 103, 104, 106, and 108) of the HCF. These areas of the HCF are kept free of contamination and are maintained at an ambient pressure. In addition, the Zone 3 ventilation system serves all general office areas in B6580 and B6581. The primary function of this system is to supply air to the normal building environments in B6580 and B6581. It also supplies air to the HCF Zone 2 ventilation system. This system is used exclusively for building heating and cooling and to supply fresh air to the general work areas of the HCF. It depends on the normal electrical power system for operation.

Outside air is drawn into B6580, Room 103, and through a prefilter, a preheat coil (if necessary), and an air washer by the Zone 3 supply fan (Fan No. 3). Downstream of Fan No. 3, air is divided into 13 separate ductwork pathways to supply various areas within the HCF, other areas of B6580, and parts of B6581. One of these pathways is the make-up supply of Zone 2 air for the HCF, boosted by fan 13. A HEPA filter exists in the fan 13 inlet duct. Within each of these 13 ventilation pathways, a reheat coil (supplied with hot water) may be used to heat the supply air.

Thermostats in each of the 13 areas served by the Zone 3 ventilation system control the temperature of the supply air (by automatic operation of the preheat coil, the air washer, associated dampers, and the reheat coil). Return air from areas served by the Zone 3 ventilation system is collected and eventually exhausted through redundant prefilters, HEPA filters, and fan units (Fans No. 1 & 2) located at the base of the HCF stack.

2.7 Safety-Support Systems

The fire protection systems and radiation monitoring systems provide for and enhance worker safety in accordance with industrial safety practices.

2.7.1 Fire-Protection System

Fire protection is provided in the HCF. B6580 and B6581 are provided with automatic fire-protection sprinkler systems, except in areas containing significant quantities of radiological materials where water sprinklers would exacerbate radiological hazards. The building also has a fully supervised alarm and evacuation system, which includes automatic smoke and heat detectors in certain areas.

2.7.1.1 Hot-Cell Fire-Protection Systems

The B6580/81 automatic sprinkler system also serves the HCF. Standard spray automatic sprinklers are provided in occupied areas of the basement, including Rooms 100, 104, 105, 106, 107, 111, 112, 113, 113A and 114. The HCF is equipped with an independent fire-alarm control panel, located against the south end of the west wall of Room 107 that monitors all areas of the HCF. Water that may be released during fires is captured and routed to holding tanks. This capture system is described in Section 2.9.5. Any sprinkler-water flow will activate the TA-V

Fire and Evacuation Alarm system, which then sends an alarm to Sandia Security and to the KAFB Fire Department. Portable fire extinguishers are located throughout the facility.

2.7.1.2 Zone 2A Canyon Fire-Suppression System

The Zone 2A canyon foam fire suppression system is designed to suppress an oil fire which results from leakage and ignition of the oil contained in the shielding windows. This oil is the only combustible material of sufficient quantity to be a concern for fire protection in this portion of the HCF. Four fire zones are defined in the canyon, delineated by two-inch high grout dams to confine oil spills. In the event of a fire in the canyon, the charged foam supply system would be manually connected to the appropriate station and discharged into the zone. The activation of this system is at the discretion of the operators, balanced against the potential for aggravation of the radiological hazard which exists inside the zone which could occur as a result of discharge of the foam.

2.7.2 Radiation Monitoring Systems

Radiation Monitoring systems are provided to warn personnel of unexpected changes in radiological conditions and to monitor the radiation environment within the HCF. Continuous Air Monitoring Systems (CAMS) and Radiation Area Monitoring Systems (RAMS) are used. Both systems have local meter readout, visible alarm, and an audible alarm. Additionally both systems have remote readout and monitoring capabilities; however, this capability is not currently implemented.

Radiation Area Monitoring System (RAMS)
The RAMS is designed to monitor ambient gamma (γ) radiation levels. The typical range for RAMS units is 0.1 mR/h to 10 R/h. Alarm set points are established at levels appropriate to the area being monitored, and to provide an indication of an abnormal condition. RAMS are located in Zone 2 where routine manned operations are conducted. RAMS units are calibrated and tested in compliance with the SNL RPPM Chapter 12.

Continuous Air Monitoring System (CAMS)
The CAMS units consist of monitors that continuously sample air for gross beta (β) activity. These instruments require either portable vacuum pumps or connection to a house vacuum system. Like RAMS, CAMS are located in Zone 2 where routine manned operations are conducted. CAMS units also have alarm set points that are determined and established to provide an indication of an abnormal airborne condition. CAMS units detectors and flowrates are calibrated and tested in compliance with the SNL RPPM Chapter 12.

2.8 Utility Distribution Systems

2.8.1 Electrical Power Supply and Distribution

The primary source of electrical power for the HCF is obtained from the Public Service Company of New Mexico (PNM) and KAFB transmission systems, which supply power at primary voltages of 345kv, 115kV, and 46kV. Power is supplied to the KAFB East facilities through PNM's Sandia Switching Station (Sandia Switch). At that station, transformers step down the voltage from 345kV to 115kV and then to 46kV for the main KAFB East transmission lines. Closer to the point of use, the high voltage is stepped down to medium-voltage levels of 12,470V or 4160V, which are then fed to unit substations serving each facility.

The TA-V preferred power is normally transported over one 46kV transmission line that originates directly from 46kV Bus 2 of the Sandia Switch. A second transmission line of equal capacity parallels the preferred line from 46kV Bus 1 of the Sandia Switch to the 46kV Switching Station (46kV Switch) north of TA-V. This second line is normally isolated from the preferred line at the 46kV Switch by air-break intertie switches, which can be closed when required. A similar transmission scheme of parallel lines transports power to Substation 17, where the voltage is stepped down to 4160V for distribution to the TA-V unit substations. The TA-V unit substations step the voltage down to 120/208 volts and 277/480 volts for distribution to motor control centers, service entrance switchgear, and power panelboards throughout the area.

2.8.1.1 High-Voltage Feeder Grid

The main power source for KAFB East is PNM's 345kV and 115kV 3ϕ 60Hz transmission system. A 345kV transmission line from PNM's West Mesa Substation feeds the 345kV ring bus at the Sandia Switch. The Sandia Switch consists of air-break disconnect switches, buses, transformers, and other associated equipment. From the 345kV ring bus, a 400MVA transformer steps the voltage down to 115kV, then supplies power to two 115kV ring buses. Additional PNM 115kV transmission lines interconnect these 115kV ring buses to other PNM 115kV substations in the Albuquerque metropolitan area. This arrangement uses multiple-switching schemes that minimize interruption of services.

The two 115kV ring buses supply five 115kV transmission lines (EB, K5, PS, SP, and SE Lines) on PNM's Albuquerque East Area 115kV grid. This arrangement allows for multiple contingencies so that the loss of any 345kV or 115kV element will not interrupt service to the 115kv or 46kV transmission lines that feed KAFB East. Three 115kV to 46kV transformers (two 44MVA and one 80MVA) are also fed from the 115kV ring buses to supply the 46kV buses at the Sandia Switch. These 46kV buses are equipped with disconnect switches to permit switching arrangements such that the loss of any 115kV element will not interrupt service to any of the four 46kV transmission lines that feed KAFB East. Power is transported at 46kV from the Sandia Switch and supplies the 46kV Switch via two parallel lines identified as KAFB Feeder 1 (F1) and KAFB Feeder 2 (F2) (Figure 2.8-1). Either F1 or F2 can be used to supply TA-V as system condition and configuration dictates.

2.8.1.2 Medium-Voltage Feeder Loop

Preferred power to TA-V is supplied by Feeder F2. The 46kV Switch, located immediately north of TA-V, distributes power to the substations as indicated above via a paralleling line-tap arrangement. Power to TA-V over this system is supplied from Substation 17, which receives power at 46kV, steps it down through the 46kV to 4160V, 2500kVA transformer, and delivers 3ϕ power to TA-V. Two 4160V feeders (1702 and 1703) originate from Sub 17 and supply TA-V via a normally open loop. If either feeder needs to be shutdown for maintenance, the remaining feeder can supply the TA-V load. In addition, Substations 5, 6, and 7 have 4160V interties with Sub 17. This allows the substation to be shut down for maintenance and the interties will then supply the TA-V load.

All switching actions are manual for the transfer of power from one line to another. All lines are protected with fuses to prevent system damage in the event of a fault. The main switchgear in the Sandia Switch is fault-sensitive and will open on any fault current. This equipment is designed to automatically try to reestablish the circuit twice after opening on the initial fault. If the fault still prevails on the second attempt, the switchgear will stay open.

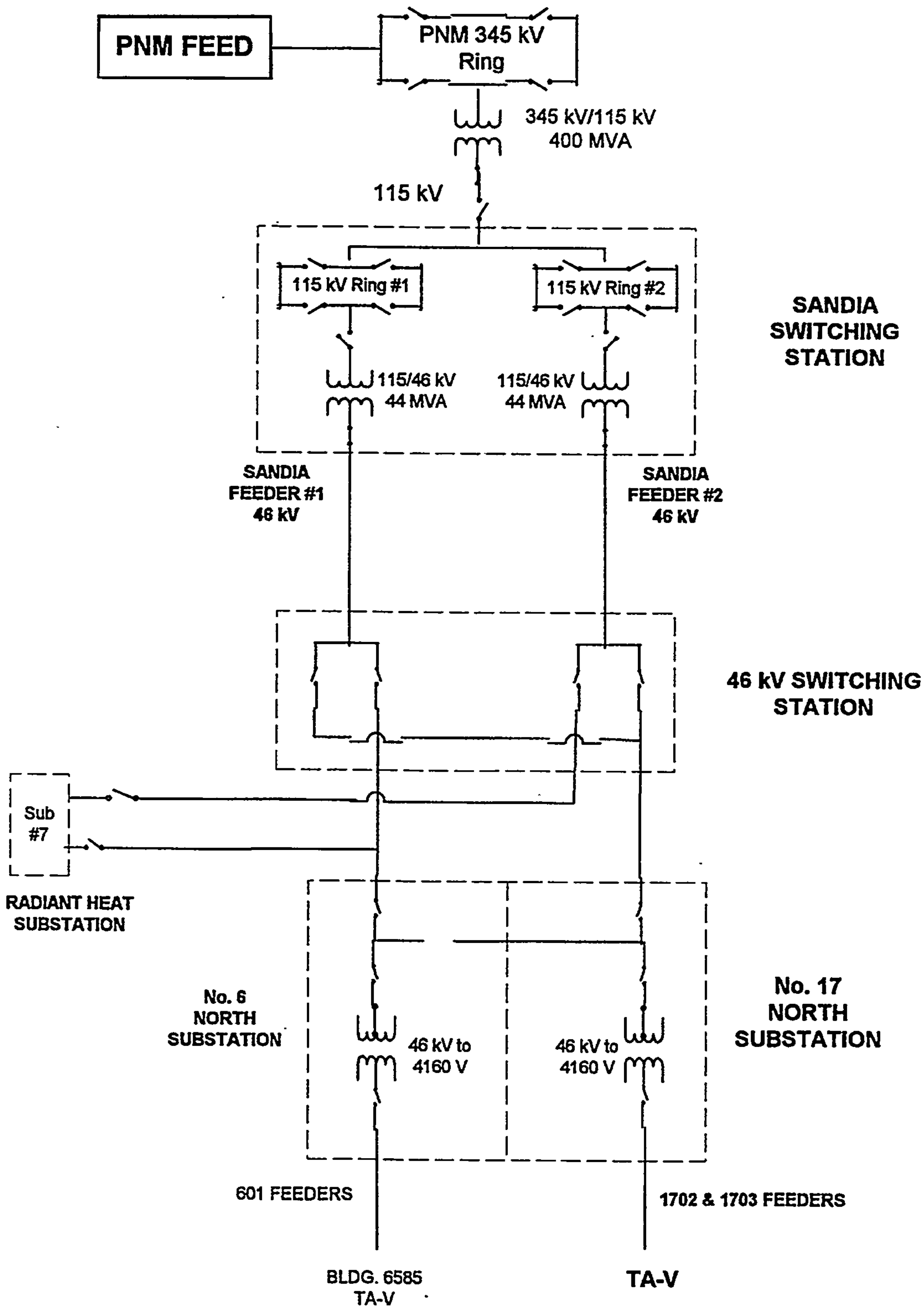


Figure 2.8-1 PNM Kirtland East Transmission System

2.8.1.3 Low-Voltage Distribution System

The basic on-site TA-V power system includes eight unit substations within the fenced area, numbered Sub LB (low-bay) and Subs 2 through 8. Power is supplied to the system from Sub 17 through two 4160V lines in underground 76.2mm (3in.) conduits. Total load capacity of each line is 1475kVA. Feeder 1702 is the primary power source for substations 2 and 3. Feeder 1703 is the primary power source for the remaining six substations. Substations 2, 3, and 4 support the HCF in various ways. Substations 5 and LB provides power to B6588.

Figure 2.8-2 is a simplified one-line diagram of the low-voltage electrical system serving the HCF and building 6588. The four substations are made up of a 5kV switch and transformer as follows:

- Sub 2 is Switch SW-6582-1 serving Transformer TF-6582-1, rated at 300kVA, 277/480V 3ϕ
- Sub 3 is Switch SW-6581-1 serving Transformer TF-6581-1, rated at 500kVA, 277/480V 3ϕ
- Sub 4 is Switch SW-6580-1 serving Transformer TF-6580-1, rated at 300kVA, 120/208V 3ϕ

<u>Transformer 6582-1</u> feeds 277/480V panel MAIN (600A) in building 6582. Its loads include:

- Three 37.5kVA 1 transformers to 120/208V outside panel MP and its subpanel C inside.
- MCC-B, serving the building 6580 Cold Exhaust system fans #1 and #2.
- Normal power (through an ATS) to MCC-A, whose loads include:
  - Building 6580 Hot Exhaust Fans #4 and #5.
  - MCC-D (in the MER), serving the other Hot Exhaust Fans and a 45kVA transformer to panel DD (in the MER), and its subpanel DD1 (in 6580) serving non-lighting loads.
  - A 45kVA transformer feeding:
    - A 50amp breaker to the UPS serving Technical Control Center panel SRT (in 6581).
    - Panel AA (at 6582) and its subpanels:
      - Panel 2AA (in 6581) and its subpanel 1AA (in 6580), serving mostly lights.
      - An ATS for Panel F (in 6580) serving alarms, the PA system, and two subpanels:
        - Panel A2 and its subpanel B2 serving pumps in the SER Pit (outside 6580).
        - Panel 1F (in 6580) serving HCF standby lighting and radiation detectors.

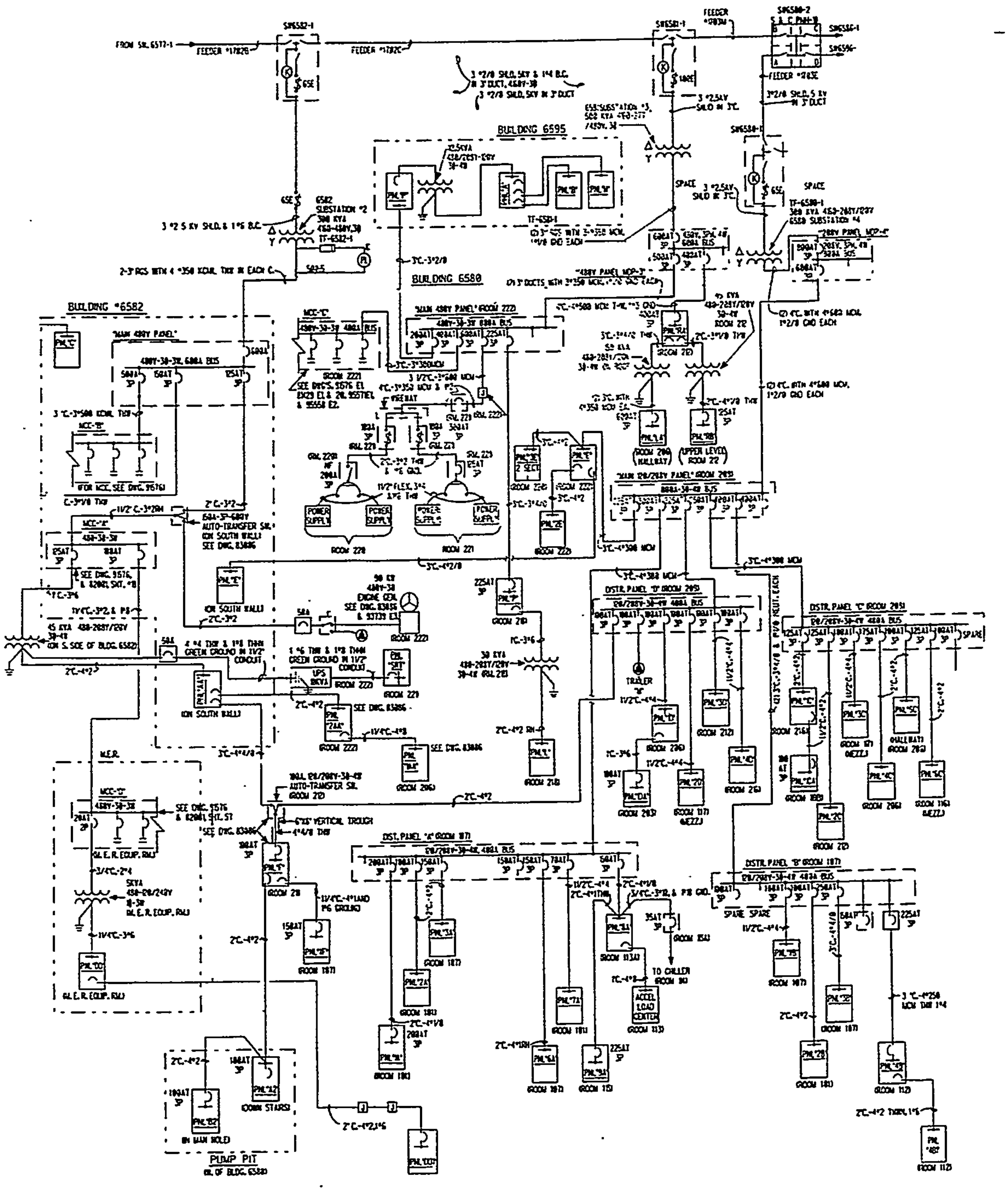


Figure 2.8-2 HCF/B6588 Low Voltage System

Transformer 6581-1 feeds two 277/480V distribution panels, RA and MAIN, in two buildings. Panel RA (400A) is mostly unloaded and served loads to the old SER reactor area (Room 212 mezzanine) of building 6580. It feeds:

- A 45kVA transformer serving 120/208V panel RB in the same area and also mostly unloaded,
- A 150kVA transformer serving 120/208V panel LA in the upper hall of building 6580, also mostly unloaded.

Panel MAIN (800A) is in building 6581 and serves these loads:

- MCC-C, which serves Fan #3, the HCF shield doors hydraulic pump, and other equipment.
- Specialized power supplies in Rooms 220 and 221 not affecting the HCF.
- A spare disconnect for a removed furnace in Room 218.
- Panel P, and panel L through a 120/208V 30kVA transformer, both in Room 218.
- Panel P in building 6595, which is the 480V service entrance to that building. Its loads include a 112.5kVA transformer serving 120/208V panel A and its subpanels B and H.

Transformer 6580-1 feeds 120/208V panel MAIN (800A) in building 6580 Room 209N, and provides most of the normal power to the building through these subpanels:

- Panel A in Room 107 of the HCF, with seven subpanels as follows:
  - Panels 1A, 2A, and 7A in Room 101, the machine shop,
  - Panels 3A and 6A in Room 107, serving Hot Cell non-lighting loads, and
  - Panels 8A and 9A in Rooms 113 and 113A.
- Panel B in Room 107A (the hall between Rooms 101 and 107), with four subpanels:
  - Panels 1B and 3B in Room 107, serving Hot Cell non-lighting loads,
  - Panel 2B in Room 101, the machine shop, and
  - Panel 4B (and its subpanel 4B1) in Room 112 to serve HCF loads there.
- Panel C in Room 209N, serving general loads throughout the office and mezzanine areas of building 6580 from subpanels 1C (and its subpanel 1CA), 2C, 3C, 4C, 5C, and 6C.
- Panel D in Room 209S, serving loads throughout the office and mezzanine areas of building 6580 from subpanels 1D (and its subpanel 1DA), 2D, 3D, and 4D. It also serves the normal side of the ATS for standby panel F in Room 211.
- Panel E in building 6581 Room 222, serving:
  - Subpanels 2E and 3E serving general loads in 6581,
  - Subpanel 1E back in 6582,
  - The large Monorail Crane east of building 6580, and
  - Panel 1 in building 6588 Room 11.

2.8.1.4 Power Outage History

Unscheduled power outages are classified as either extended or momentary. Momentary outages have duration of less than one minute and include "bumps" on PNM's system. Extended outages have a duration exceeding one minute and also include problems on PNM's system. Extended outages that have resulted in loss of power to TA-V during the 20-year period from 1977 through 1997 are summarized in Table 2.8-1. The outages listed in the Table show the causes of all power losses at TA-V due to any problem experienced by PNM, KAFB, or SNL on the entire transmission and distribution system.

Based on past experience, a loss of electrical power can occur because of storm, wind, lightning, or equipment malfunctions. Other situations could also lead to loss of power. Data on power outages for the 14 years from 1984 through 1997 show a total of 24 extended outages, with a frequency ranging from zero (1992 and 1996) to a maximum of six in a single year (1987). The duration of these outages varied from nine minutes to one with a maximum of 17 hours, with an average outage time of about 5 hours per year. Sixteen outages exceeded two hours.

The transmission lines interconnecting the 46kV Switch and respective substations are designed and constructed in accordance with industry standards for environmental conditions prevalent in the area regarding wind and ice loading, temperature, lightning, and other phenomena, so as to minimize the possibility of transmission-line failures from such causes. High-speed protective relaying is provided for all lines and equipment to ensure rapid and proper clearing of circuits in the event of electrical faults.

2.8.2 Standby Engine-Generator System

A 277/480V, 90kW, turbocharged Diesel engine-generator set in B6581, Room 222, is connected by an automatic transfer switch (ATS) in B6582 to the 480V feeder from Sub 2 and panel MAIN to MCC-A, both in B6582. Fuel for the standby diesel generator that serves the HCF ventilation system is stored in a 560-gallon above ground tank located immediately east of Building 6581. The tank is made of 12-gauge steel, is 4 ft in diameter and 6 feet, 1 inch tall. The SNL/NM motor-pool organization keeps the tank filled. If normal power is interrupted, the standby generator set starts automatically, the ATS transfers to the better source of power, and power is restored to a number of systems in three buildings. The major recipients of standby electrical power include the following:

- MCC-A (B6582), serving Hot Exhaust Fans #4 and #5 and feeders to:
  - MCC-D (in the MER), serving the other Hot Exhaust Fans and a 45kVA transformer to:
    - Panel DD (in the MER), and its subpanel 7C (B6580) serving non-lighting loads
- A 45kVA transformer (in 6582) feeding Panel AA (B6582) and its subpanels:
  - Panel 2AA (in 6581) and its subpanel 1AA (B6580), serving mostly lights
  - The UPS serving Technical Control Center security panel SRT (B6581)
  - Panel F (B6580) and its subpanels:
    - Panels A2 and its subpanel B2 serving pumps in the SER Pit
    - Panel 5A (B6580) serving HCF emergency lighting and detector systems.

Table 2.8-1. Unscheduled Power Outages, 1977-1997

Year	Date	Duration	Cause/System
1977	03 Mar 10 Jul	45 min 1 h	Feeder No. 2 fuse Lightning, fuse, Substations 6 and 17
1978	13 Mar	45 min	Lightning, fuse
1979	17 Sep	3 h	Vandals/PNM lines
1980	03 Jan 18 Jan 08 Feb 15 Apr	-- 10 s 2.5 h 17 h (Saturday)	Fuse, Substation 6, Feeder 601 Feeder No. 2 breaker open Vandals, Feeder No. 2 insulators Wind, 76 mi/h gusts, Feeders Nos. 1 and 2
1981	--	--	None on record
1982	23 Dec	Bump	PNM (Cause unknown)
1983	31 Mar 01 Apr 12 Apr 05 May 25 Jul	5 h 45 min 3 s (4) 40 min 1 h, 40 min	Wind/static wire Vehicle hit tap box, all feeders Boom truck hit 45 kV feeder Vehicle hit lines Wind
1984	29 Jun 06 Jul	8 h 2 s	Tap box blew PNM (unknown)
1985	24 Mar	7 h	Oil switch arc
1986	09 Mar 06 Oct	3.5 h 4.5 h	Wind/static lines Tap box flashover
1987	05 Jan 16 Jan 29 Jan 10 Aug 23 Sep 12 Dec	1.75 hr 2.5 hr 1.75 hr 3 hr 2 hr 3 hr	Rain/High Wind Cable Failure, Wind/Ice Storm Failed PNM Insulator Tap box fault due to water Human error, fuse installation Cable failure, high winds
1988	02 Mar 06 Apr 01 May	1.5 hr 20 min 3 hr	Tap box fault, moisture PNM Tree limb induced fault on 12.47 kV line
1989	13 Jul	10.5 hr	Tap box fault, moisture
1990	18 Jan	3 hr	High winds
1991	19 Mar 01 Nov	10 min 2.5 hr	High winds Underground cable fault
1992			No extended outages
1993	30 Sep	1.7 hr	46 kV insulator failure, PNM
1994	11 Jan 13 Feb 05 Oct	1 hr 3 hr 2.2 hr	Crane contacted 46 kV Feeder #2 PNM jumper failure on 46 kV Ideal line Ground wire failure, high wind
1995	26 Nov	9 hr	Extreme fault on Feeder #1, cause unknown
1996			No extended outages
1997	25 April 25 April	3 hr 2.5 hr	Jumper failure at Sub. 21 Static line failure on Feeder 1

This standby generator is classed as "optional standby systems" by National Electric Code Article 702, in that it is necessary to prevent damage to the facility and prevent a serious interruption of the processes in the HCF. It is not required for critical life safety (Article 700), nor to mitigate hazards or avoid hampering rescue or fire-fighting operations. The generator is operated periodically and receives preventative maintenance according to the manufacturer's recommended schedule. During the operational test, the generator is started using a manual activation of the power failure detection unit, and the ATS is transferred to the generator after the unit starts and comes on line. Records are kept in Facilities Maintenance of the generator set's performance and of the loads served during these tests.

2.9 Auxiliary Systems and Support Facilities

Auxiliary systems which exist in the HCF include material handling equipment (cranes & hoists, transporters, etc.), low pressure nitrogen, compressed air, hydraulic systems, process waste water collection system, rainwater collection drains, communications systems, and oxygen monitors. Additionally, HCF activities are supported by operations in B6595, B6596, and B6597.

2.9.1 Material-Handling Equipment

The material-handling equipment permanently installed in the HCF includes overhead bridge cranes, hoists, railways, and various types of manipulators. This equipment serves two major functions: (1) to assist in the movement of material into, out of, and throughout the HCF (including the SCBs and gloveboxes) and (2) to assist in performing maintenance activities. Other types of material handling equipment (e. g., electric forklifts, hand trucks, and dollies) may be used to support these activities. The HCF material-handling equipment is used exclusively for process- and maintenance-related activities.

Table 2.9-1 lists the overhead crane/hoist assemblies permanently installed inside and outside the HCF, their primary functions, their rated capacities, and the typical load each assembly handles. There are 19 bridge cranes located throughout the HCF; with one exception, each is equipped with a hoist. Each-bridge crane/hoist assembly is marked with the maximum load for which the assembly is rated. A rail system in the airlock is used to transfer large packages into and out of the Zone 2A canyon.

2.9.2 Low Pressure Nitrogen

Compressed nitrogen is required in the HCF for operation of manipulators. Additionally, a supply of nitrogen is required as a cover gas on the oil filled shield windows. This nitrogen is derived from the liquid nitrogen supply located east of the MER, which provides a source of nitrogen gas at 100 psig, the normal tank pressure. Standard piping is used to route this gas supply to required locations in the HCF. A regulator located above station 8 steps this pressure down to 1 inch WG for use in the windows.

Table 2.9-1. HCF Material Overhead-Crane/Hoist Assemblies

Location	Primary Function	Rated Capacity	Typical Load
East of Building 6580	Handling of Material in Storage Holes	20 Tons	16 Tons
Room 101	Transfers of Material in Room 101	6 Tons	2 Tons
	General Maintenance Support	1/2 Ton	100 lbs
Room 107	Maintenance Support for Manipulators (six crane/hoist assemblies, one per manipulator)	1/2 Ton	500 lbs
Room 111	Monorail Target Transfer Maintenance Support for Manipulator	5 Ton 1/2 Ton	5000 lbs 500 lbs
Room 112	Manipulator Maintenance Support	6 Tons	500 lb
Room 113A	General Maintenance and Process Support, Packaging Operations	2 Tons	300 lb
Zone 2A Canyon	Bridge Crane for Waste Handling, General Material Handling and Maintenance Inside the Zone 2A Canyon	4 Tons	400 lbs
SCBs	Material Transfer/Maintenance Inside SCB's (1 per SCB)	100 lb	20 lbs

2.9.3 Compressed-Air Supply System

Compressed air to operate ventilation-system dampers comes from two redundant, industrial-sized compressors [40 standard ft^3/min (SCFM) at 125 lb/in.^{2} (psi)], located in Room 222 of B6581. The two compressors operate as a primary supply and as a backup. Downstream of the normal air compressors is miscellaneous support equipment including an air receiver and filters. The air supply is then split into two separate pathways: (1) general building compressed air, and (2) dry instrument air, which is used in the HCF for ventilation system damper positioning.

Compressed air from these compressors feeds the dampers in Room 222, the plenum at the base of the HCF stack, the HCF MER, and the HCF. Should both of these compressors fail, compressed air for HCF functions is picked up by backup compressors located in Room 222 of B6581 and in the HCF MER. The B6581 backup compressor supplies the controllers in Room 222 and the controllers and dampers at the base of the HCF stack. The compressor in the MER supplies the dampers and controllers in the MER and in the basement of B6580.

2.9.4 House Vacuum System

A vacuum is installed in the HCF to provide a vacuum source for the continuous air monitors (CAMs) and other equipment in the HCF which may require vacuum. This system consists of a network of 2 inch diameter piping to various locations in the Facility, connected to a continuously operating vacuum pump in the MER, and a discharge pipe which exhausts the sampled air to the hot exhaust duct. The nominal operating pressure of the system is –10 inches WG.

2.9.5 Residual Water Collection System

The residual water collection system consists of several floor drains, underground piping, local underground holding tanks, redundant pumps, and the liquid effluent collection system (LECS) tanks located outside of TA-V. The purpose of the system is to preclude non-permitted liquid discharges to the environment. Liquids captured by the system will normally not contain any radioactive material, however, abnormal conditions or accidents could result in the generation of water which has entrained radioactive contamination present in the HCF. A Liquid Effluent Control System (LECS) is used to retain collected water to permit sampling prior to offsite release. The HCF SER tanks discharge to this system. The LECS is a wastewater treatment unit subject to regulation under the Clean Water Act, discharging to the City of Albuquerque publicly owned treatment works sewer system. The ES&H Center is responsible for operation, maintenance, and monitoring of the LECS.

2.9.6 Rainwater-Collection/Discharge System

The rainwater collection and discharge system captures rainwater at the bottom of the HCF truck ramp and discharges it to an arroyo located southwest of the HCF. The system consists of a large floor drain at the bottom of the truck ramp, an underground sump, redundant sump (discharge) pumps, and underground piping. Level indicators in the sump automatically initiate one of the sump pumps. The system sump pumps depend on the normal electrical power system for operation and, additionally, receive backup power from the standby electrical power system. Loss of the system pumps in conjunction with a heavy rainstorm could cause a temporary suspension of HCF operations and exclusion of personnel from the basement areas due to accumulation of water.

2.9.7 Communications Systems

Room 105/106 has been established as the Operations Center for the HCF, and is the normal route for entry and exit from the HCF. This Center serves as the focal point for communications to personnel working in the facility. HCF system status and radiological conditions are monitored and displayed at this Center. Additionally, there are diverse and redundant modes of communication throughout the facility, under both normal and emergency conditions. There are three communication systems used in the HCF (not including radiation, fire, or intrusion alarms): (1) a telephone system, (2) a public address (PA) system, and (3) an intercom system.

General communication devices (standard telephones and PA speakers) are located throughout the HCF. The PA system is not normally used for evacuations but can be used in the event of failure of the TA-V alarm system. If an initiating event were to disable the HCF automatic alarm systems by disrupting the main power system, the PA system has a battery back-up.

2.9.8 Building 6596 Systems

The B6596 HVAC system consists of six evaporative coolers, five unit heaters, several exhaust fans, and two circulation fans. The five evaporative coolers for the main facility and their associated ductwork into the building are located on the south wall of the building. The Chapel swamp cooler is located on the north wall of the Chapel. The unit electric heaters in both the main facility and the Chapel are located near the ridge of the respective roofs. The circulation fan for the main facility is located in the center of the north wall, while the circulation fan for the

Chapel is located on the east wall of the Chapel just south of the roll-up door. Exhaust fans are located at the roof ridges. The mechanical equipment and storage rooms are provided with electric heaters to maintain minimum temperatures.

The water supply to B6596 consists of a 6-inch riser in the mechanical equipment room that supplies water to the fire protection wet-pipe sprinkler system. Sprinkler heads have internal fusible elements that open the sprinkler flow orifice at a temperature of 165°F. Fire alarm pull stations and fire extinguishers are located in both the main facility and the Chapel.

There are no laboratory sinks or active floor drains located in the main facility. A sink located in the Chapel is connected to the TA-V Liquid Effluent Control System (LECS) since it is a potential source of radioactively contaminated discharge.

The main power supply to the building comes from a 500 kVA transformer, located south of the building, that supplies 3-phase, 208 volt power to the main circuit breaker. Service voltage to the remainder of the building is 120/208. There is no standby electrical power supply to the building, although it is equipped with battery powered emergency lights.

2.9.9 Building 6597 Systems

The B6597 high-bay HVAC system consists of six evaporative coolers, 12 unit heaters, and several exhaust fans. The mid-bay HVAC consists of four evaporative coolers, 4 unit heaters and exhaust fans. The mechanical equipment room contains an air compressor and is provided with electric heaters to maintain minimum temperatures.

The water supply to B6597 consists of a 6-inch riser in the mechanical equipment room that supplies water to the fire protection wet-pipe sprinkler system. Sprinkler heads have internal fusible elements that open the sprinkler flow orifice at a temperature of 165°F. Fire alarm pull stations and fire extinguishers are located throughout the high and mid bays. The building fire protection system also uses aqueous film forming (AFF) foam.

There is no standby electrical power supply to the building, although it is equipped with battery powered emergency lights. A mechanical equipment room in the east end of B6591 contains a boiler and air compressor that provide hot water and compressed air, respectively, to B6597.

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3.0 HAZARD AND ACCIDENT ANALYSIS

3.1 Introduction

The purpose of this chapter is to provide a comprehensive evaluation of the hazards potentially affecting the Sandia National Laboratories, New Mexico (SNL), Hot Cell Facility (HCF) in isotope production and Technical Area V (TA-V) radioactive material and equipment storage locations. This information is intended to satisfy the requirements of DOE Order 5480.23, paragraph(s) 8.b.(3)(e) and 8.b.(3)(k), as amplified in Attachment 1, paragraph(s) 4.f (3)(d)5 and 4.f.(3)(d) 11, of the Order (Topics 5 and 11). This chapter also includes information that will satisfy the requirements of DOE Order 5480.23, paragraph(s) 8.b.(3)(b), (f), and (u), as discussed in DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports" (DOE 1994b).

The hazard analysis considers the complete spectrum of accidents that may occur due to operations at the facilities, analyzes potential accident consequences to the public and workers, estimates the likelihood of accidents occurring, identifies and assesses associated preventive and mitigative features, and identifies bounding accident scenarios. Subsequent accident analysis evaluates the bounding accident scenarios for comparison with DOE Evaluation Guidelines. The scope and format of this chapter is consistent with DOE-STD-3009-94.

The level of analysis performed to characterize the hazards associated with the SNL Hot Cell Facility and the HCF associated TA-V radioactive material and equipment storage locations is consistent with the complexity, hazard potential, and life-cycle stage of the facility. Due to the limited number of systems, structures, and components (SSCs) and the relatively simple isotope processing operations and radioactive material storage process, primary emphasis is placed on the qualitative hazard screening analysis of all potential accidents. Quantitative analysis is conducted to augment and reinforce the qualitatively assigned consequence estimates of bounding accident scenarios.

3.2 Requirements

This section identifies the DOE Orders and DOE Standards that are required for establishing the hazard and accident analysis-related safety basis of the Hot Cell Facility. Provided below is a listing of each major Order, Notice, and Standard and descriptions that summarize their safety basis requirements.

DOE Order 5480.23, Chg. I, Nuclear Safety Analysis Reports, paragraphs 8.b.(3)(e) and 8.b.(3)(k), as amplified in Attachment 1 to the Order, paragraphs 4.f.(3)(d)5 (Topics 5 and 11), require the analysis of both hazards and the facility classification, along with the assessment of operational, natural phenomena, and external events postulated to occur at the facility (DOE 1994a).

DOE O 420.1, Facility Safety, paragraph 4.1.1.1, requires the detailed application of that order's requirements to be guided by safety analyses that establish the identification and functions of safety (safety class and safety significant) structures, systems, and components (SSCs) for a facility and establish the significance of safety functions performed by those SSCs. The safety analyses must consider facility hazards, natural phenomena hazards, and external man-induced hazards. Paragraph 4.4.1 requires safety analyses for hazardous facilities to include the ability of SSCs and personnel to perform their intended safety functions under the effects of natural phenomena. DOE O 420.1 (DOE 1995) incorporates requirements from the cancelled DOE Orders 5480.28 and 6430.1A (DOE 1993, DOE 1989).

DOE-STD-1027-92, Change Notice 1, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, provides guidance for performing hazard categorization and accident analysis for SARs (DOE 1992b).

DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, describes a SAR preparation method that is acceptable to the DOE. Chapter 3 of the Standard presents the format and content required for SAR hazard and accident analysis (DOE 1994b).

3.3 Hazard Analysis

This section describes the hazard identification and evaluation process performed for the SNL HCF and for the HCF associated radioactive material storage areas. The purpose of this information is to present a comprehensive evaluation of potential process-related, natural phenomena and external hazards that could possibly affect the public, workers, collocated workers, and the environment due to single or multiple failures or incidents. Consideration is given to all phases of isotope production operation of the HCF, including the activities, materials, facilities, and equipment of the production process.

Hazard analysis results are summarized and displayed. A final hazard classification of the SNL HCF and the radioactive material storage areas, consistent with DOE-STD-1027-92, is also presented (DOE 1992b). Finally, a limited set of bounding hazards is identified for further development using quantitative, deterministic techniques in Section 3.4, "Accident Analysis."

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 methodology is a largely qualitative screening approach consistent with current DOE hazard analysis practices (DOE 1992b; DOE 1994b), leading industrial hazard evaluation procedures (AIChE 1985), and Department of Defense failure analysis standards (DoD 1980). The methodology also utilizes and integrates a variety of assessment techniques to identify and evaluate hazards potentially affecting isotope production at the HCF.

The hazard analysis is performed to 1) identify and evaluate potential accidents; 2) identify bounding accident scenarios that require further quantitative development; and 3) verify the initial hazard classification assigned to the HCF and associated radioactive material storage areas.

3.3.1.1 Hazard Identification

This section identifies the methods used to identify and characterize hazardous materials and energy sources associated with the facilities, operations, and inventory. Several sources of information and hazard analysis methods were used to identify the hazardous material inventory and potential energy sources at the HCF.

Sources of information that were reviewed include:

- Primary Hazard Screening documentation for HCF isotope processing of Sandia National Laboratories' Integrated Safety Management System (SNL7A00124-001);
- The SNL ES&H Standard Operating Procedure for Separation of Molybdenum-99 from Uranium Dioxide at Technical Area V Facilities, (SP473347) dated December 7, 1996;
- Operating procedures and records for process verification and development tests;
- Memorandum reports of those tests; and
- Hot Cell Facility (HCF) Safety Analyses Report (Restrepo, 1995).

This information was supplemented with input from appropriate subject matter experts to clarify or augment specific issues associated with the identification of hazards.

Two types of assessment methods are used to initially characterize hazards: 1) a preliminary hazard checklist (PHC), and 2) external events screening. PHCs are used to identify hazards that exist for a specific HCF location as part of the isotope processing activities (e.g., hot cell laboratory, quality control laboratory, etc.) or radioactive material storage location. A PHC is a location-based form of assessment; that is, the facility is first subdivided into several distinctly separate locations or entities, then process-related hazards specific to each facility segment are identified. PHCs document energy sources and hazardous materials, potential accident initiators, and preventive or mitigative systems or practices present in each facility location. The PHCs are provided in Appendix 3A. For the purpose of the PHCs, four generic facility locations in the HCF were considered: 1) the hot cell laboratory for remote, shielded handling of radioactive material; 2) the quality control laboratory for analysis of isotope products; 3) the isotope product packaging and shipping area; and 4) the radioactive waste storage area. The PHCs also considered the several HCF associated radioactive material storage areas:

- Each of the monorail storage holes adjacent to Building 6580,
- Building 6596, (east high bay and chapel)
- Building 6597 high bay.

For the purpose of hazard evaluation, activities associated with HCF isotope processing are grouped into the following operations:

- Target transfer to the HCF;
- Chemical isotope extraction and purification processing in the Hot Cell Laboratory;
- Isotope product packaging in the packaging and shipping area;
- Isotope product quality analysis in the Quality Control Laboratory;
- Maintenance activities in the HCF; and
- Radioactive waste storage in the radioactive waste storage area.

Activities that are not addressed in this SAR include:

- Transportation of isotope products in Department of Transportation (DOT) approved shipping containers in Technical Area V or elsewhere,
- Removal of isotope process radioactive waste from the waste storage area (Room 109) or any subsequent handling of such waste,
- Transportation of radioactive waste,
- Irradiation of isotope targets,
- Handling of plutonium above the HC3 threshold in Building 6580, and
- Handling any significant quantities of pyrophoric material in the Zone 2A canyon of Building 6580.
- OSHA considerations for operation.

Standard industrial hazards (e.g., electrocution, handling accidents) are developed in the PHCs only to the extent that they are initiators and contributors to accidents that could potentially lead to the release of hazardous or radioactive material. Although major, non-contributory industrial accidents are identified in the PHCs, these hazards are screened from further evaluation.

An external event screening assessment is also used to identify hazards to the SNL HCF and associated radioactive material storage locations. This approach is consistent with the methods recommended by the Nuclear Regulatory Commission (NRC) for external events as part of probabilistic risk assessments (NRC 1983). Whereas PHCs are used to document hazards at specific facility locations (i.e., process-related hazards), external events screening is used to characterize and screen all conceivable natural and man-made external initiating events. Only those external events that present a plausible threat to the HCF or associated radioactive material storage locations are considered further in the hazard evaluation as accident initiators. Appendix 3B contains a thorough discussion of the external events screening methodology and the categorization of each event, including those events dropped from further consideration.

3.3.1.2 Hazard Evaluation

This section presents the basic approach used to generate the qualitative consequence and likelihood estimate used to categorize HCF and radioactive material storage location hazards. Two types of analytical methods are used to evaluate hazards: 1) preliminary hazards analysis (PHA), and 2) failure modes and effects analysis (FMEA). PHA is an accident scenario-based form of analysis; that is, hazardous situations (e.g., radioactive release, fire, and explosion) are first postulated, then a structured investigation of how such a situation could occur (as well as other system/facility response issues) follows. The PHA for the HCF and radioactive material storage locations documents potential accident initiating events, preventive and mitigative features, anticipated consequences, and safety enhancements (e.g., procedures, system upgrades, additional accident analysis) required to adequately compensate for the existing hazard. The PHA is presented in Appendix 3C.

FMEA is a complementary type of evaluation that utilizes a system failure-based form of analysis. Unlike PHA, the first objective of FMEA is to subdivide the facility into several different (and, to the maximum extent possible, independent) system elements. Failure modes of each system element are then postulated and a structured examination of the consequences of each failure mode follows. However, similar to PHA, FMEA documents preventive and mitigative features and anticipated accident consequences. Appendix 3D contains the FMEA for the HCF.

Two distinctly different, yet complementary, perspectives of hazards for the HCF and associated radioactive material storage locations can be obtained by using both PHA and FMEA techniques. Multiple perspectives assist in more fully identifying and developing facility designs, operational safety improvements, and administrative features contributing to defense in depth, worker safety, and environmental protection. The results of the PHA and FMEA serve as the basis for hazard ranking so that bounding accident scenarios can be selected for further development. Hazard ranking is achieved by qualitatively assigning frequency and consequence estimates to each hazard or accident scenario developed in the PHA or FMEA. Tables 3.3-1 and 3.3-2 present the hazard ranking framework used to categorize these events (consequence and frequency, respectively). All consequence and frequency estimates were based on the consensus engineering judgment of the hazard analysts conducting the PHA and FMEA. Consequence estimates were made assuming the failure of all mitigating systems and actions.

Table 3.3-3 presents the risk ranking matrix used to compare all hazards and accident scenarios identified in the PHA and FMEA. A discussion of each risk measure is also provided. The risk ranking results serve as the basis for determining if a more detailed, quantitative analysis of specified hazards or accident scenarios is required.

Table 3.3-1 Consequence Severity Categories.

Category	Affected Population/Entity			
	Public	**Environment**	**Collocated Worker**	**Worker**
A	• Immediate health effects	• Significant off-site contamination requiring cleanup	• Immediate health effects	• Loss of life
B	• Latent health effects	• Moderate to significant on-site contamination • Moderate off-site contamination	• Latent health effects	• Severe injury or disability
C	• Irritation or discomfort but no permanent health effects	• Moderate contamination of facility • Minor onsite contamination • Minor off-site contamination	• Irritation or discomfort but no permanent health effects	• Lost time injury but no disability
D	• No significant offsite impacts	• Minor contamination of facility • Negligible onsite contamination • Negligible off-site contamination	• No significant impacts	• Minor or no impact or disability

Table 3.3-2 Frequency Categories.

Category	Characteristic Word	Frequency (F) Per Year	Description
I	Normal Operations	$F \geq 1$	Normal Operations
II	Likely or Anticipated	$1 > F \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)
III	Unlikely	$10^{-2} > F \geq 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this frequency category include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
IV	Very Unlikely	$10^{-4} > F \geq 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility. This category includes the design basis accidents.
V	Extremely Unlikely	$10^{-6} > F$	All other accidents. Accidents too unlikely to be considered in the design basis. Some accidents in this frequency category may be evaluated as beyond design basis accidents.

Table 3.3-3 Risk Ranking Matrix.

Consequence Category	Frequency Category				
	I	II	III	IV	V
A	1	1	2	2	3
B	1	1	2	3	4
C	2	2	3	3	4
D	3	3	4	4	4

Risk Ranking 1: Hazard or accident scenario poses a high risk to the public, collocated workers, workers, or the environment. Immediate actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. Risk Ranking 1 events are analyzed quantitatively in the accident analysis.

Risk Ranking 2: Hazard or accident scenario poses a moderate risk to the public, collocated workers, workers, or the environment. Near- to moderate-term actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. Risk Ranking 2 events are analyzed quantitatively in the accident analysis.

Risk Ranking 3: Hazard or accident scenario poses a minor risk to the public, collocated workers, workers, or the environment. Moderate- to long-term actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. No further analysis is required for Risk Ranking 3 events.

Risk Ranking 4: Hazard or accident scenario poses a very minor risk to the public, collocated workers, workers, or the environment. Long-term actions should be considered by the facility manager to reduce the potential consequences or likelihood of these events. No further analysis is required for Risk Ranking 4 events.

3.3.2 Hazard Analysis Results

The following sections present the results of the hazard analysis. All major hazards are identified and evaluated using qualitative risk criteria; and the final hazard classification for the facility (DOE-STD-1027-92) is presented. Finally, planned design and operational safety improvements are discussed in light of the hazard analysis, and a discussion of the facilities design and administrative features contributing to defense in depth, worker safety, and environmental protection is provided.

3.3.2.1 Hazard Identification

This section presents the results of the hazards identification activities. As mentioned previously (see Section 3.3.1.1), PHCs and an external events screening assessment are used to identify and document the fundamental hazards affecting the HCF and the radioactive material storage areas. The PHCs, which are presented in Appendix 3A, identify the process-related hazards. The external events screening assessment, which is contained in Appendix 3B, identifies and categorizes the external event threats to which the facilities could be subjected. No external events were identified as posing a unique hazard, separate from the internal hazards to the HCF. Table 3.3-4 summarizes the results of the PHCs and the external events screening assessment in terms of hazard type, location, and material at risk. The hazards summarized in Table 3.3-4 apply to all facilities locations for HCF isotope production and the HCF associated radioactive material storage locations.

Because the HCF conducts primarily repetitive, isotope processing activities, the specific hazards can be readily identified as corresponding to the activities, materials, facilities, and equipment of the separation process for medical isotopes. Specific hazards were analyzed by the operation, process, and location involved. Handling and processing of various isotopes will have similar hazards that can also be characterized and evaluated against those described in this SAR.

The principal hazards associated with the HCF result from having radioactive material in the form of volatile halogens generated during processing, process solids, process solutions, and solid radioactive process waste. The type and quantity of radionuclides that could be located in the HCF are bounded by isotope production requirements. The HCF has the capacity to produce 100% of the current U.S. demand for Mo-99, which is currently estimated to be about 20,000 curies of Mo-99 per week at the time of processing. This level of production would require the processing of about 30 irradiated isotope production targets per week, or an average of six per day. The radiological inventory associated with six irradiated targets forms the basis of hazard and consequence evaluation, since the residual process materials will be solidified each day and would therefore be rendered into a much less volatile form. Each irradiated target will typically contain 9,000 to 12,000 curies, but may contain in excess of 18,000 curies of mixed fission products. The most hazardous constituent of this mix is the radioiodine inventory, which accounts for 10% to 15% of the total activity. For the Mo-99 isotope separation process, most (75%) of the target activity remains in the residual process liquid after the isotope products are extracted. After neutralization and solidification, the waste container for each target is transferred to radioactive waste barrels in the pit in the floor of the Zone 2A canyon. From there the waste barrels are moved for interim storage into Room 109 to allow fission product decay. The potential 180 waste barrels of decayed radioactive waste in the Room 109 waste storage area could contain a total fission product inventory of up to 500,000 curies.

Table 3.3-4 Hazard Identification Summary.

Hazard Type	Accident Scenario(s)	Material at Risk
Radiological (direct radiation)	• Transfer cask breach exposes target in forklift incident. • Mishandling exposes target as cask is removed from STB to Zone 2. • Mishandling during waste storage exposes fresh waste barrel. • Combined mechanical failure and human error exposes entire radioactive waste inventory. • Mishandling/procedural violation during product sample extraction or analysis. • Procedural violation during waste storage near Zone 2A canyon airlock (scattered radiation).	• Irradiated isotope production target, up to 20,000 curies. • Irradiated isotope production target, up to 20,000 curies. • Fresh waste barrel, up to 120,000 curies. • Entire waste inventory, up to 500,000 curies. • Up to approximately 10 curies of isotope product extract. • Radioactive waste inventory, up to 500,000 curies.
Radiological (spill)	• Spill of target process or residue liquid in extraction SCB. • Spill of isotope liquid product in purification SCB. • Transportation inner packaging breach spills isotope liquid product in Zone 2.	• One or multiple targets or process residues at up to 20,000 curies each. • Entire isotope product shipment, up to 1,000 curies. • Entire isotope product shipment, up to 1,000 curies.
Radiological (airborne release)	• Target/transfer cask breach releases target volatiles outside, in Zone 2, in STB, or in Zone 2A canyon. • Target volatile release prior to or during process connection to cold trap or iodine trap in extraction SCB. • Release of stored volatiles in cold traps before required decay time.	• Target volatiles up to 5,000 curies of noble gases and halogens. • Target volatiles up to 5,000 curies of noble gases and halogens. • Volatiles in process cold traps, up to 70,000 curies.
Radiological (criticality)	• Gross procedural error or rearrangement of fissile material and flooding of the HCF.	• Up to 63 kg ^{235}U in cement waste.
Radiological (contamination)	• Nitrogen release in SCB causes overpressure and contamination of Zone 2A canyon or Zone 2. • Ventilation system failure.	• Process fission products and actinides as loose contamination in SCB.

Table 3.3-4 Hazard Identification Summary (continued).

Hazard Type	Accident Scenario(s)	Material at Risk
Toxic (spill)	• Release of process extraction and purification chemicals in SCBs due to syringe or other glassware breakage. • Spill of quality control analysis bulk chemicals in the SGB or ventilation hoods, • Spill of volatile organic solvents used for maintenance in the HCF.	• Corrosive acid and base chemicals of the isotope production process in syringes, less than 400 ml per target. • Small bulk quantities of acid, base, and organic chemicals (less than a liter) used in SGB and vent hoods in quality control tests. • Small bulk quantities of volatile organic solvents (1 liter or less in Zone 2 or 2A when radiological materials present and 4 liters at other times; 100 ml or less in an SCB with radiological material present and 1 liter at other times).
Fire (radiological and toxic material)	• Forklift fire incident causes transfer cask breach with possible target exposure and airborne release • Failure of electrical equipment or system in SCBs, SGB, ventilation hood, Zone 2 or Zone 2A canyon • Lightning strike • External fire (vehicle accident, aircraft crash, other building fire)	• Irradiated isotope production target, up to 20,000 curies. • Volatiles in process cold traps, up to 70,000 curies. • Same material as toxic spill. • Residual radiological contamination.
Explosion (radiological and toxic material)	• Chemical explosion in SGB, ventilation hood, Zone 2 or Zone 2A canyon • Hydrogen explosion in Zone 2A canyon elevator pit or Room 109 radioactive waste storage area • Organic solvent explosion.	• Up to approximately 10 curies of isotope product extract. • Same material as toxic spill. • Residual radiological contamination. • Radioactive waste inventory, up to 500,000 curies.

Specific inventories of radionuclide activities for irradiated isotope production targets and associated radioactive waste are evaluated in Section 3.4 of this SAR. Administrative controls, including both HCF operations procedures and TSRs, are established based on these evaluations to accomplish processing operations safely.

Principal hazards for the HCF radioactive material and equipment storage locations are the radiological hazards associated with the radioactive materials in storage. Administrative controls are used to limit radioactive materials in each identified location outside of the basement of Building 6580 to less than hazard category 2 (HC2) levels (as defined by DOE-STD-1027-92, Change 1). Administrative controls are also used to limit the form of materials in storage. Radiological protection procedures are used to control and mitigate the radiological hazards of personnel access to this material.

The most severe hazard to HCF isotope processing personnel is the potential for direct radiation resulting from irradiated target handling in, transfers to, or transfers out of shielded processing areas and during waste storage activities. Extensive radiation shielding as an integral part of the facility is used to control the direct radiation dose for normal isotope processing operations. The shielding is designed to support the anticipated maximum level of isotope production in the shielded Hot Cell Laboratory and the waste storage area. These operations involve the greatest quantity of radioactive material for the longest periods of time. The most severe hazard to collocated occupational workers and members of the public is the potential inhalation of radioactive material released from operations in the HCF.

The procedure used to separate isotopes from uranium dioxide and to purify them involves acidic and basic chemicals to accomplish a wet chemistry process in the HCF SCBs. Dissolution of uranium dioxide for separation requires heat and resulting pressure in a sealed target. Process glassware and hardware are used for radioactive material confinement. The pressure and vacuum hazards to the worker are mitigated by the construction of the SCBs. Rubber septa in process equipment are typically weak links in confinement of the contents of the pressurized containers. The potential hazard created by the presence of process chemicals is minor compared to the radiological hazard, and will be mitigated by remote handling in the SCBs and by the sealed process hardware and glassware. Any spills of process liquids are contained in spill trays and cleaned up with an acid spill kit in the SCB.

Chemicals used in the quality control analyses in the shielded glove box (SGB) and ventilation hoods of the Quality Control Laboratory involve small (less than a liter) quantities of some acidic and basic chemicals. Small quantities of solvents and flammable organic compounds are also used during processing operations or during cleaning of process locations. Workers performing quality control analysis use chemical handling procedures as required by the Sandia ES&H Manual (SNL 1998).

The potential for explosions internal to the HCF proper to result in a release of radiological material was considered in the identification of hazards. The likelihood and severity of an explosion is limited by administrative control of the quantity of volatile materials in the HCF and by the circulation and dilution provided by the HCF ventilation system. Further, compressed gases such as acetylene or propane would be contained in standard industrial containers or bottles, which have been developed and approved for commercial use. The spontaneous failure of such containers is extremely unlikely. The potential for accumulation of explosive levels of gases in the HCF is mitigated by the operation of the ventilation system, which dilutes and removes volatile materials from the HCF atmosphere. Restrepo extensively evaluated the potential for an explosion in the HCF (Restrepo 1995). The analysis was based on the spill of up to five gallons of the most volatile solvent expected to be used in the HCF, acetone. This potential was reexamined in light of the current configuration of the ventilation system. As long as the ventilation system is operating, an explosive level of flammable vapor is precluded. Facility administrative controls can be implemented to preclude the realization of this hazard.

Liquid nitrogen is used to cryogenically trap radioactive noble gases evolved during the isotope extraction and separation process. Plumbing restricts the liquid nitrogen to the Zone 2A canyon to mitigate the liquid nitrogen cryogenic hazard.

The potential for a criticality accident in the HCF has been formally addressed in a criticality safety assessment (CSA) (Mitchell and Romero 1999). This assessment concluded, based on the quantities of fissile materials and the physical and administrative features implemented to handle fissile materials, that criticality is not a credible event in the HCF.

3.3.2.2 Hazard Classification

This section presents the results of the final hazard classification activity specified in DOE-STD-1027-92 (DOE 1992b). Hazard category 2 (HC2) is distinguished by hazard analysis that shows the "potential for significant on-site consequences" as defined by DOE Order 5480.23 (DOE 1994a). The final categorization is based on the criteria specified in DOE-STD-1027 of an unmitigated release of available hazardous material that could produce total doses of 1 rem in the range of 100 meters from the facility. The hazard classifications of the HCF and associated radioactive material storage areas are based primarily on the definitions of nuclear facilities and on the ground rules of the DOE guidance on hazard classification in DOE-STD-1027-92. In accordance with DOE-STD-1027-92, facilities or facility segments where there are combinations of radioactive materials are designated as HC 2 or 3 if the sum of the ratios of the quantity of each material to the HC 2 or 3 thresholds exceeds one or if the quantity of fissile isotopes provides the potential for a criticality event. The hazard category thresholds were taken from Table A.1 of DOE-STD-1027-92, Change 1.

The facilities have been divided into multiple segments for final hazard categorization:

- The basement of Building 6580;
- Each of the monorail storage holes adjacent to Building 6580;
- Building 6596; (east high bay and chapel)
- Building 6597 high bay.

The final hazard classification for each facility segment is shown in Table 3.3-5. Since the radiological inventory of two maximally irradiated targets will exceed the DOE-STD-1027 criterion for classification as HC2, the basement of B6580 is clearly so classified, since processing rates of up to six targets per day will be considered as routine operations. The isotope processing locations in the HCF (SCBs) are treated as one combined segment since they are in such close proximity in the basement of Building 6580 and utilize a common ventilation system.

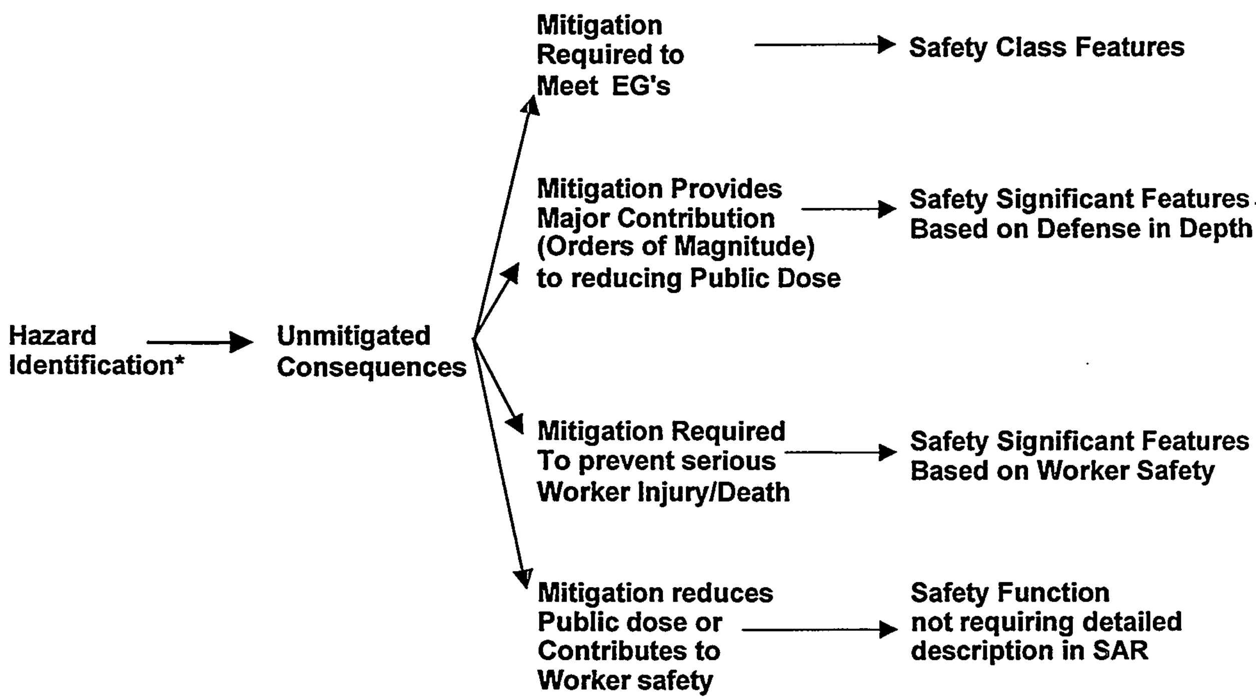
Table 3.3-5 Final Hazard Classification of Radiological Facilities Covered by this SAR.

Facility Segment	Final Hazard Category
The basement area of Building 6580 with isotope processing locations and waste storage area	2
Each monorail radioactive material storage hole outside and adjacent to Building 6580	3
Building 6596 east high bay and chapel radioactive material storage locations	3
Building 6597 high bay radioactive material storage location	3

As provided for in DOE-STD-1027, the other facility segments: each monorail storage hole, the Building 6596, and Building 6597 high bay are treated as separate segments because of the separate locations and the lack of potential for a release at one location to influence the radioactive material at another. The high degree of independence justifies this facility segmentation. The radioactive material inventories for each of the monorail storage holes, Building 6596, and Building 6597 high bay are controlled independently by administrative procedures to be less that the HC2 threshold. These procedures require the determination of radiological inventory and the comparison to HC2 thresholds each time radiological material is moved into a storage location. Since the Auxiliary Hot Cell Facility (ACHF) will be co-located in B6597, the radiological inventory in B6597 will be managed taking into account both operations. Radioactive materials associated with the HCF are used or stored at other storage locations in TA-V but the inventories of radioactive materials at these unidentified storage locations are kept below the HC3 threshold by administrative controls.

3.3.2.3 Hazard Evaluation

A systematic process is used to evaluate each of the hazards, potential consequences, and mitigative features that have been identified in the hazard analysis, using PHA and FMEA techniques. The potential mitigation which may be available in normal, abnormal, and accident conditions is then examined and an assessment made as to its contribution to public and to worker safety. This process is depicted in Figure 3.3-1, and leads to the identification of Safety SSC's and safety benefits which contribute to public or worker safety but which do not meet the criteria for identification as Safety SSCs. This identification is further reflected in HCF TSR's for Safety SSC's and in HCF operating or administrative procedures.



* Hazards are identified for purposes of SAR Accident Analysis and excludes OSHA considerations in accordance with DOE-STD-3009.

Figure 3.3-1 Hazard Evaluation Process: Identification of Safety Functions and Safety Related SSC's

The criteria which are used to identify mitigation which provides a major contributor to defense in depth or which prevents serious worker injury or death are described in DOE-STD-3009-94 (DOE, 1994b). Safety SSCs that provide mitigative or preventive functions are divided into two categories: (1) safety-class and (2) safety-significant. Safety-class SSCs (SCSSCs) are those SSCs, including environmental monitors and portions of process systems, whose failure could adversely affect the environment or safety and health of the public as identified by safety analysis. The phrase "adversely affect" refers to exceeding offsite Evaluation Guidelines (EGs) (i.e., a whole-body dose of 25 rem to the nearest located member of the public). SCSSCs are systems, structures, or components whose preventive or mitigative function is necessary to keep hazardous material exposure to the public below the EGs.

Safety-significant SSCs (SSSSCs) are those whose preventive or mitigative function is a major contributor to defense in depth (i.e., prevents an uncontrolled hazardous material release) and/or worker safety as determined from hazard analysis. SSSSC designations based on worker safety are limited to those systems, structures, or components whose failure is estimated to result in an acute worker fatality or serious injuries to workers. Serious injuries, as used here, are those injuries requiring medical treatment for immediately life-threatening or permanently disabling injuries (e.g., loss of eye or limb) from other than standard industrial hazards. It specifically excludes potential latent effects (e.g., potential carcinogenic effects of radiological exposure or uptake).

Each of the hazards and accident scenarios identified in Section 3.3.2.1 (see Table 3.3-4) is developed further using qualitative evaluation techniques (PHA and FMEA) (see Appendices 3C and 3D, respectively). Multiple qualitative evaluation techniques are used to assess the hazards from different perspectives. Based on the PHA and FMEA efforts, each hazard and accident scenario is qualitatively assigned a consequence and frequency category consistent with Tables 3.3-1 and 3.3-2, respectively. Consequences were based conservatively on releases or exposures mitigated only by the inherent physical form of the material, facility physical shielding, and ventilation system transport for stack release. From these qualitative assignments, each hazard and accident scenario is also categorized by its risk ranking (per Table 3.3-3). Table 3.3-6 summarizes the results of the hazard evaluation for the public and the environment, and the results of the hazard evaluation for workers and collocated workers are summarized in Table 3.3-7. Since these are summary tables, some of the frequency and consequence categories reflect multiple classifications. Reference should be made to the complete hazard tables in Appendix 3C for additional clarification of the summary information.

Table 3.3-6 Hazard Evaluation Results for the Public and the Environment.

Hazard Type	Accident Scenario	Frequency Category (Note 1)	Consequence Category (Note 2)	Risk Ranking (Note 3)
Radiological (direct radiation)	• Transfer cask breach exposes target in forklift incident (TT-1 through TT-4) • Mishandling exposes target as cask is removed from STB to Zone 2 (CP-2) • Mishandling during waste storage exposes fresh waste barrel (WE-3) • Combined mechanical failure and human error exposes entire radioactive waste inventory (WS109-3) • Mishandling/procedural violation during product sample extraction or analysis (Q-1 & Q-2) • Procedural violation during waste storage near Zone 2A canyon airlock (scattered radiation) (WE-2)	• III • IV • III • III • III • II	• D • D • D • D • D • D	• 4 • 4 • 4 • 4 • 4 • 3
Radiological (spill)	• Spill of target process or residue liquid in extraction SCB (CP-9) • Spill of isotope liquid product in purification SCB (CP-10) • Transportation inner packaging breach spills isotope liquid product in Zone 2 (P-3)	• I • I • IV	• D • D • D	• 3 • 3 • 4
Radiological (airborne release)	• Target/transfer cask breach releases target volatiles outside, in Zone 2, in STB, or in Zone 2A canyon (TT-3, TT-4, CP-1 & CP-3) • Target volatile release prior to or during process connection to cold trap or iodine trap in extraction SCB (CP-4, CP-6, & CP-11) • Release of stored volatiles in cold traps before decay (CP-6 & WP-2)	• III & IV • II, V, & III • V & III	• D • C-D • C & D	• 4 • 3-4 • 3 &4

Table 3.3-6 Hazard Evaluation Results for the Public and the Environment (continued).

Hazard Type	Accident Scenario	Frequency Category (Note 1)	Consequence Category (Note 2)	Risk Ranking (Note 3)
Radiological (criticality)	• Gross procedural error or rearrangement of fissile material and flooding of the HCF (CSA)	• V	• D	• 4
Radiological (contamination)	• Nitrogen release in SCB causes SCB overpressure and contamination of Zone 2A canyon or Zone 2 (CP-12) • Ventilation system failure causes contamination of Zone 1, Zone 2A canyon, or Zone 2 (CP-13)	• II • II	• D • D	• 3 • 3
Toxic (spill)	• Release of process extraction and purification chemicals in SCBs due to syringe or glassware breakage (CP-8) • Spill of quality control analysis bulk chemicals in the SGB or vent hoods • Spill of organic solvents in Zone 2, Zone 2A canyon, or SCB (HM-1)	• I • I • II	• D • D • D	• 3 • 3 • 3
Fire (radiological and toxic material)	• Forklift fire incident causes transfer cask breach with possible target exposure and airborne release (TT-4 & CP-1) • Failure of electrical equipment or system in SCBs, Zone 2A canyon, Zone 2, or Room 109 (CP-7, WP-3, WE-1, WS 109-1, & HM-2) • Lightning strike (Appendix 3B) • External fire (vehicle accident, aircraft crash, other building fire) (App. 3B)	• IV • IV • IV • IV	• D • C-D • D • D	• 4 • 3-4 • 4 • 4
Explosion (radiological and toxic material)	• Chemical explosion in Room 113 ventilation hood (Q-3) • Hydrogen explosion in Zone 2A canyon elevator pit or Room 109 radioactive waste storage area (WE-4 & WS109-2) • Organic solvent explosion in Zone 2, Zone 2A canyon, or SCB (HM-2)	• IV • IV • IV	• D • D • D	• 4 • 4 • 4

Note 1: See Table 3.3-2.
Note 2: See Table 3.3-1.
Note 3: See Table 3.3-3.

Table 3.3-7 Hazard Evaluation Results for Workers and Collocated Workers.

Hazard Type	Accident Scenario	Frequency Category (Note 1)	Consequence Category (Note 2)	Risk Ranking (Note 3)
Radiological (direct radiation)	• Transfer cask breach exposes target in forklift incident (TT-1 through TT-4) • Mishandling exposes target as cask is removed from STB to Zone 2 (CP-2) • Mishandling during waste storage exposes fresh waste barrel (WE-3) • Combined mechanical failure and human error exposes entire radioactive waste inventory (WS109-3) • Mishandling/procedural violation during product sample extraction or analysis (Q-1 & Q-2) • Procedural violation during waste storage near Zone 2A canyon airlock (scattered radiation) (WE-2)	• III • IV • III • III • III • II	• A-C & D • B-C & D • A-C & D • A-B & D • D • C & D	• 2-3 & 4 • 3 & 4 • 2-3 & 4 • 2 & 4 • 4 2 & 3
Radiological (spill)	• Spill of target process or residue liquid in extraction SCB (CP-9) • Spill of isotope liquid product in purification SCB (CP-10) • Transportation inner packaging breach spills isotope liquid product in Zone 2 (P-3)	• I • I • IV	• D • D • C & D	• 3 • 3 • 3 & 4
Radiological (airborne release)	• Target/transfer cask breach releases target volatiles outside, in Zone 2, in STB, or in Zone 2A canyon (TT-3, TT-4, CP-1 & CP-3) • Target volatile release prior to or during process connection to cold trap or iodine trap in extraction SCB (CP-4, CP-6, & CP-11 • Release of stored volatiles in cold traps before decay (CP-6 & WP-2)	• III & IV • II, V, & III • V & III	• A-C & D • C-D & C-D • D & C	• 2-3 & 4 • 3-4 • 4 & 3
Radiological (criticality)	• Gross procedural error or rearrangement of fissile material and flooding of the HCF (CSA)	• V	• D	• 4
Radiological (contamination)	• Nitrogen release in SCB causes SCB overpressure and contamination of Zone 2A canyon or Zone 2 (CP-12) • Ventilation system failure causes contamination of Zone 1, Zone 2A canyon, or Zone 2 (CP-13)	• II • II	• D • C	• 3 • 2

Table 3.3-7 Hazard Evaluation Results for Workers and Collocated Workers (continued).

Hazard Type	Accident Scenario	Frequency Category (Note 1)	Consequence Category (Note 2)	Risk Ranking (Note 3)
Toxic (spill)	• Release of process extraction and purification chemicals in SCBs due to syringe or glassware breakage (CP-8) • Spill of quality control analysis bulk chemicals in the SGB or ventilation hoods • Spill of organic solvents in Zone 2, Zone 2A canyon, or SCB (HM-1)	• I • I • II	• D • D • D	• 3 • 3 • 3
Fire (radiological and toxic material)	• Forklift fire incident causes transfer cask breach with possible target exposure and airborne release (TT-4 & CP-1) • Failure of electrical equipment or system in SCBs, Zone 2A canyon, Zone 2, or Room 109 (CP-7, WP-3, WE-1, WS 109-1, & HM-2) • Lightning strike (Appendix 3B) • External fire (vehicle accident, aircraft crash, other building fire) (App. 3B)	• IV • IV • IV • IV	• A-C & D • D-C • D • D	• 2-3 & 4 • 4-3 • 4 • 4
Explosion (radiological and toxic material)	• Chemical explosion in Room 113 ventilation hood (Q-3) • Hydrogen explosion in Zone 2A canyon elevator pit or Room 109 radioactive waste storage area (WE-4 & WS109-2) • Organic solvent explosion in Zone 2, Zone 2A canyon, or SCB (HM-2)	• IV • IV • IV	• D • C & D • D	• 4 • 3 & 4 • 4

Note 1: See Table 3.3-2.
Note 2: See Table 3.3-1.
Note 3: See Table 3.3-3.

The major findings of the hazard evaluation are summarized as follows:

- Risk to the public or the environment is minor or very minor for all hazard types due to the minor consequences of the hazard events.
- Hazards to the public are dominated by the potential for release of radioactive volatile halogens and noble gases. These hazards have the highest consequences.

- The highest risk to workers results from direct radiation exposure, airborne release hazards, or radiological contamination in the work area. These hazards involve an irradiated target or the radioactive inventory of solidified process effluent and other target residue.
- Radiological and toxic chemical liquid spills in the SCB are of minor risk to the worker even though the frequency of occurrence is high (normal operations) because the consequences are so low for material spilled in the SCBs.
- Fire and explosion are also a minor risk to the worker due to the low probability and low consequences, even in a shielded glove box or ventilation hood. The exception was a combination fire and forklift crash that stimulated or enhanced an airborne release with high to moderate consequences.

3.3.2.3.1 Planned Design and Operational Safety Improvements

Based on the hazard evaluation, no additional design and operational safety improvements are required for the SNL HCF or the HCF associated radioactive material storage areas.

The following improvements have been identified as desirable for improving operational conditions in the HCF:

- Room 109 shield door interlocks which are enabled from the Operations Center.
- Closed circuit video coverage of HCF areas for personnel monitoring during high hazard operations such as waste handling.
- Remote RAM/CAM displays and data recording in the operations center.
- Intercom communications at each operating station.
- Replacement of the shield door control system.
- Capability to retrieve solidified waste from Room 109 and prepare it for off-site shipment in Room 108.

3.3.2.3.2 Defense in Depth

This section describes the approach for identifying the elements that contribute to defense in depth in the HCF. Elements that provide a major contribution are identified as "safety-significant" in accordance with criteria specified in DOE-STD-3009-94 and are carried forward as operational commitments described in Chapters 4 and 5 of this SAR.

The defense-in-depth philosophy is a fundamental approach to hazard control for nuclear facilities. In keeping with the graded-approach concept, no requirement to demonstrate a generic, minimum number of layers of defense in depth is imposed by the DOE. However, defining defense in depth as it exists at the HCF is crucial for determining a safety basis. In the event that one layer of defense in depth is compromised from either equipment malfunction or operator error, and there is a progression from the normal to an abnormal range of operation, the next layer of defense in depth is relied upon. Structures, systems or components that are major contributors to defense in depth (i.e. prevention of uncontrolled releases of hazardous materials) are designated as safety-significant SSC's. However, not all SSC's with a safety benefit necessarily require categorization as safety-significant. Indeed, to effectively apply the graded approach, one is obligated in the SAR to distinguish between those SSC's which are major contributors (i.e., safety-significant) and those which are simply contributors, by focusing on the most important items of defense in depth whose failure could result in the most adverse uncontrolled releases of hazardous material.

The defense in depth philosophy is embodied in all HCF operations through safety features that prevent the uncontrolled release of hazardous levels of radioactive or toxic material in normal and abnormal conditions. Only a limited set of these features meet the criteria of providing a major contribution to preventing or mitigating an uncontrolled release, leading to identification as SSSSC's.

The hazards which have the greatest potential for resulting in dose consequences to the public are due to the unintended or accidental spill of volatile process constituents (i.e. noble gases and halogens) during isotope processing, as identified and summarized in Section 3.3.2.3. Under normal operating conditions, the majority of the volatile constituents will be inside process containers and the amount available for release is significantly limited. Under abnormal conditions, the constituents could be released to the process box volume, and under accident conditions, as analyzed in Section 3.4, the constituents could be released to the process box volume and/or to other regions of the HCF.

Many features, such as process containers, and processing functions which compartmentalize or reduce material volatility provide a safety benefit by physically limiting the quantities of radiological materials which are at risk of being released and the form and volatility of such materials. In fact, these features (quantity and form) reduce the hazard levels associated with isotope processing activities to very low levels of concern for public risk. During most periods (other than that period of time when handling volatile process constituents), the available source term is limited and in a form which presents a negligible hazard to the public.

Abnormal and accident events, which may occur during isotope processing, can result in the unintentional release of radiological materials to the SCB processing volume. Operator training and process equipment design are both used to reduce the likelihood of this event, however, it is an anticipated event during the lifetime of the facility. In the event of release of material from the processing containers, the processing steel confinement box (SCB) prevents the uncontrolled migration of these radiological materials. If the SCB fails or is ineffective, the Zone 2A canyon boundary acts as a secondary confinement barrier to mitigate the uncontrolled release of hazardous materials.

In normal operations, the Zone 1 ventilation system draws on the SCB volume, which gradually removes the volatile elements from the SCB volume. The halogens, which dominate the overall hazard, would first be deposited on the in-box charcoal filter. This filter acts to capture the majority of the halogens so as to mitigate buildup on the downstream ventilation system ducting and filters. The in-box filter is not relied upon, however, to perform a defense in depth function, since access to it for ascertaining functionality is difficult and it's performance to capture halogens cannot be assured on a routine basis. The Zone 1 ventilation system draws the SCB exhaust through two additional charcoal filters located in the MER, downstream of the in-box filter. The ventilation flow continues through two HEPA filters prior to being discharged from the HCF stack. The charcoal filters should remove the majority of volatile halogens, and are relied upon to meet EPA guidelines. Both filter systems perform a defense in depth function during normal and abnormal operations, as well as in most accident scenarios, by substantially mitigating the amount of radiological material which is released to the atmosphere.

In summary, the following defense in depth features exist in the HCF:

Physical Features:

- Process compartmentalization and containerization,
- Form and physical characteristics of process materials,
- Primary confinement boundary provided by the SCB's,

- Multiple primary confinement ventilation filters at disparate locations,
- Secondary confinement boundary provided by the Zone 2A canyon walls,
- Independent secondary confinement filters, and
- Confinement system maintenance and verification.

Administrative Features:

- Administrative limitations on material at risk (source term),
- Operating procedures and operator training, and
- Limitations on quantities of flammable materials which might jeopardize confinement boundaries.

Each of these features provides a safety benefit, however not all of these features are necessary to mitigate dose consequences to acceptable levels. Only those features that are relied upon to function or actuate to prevent or mitigate uncontrolled releases of radioactive materials are so identified. Analyses accomplished to evaluate the consequences of release of radiological materials, described in Section 3.4, identify those SSC's that are part of the primary success path in each scenario. The SSC's so identified are associated with a significant mitigation of radiological releases in abnormal and accident scenarios and therefore perform a defense in depth Safety Function.

While fire protection systems are typically considered important to safety, fire protection in the HCF does not provide a major contribution to defense in depth due to the limited quantity of flammable materials permitted in the process extraction SCB's and the form and containerization of the hazardous process materials. A fire in an SCB does not threaten the ventilation system filters and would normally not result in any significant release of hazardous materials. The fire scenario has been evaluated and included in the accident analyses described in Section 3.4, which indicates that the release is bounded by the consequences of a process spill in the SCB.

Identification of Safety-Significant SSC's

The confinement and filtration features that are available during processing are the major contributors to defense in depth and are identified as safety significant SSC's during normal and abnormal operations. The multiple zone confinement system isolates radiological materials in unoccupied and controlled areas of the HCF. It restricts migration of radiological materials so that workers and the public are not exposed to these materials. The filters remove hazardous radiological material that may be drawn out of contaminated areas in normal and abnormal scenarios by the ventilation system by several orders of magnitude.

The features of the confinement and ventilation system that provide defense in depth and that have been identified as safety significant are:

- Primary confinement provided by Process Extraction SCB's and Zone 1 exhaust ducting from the SCBs up to the HEPA filters at the HCF Stack,
- Secondary confinement provided by the walls surrounding the Zone 2A canyon and Zone 2A ventilation exhaust ducting up to the HEPA filters at the HCF Stack,
- Ventilation system charcoal filters in the MER, and
- Ventilation system HEPA filter at the HCF Stack.

Process Extraction SCB's (SCB's 2, 3, 4, and 5) and associated ducting

The most hazardous radiological inventory will exist in the extraction processing SCB's (SCB's 2, 3, 4 and 5), where the initial wet chemistry processes draw out the most volatile radioisotopes (noble gases and halogens). Thus, the confinement function of the extraction SCB's and associated ducting provides a major contribution to defense in depth by providing a barrier to the uncontrolled migration of these volatile constituents and assures that any materials released from the process are drawn through filters prior to being released to the environment. This also provides a contribution to worker safety by preventing the migration of these constituents into occupied areas of the HCF. Once the contaminated exhaust air passes through the charcoal filters, the halogen inventory in the flow is reduced by several orders of magnitude, significantly reducing the hazard. Although quantities of particulate in the flow stream are expected to be low, the exhaust air is also drawn through a HEPA filter prior to being discharged to the atmosphere through the HCF stack, which will remove most of the particulate that might exist.

Zone 2A Canyon Boundary and associated ducting

In the event of SCB failure, the structures comprising the boundary of the Zone 2A canyon provide a secondary confinement barrier to the release of radioactive materials to the HCF and to the environment. This is a major contributor to defense in depth in that, in abnormal or accident conditions where the SCB boundary has been degraded, an independent and redundant confinement capability exists to mitigate the release of radiological materials. The process of filtration of this airflow is similar to that for Zone 1, however only one stage of charcoal filtration is provided in the MER, based on the expectation that radiological inventories in the Zone 2A canyon will be significantly less than those in Zone 1, except under accident conditions.

Ventilation System Filters

The ventilation system is generally considered important to worker safety in facilities handling and processing radiological materials, and this is the case in the HCF. Only a portion of the ventilation system, however, meets the criteria of DOE-STD-3009-94 so as to be identified as safety significant. The principal purpose of the ventilation system is to maintain an acceptably clean working environment in Zones 1, 2A, and 2. The contamination levels of each of these zones varies considerably, with the environment in Zone 1 unsuitable for human occupancy, and that in Zone 2 expected to be normally occupied. Appropriate radiological conditions are maintained by drawing air and entrained contamination out of each of the zones and exhausting it to the environment through appropriate filters. This action establishes a pressure differential that inhibits the migration of contaminants to occupied areas of the HCF. Air is replenished in each zone from regions of lesser contamination, so the airborne contamination levels in each zone are continually lowered by operation of the ventilation system. The ventilation system also provides the capability to monitor and verify the status of the Zone 1 and Zone 2 confinement barriers by providing a pressure differential across each of the barriers.

The ventilation system purpose described above, that of cleanliness, does not meet the criteria specified in DOE-STD-3009-94 to be identified as safety-significant. Ventilation failure analyses (Mitchell and Naegeli, 1999), summarized in Section 3.4, indicate that without the ventilation system operating, the expected dose to the public is negligible, and the contamination levels which would build up in normally occupied areas of the HCF are several orders of magnitude below that necessary to result in serious injury or death. Of course, normal operations could not continue to be accomplished with an inoperative ventilation system, in that contamination levels would eventually build up in occupied areas so as to result in worker doses which exceed SNL radiation protection administrative control limits and would be operationally unacceptable. Thus, the ventilation system maintains low worker radiation exposure levels by maintaining a clean working environment.

Another purpose of the ventilation system is to filter air drawn from contaminated regions of the HCF before discharging it to the atmosphere in order to capture hazardous contaminants. This reduction in levels of contaminants provided by the charcoal filters and the HEPA filters provides defense in depth in that the concentration of radioisotopes present in the effluent is expected to be reduced by orders of magnitude as described in Section 3.4.2 and in Appendix 3E. Since levels of radioisotopes present in the extraction processing boxes may range from curie levels in normal operating conditions to thousand curie levels under abnormal conditions, this function is of considerable importance for reducing releases of radioactive materials to the atmosphere. The various operating and upset conditions, and the degree of mitigation provided by the filters, is evaluated and described in the accident analyses presented in Section 3.4.

Technical Safety Requirements for SSSSC's

Identified SSSSC's will require TSR coverage to ascertain their integrity and functionality prior to and/or during radiological operations in the facility. The scope of the TSR coverage is determined by the degreé to which the barriers or the facility safety basis are seriously challenged, and criteria for establishing TSR are contained in DOE 5480.22. The passive confinement function provided by the SCB's and the Zone 2A canyon boundary are considered design features, and will require verification of their integrity by monitoring the pressure differential across the boundary. TSRs based on defense in depth will be required for the filters in the ventilation system. The derivation of specific TSRs for the HCF is described in Chapter 5.

3.3.2.3.3 Worker Safety

There are several features protecting workers from the radiological hazards of facility operation. Each of the defense in depth elements described in Section 3.3.2.3.2 also contributes to worker safety in normal and abnormal scenarios by limiting and isolating the radiological hazard. Isotope processing operations in the HCF use radiation shielding and the ventilation system to protect workers from direct radiation and airborne radioactivity. Additionally, various administrative procedures are used to control the hazards, to ensure use of correct and safe procedures, and to mitigate the consequences of accidents. Radioactive material storage facilities at TA-V use radiation shielding, portable radiological instrumentation, contamination control measures such as wrapping or bagging, and radiological postings, as appropriate, to alert and protect workers from direct radiation and radioactive contamination in conjunction with the same types of administrative procedures.

The preventive and mitigative features that contribute to worker safety are detailed in the Hazard Tables (Appendix 3C). The specific features identified in these tables include:

- Shielding provided by Zone 2A canyon walls and windows,
- Shielding provided by Room 109 walls, doors, and ceiling,
- Shielding provided by the target transfer cask,
- Shielding provided by the 20WC shipping container DU insert,
- Access control,
- Operator training and procedures,
- Radiological instrumentation,
- Characteristics of radiological materials,
- Containerization and trapping of volatile fission products,
- In-box charcoal and HEPA filters,

- Ventilation system contamination control function,
- Ventilation system exhaust stack,
- Ventilation system filters/location of filters,
- Radiological material inventory control,
- Limitations on combustible material quantities,
- Target & container mechanical characteristics,
- Spill protection,
- Shielded Glove box/hoods,
- Shield door controls, and
- Target Entrance System Mechanical Interlock.

Programmatic elements that contribute to worker safety are listed below. Each of these safety-management programs are implemented in the HCF:

- Fire Protection Program,
- Radiation Protection Program,
- Quality Assurance Program,
- Criticality Safety Program,
- Emergency Preparedness Program,
- Conduct of Operations Program,
- Qualifications, Procedures, and Training Program,
- Maintenance Programs, and
- Configuration Management.

HCF Management is committed to strict adherence with the SNL Radiation Protection Program Manual (RPPM), which is a significant contributor to worker safety in the HCF. The SAR-related requirements for the HCF radiation protection safety management program are outlined in Chapter 7.

Identification of Safety-Significant SSC's

Of these features, only a limited number meet the criteria for designation as safety significant described in DOE-STD-3009-94. Safety-significant SSC designations based on worker safety are limited to those systems, structures, and components whose failure is estimated to result in an acute worker fatality or serious injuries to workers. (DOE, 1994b). Based on evaluations accomplished in the preparation of the hazard tables (Appendix 3C), there are no credible airborne radiological hazards for workers which could result in a worker fatality or serious injury. Thus, there are no confinement systems designated as safety significant on the basis of worker safety. The only credible risk for worker fatality or serious injury, as described in the Hazard Tables (Appendix 3C) is due to the exposure of workers who are at close proximity to the direct radiation emanating from a source equivalent to an unshielded irradiated target(s) for a significant period of time (several minutes at a distance of 3 feet).

Thus, shielding which provides sufficient attenuation of radiation that precludes death or serious injury should be identified as safety significant. One or two orders of magnitude attenuation of the radiation levels emanating from a maximally irradiated target would be sufficient to provide protection for a sufficient time for workers to separate themselves from the source. This degree of attenuation would be provided by 3 to 6 inches of steel or 10 to 20 inches of concrete. Based on the shielding requirement, the following HCF SSCs are identified as safety-significant SSCs on the basis of worker safety:

- The shield walls surrounding the Zone 2A canyon and the shield walls and doors of Room 109.
- The shielded transfer casks for irradiated target transfer from the ACRR to the HCF.
- The target entrance system features which provide shielding and prevents removal of an unshielded irradiated target.
- The hydraulic shield door controls, which prevent unintended lowering of the shield doors with waste in Room 109.

Technical Safety Requirements for Worker Safety

TSR's for worker safety are implemented principally by design features and administrative controls. These features and controls are described in Chapter 5.

3.3.2.3.4 Environmental Protection

This section summarizes the design and operational features that reduce the potential for significant radiological releases to the environment. In normal operation of the HCF and the radioactive material storage facilities, releases of hazardous liquid or solid material will not occur. Small amounts of gaseous or volatile radioactive material will be released from the HCF stack as part of normal isotope processing activities. These gaseous or volatile radioactive material releases will be continuously monitored and will be within established Environmental Protection Agency requirements. Releases of gaseous or volatile hazardous material are not expected during operation of the radioactive material storage facilities. The potential for such releases during storage is evaluated and appropriately mitigated when the stored material is brought into the specific location.

Design barriers to solid and liquid hazardous material releases include the buildings themselves as well as the process and storage hardware. Design barriers to gaseous and volatile hazardous material releases include the HCF ventilation system and associated charcoal filters.

For accidental releases, the HC3 radioactive material storage areas are administratively controlled to total radioactive inventories in each location to less than HC2 thresholds. Thus, by the definition of these thresholds in DOE-STD-1027-92, accidents in the radioactive material storage facilities would have the potential for only localized consequences. Also in accordance with the definition of the DOE-STD-1027-92 thresholds, accidental releases from the HCF have the potential only for significant on-site consequences. Thus, no release with the potential to cause significant environmental insult exists.

3.3.2.3.5 Accident Selection

Based on the results of the hazard analysis, the accidents posing the greatest risk involve direct exposure to radiation (workers) and airborne releases of radioactive material (the public). Accident analysis entails the formal quantification of a limited subset of accidents as design basis accidents (DBAs). These accidents are to represent "a complete set of bounding conditions" as noted in DOE 5480.23 (DOE 1994a). Further, as stated in DOE-STD-3009-94,

> **"The principal purpose of (SAR) accident analysis is to identify any safety-class SSCs and TSRs needed for protection of the public"** (DOE 1994b).

As indicated in Table 3.3-6, the risk to the public and the environment from the internal isotope production and radioactive material storage accidents was assessed to be minor or very minor, and the application of a graded approach to the accident analyses is appropriate. Since no unique accidents are assessed to be of high risk, representative accidents are chosen to bound a number of similar accidents and form as complete a set of bounding conditions as possible to represent the accident risk to the public and the environment. Accidents from the hazard evaluation with the greatest potential consequences to the public are emphasized in the DBA selection process.

At least one bounding accident from each of the major types has been selected unless the bounding consequences are low. Accident categories are: internally initiated operational accidents (fires, explosions, spills, and criticality); natural phenomena events for the site (e.g. earthquakes, tornadoes) that could affect the facility; and externally initiated, man-made events (e.g. airplane crashes, transportation accidents, and adjacent facility events). Criticality assessments have indicated that criticality is an incredible event for isotope processing operations. Based on these evaluations, criticality has not been included in the hazard analysis and will not be included in the accident analysis.

Most of these internal accidents could be characterized as spills although some could involve fire or explosions. Several design basis accidents (DBAs) were selected to provide representative accidents for further analysis. Besides producing the most risk and highest consequences to the public, these selected DBAs encompass a range of lesser accidents characteristic of the isotope processing operations in the HCF and radioactive material storage in the other facility segments. The DBAs and Beyond DBAs to be quantitatively evaluated as the bounding scenarios for the HCF are listed in Table 3.3-8.

3.4 Accident Analysis

3.4.1 Methodology

This section summarizes the methods used to evaluate and quantify the consequences of operational accidents, natural phenomena events, and external events selected in Section 3.3.2.3.5, Accident Selection as DBAs. Consequences to the public and the environment stem from airborne releases of radioactive material since no liquid or solid radioactive material would be released in the selected accidents. The airborne pathway is of primary interest for releases from nonreactor nuclear facilities according to DOE-STD-1027-92 (DOE 1997). Exposure to direct or scattered radiation is a hazard only for workers due to the distance to the public.

The methods used to quantify the consequences of the DBAs fall into two general categories:

- methods to estimate the radiological or other hazardous material source terms, and
- methods to estimate dose resulting from release of the source term.

Table 3.3-8. Design Basis Accidents

DBA #	Accident Description	Type	Associated Hazard Events
Design Basis Accidents			
1	Operator error or mechanical failure releases volatile contents of the target and/or acid cocktail inside an SCB	Spill	CP-4, CP-10
2	Deflagration of hydrogen in the Zone 2A canyon elevator pit	Explosion,Fire	WE-4
3	Fire in an SCB releases volatile contents of the target, iodine trap, and/or acid cocktail	Fire	CP-7
4	Energetic fork lift accident which breaches target cask, breaches the target, and releases volatile radioactive components in the target; with and without a fork lift fire	Spill, (Exposure,Fire)	TT-1, TT-2, TT-3, TT-4, & CP-1
5	Combustion of hydrogen gas or flammable material in the Room 109 waste storage area	Fire,	WS109-2
6	Ventilation system failure (loss of off-site power)	External Event	CP-13
7	Fire in a HCF associated radioactive material storage area releasing radioactive material from the stored inventory	Fire	RS-1, MS-1
8	Design Basis Earthquake	Natural Phenomena (Earthquake)	Various
Beyond Design Basis Accidents			
1	Multiple simultaneous errors or events that affect multiple SCBs, resulting in release of the volatile contents of multiple targets	Spill	CP-6
2	Earthquake	Natural Phenomena (Earthquake)	
3	Explosion	Explosion	

3.4.1.1 Source Term Estimation

The source term of radiological or other hazardous material is estimated from inventories of hazardous material present in the particular process activity or location. For example, in a spill of dissolved process material solution from one target, the DBA inventory at risk comprises all the fission products and actinides from one target. Inventories (Naegeli 1998) of these constituents have been calculated using a commonly accepted code for such calculations, ORIGEN2 (Oak Ridge Isotope Generation Code). The inventory in a given target will be dependant on the power generated in the target during irradiation (fission rate), the length of time the target was irradiated, and the time that the target was allowed to decay before processing. For Mo-99 production, targets will be typically irradiated for 3 to 7 days at powers of 15 to 20 kw, and will be allowed to decay for 12 hours. Total inventories in such targets would be 8500 to 11,400 curies. To bound future improvements in target irradiation capability, and to provide processing flexibility, the available inventory assumed in this safety analysis will be based on a target which has been irradiated at a power of 20 kW for 21 days, and allowed to decay for only 6 hours. Such a target, identified as a "maximally irradiated target", will have a total fission product inventory of about 18,400 curies, and is the basis of the accident analysis and potential consequences described in this SAR. This inventory will decay to less than 15,000 curies 12 hours after completion of irradiation, or 6 hours after being introduced into the HCF.

The spectral characteristics of the maximally irradiated target are compiled in the ORIGEN analysis of the irradiated target inventory, which characterize the gamma spectrum in 18 energy groups. These characteristics 6 hours after irradiation are summarized in Figure 3.4-1. The average gamma energy of the inventory for targets irradiated 7 and 21 days are shown in Figure 3.4-2 as a function of time after irradiation.

The release of radiological materials in any specific accident scenario is usually less than the total inventory present, depending on the postulated confinement barrier failure in the DBA and the limitations to release inherent in the physical form of the hazardous material. The source term released by initial confinement barrier failure may be reduced even further by mitigative effects which occur during transport or leakage from the facility to the environment. For example, filtration in the ventilation system will normally trap a large fraction of the fission products but would still allow the volatile noble gas fission products to be released from the HCF stack.

The final airborne source term released from the HCF to the environment is calculated using the following formulation from DOE-HDBK-3010-94 (DOE 1994d).

Release Source Term = MAR x DR x ARF x RF x LPF

where: MAR = Material-at-Risk (curies or grams),
DR = Damage Ratio (fraction of MAR affected),
ARF = Airborne Release Fraction (or fraction of MAR x DR that becomes airborne),
RF = Respirable Fraction (or the fraction of airborne particles that are small enough to enter the respiratory system of the body), and
LPF = Leakpath Factor (release reduction from facility features such as plate out, filtering, etc.).

DOE-HDBK-3010-94 provides recommended values of these factors for a wide range of accident release situations, based on tests and accident data. The radiological inventory and physical form of the inventory during processing are significant factors in determining the potential for transport of hazardous materials. Airborne release fractions (ARF) described in DOE-HDBK-3010-94 of 1.0 for halogens and 3E-5 to 6E-3 for other fission products in various liquid/solid forms indicate the degree to which the halogens would dominate the potential consequences of most abnormal and accident scenarios. Similarly, DOE-STD-1027-92 suggests release fractions of 0.5 for halogens and 0.01 to 0.001 for semi-volatile and other solid/powder/liquid materials respectively.

The accident analyses in this SAR will be developed based on the conservative assumption that the entire radiological inventory associated with the number of isotope targets expected to be simultaneously at risk is available in a form which is readily transported, i.e. an ARF of 1.0 will be assumed for all materials. This assumption will apply to the inventory contained in targets which are simultaneously "in-process". "In-process" is defined as that time during which chemical process operations are being conducted on the material subject to release, up to the point of solidification of process residuals. Once process residuals are solidified, the fission products are in a much less volatile state (see waste accident scenario analysis described in Section 3.4.2.4) and the inventory can essentially be considered to be not at risk.

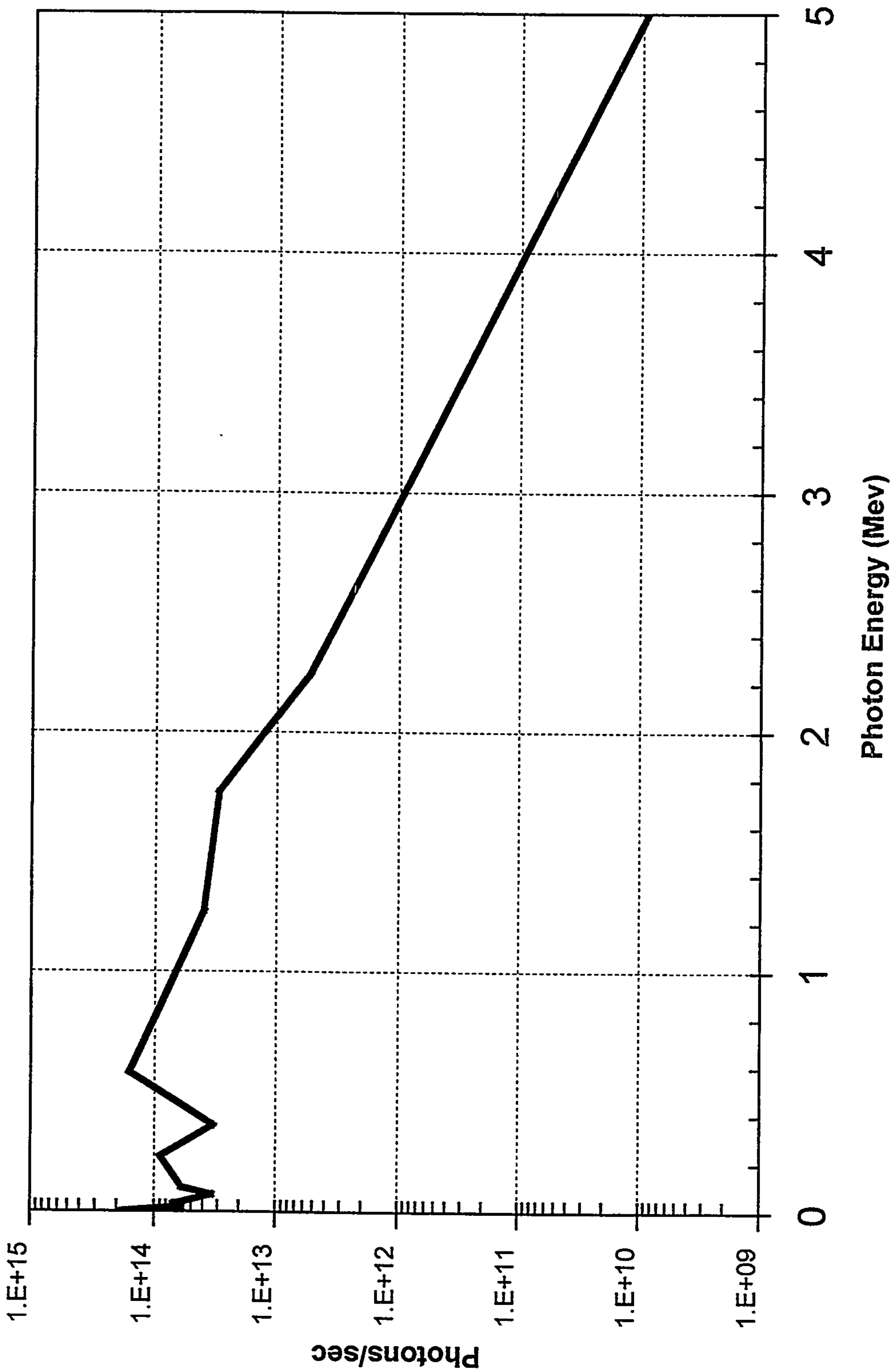


Figure 3.4-1 Maximally Irradiated Target Gamma Spectrum

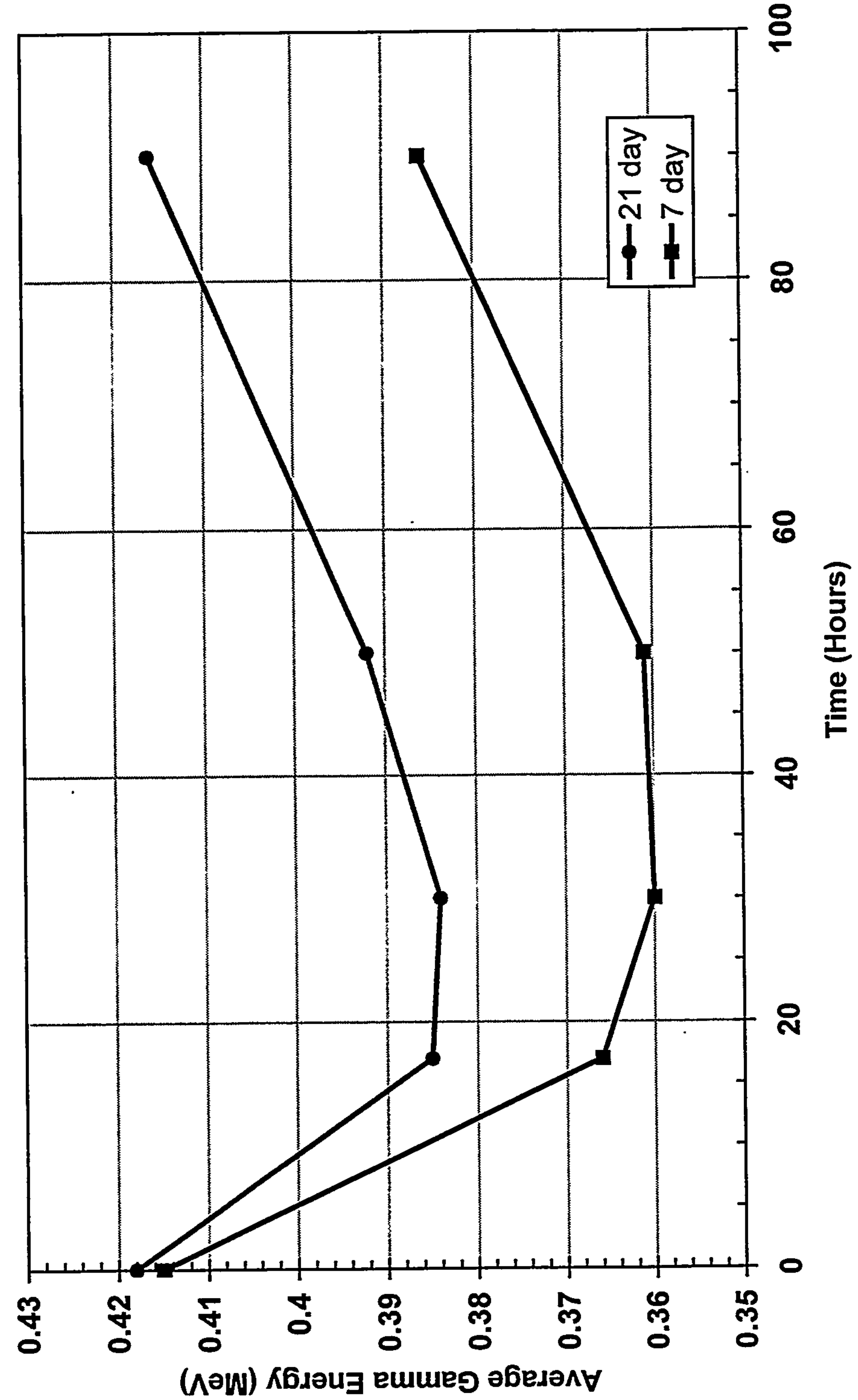


Figure 3.4-2 Average Gamma Energy for Irradiated Targets

The above assumption with regard to material at risk will be overly conservative in most process scenarios for the less volatile fission products by two to four orders of magnitude, but this will be only about a factor of four in terms of potential total dose consequences, as depicted later in Table 3.4-1. However, this assumption will encompass future unanticipated processing scenarios which might render the less volatile inventory more available for release. Based on this assumption, the hazard and accident analyses are not dependent on any specific isotope processing steps, since there are no process operations which could render the material more volatile. Thus, these process operations are not relied on to mitigate any release consequences and therefore do not perform any Safety Function.

The values for the LPF used in the analyses will be based only on filtration characteristics, i.e. no plate-out or other removal processes will be considered.

3.4.1.2 Dose Consequence Evaluation

Methods to estimate dose resulting from release of the source term are based on a database of airborne dose versus distance calculations for single isotope releases from TA-V facilities (Naegeli 1999). The database was developed using the Melcor Accident Consequence Code System Version 2 (MACCS2) computer model with a standard input for each single isotope calculation. Combining doses for individual isotopes provides the dose from the released source term.

MACCS2 had its origin in the CRAC code developed by SNL for the NRC to calculate the health and economic consequences of accidental releases of radioactive material to the atmosphere for the Reactor Safety Study (NRC 1975). MACCS, the immediate predecessor of MACCS2, has been distributed by government code centers since 1990 and was developed to evaluate the impacts of severe accidents at nuclear power plants on the surrounding public. Despite the code's intended use for nuclear power plants, many of the code's users have been engaged in studies assessing the safety of DOE facilities, and the code has occasionally been used to assess Department of Defense (DOD) nuclear facilities. DOE commissioned the MACCS2 revision of the MACCS code for safety analyses at its facilities. MACCS2 includes dose conversion factors for a much larger set of radionuclides developed by the Environmental Protection Agency (EPA) in Federal Guidance Report 11 and 12 (Eckerman, Wolbarst, and Richardson 1989, Eckerman and Ryman 1993). MACCS and now MACCS2 have been used repeatedly for SNL safety analysis reports for the HCF and TA-V reactor facilities.

The basic analytical models of MACCS2 provide atmospheric transport, dispersion, deposition, and dose calculation for the released inventory. A Gaussian dispersion model based on the Tador-Gur parameterization is used for this SAR to provide consistency with previous safety studies on the HCF. Radioactive isotopes are allowed to decay and build up daughter activity during transport and deposition. The decay is based on an input file of half-lives and decay schemes for hundreds of isotopes. Dose pathways modeled were radioactive plume inhalation and immersion, groundshine from deposited radiation, and resuspension inhalation dose. Groundshine and resuspension inhalation pathways are very minor contributors to dose.

The MACCS2 code modeled weather for transport and dispersion by sampling a database of 8760 hourly weather data covering one full year. The Typical Meteorological Year for the Albuquerque International Airport (Sunport), as developed by the National Climatic Center, was chosen as representative site weather data (Aldrich et al. 1982). This same weather file has been used for CRAC and MACCS dose versus distance calculations in TA-V SARs since 1980.

The weather data were sampled using a weather bin random sampling scheme, which sorted the single-hour weather data by wind speed, stability class, and precipitation. Then, the same numbers of single-hour weather samples were taken from each weather bin by random sampling. Each single-hour weather sample defined the start time for a 120-hour weather data case that was used for dose calculation. The same 78 weather cases were used for each isotope dose versus distance calculation. The resulting weather bin sampling doses were higher close to TA-V but doses at the 3000-m range and beyond are comparable to doses for weather cases chosen randomly from the whole 8760 hourly weather cases.

The model for dose quantification was the 95th quantile of dose for straight-line dispersion modeling. This model of dispersion combines the calculated dose at a distance with the yearly wind rose distribution of wind frequency for each of the sixteen directions of the compass to obtain sixteen doses with attendant frequencies for each weather case sampled. The MACCS2 code then tabulates dose values in an increasing dose versus cumulative frequency table. It calculates the 95th quantile dose by interpolation between increasing dose values near 95% of the total frequency. The resulting single dose at each distance for an isotope is characteristic of all wind directions and the typical range of site weather conditions. The 95th quantile dose is a conservative, worst case dose and is consistent with NRC guidance for assessing potential accident consequences of airborne releases at nuclear power plants (NRC 1982).

The database of airborne dose versus distance was calculated with a consistent, documented set of inputs that were specifically chosen for TA-V purposes. The MACCS2 inputs represent the assumptions for dose calculation in the dose versus distance database (Naegeli 1999). The dose from 1.0 curie of a single isotope was calculated at ten distance ranges for three release conditions applicable to the HCF. The conditions include releases from the HCF stack, ground releases with building wake, and ground releases without building wake.

The dose was calculated for a phantom, uniform density population during the 24-hour emergency radiation exposure period. The database provides whole body, effective dose equivalent doses for over 120 isotopes of interest to HCF operations. The long-term inhalation committed effective dose equivalent (CEDE) over 50-years and cloud shine (immersion) dose equivalent to an individual were the exposure pathways adopted by DOE in calculation of dose consequences for hazard category characterization in DOE-STD-1027-92. The whole body, effective dose equivalent that was calculated by MACCS2 for the dose versus distance database also includes external groundshine dose and internal resuspension inhalation dose pathways (both very minor contributors). Thus, the dose calculated for the accident analysis with the dose versus distance database will be slightly larger and more conservative than dose calculated with the exposure pathways of DOE-STD-1027-92 alone.

A few of the doses were calculated with an older version of the code (MACCS Version 1.5.11.1) and dose conversion factor library using the same input parameters. Both versions of the code and dose conversion factor library gave almost identical results for these inputs. Further details on the calculation method and inputs can be found in the MACCS2 user manual (Chanin and Young 1997) and in the airborne dose versus distance database documentation (Naegeli 1999).

Software quality assurance for the MACCS2 code was provided through a limited-distribution beta test with DOE users and through a formal, independent verification study of the code package by the University of New Mexico which included detailed hand calculations. An independent analyst, familiar with the MACCS2 code and its applications, performed validation of the standard input (Liscum-Powell 1997).

3.4.1.3 Evaluation Guidelines

The evaluation guideline for radiation dose to the public is 25 rem, total effective dose equivalent (TEDE) to the whole body. The purpose of the 25 rem guideline is to determine if additional accident mitigation is required and to then designate as safety-class those SSC's that are necessary to reduce the dose below the evaluation guideline. The distance at which the evaluation guideline is applied, as described in Chapter 1, is 3000 meters (1.9 mi). Calculated doses to the maximally exposed individual of the public at 3000 meters for a design basis accident (DBA) must be less than or equal to 25 rem to be within the evaluation guidelines. For the purposes of public dose comparison for the DBAs, calculated doses including CEDE and immersion dose equivalent are sufficient as these are the dominant pathways for dose in an airborne release. The dose versus distance database calculated with the MACCS2 code includes two other minor dose pathways so those calculations represent a very slightly higher and more conservative dose calculation for the DBA dose consequence comparison.

3.4.2 Design Basis Accidents

Based on a review of the hazard tables prepared for this SAR, the accidents identified as design basis accidents for more detailed quantitative evaluation in this SAR include:

- Spill of process materials in a SCB,
- Hydrogen fire/explosion,
- Fire in a process SCB,
- Fire in Room 109,
- Forklift accident during movement of an irradiated target,
- Failure of the ventilation system (loss of off-site power)
- Fire in a radioactive material storage area
- Design Basis Earthquake

These DBA's include those postulated events that pose the greatest risk and therefore bound the HCF operational risk. Failure of the ventilation system filters will be considered as a subset of each DBA by quantifying dose consequences with filtration as well as for a totally unmitigated release. Additionally, an accident from each of the major types of events identified in the hazard tables was selected even if the risk was evaluated to be low.

The development of each DBA in the accident analyses is based on application of a graded approach, as provided for in DOE-STD-3009-94. The standard states that quantitative analyses are only required to the extent necessary to demonstrate that Evaluation Guidelines are not exceeded. Further, "For nonreactor nuclear facilities, these considerations (hazard magnitude) do not support a need for probabilistic/quantitative risk assessment". Additionally, the Standard states that "The use of bounding assumptions and less detailed physical modeling in accident analysis is appropriate".

3.4.2.1 Spill of Process Materials in an SCB

The spill of process materials in an SCB is an anticipated operational event. Spills may range from minor seepage or leaks of small quantities of materials to a complete spill of the process contents due to operator error or due to failure of process containers. Process container failures may occur either spontaneously or may be induced by operator actions. Provisions for accommodating such spills have been incorporated in process equipment design in the form of spill trays, absorbent material, and SCB washdown systems. Clean up of the spilled material and returning the SCB to a clean operational state will be an operational inconvenience, but will be a routine task.

3.4.2.1.1 Scenario Development

The sequences of events that are accomplished in the SCB were evaluated to identify initiating and mitigative events that could occur during processing of a target. The scenario is focused on the time frame during which the radiological material at risk is most volatile, which is the time following dissolution of uranium oxide by the acid until the time the iodine is captured as solid copper iodide in the iodine trap. This dissolution releases all of the fission products previously contained in the fuel matrix into the liquid acid solution or into the target cover gas. At other times during processing, the material at risk is of considerably lower volatility and potential accident consequences would be correspondingly less. However, since all materials will be assumed to be equally and highly volatile (ARF=1), the spill scenario evaluated here bounds the potential consequences of all other spill accidents. The potential for process spills in extraction SCBs was examined by using event tree analysis methodology. Detailed event tree descriptions and results are contained in Appendix 3E.

The processing events that are linked to evaluate the spill scenario include:

- Attachment of process containers and piping,
- Operator detection of faulty connections,
- Target heating to dissolve the uranium dioxide,
- Operator corrective actions in the event of leakage, and
- Target/connection integrity.

In the event of leakage or failure of the target/piping boundary during processing, some fraction of the target gaseous and/or liquid contents could be vented to the SCB volume. The amount of such venting would be dependent the nature of the boundary failure and on operator intervention to respond to such an event. It is conservatively assumed for this DBA that in the event of a failure of the process container boundary, the entire fission product inventory is released to the SCB volume and is entrained in the ventilation system flowstream.

There is potential for damage to components and equipment within the SCB in the event of the release of the acid from the process container, but the confinement function of the SCB would not be adversely affected by this release. Damage to materials such as manipulator boots could create an additional flow path from Zone 2 into Zone 1, but would not result in an adverse pressure gradient that would transport material through such paths. Volatile elements released to the SCB volume would be drawn into the ventilation system and would be passed through filters to mitigate the release to the environment. As an extension to the SCB spill DBA scenario, the consideration of degradation and/or failure of the filters has also been evaluated. Such failures could be the result of an external event or natural phenomenon, which could cause failure of a confinement boundary (SCB's or ventilation ducting) or could be due to operator error in the maintenance/replacement of the ventilation system filters.

3.4.2.1.2 Source Term Analysis

As described in Section 3.4.1.1, the source term released to the environment in an abnormal or accident scenario would be expected to be only a fraction of the total available fission product inventory. The quantity of the material actually released is dependent on the specifics of the accident scenario, on the physical form and volatility of the material at risk, and on removal processes, including filtration. Leakage or spillage from a target during processing has the potential to be mitigated by operator action, however, the degree and likelihood of such mitigation would be difficult to quantify with confidence. Under any circumstances, the degree of venting or spillage is bounded by the release of the entire target contents, which will be assumed for this analysis. In this instance, the noble gases and a significant fraction of the volatile halogens would be expected to be entrained in the SCB volume. Although some of the halogens would be retained in solution in the process liquid, this effect will be neglected. The availability of other fission products would be significantly less than for the halogens, in that their volatility and release from solution is correspondingly smaller. Based on DOE-HDBK-3010-94, a maximum of two tenths of one percent of the non-volatile fission products would normally be assumed to be present in the SCB atmosphere. However, it will be conservatively assumed for these analyses that the entire fission product inventory is available as an airborne source term in the SCB in the event of a target spill. Table 3.4-1 presents quantities of fission products present in maximally irradiated targets 6 hours after irradiation as well as the unmitigated dose consequences attributable to the various elemental constituents (Mitchell and Naegeli, 1999). Iodine is the dominate contributor to dose in the highly volatile isotope group, Te-132, Ru-103, and Ru-106 are the major contributors in the semi-volatile group, and Mo-99, Y-91, Zr-95, Zr-97, La-140, Ba-140, Pr-143, Ce-143 and Ce-144 are the major contributors in the non-volatile group.

Table 3.4-1. Assumed Initial Source Terms for SCB Spill DBA

Isotopes	Maximally Irradiated Target Inventory (curies)	Unmitigated Dose Consequences at 3000 meters (mrem)
Noble Gases (Xe, Kr)	1865	0.6
Highly Volatile (I, Br)	2616	65
Semi-Volatile (Se, Cs, Te, Ru)	1044	43
Non-Volatile	12847	195
Total	18,372	303.6

The release path for the fission product inventory is through the Zone 1 ventilation system, including charcoal and HEPA filters, with discharge to the environment through the HCF exhaust stack. Upon passage through the charcoal filters, most of the volatile halogens would be expected to be captured in the filter, and most of the remaining fission products would be captured by the HEPA filters. An evaluation of the expected filter efficiencies assumed for these analyses is included in Appendix 3E. For purposes of accident analysis and consequence evaluation, filter efficiencies for fully functional filters are conservatively assumed to be 0.99 for HEPA filters and 0.95 for charcoal filters, as compared to manufacturers suggested values of 0.9997 and 0.999. In degraded modes, the corresponding efficiencies are assumed to be 0.95 and 0.5. Filter efficiencies have been incorporated into the event tree analyses described in Appendix 3E to develop overall consequence/probability matrices.

Even though only one target is ever expected to be in process at one time in each SCB, for the purposes of consequence evaluation, the event of simultaneously releasing the contents of up to six targets has been considered. The consideration of up to six targets is based on the daily processing rate representative of 100% of U.S. demand for Mo-99. Since residual materials are typically solidified each day, it would be unrealistic to consider more than six targets to be at risk at the same time. The release of the contents of multiple targets requires scenarios where a spill occurs simultaneously in multiple processing boxes or where multiple targets are processed simultaneously in a single extraction SCB and the process containers are simultaneously breached. Given that such releases would require mechanical failure and/or operator errors, the likelihood of simultaneous releases from more than one target decreases as the number of targets involved in the scenario increases.

3.4.2.1.3 Consequence Analyses

Potential doses at the 3000-m. boundary have been evaluated using methodology described in Section 3.4.1. These techniques have been used to calculate the potential dose consequences resulting from the release of the inventory described in Table 3.4-1, under various multiple target scenarios and with various degrees of mitigation. These scenarios and associated probabilities derived in Appendix 3E are summarized in Table 3.4-2.

Table 3.4-2 Process Spill Dose Consequences

No. of Targets	Filter Assumption	Likelihood	Consequences
Single Target	Fully Functional	Anticipated (>1/yr)	3.2 mrem
	Degraded	Anticipated (0.01-1/yr)	<14 mrem
	Unmitigated	Very Unlikely ($<10^{-4}$/yr)	300 mrem
Two Targets	Fully Functional	Anticipated (<0.1/yr)	6 mrem
	Degraded	Unlikely (<.01/yr)	<28 mrem
	Unmitigated	Very Unlikely ($<10^{-5}$/yr)	600 mrem
Six Targets	Fully Functional	Unlikely (<0.01/yr)	19 mrem
	Degraded	Unlikely ($<10^{-3}$/yr)	<90 mrem
	Unmitigated	Extremely Unlikely ($<10^{-6}$/yr)	1.8 Rem

These process spill scenarios range from anticipated events which result in dose consequences of 2 to 13 mrem at the exclusion area boundary to extremely unlikely events which result in dose consequences of 1.8 Rem.

3.4.2.1.4 Comparison of Consequences to Evaluation Guidelines

The maximum potential dose consequence at the 3000 meter exclusion area boundary of 1.8 Rem for the process spill scenario is well below the evaluation guideline of 25 rem.

3.4.2.1.5 Summary of Safety-Class SSC's and TSR Controls

Based on the degree to which potential consequences are below evaluation guidelines for the SCB spill scenario, no safety class equipment or associated TSR's are required to mitigate this scenario. Safety-significant SSCs and associated TSR's are described in Section 3.3.2.3.2.

3.4.2.2 Hydrogen Combustion in the Elevator Pit

Solidified process waste is contained in individual stainless steel containers which are temporarily stored along with other process waste in the Zone 2A canyon elevator pit in 55 gallon barrels. At maximum processing rates, a barrel will be filled every two days, and four barrels will be filled in about two weeks. Hydrogen will be generated by the radiolysis of water in the solidified waste. The rate of hydrogen generation from each container of waste decreases from about two liters per day immediately after solidification to about 0.1 liter per day within 60 days (Mitchell and Naegeli 1999). Hydrogen will be vented from the individual waste containers into the barrel. The barrel is also vented, so hydrogen generated in the barrel will be released into the surrounding environment.

The Zone 2A canyon elevator pit and Room 109 are the only two areas in the HCF where waste will be accumulated. By the time that the waste is moved into Room 109, the hydrogen generation rate is sufficiently low as to preclude accumulation to flammable levels (Mitchell and Naegeli 1999). The normal Zone 2A ventilation flow of 1800 cfm (which includes flow into the SCB's) will preclude any appreciable hydrogen concentrations in Room 109 or the Zone 2A canyon.

3.4.2.2.1 Scenario Development

The combustion of hydrogen requires sufficient levels of both hydrogen and oxygen, and the presence of an ignition source. Such a source exists in the elevator pit in the form of the hydraulic lift limit switch, which would close contacts in the event that the lift is lowered to the bottom of the pit. It is assumed that if this switch is activated, and if oxygen levels are sufficient, all free hydrogen at or above a concentration of 4% that exists in the pit could be ignited. The potential for hydrogen combustion in the elevator pit was examined by using event tree methodology supported by analyses of the physical characteristics of the potential storage configurations (Mitchell and Naegeli 1999). Detailed event tree descriptions and results are contained in Appendix 3E.

Potential hydrogen concentrations in a stagnant elevator pit atmosphere filled with barrels of waste have been calculated to be a maximum of about 2% (Mitchell and Naegeli 1999). Buildup to this calculated equilibrium level will require many days, during which time either barrels would be added to the pit or, if the pit is full, barrels would be removed for movement to Room 109, causing some mixing of the pit atmosphere and dilution of hydrogen concentration. Thus, a deflagration in the elevator pit is unlikely, even in the presence of an ignition source.

The potential releases of energy and subsequent pressure and temperature excursions in the highly improbable event of deflagration of hydrogen in the elevator pit have been quantitatively assessed. If combustible levels of hydrogen and oxygen are ignited in the pit, the potential pressure and temperature excursions would not be expected to result in the release of any significant radiological inventory (Mitchell and Naegeli 1999). This is due to the fact that heat transfer mechanisms are insufficient to substantially raise the temperature of the substantial mass of the waste and waste containers. The temperature of the waste would be required to be raised many hundreds of degrees to effect any release.

3.4.2.2.2 Source Term Analysis

Because the residual waste is in solidified form inside of steel containers in the elevator pit, and the combustion of hydrogen in the pit will not affect the solidified waste, the waste inventory is in a form which is not readily available for release (DOE 1994d). Thus, there is no credible source term of any significant magnitude.

3.4.2.2.3 Consequence Analyses

With no significant source term, there are no significant off-site radiological consequences for any hydrogen fire/explosion scenarios.

3.4.2.2.4 Comparison of Consequences to Evaluation Guidelines

Since there are no significant off-site radiological consequences, those consequences are less than evaluation guidelines.

3.4.2.2.5 Summary of Safety-Class SSCs and TSR Controls

Since the consequences of this DBA meet evaluation guidelines, no safety-class SSC's or TSR controls for hydrogen combustion are required.

3.4.2.3 Fire in a Process SCB

This internally initiated DBA is a potential fire in a process SCB. Limited quantities of combustible material are present in extraction SCBs during processing. Additionally, ignition sources, primarily electrical, also exist and are active during processing. Thus, the potential exists for a fire during processing of an irradiated target.

3.4.2.3.1 Scenario Development

This internally initiated DBA is a potential fire in a process SCB. The potential for SCB fire was examined by using event tree analysis methodology, which is detailed in Appendix 3E. The isotope production process steps and equipment in each type of SCB were examined for potential ignition sources and combustible material. The principal combustible material collocated with radioactive material in process SCB's consists of less than one kilogram of organic materials, mainly plastic syringes and rubber stoppers. Ignition sources consist principally of the electrical heater in the extraction SCB's, that, as a result, have the greatest potential for a fire and also the greatest radioactive inventory. Radioactive material in the extraction SCBs can be in a liquid form with the volatile halogen and noble gas fission products in a readily releasable form. The SCBs used for product purification and packaging as well as for waste storage packaging have some combustible material but reduced ignition sources. Additionally, isotope purification SCBs will contain only a small fraction of the fission products and they will be in relatively non-volatile forms. The waste storage packaging SCB has only solidified process residue contained in steel waste containers. For these reasons, a fire in an extraction SCB bounds all other potential fire scenarios, and will be considered in this DBA analysis.

The causes and preventive features for a fire in an extraction SCB were examined for the DBA accident scenario. The identified initiating events for this scenario are electrical wiring short/overheat or ignition of combustible material directly by touching the heating element of the electrical target heater. Mitigative features for this DBA are inherent in the SCB structure and HCF ventilation system. The heavy steel box construction is an effective firewall to prevent spread of fire to other SCBs. The limited quantities of combustibles in the SCB will limit the duration and extent of the fire. The physical form of the liquid process solution will also mitigate the dose to the public, since the fire will not volatilize a large fraction of the fission products in the liquid solution.

Analysis of the ventilation system indicates that combustion gases will not damage downstream components of the system (Mitchell and Naegeli 1999). Cooling of combustion gases in the approximately 20 feet of ducting from an SCB to the Zone 1 exhaust plenum will not appreciably decrease the gas temperature. However, the exhaust from each SCB is diluted by a factor of 10:1 in the Zone 1 exhaust plenum. Thus, the combustion gas exhaust from Zone 1 would have a temperature of no more than approximately 250°F and damage to the ventilation system due to the fire is an improbable event.

In all of the SCB fire scenarios, the fire was assumed to envelop the liquid dissolution cocktail in the process containers during or following UO_2 dissolution and release of radioactive material to the SCB and Zone 1 ventilation systems. While dilution of combustion products is expected to preclude damage to the ventilation system, an unmitigated release bounds the scenario where the filters or the ventilation system itself have been degraded or compromised as a consequence of a fire. The frequencies per year for such an accident developed in the event tree analysis shown in Appendix 3E.3 agree with the frequency for an extraction SCB fire as assessed in event CP-7 in the hazard evaluation (Appendix 3C).

3.4.2.3.2 Source Term Analysis

The radioactive material source term of interest is principally the fission products and actinides of one isotope production target. However, for fire scenarios, the likely buildup of fission products on in-box filters should also be considered, since the fire could involve the charcoal filter. For practical levels of in-box contamination, this buildup would likely not exceed 10% of a freshly irradiated target inventory. Buildup to greater levels would likely render the SCB unsuitable for isotope processing operations. For the purposes of consequence evaluation for fire scenarios, 110% of the content of six targets will be considered to be available for release. Stainless steel process containers, such as the target, would not themselves be breached by a fire environment due to their mechanical strength, even at elevated temperatures. However, the fire can damage organic components of process containers, which could result in loss of integrity of the container. Similarly the iodine in the iodine trap is in the form of copper iodide, with a melting point of 605°C (1090°F), and a vapor pressure of 400 mm at 1158°C (2110°F). Not only would the fire not damage the trap itself, but the copper iodide would not be significantly volatized by the fire even if the trap integrity were compromised.

The source term associated with six targets was analyzed previously in Section 3.4.2.1 (Process Spill). A small fraction of the nonvolatile liquid contents of the acid cocktail would normally be expected to be airborne and available for release from the bottle or target to the ventilation system based on DOE-HDBK-3010-94. This handbook suggests an airborne release fraction of 0.001 as the mean release fraction for boiling liquids and 0.002 as the bounding maximum airborne release fraction (DOE 1994d). Boiling liquids could be more typical of a fire scenario but the actual difference in airborne activity is small compared to the airborne activity of the volatile components of the process liquid. Based on the conservative release assumption that 110% of the inventory is released, the source term analysis for the extraction SCB fire DBA is 110% as large as that for the spill DBA. The source term analysis of the effect of charcoal and HEPA filtering is likewise applicable to this DBA. Thus, the released source term for the SCB fire is 110% of the process spill DBA.

3.4.2.3.3 Consequence Analyses

Potential doses at the exclusion area boundary (3000 m) have been evaluated using the methodology described in Section 3.4.1. These techniques have been used to calculate the potential dose consequences resulting from the released source term for this DBA, which are 110% of the process spill scenario, or a maximum of 2 rem. The probability of a fire in an SCB, however, has been assessed in Appendix 3E.3 to be three or more orders of magnitude lower than spill events (Appendix 3E.2), and fires which could result in release of radioactive materials are even less likely.

3.4.2.3.4 Comparison of Consequences to Evaluation Guidelines

The maximum potential dose consequences of 2 rem for the fire in an extraction process scenario is well below the evaluation guideline of 25 rem.

3.4.2.3.5 Summary of Safety-Class SSC's and TSR Controls

Based on the degree to which potential consequences are below the evaluation guidelines, no safety class equipment or associated TSRs are required to mitigate this scenario. Safety-significant SSCs and associated TSRs are described in Section 3.3.2.3.2.

3.4.2.4 Fire in Room 109

This internally initiated DBA is a potential fire in Room 109, in which the residual process waste, containing up to 500,000 curies of fission products, are stored to allow decay prior to off-site shipment. Only waste barrels and carts are present in Room 109, so other than the limited quantities of combustible materials present inside the barrel there are no flammable materials inside Room 109. The hydraulic fluid used to raise the shield doors might be considered a source of flammable material due to its proximity to Room 109. Ignition sources are also limited in that there are no exposed electrical circuits in this room. Thus, there is limited potential for a fire in Room 109.

3.4.2.4.1 Scenario Development

The initiation of a fire requires the presence of combustible material and an ignition source. The potential combustible materials in or near Room 109 include hydrogen evolved by the process waste, the organic process materials inside each waste barrel, and the hydraulic fluid present in the system used to raise and lower the massive shield doors. Analyses have shown that the total rate of hydrogen evolution from the waste in Room 109 is insufficient to build up to flammable levels in the room (Mitchell and Naegeli 1999). It should be noted that due to the continual evolution of hydrogen by the process waste, the internal waste barrel atmosphere will be depleted in oxygen to such a level that the flammable materials inside the barrel would not ignite, even in an extreme thermal environment.

The limited amount of electrical wiring in Room 109 is embedded in the concrete shield walls. Other than the mules which are used to push barrels into Room 109 there are no active mechanical or electrical devices in the room that could become an ignition source. Even in the event of the presence of a source, the flammable materials are physically separated from the source by metallic barriers. Based on separation of the ignition sources from the combustible material, the possibility of an internally initiated fire is considered remote. It may be somewhat more probable that the hydraulic fluid is ignited externally to Room 109 and combustion products of such a fire heat the waste. As noted above, an external thermal environment cannot ignite the combustible materials in the waste barrels due to oxygen depletion in the barrel. Additionally, the contents of Room 109 are separated from external environments by massive concrete structures, which would limit the effects of an external fire.

3.4.2.4.2 Source Term Analysis

The radiological source term in Room 109, including fission products and uranium dioxide, is in solid form (concrete), inside stainless steel canisters which are inside steel barrels. In the remote event of a fire or thermal environment, the concrete would not be volatized, even if exposed to an extreme thermal environment. A very small fraction (~0.00001) of the fission products in concrete could be available for release as particulate in the respirable size range if the concrete waste were dried for a sufficient time at temperatures exceeding 600°C (DOE 1994d). Assuming a 500,000-curie inventory of fission products for Room 109, the material available for release would be approximately 5 curies. The steel containers and barrels surrounding the concrete would mitigate the actual fraction of fission products released. Exit of the particulate would be impeded by the container and barrel vents. In addition, the HCF stack HEPA filter could further mitigate a particulate release to the extent that combustion products are drawn into the ventilation system. The reduction in the fraction of fission products resulting from these two mitigating factors are estimated to be more than a factor of ten. Thus, even if a fire occurred, there is a very limited source term available for release from the HCF to the environment.

3.4.2.4.3 Consequence Analysis

Dose consequence calculations for mixed fission products that are typical of the isotope production target show the dose at 3000 m is approximately 0.015 mrem for each curie released (Naegeli 1999, Mitchell and Naegeli 1999), or a maximum of 0.08 mrem for an unmitigated release of 5 curies of respirable material released during a fire. These calculations were done using the methodology described in Section 3.4.1.

3.4.2.4.4 Comparison of Consequences to Evaluation Guidelines

The maximum potential dose consequences for the unmitigated release are approximately 0.08 mrem and the estimated maximum potential dose consequences for a mitigated release would be less than 0.008 mrem, both well below the evaluation guideline of 25 rem.

3.4.2.4.5 Summary of Safety-Class SSCs and TSR Controls

Based on the degree to which potential consequences are below the evaluation guidelines, no safety class equipment or associated TSRs are required to mitigate this scenario. Safety-significant SSCs and associated TSRs are described in Section 3.3.2.3.2.

3.4.2.5 Forklift Accident During Movement of an Irradiated Target

This internally initiated DBA is a potential spill of available volatile target fission products during target movement from the ACRR to the HCF. After irradiation in the ACRR, targets are moved by forklift to the HCF for isotope product separation. Each target is moved separately in an isotope production target shielded cask. The greatest threat to the target in transit is an energetic forklift crash that might breach the cask and eject the target. Then the target could be breached and available volatile noble gas and halogen fission products released to the outside atmosphere. In addition to the risk to the public from an airborne release of radioactivity, the workers are at risk to direct radiation exposure as explained in the hazard evaluation.

3.4.2.5.1 Scenario Development

The potential initiating events, preventive features, and mitigating features were evaluated using event tree analysis methodology, which is detailed in Appendix 3E. The analysis showed that the accident risk could be conservatively bounded by a worst case crash of the forklift with target into fixed, unyielding features at the entrance to the HCF. The expected orientation in a collision impact would be a side impact of the cask. Structural analysis of the isotope transfer cask indicates that the cask will not be broken or breached in a conservatively worst case collision.

The frequency of the energetic forklift collision after a roll down the truck ramp, as developed by the event tree analysis, is consistent with the hazard evaluation in most cases with the event tree analysis assessing frequency the same or one level less often. The collimated radiation beam, high dose rate, and airborne release outcomes are produced by the cask lid opening or coming off in a forklift crash.

3.4.2.5.2 Source Term Analysis

For accident scenarios where the target is not breached, there is no source term available for release to the environment. About 1% of the noble gas and halogen inventory is available for release in the event of the worst case transfer accident, involving ejection and breach of the target (Mitchell and Naegeli 1999). For the maximally irradiated target characterized in Table 3.4-1, this source term amounts to 26 curies of iodine isotopes and 19 curies of noble gases.

3.4.2.5.3 Consequence Analyses

In the event of release of 1% of the volatile fission products, the dose consequences at the 3000-meter boundary will be less than 1 mrem.

3.4.2.5.4 Comparison of Consequences to Evaluation Guidelines

This 1 mrem dose is well below evaluation guidelines.

3.4.2.5.5 Summary of Safety-Class SSCs and TSR Controls

Since the consequences of this DBA meet evaluation guidelines, no safety class equipment or associated TSRs are required to mitigate this scenario.

3.4.2.6 Failure of the Ventilation System (Loss of Off-Site Power)

Loss of off-site power is an anticipated abnormal external event. Although system reliability has been improved recently by several system upgrades, the site has experienced 32 unscheduled outages during the 10 year period 1977-1986, with an average duration of 1.75 hours, and 24 outages during the 14 year period from 1984 through 1997, with an average duration of about 3 hours. Average time without power in both instances amounts to about 5 hours per year. Such power outages can be expected to continue to occur in the future. In the event of loss of off-site power, a diesel generator is available to provide power for lighting, ventilation systems and other HCF functions as deemed appropriate.

During normal HCF operations, the ventilation system maintains a zone-to-zone pressure hierarchy, which controls the migration of radiological contaminants. The normal flow of air sweeps contaminants that are present in contaminated zones (Zone 1 and 2A) through filters, which are designed to capture and retain the contaminants. Redundant fans exist for most of the ventilation zones, including Zone 1 (Fans 6 & 7), Zone 2A (Fans 8 & 9), hoods and glove boxes (Fans 15 & 16), and the overall system (Fans 4 & 5), so most ventilation functions are maintained even in the event of individual component failure. A system shutdown logic is implemented in the event of failure of both primary and backup fans to preclude pumping of potentially contaminated air into uncontaminated regions of the HCF.

3.4.2.6.1 Scenario Development

The sequence of events which follow as a result of loss of off-site power as an initiating event were examined using event tree methodology. Initially, loss of power will result in the cessation of all equipment requiring power. This includes all lighting, ventilation components, control systems, monitors, instrumentation, etc. Normally, the loss of power will cause the standby diesel generator to automatically start and supply power to designated systems. If this occurs, work could resume to place the facility in a safe configuration, following the assessment of the situation by HCF management. If the standby system also fails, the facility would be evacuated and all systems would remain inoperative. The facility would be left in whatever physical state it was in at the time of the loss of power and could include the presence of in-process radiological materials at processing stations. The DBA sequence progression following loss of off-site power would depend on the state that existed at the time. For purposes of radiological evaluation, four different situations are examined as detailed in Appendix 3E.

- Most of the time (i.e. at times other than during active isotope processing) process stations will contain only residual quantities of radiological materials.
- During normal operations, isotope processing will be in-progress a significant fraction of the time, however the amount of radiological materials available for release are limited by the quantity and form of the material in process.
- Occasionally, abnormal processing events are anticipated which would cause the volatile inventory at a process station to be elevated.
- Normally, all of the above possible radiological inventories at process stations would be contained by the process SCB, they would be drawn into the ventilation system, and trapped on ventilation system filters. If the SCB failed, or a pre-existing failure were undetected, the radiological inventory could be released directly into the Zone 2A canyon.

Each of the above scenarios may exist at the time of loss of off-site power. The likelihood of each scenario can be estimated and is independent of the likelihood of loss of power. The potential consequences of each scenario can also be examined based on the inventory available for transport.

In the event of complete loss of ventilation flow in the HCF, contaminants will be transported by diffusion from regions of high contamination to regions of lower contamination. This diffusion will occur through gaps, penetrations and crevices that exist in HCF systems and structures. Two of the known transport paths are the airlock doors and the Zone 2A canyon air supply duct. Each of these paths have double closures to minimize transport, however the closures do have finite leakage areas. Based on the expected gaps, diffusion through the Zone 2A canyon supply damper is calculated to be two orders of magnitude greater than that resulting from diffusion through the airlock. Other more direct leak paths may also exist in the HCF. Leak paths directly through the Zone 2A canyon walls with a leakage area of 10 square centimeters will have leakage similar to that calculated for the damper.

The boot that will exist on each manipulator effectively seals manipulator penetrations through the Zone 2A canyon walls, as any boot leak paths are effectively small compared to other leak paths into the facility. Similarly, each of the lighting penetrations through the shield wall have a contamination seal at the outer boundary, which is accessible during operations. SCB and Zone 2A canyon integrity is affirmed during operation by observing pressure differentials across the boundary.

3.4.2.6.2 Source Term Analysis

An evaluation of the levels of expected and potential airborne contamination levels can be based on source term characterization analyses conducted for other DBA's such as the process spill evaluation. Normally, less than 1% of a target's iodine inventory is expected to be released to the SCB during processing. Under abnormal conditions, up to 100% of the iodine inventory may be released to the SCB. These values can be used as conservative upper bound limits on the potential iodine concentration in the SCB. The radiological inventories used in this analysis are based on the inventory of a maximally irradiated target.

It is expected that under normal operational conditions, the airborne concentration level in the Zone 2A canyon would be well below the derived air concentration (DAC) limits (2E-8 ci/m3 for I-131 from 10 CFR 835). This assessment is based on normal handling and containerization of process materials and the fact that the Zone 2A canyon volume is continually circulated by the ventilation system. However, contamination above these levels may exist in the canyon on a transient basis. An accident condition, such as simultaneous process spill and SCB failure, could hypothetically release a target's volatile contents, or 100% of the iodine inventory directly to the canyon. These theoretical contamination levels can also serve as a basis for evaluation of the potential consequences of ventilation failure.

3.4.2.6.3 Consequence Analysis

Analyses of the consequences of each of the scenarios defined above have been accomplished. Each of the possible scenarios may result in various amounts of contamination of the interior of the HCF (Zone 2). These contamination levels range from picocuries to microcuries of I-131, the most hazardous contaminant. Airborne concentrations inside the HCF range from 10^{-16} to 10^{-7} curies of I-131 per cubic meter. Based on a DAC of 2×10^{-8} curies per cubic meter, which is a permissable 10CFR835 working environment, the radiological hazard to on-site workers at these contamination levels is minimal. Negligible quantities (less than microcurie levels) of contaminants would be released from the HCF, even in the worst case scenarios, with negligible off-site consequences (Mitchell and Naegeli 1999). One microcurie of

I-131 released from the HCF would provide a dose of less than 1 x 10^{-10} rem at the 3000-m site boundary.

3.4.2.6.4 Comparison of Consequences to Evaluation Guidelines

Since off-site radiological consequences are negligible, those consequences are less than evaluation guidelines.

3.4.2.6.5 Summary of Safety-Class SSCs and TSR Controls

No safety class SSCs or TSR coverage for the loss of off-site or for the availability of backup on-site power are required to meet evaluation guidelines.

3.4.2.7 Fire in a HCF Radioactive Material Storage Area

This internally initiated DBA is a potential fire in a radioactive material storage area that is associated with the HCF. Limited quantities of combustible material are present in some of the radioactive material storage areas. Additionally, ignition sources, primarily electrical, also exist and are active in some of the radioactive material storage areas. Thus, the potential exists for a fire in some of the radioactive material storage areas.

3.4.2.7.1 Scenario Development

The HCF radioactive material storage areas contain radioactive material in various forms. Each radioactive material storage area may store radioactive material in excess of the HC3 threshold but less than the HC2 threshold of DOE-STD-1027-92, Change 1 (DOE, 1992). Other areas within TA-V may be used for radiological material storage for various reasons and with varying amounts of radiological material. Only those areas listed in Chapter 2 of the HCF SAR as radioactive material storage areas associated with the HCF are considered in this design basis accident. Those areas are all outside of the basement of B6580. A fire is considered in this radioactive material storage area DBA because it has the potential to volatilize and release the largest amount of radioactive material for airborne transport to the public.

This internally initiated DBA is a potential fire in a radioactive material storage area that is associated with the HCF. The potential for a radioactive material storage area fire was examined by using event tree analysis methodology, which is detailed in Appendix 3E. The frequencies per year for such an accident developed in the event tree analysis agreed with the frequency for a radioactive material storage area fire as assessed in the hazard evaluation.

The radioactive material storage areas and the material in storage were examined for potential ignition sources and combustible material.

- The principal combustible material collocated with radioactive material in storage consists of wood, cardboard, paper, and plastic temporary packaging materials of varying amounts.
- Ignition sources are provided principally by the electrical lighting and the systems for heating, ventilation, and cooling (HVAC) in some of the radioactive material storage areas. Forklifts are used for moving material for storage so they present a limited additional ignition source and combustible material due to forklift energy sources and fuel.

- Radioactive material in the radioactive material storage areas is mostly in solid form but can be in a liquid or resin form with appropriate spill control pallets. The radioactive material stored is mostly activated equipment, irradiated experiments, residue from water purification systems (radioactive resin), and other associated materials that are being stored for possible reuse or eventual disposal as waste.

The monorail storage hole radioactive material storage areas have no ignition sources and usually no combustible material. While spontaneous combustion is theoretically possible in the monorail storage holes, the limited volume available for combustibles and the radiation shielding plug and weather cover sealing the hole make a fire caused by spontaneous combustion unlikely. Due to the separated and sealed nature of the monorail storage holes, no fire suppression systems are installed.

B6596 and B6597 high bay radioactive material storage areas have the ignition sources and combustible material listed above. Because people work in those areas to perform storage, packaging, and other operations, wet pipe sprinkler fire suppression systems are installed. In addition, appropriate portable fire extinguishers are available for use by personnel in those areas. Due to the absence of both combustible material and ignition sources in the monorail storage holes, only fires in the B6596 and B6597 high bay radioactive material storage areas are considered credible.

The causes and preventive features for a fire in a radioactive material storage area were examined for the DBA accident scenario. The identified initiating events for this scenario are electrical wiring short or overheat in lighting or HVAC circuits that ignites combustible packaging material present in the area. The subsequent fire is assumed to affect all of the radioactive material in storage and to cause a release through vents or doors in the facility. Thus, the scenario is a conservative upper bound to the radioactive material at risk to fire that should provide a conservative bound to consequences for the public. The detailed progression of the fire from ignition to involvement of all of the radioactive material was not analyzed nor were the methods of airborne release of the material or its escape from the building structure. Forklift caused fires were not considered significant relative to other sources of fire, since they could only occur during the relatively brief times that a forklift is used in the radioactive material storage areas.

Features for fire prevention were the mechanical properties of some metal material containers and radioactive material form to prevent or reduce the release, and sprinkler fire suppression systems to prevent or delay ignition of combustible materials. In addition, administrative operating procedures, hazardous material handling training and packaging requirements could also help prevent or mitigate a fire caused by an electrical wiring short or overheat.

Mitigative features for this DBA are inherent in the distance to the exclusion area boundary. In addition, low or zero ventilation rates from the HVAC system exhausts may reduce the amount of radioactive material escaping the building for airborne release.

It should be noted that the consequences of this internally initiated fire, involving all of the radioactive material in a radioactive material storage area, are the same or greater than a fire in a radioactive material storage area caused by external events.

Since there are multiple radioactive material storage areas, the issue of facility segmentation should be addressed. According to DOE-STD-1027-92, Attachment 1, "The concept of independent facility segments should be applied where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon." Thus, a fire in a radioactive material storage area can be evaluated independently (or the area segmented) if that fire will not affect the radioactive material in another radioactive material storage area, the HCF in the basement of B6580, or some other nuclear facility in TA-V. All of the radioactive material storage areas are located in physically separated buildings or separate sealed holes and not in the same building as another nuclear facility. Therefore, they can all be segmented and fires in each radioactive material storage area can be treated separately. The only exception to this segmentation would be for radioactive material storage areas in the same building or adjacent to a location that contains other radiological material. Then, the physical separation of the building walls and other features should be assessed to evaluate whether a fire in the radioactive material storage area could affect and involve the adjacent radiological material.

The radioactive material storage areas in B6596 include the east high bay, west high bay, and "chapel" area, a high roof side room addition on the north side of Building 6596. All of the radiological material in all of B6596 must be considered for the source term in this DBA. An administrative control procedure is required to ensure that the total of all radioactive material located in all parts of B6596 does not exceed the HC2 thresholds since the separate areas within B6596 cannot be segmented from the other areas containing radiological material in that building.

3.4.2.7.2 Source Term Analysis

The radioactive material storage limitation for radioactive material storage areas was used to develop the source term for an airborne release. Each radioactive material storage area may store radioactive material in excess of the HC3 threshold but less than the HC2 threshold of DOE-STD-1027-92, Change 1 (DOE, 1992). Therefore, HC2 quantities of radioactive material are the most that must be considered for a fire DBA source term. Thus, the HC2 quantities of radioactive material were used as a conservative bound to the source term. The actual inventory and isotope mix of radioactive material in a radioactive material storage area will change from time to time as new material is stored and old material is removed.

A generic approach was used to develop the source term for the airborne release from the HC2 level, material at risk since:

- The actual isotopic mix and physical form of material in a radioactive material storage area cannot be predicted;
- The actual radioactivity release fractions from multiple material types in the fire are unknown; and
- The reduction in release caused by restrictions to combustion product exhaust flow escaping from the building is unknown.

The generic approach to airborne release development was that approach used by DOE in developing the HC2 threshold quantity for each isotope as described in Attachment 1 of DOE-STD-1027-92, Change 1 (DOE, 1992). DOE developed a set of final release fraction values (FRFVs) for the various physical forms of materials that could be present in a facility. These FRFVs were used to reduce the quantity of radioisotope materials at risk for airborne release from the facility in an accident situation. The FRFVs were intended to address all of the uncertainties noted above on a facility wide basis. DOE noted that it was possible to calculate higher values for FRFVs for some physical forms and processes but that those processes were likely to be present on only a local and not a facility wide basis. Thus, DOE concluded the FRFVs were an adequate average for hazard categorization purposes. DOE used the FRFVs and a standard meteorology to calculate the airborne release dose at 300 m from the facility. To develop the HC2, threshold quantities for each isotope, the material at risk for that isotope was adjusted to result in a dose of 1 rem at 300 m. Unfortunately, DOE published only the material at risk quantities for each isotope in Table A.1 of DOE-STD-1027-92 so no listing of the resulting released quantities can be shown here.

3.4.2.7.3 Consequence Analysis

The dose consequence from a HC2 quantity inventory is calculated by applying the ratio of X/Q at 300 m to that at 3000-m with the meteorology used in the MACCS2 calculations for the dose versus distance database and applying this ratio to the value of 1 Rem at 300 m. The resulting dose will represent a conservative upper bound on the public dose since the maximum radiological inventory corresponding to HC2 levels was used in the analysis.

The 95th Quantile X/Q at 3000 m for a ground release with wake as calculated by the MACCS2 code is 5.16E-05 sec/m^3 at 3000 m and 1.16E-03 sec/m^3 at a distance of 300 m, yielding a X/Q ratio of .044. Thus, the calculated bounding dose at 3000 meters is .044 (1 rem) or 44 mrem. The DOE calculated dose and this dose that is derived from it include dose contributions from committed effective dose for 50 years (CEDE) and immersion in the radioactive plume (cloud shine). This potential dose consequence represents a conservative upper bound on the public dose since the maximum radiological inventory corresponding to HC2 levels was used in the analysis, and no mitigation of the release was taken into account.

3.4.2.7.4 Comparison of Consequences to Evaluation Guidelines

The dose consequence to the public at the 3000 meters is calculated to be 44 mrem, which is well below the evaluation guideline of 25 rem CEDE. Since the 44 mrem dose represents a conservative upper bound on the dose from a radioactive material storage area fire, it can be concluded that all such fires would meet the evaluation guideline.

3.4.2.7.5 Summary of Safety-Class SSCs and TSR Controls

Based on the degree to which potential consequences are below the evaluation guidelines, no safety class equipment or associated TSRs are required to mitigate this scenario. Safety-significant SSCs and associated TSRs are described in Section 3.3.2.3.2. An administrative control procedure is required to ensure that the total of all radioactive material located in all parts of Building 6596 does not exceed the HC2 thresholds since the Building 6596 east high bay and chapel radioactive material storage areas cannot be segmented from the other areas containing radiological material in that building for the fire DBA.

3.4.2.8 Design Basis Earthquake

The Design Basis Earthquake (DBE) is a natural phenomena event, and is based on DOE-STD-1021. During normal HCF operations, the ventilation system maintains a zone-to-zone pressure hierarchy, which controls the migration of radiological contaminants. The normal flow of air sweeps contaminants that are present in contaminated confinement zones (Zone 1 and 2A) through filters, which are designed to capture and retain the contaminants. In the event of a DBE, many of these systems are expected to fail, and the normal pressure hierarchy would not be maintained.

3.4.2.8.1 DBE Scenario Development

The initiating event for this DBA is the design basis earthquake, and for NPH performance category 2 (PC2) systems, structures and components (SSCs) is specified in accordance with DOE-STD-1020-94 as follows:

- Seismic Zone 2B
- An annual probability of exceedance of 1 x 10^{-3}
- A maximum horizontal peak ground acceleration (Z) of 0.22 g
- Importance factor (I) of 1.25

The Hot Cell Facility (HCF) was constructed to standards that are 40 years old and would not meet current seismic criteria. Some of the HCF structures and much of the installed equipment in the HCF are not expected to withstand a significant seismic event. An NPH assessment of the HCF was accomplished in accordance with DOE-STD-1021 (Mitchell and Naegeli, 1999). This assessment concluded that the shielding walls surrounding the Zone 2A canyon should be assigned an NPH Performance Category 2. All other SSCs are assigned as PC1 or PC0, and do not have a radiological Safety Function (see Section 2.4.6).

The sequence of events and resulting consequences in the event of a DBE were evaluated in Appendix 3E. The DBE is assessed to result in collapse of most above grade CMU structures, including B6580, B6580B, and B6581, with attendant damage to installed equipment. The below grade structures, including the shielding walls and the SCBs are expected to remain intact. Evaluation of the configuration of confinement following a DBE provides a basis for identifying potential leakage paths from the source term to the environment. Assessment of equipment configuration bears on the leakage paths as well as on transport mechanisms in that the ventilation fans provide a driving force to remove contamination from the facility.

Gross structural failures of confinement barriers in the basement of B6580 are not expected in a DBE but are postulated for the BDBE. Breaches in the Zone 1 ventilation piping in the basement area due to the DBE are unlikely. If breaches did occur with the fans operating, Zone 2 air would be drawn into the breach, diluting the SCB effluent, and reducing the flow drawn from the SCBs, but not significantly changing the transport of radionuclides. In the event of a complete (double ended) breach, flow from the SCB (s) would cease, and further transport would occur due only to diffusion.

The Zone 1 and Zone 2A ventilation exhaust filter housings, located in the Mechanical Equipment Room (MER), have been assessed to likely tip over in a DBE. They would also be subject to debris impacts resulting from the assessment that the MER structure would collapse in a DBE. In either case, the displacement or rotation of the filter housing would rupture the sheet metal duct transitions which attach the housings to the ducting. Failure of the transition would separate the fan suction from the Zone 1 or Zone 2A ventilation exhaust ducting. A partial breach, if the fans were operating, would result in dilution of the effluent by an inflow of ambient (MER) air, but would not result in a significant difference in the transport path. Damage to the filter housings, which would cause distortion of the housings and disruption of the filtered flow path without significantly affecting the weaker transitions, is improbable.

Power to the ventilation system components in the MER is supplied by a conduit entering the MER on the inside of the west wall, routed to a power panel mounted to an internal wall. Power to the fans is supplied by conduit that is routed from the power panel along the walls and the ceiling of the MER. Failure of these conductors would be highly likely in a DBE that caused structural collapse of the MER, either at the power panel or by failure of the individual fan conductors contained in conduit.

The CMU buildings, B6580 and B6581, were assessed to collapse in a DBE. Since the ventilation ducting between the MER and the HCF stack is routed alongside and over these buildings, breaching of the ductwork between the MER and the stack is highly likely in a DBE, and will be conservatively assumed to occur in a DBE. In the event that the ventilation system is operating, the contents of the SCBs would be drawn through the charcoal filters in the MER, and would be discharged at ground level at some location north of the MER. Fission products other than the halogens would not be captured by the charcoal filters.

In the event that the fan is not operating or the ventilation ducting is decoupled from the fan, there is no mechanism to draw contamination out of the SCBs. Release of hazardous material under these circumstances would occur at a rate determined by diffusion. Evaluations of transport of radionuclides under these conditions indicate that buildup of fission products in Zone 2 of the HCF several hours after the event is less than one microcurie. Transport of these fission products outside the confines of the HCF would be negligible, and dose consequences at 3000 meters would be negligible.

The potential for seismic events to initiate secondary events such as spills and fires has been included in the consideration of initiating events for those DBAs. Seismic initiators of secondary events provide only a small contribution to the overall likelihood of those events. For example, spills are projected to occur with a frequency of more than once per year, as compared with a DBE frequency of once per thousand years. Additionally, the consideration of spills occurring as a consequence of the DBE are incorporated in DBE event sequences 7 through 12, described below (i.e., a DBE-induced spill is embodied in the consideration of the potential source term available for release). SCB fires were incorporated in DBE event sequences 4, 5, and 6.

3.4.2.8.2 Source Term Analysis

The potential source term in B6580 for the DBE consists of residual contamination, contaminants built up on filters, the noble gas inventory in the cold trap, and any radiological materials that are in process at the time of the event. The availability of the source term for transport is dependent on the physical form of the material and the containers in which the material exists.

Residual contamination will exist in each SCB due to routine spills and incidental venting of gases evolved during processing. The principal contaminant (as well as the contaminant of most concern) will be iodine, due to its volatility and biological hazard. Iodine is rendered volatile during acidic dissolution of uranium dioxide containing fission products. Noble gases will be vented to and captured in a cryogenic cold trap. Those noble gases that are inadvertently released to the SCB environment will be entrained in the ventilation system flow and discharged immediately to the environment. Fission products other than noble gases and halogens remain non-volatile, will remain in acidic solution during processing, and will be solidified at the completion of each processing operation. The total residual inventory in the SCBs is 16 curies of iodine. The residual inventory in the Zone 2A canyon outside of the SCBs is 51 microcuries of iodine, which is the only specie with significant volatility.

The potential inventory on in-box filters totals 40 curies of I-131, and 34 curies of I-133 (Mitchell and Naegeli, 1999). This inventory would not be directly affected (released) due to seismic loads, but is potentially releasable in a fire. The inventory in the cold trap is potentially available for release in the DBE, which could disrupt the supply of LN to the trap. The noble gas inventory, based on maximum processing rates, approaches an equilibrium value of 33,000 curies of Xe-133 within about 30 days (Mitchell and Naegeli, 1999).

The material in-process inventory is that of a maximally irradiated target. During the one hour initial processing period, the entire radiological inventory is potentially available for release. Once the iodine has been collected in the iodine trap, it would not be vulnerable to DBE effects. Thus, for the remainder of the processing period only the residual process liquid, containing about 75% of the total fission product inventory and totaling about 14,000 curies, is available as a potential source term. This source term is present until the waste is solidified (approximately 3 hours).

3.4.2.8.3 Consequence Analysis

Analyses of the consequences of twelve potential DBE outcomes are described in Appendix 3E, and are summarized in Table 3.4-3.

Table 3.4-3 DBE Event Frequencies* and Consequences

DBE Event	Short Description*	Ventilation System Likelihood	Source Term Likelihood	Overall Likelihood	Dose Conseqences at 3000 m. (mrem)**
DBE1	Operating, RST	.01	.17	1.7 E-6	3.4
DBE2	Non-Operating, RST	.09	.17	1.5 E-5	3.4
DBE3	Breach, RST	0.9	.17	1.5 E-4	3.4
DBE4	Operating, RST+	.01	.01	1 E-7	3.6
DBE5	Non-Operating, RST+	.09	.01	9 E-7	3.6
DBE6	Breach, RST+	.9	.01	9 E-6	9.0
DBE7	Operating, PLST	.01	.054	5.4 E-7	190
DBE8	Non-operating, PLST	.09	.054	4.9 E-6	3.4
DBE9	Breach, PLST	0.9	.054	4.9 E-5	3.4
DBE10	Operating, EST	.01	.00017	1.7 E-9	192
DBE11	Non-operating, EST	.09	.00017	1.5 E-8	3.4
DBE12	Breach, EST	0.9	.00017	1.5 E-7	3.4

Notes: RST = Residual Source Term
RST+ = Residual Source Term and In-box filters (SCB fire)
PLST = Process Liquid Source Term
EST = Entire Target Source Term

* Frequencies were calculated in the DBE analysis on the basis of a DBE return period of 1000 years.

** Refer to Table 3E.7-1 of Appendix 3E for applicable contributors to dose consequence.

Based on DOE-STD-1027 criteria and methodology, a dose consequence at 3000 m. of 44 mrem is calculated for unmitigated release of the entire maximum inventory associated with each radioactive material storage area (RMSA). The likelihood of a release of the RMSA inventory was not assessed in the DBE analysis. If the inventories of all RMSAs were released simultaneously with the inventory of B6580, the highest total dose consequences at 3000 m. due to a DBE would be less than 300 mrem. This consequence is assessed to occur with a likelihood of less than once in one million years.

3.4.2.8.4 Comparison of Consequences to Evaluation Guidelines

The maximum potential dose consequence resulting from the DBE of 300 mrem is well below the evaluation guidelines of 25 Rem.

3.4.2.8.5 Summary of Safety-Class SSCs and TSR Controls

Based on the degree to which potential consequences are below the evaluation guidelines, no safety class SSCs or associated TSRs are required to mitigate the consequences of a DBE.

3.4.2.9 Summary of Design Basis Accident Frequency and Consequences

Table 3.4-3 contains a summary of accident frequency and consequences for all DBAs analyzed above. Dose consequences to the public are well below the evaluation guidelines for all DBAs. Frequencies of occurrence were assessed as unlikely or very unlikely for most DBAs. Frequencies for the exception, the spill of process materials in an SCB, ranged from anticipated to unlikely. Even though only one target is ever expected to be in process at one time in each SCB, for the purposes of consequence evaluation it was assumed that the contents of six targets are available simultaneously for release to accommodate processing six targets per day in a single SCB.

3.4.3 Beyond Design Basis Accidents

DOE Order 5480.23 requires the evaluation of accidents beyond the design basis to provide a perspective of the residual risk associated with the operation of the facility (DOE 1994a). Such beyond DBAs are not required to provide assurance of public health and safety. It is expected that beyond DBAs will not be analyzed to the same level of detail as DBAs. The evaluation will simply provide insight into the magnitude of consequences of beyond DBAs. This insight from beyond DBA analysis has the potential for identifying additional facility features that could prevent or reduce severe beyond DBA consequences (DOE 1994b).

Section 3.3.2.3.5, Accident Selection, identified one beyond DBA as, "Multiple simultaneous errors or events that affect multiple SCBs, resulting in release of the contents of multiple targets." Release of the fission products from multiple targets (six) in a single SCB has already been analyzed in two DBAs: Spill of Process Materials in an SCB and Fire in a Process SCB. The source term and consequences of the "Multiple simultaneous errors or events..." beyond DBA are discussed in Section 3.4.3.1 and 3.4.3.2 below. Two additional hazards are discussed in Sections 3.4.3.3 and 3.4.3.4 as beyond DBAs to provide a perspective of the residual risk associated with the operation of the facility. These beyond DBAs are: 1) seismic events resulting in a release of radiological material and 2) dispersal of radiological material by an explosion in the HCF.

Table 3.4-4. Summary of DBA Frequency and Consequences.

Design Basis Accident	Frequency of Occurrence by Bin and Times/Year	Dose Consequences to the Public at 3000 m from the HCF	Met Evaluation Guidelines of <25 rem to the Public?
Spill of Process Materials in an SCB	Frequency Bin I–V, $F \geq 1$ (Normal Operations) to $10^{-6} > F$ (Extremely Unlikely)	1 mrem to 1.8 Rem	YES
Hydrogen Combustion in the Elevator Pit	Frequency Bin IV, $10^{-4} > F \geq 10^{-6}$ (Very Unlikely)	No significant off-site radiological consequences	YES
Fire in a Process SCB	Frequency Bin V, $10^{-6} > F$ (Extremely Unlikely)	1 mrem to 2 Rem	YES
Fire in Room 109	Frequency Bin IV, $10^{-4} > F \geq 10^{-6}$ (Very Unlikely)	0.008 mrem filtered 0.08 mrem unmitigated	YES
Forklift Accident During Movement of an Irradiated Target	Frequency Bin III–IV, $10^{-2} > F \geq 10^{-4}$ (Unlikely) – $10^{-4} > F \geq 10^{-6}$ (Very Unlikely)	<1 mrem unmitigated	YES
Failure of the Ventilation System (Loss of Off-Site Power)	Frequency Bin IV, $10^{-4} > F \geq 10^{-6}$ (Very Unlikely)	Negligible off-site radiological consequences	YES
Fire in a HCF Radioactive Material Storage Area	Frequency Bin III–IV, $10^{-2} > F \geq 10^{-4}$ (Unlikely) – $10^{-4} > F \geq 10^{-6}$ (Very Unlikely)	44 mrem unmitigated	YES
Design Basis Earthquake	Frequency Bin IV-V, $10^{-4} > F \geq 10^{-6}$ (Very Unlikely) $10^{-6} > F$ (Extremely Unlikely)	3.4 to 9 mrem 192 mrem	YES

3.4.3.1 Beyond DBA Source Term Analysis for Multiple Simultaneous Events

A production level of 100% of U.S. demand for Mo-99 could require the processing of an average of six irradiated isotope production targets per day, the maximum number of in-process targets assumed available in the HCF at one time. Even though more than six targets may be processed in a single day, only one target is ever expected to be in process at one time in each SCB. For the purposes of consequence evaluation in those two DBAs, it was assumed that the contents of six targets were simultaneously available for release. The consideration of up to six targets was based on a scenario where only a single extraction SCB was available for processing while maintaining a processing rate of six targets per day.

Since the fission products from a maximum of six in-process targets were assumed to be available in the HCF at one time, the multiple simultaneous errors or events of the beyond DBA could release the contents of only six in-process targets. Trapped fission products from targets processed on previous days are stored in SCBs in iodine traps (I-traps) and cold traps (for noble gases). The I-trap holds trapped iodine by a chemical bond in a steel cylinder and the cold trap holds noble gases in an evacuated, cryogenically cooled bed. Because of the physical form of the iodine compound (copper iodide) and the relatively low dose consequences of the noble gases, the contributions of these two types of traps to public dose consequences were assessed to be insignificant compared to the in-process material (Mitchell and Naegeli 1999). Thus, the source term for the beyond DBA is the same as that developed for the spill DBA in Section 3.4.2.1.2.

3.4.3.2 Beyond DBA Consequence Analysis for Multiple Simultaneous Events

Since dose to the public from the release of the fission products from six in-process targets was calculated for two DBAs, the consequences for the results of multiple simultaneous events that affect multiple SCBs have already been assessed. They are bounded by the maximum potential dose consequences of 1.8 Rem for an unmitigated release. These dose values are lower than the evaluation guidelines (25 rem) so no additional safety-class SSCs or TSRs are identified.

3.4.3.3 Beyond Design Basis Earthquake

An evaluation of the response of the HCF in a Design Basis Earthquake (DBE) has been accomplished in Appendix 3E, and likelihoods of occurrence have been assessed for the configuration of confinement systems and availability of radiological inventory for release.

For the BDBE, structural degradation greater than that which would occur in the DBE was postulated. Additional analyses were accomplished based on larger openings in confinement barriers than were assumed for the ventilation failure analysis. As the basis for assessing the consequences, the following structural failures were assumed to occur in a BDBE, without regard to likelihood:

1. The 1-inch thick glass window in each SCB shatters, releasing the contents of the SCBs to the Zone 2A canyon.

2. Structural failures result in significant leakage areas of 50 to 270 square feet through the Zone 2A canyon confinement boundary.

3. While the continued operation of the ventilation system would be extremely unlikely, the potential consequences of both continued operation and non-operation were evaluated.

The source terms considered were the same as those described in the DBE evaluation.

In the more likely event of failure of the ventilation system, the inventory contained in the SCBs is released to the Zone 2A canyon, and subsequently diffuses into Zone 2. The rate of this diffusion is relatively slow, and at most, approximates 1 curie of I-131 after about 4 hours. The resulting dose consequences at the 3000 m exclusion area boundary in this scenario are less than 0.1 mrem.

In the less likely event of continued ventilation system operation, the source term and resulting consequences would be identical to that calculated for the same scenario in the DBE, with maximum consequences of less than 300 mrem at 3000 meters.

3.4.3.4 Explosion Hazard Beyond DBA

The potential for explosions internal to the HCF proper to result in a release of radiological material was considered in the identification of hazards and Section 3.3.2.1. The likelihood and severity of an explosion is limited by administrative control of the quantity of volatile materials in the HCF (see Chapter 8) and by the circulation and dilution provided by the HCF ventilation system.

The potential for dispersal of radiological materials by an explosion in the HCF is limited by the location and form of the radiological materials and the configuration and construction of the HCF. The massive concrete construction will constrain the expansion of products of the explosion and will limit the potential for explosion generated missiles to propagate damage. Even in the event of a severe explosion in Zone 2 of the HCF, the overpressures that would be expected in the Zone 2A canyon, which contains the radiological inventory, would be limited. The overpressure limitation is due to the volume of the facility and due to venting that would occur through weak points in the HCF boundary (e.g. the roll up doors in the truck ramp). Such doors would not withstand an overpressure of even a few psi (Glasstone and Dolan 1977). Confinement barriers (i.e. airlock doors, ventilation ducting) would probably not remain intact, although the SCBs would easily withstand the overpressure resulting from an explosion. Additionally, the steel target tubes that contain the volatile radiological material inventory would not be expected to be breached at any credible overpressure, and the non-volatile inventory, in either liquid or solid form, would not be expected to be volatilized. Even if the volatile inventory is released as a result of the explosion, the consequences are bounded by the DBAs analyzed in this chapter (spill or fire scenario). Failure of the ventilation system, including the ducting, would be bounded by the ventilation failure DBA analyzed in this chapter.

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CONTENTS

TABLES

4.0 SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

The purpose of this chapter is to identify and describe structures, systems, and components (SSCs) that were assumed explicitly in the hazard/accident analysis to have provided a safety function; that is, they were considered necessary in order to satisfy Evaluation Guidelines (EGs), provide defense in depth, or contribute to worker safety. Each of these SSCs is described along with the basis for designating the SSC as safety-related. Also provided are the applicable functional requirements, interfaces with other SSCs, and evaluations required to demonstrate performance of the SSCs safety functions under all expected accident or environmental conditions.

In accordance with DOE-STD-3009-94, (DOE 1994) safety SSCs are divided into two categories: (1) safety-class and (2) safety-significant. DOE-STD-3009-94 defines safety-class SSCs (SCSSCs) as those SSCs, including environmental monitors and portions of process systems, whose failure could adversely affect the environment or safety and health of the public as identified by safety analysis. The phrase "adversely affect" refers to exceeding offsite EGs (i.e., a whole-body dose of 25 rem to the nearest located member of the public). SCSSCs are systems, structures, or components whose preventive or mitigative function is necessary to keep hazardous material exposure to the public below the EGs.

DOE-STD-3009-94 defines safety-significant SSCs (SSSSCs) as SSCs not designated as SCSSCs but whose preventive or mitigative function is a major contributor to defense in depth (i.e., reduces likelihood of uncontrolled hazardous material release) or worker safety as determined from hazard analysis. SSSSC designations based on worker safety are limited to those systems, structures, or components whose failure is estimated to result in an acute worker fatality or serious injuries to workers. Serious injuries, as used here, are those injuries requiring medical treatment for immediately life-threatening or permanently disabling injuries (e.g., loss of eye or limb) from other than standard industrial hazards. It specifically excludes potential latent effects (e.g., potential carcinogenic effects of radiological exposure or uptake).

It is important to realize that classification for the sake of classification or the assignment of preconceived requirements to SSCs could make the design and construction of new facilities or the modification of existing ones and their operational costs prohibitive for little risk reduction gained. Therefore, the classification of SSCs and the implementation of requirements should be applied in a graded approach. The classification is therefore based on results of hazard or accident analyses.

The most important aspect of classifying SSCs is the identification of design and operational requirements associated with them, as also indicated by the Configuration Management Standard (DOE 1993). Implementation of requirements should be correlated to the safety classification of SSCs (importance to safety). Design-requirement implementation should depend also on whether the facility is new or already operating. Table 4.1-1 illustrates the correlation of design requirements to new vs. existing facilities.

Table 4.1-1. Illustration of Implementation of Design Requirements for New and Existing Facilities

Design Requirements	New Facility	Existing Facility
Single Failure Criterion Graded approach is dependent on SSC classification and operational mode (passive vs. active).	Any of the following: • Fail safe. • Redundancy or diversity. • Separation or isolation (including interfaces and boundaries).	• Evaluate for common failure modes, independence, and reliability. • Backfit only if risk/cost effective.
Seismic Qualification Facility classification dependent only.	• Graded to performance categories in DOE Order O 420.1 (DOE 1996). • SC-I/HC-1, SC-II/HC-2, etc.	• Evaluate for seismic response acceptability. • Backfit only if risk/cost effective.
Environmental Qualification SSC classification dependent.	• Testing or NDE for SCSSC. • Analysis for SSSSC.	• Review for environmental qualification by analysis only. • Backfit only if risk/cost effective.
QA Procurement Design, testing, and fabrication tied to environmental qualifications.	• QA levels correlated to SSC and hazard classification. • Commercial grade or off-the-shelf items OK if qualified for service.	• Commercial grade or off-the-shelf items OK if qualified for service.

The hazard/accident analysis of Chapter 3 did not identify any significant risks for which backfitting HCF SSCs is warranted.

4.2 Requirements

This section identifies the design codes, standards, regulations, and DOE Orders which are required for establishing the safety basis for the HCF. Only those requirements that are pertinent to the safety analysis and scope of this chapter are provided. The Conceptual Design Report (CDR) for the Additional Hot Cell Facilities, Building 6580 (CDR-HCF-84) (SNL 1984), summarizes the design requirements to which the HCF was designed.

4.2.1 DOE Orders

The following DOE orders and standards contain requirements for establishing the safety bases of DOE nuclear facilities:

DOE Order O 420.1, Facility Safety, (DOE 1996) sets forth the basic nuclear safety, fire protection, nuclear criticality safety, and natural phenomena mitigation design requirements for new DOE facilities, and major modifications of existing ones.

DOE Order 5480.22, Technical Safety Requirements (DOE 1992a), specifies the criteria, content, scope, format, approval process, revision process, and reporting requirements for DOE nuclear facility Technical Safety Requirements.

DOE Order 5480.23, Nuclear Safety Analysis Reports (DOE 1992b), specifies requirements for development and documentation of safety analyses that establish the adequacy of the safety bases for DOE nuclear facilities.

DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, (DOE 1994) describes a SAR preparation method that satisfies the requirements of DOE Order 5480.23 and is acceptable to the DOE.

4.3 Safety-Class Structures, Systems, and Components

Because of the nature of the HCF and its hazardous material inventory, no unmitigated accident scenario will result in off-site exposures greater than the off-site Evaluation Guidelines, as evaluated and described in Chapter 3 of this SAR. Therefore, no safety-class SSCs have been identified for the Hot Cell.

4.4 Safety-Significant Structures, Systems, and Components

Some HCF safety-significant SSCs serve primarily a defense in depth function. That is, they reduce either the likelihood of occurrence or the consequence of an accidental release of radioactive material (unmitigated consequences cannot exceed the off-site Evaluation Guideline of 25 rem). Other safety-significant SSCs serve primarily a worker safety function for the HCF. The evaluation of these potential consequences and the identification of the SSCs that mitigate them are described in Chapter 3 and are summarized in Table 4.4-1.

The SCBs, and the floor, walls, and ceiling of the Zone 2A canyon and Room 109 constitute the structures designed to serve a radioactive material confinement function under all normal, abnormal, and accident conditions (refer to Appendix 3E, Section 3E.7 for design basis earthquake accident analysis assumptions). By reducing the likelihood of a radioactive material release these structures provide both defense in depth and worker safety functions.

Since the Zone 1 and Zone 2A ventilation exhaust systems are not required to operate under abnormal and accident conditions, the exhaust fans have no safety function. However, these exhaust systems interface with the SCB and the Zone 2A canyon/Room 109 environments, respectively. Therefore, the exhaust ducting and filter plenums constitute extensions of the respective radioactive material confinement boundaries, and thus provide both defense in depth and worker safety functions.

Furthermore, when the ventilation system is operating (and thus removing radioactive material from the HCF confinement structures) radioactive halogens and radioactive particulate matter are removed from the exhaust gases by charcoal filters in the Zone 1 and Zone 2A ventilation exhaust systems and HEPA filters in the hot exhaust system. Thus,

Table 4.4-1. HCF Safety-Significant SSCs

Safety Function	SSC Performing Safety Function	Chapter 3 SSC Designation	Functional Requirement	Performance Criteria Requiring TSR Coverage
Control of radioactive material releases	Zone 2A canyon and Room 109 physical structures (walls and ceilings)	Defense in depth Worker safety	Provide a radioactive material confinement boundary during normal and abnormal conditions	Confinement design (Design Feature) Zone 2A-to-Zone 2 negative differential pressure
	SCBs in which radiochemical processing occurs	Defense in depth Worker safety	Provide a radioactive material confinement boundary during normal and abnormal conditions	Confinement design (Design Feature) Zone 1-to-Zone 2A negative differential pressure
	Zone 1 and Zone 2A ventilation exhaust systems (hot exhaust ducting, charcoal filters and plenums, and HEPA filters and plenums)	Defense in depth Worker safety	1. Remove iodine and radioactive particulate matter from Zone 1 and Zone 2A ventilation exhaust when the ventilation system is operating 2. Provide a confinement boundary to the HCF stack for ventilation system hot exhaust	1. HEPA and charcoal filters are in service 2. Confinement design (Design Feature)
Protection of HCF personnel from potentially lethal radiation exposures	Zone 2A canyon physical structures (concrete walls, shield steel, shielding windows)	Worker safety	Provide radiation protection such that worker exposures in continuously occupied areas under normal and abnormal conditions are in accordance with 10 CFR 835	Shield design (Design Feature); Radioactive material control (Administrative Control)
	Room 109 physical structures (walls, ceiling, beam port shield plugs)	Worker safety	Provide radiation protection such that worker exposures in continuously occupied areas from radioactive waste stored in Room 109 are in accordance with 10 CFR 835	Shield design (Design Feature); Radioactive material control (Administrative Control)
	Shield cask	Worker safety	Provide radiation protection such that worker exposures from radioactive material during cask transport are in accordance with 10 CFR 835	Shield design (Design Feature); Cask lid closure (Administrative Control)
	Hydraulic shield door controls	Worker safety	Prevent unintentional lowering of shield door 2A while shield door 1 is down, and lowering of shield door 3A with workers in the Zone 2A canyon, the Zone 2A airlock, or the north end of Room 112	Shield door control (Administrative Control)
	Target Entrance System (TES) mechanical interlock	Worker safety	Prevent removal of shield cask from STB with improperly installed cask lid	Interlock is operable

these filters provide both defense in depth and worker safety functions by reducing the likelihood of a radioactive material release when the ventilation system is operating.

The Zone 2A concrete walls, shield steel, and leaded-glass and oil-filled windows all provide radiation protection for HCF workers during isotope processing and radioactive waste preparation and handling operations. These structures also provide radiation shielding for workers following abnormal and accident conditions, including earthquakes. Similarly, the Room 109 concrete walls, ceiling, and beam port plugs provide worker radiation protection from radioactive waste stored in Room 109. Thus, these shielding structures are the only HCF SSCs that are expected to maintain their safety function following an earthquake.

The following sections further address the SSCs summarized in Table 4.4-1.

4.4.1 Zone 2A Canyon and Room 109 Structures

4.4.1.1 Safety Function

The Zone 2A canyon and Room 109 physical structures encompass all HCF isotope processing and radioactive waste handling operations. These structures serve three safety-related purposes: (1) to provide structural integrity and protection against the elements, (2) to provide radiation shielding for normal, abnormal, and accident conditions, and (3) to confine radioactive-material under normal, abnormal, and accident conditions. These structures serve no other functions that meet safety-related criteria.

Purpose 1 serves a defense in depth function by limiting the opportunities for external events and conditions to initiate or complicate abnormal/accident situations within the facility.

Purpose 2 serves a worker protection function by providing barriers to potentially lethal doses of ionizing radiation from radioactive material operations conducted within the facility.

Purpose 3 serves a defense in depth function by providing a barrier to the potential uncontrolled movement of radioactive materials within the facility.

4.4.1.2 SSC Description

A summary of the Zone 2A canyon and Room 109 structures follows. More detailed descriptions can be found in Chapter 2.

<u>Zone 2A canyon</u> -- The Zone 2A canyon, located in the basement of Building 6580, is a shielded room approximately 3 m (10 ft) wide and 4.6 m (15 ft) high. The floor is a concrete slab. The ceiling is 61 cm (2 ft) of reinforced concrete and is mounded with a minimum of 1.5 m (4.9 ft) of soil overburden. The ceiling is penetrated by a vertical access port that has been used for transferring irradiated materials into the canyon from outside the HCF. A shield plug precludes radiation streaming from Zone 2A through the access port. At the "open" end of the canyon confinement is maintained by means of an airlock. To achieve the necessary radiation protection for HCF workers, portions of the Zone 2A canyon walls are lined with steel plates. In addition, the Zone 2A canyon walls contain shielding windows, a "target-entrance system," and two "product-exit systems." More detailed descriptions can be found in Chapter 2.

Room 109 -- Room 109 is also located in the basement of Building 6580. The Sandia Engineering Reactor (SER) vessel extends into Room 109, which was originally used for irradiating materials. Thus, the massive walls and ceiling for this room were designed for both structural integrity and radiation shielding. The north and south walls of Room 109 are 8 feet thick and are constructed of 3.2 g/cm^3 magnetite concrete. The ceiling consists of 8.5 feet of normal concrete with 3.2 g/cm^3 magnetite concrete around the SER vessel. The east shield door (4 feet 10 inches thick) and the west shield door (5 feet 5 inches thick) are constructed of 4.7 g/cm^3 magnetite concrete with steel punchings. More details of Room 109 can be found in Chapter 2.

These building structures are passive safety features and therefore perform passive safety functions. The only SSC whose mis-operation can directly affect the safety function of these structures is the shield door hydraulic system [a non-safety-related (NSR) system], which is used to lower and raise the massive shield doors connecting Rooms 108 and 109, and Room 109 and the Zone 2A canyon. Mis-operation of this system with the Room 109/Zone 2A shield door down and radioactive waste in Room 109, can present a radiation hazard to workers at the north end of Room 112. The Zone 2A canyon structures, including the associated shielding windows, and the Room 109 structures are the only HCF SSCs that are required to maintain their safety functions following an earthquake.

4.4.1.3 Functional Requirements

The safety-related features of the Zone 2A canyon and Room 109 structures are inherently passive (i.e., they provide radiation shielding and radioactive material confinement functions). Thus, the functional requirements applicable to these structures are:

- To provide a radioactive material confinement barrier during normal and abnormal conditions to minimize potential onsite and offsite dose consequences (defense in depth).
- To provide radiation protection of workers from radioactive material operations during normal and abnormal conditions such that exposures to workers in continuously occupied areas of the facility are in accordance with the requirements of 10 CFR 835 (worker safety).

4.4.1.4 SSC Evaluation

Table 4.4-2 provides performance criteria needed to demonstrate that the functional requirements for the Zone 2A canyon and Room 109 structures are met. The design-basis accidents, operational events, and external events that could affect these structures are identified and analyzed in Section 3.4. Based on the results of these analyses, the confinement function is provided by the physical integrity of these structures. While the integrity of the confinement barrier can be continually demonstrated by monitoring the presence of a pressure gradient across the structure, significant degradation of the barrier cannot be positively detected. That is, a minimum detectable negative pressure differential of 0.76 mm (0.03 in) WG between the Zone 2A canyon/Room 109 and Zone 2 establishes the physical integrity of these structures, in that this pressure differential cannot be maintained in the event of significant degradation of the confinement barrier. However, absence of the minimum detectable Δp does not necessarily indicate confinement barrier degradation. In fact, positive verification of significant confinement barrier degradation is not possible with installed instrumentation. Such verification necessarily requires observation. Therefore, since the Δp instrumentation cannot be relied upon to provide an unambiguous indication of confinement barrier failure, the instrumentation itself is not classified as safety-significant.

The isotope production design objective for controlling worker exposure from external sources of radiation in areas of continuous occupancy (2000 hours per year) is to maintain exposure levels below an average of 0.5 mrem per hour. The Zone 2A canyon walls have been designed to meet this objective by providing sufficient thicknesses of shielding materials (steel and concrete) to scatter and absorb incident radiation. To ensure that the shielding design objective is maintained, the amount of radioactive material allowed within the SCBs will be administratively controlled.

Table 4.4-2. Performance Criteria for Zone 2A Canyon and Room 109

Performance Criteria	Evaluation
When the ventilation system is operating, the pressure in the Zone 2A canyon and Room 109 must be maintained negative with respect to worker occupied areas of the HCF.	The Zone 2A ventilation exhaust system maintains the Zone 2A canyon and Room 109 pressure ≤ -0.76 mm (0.03 in) WG with respect to worker occupied areas (Zone 2) of the HCF.
Worker exposures to radioactive material sources in Zone 2A and Room 109 must be maintained ALARA.	Shielding design and administrative control of radioactive material sources in Zone 2A and Room 109 maintain worker exposures below an average of 0.5 mrem per hour in continuously occupied (2000 hours per year) areas of the HCF.

4.4.1.5 Controls (TSRs)

The Zone 2A canyon and Room 109 structures provide only inherent passive safety functions (i.e., physical integrity, radiation shielding, and radioactive material confinement). A TSR requirement to verify the existence of a negative pressure gradient between the Zone 2A canyon and Zone 2 will be implemented to verify the integrity of these confinement structures. Continued design performance of the radiation shielding function will be ensured by administratively controlling the amount of radioactive material allowed within the SCBs. The Room 109/Zone 2A door only performs its radiation shielding function when the door is up. Whenever the door is lowered with waste in Room 109, administrative controls will be implemented to control worker access to the north end of Room 112.

4.4.2 Processing Steel Confinement Boxes (SCB)

4.4.2.1 Safety Function

Steel confinement boxes (located inside the Zone 2A canyon) serve as passive defense in depth barriers to the potential uncontrolled movement of radioactive materials from isotope processing activities under normal and abnormal conditions. These SCBs serve no other functions that meet safety-related criteria.

4.4.2.2 SSC Description

The SCBs are steel boxes that are mounted inside the Zone 2A canyon with the SCB window adjacent to a shielding window. The four extraction SCBs are located along the west shield wall of the canyon. Each SCB has at least one sealable penetration so that equipment and material may be transferred between the SCBs and the canyon via three under-the-box transfer systems. Some SCBs are linked by sealable pass-throughs to allow the passage of process materials between SCBs.

In addition, the SCBs are part of the Zone 1 ventilation system. Each SCB is operated independently of the other SCBs. Airborne leakage from each SCB to Zone 2 (the general work areas) is prevented by maintaining a nominal negative pressure differential of approximately 6.4 mm (0.25 in.) WG between each SCB and the Zone 2A canyon, with a similar pressure differential maintained between the Zone 2A canyon and Zone 2. SCB manipulators, which penetrate both the SCBs and the Zone 2A canyon, are sealed with a manipulator boot. More detailed descriptions of the SCBs can be found in Chapter 2.

The SCBs are passive safety features and therefore perform a passive safety function. Table 4.4-3 summarizes the interfaces of the SCBs with other safety-related and non-safety-related SSCs in the HCF.

Table 4.4-3. SCB Interfaces

Interfacing System	Classification	Description of Interface
Zone 1 Ventilation System	SSSSC	Ventilation supply and exhaust ductwork connected to each SCB.
Material Handling Equipment	NSR*	Manipulator assemblies penetrate SCBs.
Process Vacuum System	NSR*	Vacuum service lines penetrate SCBs
SCB Conveyor System	NSR*	Conveyor system interfaces with SCB through covered SCB floor openings
Zone 2A Canyon Structure	SSSSC	SCBs are totally contained within Zone 2A canyon structure. Failure of canyon structures could lead to failure of the SCBs.
SCB Water Washdown System	NSR*	Water lines penetrate SCBs
SCB Passthroughs	NSR*	Sealed ports between SCBs and SCB conveyor system and between some SCBs
SCB Utility Plugs	NSR*	Sealed utility service plugs for future use penetrate SCBs
*Indicates a non-safety-related (NSR) SSC.		

4.4.2.3 Functional Requirements

The safety-related features of the SCBs are inherently passive (i.e., they provide passive radioactive material confinement functions). Thus, the only functional requirement applicable to the SCBs is:

- To provide a radioactive material confinement barrier under normal and abnormal conditions such that diffusion transport of radionuclides is maintained ALARA in order to minimize potential off-site dose consequences (defense in depth).

4.4.2.4 SSC Evaluation

The performance criterion needed to demonstrate that the above functional requirement is met is that pressure in the SCBs must be maintained negative with respect to the Zone 2A canyon. Design-basis accidents, operational events, and external events that could affect the SCBs are identified and analyzed in Section 3.4. The passive confinement function of the SCBs is continuously demonstrated by monitoring the presence of a pressure differential across the SCB boundary (see the discussion on the use of differential pressure instrumentation for verifying confinement barrier integrity in Section 4.4.1.4). A minimum detectable negative pressure differential of 0.76 mm (0.03 in) WG between Zone 1 (the SCBs) and the Zone 2A canyon establishes the physical integrity of the SCB confinement boundary.

4.4.2.5 Controls (TSRs)

The SCBs provide only an inherent passive safety function. A TSR requirement to verify the existence of a negative pressure between the SCBs and the Zone 2A canyon will be implemented to verify the integrity of the SCBs.

4.4.3 Zone 1 and Zone 2A Ventilation Exhaust Systems

4.4.3.1 Safety Function

The safety function of the HCF Zone 1 and Zone 2A ventilation exhaust systems is to provide a controlled, filtered path for radioactive releases during normal and abnormal operating conditions. Radioactive particulate matter and iodine are removed from Zone 1 and Zone 2A exhaust air by means of HEPA and charcoal filters, respectively.

4.4.3.2 SSC Description

Chapter 2 contains detailed descriptions of the Zone 1 and 2A portions of the ventilation system. Ventilation system ducting provides the necessary confinement pathway during normal ventilation system operation to ensure filtration of exhaust gases prior to atmospheric release. The Zone 1 ventilation exhaust system contains redundant series-parallel charcoal filter banks located in the MER. The Zone 2A ventilation exhaust system contains charcoal filter banks located in the MER. In addition, ventilation system hot exhaust from Zone 1 and Zone 2A is routed through a HEPA filter before entering the HCF stack. These ventilation systems are described in more detail in Chapter 2.

The ventilation exhaust charcoal filters are physically located in the MER, which is the only interface the filters have with other HCF SSCs. Thus, structural failure of the MER is the only SSC failure that could <u>directly</u> affect the safety function of these filters. The stack HEPA filters are located within an enclosure at the base of the HCF stack. These HEPA filters do not interface with any other HCF SSCs. Thus, the failure of these structures is the only SSC failure that could <u>directly</u> affect the safety function of the HEPA filters.

4.4.3.3 Functional Requirements

The Zone 1 and Zone 2A ventilation exhaust ducting and HEPA and charcoal filters are passive components. Their safety-related function is performed continuously while the HCF ventilation system is in operation. When the ventilation system is not operating, no isotope processing operations are being conducted, and any residual radioactive materials are in non-volatile states and are confined within the SCBs and Zone 2A canyon. Thus, the functional requirements applicable to the filters are:

- To provide two stages of charcoal filtration for Zone 1 exhaust (defense in depth).
- To provide one stage of charcoal filtration for Zone 2A exhaust (defense in depth).
- To provide one stage of nuclear-grade HEPA filtration for all ventilation system hot exhaust (defense in depth).

The safety function associated with providing a confined pathway for hot exhaust gases is performed continuously while the HCF ventilation system is in operation. The applicable functional requirement is:

- To provide a confinement barrier for radioactive material entrained in Zone 1 and Zone 2A ventilation exhaust streams (defense in depth).

4.4.3.4 SSC Evaluation

Table 4.4-4 provides performance criteria needed to demonstrate that the functional requirements for the Zone 1 and Zone 2A ventilation exhaust systems are met. No operational events can affect the ability of the HEPA and charcoal filters to perform their safety functions, since these functions are only required when the HCF ventilation system is operating. Furthermore, failure of filter bank inlet or outlet dampers to remain open during ventilation system operation will essentially stop the flow of Zone 1/Zone 2A exhaust air to the HCF stack. The only events that could affect the ability of the charcoal filters to perform their safety function are a fire in the MER or an external event such as an earthquake or aircraft crash that would destroy the MER. The only events that could affect the ability of the HEPA filters to perform their safety function are similar events.

Table 4.4-4. Performance Criteria for Zone 1 and Zone 2A Ventilation Exhaust Systems

Performance Criteria	Evaluation
When the ventilation system is operating, Zone 1 exhaust airflow must be routed to charcoal filters before being exhausted from the HCF stack.	Piping and ductwork from the SCBs route airflow generated by ventilation system fans to redundant, 2-stage charcoal filter plenums in the MER.
When the ventilation system is operating, Zone 2A exhaust airflow must be routed to charcoal filters before being exhausted from the HCF stack.	Ductwork from Zone 2A routes airflow generated by ventilation system fans to parallel charcoal filter plenums in the MER.
When the ventilation system is operating, hot exhaust airflow must be routed to a HEPA filter before being exhausted from the HCF stack.	Ductwork routes airflow from the Zone 1 and Zone 2A charcoal filter plenums in the MER to a HEPA filter plenum in the HCF stack.

No operational event can affect the mechanical integrity of the ventilation system hot exhaust ducting.

The consequences of these events are no more serious than the design-basis events evaluated in Chapter 3.

4.4.3.5 Controls (TSRs)

A TSR requirement to verify that Zone 1 and Zone 2A ventilation exhaust HEPA and charcoal filters are in-service will be implemented to assure that exhaust gases are being filtered when the HCF ventilation system is in operation. A TSR requirement to verify the ventilation system fan sequencing interlock is operable will be implemented to ensure that proper building airflow patterns are maintained in the event of exhaust fan failures. The ventilation system exhaust ducting provides only an inherent passive safety function (i.e., confinement) and no specific TSR controls are required to ensure continued performance of this function.

4.4.4 Shield Cask

4.4.4.1 Safety Function

The sole purpose of the shield cask is to provide protection for workers from potentially lethal doses of radiation emitted by irradiated material during transfer operations. The shield cask also provides limited physical protection to the radioactive material should a mishap occur in transport.

4.4.4.2 SSC Description

The shield cask is fabricated from cast depleted uranium (DU) clad with stainless steel. It is nominally 16 inches in diameter, 38 inches tall, and weighs approximately 5,000 lb. Steps are incorporated into the mating surfaces between the DU sections to prevent radiation streaming through the joints. The cask is designed to be loaded underwater and a drain tube is provided to allow water to drain out when the cask is lifted out of the water. The drain tube is stepped to reduce radiation streaming and the outside end is tapped so that a specially fabricated plug can be inserted to further reduce potential radiation exposure. The cask lid weighs approximately 182 kg (400 lb.) and is provided with a hoist ring for handling and is bolted to the main cask body.

4.4.4.3 Functional Requirements

The safety-related feature of the shield cask is passive radiation shielding. Thus, the only functional requirement applicable to the cask is:

- To provide radiation protection of workers during the transport of radioactive material such that exposures to workers are in accordance with the requirements of 10 CFR 835 (worker safety).

This functional requirement is the basis for the cask design.

4.4.4.4 SSC Evaluation

The performance criterion needed to demonstrate that the above functional requirement is met is that worker exposures to radioactive material transported in the shield cask must be maintained ALARA. DU thickness is sufficient to reduce the dose rate from a maximally irradiated Mo-99 target to approximately 5 mR/hr on the outside of the cask, although some specific areas on the cask surface are calculated to have somewhat higher exposure rates. Personnel working with the cask will be inserting bolts in the lid and attaching or removing rigging near the lid-operations that involve primarily extremity (i.e., hand) exposures. The dose rate estimates in the areas above the lid will be less than the 5 mR/hr contact dose rate. Combined with the estimated time involved for these operations (approximately 10 minutes), an exposure of 2 mrem (whole-body) to an operator per target transferred to the Hot Cell Facility is anticipated.

Exposure of the forklift operator transporting the cask is estimated to be less than 1 mrem (whole-body) per target transfer, based on a 30 minute transfer operation with the cask positioned on the forklift so that the cask is approximately 3 feet from the operator's abdomen.

4.4.4.5 Controls (TSRs)

The shield cask provides an inherent, passive safety function as long as the cask lid is bolted in place whenever it contains an irradiated target. Thus, a TSR administrative control for ensuring that the cask lid is bolted in place before movement will effectively implement the required safety function.

4.4.5 Shield Door Hydraulic System Controls

4.4.5.1 Safety Function

The shield door hydraulic system controls provide a worker safety function by precluding the following unintentional door operations:

- lowering of Room 108/109 shield door (door 2A) while Room 101/108 shield door (door 1) is down.
- lowering of Room 109/Zone 2A shield door (door 3A) with workers in the Zone 2A canyon, the Zone 2A airlock, or the north end of Room 112.

Without proper controls, these door operations could result in significant radiation exposures to HCF personnel.

4.4.5.2 SSC Description

The Room 108 and Room 109 shield doors are controlled from a panel at the north end of Room 107. This panel includes up and down command buttons for each door and keyed locks that are required to enable the command function.

4.4.5.3 Functional Requirements

The Room 108 and Room 109 shield doors are normally in the up position to provide shielding from the significant radiological inventory that will exist in Room 109. Shield door 3A will be lowered for the (remote) placement of radioactive waste into Room 109 for storage. Shield door 2A will be lowered for the (remote) removal of radioactive waste from Room 109. Thus, the safety functions applicable to the shield door controls are:

- To prevent the unintentional or unauthorized lowering of shield door 2A while shield door 1 is down (worker safety).
- To prevent the unintentional or unauthorized lowering of shield door 3A with workers inside the Zone 2A canyon, the Zone 2A airlock, or in the north end of Room 112 (worker safety).

4.4.5.4 SSC Evaluation

The performance criterion needed to demonstrate that the above functional requirement is met is that key operation of the shield doors must be administratively controlled. Keyed locks for enabling shield door movement provide a positive feature that can be used to preclude unintentional or unauthorized door movement.

4.4.5.5 Controls (TSRs)

A TSR administrative control for the hydraulic shield door keys required to operate the keyed locks will effectively control shield door operations. In addition, a TSR administrative control will be used to preclude personnel access to the north end of Room 112 when the Room 109/Zone 2A shield door is down.

4.4.6 Target Entrance System Mechanical Interlock

4.4.6.1 Safety Function

The TES provides a worker safety function by preventing the removal from the STB of a shield cask containing an irradiated target without the shield cask lid properly installed. Inadvertent exposure of workers to an irradiated target could be lethal.

4.4.6.2 SSC Description

The TES is used to bring irradiated targets into the shielded processing area of the HCF. The shield cask (identified above as a SSSSC) provides the necessary shielding for protection of workers during irradiated target movement. Normally, the irradiated target will be removed from the shield cask in the steel transfer box (STB) for processing and the empty cask brought back into Zone 2. Under unusual circumstances there may be a need to remove an irradiated target from the Zone 2A canyon using this system. If the shield cask lid is properly installed, the shield cask will continue to provide the required shielding function. In the event that the lid is not installed on the cask, the potential for excessive worker exposure exists. The TES mechanical interlock thus provides a worker safety function by precluding inadvertent removal of the shield cask containing an irradiated target without a properly installed shield cask lid. This function is implemented by providing a mechanism to physically prevent the removal of the TES shield cover without a properly installed lid.

4.4.6.3 Functional Requirements

The TES mechanical interlock exists to ensure that an inadequately shielded target will not be introduced into Zone 2 from the TES. Thus, the safety function of the interlock is:

- To prevent removal from the TES of a shield cask containing an irradiated target with an improperly installed lid (worker safety).

4.4.6.4 SSC Evaluation

The performance criterion needed to demonstrate that the above functional requirement is met is that the shield cask cannot be removed from the TES with the cask lid off. Removing the cask lid in the TES results in the mechanical insertion of a locking pin between the moveable and stationary parts of the TES so that the moveable part cannot be retracted into Zone 2. The mechanical interlock provides a positive feature that precludes unintentional removal of an inadequately shielded target from the TES.

4.4.6.5 Controls (TSRs)

TSR administrative control and periodic surveillance of the functionality of this interlock will be established.

4.5 REFERENCES

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CONTENTS

TABLES

5.0 DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

5.1 Introduction

This chapter provides the bases for the Technical Safety Requirements (TSRs), derived from the safety analyses presented throughout this SAR, which, when implemented, will ensure the safe operation of the HCF. The content of this chapter provides the link between the assumptions made in the hazard/accident analysis, operational safety commitments, plant configuration, and the TSR document as required by DOE Order 5480.22, *Technical Safety Requirements* (DOE 1992a).

As part of the derivation of bases for TSRs, the following information is needed:

a. Assumptions made in the hazard and accident analysis that will help prevent or mitigate the consequences of postulated accident scenarios.

b. Design features and administrative controls that are documented in the SAR and that are of safety significance.

c. Program commitments assumed to perform institutional safety functions as documented throughout the SAR that will serve as input to the TSR administrative controls.

5.2 Requirements

This section addresses DOE Orders that are required for establishing the safety basis or operating envelope, i.e., TSRs for the HCF. Only those requirements that are specific to this chapter and which are pertinent to the safety analysis are identified.

5.2.1 DOE Orders

DOE Order 5480.22, Technical Safety Requirements (DOE 1992a), This order, along with its attachment, "Guidelines for TSRs," establishes the requirement to have TSRs prepared for all DOE nuclear facilities and delineates the criteria, content, format, approval process, and reporting requirements for TSRs and revisions thereof.

DOE Order 5480.21, Unreviewed Safety Questions (DOE 1991), This order specifies the applicable conditions and basis for determining the existence of an Unreviewed Safety Question (USQ) for proposed changes or modifications to the facility design or operation. More specifically, implementation of this order requires consideration of whether a proposed activity involves a conflict with the facility Technical Safety Requirements.

DOE Order 5480.23, Nuclear Safety Analysis Reports (DOE 1992b), This order specifies the requirements for nuclear facilities to document the safety analyses that establish the adequacy of the facility safety bases. A Safety Analysis Report (SAR) is required to document the results of the safety analysis for the facility. Furthermore, as part of the SAR, the contractor is responsible for addressing the Derivation of TSRs as indicated in Section 8 under Requirements, Part b, "Scope and Content of the SAR", subsection (p). The Attachment to the Order, "Interim Guidance for DOE Order 5480.23 - SARs," Section 4, "Interpretation," Part f, Subsection d.16, provides additional guidance on the content.

DOE O 232.1, Occurrence Reporting and Processing of Operations Information (DOE 1997), This order requires a system for reporting of operations information on unusual occurrences. Section 7, "Occurrence Categorization, Notification, and Reporting Requirements," Part (2) defines a violation of a technical safety requirement as an Unusual Occurrence, which requires DOE notification within two hours of categorization (i.e., identification of the occurrence as an Unusual Occurrence), followed by written notification within 24 hours utilizing a Notification Report.

DOE O 420.1, Facility Safety (DOE 1996), This order specifies the basic nuclear facility safety program requirements, including nuclear and explosives safety, fire protection, nuclear criticality safety, and natural phenomena hazards mitigation.

DOE-STD-3009-94 (DOE 1994a), Along with the above-mentioned DOE Orders, DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, includes guidance for preparation of this chapter of the SAR.

5.3 TSR Coverage

This section contains a summary of all SSCs and administrative controls that have been identified in Chapters 3 and 4 as necessary for 1) maintaining the consequences of facility operations below the 25 rem off-site Evaluation Guideline (EG), or 2) providing significant defense in depth or worker safety because they either reduce the likelihood or mitigate the consequences of an accident.

As indicated in Section 4.3 of Chapter 4, because of the nature of the HCF and its hazardous material inventory, no unmitigated accident scenario will result in radiological exposures at the exclusion area boundary that will approach the off-site EG of 25 rem. Therefore, there are no SSCs required to maintain the consequences of facility operations below the EG (safety-class SSCs). As a result, no TSR Safety Limits (SL) or Limiting Control Settings (LCS) are required for HCF SSCs. Section 4.4 of the chapter addresses those SSCs that perform a significant defense in depth or worker safety function. These safety-significant SSCs are summarized in Table 4.4-1.

The following criteria from DOE Order 5480.22 were used to determine the applicability of TSR Limiting Conditions for Operation (LCO) to the list of safety-significant SSCs contained in Table 4.4-1.

<u>Criterion 1</u>: Installed instrumentation that is used to detect and indicate (in a control room or other control location) a significant degradation of the physical barriers that prevent an <u>uncontrolled release</u> of radioactive materials.

<u>Criterion 2</u>: SSCs that are relied upon in the safety analyses to function/actuate to prevent or mitigate accidents or transients that involve the assumed failure of, or present a challenge to, the integrity of a physical barrier that prevents the <u>uncontrolled release</u> of radioactive materials.

<u>Criterion 3</u>: Process variables that are initial conditions for those design basis accidents or transient analyses that involve the assumed failure of, or present a challenge to, the integrity of a radioactive material barrier.

Criterion 4: Experiments and experimental facilities that could provide a path for the uncontrolled release of hazardous materials.

Criterion 5: Systems and equipment that are used for handling fissile material.

TSR selection Criterion 1 is not considered applicable for the HCF. HCF ventilation system differential pressure instrumentation functions primarily to monitor control of radioactive contamination migration across confinement barrier boundaries. Although this instrumentation provides a positive indication of Zone 1 and Zone 2A canyon confinement barrier integrity, the absence of the appropriate differential pressure gradient does not necessarily indicate a significant degradation of a confinement barrier. Therefore, application of a Limiting Condition for Operation to this instrumentation is not warranted.

Criterion 2 applies to the Zone 1 and Zone 2A canyon/Room 109 confinement structures, the Zone 1 and Zone 2A ventilation exhaust ducting and charcoal filters, and HCF stack HEPA filters. These SSCs constitute the physical barriers that function to prevent the uncontrolled release of radioactive materials from the HCF during normal and abnormal (transient) operating conditions. Thus, these items provide a defense in depth function.

There are no SSCs in the HCF for which Criterion 3 is applicable. The ventilation system Zone 1/Zone 2A and Zone 2A/Zone 2 differential pressures are barriers to the movement of radioactive contamination between zones under normal and abnormal conditions. However, failure to maintain these differential pressures does not initiate any design basis accident or transient with the potential for an uncontrolled release of radioactive materials.

Criterion 4 is not applicable to isotope processing operations and must be applied on a case-by-case basis by means of the USQ process as "experimental conditions" are proposed.

Fissile material inventories in processing SCBs cannot exceed 350 grams of ^{235}U so a nuclear criticality event is not credible. The DOT shipping container limit of 350 gram of ^{235}U per barrel will be observed for packaging of target waste. Radioactive material inventories in remote radioactive material storage areas (i.e., Building 6596, Building 6597, and the monorail storage holes) will be limited by procedure (ref. Table 3C-11, Prevention Features, Administrative) to less than the Hazard Category 2 threshold values in accordance with DOE-STD-1027-92 (DOE 1992c). A Criticality Safety Assessment of radioactive waste container storage in the Zone 2A canyon and Room 109 demonstrates that there are no conditions where nuclear criticality is credible. Therefore, Criterion 5 is not applicable.

With respect to worker safety-related TSR controls, the following definition is taken from DOE Order 5480.22 (DOE 1992a):

> *Technical Safety Requirements shall define the operating limits and surveillance requirements, the basis thereof, safety boundaries, and management or administrative controls necessary to protect the health and safety of the public and to minimize the potential risk to workers from the uncontrolled release of radioactive or other hazardous materials and from radiation exposure due to inadvertent criticality.*

On Page 4 of Attachment I (Guidelines for Technical Safety Requirements) to DOE Order 5480.22 appears the following discussion.

The TSRs are not based upon maintaining worker exposures below some acceptable level following an uncontrolled release of hazardous material or inadvertent criticality; rather the risk to workers is reduced through the reduction of the likelihood and potential impact of such events. This is accomplished by the development of safety requirements in the TSR for those systems, components, and equipment that: (a) are barriers preventing the uncontrolled release of radioactive and other hazardous materials; (b) mitigate such releases; and (c) prevent inadvertent criticality...... Consistent with relevant DOE Orders, the control of the levels of hazardous materials to which workers may, at any time, be exposed is addressed in each facilities' safety and health programs. These programs are required by reference in the Administrative Control Section of the TSR..... The protection of the health and safety of workers is assured by the combination of: (a) the development of TSRs for barriers to uncontrolled releases and for preventative and mitigative systems, components, and equipment; (b) use of PPE; (c) emergency protection programs; (d) worker education; and (e) drills.

Worker protection from radiation under normal and abnormal operating conditions is provided by means of passive engineered barriers and access controls. Protection from hazardous materials under abnormal and accident conditions is provided by establishing hazardous material inventory limits and implementing appropriate worker safety programs. The administrative controls shown were identified in Chapter 3 as providing significant safety functions (either worker safety or defense in depth) in mitigating potential accident consequences. Thus, specific hazardous material inventory limits and applicable worker safety program controls are specified in the TSR as administrative controls.

In addition, because of the potentially severe consequences associated with worker exposures to either an irradiated target or the radioactive waste contents of Room 109, the application of TSR controls to the STB cask transfer system controls and the hydraulic shield door control system is appropriate. Table 5.3-1 summarizes the type of TSR coverage associated with each of the items addressed above.

5.4 Derivation of Facility Modes

Operational modes are used to categorize the requirements placed on the facility as a convenience for management control. Furthermore, modes are used in the TSRs to clearly define operational condition boundaries and as a means of establishing facility status. They define equipment operability requirements and allowable actions by operations personnel under normal, abnormal, and accident conditions. More specifically, modes are used to define the applicability of the actions or conditions specified by the TSR limits.

Four operational modes are used to encompass all operating conditions for the HCF: 1) Processing Operation, 2) Non-processing Operation, 3) Maintenance, and 4) Shutdown. Table 5.4-1 lists these modes and their definitions (with respect to allowable facility conditions) in descending order of safety significance. That is, they progress from the highest risk mode (processing operation) to the safest mode (shutdown).

Table 5.3-1. TSR Coverage Summary

Hazard Control Feature	Basis for TSR Coverage	Types of TSR Coverage*
Zone 2A Canyon/Room 109 Confinement Integrity	Defense in Depth	LCO, SR
Steel Confinement Box Integrity	Defense in Depth	LCO,SR
Zone 1 and Zone 2A Ventilation Exhaust Systems	Defense in Depth	LCO, SR
Target Entrance System Mechanical Interlock	Worker Safety	LCO,SR
Hydraulic Shield Door Controls	Worker Safety	AC
Radioactive and Fissile Material Limits	Worker Safety/Defense in Depth	AC
Combustible and Flammable Material Limits	Worker Safety	AC
Zone 2A Airlock Access Control	Worker Safety	AC
Shield Cask	Worker Safety	DF, AC
Zone 2A Canyon Radiation Shielding	Worker Safety	DF
Room 109 Radiation Shielding	Worker Safety	DF

* LCO Limiting Condition for Operation
SR Surveillance Requirement(s)
AC Administrative Control(s)
DF Design Feature

5.5 TSR Derivation

This section presents a derivation of the HCF TSRs. Because of the hazard classification of the HCF (i.e., HC-2) and the results of the accident analysis, no safety-class structures, systems, or components (SSCs) have been identified. That is, there are no SSCs which are needed to maintain off-site consequences within the 25 rem off-site Evaluation Guideline. Therefore, the TSRs consist of Limiting Conditions for Operation, Surveillance Requirements, and Administrative Controls as shown in Table 5.3-1.

5.5.1 Zone 2A Canyon and Room 109 Confinement Integrity

The Zone 2A canyon/Room 109 physical structures constitute one of the primary confinement barriers for radioactive material in the HCF. The Zone 2A canyon and Room 109 are kept at a negative pressure relative to Zone 2 in order to minimize the spread of radioactive material to Zone 2 during isotope processing and radioactive waste handling operations. Verification of this pressure differential establishes the physical integrity of these confinement barriers.

Table 5.4-1. HCF Mode Definitions[a]

Status or Condition	Mode			
	Processing Operation[b,c]	Non-processing Operation[c]	Maintenance[c]	Shutdown
Operations	Normal activities are being performed, including isotope extraction processing, radiological material processing, and movement and handling of radiological materials.	Isotope extraction processing and radiological material processing activities are not permitted. Movement and handling of solid radiological materials is permitted.	Isotope extraction processing, radiological material processing, and movement of radiological materials are not permitted.	No operations activities are permitted in the facility.
Material Locations	Radioactive and hazardous materials may be located in all areas of the facility as described in the SAR.	Radioactive and hazardous materials may be located in all areas of the facility as described in the SAR.	To the maximum extent possible, radioactive and hazardous materials have been removed from any area undergoing maintenance.	Radiological and hazardous materials have been removed from areas with unrestricted access.
Equipment Status	Essential ventilation system equipment is in service.	Essential ventilation system equipment is operable.	No requirement.	No requirement.

a) Modes apply to activities within the Building 6580 basement and do not apply to remote radioactive material storage areas.
b) Applies only to radiochemical and material processing in SCBs.
c) These modes are applicable to each SCB individually.

5.5.1.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs or LCSs associated with Zone 2A canyon and Room 109 confinement structures. However, since these structures provide defense in depth against uncontrolled radioactive material releases, the following LCO is established to provide a positive indication of confinement barrier integrity:

- A negative pressure differential shall be maintained between the Zone 2A canyon/Room 109 and Zone 2.

5.5.1.2 Surveillance Requirements

Zone 2A-to-Zone 2 differential pressure must be monitored whenever the ventilation system is operating. To ensure the appropriate differential pressure is maintained, differential pressure instrumentation (indicators and alarms) must be checked and calibrated periodically to verify operability.

5.5.1.3 Administrative Controls

There are no administrative controls associated with maintaining Zone 2A canyon/Room 109 integrity.

5.5.2 Steel Confinement Box Integrity

SCBs are the primary confinement barriers for radioactive materials during isotope processing. They are kept at a negative pressure relative to the Zone 2A canyon in order to minimize the spread of radioactive material to the canyon during isotope processing operations. Verification of this pressure differential establishes the physical integrity of the SCBs.

5.5.2.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs or LCSs associated with the SCBs. However, since the SCBs provide defense in depth against uncontrolled radioactive material releases, the following LCO is established to provide a positive indication of confinement barrier integrity:

- A negative pressure differential shall be maintained between Zone 1 (the SCBs) and the Zone 2A canyon.

5.5.2.2 Surveillance Requirements

Zone 1-to-Zone 2A differential pressure must be monitored whenever the ventilation system is operating. To ensure the appropriate differential pressure is maintained, differential pressure instrumentation (indicators and alarms) must be checked and calibrated periodically to verify operability.

5.5.2.3 Administrative Controls

There are no administrative controls associated with maintaining SCB integrity.

5.5.3 Zone 1 and Zone 2A Ventilation Exhaust Systems

The HCF Zone 1 and Zone 2A ventilation exhaust systems provide a controlled, filtered path for radioactive releases from the HCF stack during normal and abnormal operating conditions. Ventilation system flow maintains negative Zone 1 to Zone 2A and Zone 2A to Zone 2 differential pressures to verify the integrity of Zone 1 and Zone 2A confinement boundaries. When the ventilation system is operating, any radioactive particulate matter in the exhaust air is removed by HEPA filters, while iodine is removed by adsorption on charcoal filters. When the ventilation system is not operating, isotope processing operations are not permitted, and no significant radioactive particulate matter or iodine is at risk for potential release.

5.5.3.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs or LCSs associated with the Zone 1 and Zone 2A ventilation exhaust systems. However, since these systems provide defense in depth against off-site radioactive material releases during normal and abnormal operating conditions, the following LCO is established for the processing operation mode (see Table 5.4-1):

- Zone1 ventilation exhaust charcoal filters are in service and functional.
- Zone 2A ventilation exhaust charcoal filters are in service and functional.
- The hot exhaust HEPA filter is in service and functional.

5.5.3.2 Surveillance Requirements

The pressure drop across charcoal filters must be checked periodically to verify that the appropriate filters are in service. Charcoal filter operating records must also be checked periodically to verify that the filters have been in service for a period not exceeding 5 years. The pressure drop across the in-service hot exhaust HEPA filter must be checked periodically to ensure continued performance capability. Additionally, periodic in-place testing of HEPA filters must be performed to verify filter efficiency.

5.5.3.3 Administrative Controls

HEPA and charcoal filters must not become non-functional through overloading or plugging. Thus, these filters should be replaced as necessary to ensure continued performance.

5.5.4 Target Entrance System Mechanical Interlock

The Target Entrance System (TES) mechanical interlock provides a worker safety function by preventing the removal from the TES of a shield cask containing an irradiated target without the shield cask lid properly installed. This interlock is relevant to both of the operational modes, since target transfer operations could be accomplished in either of these modes.

5.5.4.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs or LCSs associated with the TES mechanical interlock system controls. However, since this interlock provides an important worker safety function during the transfer of irradiated targets, the following LCO is established for both operational modes:

- The TES mechanical interlock shall be operable for all target transfers using the TES.

5.5.4.2 Surveillance Requirements

The TES mechanical interlock must be checked periodically to verify operability.

5.5.4.3 Administrative Controls

There are no administrative controls associated with the TES mechanical interlock.

5.5.5 Hydraulic Shield Door Controls

Administrative control of the hydraulic shield doors provides a worker safety function by 1) precluding lowering of the Room 108/109 shield door (door 2A) while the Room 101/108 shield door (door 1) is down, and 2) precluding lowering of the Room 109/Zone 2A shield door (door 3A) with workers in the Zone 2A canyon, the Zone 2A airlock, or the north end of Room 112. Keyed locks in the shield door hydraulic system control panel prevent unintended actuation of the shield doors.

5.5.5.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs, LCSs, or LCOs associated with the hydraulic shield door controls.

5.5.5.2 Surveillance Requirements

This section is not applicable since there are no SLs, LCSs, or LCOs for the hydraulic shield door controls.

5.5.5.3 Administrative Controls

Administrative control of hydraulic door actuation keys must be maintained in all modes to ensure that workers cannot be inadvertently exposed to radioactivity from the radioactive waste contents of Room 109.

5.5.6 Radioactive and Fissile Material Limits

Limits on radioactive and fissile material inventories are established by administrative controls. These limits, as described in Section 5.5.6.3, are in effect for all modes.

5.5.6.1 Safety Limits, Limiting Control Settings, and Limiting Condition for Operation

As indicated in Section 5.3, there are no SLs, LCSs, or LCOs associated with maintaining radioactive and fissile material limits.

5.5.6.2 Surveillance Requirements

This section is not applicable since there are no SLs, LCSs, or LCOs for maintaining radioactive and fissile material limits.

5.5.6.3 Administrative Controls

The total radioactive material inventory simultaneously in-process within the Zone 2A canyon is limited to the equivalent of six maximally irradiated targets to ensure that a dose of 2.0 rem at 3000 meters is not exceeded in the most bounding radiological accident scenario (unmitigated fire). The amounts of radioactive material permitted in operable glove boxes and fume hoods are negligible compared to the SCBs, and are administratively controlled to be consistent with prudent Health Physics practices. Significant amounts shall be addressed in detailed procedures that are reviewed and approved by the RCSC.

The DOT shipping container limit of 350 grams of ^{235}U per barrel will be observed for packaging of process waste.

Radioactive material inventories in each remote radioactive material storage area (i.e., Building 6596 east highbay/Chapel, Building 6597, and the monorail storage holes) will be limited by procedure (ref. Table 3C-11, Prevention Features, Administrative) to less than the Hazard Category 2 threshold values in accordance with DOE-STD-1027-92 (DOE 1992c).

Fissile material limits are outlined in the HCF criticality safety assessment for storage of medical isotope targets and process waste. The process waste storage inventory will be restricted to ensure that the SNM Category III (DOE 1994b) limit of 50 kg ^{235}U is not exceeded, which together with waste barrel loading limitations, waste barrel size, and Room 109 storage array limitations will preclude the occurrence of a criticality event.

5.5.7 Combustible and Flammable Material Limits

To minimize the potential for fires, the quantity of combustible or flammable material introduced and used in each SCB during target processing is limited. Good housekeeping practices are used to control the amount of combustible and flammable materials within the HCF for all modes.

5.5.7.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs, LCSs, or LCOs associated with combustible and flammable materials.

5.5.7.2 Surveillance Requirements

This section is not applicable since there are no SLs, LCSs, or LCOs for combustible and flammable materials.

5.5.7.3 Administrative Controls

The specific quantity of flammable material allowed in each SCB is dependent on the curie content of the SCB and the specific operations being conducted and are specified in Section 8.6.2.

5.5.8 Zone 2A Airlock Access Controls

The Zone 2A airlock access controls provide a worker safety function by preventing personnel access to the airlock (and Zone 2A) when potentially lethal radiation fields exist due to isotope processing or process waste handling activities.

5.5.8.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs, LCSs, or LCOs associated with the Zone 2A airlock access controls.

5.5.8.2 Surveillance Requirements

This section is not applicable since there are no SLs, LCSs, or LCOs for the Zone 2A airlock access controls.

5.5.8.3 Administrative Controls

Administrative control of access to the Zone 2A airlock must be maintained in both the processing operation and non-processing operation modes; that is, whenever processing operations are occurring within the SCBs, whenever processing waste is being moved within Zone 2A, or whenever hydraulic shield doors 3A or 3B are down.

5.5.9 Shield Cask

The shield cask provides a worker safety function by shielding personnel from irradiated targets during target transfer between the Annular Core Research Reactor high-bay and the HCF target entrance system.

5.5.9.1 Safety Limits, Limiting Control Settings, and Limiting Conditions for Operation

As indicated in Section 5.3, there are no SLs, LCSs, or LCOs associated with the shield cask.

5.5.9.2 Surveillance Requirements

This section is not applicable since there are no SLs, LCSs, or LCOs for the shield cask.

5.5.9.3 Administrative Controls

The shield cask, with the lid securely bolted in place, is designed to reduce the dose rate from a maximally irradiated target to approximately 5 mR/hr on contact. Therefore, installation of the shield cask lid following insertion of an irradiated target must be administratively controlled to ensure that the lid does not become disengaged from the cask during handling activities, thereby presenting the risk of lethal radiation exposure to personnel.

5.5.10 Other Administrative Controls

Other administrative controls that may not have been explicitly identified in the hazard or accident analysis include management commitments to establish, implement, and maintain appropriate controls and activities that provide additional defense-in-depth safety. Table 5.5-1 summarizes the controls required to be in-place within the HCF, along with a cross-reference to SAR sections in which these controls are described.

Table 5.5-1. HCF Administrative Control Summary

Control Function	Control Description	SAR Section
Fire Protection	- Flammable and combustible material control. - Control of ignition sources. - Fire fighting capabilities. - Emergency response (fires). - Fire department availability. - Fire protection assessment. - Automatic detection/suppression and alarm system availability. - Proper availability and maintenance of fire fighting equipment.	11.4.3 3.4.2.3/4/7 11.4.4 15.4 11.4.4 11.4.2/11.4.5 2.7.1/11.4.4 11.4.2/11.4.4
Explosives Safety	- Flammable solvent control.	5.5.7/8.6.2
Nuclear Criticality Safety	- Fissile material inventories and posting. - Oversight by safety committees. - Spacing and storage of fissile material in Rooms 108/109. - Nuclear criticality safety analyses.	6.3.1/6.4.2 6.5.1 6.4.1 6.5.4
Radiation Protection	- Radiological monitoring. - Radiation exposure control. - ALARA program. - Radiological protection training. - Radiological protection instrumentation. - Radiological protection record keeping.	7.7 7.6 7.4 7.5 7.8 7.9
Hazardous Material Protection	- Hazardous material control. - ALARA program.	8.6.2 8.4
Qualification and Training	- Training of HCF staff personnel. - Training of radiation workers and other personnel with access to the HCF.	11.3.4/12.4/ 14.3/17.3.4

Table 5.5-1. HCF Administrative Control Summary (Cont.)

Control Function	Control Description	SAR Section
Review, Audits, and Approvals	- Review of - SAR, TSR and changes thereto. -tests and experiments. -operating procedures and changes thereto. -HCF changes and modifications. -maintenance and testing activities. -conduct of operations. -operational abnormalities and occurrence reports.	11.3/17.3/ 17.4
Waste Management	- Monitoring and control of waste streams.	9.4
Initial Testing	- Verification of safety-related SSC functionality.	10.3
In-Service Surveillance	- Verification of safety-related SSC operability.	10.4
Maintenance	- Maintenance of safety-related SSC operability. - Specification of schedules, procedures and training requirements for equipment maintenance.	10.5
Emergency Preparedness	- Emergency response organization. - Emergency notification. - Emergency facilities and equipment. - Training and drills/exercise. - Protective actions.	15.4.1 15.4.3 15.4.4 15.4.6 15.4.5
Quality Assurance	- Implemented throughout the HCF for all safety-related SSCs and programs.	14.0
Record Keeping	- Maintenance of HCF operating records.	11.3.4/17.4.2/ 14.5
Configuration Control	- Identification, documentation, and maintenance of technical baseline for SSCs.	11.3.4.8/4.0/ 17.4.2
Unreviewed Safety Question (USQ)	- USQ determination for proposed changes to facility, procedures, and operational controls.	17.4.2
Procedures	- Development and maintenance of procedures.	11.3.4/12.3

5.6 Design Features

This section identifies those design features from the hazard or accident analysis which are considered passive in nature, but which provide a safety function to either prevent or mitigate the consequences of postulated accident scenarios.

5.6.1 Fire Mitigating Features

The primary construction material for the HCF is steel-reinforced concrete, which provides a fire barrier between the Zone 2A canyon and other areas within the HCF. The Zone 2 lab area is separated from the Zone 2 support areas by metal doors. The Zone 2A canyon and SCBs are separated from Zone 2 by concrete walls and lead-glass windows, respectively. Rooms 108 and 109 are separated from adjacent areas by concrete walls and hydraulically operated concrete doors. These barriers provide adequate fire protection for the HCF.

5.6.2 Hazardous Material Confinement Features

The SCBs serve primarily to confine radioactive material. The boxes are joined by sealable pass-throughs, which allow the passage of material into and out of the SCBs from the Zone 2A canyon. The SCB manipulators, which penetrate both the SCBs and the Zone 2A canyon, are sealed with a manipulator boot. The Zone 2A canyon is separated from the Zone 2 lab area by an airlock that maintains the negative operating pressure established for the Zone 1 and Zone 2A ventilation systems with respect to Zone 2.

5.6.3 Worker Radiological Protection Features

Major building structures serve to provide radiation shielding for facility workers. Most HCF operations are performed in the basement of Building 6580. Because the basement was originally used as support areas for the Sandia Engineering Reactor, the original massive walls and ceiling were designed for both structural integrity and radiation shielding. The Zone 2A canyon consists of 1.1 m (3.6 ft) thick reinforced-concrete walls with leaded-glass windows. These walls are lined with steel plate to maintain radiation exposure levels in continuously occupied (2000 hours per year) areas of the basement below an average of 0.5 mrem per hour. The Room 109 walls are constructed of magnetite concrete. The north and south walls are 2.4 m (8 ft) thick, while the east and west walls are 1.5 m (4.8 ft) thick and 1.6 m (5.4 ft) thick, respectively. Chapter 2 contains more detailed descriptions of radiation shield structures.

The shield cask serves to provide radiation shielding for facility workers during the transfer of irradiated targets from the ACRR core to the HCF steel transfer box. The thickness of DU in the cask is sufficient to reduce the dose rate from a Mo-99 target irradiated for 7 days at 20 kW fission power followed by a 6-hour decay to approximately 5 mR/hr on contact.

5.7 Interface with TSRs from Other Facilities

The TSR administrative control for maintaining shield cask integrity interfaces with a corresponding TSR administrative control for the Annular Core Research Reactor (ACRR). Operations involving installation and securing of the cask lid following insertion of an irradiated target will be jointly controlled by ACRR and HCF staff personnel to ensure worker safety during cask transfer operations. Furthermore, the cask will not be modified without a thorough review by the managers of both facilities and their respective safety committees to determine that shielding effectiveness will not be degraded by proposed changes.

The TSR administrative control associated with emergency preparedness interfaces with corresponding TSR administrative controls for other TA-V nuclear facilities, since the TA-V Emergency Preparedness Plan is common for all of theTA-V nuclear facilities.

5.8 REFERENCES

40 CFR 302, 1985, "*Designation, Reportable Quantities, and Notification*", *U.S. Code of Federal Regulations*, Title 40, Protection of Environment, Environmental Protection Agency, Office of Federal Register, Washington D.C., April 4, 1985.

40 CFR 355, 1987, "*Emergency Planning and Notification*", *U.S. Code of Federal Regulations*, Title 40, Protection of Environment, Environmental Protection Agency, Office of Federal Register, Washington D.C., April 22, 1987.

U.S. Department of Energy (DOE), 1991, *Unreviewed Safety Questions,* DOE Order 5480.21, U.S. Department of Energy, Washington, D.C., December 24, 1991.

U.S. Department of Energy (DOE), 1992a, *Technical Safety Requirements*, DOE Order 5480.22, U.S. Department of Energy, Washington, D.C., February 25, 1992.

U.S. Department of Energy (DOE), 1992b, *Nuclear Safety Analysis Reports*, DOE Order 5480.23, U.S. Department of Energy, Washington, D.C., April 30, 1992.

U.S. Department of Energy (DOE), 1992c, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92, (Change Notice 1: September 1997), U.S. Department of Energy, Washington, D.C., December 1992.

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

U.S. Department of Energy (DOE), 1994b, *Control and Accountability of Nuclear Material*, DOE Order 5633.3B, U.S. Department of Energy, Washington, D.C., September 7, 1994.

U.S. Department of Energy (DOE), 1996, *Facility Safety*, DOE Order O 420.1, Chg. 2, U.S. Department of Energy, Washington, D.C., October 24, 1996.

U.S. Department of Energy (DOE), 1997, *Occurrence Reporting and Processing of Operations Information,* DOE O 232.1A and DOE M 232.1-1A, U.S. Department of Energy, Washington, D.C., July 21, 1997.

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CONTENTS

TABLES

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6.0 PREVENTION OF INADVERTENT CRITICALITY

6.1 Introduction

This chapter provides information to demonstrate compliance with applicable requirements for the prevention of an inadvertent criticality in the Hot Cell Facility (HCF). This includes a description of all fissionable material which may be contained in the HCF and a summary of the criticality programs and processes which are followed to prevent and mitigate inadvertent criticality events.

The SNL Criticality Safety program requires the preparation of activity-specific Criticality Safety Assessments (CSAs) for storage and handling of threshold quantities of fissile material. The CSAs are individually reviewed and approved as the Facility mission dictates. The CSA for Mo-99 is typical of the analyses performed to determine criticality safety requirements; therefore, references to the Mo-99 CSA in the following sections are intended to provide an example of how the Criticality Safety program generates operational commitments.

6.2 Criticality-Safety Requirements

The pertinent requirements for nuclear criticality safety at the HCF are described in SNL ES&H Manual Supplement GN470072, "Nuclear Criticality Safety" (SNL 1998). This supplement addresses the requirements in all applicable DOE Orders, including the following:

DOE Order 5480.21, *Unreviewed Safety Questions* (DOE 1991).

DOE Order 5480.23, *Nuclear Safety Analysis Reports* (DOE 1994).

DOE Order 420.1, *Facility Safety* (DOE 1996).

The ES&H Manual Supplement also considers applicable ANSI standards, including the basis for criticality requirements, record keeping, assessments for potential criticality events, criticality safety control parameters, conducting criticality safety analyses, preparation of plans and procedures, requirements for criticality alarms, personnel training, posting, and operational considerations.

Key guidance from the SNL ES&H Manual Nuclear Criticality Safety Supplement (SNL, 1998) includes requirements to:

- Assess all potential criticality hazards associated with fissile material operations outside nuclear reactors.
- Select the parameters for preventing accidental nuclear criticality (establishing subcriticality) for all criticality-related operations at each step of the process.
- Conduct CSAs to provide assurance that the entire process will remain subcritical under normal and credible abnormal operating conditions.
- Document plans and procedures to address the handling and storage of fissile material and emergencies. All parameters of the system that are to be controlled by procedure to ensure subcriticality shall be identified and their limits specified.
- Determine the need for criticality accident alarms.
- Submit the CSAs, plans, and procedures to the appropriate safety committee for review and approval.
- Train all operations personnel so that they understand and are familiar with the criticality safety aspects of facility operating procedures.

- Post area criticality safety limits for all parameters subject to procedural control, and apply appropriate identifying labels to all fissile material.
- Establish access control for areas containing fissile material.

This document recommends a maximum value for the effective multiplication factor (including uncertainty and bias). The guidance is expressed as $k_{eff} + \varepsilon < 0.95$, for all normal and credible accident configurations. This rule is used to place engineering and administrative controls on the facility operations.

6.3 Criticality Concerns

The nature of HCF operations makes a criticality event highly unlikely; however, the HCF will process and store fissile materials in sufficient quantity to warrant a formal CSA. This section identifies the types of fissile materials that may be present within the facility, their forms and inventories, and the actual location and configuration where such materials are handled or stored. CSA's are prepared, reviewed, and approved in accordance with SNL ES&H. Supplement GN470072 to evaluate criticality concerns and document the basis for operating limitations for all planned uses of fissile materials in the HCF.

6.3.1 Fissionable materials, form and inventories

The HCF will receive, process and store fissile materials, principally for the purposes of chemical extraction of isotopes, and usually in the form of uranium dioxide enriched to 93% ^{235}U. Normally, this material will be brought into the HCF in the form of isotope "targets", which are stainless steel tubes internally coated with up to 34 grams of UO_2 (30 g ^{235}U). Irradiated targets will be processed in steel confinement boxes (SCBs), also referred to as Zone 1. During processing, the $U0_2$ inside the target is dissolved in acid and isotopes are chemically extracted from the solution. Following processing, the UO_2 solution is solidified in stainless steel waste containers as a concrete mixture. While only one target is processed at a time in each SCB, several targets or contents of targets may be present in each process box. Space limitations, the potential for window radiation damage, and isotope product contamination (i.e. product quality) concerns will impose practical constraints on the number of targets that will be permitted in a process box at any time. Normally, the waste residue containing the fissile ^{235}U will be removed from the SCB's on a daily basis. The residual materials, including the solidified UO_2, will be staged temporarily in barrels (55-gallon drums) in Zone 2A, and then transferred into the waste storage area, Room 109. The volume of the barrel and the volume of the process waste will physically limit the amount of fissile material that can be placed in a barrel, and each barrel will be administratively limited to 350 grams of ^{235}U to comply with DOT requirements. Eventually, the waste barrels will be removed from Room 109 through Room 108 for packaging and shipment to the Nevada Test Site for disposal. Room 109 will have storage capacity of 180 barrels of radioactive waste, which, if each barrel were maximally loaded, would total 63 kg ^{235}U. To accommodate operations with intermittent shipments and the potential for disposal shipment delays, the storage space will not normally be allowed to be filled to capacity.

In addition to irradiated targets brought into the HCF for processing, unirradiated targets may be brought into the HCF for examination or storage. These targets could be present in any room or area of the HCF, but will be limited in quantity. Unirradiated targets brought in for storage will be confined to designated areas and stored in safes specifically designated and dedicated for that purpose. A storage safe volumetrically filled with maximum weight targets would contain 10.5 kg ^{235}U. Other fissile materials that may be brought into the HCF for temporary examination or storage will be examined in accordance with GN470072 on a case-by-case basis for criticality compatibility with the isotope production inventory.

6.3.2 Locations

The HCF has several areas in which the potential for an inadvertent criticality exists. These are the SCBs (Zone 1), the entrance to the SCBs (Zone 2), Zone 2A, Rooms 108, 109, 111, 112, 113, 113A, 114, B6596, B6597, and the monorail storage holes. Chapter 2 describes each of these areas and the processes accomplished in each area.

6.4 Criticality Controls

A CSA (Mitchell and Romero, 1999) has been prepared and approved in accordance with the ES&H Manual Supplement to evaluate the criticality concerns and document the basis for operating limitations for planned uses of fissile materials in the HCF. Both engineered features and administrative limits are used to prevent inadvertent criticality in the HCF. These features and limits are based on physical principals of mass, geometry, and neutron moderation to provide high confidence that criticality cannot occur in the HCF under all normal, abnormal, and accident conditions. They provide the basis for an assessment of the application of the double-contingency principle implemented in the HCF.

6.4.1 Engineering Controls

Engineered features and controls utilize basic criticality safety principles to ensure criticality safety in operations where fissile material is handled and stored. CSAs, written in accordance with the ES&H Manual Supplement on Criticality Safety [SNL 1998], provide the bases for the criticality safety margins of the designs. Design features and controls that enhance criticality safety in HCF operations are shown in Table 6.4-1.

Table 6.4-1 Engineered Features and Controls That Enhance Criticality Safety in HCF Operations

Feature	Implementation in Operating Procedures
Geometry Control	The relatively small quantities of fissile material that will be placed in waste drums preclude the need for specifying drum spacing requirements in waste storage arrays.
	The relatively small quantity of fissile material contained in a Mo target precludes the need for specifying target packing requirements in unirradiated target storage.
Target Design	Limits the amount of U-235 per target to ≤ 30 g
	Target seals reduce the likelihood of internal water-logging of the target if the storage array is flooded.
Solid Waste	Solid waste form ensures that fissile species in waste drums are less likely to be rearranged into unfavorable geometry via leakage, diffusion, or other transport mechanisms.

In the example of the Mo-99 process, the waste drums are standard DOT certified 55-gal drums that are stored in room 109 on carts. The carts are designed to be loaded up to eight drums to a cart and cannot be stacked more than two drums high based on the dimensions of the drum and the height of the storage area ceiling. Unirradiated targets are stored in DOT certified transportation drums or, if in other configurations, in accordance with a CSA (Mitchell and Romero, 1999). Mo-99 targets are designed to contain no more than 30 g of U-235. Furthermore, the targets are subject to a QA program (see Chapter 14), which assures that the limit is met, and the exact loading of each target is registered prior to shipment. The QA program requires acceptance testing after receipt to document the integrity of each target. The form of the solid waste is verified and documented as part of the QA requirements of the waste recipient.

6.4.2 Administrative Controls

Administrative controls supplement engineered features to further reduce the likelihood of an inadvertent criticality. These controls include mass limits for target storage and for process SCB's, mass limits and storage configuration constraints within Zone 2A and other HCF fissile storage areas, and mass limits and storage configuration requirements for process waste. Mass limits and configuration constraints will be based on an approved CSA. Additionally, HCF operational procedures, prepared and approved in accordance with processes described in Chapter 12 of this SAR, are used for all handling, movement, and storage of fissile materials to implement these controls.

Operational controls, derived from a CSA [Mitchell and Romeo, 1999], are shown in Table 6.4-2. The referenced CSA addresses all aspects of HCF operations dealing with the chemical extraction/processing of isotopes from reactor-irradiated targets. The operational controls are implemented in accordance with the Nuclear Criticality Safety supplement to the SNL ES&H Manual.

Table 6.4-2 Operational Controls For Criticality Safety In HCF Operations

Operational Control	Value
Mass of U-235 per waste drum	≤ 350 g
Mass of U-235 per SCB	350 g in other than target form or 6 standard targets
Mass of U-235 per target	≤ 30 g
Target Storage Array	≤ 88 targets per drawer in a four drawer safe
Multiple Safe Storage Array	spacing between safe surfaces ≥ 6-feet (SNL, 1998)

The 350 g. limit per SCB and the 6 standard targets limit per SCB are shown together to allow flexibility to accept up to 350 g. of U-235, in other than target form, as a criticality safety control and, at the same time, to limit the curie inventory of the source term for accident analysis purposes.

6.4.3 Application of Double-Contingency Principle

Quantitative evaluations [Mitchell and Romero, 1999 (draft), Section 5] were conducted for normal and accident storage/handling configurations involving multiple targets and waste drums. The Mitchell and Romero reference details the conservative assumptions made on target manufacture and storage conditions. The analysis resulted in the derivation of the following limits:

• Unirradiated targets containing	$\leq$ 30 g ^{235}U each
• Storage of Targets in safe drawers	$\leq$ 88 per drawer and $\leq$ 352 (total) per safe
• Waste drums containing	$\leq$ 350 g ^{235}U each (storage in Zone 2A pit or Rm. 109)
• Drum Geometry	Standard 55 Gallon Drum Dimensions
• Additional limits (NOT driven by Criticality Safety Concerns):	$\leq$ 4 drums in Zone 2A pit @ 350 g ^{235}U each (space-limit driven) $\leq$ 50 kg ^{235}U (total) for Rm. 109 (safeguards driven)

The evaluations show that, for these limits, the calculated effective multiplication factor, k_{eff}, of any and all configurations (allowing for bias and uncertainties in reactivity due to any single contingency) is < 0.95. Normal operations are all considerably lower [Mitchell and Romero, 1999, Section 6, Evaluation and Results]. Thus,

$$k_{eff} + \epsilon < 0.95, \text{ where } \epsilon \text{ is the uncertainty and bias factor}$$

Therefore, no configuration in the proposed operations presents a criticality safety concern so long as the above limits are observed.

As stated elsewhere in this SAR, there is a ^{235}U limit in each SCB of 350 g. This amount is one-half the amount of criticality concern for an optimally moderated (i.e. solution) of ^{235}U. The SCB mass limit was set as a safeguard against a double batching error. No quantitative analysis was required for SCB-confined operations with such a low amount of fissile material. However, for completeness, this case was included in the contingency analysis (the main subject of this section).

A CSA is required for operations that involve total amounts of fissile material in excess of the threshold amount for non-aqueous forms (700 g ^{235}U) where formal criticality safety evaluations and controls are required [Philbin, 1998, Criticality Safety Supplement to the SNL ES&H Manual, Applicability Section]. The CSA requires that process designs incorporate a double-contingency principle so that at least two unlikely, independent, and concurrent changes in process conditions must occur before an accidental nuclear criticality is possible. Table 6.4-3 is a qualitative summary of the double contingency analysis from the CSA for isotope processing [Mitchell and Romero, 1999 (draft), Section 5].

There are two or more contingencies present for each activity. Therefore, more than one, unlikely (i.e., average probability $\leq 10^{-3}$ for human performance errors [Mahn, et al., 1995; Swain, et al., 1983]), independent, yet concurrent change in normal conditions would be necessary before a criticality event could occur. Since the probabilities are multiplicative, the combined probability, P, of the unlikely failures occurring simultaneously, is 10^{-6} or less, i.e., $P \leq 10^{-6}$.

Table 6.4-3 Double Contingency Analysis for HCF Operations with Fissile Material

Operation	Required Events for Exceeding K_{eff} Limit	Barriers to Event
Target Storage	Excessive ^{235}U in safe	QC program on target manufacture and acceptance for processing
	Flooding (internal & external)	Open Configuration to avoid collection of water
SCB Operations	Excessive ^{235}U in SCB(s) (Event 1)	QC program on target manufacture and acceptance for processing; SCB Administrative limit of 350 g per SCB
	Event 1 occurs over several days	Operation Procedure requires SCB cleanup – no overnight accumulation
	SCB Flooding	Limits on ^{235}U allowed in SCB
Waste Handling	Excessive ^{235}U in drum(s)	QC program on target manufacture and acceptance for processing; limit on ^{235}U allowed per waste drum
	Zone 2A pit flooding	HCF catacombs and floor space volumes will accommodate flood water
Waste Storage (room 109)	Excessive ^{235}U in multiple barrels	QC program on target manufacture and acceptance for processing ; administrative limits on Rm. 109 mass per barrel. Multiple failures are required.
	Flooding of Room 109	No source of water in Rm. 109 and HCF catacombs and floor space volumes will accommodate flood water

6.5 Criticality Protection Program

The SNL/NM criticality-safety program is described and documented in the SNL ES&H Manual, Supplement GN470072, "Nuclear Criticality Safety". This program includes provisions for planning, criticality assessments, identification of safety control parameters, use of mass controls, conduct of criticality safety analyses, use of plans and procedures, training, posting, and requirements for review and approval of handling and storage of fissile materials.

6.5.1 Criticality-Safety Organization

Final responsibility for criticality safety at the HCF rests with line management. The Radiological and Criticality Safety Committee (RCSC) is chartered by the Nuclear Facility Safety Committee (NFSC) and members are appointed by the Deputy Director for Nuclear Facility Operations. The Sandia Nuclear Criticality Safety Committee (SNCSC), with corporate responsibility for criticality safety at SNL, is chartered by the SNL Director for ES&H, and has delegated responsibility for criticality issues in TA-V to the RCSC. The Charters of both the RCSC and SNCSC require that committee have members with expertise in criticality safety. Radiation engineering support, including criticality expertise, is available both within the Nuclear Energy Technology Center and in Radiation Protection Organizations in the ES&H Center.

The RCSC provides independent reviews of criticality-safety issues and advises the HCF line management on criticality-safety matters. The RCSC reviews criticality-safety issues of proposed facility and equipment modifications, proposed experiments with fissile materials, nuclear criticality-safety limits, SNM storage procedures, and other aspects of nuclear criticality safety at the HCF. For criticality issues, the SNCSC oversees, reviews, and appraises the operation of the RCSC. The SNCSC is also available to provide additional review of criticality-safety issues when deemed appropriate, such as for issues involving a positive result from a USQD.

6.5.2 Criticality-Safety Plans and Procedures

Written procedures are used to govern all process operations in the HCF, including handling of fissile materials. These procedures include provisions for emphasizing administrative limits necessary for criticality, specifically for mass limits in storage locations, process boxes, waste containers and waste storage in Room 109. They are reviewed by cognizant safety committees as described above and are approved by HCF line management.

6.5.3 Criticality-Safety Training

Someone knowledgeable in nuclear criticality safety matters will train all personnel assigned to work with fissile material in nuclear criticality safety before beginning work. A graded approach is applied to tie the level of training to the complexity of the job. Training records will document that personnel have an adequate understanding of facility procedures and safety considerations such that they may be expected to perform their functions without undue risk. The facility manager will maintain personnel training records. The facility supervisor or manager will consider the following topics (using a graded approach) in training operations personnel: basic criticality safety; standard and emergency operations; radiological safety and control; safety and emergency systems; instrumentation and control; facility operating characteristics; principles of plant operation; material handling and storage procedures. The facility manager will ensure that operations personnel receive refresher training according to the following schedule: annually on all procedures for handling abnormal plant conditions and emergency situations relative to assigned responsibilities (for SNL personnel) and every two years on all other required subjects.

6.5.4 Determination of Operational Nuclear Criticality Limits

Inventories of less than the threshold limits defined in the Applicability Section of the Criticality Safety Supplement to the SNL ES&H Manual (which is consistent with ANSI/ANS-8.1) do not require criticality controls. However, if operations are planned to exceed those limits, appropriate nuclear criticality safety control are required. The following controls are applied to work at SNL: geometry controls, criticality index (CI) control, administrative controls, mass controls, and other nuclear criticality safety controls (density controls, neutron absorbers, and moderation controls). Preference of the control method depends upon whether the operation is temporary (e.g., an experiment) or permanent (e.g., a long-term storage facility). The first two controls are equally suitable for a storage or experimental facility, while the suite of administrative controls may be preferred for an experiment. For calculations in support of a CSA, known biases and uncertainties shall be considered when establishing k_{eff} limits for a storage area or for experiments. Generally this would take the form of $k_{eff} + \varepsilon \leq 0.95$, where ε is the uncertainty and bias factor. Benchmarks should be used to establish bias/uncertainty whenever such benchmarks are straightforward and easy to use.

The specific HCF fissile material handling and storage controls are established based upon an approved CSA. The CSA for storage of medical isotope targets and process waste used MCNP™ (Monte Carlo N-Particle Transport Code) version 4A and ENDF/B-IV cross sections. The code was validated for a wide variety of fissile systems and the results indicated that in no case did the results underestimate the measured effective multiplication of fissile arrays by more than 0.5%. Additional calculations on identical configurations were performed using KENO Va and Hansen-Roach cross sections; the results compared favorably to the MCNP results. Mitchell and Romero (Mitchell and Romero, 1999) have calculated the effective multiplication factors for the normal and credible accident conditions of various assemblies of targets and pre- and post-irradiation stored fuel. The credible configurations have low enough k_{eff} to allow the omission of the consideration of uncertainties.

With the adoption of engineered features and administrative controls of Tables 6.4-1 and Table 6.4-2, all credible configurations yield a calculated $k_{eff} + \varepsilon << 0.95$. This position is fully supported by the wide range of scenarios evaluated in the CSA when multiple low probability events are appropriately screened out. Though severe flooding of the hot cell, to a level that would totally submerge a 4-drawer storage safe, is highly unlikely (see Section 1.5.3 of the SAR), this situation was evaluated as a low-probability accident condition. All credible cases that allowed for this contingency are criticality-safe by a substantial margin, $k_{eff} + \varepsilon << 0.95$. In addition, a small fraction of the targets were also allowed to be "internally" flooded and, still, the criticality-safety criterion was satisfied. Other cases were evaluated (Mitchell and Romero, 1999), including suspension of an optimum number of targets at an optimum spacing, with no credible mechanism for maintaining this condition. This case was also suitably subcritical, but with less "margin" than the cases mentioned above. However, this case is an example of cases that were screened out because they require multiple low-probability conditions, and are, therefore, considered to be incredible. Incredible configurations need not be considered in deriving operational limitations.

A target acceptance procedure will ensure that all targets accepted for storage in an array meet target integrity and leak-check acceptance criteria. The procedure will provide assurance that no more than a small percentage of targets could credibly have defective casings or seals simultaneously and, therefore, be subject to massive internal flooding in the event that room flooding (from sprinklers or natural phenomena) would lead to a completely submerged storage array. The detailed description of the configurations evaluated, results of the calculations and conclusions leading to limitations and commitments for this SAR may be found in the CSA report (Mitchell and Romero, 1999).

6.5.5 Criticality Safety Inspections and Audits

The RCSC conducts appraisals of the HCF at least annually, and the RCSC Charter identifies criticality-safety items to be included in the audit. HCF criticality-safety issues are documented and followed up in accordance with SNL ES&H requirements of GN470072, which are reflected in nuclear facility operations procedures. HCF operational procedures require a record of HCF fissile inventory at all times. These records shall be used and maintained to document compliance with criticality mass limits.

6.5.6 Criticality Infraction Reporting and Follow Up

In the event of discovery of a non-compliance with criticality procedures, the following actions are required in accordance with the SNL ES&H Manual, Supplement GN470072:

- Stop work, leave the area, and notify co-workers of the event;
- Report the incident to the HCF Manager or the TA-V Duty Manager;
- Develop a reentry/recovery plan; and
- Obtain concurrence of recommended actions by the RCSC.

6.6 Criticality Instrumentation

No criticality instrumentation or alarms will be installed in the HCF, based on the CSA, which has established that all credible fissile configurations in the HCF will remain subcritical (Mitchell and Romero 1999).

6.7 REFERENCES

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CONTENTS

TABLES

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7.0 RADIATION PROTECTION

7.1 Introduction

This chapter describes the implementation of the radiation-protection program at the Sandia National Laboratories/New Mexico (SNL/NM) Technical Area V (TA-V) Hot Cell Facility (HCF) under normal or anticipated abnormal operating conditions. Information is included about the HCF facility and equipment design and the planning, procedures, techniques, and practices employed to meet the standards for radiation exposure and protection. A summary of the predicted annual exposures to facility workers (local and collocated) from radiation sources during normal operations is presented. In addition, this chapter describes the responsibilities of specific radiation-protection organizations at SNL/NM.

The HCF is dedicated primarily to the mission of chemical processing of radioisotopes. The radiological concerns that exist for these operations include the potential for direct personnel exposure to highly radioactive materials and the potential for uptake of contamination that might be inadvertently released to inhabited areas of the facility. These hazards are identified and described in Chapter 3.

7.2 Requirements

The following DOE Orders and Federal Regulations are applicable to HCF radiation-safety programs.

DOE Order 5400.5, Radiation Protection of the Public and the Environment (DOE 1990).

10 CFR 835, Occupational Radiation Exposure.

These regulations and orders are implemented at SNL in the form of the SNL ES&H Manual (SNL 1998b), Chapter 8, Occupational Radiation Protection, and the Radiological Protection and Procedures Manual (RPPM), MN471016 (SNL 1998a), a supplement to the ES&H Manual.

7.3 Radiation Protection Program and Organization

The radiation protection program is implemented at SNL by the ES&H Manual Supplement MN471016, Radiological Protection and Procedures Manual (RPPM) (SNL 1998a). This manual describes roles, responsibilities and requirements of radiation protection programs for SNL personnel. The ES&H Center is responsible for the SNL radiation protection program and provides the HCF with Radiological Control Technicians (RCTs) dedicated to HCF operations and personnel to staff the counting lab in TA-V which supports the HCF radiation-protection program. The HCF RCTs provide radiation-protection support on an as-needed basis for HCF operations such as the transfer or opening of packages containing radioactive material, or entries into any radiological areas.

The HCF Department Manager is responsible for the daily operational aspects and the administrative control of operational support activities, including the handling and storage of radioactive materials associated with the extraction and purification of isotopes. A complete description of the lines of responsibility for Nuclear Facility Operations is provided in Chapter 17.

The HCF supervisor is responsible for the conduct of all HCF operations on a daily basis. In line with this assignment, the HCF supervisor is responsible for preparing the facility for isotope processing and maintenance activities. This includes ensuring that all procedures and equipment are in place prior to work and that personnel involved are properly qualified. The supervisor has complete authority over all operations and maintains a surveillance program to ensure all operations are conducted in an approved and safe manner.

HCF personnel, along with ES&H line support teams, ensure that radiological operations are conducted safely. The ES&H line support teams provide the HCF staff with technical support, guidance, and assistance in matters concerning radiation protection/radiological safety, and the SNL/NM Radiation Protection Program.

7.4 ALARA Policy and Program

SNL ALARA policy, as stated in the RPPM (SNL 1998a) is that "As a minimum, Sandia shall ensure that radiation doses to its workers and the public resulting from radiation exposures or releases of radioactivity to the environment are maintained below regulatory limits. In addition, Sandia shall make deliberate efforts to further reduce doses to as low as reasonably achievable (ALARA), considering technical, economic, and social factors. Sandia is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy."

Practices and requirements are described in the RPPM to implement this policy. These requirements ensure that appropriate reviews of personnel exposures are performed, and that exposure-reducing methods are used to minimize both internal and external radiation exposures. Radiation exposure rates in work areas are maintained ALARA with proper facility design and physical characteristics (e.g., confinement, ventilation, remote handling, and shielding). In addition to engineered features, administrative controls help to maintain exposures ALARA. These include radiation worker safety training; technical review of all work involving radioactive materials and radiation-producing devices; maintaining written and approved Technical Work Documents (TWD's); radiological safety surveillance activities; and personnel dosimetry.

Every individual has a primary responsibility for the ALARA program. Individual workers are responsible for understanding the radiation hazards in the workplace. This understanding is provided by the radiation-worker safety training that all radiation workers must complete. The ES&H Center is responsible for (1) establishing and maintaining goals, objectives, and activities regarding ALARA policy, (2) reviewing those policy aspects at least annually, and (3) communicating any recommendations or changes to management personnel. The HCF Department Manager is responsible for setting radiological performance goals for HCF personnel.

7.5 Radiological Protection Training

Radiological-protection training at SNL consists of three main topical areas: (1) General Employee Radiation-Protection Training, (2) Radiation-Worker Safety Training, and (3) Site-Specific or Job-Specific Training Requirements. The formal training applicable to operations at the HCF consists of Radiation-Worker Safety Training and Criticality-Safety Training.
Radiation-Worker Safety Training is required for any employee at SNL/NM considered a "radiation worker" as specified in the SNL RPPM (SNL 1998a).

General Employee Radiological Training describes general radiation protection terminology and explanations of the potential hazards of ionizing radiation. The course addresses radiation characteristics, sources of radiation, radiation dosimetry and monitoring, radiation dose limits for general employees, the SNL policy of keeping all exposures as low as reasonably achievable (ALARA), risks (in perspective), radiological controls, manager and employee responsibilities, radiation protection personnel responsibilities, and handling of radiological incidents.

In addition, all radiological workers are required to receive radiation worker safety training in accordance with the SNL ES&H manual. This training gives the worker the academic and theoretical knowledge as well as the practical skills necessary to apply radiation protection principals to radiological work, and includes the following topics:

- Radiological fundamentals.
- Biological effects of ionizing radiation.
- Radiation limits and ALARA.
- Personnel monitoring.
- Radiological postings and controls .
- Radiological emergencies.
- Hazards of high radiation and contamination areas.
- Use of Radiological Work Permits.

After initial training, annual refresher training and biennial retraining is required for radiation workers. Site specific and job specific training is provided on a case by case basis when identified in a TWD. Specific training is used to provide information on current work area radiological conditions and any special/unique hazards or work area characteristics.

7.6 Radiation Exposure Control

SNL maintains plans and procedures, as described in the RPPM (SNL 1998a), to control personnel radiation exposures. These include administrative limits, radiological practices, dosimetry, and respiratory protection. The SNL/NM radiation-protection program for on-site exposures of personnel is described in the SNL RPPM. Radiation exposures to workers in special categories, such as those who have declared pregnancy and those who receive higher doses in emergency situations are strictly limited and monitored.

7.6.1 Administrative Limits

HCF personnel exposure is limited in accordance with the SNL RPPM. Administrative Control Levels (ACL's), trigger levels, and an established dosimetry program are used at SNL to monitor and limit the dose to radiation workers. Dose to workers in excess of 100 mrem per year must be specifically approved in accordance with the RPPM at levels as shown in Table 7.6-1. These limits are monitored and enforced through the use of dosimetry records, approved individual ACL's, and technical work documents.

Table 7.6-1. Administrative Control Level Approvals at SNL

Annual Level	Approval Level
100 – 500 mrem	Department Manager
501 – 1000 mrem	Center Director
1001 – 1500 mrem	Division Vice President
1501 – 2000 mrem	SNL President or designee
>2000 mrem	Department of Energy Secretarial Officer

7.6.2 Radiological Practices

The SNL RPPM (SNL 1998a) specifies posting of areas and work requirements where hazards from radioactive materials, radiation-producing devices, or ionizing radiation are or may be present. These areas include:

- Airborne Radioactivity Area: An area where the measured concentration of airborne radioactivity, above natural background concentrations, exceeds either (1) 10% of the derived air concentration (DAC) averaged over 8 hours or (2) a peak concentration of 1 DAC. DAC values are contained in the SNL RPPM.

- Contamination Area: An area where contamination levels are greater that the values specified in the SNL RPPM, but not exceeding 100 times those levels.

- Controlled Area: Any area to which access is controlled to protect personnel from exposure to radiation or radioactive materials.

- High Contamination Area: Any area where contamination levels are greater than 100 times the values specified in the SNL RPPM.

- High Radiation Area: An area accessible to personnel in which radiation levels could result in a dose equivalent in excess of 0.1 rem (100 mrem) in 1 hour at 30 cm (1 ft) from the source or from any surface through which the radiation penetrates. The upper threshold limit for a high radiation area is consistent with the lower threshold limit for a very high radiation area (500 rads in 1 hour at 1 meter).

- Radiation Area: An area accessible to personnel in which radiation levels could result in a dose equivalent in excess of 5 mrem in 1 hour at 30 cm (1 ft) from the source or from any surface through which the radiation penetrates.

- Radiological Area: A radiological area is currently defined in the RPPM as an airborne radioactivity area, contamination area, high contamination area, high radiation area, or a radiation area.

- Radiological Buffer Area: An intermediate area established to prevent the spread of radioactive contamination and/or to protect personnel from radiation exposure. The area surrounds or is contiguous with contamination areas, high contamination areas, airborne radioactivity areas, radiation areas, and high radiation areas.

- Radioactive Material Area: An area or structure where radioactive material is used, handled, or stored.

- Very High Radiation Area: An area accessible to personnel in which radiation levels could result in an absorbed dose in excess of 500 rads (5 Gy) in 1 hour at 1 m (3.2 ft) from a radiation source or from any surface through which the radiation penetrates.

The HCF Line Management is responsible for posting and labeling radiological hazards in accordance with the RPPM and is responsible for identifying and interpreting the appropriate regulatory requirements.

All radiological operations in the HCF are conducted in accordance with Technical Work Documents, which include approved Operating Procedures and/or Radiation Work Permits (RWPs) prepared in accordance with the SNL RPPM. The RWP is an administrative mechanism used to establish radiological controls for work activities involving known or suspected radiological hazards. RWPs are used to control nonroutine operations or work in areas with changing radiological conditions. RWPs include: information about the work to be performed, the radiological conditions of the work area, dosimetry requirements, training requirements, protective clothing and respiratory requirements, entry requirements, and any other limiting conditions involved in the operation.

RWPs are specifically required by the RPPM (SNL 1998a) for work under any of the following conditions:

- Radiation areas where exposure rates are > 10 mrem/hr.
- Contamination areas when work may change radiological conditions.
- High contamination or airborne radioactivity areas.
- Intrusive work in soil contamination areas or fixed contamination areas.
- Direct contact with radioactive material which could result in contamination of the worker or property.

7.6.3 Dosimetry

Dosimeters are the primary means of assessing external exposures. When required by a technical work document, personnel are required to wear dosimeters. Dosimeters are issued and monitored on a monthly or a quarterly basis, dependent on work requirements. Thermoluminescent Dosimeters (TLD's) are used at SNL as the basis for personnel dose exposure records. Self-reading dosimeters are used on an as-needed basis for specific jobs. Dosimeters are routinely maintained and calibrated by the SNL radiation protection organization in the ES&H Center.

If an individual's measured dose is higher than that established by a TWD or an established ACL, a member of the radiation protection organization will determine the cause of the reading and will recommend corrective measures to line management. Final authority to allow a worker who has received more than anticipated radiation dose to return to duty lies with the HCF management based on the advice of the radiation protection organization and medical personnel. The SNL RPPM provides details for release from work restrictions.

The ES&H Center administers the SNL/NM Internal Dosimetry Program. Equipment, confinement barriers, monitors and alarms, and personnel protective equipment (e.g., self-contained breathing apparatus) are all-important factors in controlling exposures to radiation sources internal to the body. The internal radiation-protection guidelines are presented in the RPPM. Bioassays, personal air sampling, and whole body counting are used to assess internal exposures. Whole body counts, urine and/or fecal samples, and nasal swipes are used as necessary. Bioassay policy and procedures and requirements for worker evaluations are described in the RPPM. (SNL 1998a)

7.6.4 Respiratory Protection

Engineered controls in the HCF are sufficient to preclude the need for respiratory protection during routine processing operations. HCF management identifies HCF personnel who require respiratory protection to perform HCF-related activities to the SNL/NM Respiratory Protection Program. The program provides the necessary training (to comply with OSHA requirements), ensures that workers are cleared by the SNL/NM Medical Department, conducts fit-testing of the specific types of respiratory protective devices, and issues the equipment to the individuals. Specifics for respiratory usage, including the types of protection required and the level of airborne radioactivity concentration requiring protection, are outlined in the SNL/NM ES&H Manual. Contract or other nonfacility personnel who require respiratory protection in the HCF must also comply with training and fit-testing requirements before an operation begins. Each person issued this equipment is responsible for its maintenance and care. The centralized ES&H training database notifies SNL personnel when training, medical, or fit-testing requirements become due. Respiratory protection may be required for non-routine and certain maintenance operations.

7.7 Radiological Monitoring

Contamination control at the HCF is achieved through a combination of engineered and administrative controls (See Section 7.6). Additionally, radiobiological safety engineers are available in the ES&H center to assist during work planning activities in the implementation of any necessary radiological controls. Existing engineered features that prevent the spread of contamination include the SCBs and the differential air pressures maintained between zones by the ventilation systems. These engineered features are discussed in detail in Chapter 2 of this SAR. Appropriate monitoring instruments are located and used to prevent personnel from spreading contamination into other areas of the HCF.

Administrative controls, implemented by procedures or TWD's, include requirements to use protective (anticontamination) clothing, personnel and personal property monitoring, and step-off pads. Other requirements specified in the RPPM include consumption control (i.e., no smoking, eating, or drinking), area posting, container labeling, and maintaining a clean work environment.

In addition to these administrative controls, RCTs provide workplace surveillance, including air monitoring, air sampling, area radiation surveys, and surface contamination surveys. These surveillances evaluate the effectiveness of the contamination-control program by identifying areas and activities needing improvement. Release of materials and equipment from radiological areas is controlled by the requirements of the RPPM.

Continuous monitoring of all gaseous effluents released from the HCF to the environment is accomplished to measure expected releases of airborne radioactive isotopes that are routinely evolved as a normal consequence of isotope processing. These released effluents will principally consist of small quantities of noble gases and radioiodine. Additional information regarding the quantities and monitoring of liquid and gaseous radioactive effluents is contained in Chapter 9, Section 9.4.

Environmental monitoring at SNL is conducted on a site-wide basis and includes both air and liquid effluent monitoring for hazardous and radiological constituents, as well as environmental surveillance (terrestrial, ecological, and ambient air monitoring). The environmental monitoring is conducted in accordance with DOE Order 5400.1, *General Environmental Protection* and DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* The scope and details of the program are described in the *Environmental Monitoring Plan (EMP),* PLA95-37, which is revised every three years (SNL 1995). Development, review, and implementation of the EMP are the responsibility of the ES&H Center. Results of monitoring and surveillance are reported to the DOE and made public in the Annual Environmental Reports. These reports will also include the results of the continuous stack monitoring performed at the HCF.

7.8 Radiological Protection Instrumentation

This section describes the equipment used for radiation monitoring inside the HCF, including the applicable placement, instrumentation, and surveillance requirements. This section also discusses the appropriate placement, calibration, and selection of the equipment based on the function and sensitivity of each instrument.

7.8.1 Fixed Equipment

The fixed equipment used for monitoring radiation inside the facility consists of two systems: (1) the radiation area monitoring system (RAMS), used to measure the level of gamma radiation, (2) the continuous air monitoring system (CAMS), used to monitor airborne activity. The number and location of these monitoring instruments is determined based on workplace needs, with advice from SNL Radiation Protection Organizations. They will be located in areas with the potential for significant radiation levels. It is currently anticipated that three RAMS will be permanently installed, one near the exit of the Zone 2A airlock, one in Room 111 near the target entrance/product exit systems, and one in Room 107. CAMS will also be located in these areas, with additional CAMS coverage of the quality control laboratory in Room 113.

Continuous air monitoring of HCF emissions to the environment is accomplished at the Hot Cell Facility using an Eberline SPING-3A, designed to monitor air effluent for particulate, iodine and noble gases. This instrument is located in the HCF ventilation exhaust duct at the north wall of Building 6580.

7.8.2 Portable Equipment

There are several types of portable instruments used in the HCF. These instruments are used routinely by RCTs to monitor and survey the facility, monitor the movement of materials, and monitor facility personnel. Hand and foot monitors and whole body counters are used to routinely monitor all personnel exiting the facility.

7.8.3 Calibration

Representatives of the organization in the ES&H center delegated the responsibility for radiation protection instrumentation are responsible for specifying, maintaining, and calibrating all fixed and portable radiation instruments. They are also responsible for calibration and quality assurance for these instruments in accordance with the RPPM. Periodic operability checks are accomplished by the radiation protection organization.

7.9 Radiological Protection Record Keeping

The radiation protection personnel in the ES&H Center maintain records of all radiation-protection surveys it performs at the HCF. These records include the type of survey performed, who performed the survey, for whom the survey was performed, and why the survey was performed. Current records of personnel dosimetry records are maintained in a centralized SNL database. Radiation workers can receive a record of their exposure at anytime upon request. In addition to this, an annual summary of total effective dose equivalents (TEDE) is provided to all radiation workers. These records are also available when the worker's employment is terminated.

Written plans and procedures for accomplishing work in the HCF are in the form of technical work documents (TWD's), such as SOPs and RWPs. The HCF Department Manager or designee is responsible for reviewing and approving all HCF TWD's involving ionizing radiation, radioactive material, or radiation sources. All personnel conducting operations in the HCF must follow approved TWD's, as specified by the RPPM (SNL 1998a).

7.10 Occupational Radiation Exposures

This section provides an estimate of the projected (calculated) annual exposures to facility workers and TA-V collocated workers from normal operations in the HCF. Normal operations include all activities associated with the chemical extraction of isotopes; the transfer of irradiated targets to the HCF, quality control assessment of the product material, the packaging of product material for offsite shipment, and the packaging and storage of the radioactive waste.

For maximum processing levels, the average dose rate at the initial processing station within the HCF is projected to be less than 0.5 mR/hr during the isotope extraction process, and less than 0.2 mR/hr elsewhere in the facility. The average time that process operators will require performing initial processing will be 3 to 4 hr/day and the balance of the workday will be spent in other portions of the facility. This will result in an average occupational dose to operators involved in initial processing of 2.1 mrem/day. For a 235 day working year, this will result in an annual occupational dose of less than 500 mrem/yr to personnel directly involved in processing operations on a full time basis. Other operations staff who are not directly involved with the initial processing stage will receive a lower dose.

For collocated workers, the average dose field outside the HCF due to isotope processing operations is expected to be less than 0.05 mR/hr. For continuous occupational exposure, the total dose should be less than 100 mrem/year. Work area TLD's are used by the radiation protection organization to monitor dose rates in the general area, and appropriate postings are displayed if the potential exists for dose to personnel greater than 100 mrem/yr. Because these operations have not previously been performed at SNL/NM on a routine basis, there is no historical data with which to compare these predictions for operators or collocated workers.

At a processing rate of 30 maximally irradiated targets per week, approximately 24 individuals would be subjected to the maximum estimated dose burden of 2.1 mrem/day. An additional 36 individuals would be subjected to lesser exposure rates, estimated at a maximum of 0.2 mrem/hr or 1.6 mrem/day. This results in a total occupational dose burden of 25.3 person-rem/year at maximum processing rates. Actual occupational dose burdens are expected to be well below these maximum estimates. The total number of collocated workers has been identified in Chapter 1 as 204 individuals. At a maximum of 100 mrem/yr, the total maximum dose burden for collocated workers would be less than 20 person/rem/yr.

7.11 REFERENCES

10 CFR 835, 1993, *Occupational Radiation Protection*, U.S. Code of Federal Regulations, Title 10, Energy, Chapter III, Department of Energy, Office of Federal Register, Washington D.C., January 1, 1998.

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Sandia National Laboratories (SNL), 1998b, *Environment Safety and Health (ES&H) Manual*, MN471001, Issue BW, Sandia National Laboratories, Albuquerque, NM, September 10, 1998 (SNL Internal Web).

U.S. Department of Energy (DOE), 1990, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 (Change 2: January 7, 1993), U.S. Department of Energy, Washington, D.C., February 8, 1990.

CONTENTS

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8.0 HAZARDOUS MATERIAL PROTECTION

8.1 Introduction

This chapter describes the hazardous material protection program at Sandia National Laboratories/New Mexico (SNL/NM) and its implementation at the Technical Area V Hot Cell Facility (HCF). The hazardous materials within the facility are identified and the types of hazards they might pose to workers, the public, and the environment are discussed. The applicable safety requirements, controls, and administrative policies and programs instituted at SNL/NM and within the HCF with respect to hazardous materials are also discussed.

The primary mission of the HCF is to provide the capability to extract, purify, package radioisotopes for sale by the DOE and to stage the resulting low level radioactive wastes until they are transported to a DOE disposal site. In addition, the HCF is used to support a variety of experiments involving radioactive and other hazardous materials. Many of these HCF activities involve the use of hazardous materials. The hazardous material activities that could affect the HCF include direct exposure to hazardous materials and a release of hazardous materials into the environment.

To maintain a work environment that is as safe as possible, there are hazardous material limits for the HCF. These limits are administratively controlled and restrict the quantity and type of material brought into the facility.

8.2 Requirements

The HCF hazardous-materials safety program is implemented by the SNL ES&H Manual, MN471001 (SNL 1998) and supplements to the manual. This manual incorporates all applicable DOE Orders and Directives as well as OSHA and other applicable standards, including 29 CFR 1910, DOE 5480.4 (DOE 1984), and DOE 5484.10 (DOE 1981).

8.3 Hazardous Material Protection and Organization

8.3.1 SNL/NM Industrial Hygiene Program

Sandia National Laboratories executes a comprehensive ES&H program that includes provisions for hazardous materials protection. Provisions for hazardous materials protection are addressed as a part of the SNL/NM Industrial Hygiene Program, implemented by the ES&H Manual Supplement PG470019 (SNL 1997), within the SNL ES&H program. The SNL/NM Industrial Hygiene Program is defined in the SNL/NM Industrial Hygiene Program and Chapter 6, Industrial Hygiene, of the SNL ES&H Manual (SNL 1998).

The overall purpose of the SNL/NM Industrial Hygiene Program is to provide a healthful working environment. Industrial hygiene staff within the Environment, Safety & Health Center (7500) have general responsibilities for the SNL/NM Industrial Hygiene Program. These general responsibilities include:

Providing an industrial hygiene advisory service to line organizations in a cost-effective and simple manner, with consideration of business needs, including, but not limited to:

- Identifying and documenting existing and potential occupational health hazards.
- Determining the extent of identified health hazards.
- Recommending measures to control health hazards.
- Assisting in the education of employees in health hazard identification, evaluation, and control.
- Providing information regarding health hazards requiring medical monitoring.
- Recommending and communicating actions to achieve compliance with occupational safety and health standards and applicable rules, regulations, and orders.
- Communicating and providing regulatory interpretations.

Supporting the SNL/NM Industrial Hygiene Program including, but not limited to:

- Actively participating in the Industrial Hygiene Program Working Group.
- Providing SNL/NM Industrial Hygiene Program related technical input and support to other organizations.
- Serving as technical consultants in developing and maintaining training courses on industrial hygiene topics.
- Providing industrial hygiene services (e.g., ES&H Support Team participation, record keeping, respirator issuance, hood certification, confined space inventory) to internal and external customers.
- Adhering to, and supporting, the SNL/NM Industrial Hygiene Program policies, processes, and procedures.
- Participating and supporting internal and external audits, assessments, and self-assessments of SNL/NM Industrial Hygiene Program.

8.3.2 HCF Implementation of the Hazardous Material Protection Program

The HCF hazardous material protection program complies with the applicable parts of SNL/NM Industrial Hygiene Program and Chapter 6, Industrial Hygiene, of the SNL ES&H Manual (SNL 1998). Isotope production activities apply the Hazard Communication Program defined in Chapter 6, Section D, Hazard Communication Standard, of the SNL ES&H Manual. Other activities, such as standard laboratory operations, apply the Laboratory Standard defined in Chapter 6, Section E, Laboratory Standard, of the SNL ES&H Manual.

Although the SNL/NM site programs for hazardous material protection are the responsibility of the ES&H Center, the HCF Department Manager is responsible for ensuring that all hazardous material program requirements are met. If questions arise with respect to hazardous material protection at the HCF, the HCF Supervisor or Department Manager consults with the ES&H Center personnel prior to the commencement of activities.

8.3.3 Management Structure

The HCF Department Manager has the responsibility for proper conduct of all HCF operations and must prepare the facility for work activities, facility operations, and maintenance activities. This includes ensuring that all proper procedures and equipment are in place prior to commencement of work activities and that personnel are properly qualified. With respect to hazardous material protection, the HCF Supervisor and HCF personnel, along with ES&H Center personnel, ensure that operations with hazardous materials are conducted safely. The line of management responsibility for operation of the HCF is described in Chapter 17 of the SAR.

The Industrial Hygiene Program Department is responsible for providing integrated multi-disciplined ES&H support to meet programmatic objectives in a safe, healthful, and environmentally conscious manner. The HCF Department Manager is responsible for the implementation of the IH program within the facility. This department is part of the Environment, Safety and Health Center, which reports to the Division Vice-President for Laboratories Services.

8.4 ALARA Policy and Program

The ALARA policy and philosophy with regard to hazardous materials, as specified in the ES&H Manual (SNL 1998), is to control personnel exposure such that neither the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) nor the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) are exceeded. Exposure to hazardous material in HCF work areas is maintained ALARA through proper facility design, equipment layout, PPE, physical controls (e.g., confinement and ventilation), and administrative controls.

8.5 Hazardous Material Training

Chapter 11 of the ES& H Manual describes the ES&H training methods and requirements for all SNL employees, onsite contractors, and visitors (SNL 1998). The corporate ES&H training requirements are cited in the appropriate chapters of the ES&H Manual and its supplements. Because of the specific nature of workplace and job hazards, personnel may require additional training on facility- or project-specific processes and procedures. SNL managers are responsible and accountable for:

- Determining the additional ES&H training requirements for their employees and onsite contractors.
- Ensuring that training activities are established and documented to fulfill these requirements.
- Maintaining the training completion records that are not maintained in the corporate training database.

The HCF staff, supervisors and managers are trained commensurate with the level of assigned tasks. Individual training requirements are specified in a Training Implementation Matrix (see Section 12.4). The training program is based on the configuration and work activities and emphasizes hazard communications and the five step Integrated Safety Management System (ISMS) process. The methods of conducting this training may include required reading, classroom lecture, demonstration, table top drills, and/or management discussions. Training of personnel is implemented at the HCF through a formalized training program as described in Chapter 12.

8.6 Hazardous Material Exposure Control

8.6.1 Hazardous Material Identification Program

The hazardous material identification requirements applied to SNL/NM facilities are defined in the SNL ES&H Manual, Chapter 6, Sections D and E, Hazard Communication Standard and Laboratory Standard, respectively (SNL 1998). These standards address the labeling of hazardous chemicals and the availability of Material Safety Data Sheets (MSDSs). HCF activities will follow the Hazard Communication Standard (for isotope processing operations) and the Laboratory Standard (most other activities). The requirements within these standards vary slightly, however, both require appropriate hazards labeling and the availability of MSDSs.

8.6.2 Administrative Limits

The quantity of hazardous materials will be minimized in the HCF consistent with accomplishing the intended isotope processing function of the facility. In general, hazardous materials, and especially flammable materials, will be separated from radiological materials except as necessary to accomplish isotope processing operations and these operations will be specifically defined in approved ES&H SOP's. Isolated and approved hazardous material storage locations will be specifically and appropriately identified in the HCF.

Hazardous material limits in the Building 6580 basement area of the HCF are defined in terms of the reportable quantities provided in 40 CFR 302, 355, 370 and 29 CFR 1910 (see references). For hazardous substances or hazardous chemicals listed in the above regulations which have not been otherwise specifically evaluated in an SNL ES&H SOP (e.g. chloroform used in the QC laboratory), the maximum permissible quantity in the HCF shall be the lowest reportable quantity or 20 kg (45 pounds), whichever is less. These limits are established as a good practice and to maintain hazardous material exposure to a level as low as reasonably achievable (ALARA).

Flammable chemicals are to be stored only in Zone 2 or Zone 3 of the HCF in approved storage containers. The quantity of flammable chemicals in storage in the HCF is limited to 20 kg (5 gallons) for each chemical, in containers no larger than 4 liters.

The maximum quantities of any flammable chemicals which are permitted to be in use in the HCF is dependant on the location the chemicals are to be used and the radiological conditions which are present in that location.

For Zone 1, in each SCB

- 50 ml when radiological materials are present in the SCB (excluding residual contamination)
- 1 liter at other times

For Zone 2A

- 1 liter, when radiological materials are actively in process in any SCB
- 4 liters at other times

For Zone 2

- 1 liter when radiological materials are in process within the room (e.g. 107, 111, 112, 113, 113A, 114)
- 10 liters at other times

The maximum quantity of any flammable solvent that can be used in an SCB is 50 ml (1.7 fl oz), to prevent the lower explosive limit (LEL) of the most volatile solvent (acetone) from being reached under any circumstances. Maximum quantities in other areas of the HCF are established as a good practice to minimize the likelihood and/or severity of a fire or explosion and to keep worker exposure to chemicals ALARA.

Personnel exposure to hazardous substances is controlled such that exposures do not exceed the most restrictive of either OSHA's Permissible Exposure Limits (PELs) or the ACGIH Threshold Limit Values (TLVs). (ES&H Manual, Chapter 6, Sections D and E)

8.6.3 Occupational Medical Programs

The SNL Occupational Medicine program is described in PG470188, "Occupational Medicine" (SNL 1995) and provides medical services in support of the Chemical Hazard Identification Evaluation, and Control Program, Laboratory Standard Program, Chemical Carcinogen Control Program, Hearing Conservation Program, and Bioassay Program. The SNL/NM Health Services Center (HSC) provides required periodic medical surveillance examinations and certifications for employees who may potentially confront specific physical, chemical, or biological hazards and ensures the appropriate records are kept. The HSC also provides medical field response consistent with the roles and responsibilities defined in the SNL/NM Emergency Preparedness Plan.

The HCF Manager determines whether an employee is subject to a medical surveillance program based on workplace exposure and evaluation by the industrial hygiene staff.

8.6.4 Respiratory Protection

HCF personnel may be required to wear respirators for hazardous material protection if, based on ES&H personnel review, a particulate material hazard is suspected. The HCF Supervisor could require organic-type respirators if a suspected organic vapor hazard exists.

Chapter 6, Section C of the SNL ES&H Manual specifies the SNL respiratory usage policy and program (SNL 1998). This program described in the ES&H Manual provides the necessary training (to comply with OSHA requirements), conducts fit testing of the specific types of respiratory protective devices, and issues the equipment to the individuals. Each person issued this equipment is responsible for the proper use and care of the items. ES&H Center personnel perform respirator maintenance. The centralized ES&H training database is used to notify each individual when training or medical and fit-testing requirements become due. Contract personnel or other non-facility personnel who may require respiratory protection in the HCF must comply with the SNL/NM-mandated training and fit-testing requirements before an operation begins.

Respiratory protection for emergency response personnel and the hazardous material (HAZMAT) team members is also specified in Section C of Chapter 6 of the SNL ES&H Manual.

8.7 Hazardous Material Monitoring

Because of the small quantities of hazardous materials used in the HCF, the need for hazardous material monitoring is limited. SNL industrial hygiene personnel in the ES&H Center are available to assist HCF operations staff in selecting and providing any monitoring or instrumentation required to perform operations conducted with hazardous materials. The need for such assistance is established during work planning activities required for HCF activities.

The Environmental Monitoring and Surveillance Program (PG470103) at SNL includes both air and liquid effluent monitoring for hazardous and radiological constituents as well as environmental surveillance, (terrestrial, ecological and ambient air monitoring) and is documented in the Annual Site Environmental Report. Air emissions for hazardous materials from the HCF are reported on an annual basis to the Environmental and Emergency Management Department to meet the NESHAP requirements as specified in Chapter 17 of the ES&H Manual.

8.8 Hazardous Material Protection Instrumentation

The HCF has no permanently installed hazardous material instrumentation due to the limited quantities and handling of hazardous materials. Any hazardous material instrumentation identified as required for HCF operations will be identified and specified by SNL industrial hygiene personnel for either permanent or temporary use.

8.9 Hazardous Material Protection Record Keeping

A current inventory of chemicals is maintained for the HCF through the use of the SNL Chemical Inventory System (CIS) as described in Chapter 6, Section U of the SNL ES&H Manual (SNL 1998). Managers are required to keep an inventory of chemicals stored or used and to maintain a current CIS inventory. Locations where chemicals are used or stored are identified in the CIS. The CIS also tracks the status and ownership of these chemical use/storage locations.

The ES&H Manual recommends an annual reconciliation of the physical inventory and the CIS. A Location Description Form is submitted when:

- Chemicals are first stored at a new location,
- All chemicals are permanently removed from a location, or
- Ownership of a location changes.

SNL maintains laboratory-wide programs for personnel dosimetry, medical monitoring/surveillance, and environmental monitoring which are addressed in detail in other chapters of the SAR.

8.10 Hazard Communication Program

The hazard communication programs applied to SNL/NM facilities are defined in Section D, Hazard Communication Standard, and Section E, Laboratory Standard of Chapter 6 of the SNL ES&H Manual (SNL 1998). These standards address the 10CFR1910 criteria, training of employees, the availability of Material Safety Data Sheets (MSDSs), and the use of the CIS described in the previous section. HCF activities will follow these two standards appropriate to the activity. Requirements within these standards vary slightly, however, both address worker training, hazards labeling, and the availability of MSDSs.

8.11 Occupational Chemical Exposures

HCF personnel exposure limits with respect to hazardous materials are based on the SNL ES&H Manual. Material-specific limits are based on MSDS information provided by the manufacturer.

Due to the containerized nature of limited hazardous material stored in the HCF, the small quantities that are used in HCF processes, and the well-confined and well-ventilated process areas where hazardous materials are used, workers are not expected to receive any measurable occupational exposure to chemicals. If exposure is anticipated or suspected, SNL industrial hygiene personnel will assist in establishing the potential for exposure or in estimating exposures and will make recommendations to implement any necessary corrective actions. There have been no chemical over-exposures associated with past activities in the HCF.

8.12 REFERENCES

29 CFR 1910, *Occupational Safety and Health Standards*, U.S. Code of Federal Regulations, Title 29, Labor, Part 1910, Office of the Federal Register, Washington, D.C., July 1, 1994.

40 CFR 302, *Designation, Reportable Quantities, and Notification*" U.S. Code of Federal Regulations, Title 40, Protection of the Environment, Part 302, Office of the Federal Register, Washington, D.C., July 1, 1994.

40 CFR 355, *Emergency Planning and Notification*" U.S. Code of Federal Regulations, Title 40, Protection of the Environment, Part 355, Office of the Federal Register, Washington, D.C., July 1, 1994.

40 CFR 370, *Hazardous Chemical Reporting: Community Right-to-Know*, U.S. Code of Federal Regulations, Title 40, Protection of the Environment, Part 370, Office of the Federal Register, Washington, D.C., July 1, 1994.

Sandia National Laboratories (SNL), 1995, *Occupational Medicine*, PG470188, Issue A, Sandia National Laboratories, Albuquerque, NM, August 31, 1995 (SNL Internal Web).

Sandia National Laboratories (SNL), 1997, *SNL/NM Industrial Hygiene Program*, PG470019, Issue B, Sandia National Laboratories, Albuquerque, NM, April 16, 1997 (SNL Internal Web).

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U.S. Department of Energy (DOE), 1984, *Environmental Protection, Safety, and Health Protection Standards*, DOE Order 5480.4 (Change 4: January 7, 1993), U.S. Department of Energy, Washington, D.C., May 15, 1984.

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FIGURES

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9.0 RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 Introduction

This chapter describes the systems, policies, and procedures associated with the collection and disposal of wastes generated in the Hot Cell Facility (HCF). In particular, the chapter includes a description of the functions performed by representatives of the Environment, Safety, and Health (ES&H) Center that are involved in the different aspects of waste management at SNL. The program addresses radioactive, hazardous, and mixed wastes from their generation through their final disposition or destruction. The program includes a waste minimization program to reduce the total quantities of wastes generated.

9.2 Waste Management Requirements

Waste-management requirements applicable to the operation of the HCF are established by DOE Orders and federal, state, and local statutes and regulations. The SNL ES&H Center reviews these directives for applicability and implements lab-wide programs to address the pertinent requirements. Site-specific implementation guidelines are adapted to meet the requirements established by the corporate program and are reviewed for adequacy.

Waste-management policies, guidelines and procedures implemented at SNL (and the TA-V nuclear facilities) are in accordance with:

DOE Orders 5400.5 (DOE 1990) and **5820.2A** (DOE 1988), and applicable U.S. Environmental Protection Agency (EPA) regulations (40 CFR 260-270) and State of New Mexico regulations (20 NMAC 4.1).

The disposal of chemical and hazardous waste is regulated by:

DOE Order 5820.2A (DOE 1988), Chapter 19 of the SNL ES&H Manual (SNL 1998b), EPA regulations (40 CFR 260-270), New Mexico hazardous waste management regulations (20 NMAC 4.1).

9.3 Waste Management Program Organization

The waste management program at SNL is conducted under the auspices of the SNL Environment Safety, and Health Center, which delegates responsibilities for different aspects of waste management to several departments. The following sections describe the groups within the ES&H Center that support or conduct waste management activities related to the HCF.

As described in the SNL ES&H Manual, administration of the waste management program at the HCF is the responsibility of the Hot Cell Facility Department Manager (SNL 1998b). The Manager assures that waste management tasks are assigned and satisfactorily completed. The Manager ensures that the HCF staff is aware of their responsibilities in handling hazardous/radioactive materials and wastes, and that the staff receives ES&H training for handling these materials commensurate with their assigned duties. The Manager provides the operations staff with approved department procedures for facility-specific aspects of waste management, which are developed as needed. The Manager must maintain documentation to demonstrate compliance.

The HCF Supervisor and Operators are responsible for performing their respective duties according to established procedures and ES&H training that they have received.

The ES&H Training Department provides waste management training. Specific training courses include hazardous waste generator, radioactive and mixed waste generator, and waste custodian. These courses address the specific regulatory requirements, SNL policies and procedures, and administrative actions necessary for the collection, storage, and disposal of generated wastes.

Facility personnel conduct periodic facility inspections to ensure storage requirements are followed. SNL, DOE, and state agencies conduct periodic audits and inspections. All audits are coordinated through the SNL ES&H Center, as outlined in the SNL ES&H Manual (SNL 1998b).

Documentation associated with HCF waste management activities and maintained in the HCF Facility includes Chemical Waste Disposal Requests, Radioactive/Mixed Waste Disposal Requests, Radioactive Waste Traveler Forms, Radioactive and Chemical Waste Addition Logs, and storage-facility periodic inspection checklists. The respective waste management group within the ES&H Center, as described below, maintains the original disposal requests.

9.3.1 Radioactive and Mixed Waste

The ES&H Center develops, maintains, and supports the implementation of a corporate management system for radioactive and mixed waste. Services provided include waste collection, storage, treatment, packaging, shipping, disposal, policy communication, and training. All radioactive and mixed waste generated in the HCF is ultimately submitted to representatives of the ES&H Center responsible for the management of radioactive and mixed waste. The treatment and storage of the high activity isotope production waste and the preparation of procedures for these activities has been delegated to the Medical Isotope Production Program. The issue of when ownership of this high activity waste will be transferred to the ES&H Center will be determined through negotiations between the Medical Isotope Production Program and the ES&H Center.

9.3.2 Environmental Monitoring

Representatives within the ES&H Center responsible for environmental monitoring oversee the collection of data to assess, document, and report the impact of SNL operations on the environment and to provide guidance on air and water quality issues. These representatives are responsible for working with the HCF Manager and staff on issues concerning stack monitoring and reporting.

9.3.3 Solid and Hazardous Waste

Representatives of the ES&H Center develop, maintain, and support a corporate waste management system for SNL. Services provided include solid and hazardous waste collection, storage, treatment, packaging, shipping, disposal, policy communication, and training. All hazardous waste and non-regulated solid waste generated in the HCF are submitted to representatives of the ES&H Center responsible for the management of solid and hazardous waste at SNL.

9.4 Radioactive and Hazardous Waste Streams or Sources

9.4.1 Waste Management Process

SNL is subject to all applicable laws and regulations regarding the management and release of waste products generated as a result of its operations, and the protection of personnel, equipment, and the environment. SNL has adopted a proactive philosophy to ensure that all releases to the environment and personnel exposures are kept as low as reasonably achievable (ALARA) and below acceptable guidelines. Corporate programs have been implemented to address waste collection and disposal practices. These programs are described in the SNL ES&H Manual (SNL 1998b).

As noted above, policies addressing the generation, collection and the ultimate disposal of radioactive, mixed, and hazardous waste are developed by SNL's ES&H Center. Groups within this center are responsible for assessing the pertinent regulations and identifying the requirements necessary to comply with various regulatory guidelines. As new requirements or recommendations are identified, representatives of the ES&H Center notify the waste generators with recommended methods for meeting compliance through the ES&H Manual. The generator is then required to meet the new criteria either by implementation of a corporate-wide policy or the development and implementation of an activity-specific or site-specific procedure or instruction.

Small batch quantities of mixed waste are generated in the HCF as part of the isotope extraction and quality control assessment activities. However, the HCF is operated as a satellite accumulation area, and is not a Resource, Conservation, and Recovery Act (RCRA)-permitted storage facility. Therefore, mixed waste cannot be stored in quantities greater than 55 gallons for more than three days. Only mixed wastes generated in the HCF can be stored in the HCF. In addition, as defined by 40 CFR 260.10, the stainless steel cylinders in which the liquid waste from isotope extraction is solidified and neutralized are operated as "elementary neutralization units". Neutralization records will be retained and reported as waste required by state and federal law.

Process knowledge and samples taken of the solidified waste material from the processing of unirradiated depleted uranium dioxide targets with simulated materials have indicated that no RCRA regulated hazardous constituents are present above applicable regulatory levels. Based on this information, it is concluded that after the high activity waste is neutralized, it is radioactive waste that no longer exhibits any hazardous characteristics.

9.4.2 Waste Sources and Characteristics

The types of wastes generated within the HCF include sanitary sewage from sinks; chemical wastes from equipment maintenance, service, and cleaning; and radioactive wastes and mixed wastes generated during isotope extraction and purification, quality control testing of product material, and decontamination activities. Radiological monitoring is performed to screen waste materials leaving Radiological Material Management Areas (RMMAs) to ensure wastes are not inadvertently released.

9.4.2.1 Radioactive Waste (non-mixed)

Radioactive wastes are generated in the HCF in the form of solid materials, liquids, and gases. The annual volume of waste generated is dependent on the number of targets processed in the HCF in a given year. All radioactive waste generated is low-level waste (LLW). There are no high level wastes (HLW) or transuranic (TRU) wastes generated from isotope extraction or purification activities. (That is, the waste generated during isotope extraction and purification does not contain transuranic radionuclides in activity concentrations greater than 100 nCi/g, and does not result from the first cycle of fuel reprocessing.)

9.4.2.1.1 Solid

Typical solid radioactive waste generated in the HCF as a result of isotope processing activities includes the following:

- Protective clothing such as gloves, paper lab coats and smocks, coveralls, booties, caps, and respirator cartridges;
- Contamination control materials such as plastic bags, absorbent sheeting, towels, and aluminum foil;
- Packaging materials including cardboard, metal, wood, and plastic containers;
- Particulate filters from facility exhaust systems;
- Contaminated solid items from target processing or quality control activities, such as syringes, needles, filters, resin columns, and glass bottles;
- Materials activated in the ACRR, such as the steel target tube and handling fixture;
- Materials contaminated during the collection of fission gases as part of target processing, such as copper wool and copper tubing;
- Cylinders containing concrete-stabilized waste;
- Charcoal and HEPA filters from the facility ventilation system; and
- Resins from the process and glove box cleaning systems.

The processing of 1,500 targets per year in the HCF for isotope extraction purposes is expected to result in the generation of 100 m^3 (3,500 ft^3) of solid radioactive waste. This level of processing is considered to be 100% of the facility capacity.

9.4.2.1.2 Liquid

Small quantities of liquids are used in the SCBs as part of the isotope extraction process. However, these liquids are stabilized as part of the extraction process and do not enter the waste stream as liquids. Water is used during decontamination activities, such as cleaning of the shipping casks and the SCBs. However, the decontamination processes will be largely closed-loop systems and the estimated volume of waste liquid that will be generated from these types of activities during the processing of 1,500 targets each year is expected to be 1,000 L (L).

Maintenance related liquid wastes account for a small volume of wastes. These wastes are limited to contaminated oil from vacuum pump systems and potentially from the elevator in Zone 2A. Draining and replenishment of this oil is infrequent and is expected to produce 57 L (15 gal) per year during the processing of 1,500 targets each year.

9.4.2.1.3 Gaseous

Some of the gases removed from irradiated targets as part of isotope processing activities will be used for additional isotope recovery activities. However, gaseous radioactive waste will be generated as gases not used for isotope extraction or recovery activities. This gaseous waste is released from the cold trap system, which is used to collect and temporarily store (for decay) the fission gases removed from irradiated targets at the start of the extraction process. The HCF includes activated charcoal filtration to remove the halogens from the gaseous waste stream and a cryogenic collection system to store gases, particularly noble gases, to allow for decay prior to release to the stack.

The cold trap system will store the collected gases for an appropriate time period prior to release to the TA-V stack. The length of this storage period will be determined by negotiations with representatives of the ES&H Center responsible for environmental monitoring and will insure compliance with NESHAPS regulations. In terms of permitting for effluent discharges, DOE holds an Authority to Construct Permit with the EPA and the City of Albuquerque for isotope production in the HCF. This permit requires continuous monitoring of stack discharges during production. It is estimated that the processing of 1,500 targets a year, as part of the isotope production activities in the HCF will result in the release of 1,000 curies (Ci) of xenon and 2 Ci of iodine.

9.4.2.2 Hazardous Waste

9.4.2.2.1 Solid

Solid hazardous wastes generated in the HCF are items such as alkaline and lithium batteries used in portable electrical instruments, materials (e.g., rags and paper towels) used with cleaning solvents to clean equipment and components, and sodium vapor or mercury lamps. The estimated volume of solid hazardous waste generated annually does not exceed 0.28 m^3 (10 ft^3).

9.4.2.2.2 Liquid

Liquid hazardous waste generated by HCF operations include waste solvents, paint, lubricating oils, and chemicals used in maintenance activities. Only limited quantities of solvents are used, including methanol, propanol, acetone, and limited quantities of mineral acids and bases. A concerted effort has been undertaken to minimize the volume of hazardous liquids on hand, as well as substitution of non-hazardous materials. The estimated volume of hazardous liquid waste generated during the processing of 1,500 targets is approximately 38 L (10 gal) per year.

9.4.2.2.3 Gaseous

Gaseous hazardous waste consists primarily of the vapor produced by evaporation during use of the liquids noted in paragraph 9.4.2.2.2. There are no processes or activities that release hazardous gases into the environment in quantities that could exceed the volumes described in Section 9.4.2.2.2. The most common cleaning solvents used in the HCF have been identified in the previous section.

9.4.2.3 Mixed Waste

9.4.2.3.1 Solid

Examples of typical mixed wastes generated in the HCF as part of isotope processing are lead shielding materials, batteries, electronic parts or instruments containing large quantities of solder, and contaminated sodium vapor or mercury lamps. The volume of solid mixed waste generated annually is approximately 0.57 m^3 (20 ft^3). Procedures for managing these wastes are outlined in the ES&H Manual (SNL 1998b).

9.4.2.3.2 Liquid

Liquid mixed waste is generated in the HCF mainly during the quality control activities associated with the assessment of isotope product material. The mixed waste consists primarily of contaminated solvents, such as chloroform and ethyl acetate, and acids or bases. In addition, contaminated oils from pumps or cranes are assessed to determine if they must be categorized as mixed waste. The volume of liquid mixed waste generated annually is estimated to be 800 L during the processing of 1,500 targets each year.

9.4.2.3.3 Gaseous

There are no gaseous mixed wastes generated in the HCF.

9.4.3 Waste Handling or Treatment Systems

9.4.3.1 Solid Wastes

9.4.3.1.1 Collection and Storage

All solid wastes generated are evaluated at time of generation and categorized as radioactive waste, mixed waste, or non-radioactive waste based on process knowledge. The wastes are collected in appropriate containers (e.g., plastic-lined trash containers, cartons, and crates). Containers are surveyed by Radiological Control Technicians to determine exposure rates and are appropriately labeled. Disposal Requests or Traveler forms are forwarded to representatives of SNL's ES&H Center responsible for radioactive and mixed waste management. Waste with contact exposure rates less than 200 milliroentgen/hour (mR/hr) is scheduled for pick up, and transport to a centralized storage facility under the control of the ES&H Center. SNL waste acceptance criteria given in the ES&H Manual provide packaging, dose rate, and handling criteria requirements (SNL 1998b).

The high activity waste generated as a direct result of isotope extraction and purification has a contact exposure rate much greater than 200 mR/hr and cannot be accepted for storage by the ES&H Center. After generation in the SCBs, this waste will be collected in 55-gallon drums staged in Zone 2A. When a drum is full, it will be transferred to Room 109 of the HCF for temporary storage to allow the shorter-lived fission products to decay (Figure 9.4-1). Each 55-gallon drum will contain the waste from approximately five to twelve targets and is expected to be stored in Room 109 for a minimum of six months.

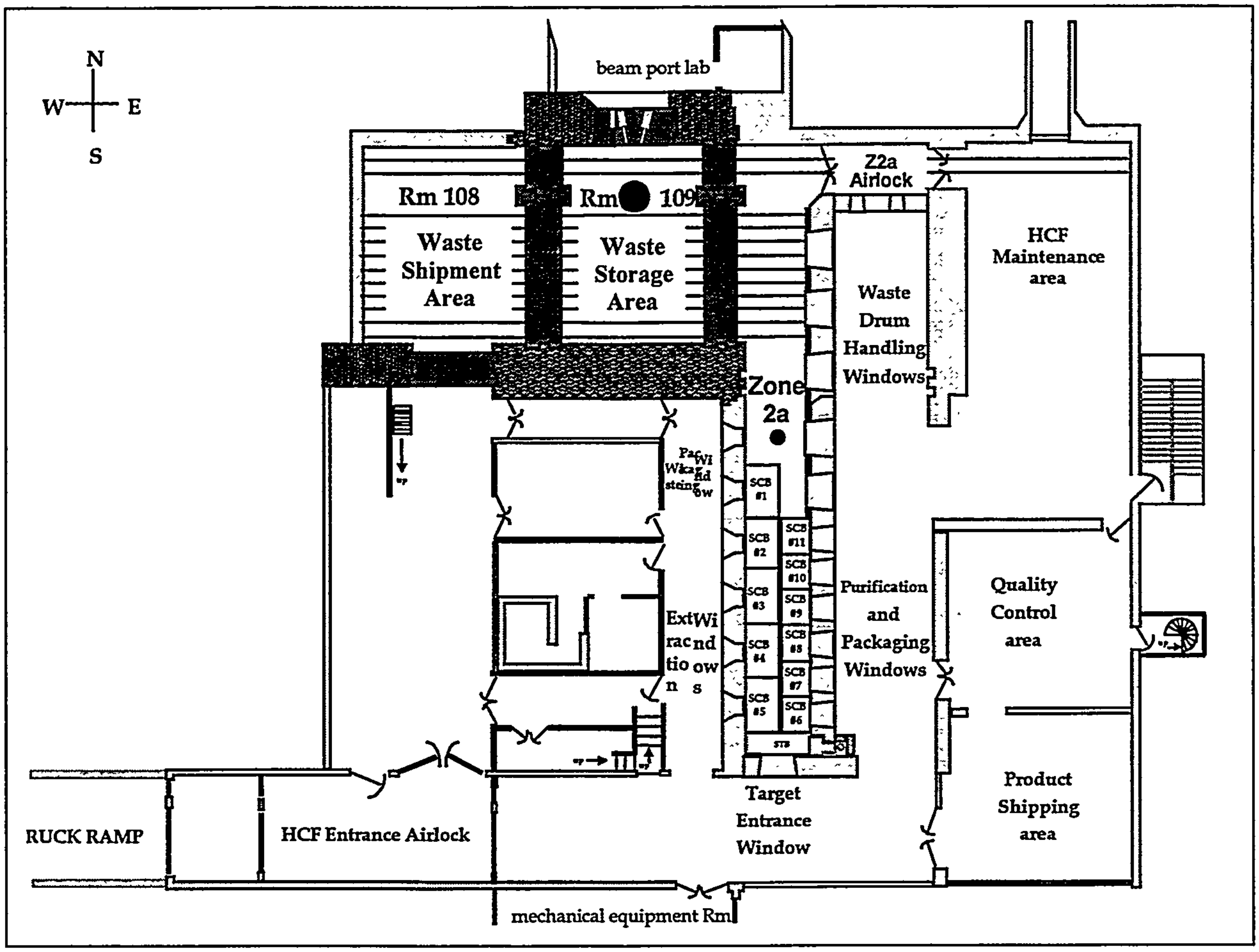

Figure 9.4-1. Hot Cell Facility Waste Storage Area

9.4.3.1.2 Treatment of Solid Waste

No treatment processes are employed to alter the physical or chemical composition of solid wastes generated in the HCF.

9.4.3.1.3 Disposal of Solid Waste

Non-hazardous solid waste is disposed in a sanitary landfill through SNL's Solid Waste Transfer Facility, while some waste streams (e.g. paper) are diverted to recyclers. Hazardous solid waste is disposed of through SNL's Hazardous Waste Management Facility.

Radioactive waste is transferred to the Radioactive and Mixed Waste Management Facility, or to another facility operated by representatives of the ES&H Center responsible for radioactive and mixed waste management. Radioactive waste is ultimately shipped for disposal at a disposal site approved by DOE.

9.4.3.1.4 Packaging and Shipping

The ES&H Center is responsible for all off site waste shipments. Regulatory requirements for packaging and off site shipment are outlined in the SNL ES&H Manual (SNL 1998b).

9.4.3.2 Liquid Wastes

9.4.3.2.1 Collection and Storage

Liquid wastes generated in the HCF include spent solvents, acids, and bases generated during quality control activities, oils, and liquids used in decontamination activities. Liquid wastes are stored in approved locations utilizing spill-containment devices to prevent uncontrolled release in the event of container leakage or breakage. Liquid wastes are inspected during waste in- and out-processing to ensure container integrity. Small volumes of hazardous liquid wastes are generated outside the RMMA. These wastes are collected and stored in appropriate containers until disposed of by representatives of the ES&H Center responsible for hazardous waste disposal. The HCF has numerous floor drains for the collection of water from emergency eyewash stations, showers, utility sinks, or other potable water sources. The drains are connected to the Liquid Effluent Control System (LECS). The water collected in the underground tanks is monitored for radionuclides (to ensure the levels are less than the acceptable release limits) before it is discharged into the LECS and, subsequently, the sanitary sewer system. The limits for radionuclides discharged into the sanitary sewer system are established by DOE Order 5400.5 (DOE 1990), and local regulations.

9.4.3.2.2 Treatment of Liquid Waste

The high activity liquid waste generated during isotope extraction has a pH of about 1 when initially generated and could potentially be categorized as corrosive under 40 CFR 261.22. To stabilize this material so that it can be more safely handled and stored, the liquid waste is drained into a steel containment vessel pre-loaded with a stabilization agent. Because the stabilization agent also serves to neutralize the acidic liquid, the containment vessel is classified as an "elementary neutralization unit" as defined in 40 CFR 260.10. Because the final waste form is solidified, pH-neutral material, the material is no longer considered corrosive and is not regulated under the Resource Conservation and Recovery Act [40 CFR 261.2(d)(1)].

9.4.3.2.3 Disposal of Liquid Waste

The liquid radioactive, hazardous, or mixed wastes generated in the HCF during isotope processing that are not solidified are disposed of through the appropriate group within SNL's ES&H Center. The liquid waste collected by the drain system is disposed of via a sanitary system managed by representatives of the ES&H Center responsible for liquid effluents.

9.4.3.2.4 Packaging and Shipping

Groups within the ES&H Center are responsible for all off site waste shipments. Regulatory requirements for packaging and off site shipment are outlined in the SNL ES&H Manual (SNL 1998b). The ES&H Center is responsible for ensuring that offsite waste shipments meet all applicable Department of Transportation requirements, RCRA manifesting requirements, and the waste acceptance criteria of the receiving treatment and/or disposal facility.

9.4.3.3 *Waste Management Instrumentation*

For waste packages with exposure rates less than 200 mR/hr, radiation detection instrumentation is used to identify dose rate and the contamination level on the outside of the container. In some cases, specific isotopes are identified using gamma spectral analysis. No measurements are made of the high activity waste from the extraction boxes.

9.4.3.3.1 Monitoring Techniques

The release point for the HCF ventilation system exhaust is the HCF exhaust stack. Gaseous effluent discharged in the ventilation system is continuously monitored. The monitor electronically records selected beta-gamma emitting radionuclides as well as noble gases. The system is calibrated and maintained by representatives of the SNL ES&H Center and is discussed in Chapter 7. Liquid effluent from the LECS is sampled prior to release into the sanitary system. The samples are analyzed by gamma spectroscopy and liquid scintillation. No discharges to the sanitary system are allowed until analyses show that levels are within the established release limits.

9.4.3.3.2 Instrument Calibration

Radiation detection instrumentation used in the HCF is calibrated and maintained by representatives of the ES&H Center responsible for calibration of radiation protection instrumentation. Calibration due dates are monitored and instrument recall actions are typically initiated prior to expiration of the calibration due date. Instrumentation is replaced in the event of failure or malfunction. Specifics about the procedures used to calibrate instruments, the traceability of calibration standards, and applicable QA procedures are discussed in the ES&H Manual Supplement, "Radiological Protection Procedures Manual" (SNL 1998a).

9.5 REFERENCES

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CONTENTS

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10.0 INITIAL TESTING, INSERVICE SURVEILLANCE, AND MAINTENANCE

10.1 Introduction

This chapter describes the plans and provisions for the initial testing, inservice surveillance, and maintenance programs for the structures, systems, and components (SSCs) and the design features associated with the Hot Cell Facility (HCF).

10.2 Requirements

DOE O 425.1, Startup and Restart of Nuclear Facilities (DOE 1995).

Supplemental Directive AL 425.1, Startup and Restart of AL Activities (DOE 1998).

DOE Order 4330.4B, Maintenance Management Program (DOE 1990).

DOE Order 5480.20A, Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities (DOE 1994).

10.3 Initial Testing Program

HCF personnel, ES&H Center personnel, and Facilities Operations and Engineering (FOE) Center personnel share responsibilities for initial startup testing at the HCF. For example, HCF personnel may functionally test tools and equipment intended for use in the steel confinement boxes (SCBs) using the mockup manipulator arm located in Room 101 before the tools and equipment are inserted into the SCBs. ES&H Center personnel test the radiation-monitoring system. Facilities Operations and Engineering Center personnel are responsible for performing initial tests on all major modifications, and SSCs under their jurisdiction (e. g., fire-suppression system).

Initial startup testing procedures have been prepared and implemented to demonstrate that structures, systems, and components (SSCs) and processes will perform as intended. Initial testing includes, as appropriate, bench tests and proof tests prior to installation, mockup tests, pre-operational tests, post-maintenance tests, post-modification tests, and operational startup tests. Safety-related items are subject to the quality-assurance requirements of SNL/NM Research Reactor and Experimental Programs (RREP) Quality Assurance Program Plan (SNL 1998a), as implemented by the facility Project/Experiment Quality Plan (PEQP). Testing includes those initial tests mandated by applicable Technical Safety Requirement (TSR) surveillance requirements (see Chapter 5.0, "Derivation of Technical Safety Requirements") and Operational Readiness Review (ORR) requirements (see DOE O 425.1 and DOE-STD-3006-93).

Since the HCF has undergone significant modification to accommodate the isotope processing mission, some initial testing will resemble that for a new facility. Functional performance tests, with an emphasis on safety functions, will be conducted as follows:

- source testing of radiation shield structures, especially Zone 2A and Room 109 structures;

- ventilation system operation, including fan startup sequencing, fan shutdown interlocks, system damper control, operating range differential pressure verification, and software controls;
- target entrance system mechanical interlock;
- SCB conveyor system operation;
- SCB passthrough port operation;
- Zone 2A hydraulic elevator operation;
- fire detection system operation;
- fire suppression system operability;
- process vacuum system operation;
- standby electrical power system operation;
- radiation monitoring system operation, including alarm setpoint verification; and
- product exit system (PES) operation.

10.4 Inservice Surveillance Program (ISP)

10.4.1 Compliance with Technical Safety Requirements

Inservice verification and testing of safety-related SSCs is conducted by HCF personnel in compliance with TSR surveillance requirements. These operational activities consist of Zone1-to-Zone 2A and Zone 2A-to-Zone 2 ventilation system differential pressure verification, differential pressure instrumentation channel functional testing, ventilation fan sequencing interlock operability testing, and ventilation system hot exhaust filter operability verification. Details of these TSR surveillance tasks and the frequency with which they are to be performed are formalized in an operational surveillance procedure.

10.4.2 Other Operational Tests and Inspections

Additional inservice surveillance testing and inspections are performed for two primary purposes. The first is to determine actual facility operating conditions, and to verify the status of operating equipment and the operability of standby equipment and alarms. The second is to identify operational deficiencies that may be present and initiate appropriate corrective actions. Details of these tasks and the frequency with which they are performed are formalized in an operational surveillance procedure.

10.4.3 Surveillance Test Controls and Reviews

Test control procedures, control of measuring and test equipment, training and qualification of personnel performing surveillance tests, and surveillance test program reviews are governed by the SNL RREP Quality Assurance Program Plan as implemented by the facility PEQP. Review of surveillance test results is performed in order to monitor facility system and equipment performance, to identify the onset of degraded operations, and to assure continued TSR compliance.

10.5 Maintenance Program

The HCF maintenance management program is described in the SNL/NM Nuclear Facility Maintenance Implementation Plan (MIP) in (SNL 1997) and the SNL/NM Site Maintenance Plan (SNL 1993). Maintenance activities for the HCF are conducted by the three groups mentioned above; that is, HCF personnel, ES&H Center personnel, and FOE Center personnel. The scope of SSCs for which maintenance will be performed is established by the latest edition of the HCF Master Equipment List (MEL). This list differentiates between safety-related and nonsafety-related SSCs and specifically identifies those SSCs for which TSR surveillance requirements have been established. It also identifies the organization responsible for performing maintenance on each item.

10.5.1 Maintenance Organization and Administration

The MIP addresses the organization and administration of maintenance functions at the HCF, including the assignment of authority, responsibilities, and control of maintenance activities. In addition, the Partnering Agreement for Technical Area V delineates the scope of maintenance responsibilities and interfaces between the FOE and HCF organizations. HCF personnel are responsible for performing maintenance on "programmatic" property as indicated in the MEL. All "real" property (i.e., permanently installed buildings, structures, and non-programmatic equipment), and selected "programmatic" property as identified in the MEL, is maintained by Facilities Operations and Engineering Center personnel in accordance with the Partnering Agreement. Maintenance of radiation monitoring equipment is the responsibility of ES&H Center personnel.

The manager of the HCF organization is responsible for obtaining the resources necessary to perform in a timely manner the required preventive and corrective maintenance of those safety-related items for which the organization is responsible. ES&H Center personnel are responsible for obtaining the resources necessary to perform in a timely manner the required calibration and preventive and corrective maintenance of the radiation-monitoring equipment. All of these personnel report to senior SNL/NM managers to obtain prompt resolution of any maintenance problems that could affect the safety of the HCF.

Planning, scheduling, and coordinating preventive, corrective, and predictive maintenance and testing at the HCF is the responsibility of the HCF Supervisor. The HCF Supervisor is also responsible for developing appropriate maintenance procedures, instructions, or guidelines and for ensuring that HCF personnel perform maintenance activities in compliance with these documents.

Planning, scheduling, and coordination of FOE maintenance activities is the responsibility of the FOE organization subject to concurrence by the HCF Supervisor. Accountability for the performance of maintenance activities by FOE personnel is controlled within the SNL/NM Site Maintenance Plan.

10.5.2 Training and Qualification of Maintenance Personnel

The MIP addresses the training program for HCF personnel performing maintenance activities. It establishes individual responsibilities and maintenance training program requirements. Training and qualification of personnel is conducted under the TA-V training, qualification, and certification program for nuclear facility personnel. This program consists of initial and continuing classroom training, testing and qualification, and on-the-job training

(OJT) and is designed to develop and maintain the knowledge and skills needed by facility personnel to effectively achieve HCF maintenance objectives. Qualification criteria are established by the Nuclear Facility Support Manager and described in the latest edition of the Training Implementation Matrix. The Nuclear Facility Support Department maintains training and qualification records of HCF personnel. The Site Maintenance Plan describes the training and qualification requirements for FOE Center personnel. Together these programs implement, as appropriate, the guidelines defined by DOE Order 5480.20A, *Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities.*

10.5.3 Maintenance Facilities, Equipment, and Tools

The HCF provides adequate space for all maintenance work, storage, laydown, material staging, and decontamination activities. Work areas are maintained in a clean, uncluttered condition with adequate lighting to provide for safe and efficient working conditions. Office space at the HCF is adequate and provides the necessary equipment for all maintenance documentation and site communications. All tools and equipment used by HCF personnel, including special tools, test equipment, hoists, and ladders, are located in areas either adjacent to work areas, in the machine shop, or in designated service areas to provide for ease of access.

10.5.4 Maintenance Procedures

The HCF Supervisor is responsible for identifying the need for and developing maintenance procedures. However, many maintenance activities at the HCF fall within the scope of skills and knowledge possessed by qualified personnel, and do not require formalized written procedures. For these activities, checklists, maintenance service requests, and work packages can be used. The MIP invokes the TA-V Conduct of Operations Manual (SNL 1998b) with respect to the development and preparation of formal maintenance procedures as well as their verification and validation, approval, use, control, periodic review, and revision.

10.5.5 Control of Maintenance Activities

Maintenance activities at the HCF are conducted in accordance with either a work control instruction, for maintenance performed by HCF personnel, or the SNL/NM Site Maintenance Plan, for maintenance performed by FOE personnel. These documents govern the preparation of maintenance work packages. In addition, the MIP addresses supervision of maintenance activities, review of completed work requests, temporary repairs, and control of contract personnel.

10.5.6 Post-maintenance Testing

Post-maintenance testing is required for all safety-related items prior to returning them to service after completion of maintenance. For maintenance performed by HCF personnel, the HCF Supervisor is responsible for determining the required scope of post-maintenance testing and for developing a guidance procedure to conduct such testing following maintenance activities. The Site Maintenance Plan describes the applicability and control of post-maintenance testing activities for maintenance performed by FOE personnel. Post-maintenance testing requirements for both safety-related and nonsafety-related SSCs are to be specified in the maintenance work package instructions. Determination of the specific test(s) to be conducted is based upon the need to verify that an item will fulfill its design function when returned to service and upon the importance of the item to HCF safety. The MIP addresses these items as well as control, documentation, and acceptance of post-maintenance testing.

10.5.7 Control and Calibration of Measuring and Test Equipment

The ventilation system differential pressure instrumentation is the only HCF safety-significant instrumentation requiring calibration. Control and calibration of Measuring and Test Equipment (M&TE) used to calibrate the differential pressure instruments is addressed in the MIP. Calibration of M&TE is performed in accordance with procedure CPR100.3.1(SNL **DATE**), which specifies traceability to the National Institute of Standards and Technology (NIST) or to the standard of record for the M&TE. CPR100.3.1 also governs the following:

- control, notification, and evaluation method for defective or out-of-calibration M&TE;
- limited use designations for M&TE;
- issue and recall of M&TE;
- control of contractor M&TE; and
- trending of previous M&TE calibrations to update required recalibration frequencies and identify possible problems.

10.5.8 Maintenance History and Trending

The HCF Department Manager is responsible for specifying the requirements, responsibilities, and implementation plan for documenting equipment maintenance histories. Specific equipment for which maintenance histories will be required is identified in the HCF MEL. Material history data for such equipment will be used for planning, scheduling, and performing maintenance on these items and to provide information for evaluation. The Site Maintenance Plan describes how similar information is captured within the FOE work control system.

10.6 REFERENCES

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11.0 OPERATIONAL SAFETY

11.1 Introduction

This chapter provides a general description of how Hot Cell Facility (HCF) operations are performed safely. The objectives of the chapter are to demonstrate that programs are in place to ensure that:

- HCF activities are managed, organized, conducted, and controlled in a safe manner;
- Criticality safety requirements have been identified and implemented for the safe storage of special nuclear material; and
- Facility radiation protection, fire protection, and chemical risk management programs are appropriate to the hazards in the facility.

11.2 Requirements

This chapter is the basis for the Conduct of Operations program required by DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities* (DOE 1990) and the fire protection program required by DOE O 420.1, *Facility Safety* (DOE 1995).

11.3 Conduct of Operations

This section presents a summary of general organizational, procedural, and administrative information concerning operation of the HCF, including, but not limited to:

- Basic organizational structure and responsibilities;
- Operational training programs; and
- Development and use of written procedures.

11.3.1 Organization and Administration of Nuclear Facility Operations

The organizational structure and responsibilities for HCF operations are addressed in Chapter 17, Sections 17.3.2 and 17.3.3.

11.3.1.1 Safety Responsibility

Nuclear safety responsibility is set forth in the Nuclear Safety clause of the DOE Contract. It states that "Sandia Laboratories recognizes that the activities under this contract involve the risk of a nuclear incident which, while the chances of its occurrence are remote, could adversely affect the public health and safety. In the conduct of its activities hereunder, Sandia Laboratories will exercise a degree of care commensurate with the risk involved."

11.3.1.2 Management Responsibility and Authority

The chain of command both for operations and for safety of nuclear facilities is the same. The safety chain has provisions for advisory safety committees. This group is comprised of persons who are knowledgeable of both the operational and administrative requirements for hot cell operations. The chairman and the majority of the committee are not directly associated with HCF operations. The safety committees act in an advisory capacity to line management.

11.3.1.3 Hot Cell Facility Manager

The Hot Cell Facility Manager is responsible for the conduct of all HCF operations, maintenance activities, and tests and experiments in accordance with approved plans, procedures, Technical Safety Requirements (TSRs), and other approved control documents. The Department Manager has complete authority over all HCF operations and support functions that may affect them, and has responsibility to ensure they are being conducted safely. In addition, the Department Manager is responsible for ensuring that maintenance schedules, HCF operations, and a facility training program are established and maintained in accordance with applicable DOE Orders and SNL/NM implementing documents.

11.3.1.4 HCF Staff and Support Personnel

Brief descriptions of the duties and responsibilities of HCF staff and support personnel are included below.

<u>HCF Operations Facility Supervisor</u>
Job responsibilities of the HCF Operations Facility Supervisor involve the direction of radiation workers to maintain hot cell facility operability in accordance with regulatory and ES&H requirements. This includes monitoring facility performance, work planning and control, facility maintenance, operation in accordance with Technical Safety Requirements, maintenance of facility records, logs and associated documentation, and the support of production operations.

<u>HCF Operator</u>
Job responsibilities of an HCF Operator include:

- Operation of hot cell facility systems and control of all aspects of normal operation (i.e. monitoring of releases of radioactive material);
- Conduct/oversight of facility maintenance activities;
- Operational compliance with Technical Safety Requirements; and
- Maintenance of facility records, logs and associated documentation.

<u>Systems Maintenance Technician</u>
Job responsibilities of this technician include the maintenance of ventilation system components, remote manipulators and other electromechanical systems, pressure/vacuum systems, and hydraulic/pneumatic systems.

<u>Nuclear Safety Support</u>
The Nuclear Safety Support function is responsible for maintaining the HCF safety basis (including the Safety Analysis Report (SAR) and TSRs) and performing and/or directing analysis necessary to maintain the safety basis.

Facility Engineering Support
The Facility Engineering Support function is responsible for evaluating design, maintenance, and reliability problems at the HCF involving the ventilation system, manipulators, shield windows, remotely operated jigs and fixtures, and information display consoles. In the longer term, these responsibilities may also include facility structural modifications and robotically controlled chemical process routines for isotope processing.

Isotope Processing Supervisor
Job responsibilities of the Isotope Processing Supervisor include providing day to day work direction for the technicians and operators producing isotopes in the HCF. This includes the coordination of personnel work activities, completion of all required production documentation to meet Food and Drug Administration (FDA) requirements, and personnel scheduling for required coverage.

Process Operators
Job responsibilities of process operators include the remote manipulator processing, purification, and packaging of isotope product extracted from irradiated uranium bearing targets. These operations are conducted in radiological confinement boxes and involve weighing of materials, chemical dissolution of the target coating, separation of the product from the fission inventory in a processing ladder, purification and filtration of product, extraction of the QC sample, volumetric product measurement, dispensing of final product, packaging of the product into shipping containers, and leak checking of the shipping container. Radioactive material transfers between processing stations and into and out of processing stations is required.

Process Support Personnel
A number of personnel will be required to perform isotope production operations in the HCF. These personnel will require access to and will perform radiological work in the HCF. This includes movements of radioactive and process materials into and within the HCF, packaging and shipping functions, quality control functions, and waste handling operations.

Radiological Control Technician
Job responsibilities of the Radiological Control Technician (RCT) involve monitoring the radiological environment in the HCF and advising workers of radiological conditions and the status of radiological protection/protective measures.

11.3.2 HCF Operations

11.3.2.1 Process Operations

The extraction process for radioisotopes is a combined chemical/distillation process in which the noble gases and iodine are first condensed from the target fill gas. Next, the UO_2 fuel and fission products are dissolved from the inside of the target in an acidic solution and a wet chemistry process is used to selectively precipitate isotopes of interest. The precipitates are further washed, filtered, redissolved and purified. Finally, the isotope solution is prepared for shipment.

Residual process liquid resulting from target processing, containing most of the remaining fission products, is neutralized, stabilized, allowed to decay, and eventually shipped in solid form to an approved low-level waste site. Target processing takes place in accordance with approved procedures in shielded confinement boxes using fixtures to facilitate the remote handling of radioactive materials.

Quality control procedures are performed on very small samples extracted from the product liquid, that are diluted to prevent excessive dead-time within the gamma spectroscopy equipment that is used to determine the isotopic content of the product. Following QC, the isotope product is bottled and packaged for shipment in DOT containers.

Processing operations will generate the following waste streams:

Trash and Chemical Waste
Office trash, lab trash, and some chemical waste from research and development activities or from expired, contaminated, or otherwise unusable chemicals will be handled through the established waste management processes at SNL.

Low-level Radioactive Waste
HCF low-level radioactive wastes (LLW) include personal protective equipment (PPE), extraction processing wastes, and expendable or unserviceable contaminated equipment. Extraction processing involves a number of wet chemical processes and is expected to account for the majority of the low-level radioactive waste volume. LLW will be disposed of in accordance with the SNL LLW disposal permit.

Mixed Waste
Mixed wastes that may be generated as a result of HCF operations include hazardous wastes such as absorbent wipes, spent solvents, solvent rags, vacuum pumps, lubricants, etc. that become contaminated with radioactive materials. Mixed wastes will be disposed of in accordance with SNL processes that ensure compliance with the Resource Conservation and Recovery Act (RCRA).

11.3.2.2 Control of Experiments

To accommodate HCF experimental capabilities, a defined process for the preparation, review, and approval of experiments is established as an important element of facility safety. Experiment control is exercised through a system of administrative procedures that are applied to classify experiments into three broad categories (Class I, II, or III) in accordance with the RCSC charter. In addition, all experiments must be conducted in accordance with the approved Technical Safety Requirements, and potential consequences of conducting the experiment must be bounded by the safety analysis in Chapter 3 of this SAR. Proposed experiments that would exceed either of these constraints must be submitted to the SNL Nuclear Facilities Safety Committee (NFSC) and to DOE/AL for review and approval.

11.3.3 Review and Appraisal of Operations

A policy and procedures for the review and appraisal of HCF operations have been established to achieve the following goals:

- Independent review and approval of certain experiments and proposed modifications;
- Assurance that all operations, maintenance, tests, experiments, and emergencies are handled in accordance with approved procedures;
- Assurance that applicable safety criteria have been identified and established; and
- Assurance that the facility training program is in compliance with DOE Orders.

Review and appraisal of activities involving nuclear material that have criticality safety concerns are the primary responsibility of the Sandia Independent Review and Appraisal System (SIRAS). This function is addressed in more detail in Chapter 17, Section 17.3.3.3.

11.3.4 Control of Facility Operations

Administrative control over HCF operations is imposed in a manner proportional to the risk of the activity to be controlled. Tech Area V maintains a Conduct of Operations (CoO) Manual (SNL 1998c) that governs nuclear facility operations and complies with the requirements of DOE Order 5480.19 (DOE 1990). The purpose of the manual is to identify operational requirements and provide formal guidance in the implementation of those good practices by which TA-V nuclear facilities should be operated in order to achieve excellence in operations. The manual addresses each of the eighteen chapters of the DOE order and identifies the applicable procedures that implement Conduct of Operations program elements at the TA-V nuclear facilities.

11.3.4.1 Operations Organization and Administration

The requirements that define the conditions, safe boundaries, and the management of administrative controls necessary to ensure the safe operation of a nuclear facility are contained in the Technical Safety Requirements for the facility. Figure 17.3-1 is an organization chart delineating the line of authority for HCF operations. Position descriptions defining the duties and responsibilities of each management and supervisory position are maintained and are readily available.

11.3.4.2 Operating Practices

It is the responsibility of all operations staff personnel to safely operate nuclear facilities through adherence to operating procedures, technical safety requirements, and specifications, safety regulations, and approved operating practices. Facility supervisors oversee and coordinate all routine and planned activities and assignments at their facilities, and are responsible for the day-to-day operations. Only trained and qualified personnel or trainees under supervision are allowed to operate facility equipment. Facility operations and maintenance are performed in accordance with applicable procedures. Facility operators periodically monitor equipment to ensure that it is operating properly and take appropriate action to correct or report deficiencies noted during inspections. Facility supervisors authorize any planned facility status changes and any work that affects safety or control panel indications and alarms in accordance with TA-V change control processes. All personnel adhere to the requirements of the SNL ES&H Manual (SNL 1998f), its supplemental safety programs, and the applicable ES&H SOPs and operations procedures in their facilities. Any operation that is in violation of a safety requirement is to be stopped and reported immediately to the Facility Supervisor or the Department Manager.

Accident response for HCF activities is addressed in the TA-V Emergency Plan. In the event of an accident, all personnel evacuate to the Emergency Assembly Point, the Emergency Control Room, or the Emergency Response Team assembly area, depending on their assignments.

11.3.4.3 "At the Controls" Area Activities

The HCF includes an operations center and numerous process stations associated with isotope processing activities. While major HCF systems are controlled from the operations center, process station operators control local process parameters. The principles of an "at the controls area" as embodied in the Conduct of Operations Manual apply to both the operations center and the individual process stations. These include personnel access control, data monitoring, and minimization of ancillary duties and distractions.

11.3.4.4 Communications

Department managers are responsible for ensuring that requirements for effective communications are implemented. Facility supervisors are responsible for ensuring that facility communications are conducted in a professional manner and that a periodic test is conducted to verify that all facility personnel can be notified of emergencies. Operations personnel are responsible for conducting verbal communications in accordance with CoO Manual guidelines and for reporting defective communication equipment to the proper SNL organization for repair or replacement (SNL 1998c).

An intercom system and telephones in Rooms 104, 106, 107, 111, and 112 accommodate communications within the Hot Cell Facility. The TA-V emergency evacuation system provides immediate notification to all personnel in TA-V to evacuate in the event of a fire, radiological emergency, security problem, or other site-wide problem. The TA-V alarm may be initiated from building exits throughout TA-V. An area-wide public-address system, portable radios, and pagers supplement telephone communication and FAX capabilities to line management, SNL Incident Commander, DOE, and key ES&H staff.

11.3.4.5 Training Program

The main objective of the TA-V training program is to provide existing and potential supervisors and operators with the knowledge, skills, and abilities to operate the nuclear facilities and their associated systems. The On-the-Job-Training program is conducted so that the trainee satisfactorily completes all of the required training objectives and receives the maximum learning benefit from the experience while operations continue to be conducted in a safe manner. HCF training program details are documented in Chapter 12.

11.3.4.6 Investigation of Abnormal Events/Occurrences

Investigation of abnormal events/occurrences is accomplished by means of a thorough review process that is documented in Chapter 18 of the SNL ES&H Manual. This formal process ensures that all significant aspects of an abnormal event are identified, investigated, and resolved. The process identifies those types of events that require investigation, assigns responsibility for conducting the investigation, lists necessary qualifications for those conducting investigations, lists the necessary information that should be examined, outlines the steps for performing an investigation, and establishes guidelines for assigning and completing corrective actions.

Department managers are responsible for ensuring that abnormal events/occurrences are investigated according to the guidelines in the ES&H Manual Supplement, *Performing Root Cause Analysis and Developing Corrective Actions* (SNL 1997a). Facility supervisors are responsible for defining the investigation, identifying corrective actions, and preparing an investigation report. Operations personnel are responsible for promptly notifying management of events and conditions that could have adverse safety, health, quality, security, operational, or environmental implications.

11.3.4.7 Notifications/Occurrence Reporting

Chapter 18 of the SNL ES&H Manual provides the requirements, instructions, and procedures for reporting, investigating, and correcting ES&H-related events such as emergency and non-emergency events, injuries and illnesses, releases or spills of hazardous materials, damage to property, vehicle accidents, and contamination of work areas (SNL 1998f). Department managers are responsible for ensuring that all occurrences are reported in accordance with the procedures set forth in Chapter 18 of the ES&H Manual. Facility supervisors are responsible for ensuring that personnel are trained in notification procedures, notifying the department manager of all occurrences, and ensuring that notifications are documented and records maintained. Operations personnel are responsible for reporting all occurrences to facility management.

11.3.4.8 Control of Equipment and System Status

SNL organizational responsibility for maintenance of HCF systems and equipment is addressed in a TA-V Internal Lease Agreement (ILA). In accordance with this document, the SNL Corporate Landlord is responsible for the maintenance of real property, which encompasses buildings, fences, roads, landscaping, common-use equipment, and utility systems such as water, sewer, electrical, heating, natural gas, steam, and ventilation. The HCF Department is then responsible for programmatic property that directly supports specific programs and other HCF functions. Programmatic property includes

- Program-specific, experimental, or operational equipment extending to building utility supply connections (e.g., pumps, fumehoods, etc.);
- HCF operational process equipment (e.g., the nitrogen fire suppression system); and
- Occupancy-specific protection systems (e.g., radiation monitoring, personnel access control, etc.)

Specific identification of real and programmatic equipment in the HCF is accomplished by the HCF Master Equipment List (MEL). The MEL also identifies equipment that is the responsibility of the HCF Department, but for which maintenance is performed by the Corporate Landlord in accordance with the ILA.

Facility configuration is controlled in accordance with the Conduct of Operations Manual by means of an Equipment Status List (ESL). The ESL also identifies all maintenance or corrective actions that cannot be completed due to lack of replacement parts, scheduling conflicts, or other extenuating circumstances. Inspection checklists and the operations narrative log play a major role in maintaining awareness of the status or operability of equipment.

The Department Manager is responsible for maintaining control of facility equipment and system status by means of the following activities:

- Identifying those systems and components which are important to safe facility operation;
- Ensuring that a system is in place to control temporary facility modifications;
- Ensuring that a system is in place to provide operators with the latest revisions to documents for operating equipment and systems;
- Providing review and approval to perform facility modifications; and
- Providing review and approval signifying satisfactory completion of a modification.

Facility supervisors are responsible for daily operations involving major equipment and safety-related systems, including the following:

- Maintaining proper facility configuration by authorizing changes to equipment and system status;
- Ensuring the proper alignment of equipment and systems prior to placing them in service;
- Signing and approving completed alignment checklists;
- Implementing an administrative system to document compliance with operational limits;
- Implementing a system to document equipment deficiencies;
- Authorizing activities that change the status of systems or equipment important to safety, or that affect control indications or alarms;
- Verifying that operational testing is performed following maintenance on equipment and systems important to safety to ensure that they are capable of performing their intended function;
- Ensuring that facility systems have been placed in a safe condition prior to allowing work on a modification; and
- Verifying that work on a modification will not remove equipment from service if TSR or ES&H compliance requires the proper operation of that equipment.

Operations personnel are responsible for providing timely status of equipment and facility configuration changes to the Facility Supervisor. Compliance with equipment/system operational limits is ensured by means of SOPs (SNL 1998d, Chapter 21 of SNL 1998f). All equipment/system modifications are controlled by means of the Facility Modification Request (FMR) process and the Maintenance Implementation Plan (SNL 1997c).

11.3.4.9 Lockout/Tagout

The SNL ES&H Manual Supplement, *Lockout/Tagout Procedure for the Control of Hazardous Energy*, (SNL 1998b) prescribes lockout/tagout (LOTO) procedures during maintenance, repair, adjustments, and installation of hydraulic, pneumatic, thermal, chemical, mechanical, or electrical equipment or of systems that, if unexpectedly energized, could harm people or property. The supplement contains the following:

- Basic LOTO procedures;
- Guidance on developing and reviewing LOTO-related operations procedures;
- LOTO training requirements;
- Instructions for ordering locks, decals, and tags;
- LOTO inspection requirements; and
- Program record requirements.

Department managers are responsible for ensuring that operations personnel have completed the appropriate LOTO training, SOPs or other operations procedures properly address LOTO when necessary, and LOTO inspections are conducted periodically. Facility supervisors are responsible for ensuring that new, modified, or retrofitted equipment or systems, which have hazardous energy sources, are capable of being locked out, implementing a LOTO record system and ensuring that records are kept, and supervising the removal of locks and tags when an employee who had previously applied a lockout or tagout is absent. Operations personnel are responsible for following LOTO procedures in accordance with the ES&H Manual supplement and the Conduct of Operations Manual (SNL 1998b, SNL 1998c).

11.3.4.10 Independent Verification

The independent verification process provides a high degree of reliability in ensuring the correct operational status of equipment. The requirement to have individuals sign (or initial) for an action is intended to focus their attention and gain their personal assurance that there is accuracy and accountability in what has been done.

Department managers are responsible for identifying equipment critical to safe, reliable operation of the facility and their associated independent verification requirements, identifying occasions in operations when independent verification is required, and ensuring that all appropriate personnel are thoroughly familiar with independent verification practices and requirements. Facility supervisors are responsible for implementing the independent verification program in the facility, training facility personnel on independent verification requirements and techniques, ensuring only qualified personnel perform independent verifications, and determining the appropriate corrective actions to be taken when discrepancies are discovered.

Personnel performing independent verifications are responsible for identification of equipment whose status is to be verified, determination of both the required equipment status and the actual status, and reporting of identified discrepancies to the Facility Supervisor. Operations personnel are responsible for recommending independent verification when questions exist regarding the status of equipment.

11.3.4.11 Log Keeping

Various records, including a narrative log, equipment status log, maintenance log, periodic surveillance log, and a lockout/tagout log are used to establish formality in operating practices and provide individual accountability for decisions and actions. The narrative log is used to document any item of an operational nature including:

- The occurrence of any significant event affecting facility status (e.g., shutdown, off-normal occurrences, unusual occurrences, emergencies);
- The occurrence of security incidents;
- Potential ES&H threats or near misses;
- Significant operational or maintenance evolutions;
- Initiation and completion of surveillance tests;
- Abnormal facility configurations;
- Status changes to safety-related and other major facility equipment; and

- Out-of-specification conditions.

Department managers are responsible for conducting a biweekly review of facility logs to monitor the accuracy and completeness of log keeping and to look for facility trending information. Facility supervisors are also responsible for conducting biweekly reviews of logs and, in addition, are responsible for training facility personnel on the requirements for keeping logs. Operations personnel are responsible for recording operating experiences and noteworthy items as directed by facility procedures, reviewing logs to keep up to date on current activities and equipment status, and bringing events which are potentially reportable to the attention of operations line management. Narrative logs are retained for the life of the facility. Other completed logs and records are maintained as shown in Table 17.4-1.

11.3.4.12 Operations Turnover

The CoO Manual provides guidance to ensure that each operator is provided the knowledge required to adequately accomplish his or her responsibilities following a shift turnover (SNL 1998c).

Department managers are responsible for determining the need for the development of turnover checklists to aid in the turnover process. Facility supervisors are responsible for periodically monitoring turnovers to assure formality and completeness and for conducting operations personnel briefings, as necessary.

Off going operations personnel are responsible for:

- Preparing for their shift relief by having round sheets, status lists, and logs complete, as appropriate, and ready for review;
- Discussing and explaining any important items which affect facility operations and safety with oncoming personnel; and
- <u>Not</u> transferring responsibility unless satisfied that the oncoming operator understands the current status of workstation equipment and systems and is physically and mentally capable of assuming responsibility for their shift position.

Oncoming operations personnel are responsible for reviewing logs and records as specified by facility management and verifying important operating parameters, especially those pertaining to safety systems, prior to assuming responsibility for their shift position.

Operations personnel and facility supervisors are responsible for reviewing the following items prior to assuming their duties:

- The required reading index sheet;
- The narrative log for operations conducted that day;
- The configuration of facility equipment; and
- The facility tagout log.

11.3.4.13 Facility Chemistry and Unique Processes

The CoO Manual (SNL 1998c) provides guidance for controlling the effects that "unique processes" may have on isotope production and other HCF operations and for ensuring that adverse impacts are avoided. Unique processes are separate activities or operations that are not directly controlled by HCF personnel, but which can affect, or be affected by, facility operations. Examples of unique processes are special maintenance activities and hazardous waste pick-ups. HCF personnel monitor such processes to verify that system operations are in conformance with design expectations and that problems are identified before safety or quality are adversely affected.

The HCF Department Manager is responsible for ensuring that specific duties with respect to facility unique processes are covered by approved procedures and facility personnel are trained and knowledgeable about such unique processes and process interactions. Facility supervisors are responsible for defining each individual's specific responsibilities with respect to process control and ensuring that personnel are able to provide timely corrective action for process-related problems. Operations personnel are responsible for monitoring applicable unique processes to anticipate problems, non-compliance conditions, or other adverse conditions, and initiating appropriate corrective actions, consulting with process support personnel and coordinating activities, and identifying the status of unique processes as part of operations turnovers.

11.3.4.14 Required Reading Program

TA-V nuclear facilities are required to maintain a required reading file containing the following types of documents:

- Operations procedures (and changes thereto);
- Operation plans (and changes thereto);
- Directives addressing facility requirements;
- Notices of facility performance data (and changes thereto) required for safety or to meet performance requirements;
- Facility configuration changes, equipment changes or modifications to the facility;
- Related industry and in-house operating experiences information, including Safety Notices published by the Office of Nuclear Safety; and
- Other information necessary to keep operations personnel aware of current facility activities and status.

A required reading index is used to make and categorize required reading assignments, to establish time requirements for their completion, and to document completion of required reading assignments.

Department managers are responsible for determining what type of information will be designated as required reading, making required reading assignments and categorizing their urgency as immediate or otherwise, and periodically reviewing facility required reading files to ensure that the required reading has been completed within the required time. Facility supervisors are responsible for implementing the required reading program, and verifying that facility personnel have completed their assigned reading. Operations personnel are responsible for reading and signing off required reading material by the assigned completion date, and requesting clarification from their facility supervisor or department manager when they do not understand something in a required reading document.

11.3.4.15 Timely Instructions to Operators

Timely Instructions are issued whenever it is necessary to rapidly communicate information related to the conduct of facility business. They may be used in the daily work environment to provide direction or information to personnel in the absence of management. Examples of information that could be included in Timely Instructions are:

- Notifications of work priorities;
- Special operations;
- Nonroutine tests;
- Data collection requirements;
- Upcoming events and audits;
- Announcements of administrative items, policies, procedure changes, or specific activities; or
- Notice of documents requiring immediate reading in the required reading notebook.

Department managers are responsible for issuing Timely Instructions to operations personnel and periodically reviewing each facility's Timely Instructions file. Facility supervisors are responsible for periodically reviewing their facility's Timely Instructions file to ensure that the appropriate personnel have signed off on assigned instructions and for removing outdated instructions from the file. Operations personnel are responsible for promptly reading and signing off the instructions issued to them and for requesting clarification from their facility supervisor or department manager when they do not understand something in an instruction.

11.3.4.16 Operations Procedures

Operations procedures are a key factor affecting operator performance and are used to ensure that facilities and equipment are operated within their design limits, and that hazardous activities are performed safely. Standard Operating Procedures (SOPs), Safe Work Permits (SWPs), or Operating Procedures (OPs) are used to control hazards identified in Primary Hazard Screens (PHS). ES&H SOPs or SWPs are normally required for the particular hazards listed in *Developing and Implementing ES&H SOPs and SWPs* (SNL 1998d, Chapter 21 of SNL 1998f). TA-V SOPs are required by a TA-V facility's Technical Safety Requirements to address specific topics (e.g., maintenance, startup, operation, and shutdown). OPs are developed for those anticipated operations, tests, and abnormal or emergency situations that are not already adequately covered by other guidelines, such as operating or ES&H manuals. OPs contain specific instructions and operating steps that may not be detailed in a SOP on the subject. OPs do not introduce new hazards and do not require safety committee review, except at the discretion of the Department Manager.

Department managers are responsible for 1) implementing procedures for writing, formatting, reviewing, approving, and revising operations procedures, 2) ensuring that operations procedures incorporate all applicable standards, design criteria, operational limits, and ES&H and customer requirements, and 3) approving and periodically reviewing SOPs and Department Level Administrative Procedures. Facility supervisors are responsible for training operators in the use of appropriate operations procedures, periodically reviewing OPs, and ensuring that the latest versions of applicable operations procedures are maintained in a central location readily available to the operations staff. Operations personnel are responsible for performing their work using only approved operations procedures and suspending an activity and notifying their facility supervisor if procedural errors are encountered.

11.3.4.17 Operator Aids

Facility operator aids provide information useful to operators in performing their duties. Examples of operator aids are excerpts from technical manuals, procedures, system drawings, information tags, curves, graphs, or other documents that are properly controlled to ensure that they are current, complete, and necessary. In accordance with the Conduct of Operations Manual, the HCF Department Manager is responsible for ensuring that written guidelines exist for the control of operator aids (SNL 1998c).

Facility supervisors are responsible for the following:

- Authorizing the posting and removal of operator aids in their facilities;
- Periodically reviewing the posted operator aids to ensure that they are still correct and necessary;
- Maintaining a listing of facility operator aids not governed by separate instructions; and
- Approving each operator aid prior to posting.

Operations personnel are responsible for:

- Following approved guidelines for developing operator aids;
- Submitting proposed operator aids to their facility supervisor for inclusion in the program;
- Using only current and approved operator aids in the performance of their duties; and
- Reporting any incorrect operator aids observed to their facility supervisor for resolution.

11.3.4.18 Facility and Equipment Labeling

Equipment labeling helps ensure that facility personnel are able to positively identify the equipment they operate, thus enhancing training effectiveness and reducing operations and maintenance errors resulting from incorrect identification of equipment. Guidelines for equipment labeling are contained in the TA-V Conduct of Operations Manual (SNL 1998c). Facility supervisors are responsible for ensuring that 1) facility equipment, piping, and spaces are properly labeled in accordance with the labeling program, 2) labels are properly placed and oriented to enhance readability and equipment identification, and 3) missing, damaged, or incorrect labels are promptly replaced. Operations personnel are responsible for identifying missing, damaged, or incorrect labels to their facility supervisor.

11.4 Fire Protection

This section addresses the SNL fire protection program. Sandia's Environment, Safety, and Health (ES&H) Policy is the underlying foundation for the program (SNL 1997b). A fire hazard analysis together with Chapter 5 of the SNL/NM ES&H Manual and the Sandia National Laboratories Integrated Safety Management System provide the bases for implementation of the fire protection program (SNL1998e).

11.4.1 Fire Hazards

The HCF is located within building 6580, which is part of the building complex comprised of buildings 6580, 6581 and 6588. Building 6580 is segmented into zones based on the potential for radiological contamination and for Heating, Ventilation and Air Conditioning (HVAC) purposes. However, the zones are not separated by rated firewalls or enclosures, but are separated by significant construction features. Therefore, since the zones coincide with the Uniform Building Code occupancy classifications, the zone classification provides logical boundaries for addressing the fire hazards within the HCF.

Zone 1 consists of the Steel Confinement Boxes (SCBs) located within Zone 2A (hot cell canyon). The SCBs are considered to be a normally contaminated area and is classified as an H7 occupancy. The SCBs are constructed of stainless steel and will contain low volumes of combustible materials and process chemicals. The combustibles primarily consist of small amounts of plastics and charcoal filter media. The plastics consist principally of syringes and bottles needed for the extraction of the isotopes. The ignition sources within the SCBs are electrical outlets and target heaters.

It is unlikely that a fire will occur in any of the SCBs. However, if a fire were to occur, it would not extend beyond the involved SCB due to the solid stainless steel construction and lack of combustibles both inside the SCBs and in Zone 2A. The worst-case, unmitigated fire in a process SCB is conservatively evaluated in Chapter 3 and would result in an off-site dose of approximately 1.8 Rem at the exclusion area boundary (3000 m).

The Zone 2A canyon is considered to be a potentially contaminated area and is classified as an H7 Occupancy. The canyon will be used for short-term storage of drums containing highly radioactive waste. The drums are made of metal and will contain a cement waste mixture. The interior of the canyon is essentially free of combustible materials. However, a major source of combustible material that has the potential of being introduced into the canyon is the mineral oil contained within the radiation shielding windows. A window leak or failure could introduce a substantial quantity of mineral oil into the canyon. Potential fire ignition sources in the canyon include electrical outlets, lighting fixtures, and electric motors for the SCB conveyor system, the bridge crane, and a battery operated cart. Mineral oil is normally difficult to burn unless its bulk temperature is raised to the combustion temperature by sustained heating. If this were to occur, the resultant pool fire could challenge other windows, causing them to fail and intensifying the fire. However, it is highly unlikely that oil collected on the floor of the canyon could be ignited by any of the existing ignition sources.

An analysis of hydrogen generation by radioactive waste and the fire hazard it presents was also performed and described in Chapter 3. This analysis concluded that the highest concentration of hydrogen will be well below the lower explosive limit (LEL) for hydrogen and will not pose a significant fire hazard for the facility. In addition, since none of the at-risk waste inventory is in a form that is available for release, there are no potential off-site radiological consequences for a hydrogen fire scenario.

Zone 2 is the area surrounding the Zone 2A canyon. This area is normally non-contaminated and is an F1 Occupancy. (Note, however, that gloveboxes within Zone 2 are used for quality control and packaging activities.) Zone 2 activities consist of HCF operations, shipping, quality control, equipment maintenance and handling of target casks. Zone 2 contains ordinary combustibles. The overall volume of combustible materials is low and there are no special hazards located within Zone 2.

Zone 3 is the portion of Building 6580 not directly involved in Hot Cell Facility activities. This portion consists primarily of office space and is classified as B occupancy. This area does not contain any special hazards. Most of the combustibles present in this area are ordinary (i.e., office furniture, papers, etc.). Several potential ignition sources and ongoing activities exist in this area. However, a fire in this area will not significantly challenge nuclear materials within the hot cell canyon.

11.4.2 Fire Protection Program and Organization

Sandia National Laboratories/New Mexico must meet the requirements of all applicable DOE orders and design criteria. In addition to the DOE guidance, the fire protection program uses nationally recognized codes, standards and industry practices to achieve the requisite level of fire protection and life safety.

The fire protection program organization is outlined in the Corporate Fire Protection Program document. The objectives of the fire protection program and organization are the following:

- Minimize the potential for the occurrence of a fire.
- Ensure that fire does not cause an on-site or off-site release of radiological and other hazardous material that will threaten the public health and safety or the environment.
- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel and ensures that there are no undue hazards to the public from fire and its effects in DOE facilities.
- Ensure that process control and safety systems are not damaged by fire or related perils.
- Ensure that vital DOE programs will not suffer unacceptable delays as a result of fire and its effects.
- Ensure that property damage from fire and related perils does not exceed an acceptable level.

11.4.3 Combustible Loading Control

Guidance for controlling combustible materials is provided in Chapter 5 of the SNL ES&H Manual. Materials used in construction must meet criteria established to limit the combustibility, flame spread and smoke generation potential of the materials. Minimization of combustible materials is also achieved by good housekeeping practices to reduce unnecessary items and lower the overall fire load. Periodic assessments, which work in conjunction with housekeeping, are conducted to identify any materials or hazards that need to be removed.

11.4.4 Fire Fighting Capabilities

Zones 2 and 3 of the HCF are protected by an automatic wet-pipe sprinkler system. The sprinkler system is designed for Ordinary Hazard Group 2 occupancy. Therefore, this system will be able to accommodate any unforeseen increases in "ordinary" combustible loading. The HCF is below grade and will contain any firefighting water used. It is also equipped with heat detectors supervised by SNL Proprietary Alarm Service, which provides redundant fire protection when coupled with fire department response.

The 1-hour separation required between the different occupancy classifications of Zone 2 and the Zone 2A canyon cannot be achieved due to unsealed and non-rated penetrations in the hot cell canyon walls. Although the potential of a fire occurring in the Zone 2A canyon is very small, a manual foam suppression system has been provided for fires in the canyon to provide defense in depth. The pre-piped nozzles allow the application of a fixed amount of foam into the hot cell canyon from Zone 2, without exposing operators or emergency responders to high radiation levels, if a fire were to occur.

Portable fire extinguishers are located throughout the HCF. Their location, size and type are adequate for the hazards contained within the building.

Response to a fire in the HCF would consist of the Tech Area V Emergency Response Team, the Incident Commander, the Kirtland Air Force Base (KAFB) Fire Department and additional organizations as needed (i.e., security, hazardous materials team, etc.). The KAFB Fire Department provides a full range of fire and rescue services operating out of four continuously staffed stations. KAFB firefighters are trained to Air Force firefighting qualifications that meet or exceed state of New Mexico firefighter qualifications.

First response to Tech Area V is from fire station #3, which is located approximately 3 miles to the east in the Manzano foothills. Additional fire companies respond as needed from station #1, located at Wyoming and F street, and station #2, located on the north side of the KAFB/Albuquerque International Sunport runway. Should additional personnel or equipment be required, the KAFB Fire Department has mutual aid agreements with local fire departments and emergency response agencies.

11.4.5 Fire Fighting Readiness Assurance

In order to maintain a level of assurance from a fire and life safety standpoint that the facility protection is adequate, periodic inspections and assessments are conducted. Guidance governing the performance of fire prevention inspections can be found in Corporate Fire Protection Procedure FPP G-01.1, General Fire Prevention Inspections. Fire Protection Assessments (FPAs) that meet the objective of DOE O 420.1 are performed to evaluate building construction, building systems, occupancy, fire hazards and fire protection features. These assessments identify changes in occupancy, deficiencies in fire protection systems, increased building fire hazards and other relevant life safety issues. Findings and recommended corrective actions resulting from periodic inspections and assessments are tracked by Fire Protection Engineering using existing Facilities databases.

To aid in firefighting operations, the KAFB Fire Department maintains pre-plans for the Hot Cell Facility. The fire pre-plans serve as a "quick-reference" to assist arriving fire companies in developing strategies. The pre-plans identify building features such as the location of exits, fire systems, mechanical systems, special hazards and general floor plans. The fire department updates the pre-plans after performing building "walk-thru" inspections or if facility changes are made. Fire Protection Engineering maintains records of all inspections and assessments conducted. Fire Protection Maintenance maintains records of alarm and sprinkler system testing.

Fire protection training for members of the TA-V emergency response organization is conducted within the context of the TA-V Emergency Preparedness Plan (SNL 1998a) for the purpose of maintaining a highly acceptable level of emergency preparedness proficiency. Emergency response for the HCF as part of the Emergency Preparedness Program is addressed in Chapter 15.

11.5 REFERENCES

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CONTENTS

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12.0 PROCEDURES AND TRAINING

12.1 Introduction

12.1.1 Purpose

This chapter describes the Hot Cell Facilities (HCF) technical procedures and personnel training processes. It describes the development of training and procedures for the conduct of normal, abnormal, and emergency operations. Procedure development, maintenance, review, and approval is performed through the lab wide Environmental Safety and Health (ES&H) Standard Operating Procedure (SOP) program and Technical Area V (TA-V) Conduct of Operations. Training of personnel is implemented at the HCF through a formalized training program as identified in the Training Implementation Matrix (SNL 1997).

12.1.2 Definitions

ES&H Standard Operating Procedures (ES&H SOP): Operation procedure used to help plan the conduct of hazardous activities by describing the activity, the associated hazards, and the mitigation of those hazards.

On-The-Job Training (OJT): Practical and operational hands-on training provided in the facility environment designed to give operating experience. This type of training progresses in responsibility and complexity as the trainee advances through the program.

Operating Procedure (OP): A procedure that provides step-by-step requirements for specific facility operations or activities to ensure that they are performed correctly, safely, and consistently.

TA-V Standard Operating Procedure (TA-V SOP): Operations procedure which implement the Technical Safety Requirements (TSR), to address specific topics (e.g. isotope processing, maintenance, normal operations), or required by the SNL ES&H manual to address special hazard categories. TA-V SOPs are reviewed by the appropriate HCF safety committee and are approved by line management prior to implementation.

Training Implementation Matrix (TIM): A document describing implementation of the training program for reactor and nuclear facilities in TA-V. The document implements compliance with DOE Order 5480.20A (DOE 1994) for nonreactor nuclear facilities.

Organization 6400 Administrative Procedures (6400 ADPROs) - The policies, programs, and practices concerning both administrative and other activities in the Center for Nuclear Energy Technologies. For example, this Conduct of Operations (CoO) Manual is the 6400 ADPRO that establishes the CoO procedures to be used by all the Center's nuclear facilities.

Department-Level 64xx Administrative Procedures (64xx ADPROs) - define the communication and coordination activities necessary to carry out a facility's technical and management control programs. These procedures describe the processes to be followed to ensure that all of the various programs' functions are effectively integrated and that the programs' requirements are applied appropriately throughout a facility. ADPROs are approved by department managers.

12.2 Requirements

DOE Order 5480.20A, Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities, (DOE 1994).

DOE Order 5480.19, Conduct of Operations (DOE 1990).

12.3 Procedures

Procedures at the HCF include ES&H SOPs, TA-V SOPs, and OPs. Preparation, approval, and use of procedures are described in the TA-V Nuclear Facilities Conduct of Operations (COO) Manual (SNL 1998a). The procedure program at the HCF documents procedure development, training, and implementation.

12.3.1 Development of Procedures

HCF procedure development maintains consistency by following the TA-V Nuclear Facilities Conduct of Operations Manual (SNL 1998a) and the SNL ES&H Manual (SNL 1998b). These documents describe procedure format and content, including: Purpose, Scope, Ownership, Responsibilities, Definitions and Acronyms, Hazard Identification, Equipment and Materials, Format, Review and Approval Authority, and Document Control. Use of this format complies with DOE Order 5480.19, Conduct of Operations, Chapter 16 (DOE 1990). TA-V Standard Operating Procedures are written for tasks specifically identified in the Technical Safety Requirements (TSR) or as required by other directives or the SNL ES&H manual to address special hazards. TA-V document types and hierarchy is described in TA-V Nuclear Facilities Conduct of Operations Manual (SNL 1998a) Chapter 16.

Operations procedures shall be developed for those anticipated operations, tests, and abnormal or emergency situations that are not already adequately covered by other guidelines, such as operating or ES&H manuals. The level of detail in a procedure shall depend on the intent of the procedure, the complexity of the task, the significance of the consequences of error, the frequency of performance, and the skill level and experience of the user(s). Before operations procedures can be approved, they receive an informal review by all the facility's operators (and supervisors). Unresolved issues are directed to the facility supervisor or department manager as appropriate. The author recommends approval of the operations procedure after validating it using simulations or other methods.

TA-V SOPs require safety committee review. The author shall ensure that they are presented to the appropriate safety review committee (e.g., Radiation and Criticality Safety Committee). The department manager may informally review a TA-V SOP before it is presented for safety committee review. Department managers approve TA-V SOPs based on the recommendation of the safety review committee; they also approve OPs and ADPROs. In addition, approval authority for some lower order, facility-specific OPs may be delegated to a facility supervisor.

The content and format for HCF procedures is specified in the TA-V Conduct of Operations Manual and in the SNL ES&H Manual Chapter 21. Introduction, procedure steps, prerequisites, warning notes, cautions, limits, and tolerances are to be included as applicable. Component or system shutdown and restoration requirements following activities are specified and controlled by procedures. Several factors are taken into account for procedure development, including complexity of the task, frequency of the task, training of the user, and consequence of failure to complete the task correctly. Procedures are normally written so that there is only one action per step. Special requirements and operational limits shall be easily discernible.

12.3.2 Maintenance of Procedures

HCF procedure revisions may be initiated by operations or production personnel, supervisors, and management and are reviewed and approved in accordance with TA-V Nuclear Facilities Conduct of Operations (SNL 1998a) manual Chapter 16.

Based on the TA-V Conduct of Operations Manual (SNL 1998a), the title page shall include a statement indicating that the procedure is a controlled document, and controlled copies shall be numbered sequentially. HCF operators and technicians use controlled procedures that are marked as "Controlled Copy #_____." Copies for information purposes are marked "FOR INFORMATION ONLY" and are not numbered or used in place of controlled copies. A controlled copy of the procedure shall be available for use by HCF personnel.

All employees authorized to operate under the provisions of the operations procedure shall be trained before performing any operations covered. Unless otherwise specified, training shall be satisfied by the provisions of the TA-V Conduct of Operations required reading program. Only employees meeting the job qualifications and specific training requirements are authorized to use the procedure.

12.4 Training

Training is performed within SNL through three primary methods including Corporate Training, Facility Specific Training (DOE Order 5480.20A), and Quality Assurance Training. Corporate training includes professional development training and ES&H training. A facility specific training program for all personnel performing work in the HCF is established to ensure personnel are qualified to perform the necessary tasks to meet the mission requirements of the facility. Training is provided in areas of health and safety, HCF systems and ancillary systems, normal and abnormal operating requirements, and production related tasks. Training consists of on-the-job facility-specific training, classroom lecture, and self study. The HCF operating staff is primarily responsible for facility-specific OJT. Formal training in areas such as basic nuclear theory and radiation safety is provided by subject matter experts. The training program consists of administrative procedures which clearly define responsibilities and process for the selection, training, and certification or qualification of facility staff.

The objectives of the training program are summarized as follows:

- To ensure that personnel working in the HCF are properly trained for assignments.
- To ensure that personnel are certified in accordance with DOE Order 5480.20A.
- To provide a coordinated method for dissemination of information pertinent to the operation of the HCF.
- To ensure an auditable system of training records is maintained.

12.4.1 Development of Training Programs

All personnel at the Hot Cell receive facility-specific training on TA-V hazards, alarms, and responses. The HCF operations personnel training progress is tracked using a General Facility Training Checklist. The candidate is evaluated in TA-V layout, emergency procedures, health physics requirements, industrial safety, site-specific hazards, precautions, radiation-monitoring instrumentation, TA-V utilities, and any facility-specific training such as rigging or forklift equipment. Training needs that are individual specific are based upon previous education and experience. All HCF personnel are trained commensurate with the level of assigned tasks.

Training in the facility is grouped into four categories:

- Administrative responsibilities, such as procedures used and the hierarchy.
- Hot Cell Facility Design and Operation, which consists of facility system description, usage, and supporting equipment for normal operations.
- Safety and Emergency Systems, which consist of criticality, radiation, environment conditions, equipment handling, and personnel protective equipment.
- Special Qualification Factors to include isotope processing tasks as determined by the Hot Cell Facility Supervisor and Department Manager.

The training program is based on the current facility configuration and work activities. The technical content of the training materials is developed from existing facility documentation and through research by the trainer. The information relevant to a system modification, change of operations, or other change that could affect worker or workplace safety may be presented to the staff by various means. The methods of conducting this training may include required reading, classroom lecture, demonstration, tabletop drills or management discussions.

The Deputy Director, Nuclear Facility Operations is responsible for the establishment and maintenance of the TA-V nuclear facility qualification training and continuing training programs in accordance with DOE Order 5480.20A (DOE 1994). In this capacity, the Deputy Director is responsible for (1) assuring the nuclear facility operator training and qualification programs are approved, (2) approving the qualification of OJT instructors, (3) ensuring policies are available for the content, administration, and evaluation of examinations, (4) appointing members to an oral examination board, when appropriate, and (5) issuing all letters of certification and confirmation of completion of the continuing training cycles. The training program is organized and administered by a TAV Training Coordinator in the Nuclear Facilities Support Department. HCF continuing training exams are approved by the HCF Manager. Each Department manager is responsible for ensuring that operations personnel are trained in accordance with the requirements of the DOE order. Subject matter comprehension is normally verified by oral or written examination.

ES&H Training topics offered by the SNL/NM are detailed in the ES&H Training Catalog. The catalog helps the manager determine which courses are required, non-required best practices, or non-applicable. Additionally, the catalog lists a general description of each offered course, and any prerequisites for that course. An ES&H coordinator normally assists the manager in determining course needs. The record of ES&H courses completed by each individual is maintained in a central database and is accessible by the Department Manager.

HCF training courses may include instructors from the HCF or from outside the HCF department. Typically, the course development is either HCF-specific training or ES&H related. Courses instructed by HCF personnel exempt the instructor from the exam for the material presented.

A job task analysis is accomplished as the basis for the training content and requirements. As stated in the TIM, OJT is "job intensive," which means that the training emphasizes systems, equipment, maintenance, and operation of the HCF and its support systems. The following are typical of HCF OJT subjects:

- Procedure review and hands-on training on the ancillary equipment and systems.
- Operation and use of the master-slave manipulators.
- Pre-experiment briefings by project leaders and dry runs of experiments.
- Record keeping.
- SNM accountability requirements.
- Normal and Emergency procedures.
- Operation and maintenance of new equipment.
- Isotope Processing tasks performed in the HCF or HCF support areas.

The OJT provides hands-on experience; however, HCF personnel do not perform tasks unsupervised until they are certified or qualified to perform a specific operation unsupervised.

12.4.2 Maintenance of Training Programs

The training program requires that training be reviewed periodically by the appropriate Sandia Safety Committee. The training program allows the operational staff to critique the program in order to identify its strengths and weaknesses. This feedback is an important factor in providing effective performance-based training. This review will ensure that training programs reflect actual HCF conditions and procedures and that necessary coordination is done before introducing new training programs or introducing changes in procedures covered by training programs.

New modules are developed for facility modifications, procedural changes, and other requirements. Training on revised procedures is accomplished through the required reading, OJT, or classroom training. Lessons learned may be used to update deficiencies in the training program.

12.4.3 Modification of Training Materials

Training materials are modified if a deficiency in operations is identified. For example, a modification in the HCF processing operation would be identified and the level of training would be commensurate with the level of change in the process. Training could be accomplished as a practical factor On-the-Job-Training, trained by required reading, or it may be added to the training module. The primary method to update the HCF training modules is through periodic review of the implementing procedures by the Facility Training Coordinator. Action items from an occurrence report or assessment findings may include requirements for updating training materials and subsequent training to correct a deficiency.

12.5 REFERENCES

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CONTENTS

TABLES

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13.0 HUMAN FACTORS

13.1 Introduction

This chapter addresses the provisions for incorporating human factors engineering concepts into the design and operation of the Hot Cell Facility (HCF). It specifically identifies the human-machine interfaces necessary for the surveillance and maintenance of safety-related SSCs during normal operations, and the human-machine interfaces required for ensuring safety function performance during normal, abnormal, and emergency operations. It also addresses the results of a systematic inquiry into the design optimization of these human-machine interfaces to enhance human performance.

Human-factors safety, as used here, refers to the biomedical, psycho-social, workplace-environment, and engineering considerations pertaining to people in a human-machine system. Some of these considerations are the preparation, validation, and use of procedures to guide operations, surveillance, and maintenance; the training requirements related to human factors; and the workplace environmental conditions.

13.2 Requirements

DOE Order 5480.23, Nuclear Safety Analysis Reports (DOE 1994a), Paragraph 8b(3)(n), as amplified by Attachment 1, Paragraph 4f(3)(d)14, of the order (Topic 14) requires a systematic inquiry into or evaluation of human factors for the facility. DOE Memorandum, *Safety Analysis Report Guidance - Human Factors*, DOE/DP-625 (DOE 1992), indicates that the use of the Human Factors Safety Analysis checklist will satisfy the requirements of DOE Order 5480.23 concerning human factors for existing facilities.

DOE Order 5480.22, Technical Safety Requirements (DOE 1996), requires the development of facility operational or administrative limits for which human factors must be a significant consideration.

DOE O 232.1A, Occurrence Reporting and Processing of Operations Information (DOE 1997), establishes criteria and procedures for the reporting of unusual occurrences, including those that are the result of human error and that have programmatic significance.

DOE Order 5480.20A, Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities (DOE 1994b), establishes requirements for the selection, qualification, and training of HCF staff. The purpose of these requirements is to enhance human performance with respect to operation and maintenance of the facility.

13.3 Human Factors Process

As stated in DOE-STD-3009-94, in order to meet the human-factors safety requirements of DOE Order 5480.23, a systematic inquiry into human factors must be performed. An effective method for accomplishing this for existing facilities is through the application of the Human Factors Safety Analysis checklists found in reference DOE 1992.

These checklists require examination of:

1) a facility's historical record for operating the facility within established safety limits;
2) the adequacy of written procedures for performing normal and emergency operations;
3) the adequacy of facility operations, maintenance, and support staff qualification and training;
4) the adequacy of facility staffing;
5) the adequacy of human-machine interfaces; and
6) the adequacy of safety-related control function allocation between humans and automatic devices.

Although the HCF has been extensively modified to accommodate a change in mission, it is in fact an existing facility, which imposes some practical constraints with respect to human-machine interface optimization. It is therefore appropriate to use the checklist approach for performing a human factors evaluation of the HCF. Such an evaluation has been performed. Evaluation results for the first four checklist areas are addressed in this section, while adequacy assessments of the human-machine interfaces and control function allocation will be addressed in Sections 13.4 and 13.5, respectively.

13.3.1 HCF Operational Record

The unmitigated consequences at the exclusion area boundary for credible HCF accidents are well within the off-site Evaluation Guideline of 25 Rem. Since the HCF had no Technical Safety Requirement (TSR) related safety limits, there have been no past safety limit violations. Furthermore, there have been no significant violations of OSR-related surveillances or administrative controls in the HCF historical record.

13.3.2 Adequacy of Procedures

The processes for development and maintenance of HCF procedures are addressed in Chapter 12. Standard Operating Procedures (SOP) have been prepared for both operations and maintenance activities. These SOPs address 1) the scope of HCF systems and equipment covered by operations and maintenance procedures or other procedure-like documents; 2) organizational responsibilities for preparation and conduct of these procedures; 3) personnel qualifications for performing these activities; and 4) general conduct of operations and maintenance requirements. Individual operating procedures govern process-related systems and equipment. The conduct of TSR-required and other operational surveillances is covered by a periodic surveillance operating procedure. These procedures are adequate for operation of the facility under both normal and abnormal conditions.

Emergency procedures for TA-V facilities, including the HCF, are provided in the TA-V Emergency Preparedness Plan (SNL 1998). When the TA-V Fire/Evacuation Alarm System is activated, HCF personnel are to immediately evacuate to the Building 6582 Emergency Assembly Point. There are no emergency conditions that require HCF personnel to remain in any of the facility workspaces to perform emergency operations. As noted in the previous section, the unmitigated consequences at the exclusion area boundary for credible HCF accidents are well within the off-site Evaluation Guideline of 25 Rem. As a result, the HCF does not contain any "emergency" instruments or controls, and thus has no emergency operating procedures.

13.3.3 Adequacy of Qualification and Training

The process for developing the technical content of training materials, as well as training methods and qualification requirements are addressed in Chapter 12. As indicated above, there are no emergency conditions that require HCF personnel to remain in any of the facility workspaces to perform emergency operations. Personnel training consists of both classroom instruction and on-the-job training. Classroom instruction includes 1) understanding the facility authorization basis, 2) operation of HCF systems and equipment, 3) conduct of operational surveillances, and 4) identification of and response to abnormal conditions. On-the-job training is based on a table-top job analysis. The training and qualification program is adequate to ensure safe operation of the HCF.

13.3.4 Adequacy of Staffing

The HCF does not have the type of control room that is typical of nuclear reactor facilities. Instrumentation and controls in the HCF operations center consist primarily of the Energy Management Control System (EMCS) computer monitor and keyboard. This system is used for operating the HCF ventilation system, which is the primary HCF operating system whose performance warrants close operator attention. During processing operations, one facility operator and a facility supervisor are on duty. In addition, a radiological control technician will be available to attend to radiological matters.

Individual isotope processing workstations will generally be operated by two process operators (one operator to operate each of two workstation manipulators). A single processing supervisor will be available to oversee isotope processing activities.

Generally, the staff represented by these individuals will be supplemented by additional HCF personnel. These additional personnel will be adequate to respond to all anticipated upset conditions. There are no emergency conditions for which HCF personnel will be required to perform emergency operations. Initially, HCF operations will be limited to a single day shift. As the need presents itself, additional operations, production, and radiological control personnel will be added to support multiple shift operations.

13.4 Identification of Human-Machine Interfaces

The HCF is subject to only two types of operational "emergency" conditions for which engineering controls are provided — fire and high radiation conditions. The engineered systems that function to warn workers of fire and high radiation hazards are the fire detection and radiation monitoring systems, while the ventilation system provides a worker protection function by controlling the potential migration of highly radioactive materials in the facility. Within the HCF the TA-V Fire/Evacuation Alarm System is automatically activated only by the fire detection system. It can also be activated by manual operation of alarm system pull boxes that are located at most TA-V building exit doors. Manual operation of this system is used to annunciate both fire and radiation types of emergencies. When the system is activated, HCF personnel are to immediately evacuate to the Building 6582 Emergency Assembly Point. Because there are no emergency conditions that require HCF personnel to remain in any of the facility workspaces to perform emergency operations, the HCF does not contain any emergency instruments or controls and does not have any facility-specific emergency operating procedures.

Thus, only normal and abnormal HCF operations involve safety-related human-machine interfaces. These interfaces are summarized in Table 13.4-1. The table identifies the applicable SSCs, their safety-related functions, the associated human interfaces, and the administrative and physical interface controls intended to enhance performance on the human side of the interface.

It is evident from Table 13.4-1 that the HCF ventilation system is the safety-related SSC whose human-machine interfaces are the most numerous and also the most critical with respect to preventing uncontrolled off-site radioactive material releases. This system thus warrants close operator attention. Ventilation system fans and dampers are operated from the EMCS keyboard located in the Operations Center. The following HCF ventilation system displays and alarms are input to the EMCS display monitor:

- fan operating status and failure alarm
- SCB differential pressure display and alarm (for each of 11 SCBs)
- SCB flowrate display (for each of 11 SCBs)
- Zone 2A/Zone 2 differential pressure display and alarm
- Zone 2/Zone 3 differential pressure display and alarm
- Zone 1 and stack exhaust static pressure alarms
- Zone 2A and Zone 2 exhaust flowrate alarms
- stack HEPA filter bank differential pressure display and alarm
- Zone 1 charcoal filter bank differential pressure display
- Zone 2A charcoal filter bank differential pressure display
- glovebox exhaust HEPA filter bank differential pressure display and alarm
- fumehood exhaust HEPA filter bank differential pressure display
- Zone 2A/Zone 2 fire/smoke damper alarm
- Zone 2A exhaust static pressure display

Process operators control SCB ventilation flowrate by means of SCB exhaust valve controls located in a local control panel at each processing station. The following HCF ventilation system displays and alarms are also located in these panels:

- SCB differential pressure display and alarm (for each of 11 SCBs)
- SCB flowrate display (for each of 11 SCBs)
- Zone 2A/Zone 2 differential pressure display and alarm

These human-machine interfaces are suitable for meeting both the operational and safety needs of HCF operations personnel.

Table 13.4-1. Identification of Human Interfaces with Safety-Related SSCs

SSC	Safety Function	Human-Machine Interface	Interface Controls
Steel Confinement Boxes (SCBs) 2, 3, 4, and 5	Radioactive material confinement.	Process operators must transfer materials in and out of the SCBs by means of passthrough ports between the SCBs and the under-box-transfer system, thereby temporarily compromising Zone 1 integrity.	Administrative controls are in place to ensure that SCB passthrough ports are closed and sealed except when transferring materials in and out of SCBs.
Zone 1 (SCB) Ventilation Exhaust	Control of off-site radioactive material releases.	1. Process operators must maintain Zone 1 (SCB) confinement boundary integrity during isotope processing operations.	1. Administrative controls are in place to ensure that the process operator maintains the necessary SCB exhaust flowrate to achieve the required SCB-to-Zone 2A Δp. Exhaust flowrate and Δp indicators are provided at the local control panel for each SCB. An alarm alerts the SCB operator when the differential pressure decreases below the established alarm setpoint.
		2. Zone 1 confinement boundary integrity must not be compromised by ventilation system fan mis-operation or malfunction.	2. A ventilation system fan sequencing interlock ensures that the backup exhaust fan is automatically started upon loss of the primary operating fan. An alarm alerts the operations staff upon loss of the operating Zone 1 exhaust fan.
		3. HCF operators must maintain the required functional performance of confinement monitoring instrumentation and controls.	3. Administrative controls are in place to ensure periodic channel functional testing and calibration of Δp instrumentation, and ventilation system fan sequencing interlock testing.
		4. A minimum residence time for Zone 1 exhaust through the charcoal filters must be maintained.	4. Administrative controls are in place to ensure that the exhaust fan inlet volume control damper is set to limit the Zone 1 flow rate. An alarm alerts the operations staff if the flow rate exceeds a maximum value.

Table 13.4-1. Identification of Human Interfaces with Safety-Related SSCs (cont.)

SSC	Function	Human-Machine Interface	Interface Controls
Zone 1 Ventilation Exhaust (cont.)		5. HCF operators must verify that Zone 1 exhaust charcoal filters are in service during ventilation system operation.	5. Administrative controls are in place to ensure periodic monitoring of charcoal filter Δp.
Zone 2A Ventilation Exhaust	Control of off-site radioactive material releases.	1. Zone 2A confinement boundary integrity must be maintained during isotope processing operations.	1. A Zone 2A-to-Zone 2 Δp indicator is located on the local control panel in Room 112. An alarm alerts the operations staff when the differential pressure decreases below the established alarm setpoint.
		2. Zone 2A confinement boundary integrity must not be compromised by ventilation system fan mis-operation or malfunction.	2. A ventilation system fan sequencing interlock ensures that the backup exhaust fan is automatically started upon loss of the primary operating fan. An alarm alerts the operations staff upon loss of the operating Zone 2A exhaust fan.
		3. HCF operators must maintain the required functional performance of confinement monitoring instrumentation and controls.	3. Administrative controls are in place to ensure periodic channel functional testing and calibration of Δp instrumentation, and ventilation system fan sequencing interlock testing.
		4. A minimum residence time for Zone 2A exhaust through the charcoal filters must be maintained.	4. Automatic controls are in place to ensure that the exhaust fan inlet volume control damper limits the Zone 2A flow rate. An alarm alerts the operations staff if the flow rate exceeds a maximum value.
		5. HCF operators must verify that Zone 2A exhaust charcoal filters are in service during ventilation system operation.	5. Administrative controls are in place to ensure periodic monitoring of charcoal filter Δp.

Table 13.4-1. Identification of Human Interfaces with Safety-Related SSCs (cont.)

SSC	Function	Human-Machine Interface	Interface Controls
Ventilation Hot Exhaust (Zones 1 and 2A combined exhaust)	Control of off-site radioactive material releases.	1. Hot exhaust confinement boundary integrity must not be compromised by ventilation system fan mis-operation or malfunction. 2. HCF operators must maintain the required functional performance of confinement controls. 3. HCF operators must verify the functional performance of the hot exhaust HEPA filters.	1. A ventilation system fan sequencing interlock ensures that the backup exhaust fan is automatically started upon loss of the primary operating fan. An alarm alerts the operations staff upon loss of the operating stack exhaust fan. 2. Administrative controls are in place to ensure periodic ventilation system fan sequencing interlock testing. 3. Administrative controls are in place to ensure periodic functional performance and efficiency testing of the HEPA filters.
Target Entrance System Mechanical Interlock	Protection of HCF personnel from potentially lethal radiation exposures.	The TES mechanical interlock must prevent a STB operator from removing the TES shield cover when the lid has been removed from a shield cask inside the TES.	Administrative controls are in place to ensure periodic testing of the TES mechanical interlock that prevents removal of the TES shield cover when the shield cask lid has been removed.
Shield Door Hydraulic System Controls	Protection of HCF personnel from potentially lethal radiation exposures.	HCF operators must ensure that shield door 1 is not lowered while shield door 2A is down and that shield door 3A is not lowered with workers in Zone 2A, the Zone 2A airlock, or the north end of Room 112.	Administrative controls are in place to ensure adequate control of shield door operating keys.
Shield Cask	Protection of HCF personnel from potentially lethal radiation exposures.	Workers must ensure shield cask integrity prior to and during movement of the cask from the ACRR highbay to the HCF with an irradiated target.	Administrative controls are in place to ensure that the cask lid is securely bolted in place prior to cask movement and to minimize the potential for accidents during cask transport.

13.4.1 Steel Confinement Boxes (SCB)

SCBs 2, 3, 4, and 5 serve as the primary barriers for confining radioactive materials during isotope processing operations. During normal operations, processing materials are brought into the SCBs by means of passthrough ports in the bottom of the SCBs and an under-box-transfer system. Except when materials are being transferred, these ports are to be closed and sealed. Following an abnormal occurrence such as a radioactive material spill, these ports are not to be opened until the abnormal condition has been corrected. Administrative controls in the form of process operating procedures and operator training are used to ensure that confinement boundary integrity is not compromised by operator failure to keep the passthrough ports closed.

13.4.2 Zone 1 Ventilation Exhaust System

Operation of the Zone 1 ventilation exhaust system requires actions that have been allocated to both staff personnel and machines. Process operators control the redundant SCB exhaust valves from a local control panel (LCP) at each processing station. These independent and parallel valves are used to establish the SCB flowrate. The negative SCB-to-Zone 2A differential pressure provides a continuous indication of SCB (Zone 1) confinement integrity. Normally, one of the valves will be closed, and the other will be adjusted to achieve the desired flowrate. A green operational status light on the LCP indicates that the appropriate differential pressure is being maintained. An audible alarm and associated red operational status light will activate on the LCP when the differential pressure decreases below the established alarm setpoint. In addition to the operational status lights and alarm, SCB exhaust flowrate and SCB-to-Zone 2A differential pressure indicators are provided on the LCP.

SCB pressure will equalize with Zone 2A whenever the SCB passthrough port is opened to the under-box-transfer system, thus activating the differential pressure alarm. This is a temporary condition that is necessitated by the process and will correct itself naturally when the passthrough port is closed and re-sealed. Once the required differential pressure is re-established, the alarm is automatically silenced, the red operational status light is extinguished, and the green status light is re-illuminated. Should a loss of SCB-to-Zone 2A differential pressure occur under other circumstances, the process operator is required to investigate the reason(s) for the abnormal condition and take appropriate corrective action.

A ventilation system fan sequencing interlock ensures that Zone 1 confinement boundary integrity is not compromised by either exhaust fan failures or operational errors. This interlock automatically starts the backup exhaust fan if the operating exhaust fan fails, thereby maintaining the desired directional airflow control across ventilation exhaust system boundaries. Thus, no operator action is required to maintain Zone 1-to-Zone 2A differential pressure in the event of exhaust fan failures.

HCF and process operators use the performance monitoring instrumentation and controls described above to maintain Zone 1 confinement boundary integrity. The functional performance of this equipment is assured by means of administratively controlled TSR surveillance activities. SCB-to-Zone 2A differential pressure instrumentation is subject to periodic channel functional testing and calibration, and the ventilation system fan sequencing interlock is periodically tested by HCF operations personnel in accordance with operating procedures.

The Zone 1 exhaust fan inlet volume control damper is manually set to maintain the total SCB exhaust flow rate in order to achieve the necessary residence time for exhaust gas in the charcoal filters. This ensures that radioactive iodine is removed from the Zone 1 exhaust gas before the exhaust gas is released to the environment. An alarm is provided to alert the operations staff if the flow rate exceeds the established setpoint. Should this occur, HCF operations personnel will investigate the reason(s) for the abnormal condition and take appropriate corrective action, which may include re-adjustment of the volume control damper. Since such an occurrence is not an initiator for a radioactive material release event, operator action is an appropriate response. In addition, certain activities in the SCBs may be curtailed until the condition is corrected.

Charcoal filter operability is ensured by means of an administratively controlled TSR surveillance activity. This activity involves periodic monitoring of the filter differential pressure during ventilation system operation, in accordance with operating procedures.

13.4.3 Zone 2A Ventilation Exhaust System

Operation of the Zone 2A ventilation exhaust system also requires actions that have been allocated to both staff personnel and machines. HCF operators monitor the Zone 2A-to-Zone 2 differential pressure by means of a differential pressure indicator on a LCP in Room 112. A green operational status light on the LCP indicates that the necessary differential pressure is being maintained. An audible alarm and associated red operational status light will activate on the LCP when the differential pressure decreases below the established alarm setpoint. Should this occur, HCF operations personnel will investigate the reason(s) for the abnormal condition and take appropriate corrective action. Since such an occurrence is not an initiator for a radioactive material release event, operator action is an appropriate response. In addition, certain activities in Zone 2A may be curtailed until the condition is corrected. When the required differential pressure is re-established, the alarm is automatically silenced, the red operational status light is extinguished, and the green status light is re-illuminated.

The ventilation system fan sequencing interlock ensures that Zone 2A confinement boundary integrity is not compromised by either exhaust fan failures or operational errors. This interlock automatically starts the backup exhaust fan if the operating exhaust fan fails, thereby maintaining the desired directional airflow control across ventilation exhaust system boundaries. Thus, no operator action is required to maintain Zone 2A-to-Zone 2 differential pressure in the event of exhaust fan failures.

HCF operators use the instrumentation described above to monitor Zone 2A confinement boundary integrity. The functional performance of this equipment is assured by means of administratively controlled TSR surveillance activities. Zone 2A-to-Zone 2 differential pressure instrumentation is subject to periodic channel functional testing and calibration, and the ventilation system fan sequencing interlock is periodically tested by HCF operations personnel in accordance with operating procedures.

The Zone 2A exhaust fan inlet volume control damper is automatically modulated to maintain the nominal Zone 2A exhaust flow rate in order to achieve the necessary residence time for exhaust gas in the charcoal filters. This ensures that radioactive iodine is removed from the Zone 2A exhaust gas before the exhaust gas is released to the environment. An alarm is provided to alert the operations staff if the flow rate exceeds the established setpoint. Should this occur, HCF operations personnel will investigate the reason(s) for the abnormal condition and take appropriate corrective action. Since such an occurrence is not an initiator for a radioactive material release event, operator action is an appropriate response. In addition, certain activities in Zone 2A may be curtailed until the condition is corrected.

Charcoal filter operability is ensured by means of an administratively controlled TSR surveillance activity. This activity involves periodic monitoring of the filter differential pressure during ventilation system operation, in accordance with operating procedures.

13.4.4 Ventilation Hot Exhaust

The ventilation system fan sequencing interlock ensures that hot exhaust confinement boundary integrity is not compromised by either stack exhaust fan failures or operational errors. This interlock automatically starts the backup stack exhaust fan if the operating stack exhaust fan fails, thereby maintaining the desired directional airflow control across ventilation exhaust system boundaries. Therefore, operator action is not required to maintain Zone 1-to-Zone 2A and Zone 2A-to-Zone 2 differential pressures in the event of stack exhaust fan failures.

HCF operators are dependent on the performance of the ventilation system fan sequencing interlock to ensure hot exhaust confinement boundary integrity. Therefore, the interlock is periodically tested by HCF operations personnel in accordance with operating procedures to verify proper performance.

HEPA filter performance for the removal of radioactive particulate matter in the ventilation system hot exhaust is ensured by means of administratively controlled TSR surveillance activities. HEPA filters are subject to periodic pressure drop testing to verify operability (i.e., to verify that the filters are not plugged). They are also subject to periodic efficiency testing to verify the required level of particulate matter removal efficiency. HEPA filters are to be replaced, in accordance with operating procedures, when they become plugged or when the required efficiency can no longer be achieved.

13.4.5 Target Entrance System Mechanical Interlock

A shield cover in the Target Entrance System (TES) is designed to remove the shield cask lid so that the cask and target can be translated after the lid is removed. A mechanical interlock (a metal pin) is physically pushed by the shield cask lid when it is removed from the cask. This pin extends into the shielding wall to prevent the removal of the TES shield cover with the cask lid removed. This assures that workers cannot be exposed to an unshielded irradiated target when the cask is removed from the TES.

13.4.6 Shield Door Hydraulic System Controls

Control of Room 108 and Room 109 shield door operation will be ensured, initially, by means of administrative control of the door operating keys with waste stored in Room 109. Such control precludes unintentional lowering of the Room 108/109 shield door (door 2A) while the Room 101/108 shield door (door 1) is down, as well as lowering of the Room 109/Zone 2A shield door (door 3A) with workers in Zone 2A, the Zone 2A airlock, or the north end of Room 112.

Administrative control of the door operating keys is adequate for protecting workers while meeting the operational needs of HCF operations personnel.

13.4.7 Shield Cask

Minimization of shield cask transport accidents that could expose workers to a lethal source of radiation is ensured by means of an operating procedure that requires correct installation of bolts on the cask lid after an irradiated target is inserted into the cask and before the cask is transported out of the ACRR highbay. This procedure also governs all activities involved in the movement of a loaded shield cask from the ACRR highbay to the HCF target entrance system. Personnel qualification to operate a forklift is an additional administrative control designed to minimize the occurrence of shield cask transport accidents. Although the shield cask is designed to provide radiation shielding rather than radioactive material containment, analysis has indicated that it will protect the contents and not suffer severe structural damage under anticipated accident conditions. Therefore, the only operator action that is relied upon to prevent a potentially fatal worker radiation exposure in an accident involves the proper installation of the cask lid. Administrative control of shield cask lid installation is adequate to protect workers involved in irradiated target transfer activities.

13.5 Optimization of Human-Machine Interfaces

The HCF is an existing facility that has undergone numerous modifications. Because of this, the facility and many of its operating systems were not designed to meet current human-factors standards. However, human-factors considerations influence the design and operation of new HCF equipment such as control panels, manipulators, and performance monitoring instrumentation.

As indicated in Section 13.4, only normal and abnormal HCF operations involve safety-related human-machine interfaces. Most of these interfaces do not require rapid responses to abnormal conditions in order to prevent a degradation of radioactive material confinement boundaries, which would increase the risk of a radioactive material release to the environment. Therefore, it is appropriate to allocate such functions to the human side of the interface. However, where a rapid response is necessary to prevent physical damage to radioactive material confinement structures, such functions have been allocated to the machine side of the interface.

The primary function allocated to the human side of the safety-related human-machine interface involves maintaining radioactive material confinement integrity through proper operation of the HCF ventilation system. Ventilation system displays and controls enable facility operators to adequately control ventilation system operation under all normal and abnormal conditions. The important parameters in the ventilation system are the zone-to-zone differential pressures and the flow rate of hot exhaust gas through the charcoal filters. Automatic monitoring devices <u>directly</u> measure the zone-to-zone differential pressures and the Zone 1 and Zone 2A exhaust gas flow rates. These direct measurements and associated alarm setpoints provide the operations staff with a clear understanding of radioactive material confinement barrier integrity and charcoal filter effectiveness for the removal of radioiodine from ventilation exhaust gases. However, a temporary loss of zone-to-zone differential pressures is not an accident initiating event. Although this condition increases the risk of a radioactive material release event, the physical confinement structures (SCBs and hot cell canyon) mitigate against an uncontrolled release. System alarms provide operations personnel with ample time to take corrective and/or compensatory actions in the event of abnormal ventilation system conditions.

The primary function allocated to the machine side of this interface involves prevention of adverse pressure differentials. This function is performed by the ventilation system fan sequencing interlock, which establishes a hierarchy of fan operation to ensure that hot exhaust ducting does not get pressurized in the event of exhaust fan failures or mis-operation. An interlock automatically starts the backup fan upon loss of an operating fan. In addition, the interlock automatically shuts down all upstream fans if both of the Zone 1, Zone 2A, or stack exhaust fans fail. The interlock also allows only a sequenced startup of ventilation system fans to prevent pressurization of the hot exhaust ducting because of operator failure to adhere to the required fan startup sequence.

Other human factors issues such as communications, operator aids, and equipment labeling are addressed in Chapter 11.

13.6 REFERENCES

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

DOE Memorandum, *Safety Analysis Report Guidance — Human Factors*, DOE/DP-625, U.S. Department of Energy, Washington, D.C., December 1, 1992.

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

DOE O 232.1A, *Occurrence Reporting and Processing of Operations Information*, U.S. Department of Energy, Washington, D.C., August 21, 1997.

DOE Order 5480.20A, *Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Nonreactor Nuclear Facilities*, U.S. Department of Energy, Washington, D.C., November 15, 1994b.

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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CONTENTS

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14.0 QUALITY ASSURANCE

14.1 Introduction

This chapter describes the Quality Assurance Program (QAP) used for the facilities in TA-V (including HCF) as well as experiments conducted in TA-V. The description is done by presenting a summary of the requirements from laws and DOE Orders, followed by a brief description of the TA-V QAP. The program description is organized into three major subsections: (1) management, (2) performance, and (3) assessment. These subsections correspond to major areas of the QAP. The subsections show how the HCF QAP elements address (map into and satisfy) the "criteria" that have been established by DOE for an acceptable QAP. The QAP also invokes industry best practices. The contents of this chapter were chosen and arranged using the guidance for format and content given in DOE-STD-3009-94 (DOE 1994a).

The QAP for the TA-V facilities and experiments is documented in the *Sandia Research Reactor and Experimental Programs Quality Assurance Program Plan* (RREP-QAPP) (SNL 1998).

14.2 Requirements

10 CFR 830.120, Quality Assurance Requirements, This section of the Code of Federal Regulations (Code) establishes the Quality Assurance (QA) requirements for all DOE nuclear facilities. QA requirements are to be implemented through a written Quality Assurance Program (QAP). The QAP is developed by addressing the ten QA criteria stated in this section of the Code.

DOE Order 5480.19, Conduct of Operations (COO) (DOE 1990), requires that the line organization responsible for operations at nuclear facilities have an Organization and Administration document that clearly describes job responsibilities, resources, and support infrastructure. The COO order also requires written procedures for critical operations, configuration control for the facility safety equipment, and formal processes for inspection of equipment, operations, and procedure improvement. The order further specifies that records of operations and maintenance be made and maintained and that managers assess operations and identify problems and correct them in a timely manner.

DOE Order 5480.23, Nuclear Safety Analysis Reports, (DOE 1992) Paragraphs 8b(3)(r), as amplified in Attachment 1, and 4f(3)(d)18 of this order (Topic 18) require that the QAP for the facility be addressed as part of the Safety Analysis Report (SAR) (DOE 1992).

DOE O 420.1, Facility Safety, (DOE 1996) Paragraph 4.1.1.2 specifies that safety structures, systems, and components be designed in accordance with a quality assurance program that satisfies 10 CFR 830.120.

14.3 Management

14.3.1 Program

Quality Assurance is a line responsibility. The management is committed to implementation of the RREP QAPP (SNL 1998) in accordance with appropriate codes, regulations and standards. The achievement of quality is the responsibility of all personnel associated with the activities. The QA Program describes the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the adequacy of work. Organizational structure, functional responsibilities, and interfaces are addressed in Section 17.3.

The SNL QA Program has been developed in response to 10 CFR 830.120 and has been approved by the DOE. The RREP-QAPP and the Project/Experiment Quality Plan for Hot Cell Facility fulfill all four management criteria from 10 CFR 830.120, namely:

(1) to maintain a written Quality Assurance Program,

(2) to ensure that personnel are trained and qualified to perform their assigned work and continue to be trained to ensure proficiency,

(3) to have processes to detect and prevent quality problems, and

(4) to specify, prepare, review, approve, and maintain documents and records that prescribe processes, specify requirements, and establish design.

Implementation of management criteria two through four is briefly described in the remainder of Section 14.3.

14.3.2 Personnel Training and Qualification

Quality training is achieved through a program conducted by the Quality Assurance Coordinator, who reports to the Nuclear Facility Support Manager. The QA training for the facility staff (and experimenters who use the facility) meets the requirements of 10 CFR 830.120 and, for most of the operators and technical staff, consists of self-study of the QAPP on a two-year cycle. However, there are additional study and test requirements for "inspection, test, and non-destructive testing (NDT) personnel." The Quality Assurance Coordinator maintains records of all Quality training, test results, and self-study completions. The retraining cycle of two years ensures that proficiency in QA is maintained.

Technical proficiency of facility personnel is achieved through a separate program that meets the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, Training, and Staffing Requirements at DOE Reactor and Non-Reactor Nuclear Facilities* (DOE 1994b). Personnel training requirements are identified based on assigned tasks. The corporate safety training is tracked (records of completion) through a corporate database, TEDS. Technical proficiency training is administered by the Nuclear Facilities' Training Coordinator, who also reports to the Department Manager for Nuclear Facility Support. The training program is described in more detail in Chapter 12 of this SAR.

HCF Operators demonstrate technical proficiency through written, oral, and practical OJT tests and/or demonstrations. In addition to initial qualification, operators must requalify on a two-year cycle. Records showing progress (including written test results) is maintained for each HCF operator by the Nuclear Facilities' Training Coordinator. An overview page in each operator's notebook shows the progress of that operator in the current training cycle.

14.3.3 Quality Improvement

Processes to detect and prevent quality problems as well as ensure quality improvements are established in the RREP-QAPP and implemented through several QA Implementing Procedures. The extent to which each applies to the various activities, operations, projects, and experiments at the Hot Cell Facility is described in the HCF PEQP. Four grouping of safety importance (graded approach) are defined in that RREP:

- TSR (OSR)-required equipment for safe operation (additions, modifications, replacements, repair, maintenance, and calibration).
- Support equipment (not required by the TSRs (OSRs) but described in the SAR) (additions, modifications, replacements, repair, maintenance, and calibration).
- Operating procedures required by the TSRs (OSRs) and ES&H SOPs.
- Activities requiring Radiological and Criticality Safety Committee (RCSC) review, which are not included in Groups 1-3.

Examples of RREPs supporting the quality criterion are:

- RREP 2-1, *Quality Levels.* This RREP describes the implementation of the graded approach as required by 10 CFR 830.120.
- RREP 3-1, *Design Control.* This RREP describes acceptable design review and verification methods. These include, but are not limited to, any one or a combination of the following: design review, alternate calculations, and qualification testing.
- RREP 3-2, *Computer Software Control.* This RREP describes the QA controls for software that is developed and applied in facility and experiment operations. A Quality Level is assigned to software based on the possibility that its use or failure may adversely affect the environment, safety and health and the RREP's mission and goals. Requirements must be documented and the design must be based on those requirements. The requirement and design phases are the first two (of six) distinct phases in a software's lifecycle. The implementation phase has requirements for debugging and generating user documentation. There are additional requirements for the remaining phases of testing, installation and checkout, operations, and maintenance.
- RREP 3-3, *Control and Verification of Analyses and Calculations.* The purpose of this procedure is to identify the actions and responsibilities of persons who perform analyses or calculations in support of facility operations or experiment activities. The procedure also establishes controls for technical review of such analyses and calculations.
- RREP 10-2, *Quality Surveillances.* This document specifies the actions to be taken in conducting quality surveillances of the facility operations or experiments. The procedure ensures that processes are controlled and helps identify potential problems.
- RREP 18-1, *Independent Assessments.* This document establishes the requirements for conducting internal and external quality assessments of Level I (critical), Level II (major), and selected Level III (minor) projects and experiments. The assessments

promote improvement and evaluate adequacy and quality. The assessments are documented and recommendations are acted upon.

Items and processes that don't meet established requirements are identified, controlled, and corrected through other RREPs. Examples of this set of RREPs are:

- RREP 5-2, *Assembly Procedures.* This procedure assures that projects, experiments, inspections, and tests are planned, documented, and verified as completed in a systematic, orderly, and controlled sequence to prevent (or minimize) product defectiveness and variability.
- RREP 8-1, *Identification and Control of Items.* This procedure establishes methods for controlling the identification, handling, storage, and shipping of items to prevent their damage, loss, or deterioration.
- RREP 9-1, *Control of Processes.* This procedure establishes controls to be applied to HCF work processes. Personnel performing the work must be qualified, equipment must be suitable, and the work must be performed using approved (and controlled) procedures.
- RREP 15-1, *Control of Nonconforming Items.* The procedure establishes the controls for initiating, processing, dispositioning, and closing a Nonconformance Report. It applies to Levels I (Critical) and II (Major) items, services, data, and activities (in all of 4 groups).
- RREP 16-1, *Corrective Action.* This procedure describes a process for documenting significant conditions adverse to quality to ensure effective corrective action and process improvement. It is consistent with SNL/NM's implementation procedure for DOE O 232.1A, *Occurrence Reporting and Processing of Operations Information* (DOE 1997) for those categories that require reporting to DOE. The RREP specifies the identification, through self-reporting, of actions and occurrences, which may be adverse to quality. A Root Cause Analysis Process ensures that corrective actions are directed at areas (of improvement) that will prevent recurrence.

14.3.4 Documents and Records

Documents that prescribe HCF-related processes, specify HCF requirements, and/or establish HCF (or Experiment) design, must be prepared according to the QAP. The QAP also ensures that these documents are reviewed, approved, issued, used, and revised.. The QAP also incorporates a process for ensuring that records are specified, prepared, reviewed, approved, and maintained.

14.4 Performance

14.4.1 Work Processes

Work is performed under controlled conditions by using a "graded approach" as required by 10 CFR 830.120 and as implemented in the Org. 6431/6433 Work Control Instruction. This instruction requires the development of a Project/Experiment Quality Plan (PEQP) to ensure that all safety related work will be performed to meet the requirements of 10 CFR 830.120.

The PEQP assigns a "Quality Level" to all projects and experiments. Experiments, operations, and other activities (e.g., conduct of operations procedures) that are "not included in the PEQP safety importance groups" do not require a PEQP or formal quality level assignment. These types of activities are addressed for quality issues on a "case-by-case" basis or through department instructions that address quality and excellence.

The PEQP also requires a detailed analysis of the risks associated with all aspects of a particular activity. Project/Experiment Quality Plans are described in detail in the QAP. The overall QAP (SNL 1998) requires that work be performed to established technical standards and administrative controls. The QAP provides a checklist to assist personnel in incorporating QA requirements in the work process in a graded fashion. Processes are controlled by SOPs and instructions.

14.4.2 Design

The QAP guarantees that items and processes are designed using sound engineering/scientific principles and to appropriate standards. The QAP also ensures that design work, including changes, incorporates applicable requirements and design bases. The QAP also requires that design interfaces are identified and controlled. It further requires that the adequacy of design products be verified or validated by individuals or groups other than those performing the work. The verification and validation processes are also described in QA-implementing procedures.

The hazard classification of the facility dictates the QA levels that are assigned to the facility, structures, systems, and components (SSCs), based on the consequence of failure. The extent of requirements and depth of QA activity are commensurate with the scope, complexity, importance, and degree of risk of a SSC. Through the use of quality levels, the stringency of the requirements is applied in a graded approach to all SSCs within the facility. The most stringent requirements (Quality Level I) apply, by default, to all safety- class SSCs, which are specified in accordance with DOE Orders and Standards [i.e., DOE Order 5480.23 (DOE 1992) and DOE-STD-3009-94 (DOE 1994a). As described in Chapter 3, no safety class SSCs are identified for the HCF.

14.4.3 Procurement

The QAP (SNL 1998) ensures that procured items and services meet established requirements and perform as specified. The QAP also demonstrates that prospective suppliers are evaluated and selected on the basis of specified criteria. The methods by which the line organizations ensure that approved suppliers can continue to provide acceptable items and services are also described in this procedure.

14.4.4 Inspection and Testing for Acceptance

The QAP ensures that inspection and acceptance testing of specified items and processes are conducted using established acceptance and performance criteria. The QAP also provides assurance that equipment used for inspections and test is calibrated and maintained.

14.5 Assessment

14.5.1 Management Assessment

The QAP ensures that management at all levels assess the integrated QA program and its performance. Any problems that hinder the organization from achieving its objectives are identified and corrected according to this QA-implementing procedure.

14.5.2 Independent Assessment

The QAP ensures that planned and periodic independent assessments are conducted to measure item quality and process effectiveness and to promote improvement. The QAP emphasizes that organizations performing independent assessments must have sufficient freedom and authority from the line organization to carry out their responsibilities. The QAP also require that personnel conducting independent assessments be technically qualified and knowledgeable in the area being assessed.

14.6 REFERENCES

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Sandia National Laboratories (SNL), 1998, *Sandia Research Reactor and Experimental Programs Quality Assurance Program Plan (RREP-QAPP),* Sandia National Laboratories, Albuquerque, NM, March 1, 1998.

U.S. Department of Energy (DOE), 1990, *Conduct of Operations for DOE Facilities,* DOE Order 5480.19 (Change 1: May 18,-1992), U.S. Department of Energy, Washington, D.C., July 9, 1990.

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FIGURES

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15.0 EMERGENCY PREPAREDNESS

15.1 Introduction

A Technical Area V (TA-V) emergency preparedness plan (SNL 1998) outlines the general emergency-response activities for operations within TA-V and the interface with the overall Sandia National Laboratories/New Mexico Emergency Plan (SNL 1999). The TA-V Emergency Preparedness Plan (TA-V EPP) is an integral part of the Sandia National Laboratories/New Mexico Emergency Plan (SNL/NM EP). The TA-V EPP establishes the site-specific emergency response actions for TA-V and provides all personnel in TA-V, both permanent and temporary, with the directives and necessary supporting information to respond safely and promptly in the event of an emergency situation occurring at the site. The plan addresses the response of personnel within the TA-V double fence and those in the TA-V building 6585. The emergency drills conducted with the Hot Cell Facility, TA-V reactors, and the Gamma Irradiation Facility demonstrate that the plan is functional. The plan stresses the concept that all emergencies are to be treated as serious occurrences and that appropriate responses are expected from the general TA-V population in all cases.

15.2 Requirements

The requirements for the HCF emergency preparedness program are established or implemented by the following documents:

- TA-V Emergency Preparedness Plan (SNL 1998).
- PN 471011, SNL/NM Emergency Plan (SNL 1999).
- DOE Order 151.1 Change 2, *Comprehensive Emergency Management System,* August 21, 1996 (DOE 1996).

15.3 Scope of Emergency Preparedness

Planning for emergency preparedness is based on the analyses of potential HCF accidents evaluated in this SAR are presented in Chapter 3. No credible HCF accidents are postulated to pose significant hazards to other TA-V personnel, off-site personnel, the general public, or the environment, and only a few of those analyzed result in localized radiological consequences to personnel and facilities.

Because TA-V includes Category 2 reactor and hot-cell facilities, the TA-V EPP is based on accidents with the potential for moderately severe consequences. The Emergency Planning Zone (EPZ) that is consistent with those radiological consequences is defined by a radius of 3000 m. As a result, the EPZ is entirely within the Kirtland Air Force Base (KAFB). The area closest to TA-V is controlled during an emergency by the roadblocks that are established to control vehicle traffic through the area.

For most accidents, several mitigation features are presented which limit the consequences of the accident. The facility itself provides a measure of protection against exposure of facility personnel to the effects of an accident or abnormal event because of the inherent safety provided by shielding.

Accident analyses indicate that the potential of the HCF to impact non-facility personnel is minor. The radiological dose consequence to personnel based on the Design Basis Accident is 1.8 Rem. The evaluation guideline described in Chapter 3 is 25 rem at the site boundary. Since the dose consequence is a small fraction of the evaluation guideline, this meets the definition of an Alert Class emergency as specified in DOE Order 151.1 (DOE 1996). There are no direct radiation paths between the HCF and the emergency assembly building or the emergency control room to which TA-V personnel deploy when the area alarm sounds.

15.4 Facility Planning and Preparedness for Operational Emergencies

The TA-V EPP is an integral part of the SNL/NM EP which establishes and describes a laboratory-wide emergency-response organization. Documentation directly related to emergency preparedness activities includes:

1. SNL/NM Emergency Plan (SNL 1999).
2. TA-V Emergency Preparedness Plan (SNL 1998) facility-specific instructions for:
    - External fire,
    - Loss of electrical power,
    - Criticality,
    - Fire in the Hot Cell / SCB,
    - Fire in the HCF,
    - Low oxygen alarm, and
    - Loss of containment.

The SNL/NM EP is the master control plan for all SNL/NM emergency-preparedness activities and within this document is the Incident Command Structure (ICS), which is identified as the primary field organizational structure for the on-scene management of emergencies.

The SNL/NM EP is prepared by the SNL/NM ES&H Center. The SNL/NM EP establishes policy and procedures for the emergency-response requirements for all SNL/NM operations, sites, and facilities. The SNL/NM EP identifies planning, preparedness, and recovery activities which are instituted for the purpose of minimizing the consequences of emergencies. It describes the activities necessary to implement the program and addresses both on-site and off-site emergency situations and the associated expected responses. TA-V and the adjacent building 6585 are covered in the TA-V Emergency Preparedness Plan (see Figure 15.4-1).

The TA-V EPP provides guidance for the overall conduct of the emergency preparedness and response program within TA-V. It identifies expected types of emergencies, guidelines for response actions, and an emergency organization dedicated to the conduct of emergency operations. Within the plan are facility-specific instructions for each principal TA-V facility, including the HCF, describing specific responses to be taken in the event of an emergency. These responses are geared for the particular equipment and systems at each facility and provide guidance to operating personnel for safely securing the facility.

The TA-V EPP is reviewed periodically for updating in accordance with DOE Order changes and through information acquired during drills and actual emergencies. If the changes are judged to be significant, a revised TA-V EPP is prepared and submitted to the TA-V Emergency

Planning Committee for formal review. Based on the committee review and recommendations, the revised plan is then submitted to TA-V management for approval.

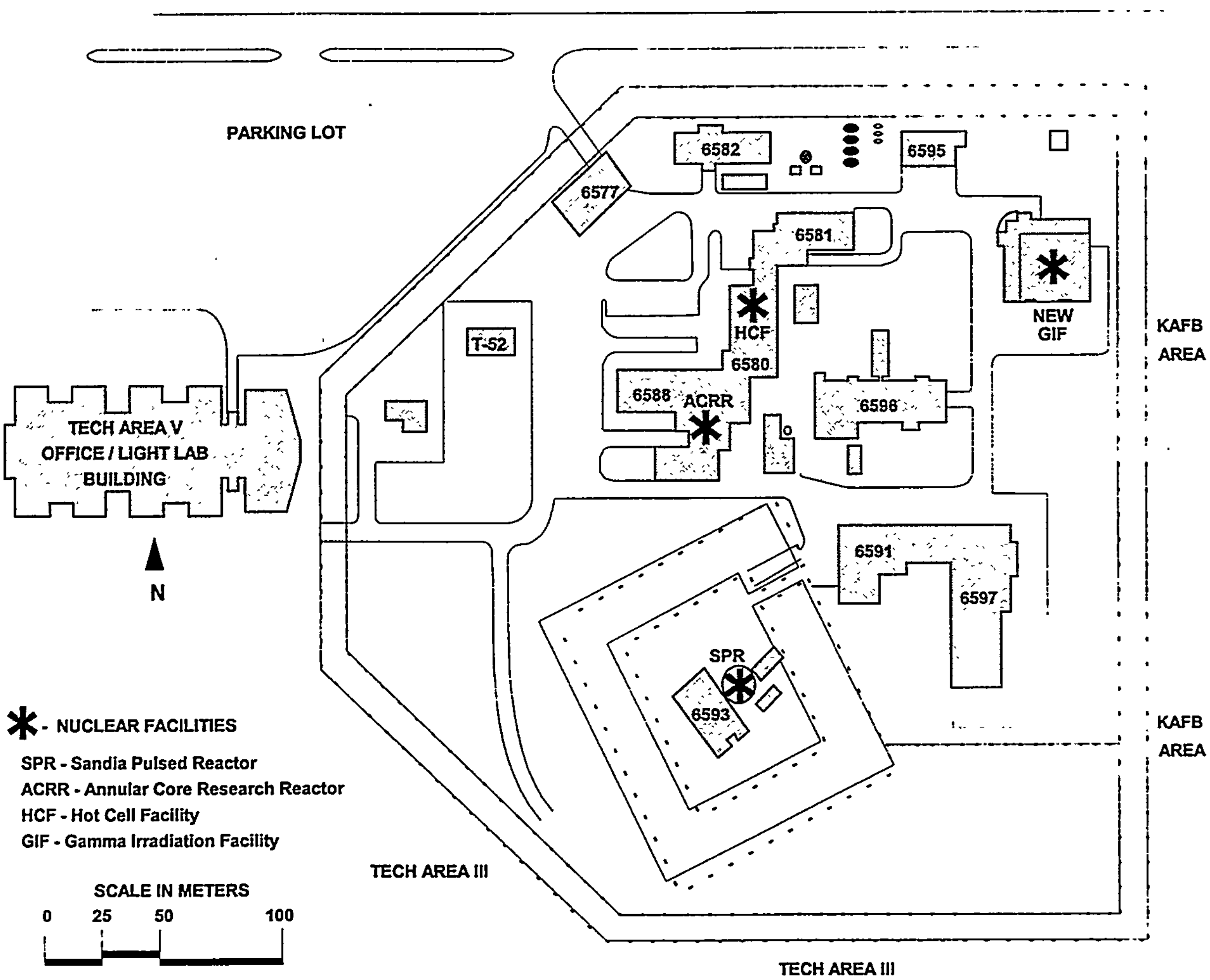

Figure 15.4-1. Plot Plan of TA-V

15.4.1 Emergency Response Organization

15.4.1.1 TA-V Emergency Response Organization

The SNL/NM Emergency Plan establishes an Emergency Response Organization (ERO). Central to this is the SNL/NM Emergency Operations Center in Technical Area I (TA-I). The Senior Management Representative (SMR) in the EOC is a designated manager with the training, authority, and responsibility for overall emergency response at SNL/NM. The Incident Command Structure (ICS) is the field element of the ERO, with the Incident Commander (IC) having command and control authority and responsibility. The SNL EP identifies the principal management units, which are the SNL/NM IC, the Operations Section, the Logistics Section, the ES&H Section, the Planning Section, and in the case of TA-V, the TA-V Emergency

Supervisor (EMSUP) and emergency staff. The TA-V emergency preparedness and response organization is shown in Figure 15.4-2.

The TA-V Deputy Director for Operations is responsible for developing an emergency preparedness and response plan for TA-V and assuring that the plan is consistent with the overall SNL/NM EP. The TA-V EPP is referenced in the SNL/NM EP. Copies of the SNL/NM EP and the TA-V EPP are placed in strategic emergency facilities within TA-V. The TA-V Deputy Director for Operations has direct administrative responsibility for all emergency preparedness activities and authority for implementation of the TA-V EPP, and is vested with the authority to exercise operational control of non-security-based emergencies within TA-V.

The responsibility for conduct of emergency operations within TA-V is delegated on a rotating basis to one of the duty Emergency Supervisors. During an emergency the EMSUP is stationed in the TA-V Emergency Control Room (ECR). Within the framework of the SNL/NM ICS, the EMSUP reports to the SNL/NM IC. Upon arrival at TA-V, the IC elects at his or her discretion to assume control of a TA-V emergency incident.

The EMSUP and the SNL/NM IC coordinate all emergency response activities within TA-V. The EMSUP is vested with the authority to direct such activities until the SNL/NM IC assumes control (if done), except those determined by the senior-on-scene Protective Force supervisor to be security related. For those cases, the Protective Force organization assumes control, and the IC, EMSUP, and other TA-V emergency staff will provide support.

15.4.1.2 Off-Site Response Interfaces

During emergencies within TA-V, the SNL/NM IC established by the ICS and the TA-V duty EMSUP established by the TA-V EPP share mutually supporting roles. Upon arrival at TA-V, the SNL/NM IC normally conducts or coordinates all communications through the ICS; prior to that, the TA-V EMSUP coordinates external communications through the TA-V Emergency team's External Communicator.

Several groups within SNL/NM are available to provide support during emergencies. These are the security forces (outside TA-V), medical services, ES&H, and radiation protection. The Kirtland AFB Fire Department provides immediate response upon fire alarm activation or when called. In addition to these groups, there are other services that are available, though not necessarily on an immediate basis. These services, provided through the ICS, include engineering support, transportation, and public information. Emergency services are available from offsite agencies such as FEMA and other Federal agencies, State and local government, Isleta Pueblo, UNM, Red Cross, and local hospitals.

The EMSUP, or a designated member of the TA-V emergency organization, briefs support groups that report to TA-V, including the KAFB Fire Department, which automatically proceeds to TA-V any time the TA-V alarm sounds. Support groups are retained at the Perimeter Access Building (PAB) until authorized by the EMSUP or SNL/NM IC to enter the area. In the event the emergency involves potential radiation exposure to support personnel, entry is authorized by the EMSUP only within established SNL/NM guidelines. Projected total dose is limited to 5 rem per person unless otherwise specifically authorized.

Coordination of emergency activities with other groups or organizations outside TA-V or SNL/NM is the responsibility of the SMR. These agencies include the US Air Force (Kirtland

Air Force Base), DOE, local hospitals, and various local and state government emergency-response organizations.

The EOC maintains a complete file of written agreements between SNL/NM and these organizations, and a file of their emergency capabilities. If assistance is required of an outside organization, the request will be made by the EOC.

15.4.2 Assessment Actions

Consequence assessment involves three phases: (1) pre-emergency planning data and analyses, (2) on-scene emergency response evaluation, and (3) post-emergency residual effects assessment.

Phase one provides estimates of the consequences based on predetermined data consisting initially of a Primary Hazard Screening submitted by the facility manager. The hazard assessment developed from this becomes the basis for emergency planning.

Phase two is the on-scene consequence assessment made by the TA-V Emergency Response Team on the basis of initial information available at the ECR, augmented by additional data from the Reentry Team when they physically survey the area.

Phase three includes an assessment of residual environmental effects that may result from the event, and is performed by TA-V personnel augmented by specialized SNL/NM response teams.

15.4.3 Notification

The TA-V EPP describes the provisions for prompt notification of emergency-response personnel and other organizations both on-site and off-site. It describes the system for notification of all on-site personnel and the required response. All messages and notifications are accomplished in a prearranged manner as prescribed in the TAV EPP. Communications external to SNL/NM are handled through the SNL/NM EOC, as described in the SNL/NM EP.

Communication systems are categorized as on-site TA-V and off-site TA-V. The on-site systems consist of the TA-V intercommunications system, TA-V paging system, telephones, and the TA-V Evaluation Team radio net. The off-site system consists of telephones and the SNL/NM radio-communications network. Initial communications with SNL/NM groups outside TA-V and the KAFB Fire Department are coordinated by the TA-V EMSUP and the external communicator.

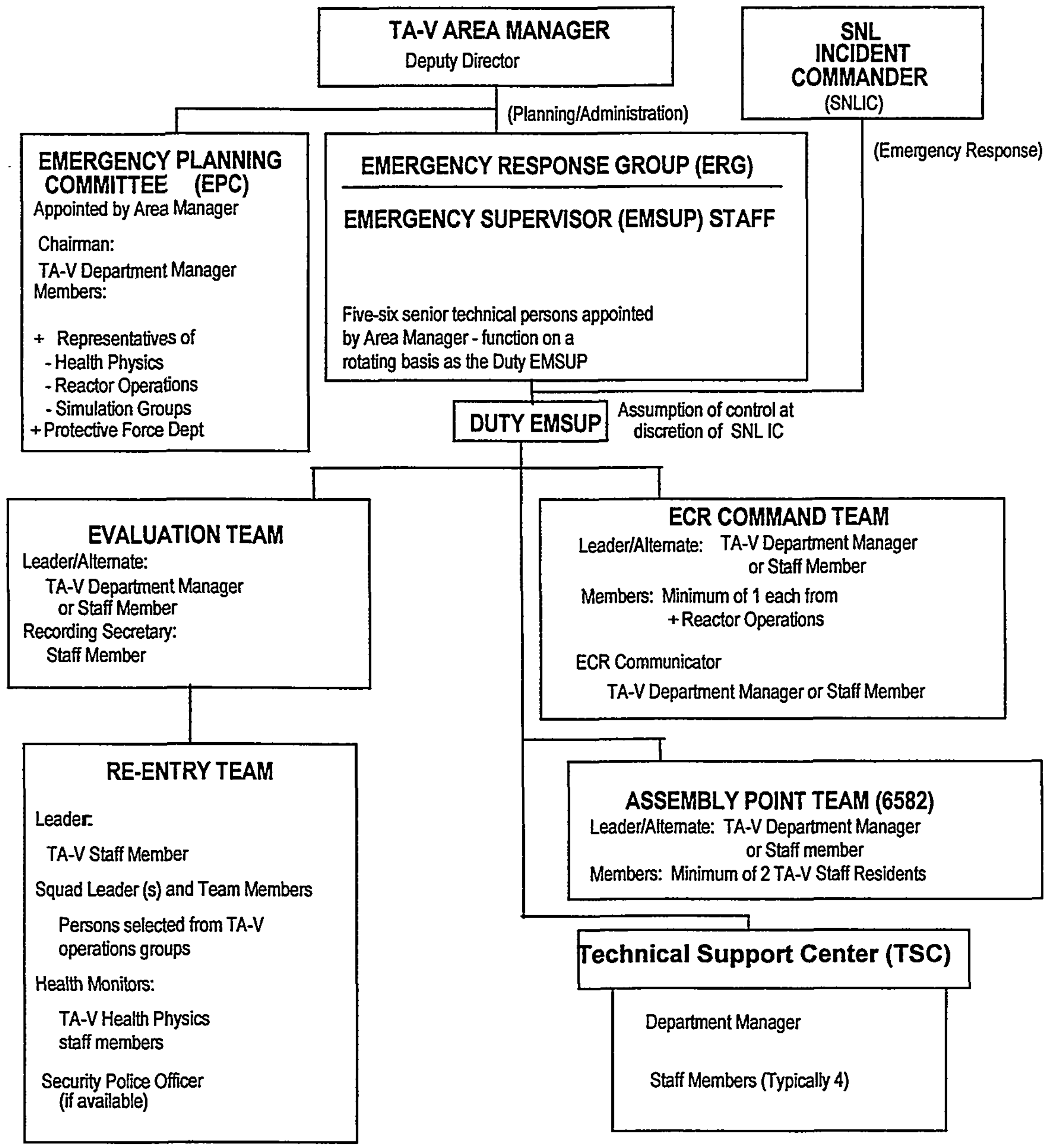

Figure 15.4-2. Emergency Response Organization

15.4.4 Emergency Facilities and Equipment

The principal emergency facilities are the TA-V Emergency Control Room (ECR, Bldg. 6577), the TA-V Reentry Team facility, and the TA-V Emergency Assembly Point in Building 6582 (referred to as the "assembly building"). Figure 15.4-1 illustrates the main TA-V emergency facilities. If an alarm is activated, the response by TA-V personnel is immediate evacuation with the selected emergency response personnel reporting to the ECR or the Reentry Facility, and the remaining people reporting to the assembly building. The group that reports to the ECR includes individuals who have the knowledge to make an assessment of the emergency and are qualified to direct emergency response activities. The ECR is equipped with a selection of emergency equipment that enables the emergency team personnel to make this evaluation. The assembly building provides a location for accounting for on-site personnel and a filtered air environment that affords reasonable protection against potentially hazardous releases. Thus both the ECR and the assembly building provide safety for personnel by virtue of their construction, their separation from the HCF, their ventilating systems, and the shielding from the HCF provided by the earth and concrete walls.

The response actions required of TA-V personnel in the event of an accident or abnormal event are discussed in the TA-V EPP. All personnel within the TA-V perimeter are instructed to evacuate the TA-V facilities and proceed to the assembly building over prescribed routes unless specifically exempted for a particular critical operation. Members of the various TA-V emergency teams report to their EPP designated locations. The short evacuation time coupled with the generally low inventory of radioactive or other hazardous materials and the inherent shielding of the structure provides an effective mechanism for mitigating the consequences of an accident.

The ECR is located in the TA-V Perimeter Access Building (Bldg. 6577) and is supplied with full time High Efficiency Particulate Air (HEPA) filtered air. It is equipped with a fire-alarm readout panel, a personnel-accountability system, a Radiation Area Monitor (RAM), a radiation-readout panel, several internal and external communication systems, and a small meteorology station (wind speed, direction, and temperature). The ECR is equipped with copies of the TA-V EPP and plot plans of TA-V buildings and areas surrounding TA-V. Building 6577 electrical power includes a standby diesel generator backup system.

The TA-V Assembly Building is designed to provide for the occupancy for personnel within TA-V when the alarms sound. The Building 6582 EAP has a full-time ventilation system that operates under manual control in two modes: Normal or Emergency. When switched to Emergency (normally performed by the EAP team), all makeup fresh air is filtered through a bank of HEPA and charcoal filters. The air-conditioning system consists of a heating/cooling system that recirculates room air with small make-up during routine operation. The ventilation system is designed to maintain a positive pressure inside the building with respect to the outside to prevent in-leakage of air. The assembly point building is equipped with a RAM.

The types of emergency equipment available for TA-V include the standard communications systems. In addition, other equipment and systems are in place as part of the routine monitoring activities such as the Remote Area Monitoring Systems and Continuous Air Monitoring System. Specialized equipment is in place in specified areas to measure environmental conditions such as oxygen concentration and static voltage.

Medical equipment is available on a limited basis. Basic first-aid kits are distributed throughout TA-V, and a more comprehensive supply is provided at the Emergency Assembly Building. This equipment includes a decontamination shower and a selection of first-aid materials for personnel decontamination, either radioactive or hazardous. Wall-mounted stretchers are placed at various locations throughout TA-V. TA-V Reentry Team members and other TA-V personnel receive site-specific first aid training, including CPR.

15.4.5 Protective Actions

The TA-V EPP serves as a general protective action guideline for all personnel in TA-V, including members of the emergency response organization. The facilities, equipment, and procedures described in that plan are consistent with the overall protective action requirements established in the SNL/NM EP. Typically, as demonstrated by drills, the time required for personnel to evacuate TA-V facilities is less than 3 minutes, with all personnel in the appropriate assembly building within 10 minutes.

Even though area evacuation is not required for Alert class emergencies, it is the primary protective action to evacuate to the Emergency Evacuation Building 6582 under all accident conditions. Further protective actions are decided by the TA-V Emergency Response Organization and the SNL Incident commander, depending on an assessment of the emergency situation.

The HCF, located in Building 6580, is located immediately southeast of the assembly building, Building 6582. The evacuation route is a direct line between the two buildings. HCF personnel will report to the assembly building whenever a TA-V alarm is activated. Personnel can be evacuated from this building via two routes. The normal entrance and the conference room north door lead to the outer perimeter fence. If the normal entrance is used, personnel will proceed directly to the main security-control building for out-processing. If the auxiliary doors are used, egress is through a set of personnel gates in the security fence that are controlled and monitored by the Security forces.

If TA-V site evacuation is required, personnel are instructed to leave TA-V (on foot) through the perimeter gate. Personnel then can either use personal vehicles, which are parked outside TA-V, or if time permits, the SNL/NM transportation group will provide buses outside TA-V for the transport of personnel. In any event, a member of the SNL/NM Security Forces will escort vehicles from the area. Everyone must proceed to the designated assembly point to accomplish accountability checks and debriefings.

If an emergency vehicle must enter TA-V as part of an emergency situation, the vehicle is surveyed for radioactive material prior to its exit from the area. (This procedure is identical for all vehicles departing TA-V regardless of whether or not an emergency situation exists.)

There are two primary routes from TA-V that can be used for the evacuation of personnel from TA-V. One route is the main paved highway east from the area that connects with the principal road through the south portion of SNL/NM (Pennsylvania Avenue). At this road junction, the option is available to turn north or south with north being the preferred direction because that route leads back to the main area of SNL/NM and egress from Kirtland AFB. The south route leads into an isolated area. If the south route is chosen, personnel would be required to remain at the remote location until it is deemed safe to travel the main north-south road.

The second emergency route leads west from TA-V through the TA-III network of roads. Depending upon the incident, personnel can be escorted to a holding area about one mile from TA-V or via the roads that lead off the base and eventually join the main state highway system.

Personnel in building 6585 are instructed by the EPP to stay inside the building. Information is provided to the 6585 personnel by the public address system or through the telephone messaging system.

15.4.6 Training and Drills/Exercises

Drills and Exercises are the two basic methods conducted at TA-V for the purpose of maintaining emergency preparedness proficiency. The first type consists of drills that are conducted to exercise only the TA-V emergency organization; the second type consists of Exercises that exercise the overall SNL/NM emergency-preparedness organization through a coordinated drill involving TA-V and the SNL/NM emergency preparedness organization. Typically, drills are conducted on an annual basis. As part of these drills, table-top and walk-through training sessions for emergency team members may be performed prior to the drill.

Training is provided generally on a practical basis wherein drills are planned and conducted on an annual basis. Additional training is provided for the reentry team in self-contained breathing apparatus, CPR and first-aid training, and practical exercises in the rescue of personnel. The individuals identified as Emergency Supervisors and personnel on the reentry team receive training in ES&H measures (hazardous materials) to identify the problem and affect initial control measures. This training is provided by groups outside the TA-V organizations and is conducted at the First Responder Level. TA-V emergency team members are not trained to control large fires or events involving significant quantities of hazardous materials. Training is primarily directed toward evacuation of the area, accountability of personnel, identification of the source of the emergency, and implementation of initial measures to minimize the consequences of the emergency.

Whenever drills are performed at TA-V for emergency training, a planning group is selected for the purpose of establishing drill objectives and a drill scenario. Drill scenarios are restricted to be consistent with the operations conducted at the facilities within and immediately adjacent to TA-V. Unique drill objectives are defined for each drill. These objectives permit the evaluation of selected parts of the emergency plan by demonstrating adequacy of the plan through actual application. Consequently, objectives are not complicated but provide for a simple and direct means for evaluating compliance. A critique session is conducted following each drill to review the conduct of the drill. Performance of the emergency organization, lessons learned, and changes that may be needed to the TA-V EPP are discussed at the session.

15.4.7 Recovery and Reentry

The TA-V Reentry Team performs only initial assessment, immediate rescue of personnel under certain conditions, and some mitigation where appropriate (e.g., turning off an equipment switch). The TA-V Reentry Team members are certified for use of self-contained breathing apparatus.

A small assortment of materials and equipment is available for the control of the release of hazardous materials, such as small leaks and spills; however, these materials and equipment are intended for use only on a "First Responder" level. TA-V personnel are not trained to respond to emergencies involving hazardous materials to a level higher than this. Similarly, TA-V personnel, including the Emergency teams, will engage only small incipient fires capable of being controlled with local fire extinguishers. They are instructed not to fight structural fires nor to attempt entry into fire areas.

More extensive reentry and all recovery operations are performed by specialized SNL/NM teams in accordance with procedures contained in the SNL/NM EP.

15.5 REFERENCES

B. F. Estes, D. A. Nelson, 1998, *TA-V Emergency Preparedness Plan*, Sandia National Laboratories, Albuquerque, NM, January 1998.

Sandia National Laboratories (SNL), 1999, PN471011, *SNL/NM Emergency Plan, Issue A,* Sandia National Laboratories, Albuquerque, NM, March 1999.

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

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16.0 PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

16.1 Introduction

This chapter addresses the decontamination and decommissioning (D&D) plans and procedures that exist with respect to the SNL TA-V Hot Cell Facility (HCF).

16.2 Requirements

The DOE Orders applicable for the decommissioning and decontamination of the HCF are listed below.

DOE Order 5480.23, Nuclear Safety Analysis Report (DOE 1992), Paragraph 8b(3)(t) of this order, as amplified in Attachment 1, Paragraph 4f(3)(d)20 (Topic 20), requires that the decontamination and decommissioning of the facility be addressed in the SAR.

DOE Order 5820.2A, Radioactive Waste Management (DOE 1988), Chapter V of this order, "Decommissioning of Radioactively Contaminated Facilities," provides guidelines and requirements for the management, decontamination, and decommissioning of radioactively contaminated facilities.

DOE Order 5400.5, Radiation Protection of the Public and the Environment (DOE 1990), Chapter IV of this order presents requirements and guidelines for cleanup of residual radioactive material and the management of the resulting wastes and residues from the facility.

16.3 Description of Conceptual Plans

An ongoing contamination control and monitoring program minimizes the amount of surface contamination that may exist in all areas of the HCF (SNL 1991). (See Chapter 7, "Radiation Protection," for a discussion of the HCF contamination-control program.) In addition, the waste generated during the processing of individual targets will be removed from the SCBs, and packaged for storage and disposal after target processing is complete. Only materials that are used for the processing or handling of multiple targets will remain in the process boxes. The solidified waste, contaminated syringes and glassware, and the empty target tube associated with the processing of targets will be removed at the end of each processing cycle. This ongoing waste removal process will limit the accumulation of waste and radioactive material in the SCBs.

Final decontamination efforts for fixed HCF structures will be facilitated by many design features that exist in the HCF:

- The HCF operating areas (Zones 1, 2A, 2, and 3) are maintained at increasingly negative pressures (from least contaminated to most contaminated) to prevent the spread of airborne radioactive contamination.

- All operations with loose radioactive materials occur in sealed confinement structures, such as the Room 113 gloveboxes, the SCBs, the Steel Transfer Box (STB), or under the Room 113A fumehood. These confinement structures are well ventilated and the exhaust filtered through the HCF "hot" exhaust system. (See Chapter 2, "Facility Description," for a discussion of these and other facility design features that limit the spread of contamination.)
- The SCBs will be routinely cleaned using a closed-loop wash system, reducing the accumulation of contamination.

In addition, the short target irradiation times used during isotope production result only in the generation of low-level waste; no transuranic waste is generated.

If there are no major accidental releases of radioactive material during the remaining life of the HCF, final decontamination activities will be straightforward. All remaining radioactive material and contaminated, removable equipment will be characterized, packaged and transported to an appropriate storage or disposal site, followed by general housekeeping and documenting activities. The most difficult portion of the HCF to decontaminate will be the "hot" ventilation systems (the Zone 1 and 2A systems, including the stack exhaust system). However, inbox filters used during isotope production are intended to reduce the level of contamination in the ducts. If the basement of Building 6580 (which constitutes most of the HCF) is to be decommissioned, the ventilation system exhaust ductwork will most likely be removed rather than decontaminated.

Plans for decontamination of the HCF in response to an accidental release would be formulated subsequent to a detailed assessment of the event. All *in-situ* decontamination of HCF structures and equipment will be conducted in accordance with DOE and SNL radiation-safety and contamination-control policy. All decontamination plans would be submitted through the appropriate unreviewed safety question determination (USQD) channels for approval before implementation.

A fundamental concern of all potential decontamination activities is to minimize the amount of radioactive or otherwise hazardous waste generated. In particular, care will be taken to design decontamination or equipment/structure removal activities to minimize the amount of mixed or high-activity (>200 mR/hr) waste. The ongoing removal of the high activity waste associated with the processing of individual targets will greatly reduce the amount of high activity waste generated during final facility decontamination.

Specific Hot Cell design features that help to reduce the amount of routine contaminations required include the following:

- airflow through the ventilation zones in the HCF is from lowest area of contamination to the highest;
- the airlock between the Zone 2A canyon and Zone 2 serves to limit the release of contamination from the areas of highest contamination;
- the Zone 1 in-box particulate filters limit the contamination of downstream ducting;
- the Zone 2A canyon ventilation exhaust HEPA filter limits the contamination of downstream ducting;
- the process boxes are constructed of stainless steel;
- the box wash down system will be used to remove contamination on a regular schedule;

- epoxy paint used in the Facility will make contamination removal easier and will reduce the penetration of contamination;
- trays and absorbent material under process equipment will reduce the spread of contamination from drips and spills and protect the surface of the process boxes;
- bermed segments in the Zone 2A canyon will reduce the spread of contamination if spills occur;
- alpha seals on the windows will reduce the spread of contamination to rooms adjacent to the Zone 2A canyon and the process boxes when the windows are pulled for maintenance;
- epoxy seals on floors will reduce the penetration of contamination; and
- stainless steel ventilation ducting will reduce the penetration of contamination.

In addition, the experience gained during the extensive HCF decontamination efforts accomplished during the period 1995 to 1998 resulted in the identification of a number of commercially-available products for use in decontamination activities that do not result in the generation of hazardous or mixed wastes. Techniques and low-cost equipment that are especially effective for decontamination in the HCF were also identified. During that effort, contamination levels in some areas of the HCF were reduced from millions of dpm/100 cm^2 to much lower levels, and a large quantity of material was free-released. All waste generated as part of HCF decontamination activities will be properly characterized, stored, and ultimately disposed according to SNL and DOE waste management requirements.

16.4 REFERENCES

Sandia National Laboratories (SNL), 1991, *Sandia National Laboratories Radioactive Contamination Control and Monitoring Program*, PG470144, Issue A, Sandia National Laboratories, Albuquerque, New Mexico, February 3, 1991.

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

U.S. Department of Energy (DOE), 1990, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5 (Change 2: January 7, 1993), U.S. Department of Energy, Washington, D.C., February 8, 1990.

U.S. Department of Energy (DOE), 1992, *Nuclear Safety Analysis Reports*, DOE Order 5480.23 (Change 1: March 10,1994), U.S. Department of Energy, Washington, D.C., April 30, 1992.

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17.0 MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 Introduction

The purpose of this chapter is to describe safety management policies and programs, other than those described in Chapter 11, "Conduct of Operations," and Chapter 7, "Radiation Protection." It focuses on how safety issues are identified, communicated, managed, and resolved by the SNL/NM organizations responsible for facility design, construction, and operation of the HCF. Interfaces between support organizations and operating organizations are described. The ES&H Manual, MN471001 (SNL 1998d) contains relevant supplemental information. Sufficient information on SNL/NM safety management policies and programs is provided to demonstrate that facility management is committed to a safety conscious environment.

17.2 Requirements

This section identifies the principal requirements, standards, and criteria applicable to the HCF management, organization, and institutional safety infrastructure. The Requirements sections of the orders formally delegate responsibility to the DOE contractor management (SNL/NM line management) to develop, implement, and document programs to ensure that specific institutional safety responsibilities are recognized, provisions are established, and activities are performed. The following are the principal DOE requirements:

36 CFR Chapter XII, Subchapter B and DOE G 1324.5B (DOE 1996), Records management and disposition.

DOE Order 4330.4B (DOE 1994a), Maintenance management at the facility.

DOE O 420.1 (DOE 1995b), Facility Safety.

DOE O 232.1A (DOE 1997), Occurrence reporting and processing of operations information.

DOE Order 5480.19 (DOE 1990), Conduct of operations (including administration, communication, philosophy and standards for excellence in operations, and the identification, management, and resolution of safety and operational issues.

DOE Order 5480.20A (DOE 1994b), Selection, qualification, training, and certification of operators.

DOE Order 5480.21 (DOE 1991b), Discovery communication, and determination of proper review level of unreviewed safety questions.

DOE Order 5480.22 (DOE 1992a), Derivation of Technical Safety Requirements.

DOE Order 5480.23 (DOE 1992b), Derivation of a facility Safety Analysis Report.

DOE O 151.1, Chg. 2 (DOE 1995a), Comprehensive Emergency Management.

10 CFR 830.120 & DOE Order 5700.6C (DOE 1991a), Quality Assurance; actions which provide confidence that items and processes meet or exceed requirements and expectations.

Additional standards and criteria that apply to the HCF are tabulated in GN470089, "Risk Management Requirements for Moderate- and High-hazard Nonnuclear, Accelerator, and Nuclear Facilities" (SNL 1996). In accordance with this document, Line Management is responsible for:

- Ensuring that the Laboratories' Environment, Safety, and Health (ES&H) policies are followed;
- Ensuring that SOPs are developed for operations that involve significant hazards;
- Inspecting work areas on a regular basis;
- Investigating unusual occurrences;
- Being knowledgeable about applicable regulations and coordinating activities to assure compliance; and
- Maintaining appropriate documentation to demonstrate compliance and effectiveness of the Laboratories' ES&H Program.

The SNL Laboratory Standards Department maintains a file of previous assessments and analyses of compliance with DOE order requirements. This file documents the status of HCF compliance and identifies the order expert, the facility expert, and the implementing documentation for each requirement. The file is being maintained in response to the Defense Nuclear Facility Safety Board recommendations. See Section 17.3.3.3 for more discussion about the role of the Laboratory Standards Department in providing compliance assurance information and support.

17.3 Organizational Structure, Responsibilities, and Interfaces

17.3.1 Operations

Responsibility for the safe operation of the facilities, the Safety and Health of the employees and the public, and protection of property and the environment resides with the Executive Staff and line management at all levels. This responsibility is fulfilled with the same commitment and accountability afforded all other primary responsibilities in the Lockheed Martin DOE Contract.

17.3.2 Organizational Structure

The Hot Cell Facility is operated by Sandia National Laboratories through Lockheed Martin, a prime contractor of the United States Department of Energy (DOE).

The general management organization for the Hot Cell is illustrated in Figure 17.3-1. Direct responsibility for safe operation of the facility rests with the HCF Manager. Support for the HCF is divided along the areas of compliance with DOE Orders. That is, an organization is normally assigned to implement a particular support activity for the HCF (e.g., facility safety) which is covered by a specific DOE Order (e.g., DOE O 420.1). Table 17.3-1 identifies the major SNL/NM organizations providing support to the HCF.

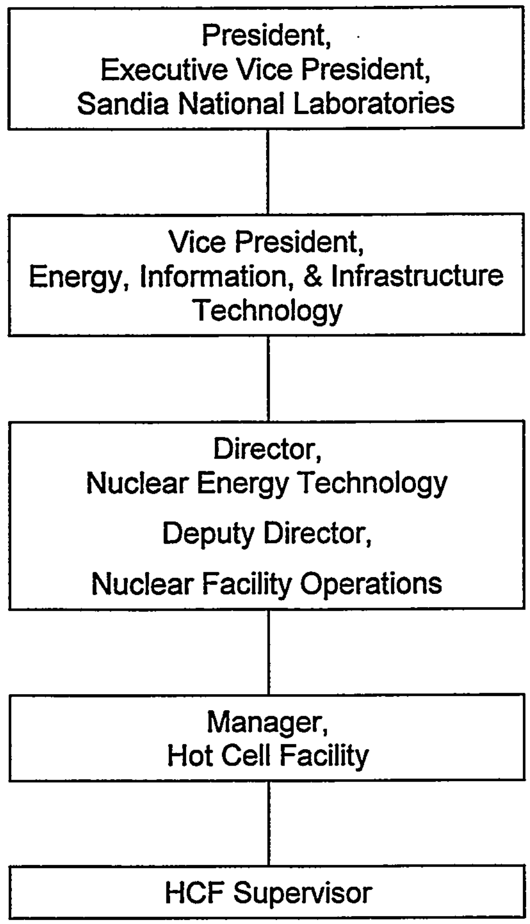

Figure 17.3-1. Management Organization for the Hot Cell Facility

Table 17.3-1. SNL/NM Support Organizations

Organization	Support Functions
Environmental and Emergency Management Department	NESHAPS (Air Emissions) Compliance
Appraisal Management Office	Audit Issues Data Base
Solid and Hazardous Waste Management Department	Chemical Waste Disposal
Laboratory Standards Department	DOE Order Compliance Determination
Environmental and Emergency Management Department	Emergency Preparedness Compliance
Compliance & Metrics Department	Performance Indicators
Facilities Management Center	Compliance with Design Criteria
Nuclear Facility Support Department	Training Program
ES&H Teams and Risk Management Department	Worker/Workplace Chemical Safety
Nuclear Facility Support Department	Quality Assurance
Hot Cell Facility Department	Computer Code Calculations
Medical Clinic Department	Medical Surveillance
Facilities Operations and Engineering Center	Utility Service (Electricity, Water)
ES&H Teams and Risk Management Department	Health Physics Services
Personnel Monitoring and Laboratory Services Department	Health Physics Instrumentation, Health Physics Training
Radioactive and Mixed Waste Management Department	Radioactive Mixed Waste Disposal
ES&H Teams and Risk Management Department	Interface with DOE, Compliance, USQD
ES&H Teams and Risk Management Department	Industrial Safety/OSHA Compliance
Environmental and Emergency Management Department	Water Quality Issues

17.3.3 Organizational Responsibilities

The safe operation of the HCF is governed by DOE O 420.1 (DOE 1995b). Operations are the responsibility of the Hot Cell Facility Department Manager. This department has responsibility for the conduct of operations (DOE Order 5480.19, DOE 1990), maintenance management program (DOE Order 4330.4B, DOE 1994a), assuring that training is conducted in accordance with provisions of DOE Order 5480.20A (DOE 1994b), and servicing the needs of experiments (customers). Training is coordinated by the TA-V Training Coordinator, who reports directly to the Nuclear Facility Support Manager. Health Physics services are provided by the Division 6000 line support team in the ES&H Teams and Risk Management Department.

17.3.3.1 Technical and Engineering Support, Maintenance, and Modifications

Technical and engineering support is provided by TA-V analysts and designers. Maintenance and modifications of the equipment is performed by the facility operators, except for a major construction or modification or skilled craft work requiring a qualified plumber, electrician, or carpenter. If work on safety systems is performed by non-operators, the work is overseen by the operators and a checkout of the safety system is performed by the operators at the conclusion of the work to assure that the system(s) operates within specifications before operations are resumed. Facility Modification Requests (FMRs) are reviewed by an independent safety review committee, the Radiological and Criticality Safety Committee (RCSC), so that potential safety concerns are identified and referred to the proper level of line management or the DOE for resolution and approval.

17.3.3.2 Safety and Compliance Issue Identification, Management, and Resolution

Safety is a line responsibility that is shared by the operators, facility supervisor, facility manager, Director, and Vice President. The staff is procedurally trained to understand and obey the Technical Safety Requirements (TSRs) of the facility. If plant conditions change such that TSRs are threatened by operations, experiments, equipment failures or external forces, then operations are immediately terminated to minimize the possibility of a TSR violation and a potential unanalyzed or unsafe condition. The Hot Cell Facility Periodic Maintenance/ Surveillance Operating Procedure (SNL 1997c) requires periodic inspection and checkout of important safety equipment and safety system settings to minimize the chance of "undetected" degradation of safety equipment that could lead to a safety function failure.

Staff personnel are encouraged to identify potential safety issues and to report problems and concerns directly to the HCF Manager. Off-normal occurrences, unusual occurrences (including TSR violations), and emergencies are reported to the DOE in accordance with Chapter 18 of the SNL ES&H Manual (SNL 1998d), which satisfies the requirements set forth in DOE O 232.1A (DOE 1997). Chapter 18 contains the requirements, instructions, and procedures for reporting and investigating ES&H-related events (e.g., operational emergencies, equipment failures or malfunctions, spills or releases of hazardous materials, contamination of work areas, procedure or program deficiencies, etc.). ES&H Manual Supplement GN470036 (SNL 1997b) provides the details for performing root cause investigations and for developing and implementing appropriate corrective actions.

External audits (by DOE/Albuquerque Operations, for example) and internal audits and appraisals are conducted on a periodic basis on the following topics:

- Inspection and Evaluation (I&E);
- Criticality Safety;
- Radiation Protection;
- SNM Materials Accountability;
- Industrial Safety;
- Industrial Hygiene;
- Quality Assurance;
- Technical Safety Appraisal Criteria; and
- Records Management.

These audits and appraisals provide an important element of compliance evaluation leading to improved compliance.

SNL/NM maintains an audit issues database to track the closure of external audit "findings." TA-V also maintains local action item databases to track closure on action plans developed to close audit findings as well as items identified by local safety committees like RCSC. Reports for each of these databases are issued periodically to responsible individuals to remind them of due dates on these items.

The SNL Compliance & Metrics Department tabulates a set of Performance Indicators (PIs) for SNL/NM facilities and issues a quarterly report to track trends and provide data for analysis on these PIs. The PIs with particular applicability to HCF operations include personnel radiation exposures, low-level radioactive waste generation, reportable releases to the environment, DOE reportable occurrences, and Price Anderson Amendments Act violations.

Compliance determination for all applicable DOE Orders is provided by the self-assessment formalism prescribed by the Laboratory Standards Department. This department acts as a liaison between the DOE and key individuals at SNL/NM who act as the Order Experts responsible for implementing the Orders at the various facilities. The Laboratory Standards Department documents the requirements, documents how SNL/NM organizations implement the requirements, and reports on the SNL/NM compliance status to DOE/HQ.

The ES&H Teams and Risk Management Department is responsible for assuring the DOE that SNL/NM line organizations systematically manage risk and comply with all applicable orders and regulations dealing with safety. This department insures that nuclear facility safety documents (e.g., Safety Analysis Reports and Technical Safety Requirements) are properly reviewed, provides guidelines and risk-acceptance criteria, integrates information from the line organizations into databases, and provides DOE liaison and support. The ES&H Teams and Risk Management Department is the point of contact at SNL/NM for receiving DOE ES&H regulations and transmitting back to the DOE formal commitment documents in fulfillment of those regulations.

The Environmental and Emergency Management Department is responsible for ensuring that SNL/NM line organizations comply with NESHAPS (air emission) regulations (40 CFR 61).

17.3.3.3 Sandia Independent Review and Appraisal System

The Sandia Independent Review and Appraisal System (SIRAS) has been established to provide enhanced safety in nuclear facility operations and to ensure compliance with DOE orders. The SIRAS, composed of the Nuclear Facilities Safety Committee (NFSC) and its subordinate groups [including the Radiological and Criticality Safety Committee (RCSC) for the HCF], provides independent and objective safety review to advise line management on safety matters for activities at the TA-V nuclear facilities. The SIRAS makes recommendations to line management on these matters and also conducts annual appraisals of the TA-V nuclear facilities. The subordinate safety committees have been established to provide safety review by individuals who are most directly involved with the activities being reviewed and to assure that items brought to the NFSC have had the benefit of detailed review by on-site specialists.

The NFSC is chartered by and directly responsible to the Vice President with line responsibility for the TA-V nuclear facilities, the Energy, Information, and Infrastructure Technology Division. The NFSC acts in an advisory capacity to the line director responsible for the nuclear facilities. The subordinate facility safety committees (e.g. RCSC) are authorized to make recommendations to line management regarding the safety of matters that satisfy general criteria that have been reviewed by the NFSC and are delineated in the subordinate safety committee charter.

The RCSC is the basic internal safety review committee for HCF activities, providing an independent safety review of proposed activities and facility modifications. The committee acts in a advisory capacity to line management, and conducts reviews as set forth in an operational committee charter approved by the SNL Deputy Director, Nuclear Facility Operations. The RCSC ensures HCF operations are based on sound engineering principles and are maintained within the approved Technical Safety Requirements (TSRs).

The structure and assigned responsibilities of these SIRAS committees assures an independent examination of significant HCF activities from administrative and operational viewpoints. Interface between the two safety review committees is shown in Figure 17.3-2.

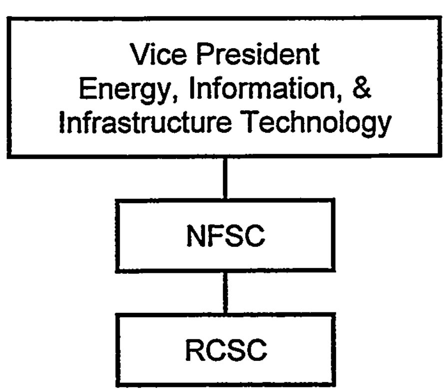

Figure 17.3-2. Safety Review Committee Interfaces

17.3.3.4 Safety-Analysis Services, Including Safety Evaluation Process

Safety-analysis capabilities are contained within the Nuclear Facility Operations and Nuclear Technology Programs organizations. These organizations produce Safety Analysis Reports for both reactor and nonreactor nuclear facilities, primarily in TA-V. Other organizations provide specialized safety-analysis support in the form of mechanistic accident-progression analysis, heat transfer, structural analysis, neutron transport, nuclear criticality safety, and other areas upon request.

The RCSC performs detailed technical reviews of safety-analysis documents and Unreviewed Safety Question (USQ) safety evaluations and makes recommendations to HCF line management. The procedure for implementing the USQ process at SNL nuclear facilities is titled, "Implementing the Unreviewed Safety Question (USQ) Process for Nuclear Facilities" (SNL 1997a). This procedure describes responsibilities, procedures, and records management requirements for identifying and addressing potential unreviewed safety questions at nuclear facilities. The ES&H Teams and Risk Management Department ensures that the USQ process is implemented properly.

17.3.3.5 Support Services: Utilities and Other Off-Site Support

Utility service is coordinated through the Facilities Operations and Engineering Department. Electrical service into the area is from either of two feeder stations. Water is currently supplied through a 254-mm (10-in.) diameter pipe, which loops around the area. The water mains are controlled by the Air Force. This system permits service to most of the area even if a segment is valved out for maintenance or repair. Additional details on utility service can be found in Chapter 2.

17.3.3.6 Design and Construction

Design criteria for nonreactor nuclear facilities are found in DOE Order 420.1. The HCF was constructed prior to the issuance of this order, but future modifications to the facility are governed by this order. The Facilities Management Department is the primary organization responsible for assuring compliance with this order.

17.3.3.7 Emergency Planning

The TA-V Emergency Plan (the Plan) describes the structure of the TA-V Emergency-Response Organization (SNL 1998a). The Plan contains procedures for responding to different types of emergencies. It also describes the types of emergency equipment and systems that support the emergency-response organization. The Plan was written to satisfy the requirements of DOE O 151.1, Change 2 (DOE 1995a).

The Plan is an integral part of SNL's Emergency Preparedness Program (EPP), as described in Chapter 15. The EPP implements a laboratory-wide emergency-response field-management organization operating as the Incident Command Structure, modeled after a national standard for emergency response organizations (such as city fire and police).

17.3.4 Staffing and Qualifications

Entry-level requirements for Hot Cell Facility operating personnel are intended to assure that these personnel have the knowledge, skills, and abilities to operate and maintain the Hot Cell Facility. This includes operating and maintaining related support systems and process equipment in a safe and reliable manner under all conditions. The minimum education and experience requirements for Manager, Facility Supervisor, Hot Cell Operator, technical support staff and technicians are provided in the Training Implementation Matrix (SNL 1997d) for the Technical Area V Nuclear Facilities. Briefly, a Bachelor of Science in Engineering or Science plus one year nuclear facility experience are the minimum requirements for Manager, Facility Supervisor, and Technical Staff Member positions. Operators and technician positions require a minimum of a high school diploma plus 1 year job-related practical experience.

For isotope processing operations, the staffing for each shift would typically include the following:

- One HCF Supervisor;
- One HCF Operator;
- A process operator for active process stations;
- Several (up to 3) personnel to help the operators complete processing procedures (bring targets and chemicals into the facility, perform some processing steps, process and store waste, perform quality assays, ship and package products and supplies, etc.); and
- A radiological control technician.

Technical staff, including a process engineer, quality engineer and safety engineer will also be available to support operations. Appropriate numbers of operators and technicians will be available to cover double shifts, training periods, and vacations.

The Facility Supervisor and Hot Cell Operators are qualification positions requiring successful completion of a formal training program before an individual is allowed to operate specific HCF equipment and/or controls unsupervised. Proficiency for the qualified positions is demonstrated by minimum acceptable scores on written tests and by observation of the individual's operating skill with manipulators, production process equipment, and plant safety equipment and safety systems. Qualification also requires demonstrated adherence to conduct of operations principles, ability to follow procedures, and commitment to cultivating an environment of teamwork and continuous improvement. Staff contributions to improvement of procedures and processes are actively encouraged as a way to enhance the safety and work culture.

Staff members who perform and document analyses for the SAR and TSR are experienced nuclear engineers with advanced degrees (e.g., M.A., M.S., or Ph.D.). Likewise, the members of RCSC are familiar with nuclear facility operations and usually have advanced degrees in nuclear engineering or radiation protection. The committee membership includes personnel with extensive experience in performing criticality safety calculations or criticality experiments.

17.4 Safety Management, Policies, and Programs

This section describes a safety philosophy and various policies and programs that support safety management. Some of these programs have been described in more detail in other chapters, but not necessarily in the context that we wish to convey here. Sandia has operated the HCF safely since 1978. This safety record stems from the application of the following principles:

- Defense in Depth Design. To compensate for potential human and mechanical failures, a defense-in-depth concept is implemented in the design of the HCF and its safety systems.
- Administrative Controls. Appropriate administrative controls are used for personnel selection, training, documentation of plans and procedures, quality assurance, rigid enforcement of Technical Safety Requirements, and independent safety controls.
- Technical Surveillance. The HCF staff has in-depth understanding of the HCF and its operations, safety systems, and safety issues. The operators perform regular surveillance and periodic maintenance as required by the TSRs to assure that the facility is operating in a safe and efficient manner. Also, TA-V has a cadre of technical experts who provide additional technical support for the facility.
- ALARA. All activities in Area V maintain operational exposure As Low As Reasonable Achievable consistent with programmatic and cost constraints.
- Quality Assurance. The Quality Assurance Program for HCF operations is documented in the Sandia Research Reactor and Experimental Programs Quality Assurance Program Plan (QAPP, SNL 1996b). The QAPP is used in conjunction with facility operations procedures to collectively satisfy the requirements of 10 CFR 830.120.
- Conduct of Operations. The conduct of operations program for the Hot Cell Facility is documented in the TA-V Conduct of Operations Manual (SNL 1998c). The manual procedures comply with the requirements of DOE Order 5480.19 (DOE 1990) and serve as the instrument for implementation of the Order.
- Risk Management. The ES&H Teams and Risk Management Department has developed a process for categorizing and managing risk across the laboratory. The process is described in Chapter 13 of the ES&H Manual.

17.4.1 Safety Review and Performance Assessment

The operators and line management are primarily responsible for the safe operation of the HCF. Procedures written by the line organization ensure that activities are reviewed by TA-V management and the appropriate safety committee. Procedures implement the Conduct of Operations principles as prescribed in DOE Order 5480.19 (DOE 1990). These procedures address all aspects of safe operation, configuration control, review and approvals, assignment and transfer of responsibilities, and performance assessment by management. Additional information on Conduct of Operations is found in Chapter 11.

Management also assesses performance by using reports from the TA-V Action Item Tracking System as a management tool to monitor progress on self-assessment or externally identified deficiencies. The system tracks progress on (1) closing out safety committee (or line-initiated) action items and (2) completing tasks from action plans developed to eliminate the root causes of findings assessed on external audits and appraisals.

Requirements for an independent review and appraisal system for nuclear facilities were originally contained in canceled DOE Order 5480.6 (DOE 1986). These requirements were implemented by means of the Sandia two-tiered independent safety review, as described in the NFSC and RCSC charters. The RCSC performs an annual review of HCF operations that involve radiological and criticality safety, and advises the line organization (responsible for the safe operation of HCF) on these matters. Additional information on the NFSC and the RCSC can be found in Section 17.3.3.3.

The ES&H Teams and Risk Management Department is the interface (Point of Contact) between the HCF and the DOE on risk management-related requirements and safety documentation.

17.4.2 Configuration and Document Control

The TA-V Conduct of Operations Manual contains requirements for identifying and controlling important safety-related documents under the control of the Deputy Director, Nuclear Facility Operations. Configuration control is accomplished by line organization procedures, which require that all proposed changes, major modifications, and USQ safety evaluations must be reviewed by the RCSC and approved by the line manager. The RCSC charter requires the committee to review (a) safety-related modifications to the facility, (b) operating procedures, or (c) experiments with potential for altering safety systems or operating parameters. This review ensures that proposed changes do not compromise the safety margins defined by the Technical Safety Requirements.

Copies of Hot Cell Facility documents and records (e.g., SAR, TSR, operations logs, maintenance logs, and experiment logs) and external audit reports and action plans in response to those audit reports are maintained in the TA-V Nuclear Facilities Document Collection library in Building 6588.

The current policy for retention of HCF records is uniform and consistent for all of the nuclear facilities within the Nuclear Facility Operations organization. That policy, as stated in the Hot Cell Facility TSRs, is that records in the following categories shall be maintained for <u>at least</u> six years:

- Maintenance activities on all safety systems
- Surveillance activities required by the TSRs
- Fuel inventories and transfers
- Experiment plans

Further guidance for retention of many different types of records, as compiled from DOE Orders for DOE records' schedules, is given in Table 17.4-1. The retention period for training and test records is one training cycle (2 years). The requirement for the 6-year record retention of the bulleted items above stems from DOE Order 5480.6 (DOE 1986). The 6-year retention period is 1 year longer than required by ANSI/ANS Standard 15.1-1990 (ANS 1990), a widely-used standard for research reactor facilities.

Table 17.4-1. Guidelines for Records Retention from DOE Orders

Description	Retention Period
Training Records	One cycle (2 years)
Narrative Logs	Life of the facility
Maintenance Logs	6 years
Experiment Records	6 years
Surveillance Activities in Compliance with TSRs	6 years
Audit Records and Meetings	6 years
Drawings of the Facility	Life of the facility
Fuel Inventories	Life of the facility
Gaseous and Liquid Effluent Releases	Life of the facility
Reportable Occurrences	75 years
Radiation and Contamination Surveys	75 years
Personnel Radiation Exposure Records	75 years

The retention period for narrative logs, facility drawings, routine release records or estimates, and fuel inventories is the "life of the facility." The retention period for other records, such as unusual occurrence reports involving releases to the environment, contamination, and personnel exposure dose records, is 75 years.

17.4.3 Occurrence Reporting

Requirements are specified by DOE O 232.1A (DOE 1997). These requirements are implemented by the means of Chapter 18 of the SNL ES&H Manual (SNL 1998d) and ES&H Manual Supplement GN470036 (SNL 1997b). Additional information on occurrence investigation and reporting is found in Chapter 11.

17.4.4 Safety Culture

Sandia National Laboratories is committed to performing work safely and ensuring the protection of workers, the public, and the environment. SNL is also committed to performing work effectively and efficiently, ensuring that the customer receives the best possible value for each dollar spent by having minimum overhead loads and effective management practices. To help meet these commitments, SNL has developed and is implementing an integrated safety management system (ISMS). This safety management system follows seven guiding principles to ensure that:

- Line management is responsible for the safety of workers and the public and protection of the environment.
- All organizations establish clear roles and responsibility for safety.

- Sandia effectively allocates resources to safety, programmatic, and operational considerations.

- Workers' competence matches their responsibilities.

- Sandia identifies safety standards and requirements that fit the work hazards.

- Hazard controls fit the work being performed.

- SNL and DOE agree on conditions required to start and do work.

These guiding principles are implemented by applying the following five safety management functions to all corporate and facility-specific programs:

- Define the scope of work.

- Analyze the hazards.

- Develop and implement hazard controls.

- Perform work within controls.

- Provide feedback and continuous improvement.

Ultimate responsibility for ES&H resides with the executive staff and line management at all levels. This responsibility is fulfilled with the same commitment and accountability afforded all other primary responsibilities. All line Managers are charged by the President, Sandia National Laboratories to ensure that the Laboratories' ES&H policies are followed within their organizations and that all employees are aware of and adhere to all ES&H procedures related to their operations and tasks, including how to respond to emergencies.

SNL/NM deems the protection of human life and health and the environment to be among its primary responsibilities. Accordingly, Sandia designs products and conducts operations with the highest regard for the safety and health of its personnel, contractors, and the public and for the protection and preservation of the environment. Concern for environment, safety and health (ES&H) is built into programs, from planning to completion. The aim is not simply to comply with legal requirements but to strive actively to reduce risks to the lowest reasonable levels for employees, contractors, the public, and the environment. The details of this commitment to ES&H are contained in (SNL 1998d).

Sandia's ES&H requirements are derived from federal, state, and local laws and regulations, DOE directives, and internal SNL/NM best practices. The ES&H support organizations interpret ES&H requirements, provide resources aimed at communicating and clarifying those requirements, and assist the rest of SNL/NM in developing programs and procedures necessary to implement the requirements. The means by which the ES&H support organizations communicate requirements applicable to operations at SNL/NM is through the ES&H Manual and its supplements.

In accordance with SNL/NM policy, TA-V holds periodic safety meetings to communicate important safety information, report on safety inspections, and allow opportunities for open discussion of important safety matters.

17.5 REFERENCES

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APPENDIX 3A

PRELIMINARY HAZARD CHECKLIST

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Introductory Material

Preliminary Hazard Checklists (PHCs) are used to identify hazards that exist for a specific HCF location as part of the isotope processing activities (e.g., hot cell laboratory, quality control laboratory, etc.) or radioactive material storage location. A PHC is a location-based form of assessment; that is, the facility is first subdivided into several distinctly separate locations or entities, then process-related hazards specific to each facility segment are identified. PHCs document energy sources and hazardous materials, potential accident initiators, and preventive or mitigative systems or practices present in each facility location.

For the purpose of the PHCs, four generic facility locations in the Building 6580 basement HCF were considered: 1) the hot cell laboratory for remote, shielded handling of radioactive material; 2) the quality control laboratory for analysis of isotope products; 3) the isotope product packaging and shipping area; and 4) the radioactive waste storage area. The PHCs also considered the several HCF associated radioactive material storage areas:

- Each of the monorail storage holes adjacent to Building 6580,
- The Building 6596 east high bay, and
- Building 6597 high bay.

Information on the four generic facility locations for the Building 6580 basement HCF was reported on first set of the six data forms that comprise the PHC. Information on the HCF associated radioactive material storage areas was reported on the second set of PHC data forms.

The six PHC data forms are designed to capture information on a variety of hazards for each location or entity considered. The six PHC data forms are titled:

- General Information.
- Radiological Hazards.
- Fire Hazards.
- Explosive Hazards.
- Toxic Hazards.
- Industrial/Other Hazards.

Standard industrial hazards (e.g., electrocution, handling accidents) are developed in the PHCs only to the extent that they are initiators and contributors to accidents that could potentially lead to the release of hazardous or radioactive material. Although major, non-contributory industrial accidents are identified in the PHCs, these hazards are screened from further evaluation.

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PRELIMINARY HAZARD CHECKLIST

DATA FORM 1	GENERAL INFORMATION

SNL facility name: **Hot Cell Facility (6433)** Date: **3/4/98**

Facility segment location: **Building 6580, Technical Area V, Sandia National Laboratories, Kirtland AFB, Albuquerque, NM**

Facility (unique identifier): **Isotope production facility for chemical separation and purification of medical isotopes as part of the DOE Isotope Production and Distribution Program.**

SNL operations contact: **Jeffrey S. Philbin** Phone: **505-845-9036**

PHC completed by: **Rob Naegeli** Phone: **505-845-3233**

Briefly describe the facility segment being reviewed: **Facilities segment consists of 1) the hot cell laboratory for remote, shielded handling of hazardous material, 2) the quality control laboratory for analysis of isotope products, 3) the isotope product packaging and shipping area, and 4) the process radioactive waste storage area.**

Identify major process-related equipment: **Forklift, crane, elevator, shield doors, remote manipulators, chemical processing glassware and hardware, quality control testing glassware and hardware, radioactive waste packaging and barrels, waste carts and associated remote movers (mules), irradiated isotope production target cask, quality sample shielding pigs, isotope product shipping containers and leak check equipment.**

Identify possible safety-related systems, structures, or components: **Radiation shielding of the hot cell laboratory shielded support area and steel confinement boxes, HCF ventilation system, shielded glove box and ventilation hoods of the quality control laboratory, and shield doors of the process radioactive waste storage area.**

Describe adjacent facility or area hazards: **Adjacent Technical Area V storage facilities may contain stored nuclear or hazardous material. In addition, adjacent nuclear reactor facilities may contain nuclear radiological or fissile material.**

List safety documents (e.g., SAR, TSRs, BIO, SA, SOPs) covering this location: **SAND94-2650 (12/31/96), SP473347, SNL7A00124-001, and SAND88-1723 (12/88, revised 8/97). (These** old documents were consulted for information only in developing the new HCF SAR.)

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PRELIMINARY HAZARD CHECKLIST

DATA FORM 2	RADIOLOGICAL HAZARDS

I. HAZARDS

Instructions: Please list below each radiological hazard that exists at the facility location. Radiological hazards are a combination of (1) the material and (2) an initiating event. For example, one type of radiological hazard could be a spill involving 20g of Pu-239 caused by fatigue failure of a container. Additional notes could identify that the plutonium is in a powder form and that the spill would most likely occur immediately outside the glove box transfer port. Attach additional sheets if more space is required to document radiological hazards.

Hazard	Type/quantity of material involved	Initiating Events	Additional Notes
Direct radiation exposure	-Irradiated isotope production target, up to 20,000 curies -Fresh waste barrel, up to 120,000 curies -Entire waste inventory, up to 500,000 curies	-Forklift accident -Mishandling during waste storage -Combined mechanical failure and human error	Direct exposure to these radiation hazards is normally prevented by radiation shielding.
Spill of process, product, or quality sample liquids	-Entire or multiple targets or process residues at up to 20,000 curies each -Entire isotope product shipment, up to 1,000 curies	-Breached container -Fatigue failure of container -Mishandling/procedural violation -External event	The irradiated target activity is liquefied in the shielded hot cell laboratory. Only product and quality samples emerge as liquid. Process residue is solidified.
Airborne radioactive release	-Volatiles in process cold traps, up to 5,000 to 70,000 curies	-Fatigue failure of container -Mishandling/procedural violation -Loss of liquid nitrogen supply -External event	Local or central cold traps use liquid nitrogen and vacuum to trap process volatiles. Warming or venting before minimum decay could release excess volatiles.
Criticality	^{235}U in cement waste, up to 68 kg	-Flooding of Room 109 -Gross procedural error -Gross rearrangement of fissile material	Transportation requirements limit each waste barrel to no more than 350 g of ^{235}U in the cement waste containers. The waste storage area, Room 109, holds up to 180 barrels.
Contamination	Process fission products and actinides	-Overpressure in steel confinement box (SCB) -External event -Breached container	Liquid nitrogen for cooling in SCBs may leak or otherwise evolve N2 gas forcing out the manipulator boots.
Overexposure	-Larger product quality sample or production targets -Scattered radiation from radioactive waste storage	-Mishandling/procedural violation	-Shielded glove box may not reduce dose enough. -Scatter is through Zone 2A airlock doors.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are fixed radiation monitors used? Yes ☑ No ☐ If yes, describe type, quantity, and location: **Radiation monitoring systems warn of unsafe radiation conditions and verify by measurement that a safe radiation environment is maintained within the HCF. Continuous air monitoring systems and remote area monitoring systems in the vicinity of the SGB and ventilation hoods warn workers if gamma dose rates or airborne contamination rates exceed set levels. Remote area monitoring systems in the vicinity of the Zone 2A airlock entrance in Room 112 warn workers if scattered gamma dose rates exceed set levels.**

Are portable radiation monitors used? Yes ☑ No ☐ If yes, describe type and how used: **Area radiological control technicians monitor the fixed radiation monitor systems and use portable hand held gamma monitors to verify that safe conditions exist at key points in the process.**

Are criticality monitors present? Yes ☐ No ☑ If yes, describe type, quantity, and location:

Describe radiation shielding: **The hot cell laboratory shielded support area and SCBs combined shielding provides protection against direct radiation dose to workers. A combination of added shielding and administrative controls to restrict entry protects against scattered radiation near the entrance to the Zone 2A airlock in Room 112.**

Describe special clothing or respiratory protection required:. **Appropriate gloves and other personnel protective equipment are used when working in the ventilation hoods with the low activity, product dilution samples. Anticontamination clothing and respirators may be required when entering Zone 2A for maintenance.**

Other radiation protection information/issues: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) any radiological incident (e.g., spill, criticality, contamination event, etc.)? Yes ☑ No ☐ If yes, please describe: **The HCF has not previously experienced any major accidents or hazardous situations (e.g., fires, explosions). Minor contamination events of personnel and equipment have occurred in Zone 2 that were satisfactorily resolved by removal of the contamination. Some spills in the shielded hot cell laboratory steel confinement boxes during isotope production process verification and development tests did not result in large releases and were mitigated using established spill control and cleanup equipment and procedures.**

PRELIMINARY HAZARD CHECKLIST

PRELIMINARY HAZARD CHECKLIST

DATA FORM 3

FIRE HAZARDS

I. HAZARDS

<u>**Instructions:**</u> Please list below the fire hazards that exist at the facility location. Fire hazards are a combination of (1) an ignition source, and (2) combustible material. For example, and ignition source could be an electrical outlet inside of a glove box and the combustible material could be 50 ml of organic solvents collocated in the glove box. Additional notes could describe the likelihood of propagation, fire barriers, etc. Attach additional sheets if more space is needed to document fire hazards.

Ignition Source	Type/Quantity of Combustible Material	Additional Notes
Forklift energy sources (e.g., hot brake pads, battery failure, electrical system failure, collision, etc.)	Hydraulic oil, diesel fuel, gasoline, propane fuel	Irradiated isotope production target shielding casks are not combustible but heat of a fire could pressurize the target. Some forklifts in HCF are electric so no fuels present.
Facility electrical system	-Absorbent material for spill clean up in SCBs, SGB, or ventilation hoods -Electrical insulation of motors in process equipment, etc. -Product transportation packaging over pack	-Organic solvents are not used in even moderate quantities in the HCF for isotope production or quality analysis. -Water based cleaner used for decontaminating product transportation packaging.
Spontaneous combustion	Limited combustibles in waste or other process containers.	Spontaneous combustion is unlikely.
Lightning strike	Building 6580 structure	Building 6580 is equipped with a lightning protection system (not maintained). Building fire protection system would suppress the spread of fire to the basement HCF.
Vehicle accident (outside HCF)	Vehicle fuel tank contents; miscellaneous vehicle combustibles	No threat to Building 6580. The drain grating would catch combustible liquids draining down the truck ramp to HCF.
Adjacent accidents (aircraft crash, adjacent facility fire/explosion)	Jet fuel; combustible contents of adjacent facilities	

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are heat/smoke detectors present? Yes ☐ No ☑ If yes, describe type and location:

Is there a suppression system? Yes ☑ No ☐ If yes, describe type, layout, capability, etc.: **Buildings 6580 and 6581 are provided with automatic, fire protection sprinkler systems throughout, except the Zone 1 SCBs and Zone 2A where water sprinklers would create a hazard. Zone 2A is equipped with manual AFFF fire suppression systems. The Zone 1 SCBs do not have fire suppression systems of any kind but they do have inherent fire dampers between the SCBs and the rest of the HCF due to their heavy steel wall construction. In addition, the low ventilation flow rate through the SCBs and the relatively small box size will limit the oxygen available to sustain an SCB fire.**

Does the facility location use automatic temperature controllers? Yes ☑ No ☐ If yes, describe: **Conditioned Building 6580 "house" air is supplied to the basement HCF ventilation system for introduction to Zone 2. Automatic temperature controllers determine the temperature of air exiting the building heating and cooling system. Separate temperature controllers operate the cooling coils in the ducting to provide additional cooling before the air is introduced to Zone 2. That additional cooling is needed to handle the HCF heat loads.**

Other fire protection features/issues: **All forklifts have fire extinguishers attached for the class of fire hazard applicable to the fuel and energy sources of the forklift.**

III. HISTORICAL INFORMATION

Has there been (or have you heard of) a fire or fire-related event at this facility location?
Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 4

EXPLOSION HAZARDS

I. HAZARDS

Instructions: Please list below the explosion hazards that exist at the facility location. Explosion hazards are a combination of (1) an initiating event, and (2) explosive material. For example, and initiating event could be a dropping accident and the explosive material could be 25g of PETN. Additional notes could describe possible secondary effects of the explosion (e.g., fire, structural damage), explosive barriers, etc. Attach additional sheets if more space is needed to document explosive hazards.

Initiating Event	Type/Quantity of Explosive Material	Additional Notes
Spontaneous explosion	Hydrogen gas from radiation driven electrolysis of water in the radioactive concrete waste. Hydrogen gas evolution is continuous and could approach explosive mixtures if unventilated.	Stainless steel radioactive concrete waste containers and waste barrels are intentionally vented to prevent hydrogen pressure build up in storage. Explosion in Room 109 or Zone 2A elevator pit or could cause fire, damage facility, or injury.
Reactive metal-water explosion	No solid reactive metals in process materials or equipment. Sodium is in water solution already.	Extremely unlikely.
Run away chemical reactions	Corrosive acid and base chemicals of the isotope production process, less than 400 ml per target.	-Operations are in the SCBs and involve only small pre-measured quantities of acidic or basic chemicals in syringes or a closed container. Prepared as kits for one target in a separate facility, the syringes are introduced to the SCBs and used only as needed. -Quality control analysis operations involve only small quantities (less than a liter) of chemicals that are prepared in a separate facility. -Minimal to no secondary effects.
Fire (internal or external)	-Hydrogen gas from radiation driven electrolysis of water in the radioactive concrete waste. -Propane, gasoline, and diesel fuel vapors from forklift operation.	-Potential for facility damage or worker injury. -Explosive organic solvents are not used in even moderate quantities in the HCF for isotope production or quality analysis.
Adjacent accidents (aircraft crash, adjacent facility explosion)	Jet fuel; explosive components within adjacent facilities	Heavy construction and basement location should limit damage from adjacent accident explosions.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are pressure sensors or alarms present? Yes ☐ No ☑ If yes, describe type, location, etc.:
No pressure sensors or alarms fpr explosive hazards are pesent in the facility.

Are there pressure relief mechanisms? Yes ☐ No ☑ If yes, describe:

Describe critical ventilation/inerting systems:
The HCF ventilation system provides a safe operating environment for workers within the facility by dividing the airflow into four distinct zones for control of radioactive contamination. Proper differential air pressures are maintained by the system controls so that leakage is from zones of lesser contamination (Zone 3) to zones of higher contamination (Zone 1). Nuclear-grade HEPA filters treat the exhaust from Zone 1 and Zone 2A to remove particulate contaminants from the exhaust air prior to release to the atmosphere through the exhaust stack. In addition, charcoal filters in the SCBs and Zone 1 exhaust are designed to trap iodine vapors to control radioactive contamination in the SCBs and ventilation ducts. Motor control circuits provide sequential control to prevent over pressurization of any part of the ventilation system.

Describe explosive barriers:
The massive concrete and steel walls of the hot cell laboratory shielded support area and the Room 109 waste storage area provide some inherent barriers to explosions there. Personnel outside these areas might receive some protection from the effects of an explosion but damage to the HCF and Building 6580 might result.

III. HISTORICAL INFORMATION

Has there been (or have you heard of) an explosion or explosion-related event at this facility location? Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 5

TOXIC HAZARDS

I. HAZARDS

<u>**Instructions:**</u> Please list below the toxic hazards that exist at the facility location. Toxic hazards are a combination of (1) an initiating event, and (2) toxic material. For example, and initiating event could be the fatigue of a storage tank and the toxic material could be 5000 gal of HCl. Additional notes could describe spill barriers and the mitigation pathway of liquids or solids. Attach additional sheets if more space is needed to document toxic hazards.

Hazard	Type/Quantity of Material Involved	Initiating Event	Additional Notes
Spill (isotope extraction and purification chemicals)	Corrosive acid and base chemicals of the isotope production process, less than 400 ml per target. Milliliter to tens of milliliter amounts of the process chemicals are loaded into hypodermic syringes at a separate facility.	Major mishandling event in SCB; operator error during chemical addition; multiple container/syringe failure; external forces applied to SCBs (natural phenomena/ external event)	-The chemicals in syringes are transported to the SCBs in kits of materials and equipment. -The chemical hazard from acid and base corrosive chemicals will be mitigated by remote handling in the SCBs and by the sealed process hardware and glassware. -Any spills are contained in a spill tray and cleaned up with an acid spill kit in the SCB.
Spill (isotope quality control analysis chemicals)	Small bulk quantities of acid and base chemicals (less than a liter) are prepared in a separate facility and used in SGB and vent hoods in the quality control laboratory for isotope product quality analysis procedures.	Operator error during chemical addition or handling; container failure	-Chemical processes for quality control analysis use small amounts of prepared chemicals in a SGB or ventilation hoods. -Any spills are contained in a spill tray and cleaned up with a spill kit. -Workers performing quality control analysis use basic safe chemical handling procedures as spelled out in the Sandia ES&H Manual.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are toxic monitors present? Yes ☐ No ☑ If yes, describe type, location, etc.:

Are toxic materials handled in fume hoods, glove boxes, or other ventilated enclosures?
Yes ☑ No ☐ If yes, please describe: **Corrosive acid and base chemicals of the isotope extraction and purification production process are used in prepared syringes and sealed containers in eight of the eleven steel confinement boxes (SCBs) of the hot cell laboratory (ventilation Zone 1). Small bulk quantities of acid and base chemicals for isotope quality control analysis are used in a shielded glove box (SGB) and ventilation hood in the quality control laboratory.**

Describe toxic material handling or storage safeguards (e.g., spill-control pallets, handling SOPs):
All isotope production process chemicals are prepared in a separate facility and only transferred to the HCF as used. Administrative controls limit production back up quantities in the HCF. Workers use basic safe chemical handling procedures as spelled out in the Sandia ES&H Manual and appropriate SOPs and operating procedures. Any spills are contained in a spill tray and cleaned up with a spill kit.

Describe special clothing or respiratory protection required: **No special clothing is required for working with chemicals in the SCBs. Gloves, aprons, face shields, etc. for personnel protective equipment are established by the Sandia ES&H Manual and appropriate SOPs and operating procedures for work in the ventilation hoods and while loading chemicals into the SCBs, SGB, or ventilation hoods.**

Other toxic material protection information/issues: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) a toxic material spill release at this facility location?
Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 6

INDUSTRIAL/OTHER HAZARDS

I. HAZARDS

<u>**Instructions:**</u> Please list each major industrial or other type hazard not previously identified. Consider hazards such as electromagnetic radiation; electrical, mechanical, thermal, or pressurized equipment; or other hazards that could cause or contribute to serious injuries. For example, an industrial hazard could be electrocution caused by worker or procedural error. Additional notes could include a discussion of safeguards that are in place to prevent such an event. Do not list trivial hazards (i.e., those events that could only produce minor injuries).

Type of Hazard	Cause/Consequence	Other Information
Product shipping container package mishandling	Package overturns; worker crushed by package falling from crane or similar injury	Personal injuries ranging from minor to serious could result.
Electrical	Worker error during electrical work; electrocution	Procedures/training in place for all electrical workers
Hand or body caught in new target in system, product exit system, or Zone 2A airlock doors	Worker error/inattention during system or airlock door operation	Procedures/training in place for all equipment in HCF. Entry to Zone 2A is required infrequently.
Medical emergencies	Worker health condition (heart attack, stroke, etc.)	Multiple personnel are present during all isotope production operations in the HCF.
Burns/smoke inhalation	Non-radiological fire (including forklift, electrical system)	Portable fire extinguishers are located on all forklifts and in HCF.
Cryogenic burn in Room 107	Liquid nitrogen exposure from storage dewar/piping due to fitting/regulator failure, human error, or external events	Planned modification will eliminate temporary dewar and piping from Room 107
Vehicle accident (forklift)	Worker error; vehicle malfunction.	Personnel receive forklift training.
Asphyxiation in Room 107	Nitrogen release from storage dewar/piping due to fitting/regulator failure, human error, or external events	Planned modification will eliminate temporary dewar and piping from Room 107

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Provide other information describing industrial or other, non-standard hazards: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) a major industrial or other type of accident at this facility location? Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 1	GENERAL INFORMATION

SNL facility name: **Hot Cell Facility Radioactive Material Storage Areas** Date: **4/3/98**

Facility segment location: **Buildings 6580, 6596, & 6597, Technical Area V (TA-V), Sandia National Laboratories, Kirtland AFB, Albuquerque, NM**

Facility (unique identifier): **Radioactive material and equipment storage for reuse in continuing or future TA-V operations associated with the Hot Cell Facility (HCF). Facilities provide storage for hazard category 3 total activity amounts of materials and equipment.**

SNL operations contact: **Jeffrey S. Philbin** Phone: **505-845-9036**

PHC completed by: **Rob Naegeli** Phone: **505-845-3233**

Briefly describe the facility segment being reviewed: **Facilities segments consist of 1) each of the monorail storage holes adjacent to Building 6580; 2) the Building 6596 east high bay; and 3) the Building 6597 high bay.**

Identify major process-related equipment: **In 1) above: monorail crane, hole shielding plugs, and associated shielding casks; in 2) above, Forklift, crane, shielded containers, temporary shielding structures, and spill control pallets; and in 3) above, Forklift, crane, shielded containers, temporary shielding structures, and spill control pallets.**

Identify possible safety-related systems, structures, or components: **In 1) above, the hole shielding plugs installed at the top of each monorail storage hole where radioactive material is stored; and in 2) and 3) above, none.**

Describe adjacent facility or area hazards: **Adjacent Technical Area-V facilities may contain nuclear or hazardous material. In addition, adjacent nuclear reactor facilities may contain nuclear radiological or fissile material.**

List safety documents (e.g., SAR, TSRs, BIO, SA, SOPs) covering this location: **SAND94-2650 (12/31/96).**

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PRELIMINARY HAZARD CHECKLIST

DATA FORM 2

RADIOLOGICAL HAZARDS

I. HAZARDS

Instructions: Please list below each radiological hazard that exists at the facility location. Radiological hazards are a combination of (1) the material and (2) an initiating event. For example, one type of radiological hazard could be a spill involving 20g of Pu-239 caused by fatigue failure of a container. Additional notes could identify that the plutonium is in a powder form and that the spill would most likely occur immediately outside the glove box transfer port. Attach additional sheets if more space is required to document radiological hazards.

Hazard	Type/quantity of material involved	Initiating Events	Additional Notes
Direct radiation exposure	Radioactive materials and equipment in storage in excess of the hazard category 3 activity thresholds but below hazard category 2 activity	-Forklift accident -Mishandling during storage -Combined mechanical failure and human error	Direct exposure to these radiation hazards is normally controlled by a combination of radiological area posting and radiation shielding.
Spill of radioactive liquid materials	Spill of radioactive resin or other debris <55 gallons per drum	-Forklift puncture -Toppling of container (mishandling, energetic external event) -Fatigue failure of container	Liquid radioactive material containers require mounting on spill pallets to control leaks and spills.
Criticality	^{235}U in various experiment assemblies	-Flooding of monorail storage holes or the high bay areas -Gross procedural error -Gross rearrangement of fissile material	-Small masses of fissile material in large assemblies preclude criticality. -Monorail holes topped by weather seal covers.
Contamination	Materials in storage with radioactive contamination from previous use	-Breached container or wrapping -External event	-Items with contamination wrapped for control -Contamination areas posted

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are fixed radiation monitors used? Yes ☐ No ☑ If yes, describe type, quantity, and location:
None

Are portable radiation monitors used? Yes ☑ No ☐ If yes, describe type and how used:
Area radiological control technicians use portable, hand held gamma monitors to verify that safe conditions exist during operations in the radioactive material storage facilities.

Are criticality monitors present? Yes ☐ No ☑ If yes, describe type, quantity, and location:
None

Describe radiation shielding: **Shielded containers and moveable, temporary radiation shielding around radiation sources to control exposure consistent with radiological control requirements and ALARA considerations.**

Describe special clothing or respiratory protection required:. **Appropriate personnel protective clothing as required by applicable Radiological Work Permits are used when working with wrapped contaminated materials and equipment.**

Other radiation protection information/issues: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) any radiological incident (e.g., spill, criticality, contamination event, etc.)? Yes ☐ No ☑ If yes, please describe:
None known.

PRELIMINARY HAZARD CHECKLIST

DATA FORM 3

FIRE HAZARDS

I. HAZARDS

Instructions: Please list below the fire hazards that exist at the facility location. Fire hazards are a combination of (1) an ignition source, and (2) combustible material. For example, and ignition source could be an electrical outlet inside of a glove box and the combustible material could be 50 ml of organic solvents collocated in the glove box. Additional notes could describe the likelihood of propagation, fire barriers, etc. Attach additional sheets if more space is needed to document fire hazards.

Ignition Source	Type/Quantity of Combustible Material	Additional Notes
Forklift energy sources (e.g., hot brake pads, battery failure, electrical system failure, collision, etc.)	Hydraulic oil, diesel fuel, gasoline, propane fuel	-Some forklifts are electric so no fuels present. Portable fire extinguishers located on forklifts. -Wood or cardboard storage boxes could be ignited.
Facility electrical system (ceiling fluorescent lights and wall mounted heating/cooling equipment in Building 6597 high bay)	-Wood or cardboard storage boxes -Electrical insulation and components of lights and of motors for heating/cooling units	No electrical systems in the monorail storage holes
Spontaneous combustion	Limited combustibles in storage	Spontaneous combustion is unlikely.
Lightning strike	Wood or cardboard storage boxes	-Building 6596 and 6597 have a lightning protection system (not maintained). -Monorail holes have steel hole liner and top cap.
Vehicle accident (outside buildings)	Vehicle fuel tank contents; miscellaneous vehicle combustibles	-No threat to Buildings 6596 and 6597. -Monorail hole weather seal covers exclude burning combustible liquid.
Adjacent accidents (aircraft crash, adjacent facility fire/explosion)	Jet fuel; combustible contents of adjacent facilities	-Adjacent external accidents might not pose a significant threat to facilities if doors were closed (depending on the proximity. -Adjacent external accidents with doors open are extremely unlikely events whose consequences would be similar to an internal fire. -Fire protection systems in adjacent buildings would suppress spread of fires from adjacent buildings to the radioactive storage facilities.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are heat/smoke detectors present? Yes ☑ No ☐ If yes, describe type and location:
No heat/smoke detectors are present in the monorail storage holes. Both Building 6596 east high bay and Building 6597 high bay have heat/smoke detectors at the ceiling level.

Is there a suppression system? Yes ☑ No ☐ If yes, describe type, layout, capability, etc.:
Buildings 6596 and 6597 have automatic fire protection, sprinkler systems throughout the high bay areas, at the ceiling level. The monorail storage holes do not have fire suppression systems of any kind but they do have inherent fire dampers due to their in ground location and steel liner construction.

Does the facility location use automatic temperature controllers? Yes ☑ No ☐ If yes, describe:
The monorail holes do not have any kind of automatic temperature control or ventilation but the in ground location regulates temperature of the contents. The Building 6596 east high does not have automatic temperature control or ventilation of any kind. The Building 6597 high bay has automatic temperature control provided by several wall mounted heating/cooling units. These units also supply ventilation air to the high bay room. Six ceiling vents exhaust air from the high bay room. Ventilation air is required in the Building 6597 high bay to allow a working environment for preparation of radioactive material and equipment for storage, for reuse, or shipment for processing as waste.

Other fire protection features/issues: **All forklifts have fire extinguishers attached for the class of fire hazard applicable to the fuel and energy sources of the forklift. Wall mounted fire extinguishers are provided in Building 6596 and 6597 high bays.**

III. HISTORICAL INFORMATION

Has there been (or have you heard of) a fire or fire-related event at this facility location?
Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 4	EXPLOSION HAZARDS

I. HAZARDS

Instructions: Please list below the explosion hazards that exist at the facility location. Explosion hazards are a combination of (1) an initiating event, and (2) explosive material. For example, and initiating event could be a dropping accident and the explosive material could be 25g of PETN. Additional notes could describe possible secondary effects of the explosion (e.g., fire, structural damage), explosive barriers, etc. Attach additional sheets if more space is needed to document explosive hazards.

Initiating Event	Type/Quantity of Explosive Material	Additional Notes
Spontaneous explosion	-No explosive gas or dust mixtures are stored in the radioactive material storage areas. -Hydrogen gas from radiation driven electrolysis of water is not expected in the stored material.	-Containers for radioactive materials that could evolve hydrogen gas by electrolysis are intentionally vented to prevent hydrogen accumulation or pressure build up in storage..
Reactive metal-water explosion	No solid reactive metals in stored radioactive materials or equipment.	Extremely unlikely.
Fire (internal or external)	-Propane, gasoline, and diesel fuel vapors from forklift operation.	-Potential for facility damage or worker injury. -Consequences would be the same as a facility fire.
Adjacent accidents (aircraft crash, adjacent facility explosion)	Jet fuel; explosive components within adjacent facilities	-Adjacent accident explosions could pose a significant threat to the Building 6596 and 6597 high bays. A facility fire would bound the consequences. -Adjacent accident explosions, including those in adjacent monorail storage holes, would not pose a significant threat to the monorail storage holes due to their in ground location and steel construction for top and liner.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are pressure sensors or alarms present? Yes ☐ No ☑ If yes, describe type, location, etc.:

Are there pressure relief mechanisms? Yes ☐ No ☑ If yes, describe:

Describe critical ventilation/inerting systems:
The Building 6597 high bay heating/cooling and air supply units combined with the exhaust vents comprise a personnel air ventilation system strictly intended to provide a safe working environment. No filters treat the exhaust air prior to release to the atmosphere. Thus, the ventilation in Building 6597 high bay is not critical to control any explosive or radiological hazard.

Describe explosive barriers:
None of the radioactive material storage facilities have explicitly designated explosive barriers but some massive, temporary, moveable concrete radiation shielding could mitigate the consequences of an explosion somewhat. The Building 6596 east high bay has such moveable concrete shielding on one side of the exterior of the building. Both Building 6596 and 6597 high bays could have moveable concrete shielding around certain areas inside the facility. The monorail storage holes are similarly protected by their in ground location and steel construction for top and liner.

III. HISTORICAL INFORMATION

Has there been (or have you heard of) an explosion or explosion-related event at this facility location? Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 5

TOXIC HAZARDS

I. HAZARDS

Instructions: Please list below the toxic hazards that exist at the facility location. Toxic hazards are a combination of (1) an initiating event, and (2) toxic material. For example, and initiating event could be the fatigue of a storage tank and the toxic material could be 5000 gal of HCl. Additional notes could describe spill barriers and the mitigation pathway of liquids or solids. Attach additional sheets if more space is needed to document toxic hazards.

Hazard	Type/Quantity of Material Involved	Initiating Event	Additional Notes
Spill (liquid radioactive materials–toxic constituents)	Various hazardous radioactive liquids	-Forklift puncture -Toppling of container (mishandling, energetic external event) -Fatigue failure of container	-Liquid radioactive material would be contained in spill control pallet. -Spill would be limited to area immediately surrounding container. -Procedures and training direct workers to leave area immediately.
Spill (solid radioactive materials–toxic constituents)	Various hazardous radioactive solids	-Forklift puncture -Toppling of container (mishandling, energetic external event) -Fatigue failure of container	-Spill would be limited to area immediately surrounding container. -Procedures and training direct workers to leave area immediately.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Are toxic monitors present? Yes ☐ No ☑ If yes, describe type, location, etc.:

Are toxic materials handled in fume hoods, glove boxes, or other ventilated enclosures?
Yes ☐ No ☑ If yes, please describe:

Describe toxic material handling or storage safeguards (e.g., spill-control pallets, handling SOPs):
Spill control pallets are required to hold all radioactive liquid or slurry materials such as resins. The spill control pallets are designed to contain spills or leaks of the materials. The SNL ES&H Manual requires evacuation for all spills and subsequent cleanup by a specially equipped team unless the spill is very small. Most small spills and minor leaks will be cleaned up using standard spill cleanup procedures and established radioactive waste streams for the contaminated cleanup materials.

Describe special clothing or respiratory protection required: **Appropriate personnel protective equipment, as required by applicable Radiological Work Permits, is used when working with wrapped contaminated materials and equipment or to cleanup spills.**

Other toxic material protection information/issues: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) a toxic material spill release at this facility location?
Yes ☐ No ☑ If yes, please describe:

PRELIMINARY HAZARD CHECKLIST

DATA FORM 6	INDUSTRIAL/OTHER HAZARDS

I. HAZARDS

Instructions: Please list each major industrial or other type hazard not previously identified. Consider hazards such as electromagnetic radiation; electrical, mechanical, thermal, or pressurized equipment; or other hazards that could cause or contribute to serious injuries. For example, an industrial hazard could be electrocution caused by worker or procedural error. Additional notes could include a discussion of safeguards that are in place to prevent such an event. Do not list trivial hazards (i.e., those events that could only produce minor injuries).

Type of Hazard	Cause/Consequence	Other Information
Radioactive material container package mishandling	Package overturns; worker crushed or similar injury	Personal injuries ranging from minor to serious could result.
Electrical	Worker error during electrical work; electrocution	Procedures/training are in place for all electrical workers.
Falling from stacked equipment or materials	Worker error/inattention during storage operation	Access to top of stacks is required very infrequently.
Medical emergencies	Worker health condition (heart attack, stroke, etc.)	Multiple personnel are present during all radioactive material storage operations.
Burns/smoke inhalation	Non-radiological fire (including forklift, electrical system)	Portable fire extinguishers are located on all forklifts and in the high bay storage facilities of Building 6596 and 6597.
Vehicle accident (forklift)	Worker error, vehicle malfunction.	Personnel receive forklift training.

PRELIMINARY HAZARD CHECKLIST

II. PREVENTION, DETECTION, AND MITIGATION INFORMATION

Provide other information describing industrial or other, non-standard hazards: **None**

III. HISTORICAL INFORMATION

Has there ever been (or have you heard of) a major industrial or other type of accident at this facility location? Yes ☐ No ☑ If yes, please describe:

APPENDIX 3B

EXTERNAL EVENTS SCREENING ASSESSMENT

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EXTERNAL EVENTS SCREENING ASSESSMENT

This appendix presents the potential external events that are considered in the hazard analysis of the Hot Cell Facility (HCF) and its associated radioactive material storage facilities. From this list of events, a screening assessment was performed to eliminate from further consideration any of the events that posed little or no hazard to the HCF and associated radioactive material storage facilities or their contents. Events that were not eliminated in this screening process were to be analyzed more closely as part of the qualitative analyses contained in Appendix 3C or 3D (and are summarized in Section 3.3.2, "Hazard Analysis Results").

Potential external events were identified by reviewing previous Safety Analysis Reports of similar DOE facilities (Restrepo 1995) and the recommended list of external events used to evaluate commercial nuclear power plant risks (NRC 1983). In addition, an attempt was made to identify any other potential external-initiating event unique to the site that had not been considered in previous studies. It is important to note that operational accidents (e.g., criticality, internal fires) occurring inside the HCF and associated radioactive material storage facilities are not considered in this screening process. These types of "internal" initiating events are identified separately using preliminary hazard checklists (see Appendix 3A).

Table 3B-1 presents the events that were considered for the HCF and associated radioactive material storage facilities. The "Screening Results" column summarizes how each event was categorized in the screening process. The four criteria used in the screening process are as follows:

- **Group 1 -** The event is impossible or highly improbable due to the size or location of the HCF and associated radioactive material storage facilities; the characteristics of the regional geography, topography, or hydrology; or the nature of the materials handled or the operations performed.

- **Group 2 -** The event produces stresses that are similar or obviously less severe than other events under consideration.

- **Group 3 -** The event would not result in any potential for adverse consequences.

- **Group 4** - The event could not be eliminated from consideration by screening; some level of qualitative or quantitative analysis is required.

All of the events listed in Table 3B-1 were eliminated from further consideration by using this screening process. (Some events were eliminated based on multiple criteria.) This does not mean they are all eliminated from all further consideration in the HCF SAR. Some external events are considered in Appendix 3C, "Preliminary Hazard Analysis," or Appendix 3D, "Failure Modes and Effects Analysis," as potential initiators to internal hazard events.

Table 3B-1. Potential external events.

External Event	Group	Screening Results
Aircraft Impacts	1	Not possible or plausible at this site or facility.
Avalanches/Landslides	1	Not possible or plausible at this site or facility.
Chemical/Toxic Gas Releases	3	No potential for adverse consequences.
Coastal Erosion	1	Not possible or plausible at this site or facility.
Drought	3	No potential for adverse consequences.
Earthquakes	2	Less severe than other potential events.
External Explosions	3	No potential for adverse consequences.
External Fires	3	No potential for adverse consequences.
External Floods	3	No potential for adverse consequences.
Fog	3	No potential for adverse consequences.
Forest/Grass Fire	2	Less severe than other potential events.
Frost	3	No potential for adverse consequences.
Hail	2	Less severe than other potential events.
Ice	2	Less severe than other potential events.
Industrial or Military Facility Accident	2	Less severe than other potential events.
Lightning Strikes	3	No potential for adverse consequences.
Loss of Off-Site Power	2	Less severe than other potential events.
Low Lake or River Water Level	3	No potential for adverse consequences.
Meteor Strikes	1	Not possible or plausible at this site or facility.
Missiles	3	No potential for adverse consequences.
Pipeline Accidents	2, 3	Less severe than other potential events. No potential for adverse consequences.
River Diversions	3	No potential for adverse consequences.
Sandstorms/Duststorms	3	No potential for adverse consequences.
Seiche	1	Not possible or plausible at this site or facility.
Snow	2	Less severe than other potential events.
Straight Winds	2	Less severe than other potential events.
Structural Interactions	2	Less severe than other potential events.
Temperature Extremes	3	No potential for adverse consequences.
Tornadoes	2	Less severe than other potential events.
Transportation Accidents	1	Not possible or plausible at this site or facility.
Tsunami	1	Not possible or plausible at this site or facility.
Volcanic Activity	1	Not possible or plausible at this site or facility.

All of the events considered in this assessment, along with brief descriptions of their screening rationale, are listed below.

Aircraft Impacts

Aircraft impacts were eliminated from consideration because of the very small target area presented by the HCF and associated radioactive material storage facilities. Only a direct or a near-direct crash into a facility would damage the structures. An aircraft crash screening was performed for the HCF, based on the methodology of DOE-STD-3014-96 (DOE 1996), Accident Analysis for Aircraft Crash into Hazardous Facilities. That DOE-STD-3014-96 screening showed that the total hazardous material in the facility does not pose a significant threat to the public and that the aircraft crash impact does not pose a significant threat to the facility (Mitchell and Naegeli 1998). Based on this information, aircraft impacts are eliminated from further consideration.

Avalanches/Landslides

Avalanche/landslides are not a concern due to the location of the facilities on gently sloping, flat terrain.

Chemical/Toxic Gas Releases

Release of chemical or toxic gas external to the structures (e.g., chlorine truck accident) would not result in any hazard to the contents of the facilities. Evacuation may be required in such an event, but abandoning operations results in no hazard to the facilities' contents.

Coastal Erosion

The site is not subject to coastal erosion.

Drought

Droughts are possible at the site, but there is no potential for adverse effects to the facilities or their contents.

Earthquakes

Seismic events would produce stresses and potential releases that are similar or less severe than other events under consideration. The major HCF building structures were designed and constructed according to the prevailing industry codes of the period. Sandia National Laboratories has evaluated their building inventory for potential seismic risks and estimated the costs of mitigating the unacceptable seismic risks in those buildings in its response to Executive Order 12941 (SNL 1998). Sandia National Laboratories ranked risk by failure consequence and building vulnerability. In addition, a seismic evaluation was performed on the HCF and all other non-exempt buildings. They found the HCF was not in the extremely high-risk group(SNL 1998). Other SAR analyses have indicated that the major HCF building structures can withstand earthquake forces in excess of 0.22 g (the evaluation basis earthquake, EBE) without structural failure (Restrepo 1995, Chavez Grieves 1997). Other portions of the HCF confinement systems, including SCBs and associated ventilation systems, are not specifically designed for earthquake loads, although analysis has indicated that these systems would likely survive the EBE (Dempsey 1992). The accident initiating effects of this event on the facilities and their contents are considered qualitatively in the PHA (Appendix 3C).

External Explosions

Blast pressures caused by the closest potential explosion to the facilities are not anticipated to cause damage to the HCF or its associated radioactive material storage areas. The effect the explosion through the HCF stack on internal HCF filters would be to blow the filters and any radiation freed from them back into the HCF ventilation system and not out of the facility to the public and environment (Restrepo 1995).

External Fires

The only credible external fire threat is from range fires and from fires involving vehicles that may be close to the facilities. Range fires are considered separately under Forest/Grass Fires. Vehicle fires near the facilities and fires in adjacent buildings would not result in any potential for adverse consequences due to the fire resistant concrete and steel building construction. Vehicle fires near the facilities are considered qualitatively in the PHA (Appendix 3C).

External Floods

Localized water on the ground due to rainwater is possible near some facilities, but the general inundation of the facilities is considered incredible due to the site gradient as TA-V is on a slight ridge that provides general drainage away from the facilities. This assessment is supported by analysis of flooding of the Sandia Pulsed Reactor, conducted in 1999 (Pickard 1999). Rainwater entry to the basement HCF areas is possible but a trench floor drain at the base of the truck ramp entrance to the basement is placed to stop and divert away any flow of rainwater into the HCF. Even if some limited rainwater entered the HCF, only slight wetting of the floor and no impact to the radiological material is anticipated. Flooding from the Rio Grande River is considered incredible as TA-V is at an elevation that is approximately 152 meters above the riverbed and 14 kilometers east of the main channel.

Fog

Fog presents no hazard to the facilities or their contents.

Forest/Grass Fires

Because the site is located in an area of light desert vegetation, forest fires are not a concern. Although grass/range fires are possible at the site, a substantial distance of crushed rock or pavement exists as a firebreak between a grass/range fire and the facilities. This event is considered less severe than the other fire scenarios considered under External Fires.

Frost

Frost presents no hazard to the facilities or their contents.

Hail

Hail is not a concern because of the structural characteristics of the facilities (steel reinforced concrete roof/walls). Furthermore, any potential effects of hail on the facilities (i.e., collapse) are subsumed in the consideration of Earthquakes.

Ice

Ice loading is not a concern because of the structural characteristics of the facilities (steel reinforced concrete roof/walls). Furthermore, any potential effects of ice loading on the facilities (i.e., collapse) are subsumed in the consideration of Earthquakes.

Industrial or Military Facility Accident

Because of the large restricted area around the facilities and the remote location of the site, no industrial facility accidents are credible. The hazards associated with military accidents (i.e., explosions, aircraft crash) are considered separately in the discussions of Aircraft Impacts, Chemical/Toxic Releases, External Explosions, and Missiles. Accidents in adjacent facilities in TA-V, such as the adjacent reactor facilities, could have limited impact on the HCF as those facilities are in separate buildings or physically separated from the HCF in an adjoining building. The nuclear facilities have been designed to prevent accidents with the hazardous material in one facility from affecting the material in another facility. Thus, the impact of those adjacent facilities on the HCF would likely be the same or less than External Fires.

Lightning Strikes

Because of the lightning protection system installed throughout each facility or the protected nature of the contents inside the facilities, this event is not considered a credible threat to the facilities or their contents.

Loss of Off Site Power

The effect of a loss of off-site power would be to temporarily shutdown the HCF ventilation system if standby diesel generator power were not available. Thus, no releases to the environment would occur and slow local contamination within limited areas the HCF might occur if power were not restored to the ventilation system for an extended period.

Low Lake or River Water Level

This hazard is considered only if off site water sources are required for safety-related cooling purposes. No such cooling requirements exist for the operations conducted in the facilities.

Meteor Strike

The U.S. Nuclear Regulatory Commission has excluded meteor strikes as a credible threat to nuclear power plants (NRC 1987) so they are not considered further.

Missiles

Missiles generated as a result of straight winds or tornadoes are not required to be considered in the evaluation of existing DOE facilities for natural phenomena hazard, performance category 2 structures, systems and components (DOE 1994). The HCF is considered natural phenomena hazard, performance category 2 since it has safety-significant structures, systems and components but no safety-class structures, systems and components (DOE 1993). No rotating machinery that is located within the HCF ventilation zones has the potential to generate missiles that could potentially adversely affect the facilities or their contents. Rotating centrifuge facilities in TA-III are below grade so would not have a potential to generate missiles to impact TA-V facilities such as the HCF (Restrepo 1995).

Pipeline Accidents

There are no pipelines located sufficiently close to the facilities to present a hazard to the structure or their contents.

River Diversions

This potential hazard is only relevant for facilities that depend on near-site rivers for safety-related cooling purposes. Therefore, it is not relevant to the facilities.

Sandstorms/Duststorms

Because of the sealed nature of the facilities, sandstorms and dust storms would not represent a hazard to the structures or their contents.

Seiche

Seiches are not a concern for the facilities because no large shallow bodies of water are located near the site.

Snow

Snow loading is not a concern because of the structural characteristics of the facilities (steel reinforced concrete roof/wall). Furthermore, any potential effects of snow loading on the facilities (i.e., collapse) are subsumed in the consideration of Earthquakes.

Straight Winds

The structural characteristics of the facilities (steel reinforced concrete roof/walls) make them impervious to all credible straight winds occurring at the sites. In general, straight winds present less of a challenge to the facilities than earthquakes. Any effects of straight winds are therefore subsumed in the consideration of Earthquakes.

Structural Interactions

The 125-foot tall exhaust stack for the HCF is the only structure in the immediate vicinity of the facilities that could cause an interaction by falling onto the HCF building 6580. Due to the structural characteristics of the facilities (steel reinforced concrete roof/walls) and the basement location of the HCF, the potential for adjacent structure interaction causing damage that would release radioactive material to the environment is not credible. Fires in adjacent buildings are considered under external fires. Therefore, any effects of structure interaction are subsumed in the consideration of Earthquakes.

Temperature Extremes

All facility contents can withstand all anticipated temperature extremes without adverse safety implications.

Tornadoes

Tornadoes present less of a hazard to the facilities than earthquakes or straight winds (LLNL 1984). Therefore, effects of tornadoes are subsumed in the consideration of Earthquakes.

Transportation Accidents

Transportation accidents could occur outside of the Technical Area-V complex, which encloses the HCF and associated radioactive material storage areas. This external transportation occurs in Department of Transportation (DOT) approved containers used for transport of radioactive materials for long distances by public carrier. Thus, the DOT approved container transport of radioactive material has been excluded for the HCF safety analysis. Transfer of radioactive materials between buildings within Technical Area V is not considered an external event and is considered under internal events. (See Appendices 3A and 3C).

Tsunami

Due to the inland location of the site, tsunamis are not relevant to the site.

Volcanic Activity

No potential for volcanic activity exists at or near the site.

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APPENDIX 3C

PRELIMINARY HAZARDS ANALYSIS

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Introductory Material

The preliminary hazards analysis (PHA) is a basic approach used to generate the qualitative consequence and likelihood estimate used to categorize HCF and radioactive material storage location hazards. The PHA is an accident scenario-based form of analysis; that is, hazardous situations (e.g., radioactive release, fire, explosion, etc.) are first postulated, then a structured investigation of how such a situation could occur (as well as other system/facility response issues) follows. The PHA for the HCF and associated radioactive material storage locations documents potential accident initiating events, preventive and mitigative features, anticipated consequences, and safety enhancements (e.g., procedures, system upgrades, additional accident analysis) required to adequately compensate for the existing hazard.

Two distinctly different, yet complementary, perspectives of hazards for the HCF and associated radioactive material storage locations are obtained for the overall hazard analysis of Chapter 3 by using both PHA and failure mode effects analysis (FMEA) techniques. FMEA is a complementary type of evaluation that utilizes a system failure-based form of analysis. Unlike PHA, the first objective of FMEA is to subdivide the facility into several different (and, to the maximum extent possible, independent) system elements. Failure modes of each system element are then postulated and a structured examination of the consequences of each failure mode follows. However, similar to PHA, FMEA documents preventive and mitigative features (failure mechanisms and compensation) and anticipated accident consequences (failure effects). Appendix 3D contains the FMEA for the HCF.

Multiple perspectives in the overall hazard analysis assist in more fully identifying and developing 1) planned design and operational safety improvements, and 2) facility design and administrative features contributing to defense in depth, worker safety, and environmental protection. In practice, the interim results of the PHA were used to guide the FMEA investigation and FMEA results were used to further develop the PHA scenarios. Thus, the results of the PHA and FMEA serve as the basis for hazard ranking in the overall hazard analysis of the wide range of HCF hazards so that bounding accident scenarios can be selected for further development in the design basis accident (DBA) analysis.

Hazard ranking in the hazard analysis is achieved by qualitatively assigning frequency and consequence estimates to each hazard or accident scenario developed in the PHA or FMEA. Tables 3C-1 and 3C-2 present the hazard ranking framework used to categorize these events in the PHA (consequence and frequency, respectively). The consequence and frequency estimates are presented only in the PHA but those estimates are also affected by FMEA results as explained above. All consequence and frequency estimates were based on the consensus engineering judgment of the hazard analysts conducting the PHA and FMEA. Consequence estimates were made assuming the failure of all mitigating systems and actions. Airborne releases originating in the HCF in the basement of Building 6580 were assumed released from the HCF stack.

Table 3C-3 presents the risk ranking matrix used to compare all hazards and accident scenarios identified in the PHA. The risk ranking results serve as one basis for determining if a more detailed, quantitative analysis of specified hazards or accident scenarios (DBA) is required.

The PHA hazard event scenarios are shown in Tables 3C-4 through 3C-11. The tables contain hazard event scenarios for a particular part of the isotope production process or radioactive material storage location. HCF maintenance task scenarios are also presented in one of the tables.

TABLES

Table 3C-1. Consequence Severity Categories

Category	Affected Population/Entity			
	Public	Environment	Collocated Worker	Worker
A	• Immediate health effects	• Significant off-site contamination requiring cleanup	• Immediate health effects	• Loss of life
B	• Latent health effects	• Moderate to significant on-site contamination • Moderate off-site contamination	• Latent health effects	• Severe injury or disability
C	• Irritation or discomfort but no permanent health effects	• Moderate contamination of originating facility • Minor onsite contamination • Minor off-site contamination	• Irritation or discomfort but no permanent health effects	• Lost time injury but no disability
D	• No significant offsite impacts	• No contamination of originating facility • No onsite contamination • No off-site contamination	• No significant impacts	• Minor or no impact or disability

Table 3C-2. Frequency Categories

Category	Characteristic Word	Frequency (F) Per Year	Description
I	Normal Operations	$F \geq 1$	Normal Operations
II	Likely or Anticipated	$1 > F \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)
III	Unlikely	$10^{-2} > F \geq 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this frequency category include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
IV	Very Unlikely	$10^{-4} > F \geq 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility. This category includes the design basis accidents.
V	Extremely Unlikely	$10^{-6} > F$	All other accidents. Accidents too unlikely to be considered in the design basis. Some accidents in this frequency category may be evaluated as beyond design basis accidents.

Table 3C-3. Risk Ranking Matrix

Consequence Category	Frequency Category				
	I	II	III	IV	V
A	1	1	2	2	3
B	1	1	2	3	4
C	2	2	3	3	4
D	3	3	4	4	4

Risk Ranking 1: Hazard or accident scenario poses a high risk to the public, collocated workers, workers, or the environment. Immediate actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. Risk Ranking 1 events are analyzed quantitatively in the accident analysis.

Risk Ranking 2: Hazard or accident scenario poses a moderate risk to the public, collocated workers, workers, or the environment. Near- to moderate-term actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. Risk Ranking 2 events are analyzed quantitatively in the accident analysis.

Risk Ranking 3: Hazard or accident scenario poses a minor risk to the public, collocated workers, workers, or the environment. Moderate- to long-term actions should be taken by the facility manager to reduce the potential consequences or likelihood of these events. No further analysis is required for Risk Ranking 3 events.

Risk Ranking 4: Hazard or accident scenario poses a very minor risk to the public, collocated workers, workers, or the environment. Long-term actions should be considered by the facility manager to reduce the potential consequences or likelihood of these events. No further analysis is required for Risk Ranking 4 events.

Table 3C-4. Target Transfer.

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of Detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
TT-1	Cask breach (i.e., lid failure), no target release (collimated beam)	-Fork lift rolls/run away (inattention, mech. Failure, load shift) -Fork hydraulic fail w/ elevated load (maint./ aging, procedure) -Fork rams fixed object (inattention, brake failure) -Another vehicle strikes load (inattention, procedure violation)	-Bolts on lid	-Target cask loading procedure to ensure lid properly installed -Target transfer procedure -Trained forklift operators -Forklift maintenance	III	Visual/ Rad. Survey Instr.	-Distance to site boundary and area fence	-Majority of workers located a significant distance from cask route -Access control -Emerg. Op. Procedures	-Potential high direct exposure dose to workers close to cask route: C -Minimal dose to collocated workers: D -Minimal dose to public: D -No contamination of environment: D	-Worker: 3 -Collocated worker: 4 -Public: 4 -Environ.: 4	-Moveable shields for recovery actions
TT-2	Cask breach, target released intact (direct high-dose field)	Same as TT-1	Same as TT-1	Same as TT-1	III	Visual/ Rad. Survey Instr.	Same as TT-1	Same as TT-1	Same as TT-1 except Workers: B	Same as TT-1 except Worker: 2	Same as TT-1
TT-3	Cask breach, target released and damaged/ breached (direct high-dose field and airborne inhalation dose)	Same as TT-1	Same as TT-1 -Target cladding	Same as TT-1	III	Visual/ Rad. Survey Instr.	Same as TT-1	Same as TT-1	-Direct exposure & airborne release doses -Workers: A-C -Collocated workers: C -Public: D -Environ.: D	-Worker: 2-3 -Collocated worker: 3 -Public: 4 -Environ.: 4	Same as TT-1
TT-4	TT-3 plus Fire (small)	Same as TT-1 -Small propane tank on backup forklift	Same as TT-3	Same as TT-1	IV	Visual/ Rad. Survey Instr.	Same as TT-1	Same as TT-1	-Direct exposure & airborne release -Workers: A-C -Collocated workers: C -Public: D -Environ.: D	-Worker: 2-3 -Collocated worker: 3 -Public: 4 -Environ.: 4	Same as TT-1

Radionuclide Inventory for Postulated Events

TT-1: Inventory = 1 irradiated target for collimated beam exposure.
TT-2: Inventory = 1 irradiated target for direct exposure.
TT-3: Inventory = 1 irradiated target for direct exposure with available volatile noble gases and halogens for airborne release.
TT-4: Inventory = 1 irradiated target for direct exposure with additional volatile noble gases and halogens freed by heat for airborne release.

Table 3C-5. Chemical Processing.

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of Detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
CP-1	Release of Volatiles (target/cask) – breach during transport in Zone 2	Mishandling event or cask fatigue with target failure; spontaneous fatigue failure/leaker; fire in Zone 2 breaches cask and target confinement boundaries; external forces applied to cask (natural phenomena/ external event)	Mechanical properties of cask; most volatiles trapped in UO_2 matrix; tie-down onto forklift	Operating procedures; training; ignition sources minimized	IV	Visual/ RAMs/ CAMs	Ventilation flow (ΔP); wet-pipe sprinkler system; stack height; distance to site boundary	EOPs; combustible material minimized;	-Release of some noble gases, some halogens, and some matrix material into Zone 2 (1 target) -Large doses to workers: A-C -Collocated workers: D -Public: D -Environment: D	2-3 4 4 4	-Moveable shields for recovery actions
CP-2	Direct Exposure of Target in Open Cask – cask exits STB entry system to Zone 2 with target & without lid	Mishandling event during removal of cask from STB; Operator error in failing to remove target from cask	Cask has massive shielded lid with mounting fixtures for handling	Operating procedures; training;	IV	Visual/ RAMs/ Rad. Survey Instr.	Massive shielded cask sides provide shielding from direct exposure to most of target, reducing dose rate	EOPs,	-Direct exposure -Workers: B-C -Collocated workers: D -Public: D -Environment: D	3 4 4 4	
CP-3	Release of Volatiles (unopened target breach) – in the STB or in the Zone 2A under-box-transfer system to SCBs	Mishandling event during transport/handling; spontaneous fatigue failure/leaker; fire in Zone 2A breaches target confinement boundaries; external forces applied to STB or SCBs (natural phenomena/ external event)	Mechanical properties of target; most volatiles trapped in UO_2 matrix; structural integrity of STB, SCBs & Zone 2A under-box-transfer system	Operating procedures; training; ignition sources minimized	III	Visual/ Rad. Survey Instr. on air duct/ MER Rad. Monitor	Ventilation flow (ΔP); shielding; stack height; distance to site boundary; charcoal filtration; N_2 from Zone 2A fire system	EOPs, combustible material minimized;	Release of some noble gases, some halogens, and some matrix material into Zone 2A (1 target) -Workers: D -Collocated workers: D -Public: D -Environment: D	4 4 4 4	-Limits on combustible material

Table 3C-5. Chemical Processing (continued).

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of Detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
CP-4	Release of Volatiles (in-process target) -- breach prior to/during Iodine Trap (I-trap)/Cold Trap pipe attachment	Mishandling event during processing; spontaneous fatigue failure of target or I-trap; fitting failure; operator error/ misconnection; faulty pressure gauge; overheat/overpressure target from UO_2 dissolution; external forces applied to extraction SCB (natural phenomena/ external event)	Mechanical properties of target & I-trap; well-designed fittings and holding fixtures; structural integrity of SCB	Operating procedures; training	II	Visual/ Rad. Survey Instr. on air duct/ MER Rad. Monitor	Ventilation flow (ΔP); shielding; low SCB air change rate; stack height; distance to site boundary; charcoal filtration	EOPs	-Release of noble gases, halogens, and some matrix material into extraction SCB (1 target) -Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Ensure manipulator boot/ penetration integrity
CP-5	Release of Volatiles (one in-process I-trap used for 1 to 10 targets) -- breach after purging target	Mishandling event during processing or failure of fittings/mechanical fatigue in extraction SCB breaches I-trap and releases available volatiles; external forces applied to extraction SCB (natural phenomena/ external event)	Mechanical properties of I-trap; chemical reaction prevents iodine escape; well-designed fittings and holding fixtures; structural integrity of SCB	Operating procedures; training	III	Visual/ Rad. Survey Instr. on air duct/ MER Rad. Monitor	Ventilation flow (ΔP); shielding; low SCB air change rate; stack height; distance to site boundary; charcoal filtration	EOPs	-Release of minimal halogens into SCB (1 I-trap) -Workers: D -Collocated workers: D -Public: D -Environment: D	4 4 4 4	-Ensure manipulator boot/ penetration integrity
CP-6	Release of Volatiles in all process SCBs (maximum radionuclide inventory in all process SCBs) – breach of all in-process/ storage confinement barriers	Simultaneous multiple mishandling events during box operations; external forces applied to SCBs (natural phenomena/ external event)	Mechanical properties of targets, I-traps, and other barriers; well-designed fittings and holding fixtures; structural integrity of SCBs	Operating procedures; training	V	Visual/ Rad. Survey Instr. On air duct/ MER Rad. Monitor	Ventilation flow (ΔP); shielding; low SCB air change rate; stack height; distance to site boundary; charcoal filtration	EOPs,	-Release of entire volatile SCB in-process inventory (several targets, cocktails, product material) into Zone 1 ventilation system -Workers: D -Collocated workers: C -Public: C -Environment: D	4 4 4 4	

Table 3C-5. Chemical Processing (continued).

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of Detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
CP-7	Fire in an Extraction SCB breaches confinement barriers and releases volatile and non-volatile radioactive material	Tumbler or heat gun electrical wiring short or overheat; heat gun heating element touches and ignites flammable material	-Reliable, heavy-duty, electrical equipment; -Strong mechanical properties of targets, glassware, I-traps, and other barriers; -Well-designed holding fixtures	Operating procedures; training; ignition sources minimized	IV	Visual/ Rad. Survey Instr. On air duct/ MER Rad. Monitor	Thick steel SCB walls mitigate fire spread; ventilation flow (ΔP); shielding; low SCB air change rate; stack height; distance to site boundary; charcoal filtration; N_2 from Zone 2A fire system	EOPs, combustible material minimized;	-Release of entire volatile SCB in-process inventory (several targets, I-traps, cocktails, product material) into Zone 1 ventilation system -Workers: D -Collocated workers: C -Public: C -Environment: D	4 3 3 4	-Limits on combustible material
CP-8	Chemical Only Spill (target processing) – release of all chemical rinses, additives, etc. prior to/during SCB extraction or purification activities	Simultaneous multiple mishandling events in SCB; operator error during chemical addition; multiple container/syringe failure; external forces applied to SCBs (natural phenomena/ external event)	Well-designed storage scheme	Operating procedures; training; limited quantities	I	Visual	Ventilation flow (ΔP); low SCB air change rate; spill control pans; stack height; distance to site boundary; charcoal filtration	EOPs;	-Release of acid and bases into SCB -Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Ensure manipulator boot integrity following acid/base spill
CP-9	Radiochemical Spill (target processing) – release of cocktail into SCBs	Mishandling event; spontaneous fatigue failure of target; operator error/misconnection; overheat overpressure target; external forces applied to SCBs (natural phenomena/ external event)	Mechanical properties of targets; well-designed fittings and holding fixtures; structural integrity of SCBs	Operating procedures; training	I	Visual	Ventilation flow (ΔP); low SCB air change rate; spill collection pans; stack height; distance to site boundary; charcoal filtration	EOPs	-Release of radionuclide solution into SCB (1 cocktail/ raw product) -Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Establish radioactive material (cocktail/raw product) limit in SCBs -Ensure manipulator boot/ penetration integrity

Table 3C-5. Chemical Processing (continued).

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of Detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
CP-10	Radiochemical Spill/Contamination (transfer/ purification/ QA extraction) – release of product solution into SCBs	Mishandling event; failure of solution container; operator error/ misconnection; external forces applied to SCB (natural phenomena/ external event)	Mechanical properties of transfer, purification bottles; well-designed fittings and holding fixtures; structural integrity of SCBs	Operating procedures; training	I	Visual/ Rad. Swipes	Ventilation flow (ΔP); low SCB air change rate; spill collection pans; stack height; distance to site boundary; charcoal filtration	EOPs	-Release of radionuclide solution into SCB (1 batch) -Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Establish radioactive material (batch) limit in SCBs -Ensure manipulator boot/ penetration integrity
CP-11	Target overpressure / cocktail & volatile release in SCB during target heating for UO_2 dissolution	Target or T-section material fatigue/ failure; operator error causes target overheat /overpressure; (spontaneous or external forces)	-Target and T-section mechanical properties and pressure certification -Heat regulated by setting a thermostat	Operating procedures; training	III	Visual	Ventilation flow (ΔP); shielding; sealed penetration; stack height; distance to site boundary; charcoal filtration	EOPs;	-Release of dissolution cocktail, volatiles, & loose contamination into ventilation systems(Z1/Z2A), possible release through manipulator boots -Workers: C -Collocated workers: D -Public: D -Environment: D	3 4 4 4	-Ensure manipulator boot/ penetration integrity
CP-12	Overpressure in SCB with Cold Trap - liquid nitrogen leak from Cold Trap causes box overpressure release of loose contamination to Zone 2/2A	Cold Trap material fatigue/failure; liquid nitrogen piping/fittings mechanical fatigue/failure; operator error causes spill or misconnection; (spontaneous or external forces)	-Cold Trap mechanical properties -Piping & fittings mechanical properties -Liquid nitrogen regulator system	Operating procedures; training	II	Visual; SCB ΔP gauge	Ventilation flow (ΔP); shielding; sealed penetration; stack height; distance to site boundary	EOPs;	-Release of loose contamination into ventilation systems(Z1/Z2A), possible release through manipulator boots -Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Ensure manipulator boot/ penetration integrity -High quality liquid nitrogen regulator system to limit flow transients

Table 3C-5. Chemical Processing (concluded).

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of Detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
CP-13	Contamination Event – ventilation system confinement failure (Zone 1, 2A, & 2) – radioactive material contact with workers in Rooms 107, 110, 111, 112	Ventilation system power or equipment failure; damper failure (closed)/filter plugged with fan interlock failure; operator error (maintenance); external forces applied to ducting (natural phenomena/ external event)	Mechanical properties of system; continuous operation; permanent ducting; filters located away from occupied areas; ducting route minimizes exposure to damage	operator procedure, training	II	Audible; SCB (ΔP) monitor	manipulator boot & SCB penetration integrity; shielding; automatic (ΔP) control stops air exit from zones; stack height allows limited convective flow; distance to site boundary; charcoal filtration	Procedure, training	-Workers: C -Collocated workers: D -Public: D - Environment: D	2 3 3 3	-Ensure manipulator boot/ penetration integrity
CP-14	Contamination Event (Rooms 107, 110, 111, 112) – SCB manipulator boot/ penetration confinement failure (Zone 1) –	SCB manipulator boot/ penetration fatigue/failure; operator error; external forces applied to SCBs (natural phenomena/ external event)	Mechanical properties of boot & penetration; ventilation (ΔP) control prevents leaks by inward flow	operator procedure, training	II	Audible; SCB (ΔP) monitor	Ventilation flow (ΔP); shielding;	Procedure, training	-Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	-Ensure manipulator boot/ penetration integrity -Regular boot replacement for manipulator maintenance
CP-15	Excessive Direct Radiation Exposure (Zone 2A/Rooms 107, 110, 111) -- excessive dose to workers	Receive hotter target than anticipated; penetration radiation streaming; changed facility configuration or processing location (maintenance activities)	Shielding	operator procedures, training	II	RAMs	Shielding	Procedures	-Workers: D -Collocated workers: D -Public: D -Environment: D	3 3 3 3	

Radionuclide Inventory for Postulated Events

CP-1: Inventory = 1 irradiated target with available volatile noble gases and halogens for airborne release.
CP-2: Inventory = 1 irradiated target for direct exposure
CP-3: Inventory = 1 irradiated target with available volatile noble gases and halogens for airborne release.
CP-4: Inventory = 1 irradiated target with additional volatile noble gases and halogens freed by heated UO_2 dissolution for airborne release.
CP-5: Inventory = 1 iodine-trap with volatile halogens from 1 to 10 targets trapped and held by a chemical bond so not available for airborne release.
CP-6: Inventory = 6 targets of volatile noble gases and halogens freed by heated UO_2 dissolution, spill of 6 targets of dissolution cocktail, release of the volatiles in one 35-day accumulation cold trap, and no I-traps for airborne release of combined inventory of all in-process SCBs.
CP-7: Inventory = 2 targets of volatile noble gases and halogens freed by heated UO_2 dissolution, spill of 2 targets of dissolution cocktail, and one I-trap for airborne release of combined inventory of one extraction SCB.
CP-8: Inventory = No radiological material. Chemical spill of 1 target worth of extraction and purification chemicals.
CP-9: Inventory = 1 target worth of dissolution cocktail solution with dissolved fission product and actinide material but negligible volatiles.
CP-10: Inventory = 1 target worth of ^{99}Mo isotope product solution.
CP-11: Inventory = 1 target worth of dissolution cocktail solution and volatile noble gases and halogens freed by heated UO_2 dissolution for airborne release.
CP-12: Inventory = Accumulated loose contamination in waste SCB (~10,000,000 dpm for 100 cm^2 area).
CP-13: Inventory = Accumulated loose contamination.
CP-14: Inventory = Accumulated loose contamination.
CP-15: Inventory = 1 target of higher activity isotope material than anticipated.

Table 3C-6. Packaging.

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of Detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
P-1	Facility Degradation involves product	Product sucked into ventilation system by spill into 2R container leak check device	-Plastic bottle seal and 2R container seal	-Operations procedures -Inspection of seal rings	III	Vacuum pump dose rate	-Excess water in leak check device dilutes any spilled product		-Airborne release dose -Workers: D -Collocated workers: D -Public: D -Environment: D	-Workers: 4 -Collocated Workers: 4 -Public: 4 -Environ.: 4	
P-2	Spill product in SCB	-Operator Error -Mechanical Failure (manipulator)	-Closed container transfer and volume measurement	-Operations procedures	I	Visual	-Spill trays lined with absorbent material so all the small volume stays in the tray -Ventilation flow (ΔP) to stack	-Cleanup material kept in box.	-Airborne release dose -Workers: D -Collocated workers: D -Public: D -Environment: D	-Workers: 3 -Collocated Workers: 3 -Public: 3 -Environ.: 3	
P-3	Spill in Zone 2 (DU shield, 2R, & plastic bottle breach)	-Operator Error -Mechanical Failure of package handling equipment	-Plastic bottle in metal 2R and DU shield for double containment and shielding	-Operations procedures -Handling equipment maintenance	IV	Visual/ RAMs/ CAMs	-Ventilation flow (ΔP) in zones to stack	Access control	-Direct exposure & airborne release doses -Workers: C -Collocated workers: D -Public: D -Environment: D	-Workers: 3 -Collocated Workers: 4 -Public: 4 -Environ.: 4	

Radionuclide Inventory for Postulated Events

P-1: Inventory = 1 target worth of ^{99}Mo isotope product material.
P-2: Inventory = 1 target worth of ^{99}Mo isotope product material.
P-3: Inventory = 1 target worth of ^{99}Mo isotope product material.

Table 3C-7. Quality.

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of Detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
Q-1	Exposure in 113 SGB from Product Extract sample	-Working with improper sample size & activity -Spill of all or part of Product Extract sample -SGB boot failure	-Shielding & leaded glass -Standard size product sample vials to limit activity	-Operations procedures	III	RAMs	-Limited size & activity of product sample	-Access control	Direct exposure dose -Workers: D -Collocated workers: D. -Public: D -Environment: D	-Workers: 4 -Collocated Workers: 4 -Public: 4 -Environ.: 4	
Q-2	Exposure in 113 Hood from Dilution Transfer sample	-Working in Hood w/ improper draw size & activity	-Standard pipettes for drawing from sealed product sample in SGB	-Operations procedures	III	RAMs	-Limited size & activity of Hood diluted product sample	-Access control	Direct exposure dose -Workers: D -Collocated workers: D -Public: D -Environment: D	-Workers: 4 -Collocated Workers: 4 -Public: 4 -Environ.: 4	
Q-3	Fire or Explosion + Fire in 113 Hood (disperses, spills, and/or boils Dilution Transfer sample)	-Heat lamp igniting spill absorbing materials -Improper chemical mixture in Hood -Organic solvent spill ignited by heat lamp	-Arrangement of tools and materials in Hood -Chemicals and glassware labeled with contents -Organic solvent quantities limited	-Operations procedures	IV	Visual	-Ventilation flow limits inhalation hazard -Limited combustibles	-Access control	Airborne dose -Workers: D -Collocated workers: D -Public: D -Environment: D	-Workers: 4 -Collocated Workers: 4 -Public: 4 -Environ.: 4	

Quality Notes:

1. The ^{99}Mo product has ~ 880 Ci activity for each ~ 20,000 Ci target. Volume of the product solution is ~ 75 ml.
2. The product quality sample extraction is normally 0.3 ml volume per target. It is transported to the SGB in a lead pig for shielded storage and use. An erroneously too large product quality sample extraction of 1.0 ml was hypothesized for hazard event purposes. A secondary extraction sample of 20 λ ($\lambda = 10^{-3}$ ml) is taken from the 0.3 ml product quality sample extraction in the SGB for dilution to transfer the diluted product to the Hood. Product and product extraction samples are all the same concentration.
3. The dilution of the 20 λ product extract is done in the SGB by adding it to 100 ml of NaOH solution. The resulting dilute product solution is called the 20 λ/100 ml Dilution. A portion (10 ml) is transferred to the Hood for preparation of product quality analysis samples. Two sample sizes (20 λ and 2 ml) are extracted in the Hood from the 10 ml of 20 λ/100 ml Dilution to use in product quality analyses.
4. Activities, exposure rates in air, and dose rates (effective dose equivalent (EDE), anterior/posterior) were calculated for the unshielded case for the ^{99}Mo product extraction samples in the SGB as well as 20 λ/100 ml Dilution samples in the Hood. The results (shown below) were used to assess unmitigated consequences.
5. MICROSHIELD Version 4 was used to calculate the ^{99}Mo exposure rates in air and dose rates at 1 foot and 1 meter distances from a point source. The calculation used ^{99}Mo source spectra with a lower energy threshold of 0.015 MeV and used buildup factors in the radiation transport. Exposure rates in air for 1 Ci of ^{99}Mo at 1 foot and at 1 meter were 1.056 R/hr and 9.782E-02 R/hr. Dose rates (EDE) for 1 Ci of ^{99}Mo at 1 foot and at 1 meter were 9.207E-01 rem/hr and 8.548E-02 rem/hr.

Activity, Exposure Rate in Air, and Dose Rate (EDE) for ^{99}Mo Product Extract and 20 λ/100 ml Dilution Samples for Quality Control Analyses

	SCB 1	SGB			Hood		
	Total ^{99}Mo Product (75 ml)	^{99}Mo Product Extract, Erroneously Too Large (1 ml)	^{99}Mo Product Extract, Correct Size (0.3 ml)	^{99}Mo Product Extract, Correct Size (20 λ)	20 λ/100 ml Dilution, Transfer to Hood Correct Size (10 ml)	20 λ/100 ml Dilution for Iodine & Total Gamma Correct Size (2 ml)	20 λ/100 ml Dilution for ^{99}Mo and Alpha Content Correct Size (20 λ)
Total Activity (Ci)	880	11.7	3.52	2.35E-01	2.35E-02	4.69E-03	4.69E-05
Exposure Rate @ 1 foot (R/hr)	929	12.4	3.72	2.48E-01	2.48E-02	4.95E-03	4.95E-05
Dose Rate (EDE) @ 1 foot (rem/hr)	810	10.8	3.24	2.16E-01	2.16E-02	4.32E-03	4.32E-05
Exposure Rate @ 1 m (R/hr)	86.1	1.15	0.344	2.30E-02	2.30E-03	4.59E-04	4.59E-06
Dose Rate (EDE) @ 1 m (rem/hr)	75.2	1.0	0.301	2.01E-02	2.01E-03	4.01E-04	4.01E-06

Radionuclide Inventory for Postulated Events

All events: Quality control samples of isotope material as explained in notes above.

Table 3C-8. Waste.

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
WP-1	Spill during waste processing in SCB 1	Leak during drain/transfer.	Direct transfers (no open air), plastic-coated or metallic containers.	OP for waste process.	I	Visual	Spill trays, absorbent material in box. Small volume of waste would all stay in tray/box, volatiles removed already	Cleanup material kept in box.	Workers: D Collocated: D Public: D Environment: D	3 3 3 3	
WP-2	Release of volatiles stored in the Cold Trap in SCB 1 (maximum radionuclide inventory in Cold Trap) -- breach of confinement barriers and warming of Cold Trap	Major mishandling event during waste box operations; major fire breaches confinement barriers and releases volatiles; external forces applied to SCB (natural phenomena/ external event)	Mechanical properties of Cold Trap, and other barriers; well-designed fittings and holding fixtures; structural integrity of SCBs	Operating procedures; training; ignition sources minimized	III	Visual/ Rad. Survey Instr. on air duct/ MER Rad. Monitor	Ventilation flow (ΔP); shielding; stack height; distance to site boundary	EOPs, combustible material minimized;	-Release of entire volatile Cold Trap inventory (volatiles from multiple targets) into Zone 1 ventilation system -Workers: D -Collocated: C -Public: C -Environment: D	4 3 3 4	-Ensure manipulator boot/ penetration integrity -Limit ignition sources and combustible material
WP-3	Fire during waste processing in SCB 1	Electrical - wiring for tumbler	Limited electrical systems (tumbler only in operation)	None	IV	Visual, heat sensor	Low volatility of material, metallic containers, few combustibles	EOPs, combustible material minimized;	Airborne release doses: Workers: D Collocated: D Public: D Environment: D	4 4 4 4	

Table 3C-8. Waste (continued).

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
WE-1	Fire in Zone 2A	Electrical	Limited number of electrical systems	Limited inventory of flammables	IV	Visual, heat sensor, CAMs	Nitrogen system, low volatility of material, metallic containers	Access control	Worker: D Collocated: D Public: D Environment: D	4 4 4 4	
WE-2	Accidental exposure to scattered radiation from Zone 2A waste inventory with elevator up or in transit to 109 waste storage area	-Failed elevator (hydraulic) -Inadvertent entry to the Zone 2A airlock entry area in 112	-Backup cage and motor -Zone 2A airlock eliminates line of sight to source & reduces escape of scattered radiation	HCF OP	II	Visual RAMs	-Zone 2A shield walls -Distance from source to worker	Access control	Radiation scattered out of Zone 2A airlock causes local high dose rate at airlock entrance Worker in 112 airlock entrance area: C Collocated: D Public: D Environment: D	2 3 3 3	-Install temporary shielding outside airlock -Administrative controls and normally closed access barrier to airlock area
WE-3	Exposure of fresh waste drum inventory to workers in 112 through Zone 2A airlock doors while storing waste in row 5 of 109	Fall of waste drum from cart toward airlock door (inattention, mechanical failure, load shift)	Floor rails to guide waste cart; mounting rings on cart and rack for upper drum level hold drums on cart	HCF OP	III	Visual RAMs	-Zone 2A shield walls -Distance through Zone 2A airlock	Access control	Direct exposure high dose rate at Zone 2A airlock entry Worker near Zone 2A airlock door in 112: A–C Collocated: D Public: D Environment: D	2-3 4 4 4	-Install temporary shielding outside airlock -Administrative controls and normally closed access barrier to airlock area
WE-4	Explosion or deflagration in elevator pit with waste drums in pit	LEL for H_2 exceeded	H_2 source in vented waste drums limits H_2 level in pit; limited ignition sources; N_2 from cold trap exhausted to pit inerts the air	Operating procedures; training	IV	Visual/ audible	-Zone 2A shield walls -Distance through Zone 2A airlock	EOPs, combustible material minimized;	Potential for facility damage: Worker: C Collocated: D Public: D Environment: D	3 4 4 4	

Table 3C-8. Waste (concluded).

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
WS 109-1	Fire in 109 with or without 108 and 110 doors up	Electrical	Limited electrical systems in 109.	Limited inventory of flammables	IV	None	Low volatility of material, metallic containers.	Access and inventory control, EOPs	Worker: C Collocated: D Public: D Environment: D	3 4 4 4	*Add fire suppression and heat sensor to 109?*
WS 109-2	Explosion/fire in 109	H_2 or ignition of other combustables	Ventilation/ size of room - insufficient H_2 accum.	None	IV	None	Low volatility of material, metallic containers; door and wall thickness to shield.	Access and inventory control, EOPs	Potential for facility damage and worker injury, airborne release Worker: C Collocated: D Public: D Environment: D	3 4 4 4	*Add fire suppression and heat sensor to 109?*
WS 109-3	Exposure of inventory - both doors to 108 open, worker enters 108	Problem with seals, human error	Keyed locks on door controls	Operating Procedures	III	Visual	None	Access control	Resulting high radiation dose: Worker: A-B Collocated: D Public: D Environment: D	2 4 4 4	-Administrative control so that both doors cannot be opened at once -RAMs
WS 109-4	Partial exposure of inventory - worker in catacombs	Problem with 109 hydraulic seals, worker enters to repair the "dogs"	None	None	II (1 in 5yrs)	None	None	Access control	Radiation dose: Worker: C Collocated: D Public: D Environment: D	2 3 3 3	

WP = Waste processing
WE = Waste handling from storage in elevator pit to transfer and preparation for storage in room 109
WS109 = Waste storage in room 109

Radionuclide Inventory for Postulated Events

WP-1: Inventory = 1 target worth of fission product and actinide material in solution without volatiles eligible for spill.
WP-2: Inventory = Target volatiles (minus halogens) in on Cold Trap for 35 days of production (150 targets of graduated age for 6 targets/day).
WP-3: Inventory = 1 target worth of fission product and actinide material in solution without volatiles being tumbled and involved in fire at tumbler.
WE-1: Inventory = 4 drums in elevator and 1 drum at waste SCB with 12 targets/drum.
WE-2: Inventory = 4 drums at elevator and 1 drum at waste SCB with 12 targets/drum.
WE-3: Inventory = 1 drum at Zone 2A inner airlock door with 12 freshest targets/drum.
WE-4: Inventory = 4 or 5 drums in elevator with 12 targets/drum.
WS109-1: Inventory = maximum of 180 drums with 12 targets/drum
WS109-2: Inventory = maximum of 180 drums with 12 targets/drum
WS109-3: Inventory = maximum of 180 drums with 12 targets/drum
WS109-4: Inventory = maximum of 180 drums with 12 targets/drum. Dose to worker entering catacombs is 100 mR/hr.

Table 3C-9. HCF Maintenance.

Event No.	Event Description	Causes	Prevention Features: Design	Prevention Features: Admin.	Freq.	Method of detect.	Mitigative Features: Design	Mitigative Features: Admin.	Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
HM-1	Organic Solvent Spill in Zone 2, 2A, or SCB (Solvent used during equipment maintenance)	Mishandling event; operator error; container fatigue failure	Well-designed storage scheme; quantity in use limited	Operating procedures; training; limited quantities	II	Visual; odor	Ventilation flow (ΔP); limited quantities; limited air change rate; stack height, distance to site boundary; charcoal filtration	EOPs; workers leave area and return later to clean up spill	Release of volatile, toxic, & flammable organic solvent vapor: -Worker: D -Collocated: D -Public: D -Environment: D	3 3 3 3	
HM-2	Organic Solvent Fire or Explosion in Zone 2, 2A, or SCB (Solvent used during equipment maintenance)	Mishandling event; operator error; container fatigue failure; electrical system failure	Well-designed storage scheme; quantity in use limited; ignition sources minimized	Operating procedures; training; limited quantities; combustible material limited	IV	Visual; odor	Ventilation flow (ΔP); limited quantities; limited air change rate; stack height, distance to site boundary; charcoal filtration; fire suppression systems in Zone 2 & 2A	EOPs	Release of volatile, toxic, & flammable organic solvent vapor: -Worker: D -Collocated: D -Public: D -Environment: D	4 4 4 4	

Radionuclide Inventory for Postulated Events

HM-1: Residual radiological contamination material considered in this release, just inhalation hazard from organic, flammable, toxic solvents.

HM-2: Residual radiological contamination material considered in this release, just fire or explosion hazard from organic, flammable, toxic solvents.

Table 3C-10. Monorail Storage Holes.

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of Detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
MS-1	Radioactive release from material in storage	Spontaneous fatigue failure or fire in monorail storage hole breaches material confinement; external forces applied to monorail storage hole (natural phenomena/ external event)	Mechanical properties of material container; shielding and weather cap on hole; depth of hole; sides and bottom lined: lack of ignition sources	Regular maintenance inspections	IV		Distance to site boundary and area fence	Majority of workers located a significant distance from monorail storage holes; Emerg. Op. Procedures	-Airborne release and loose contamination doses -Workers close to Monorail Storage Holes: C -Collocated workers: D -Public: D -Environment: D	-Worker: 3 -Collocated worker: 4 -Public: 4 -Environ.: 4	

Radionuclide Inventory for Postulated Events

MS-1: Inventory = Less than the Hazard Category 2 radionuclide threshold. Stored radiological materials must be solids and not flammable.

Table 3C-11. Technical Area-V Radiological Material Storage Areas . Building 6596 (East High Bay) and Building 6597 (High Bay)

Event No.	Event Description	Causes	Prevention Features		Freq.	Method of Detect.	Mitigative Features		Unmitigated Consequences	Risk Bin	Safety Enhancement Consideration
			Design	Admin.			Design	Admin.			
RS-1	Fire in building -- radioactive release from material in storage	Electrical fire feed by packing material in storage area breaches material confinement and causes release through vents or doors; external forces applied to storage area (natural phenomena/ external event)	Mechanical properties of material containers; smoke detectors and sprinkler fire suppression	Operating procedures; hazardous material handling training; packaging requirements	III	Smoke from vents and smoke detector alarms	Distance to site boundary and area fence; low or zero ventilation rate	Majority of workers located a significant distance from storage areas; Emergency Operations Procedures	-Airborne release and loose contamination doses -Workers: C -Collocated workers: C -Public: D -Environment: D	-Worker: 3 - Collocated worker: 3 -Public: 4 -Environ.: 4	
RS-2	Broken package or liquid/resin spill causes release of radiation in material storage area	Mishandling event involving forklift or manual handling of stored material; packaging failure/fatigue; external forces applied to storage area (natural phenomena/ external event)	Mechanical properties of material containers and storage building; forklift maintenance; spill pallets for resins	Operating procedures; forklift training; hazardous material handling training; packaging requirements	III	Visual	Distance to site boundary and area fence	Majority of workers located a significant distance from storage areas; Emerg. Op. Procedures	-Contamination doses -Workers: C -Collocated workers: D -Public: D -Environment: D	-Worker: 3 - Collocated worker: 4 -Public: 4 -Environ.: 4	

Radionuclide Inventory for Postulated Events

RS-1: Inventory = Less than the Hazard Category 2 radionuclide threshold for either of the two separated storage areas. Stored radiological materials must be solids or liquids/resins on spill pallets and not flammable.

RS-2: Inventory = Less than the Hazard Category 2 radionuclide threshold for either of the two separated storage areas. Stored radiological materials must be solids or liquids/resins on spill pallets and not flammable.

APPENDIX 3D

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

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Introductory Material

Two types of analytical methods are used to evaluate hazards: 1) preliminary hazards analysis (PHA), and 2) failure modes and effects analysis (FMEA). PHA is an accident scenario-based form of analysis. The FMEA is a complementary type of evaluation that utilizes a system failure-based form of analysis. Generally, FMEAs were only accomplished for equipment which was perceived to have a significant safety role, i.e. SSCs which were anticipated to be designated as safety significant in accordance with DOE-STD-3009. Unlike PHA, the first objective of FMEA is to subdivide the facility into several different (and, to the maximum extent possible, independent) system elements. Failure modes of each system element are then postulated and a structured examination of the consequences of each failure mode follows. However, similar to PHA, FMEA documents preventive and mitigative features (failure mechanisms and compensation) and anticipated accident consequences (failure effects). This appendix documents the FMEA for the HCF.

Two distinctly different, yet complementary, perspectives of hazards for the HCF and associated radioactive material storage locations are obtained for the overall hazard analysis of Chapter 3 by using both PHA and FMEA techniques. Multiple perspectives in the overall hazard analysis assist in more fully identifying and developing 1) planned design and operational safety improvements, and 2) facility design and administrative features contributing to defense in depth, worker safety, and environmental protection. In practice, the interim results of the PHA were used to guide the FMEA investigation and FMEA results were used to further develop the PHA scenarios. Thus, the results of the PHA and FMEA serve as the basis for hazard ranking in the overall hazard analysis of the wide range of HCF hazards so that bounding accident scenarios can be selected for further development in the design basis accident (DBA) analysis.

Hazard ranking in the hazard analysis of Chapter 3 is achieved by qualitatively assigning frequency and consequence estimates to each hazard or accident scenario developed in the PHA or FMEA. Then, the risk ranking is assigned to each hazard scenario based on its frequency and consequence. The risk ranking results serve as one basis for determining if a more detailed quantitative analysis of specified hazards or accident scenarios (DBA) is required. The consequence, frequency, and risk ranking estimates are presented only in the PHA but those estimates are also affected by FMEA results as explained above. All consequence and frequency estimates were based on the consensus engineering judgment of the hazard analysts conducting the PHA and FMEA.

The FMEA for each distinct system element is shown in Tables 3D-1 through 3D-4. The tables contain the effects of failures of various systems and subsystems in the HCF. The safety significance of those structures, systems, and components can be inferred from the FMEA and PHA results.

TABLES

Table 3D-1. Ventilation System FMEA Results.

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.1	Stack exhaust fans #4 & #5 (Transports the ventilation system filtered exhaust out of the HCF stack and controls flow rate through the stack HEPA filter.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	Two parallel fans provide redundant flow.	Complete loss of ventilation flow if both fans stop. Loss of flow forces shutdown of HCF ventilation system.
1.2	Building 6580 house-air supply fan #3 (Provides conditioned ventilation air supply to the HCF through Zone 2 fan #13.)	Shutdown due to loss of electrical power or fan electrical failure	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	None	Loss of conditioned intake air (less than 6 air changes per hour)
1.3	Zone 2 HCF air supply fan #13 (Provides conditioned ventilation air supply to the HCF and controls flow rate through the supply HEPA filter.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	Leakage drawn from outside air through cracks in doorframes, etc. could provide some limited air supply.	Loss of conditioned intake air (less than 6 air changes per hour)
1.4	Zone 2 air circulation fan #11 (Cools and re-circulates ventilation air in Zone 2 and controls flow rate through the combined HEPA filter and chiller. Provides entrance and cooling of HCF supply air from fan #13.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	None	Loss of temperature control in Zone 2

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.5	Zone 2 active damper pressure control system (Provides a (Δp) pressure differential for contamination control to Zone 3 (Building 6580) by restricting house air input from fan #3).)	Fail closed causes increased Δp to from Zone 2 to Zone 3	Mechanical failure of active damper, loss of air pressure for damper pneumatic actuator, or programmed control system failure	Control and monitoring system indications and periodic maintenance inspections	Leakage drawn from outside air through cracks in doorframes, etc. could provide some limited air supply to reduce Δp somewhat	No effect to positive effect since the increased Δp provides better contamination control. Reduced Zone 2 air flow (less than 6 air changes per hour)
		Fail open causes decreased Δp from Zone 2 to Zone 3			Leakage drawn from outside air through cracks in doorframes, etc. may decrease to increase Δp somewhat	No effect to loss of positive contamination control and potential, slow spread of any contamination present in Zone 2 to the basement of Building 6580
1.6	Zone 2 air exhaust new booster fan #18 (Transports the Zone 2 exhaust to the HCF stack through the Zone 2 HEPA filter.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	None	Reduced ventilation flow through Zone 2 impedes removal of stale air (less than 6 air changes per hour).

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.7	Zone 2A active damper Δp control system (Provides active Δp adjustment for control of contamination from Zone 2A to Zone 2 and HEPA input air filtration.)	Fail closed causes increased Δp to from Zone 2A Zone 2	Mechanical failure of active damper, loss of air pressure for damper pneumatic actuator, programmed control system failure, or plugged filter	Control and monitoring system indications and periodic maintenance inspections	Leak rate through airlock doors and Room 109 shielded door may increase to reduce Δp somewhat.	No effect to positive effect since reduced flow may extend residence time in Zone 2A HEPA and charcoal exhaust filters
		Fail open causes decreased Δp from Zone 2A to Zone 2			Leak rate through airlock doors and Room 109 shielded door may decrease to increase Δp somewhat.	No effect to loss of positive contamination control and potential, slow spread of any contamination present in Zone 2A
1.8	Zone 2A air exhaust fans #8 & 9 and manual damper (Transports the Zone 2A exhaust to the HCF stack. Fan and manually operated damper control flow rate and residence time through the HEPA filter in Zone 2A and the charcoal filter in the MER.)	Shutdown due to loss of electrical power, fan electrical failure, plugged HEPA or charcoal filter, or erroneously closed damper	Onsite or offsite electrical or mechanical malfunction and operator error	Control and monitoring system indications and periodic maintenance inspections	Two parallel fans provide redundant flow.	Loss of almost all ventilation flow through Zone 2A. Possible loss of positive contamination control and potential, slow spread to Zone 2

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.9	Zone 1 SCB passive Δp control systems (Provide a Δp by restricting intake air from the Zone 2A air supply plenum to SCBs for contamination control to Zone 2A and Zone 2 as well as HEPA input air filtration through conveyor plenum.)	Fail closed causes Increased Δp to Zone 2A and Zone 2	Mechanical failure of multiple ball check valves per SCB or plugged HEPA filters on air supply plenums	Control and monitoring system indications and periodic maintenance inspections	Leak rate through manipulator boots from Zone 2 may increase to reduce Δp somewhat.	No effect to positive effect on spread of contamination since reduced flow may extend residence time in Zone 1 SCB charcoal exhaust filters
		Fail open causes decreased Δp to Zone 2A and Zone 2			Open passive system fails Δp to the Zone 2A to Zone 2 Δp	Some slow inter-SCB spread of contamination since increased flow may reduce residence time in Zone 1 SCB charcoal exhaust filters

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.10	SCB to Zone 1 flow rate control systems (Controls the flow of SCB exhaust to the Zone 1 exhaust line. Two manually operated dampers control flow rate and residence time through the two SCB charcoal filters for contamination control.)	High flow rate reduces residence time in charcoal filter and reduces iodine removal efficiency required for inter-SCB contamination control.	Onsite mechanical malfunction and operator error	Control and monitoring system indications for flow rate at the SCB and periodic maintenance inspections	Two parallel flow damper and charcoal filter exhausts on each SCB provide redundant flow paths.	Loss of positive iodine contamination control and potential, slow spread to other Zone 1 SCBs, Zone 2A, Zone 2, MER and the HCF stack
		Low flow rate increases residence time in charcoal filter and increases iodine removal efficiency required for inter-SCB contamination control.				Positive iodine contamination control maintained due to increased charcoal filter iodine removal efficiency
1.11	Zone 1 air exhaust fans #6 & 7 and manual damper (Transports the Zone 1 exhaust to the HCF stack. Fan and manually operated damper control flow rate and residence time through the Zone 1 charcoal filter.)	Shutdown due to loss of electrical power, fan electrical failure, plugged charcoal filter, or erroneously closed damper	Onsite or offsite electrical or mechanical malfunction and operator error	Control and monitoring system indications and periodic maintenance inspections	Two parallel fans provide redundant flow.	Loss of all ventilation flow through Zone 1. Loss of positive contamination control and potential, slow spread to Zone 2A and Zone 2

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.12	Room 113 ventilation hood exhaust fan #17 (Transports the hood exhaust to the HCF stack through the hood HEPA filter.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	None	Loss of all ventilation flow through hood. Loss of positive contamination control and potential, slow spread to Zone 2
1.13	Room 113 shielded glove box (SGB) passive Δp control system (Provides Δp for control of contamination to Zone 2.)	Fail closed causes Increased Δp to Zone 2	Mechanical failure of multiple ball check valves or plugged air supply plenums	Control and monitoring system indications and periodic maintenance inspections	None	No effect to positive effect since increased Δp may improve contamination control
		Fail open causes decreased Δp to Zone 2				No effect to loss of positive contamination control and potential, slow spread of any contamination present to Zone 2
1.14	Room 113 SGB exhaust fans #15 & 16 (Transports the SGB exhaust to the HCF stack through the SGB HEPA filter.)	Shutdown due to loss of electrical power, fan electrical failure, or plugged HEPA filter	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	Two parallel fans provide redundant flow.	Loss of all ventilation flow through SGB. Loss of positive contamination control and potential, slow spread to Zone 2.
1.15	Mechanical equipment room (MER) exhaust fan #14 (Provides ventilation for the equipment access area of the little room of the MER and transports the exhaust to the HCF stack.)	Shutdown due to loss of electrical power or fan electrical failure	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	None	Loss of all ventilation air flow through the equipment access area of the little room of the MER.

Table 3D-1. Ventilation System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
1.16	Ventilation programmed control system (Controls Δp in zones through active damper control of exhaust flow.)	Shutdown due to loss of electrical power or electrical failure	Onsite or offsite electrical or mechanical malfunction and operator error	Control and monitoring system indications and periodic maintenance inspections	Last position of dampers retained to provide some Δp	Loss of active control of the ventilation system Δp differential between zones and some eventual spread of contamination.
1.17	Room 222 air compressors for pneumatic control air pressure (Provides air pressure for pneumatic damper actuators that control Δp in ventilation zones in response to commands from the programmed control system.)	Shutdown due to loss of electrical power or electrical failure	Onsite or offsite electrical or mechanical malfunction and operator error	Control and monitoring system indications and periodic maintenance inspections	Last position of dampers retained to provide some Δp	Loss of active control of the ventilation system Δp differential between zones and some eventual spread of contamination.

Table 3D-2. Vacuum System FMEA Results.

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
2.1	Vacuum pump in MER (Provides system vacuum for chemical processing.)	Shutdown due to loss of electrical power or electrical failure	Onsite or offsite electrical or mechanical malfunction	Control and monitoring system indications and periodic maintenance inspections	Redundant pumps	Loss of all vacuum for controlling noble gas and halogen releases and for moving process fluids.
2.2	Vacuum supply line from MER to Zone 2A (Transports vacuum for chemical processing.)	Broken or plugged line	Mechanical malfunction or worker error	Control and monitoring system indications and periodic maintenance inspections	None	Loss of all vacuum for controlling noble gas and halogen releases and for moving process fluids.
2.3	Vacuum system filters in SCBS (Captures remaining radioactive material and contaminants from chemical processing.)	Broken or plugged line	Mechanical malfunction or worker error	Control and monitoring system indications and periodic maintenance inspections	Cold traps act as backup to in-box filters; exhaust vented to Zone 1 filters	Loss of all vacuum for controlling noble gas and halogen releases and for moving process fluids.
2.4	Cryogenic cold traps in Zone 2A. (Capture process radioactive noble gas in the vacuum system flow to control release.)	Plugged trap or broken vacuum line	Mechanical malfunction or worker error	Control and monitoring system indications and periodic maintenance inspections	Redundant cold traps provide multiple flow paths for vacuum.	Loss of vacuum and potential release of noble gas.
		Broken, plugged, or shut off liquid nitrogen supply or exhaust lines	Mechanical malfunction or worker error	Control and monitoring system indications and periodic maintenance inspections	Redundant cold traps provide multiple flow paths for vacuum.	Loss of cold trapping for control of noble gas and potential release of noble gas.

Table 3D-2. Vacuum System FMEA Results (continued).

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
2.6	Vacuum lines to each SCB from the cold traps (Transports vacuum for chemical processing.)	Broken or plugged line	Mechanical malfunction or worker error	Control and monitoring system indications and periodic maintenance inspections	Alternate processing stations.	Loss of vacuum for controlling noble gas and halogen releases and for moving process fluids.

Table 3D-3. Room 109 Shield Door Controls FMEA Results.

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
3.1	Room 101/108 Door control (enables door movement)	Inadvertent door motion	Electrical malfunction (contact closure or short) or multiple operator errors	Observation of door movement	None	None
3.2	Room 108/109 Door control (enables door movement)	Inadvertent door motion	Electrical malfunction (contact closure or short) or multiple operator errors	Observation of door movement; RAM Alarm	Access control	High radiation in Room 108
3.3	Room 109/2A Door Control (enables door movement)	Inadvertent door motion	Electrical malfunction (contact closure or short) or multiple operator errors	Observation of door movement; RAM Alarm	Access control	High radiation in Room 112
3.4	Door hydraulic system (applies force for door movement)	Door drive inoperative	Mechanical failure (leak or rupture); pump failure	Inability to drive doors; doors lower when being driven up	Access control	None (doors remain in position, or doors lower if in motion)

Table 3D-4. Target Entrance System (TES) FMEA Results.

ID No.	System Element (Function)	Failure Mode	Failure Mechanism	Failure Detection	Failure Compensation	Failure Effect(s)
3.1	Mechanical interlock (prevents removal of cover with cask lid captured)	Cover raised with captured cask lid	Mechanical Failure; Operator applies excessive force	Visual observation, RAM Alarm	Access control, evacuation	Potential for high radiation in room 111.

APPENDIX 3E

DBA EVENT TREE ANALYSES

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CONTENTS

FIGURES

TABLES

3E.1 ENERGETIC FORKLIFT ACCIDENT

3E.1.1 Forklift Accident Sequence Development

This DBA is defined as an energetic forklift accident, which breaches the target cask, breaches the target, and releases volatile radioactive components in the target; with or without a forklift fire. This section is concerned with scenario development. The initiating events, preventative controls, and mitigating controls from the hazard evaluation are analyzed to aid in accident progression development.

Initiating Events:

1. Forklift rolls/runs away down HCF truck ramp due to operator inattention or mechanical failure.
2. Forklift strikes fixed object due to operator inattention or mechanical failure.
3. Another vehicle strikes the forklift load due to operator inattention or procedure violation.
4. Cask falls off the forklift when the load is elevated due to operator inattention or mechanical failure.

Initiating event alternatives 1 and 2 are really the same, possibly differing only in impact velocity when striking a fixed object. Alternative 3 represents a less defined crash of the forklift/cask, which may produce less stress on the cask due to the yielding of the other vehicle. In addition, such an other-vehicle crash is unlikely since access to the transfer route is required to be limited during the actual transfer operation. The cask is not elevated while on the forklift in transit from the ACRR to the HCF. The cask is raised and lowered by crane and positioned for transport in a special carrier basket, previously attached to the forklift tines. In conclusion, the initiating event is chosen to be "Forklift strikes a fixed object due to operator inattention or mechanical failure."

Both the ACRR high bay exit ramp and HCF truck ramp entrance must be traversed for every target transfer to the HCF. Both ramps are 110 feet long. The HCF truck ramp falls 9 feet and the ACRR truck ramp falls 5 feet. Of the two ramps on the transfer route, the HCF truck ramp is the steepest and the only one with a steel door and fixed wall at the bottom. The roll down the HCF truck ramp will be examined as a bounding case on velocity since rolling down hill can increase the forklift speed.

Preventive Controls:

1. Regular maintenance of the forklifts could prevent brake or other mechanical failure.
2. Training for operators could prevent driving errors leading to a crash.
3. Bolts on the cask lid and the operating procedure to install them on a loaded cask could prevent the lid coming off and the target coming out in a crash.

Preventive controls 1 and 2 both represent measures to avoid a crash. Preventive control 3 represents the ability of a safety structure, the cask, to prevent release of hazardous radioactive material. The cask, depicted in Figure 3E.1-1, was only designed to provide shielding for the target in transit and not to contain volatile material. In fact, no seal is installed on the lid during cask loading and no leak test is performed. The target will be protected in a crash if it remains in the cask and the cask is not breached or broken open in the crash.

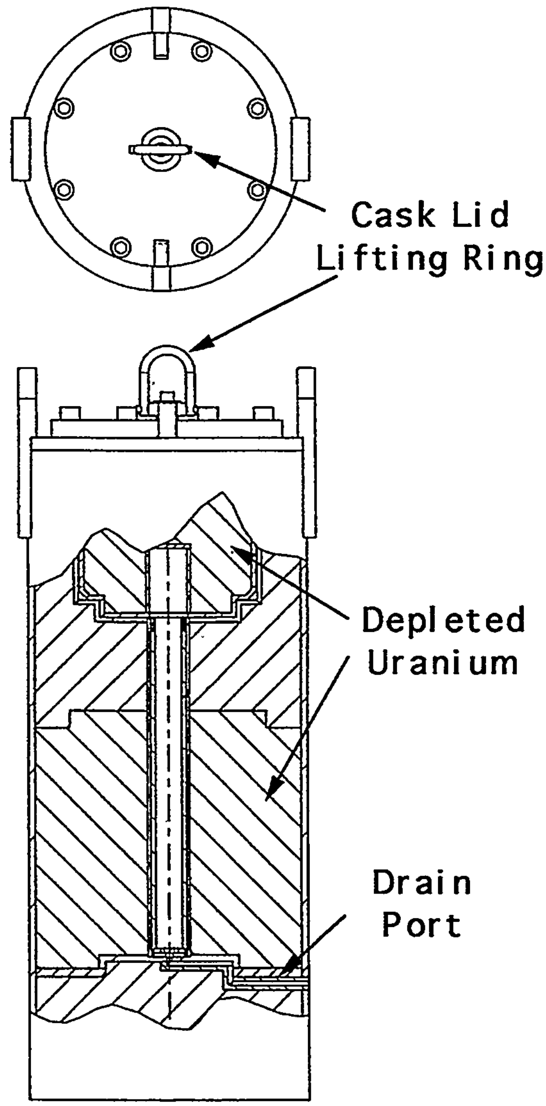

Figure 3E.1-1 Target Transfer Cask

Mitigative Controls:

1. Access control to the transfer route, distance to the majority of collocated workers in TA-V, and emergency procedures could mitigate direct and airborne radiation doses to workers.
2. Distance to the site boundary could mitigate direct and airborne radiation doses to the public.

While both mitigative controls could reduce dose to workers and the public, they are limited by the location of the accident if it is outside of TA-V buildings. No containment of airborne radioactivity is possible in building filters or ventilation systems for outside accidents. Emergency shielding is limited to existing buildings and access control is limited by the need to support other TA-V operations.

The DBA accident progression sequence is defined as follows:

1. The forklift rolls or runs away down the HCF truck ramp.
2. The operator fails to slow the forklift due to error or brake failure.
3. The forklift strikes the concrete wall of the truck ramp, the concrete pillar between the truck door and personnel door, or the closed truck door. The cask in its basket strikes the fixed wall, pillar, or door.
4. The cask is broken or the lid comes off throwing the target out onto the ground. The radioactive target exposes individuals in the surrounding area to a radiation dose rate.
5. The force of the crash, the fall, or the forklift falling on it breaks the target. Available volatile radioactive target components are released and could provide an airborne dose in the resultant plume.
6. If a propane or diesel forklift is used, the impact ruptures the fuel tank and releases burning fuel onto the ground and the target. Heat of the fire pressurizes the target and aids dispersal of the volatile radioactive material. (Not analyzed here due to the low frequency of use of a propane or diesel forklift.)

3E.1.2 Probability Assessment

Event tree (ET) analysis will be used to analyze the accident sequence and to evaluate the accident frequency as suggested in (DOE 1997) and (Mahn et al. 1995). ET analysis is a simple approach to delineating sequences of events that could lead to an undesired event. In the ET analysis, for each initiating event, various systems or barriers are identified. These systems or barriers are designed to prevent the occurrence of the undesired event or to mitigate the progress of the accident. At each node, the success or failure of these systems or barriers, known as event tree headings, is graphically shown. The result is a pictorial representation of various combinations of systems or barriers that succeed or fail to prevent the occurrence of the undesired event or to achieve a final safe condition. ET analysis is most helpful for delineation of sequences of events leading to release of material when there are multiple or redundant barriers for mitigation of the progression of the accident. ET analysis best represents the combination of barrier successes and failure. Accident frequency is analyzed by assigning a frequency factor to each success or failure for the specific accident sequence leading to the undesired event.

For this DBA, the undesired event is release of the target from the transfer cask and target breach. Failure frequencies for the various nodes were developed from (Mahn et al. 1995) and (DOE 1996). The ET analysis diagram is shown in Figure 3E.1-2. This figure does not include a fire of the forklift fuel. The outcomes of the ET analysis in Figure 3E.1-2 are shown as eleven branches. The outcomes represent the following detailed accident occurrence scenarios.

1. Forklift rolls down truck ramp	2. Brakes applied by operator	3. Brakes work to slow forklift	4. Cask lid bolts were installed	5. Cask lid bolts do not all break	6. Target not ejected & breached	
Yes	Yes	Yes	yes	yes	Yes	Branch A
		No	yes	yes	Yes	Branch B
				no	Yes	Branch C
					No	Branch D
			no	yes	Yes	Branch E
					No	Branch F
	No	Yes	yes	yes	Yes	Branch G
				no	Yes	Branch H
					No	Branch I
			no	yes	Yes	Branch J
					No	Branch K

Figure 3E.1-2. ET Analysis Diagram for the Forklift DBA.

Branch A. This branch is the safe completion of the cask transfer operation.

Branch B. In Branch B, the forklift brake system fails causing a collision accident without lid failure or release of radioactive material. This accident would be an OSHA type industrial accident.

Branch C. In Branch C, the forklift brake system fails and the cask lid bolts all break causing the lid to possibly open or come off of the cask and produce a collimated beam of direct radiation from the target. The target could be ejected from the cask but not be breached in Branch C.

Branch D. In Branch D, the forklift brake system fails, the cask lid bolts all break causing the lid to come off, and the target is ejected and breached through a structural failure of the target. The result of the target ejection from the cask would be high dose rate direct radiation. The result of the target breach would be release of available volatile components of the target radioactive materials.

Branch E. In Branch E, the forklift brake system fails and the cask lid bolts were not installed causing the lid to possibly open or come off of the cask and produce a collimated beam of direct radiation from the target. The target could be ejected from the cask but not be breached in Branch E.

Branch F. In Branch F, the forklift brake system fails, the cask lid bolts were not installed causing the lid to come off, and the target is ejected and breached through a structural failure of the target. The result of the target ejection from the cask would be high dose rate direct radiation. The result of the target breach would be release of available volatile components of the target radioactive materials.

Branch G. In Branch G, the forklift operator fails to apply the brakes causing a collision accident without lid failure or release of radioactive material. This accident would be an OSHA type industrial accident.

Branch H. In Branch H, the forklift operator fails to apply the brakes and the cask lid bolts all break causing the lid to possibly open or come off of the cask and produce a collimated beam of direct radiation from the target. The target could be ejected from the cask but not be breached in Branch H.

Branch I. In Branch I, the forklift operator fails to apply the brakes, the cask lid bolts all break causing the lid to come off, and the target is ejected and breached through a structural failure of the target. The result of the target ejection from the cask would be high dose rate direct radiation. The result of the target breach would be release of available volatile components of the target radioactive materials.

Branch J. In Branch J, the forklift operator fails to apply the brakes and the cask lid bolts were not installed causing the lid to possibly open or come off of the cask and produce a collimated beam of direct radiation from the target. The target could be ejected from the cask but not be breached in Branch J.

Branch K. In Branch K, the forklift operator fails to apply the brakes, the cask lid bolts were not installed causing the lid to come off, and the target is ejected and breached through a structural failure of the target. The result of the target ejection from the cask would be high dose rate direct radiation. The result of the target breach would be release of available volatile components of the target radioactive materials.

The target transfer operation will occur 6 times per day, 5 days per week, and 50 weeks per year for a total of 1500 times per year. Failure probabilities for the various initiating events, operator response, system operation, and barrier resistance in the ET analysis are as follows:

1. Forklift rolls down truck ramp- This event will occur 1500 times per year.
2. Brakes applied by operator- This human error (initiator) failure probability is 1.0E-04 per demand from page 26 of (Mahn et al. 1995). This probability includes training, familiarity with task, established procedures and easy to interpret clues to a simple reaction.
3. Brakes work to slow forklift- This brake system equipment failure probability is 5.0E-05 per operation from page B-9 of (DOE 1996).
4. Cask lid bolts were installed- This human error (pre-initiator) failure probability is 1.0E-3 per demand from page 26 of (Mahn et al. 1995). The lid must stay on to keep the target in the cask and the bolts are designed to retain the lid.
5. Cask lid bolts do not all break- This structural failure probability is 5.0E-02 per demand from page 27 of (Mahn et al. 1995). Structural analyses have shown the weak link to cask retention of its lid and radioactive contents is the strength of the lid attaching bolts in various impact accidents. For this reason, only failure of the cask lid retention bolts is considered in the ET analysis.
6. Target not ejected & breached- This second structural failure probability is for failure of the target structure. The result is release of volatile radioactive material. This second structural failure probability is also 0.05 per demand from page 27 of (Mahn et al. 1995).

The frequency of each operational outcome or branch for the event tree of Figure 3E.1-2 has been calculated for the forklift DBA as shown in Table 3E.1-1.

Table 3E.1-1. Frequency of Occurrence Outcomes for Each Branch of the ET Analysis Diagram for an Energetic Forklift Accident.

Branch	Initial Event 1 (per year)	Human Error 2 (prob.)	Brake System Fails 3 (prob.)	Barrier Fails 4 No Bolts (prob.)	Barrier Fails 5 Bolts not all Broken (prob.)	Barrier Fails 6 Target Breach (prob.)	Branch Freq. (per year)	Freq Bin	Result
Branch A	1500	1	1	1	1	1	1500	I	Safe
Branch B	1500		5.0E-05	1	1	1	7.5E-2	II	OSHA Accident
Branch C	1500		5.0E-05	1	5.0E-02	1	3.76E-03	III	Radiation Beam
Branch D	1500		5.0E-05	1	5.0E-02	5.0E-02	1.88E-04	III	High Dose Rate & Airborne Release
Branch E	1500		5.0E-05	1.0E-03	1	1	7.5E-05	IV	Radiation Beam
Branch F	1500		5.0E-05	1.0E-03	1	5.0E-02	3.76E-06	IV	High Dose Rate & Airborne Release
Branch G	1500	1.0E-04	1	1	1	1	1.5E-01	II	OSHA Accident
Branch H	1500	1.0E-04		1	5.0E-02	1	7.55E-03	III	Radiation Beam
Branch I	1500	1.0E-04		1	5.0E-02	5.0E-02	3.8E-04	III	High Dose Rate & Airborne Release
Branch J	1500	1.0E-04		1.0E-03	1	1	1.5E-04	III	Radiation Beam
Branch K	1500	1.0E-04		1.0E-03	1	5.0E-02	7.5E-06	IV	High Dose Rate & Airborne Release

3E.1.3 Comparison of Accident Frequency from Event Tree Analysis to the Hazard Evaluation Results

Three events in the hazard evaluation (TT-1, TT-2, and TT-3) were covered by ET analysis of the forklift DBA. All of the three events were assessed the same frequency in the hazard evaluation, a frequency of III. Corresponding Branches C–F and H–K in the ET analysis had frequencies ranging from III to IV. A specific frequency comparison is shown in Table 3E.1-2.

Occurrence frequency for the hazard evaluation compares well to the ET analysis results with the ET analysis assessing frequency to be the same or one level less often in all branches. The collimated radiation beam, high dose rate, and airborne release outcomes are produced by the lid opening or coming off in a forklift crash. Opening or removal of the lid in the ET analysis is facilitated by either failure to install the lid bolts or breakage of all bolts. Breakage of the lid bolts is assessed to be 50 times more likely than the operator error of not installing the bolts!

Table 3E.1-2. Accident Frequency from Event Tree Analysis Compared to Hazard Evaluations for a Forklift Accident.

Outcome	ET Analysis			Hazard Evaluations	
	Branch	Freq.	Failures Modeled	Event	Freq.
Radiation Beam	C	III	Brakes fail & lid bolts break	TT-1	III
Radiation Beam	H	III	Operator error & lid bolts break	TT-1	III
Radiation Beam	E	IV	Brakes fail & lid bolts missing	TT-1	III
Radiation Beam	J	III	Operator error & lid bolts missing	TT-1	III
High Dose Rate & Airborne Release	D	III	Brakes fail, lid bolts break, & target breached	TT-2, TT-3	III
High Dose Rate & Airborne Release	I	III	Operator error, lid bolts break, & target breached	TT-2, TT-3	III
High Dose Rate & Airborne Release	F	IV	Brakes fail, lid bolts missing, & target breached	TT-2, TT-3	III
High Dose Rate & Airborne Release	K	IV	Operator error, lid bolts missing, & target breached	TT-2, TT-3	III

3E.2 Spill of Process Materials in an SCB

The spill of process materials in an SCB is an anticipated operational event. Spills may range from minor seepage or leaks of small quantities of materials to a complete spill of the process contents due to operator error or due to failure of process containers. Process container failures may occur either due to spontaneous mechanical failures and/or may be induced by operator actions. Provisions for accommodating such spills have been incorporated in process equipment design in the form of spill trays, absorbent material, and SCB washdown systems. Clean up of the spilled material and returning the SCB to a clean operational state will be an operational inconvenience, but will be a routine task.

3E.2.1 Process Spill Scenario Development

The sequences of events that are accomplished in the SCB were evaluated to identify initiating and mitigative events that could occur during processing of a target. The scenario is focused on the time frame during which the radiological material at risk is most volatile, which is the time following dissolution of uranium oxide by the acid until the time the iodine is captured as solid copper iodide in the iodine trap. This dissolution releases all of the fission products previously contained in the fuel matrix into the liquid acid solution or into the target cover gas. At other times during processing, the material at risk is of considerably lower volatility and potential accident consequences would be correspondingly less. It will be conservatively assumed for this scenario that all fission products are highly volatile and released to the SCB volume as a consequence of a spill. This assumption bounds all process specific assumptions that might affect material volatility. Thus, the spill scenario evaluated here bounds the potential consequences of all other spill accidents. The potential for process spills in extraction SCBs was examined by using event tree analysis methodology.

The processing events that are linked to evaluate the spill scenario include:

- Attachment of process containers and piping;
- Operator detection of faulty connections;
- Target heating to dissolve the uranium dioxide;
- Operator corrective actions in the event of leakage; and
- Target/connection integrity.

This scenario begins with the attachment of the T-section to the target. This configuration is shown in Figure 3E.2-1. If this section is improperly attached, or is damaged during subsequent handling such that the boundary is not intact, the potential exists for leakage of the constituents. There is an opportunity for the operator to detect and correct this situation when the acid cocktail is injected into the target to dissolve the uranium dioxide coating. If the target is intact, the chemical reaction that releases oxides of nitrogen will pressurize the target. The pressurization and subsequent stabilization is observed by the operator. If the target is leaking, the pressure would not increase and/or stabilize. Some fraction of the target contents would undoubtedly leak prior to detection and correction.

Following attachment of the T-section and injection of the acid cocktail, the target is heated, using electrically heated forced air, to dissolve the UO2, with subsequent liberation of all of the noble gases and a significant fraction of the halogens into the free volume of the target. Some fraction of the total halogen inventory would be in solution in the acidic process liquid, however the majority would be expected to be in the cover gas free volume. It will be conservatively assumed for the purposes of DBA analyses that the entire halogen inventory is present in the cover gas and available for release as a gas.

Power to the heater is controlled by sensing air temperature, with a 140 C set point. The target pressure increases during heating to a nominal 100 to 150 psig. This pressure is determined by the quantity of gas evolved from the dissolution process and the temperature to which the target is heated. The quantity of gas is limited by the quantities of reactants in the target. To effect the dissolution, 0.08 moles of nitric acid (HNO_3) are nominally used in the Mo99 separation process. The nitric acid reacts with the UO_2, evolving nitrogen oxide (NO). Thus, a maximum of .08 moles of NO (1.7 liters at STP) could be released in the dissolution, which would pressurize the target to about 100 psig, assuming a complete reaction.

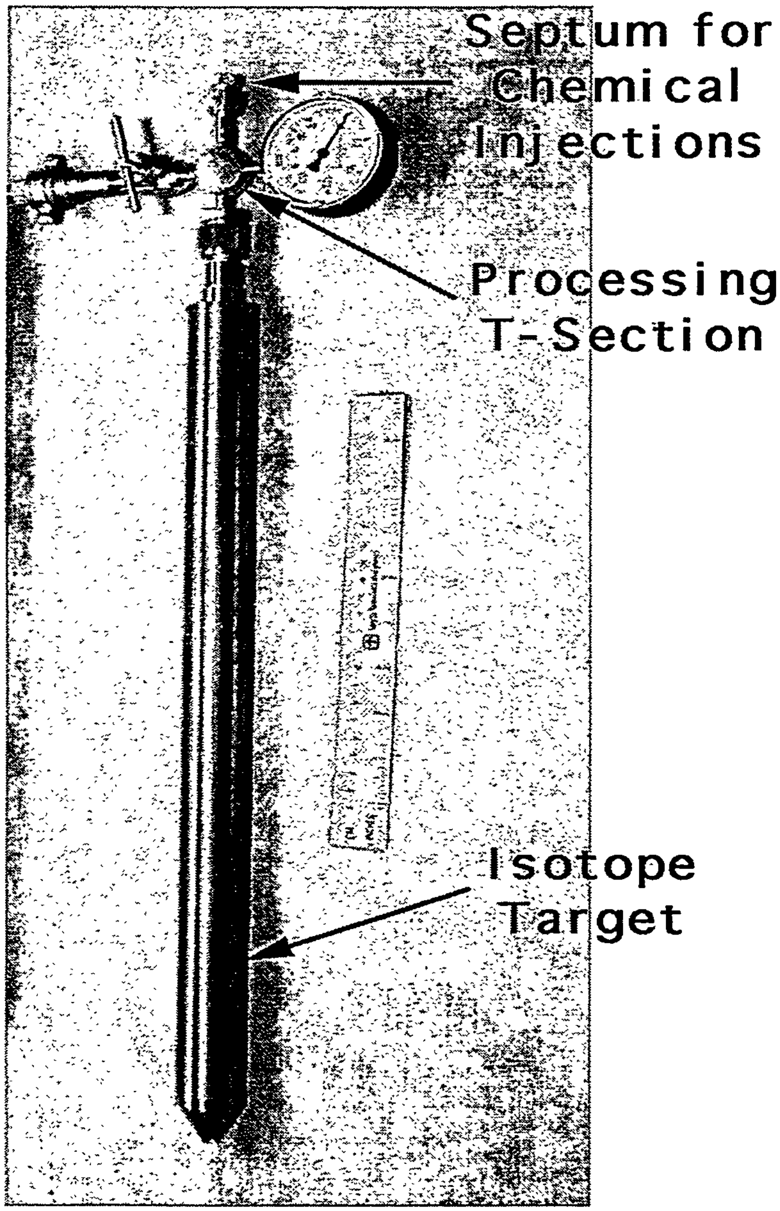

Figure 3E.2-1 Target and Attached T-Section

Pressure above this level is due to heating the target above its ambient starting temperature of approximately 30 ^{O}C . By simple gas laws, a temperature of 140 ^{O}C would increase the pressure about 40%, to 140 psig. These parameters are monitored closely by the process operator. The potential exists, due to an error in the quantities of reactants, controller malfunction, or due to operator error in establishing the temperature set point, for the target to be excessively heated and therefore pressurized to greater than the nominal condition. The weakest portion of the target/tree configuration is the rubber septum, which has been determined by test to fail at a pressure of approximately 200 psig. The typical failure mode is a localized separation of the rubber and is self-healing in that a reduction in pressure will allow the rubber material to reestablish a seal. In addition to septum failure due to over-pressurization, the potential exists for spontaneous septum failure due to defects in manufacture. The septa are subjected to pressure testing prior to use to detect such a condition. The potential also exists that some other portion of the target or T-section might fail, however these metallic components have failure pressures of several thousand psi, and have been subjected to quality control acceptance testing which would decrease the likelihood of such failures.

In the event of leakage or failure of the target/tree boundary under any of the situations described above, some fraction of the target contents would be vented to the SCB volume. The amount of such venting would be dependent on operator intervention to respond to such an event. The potential exists to vent both the gaseous as well as the liquid contents of the target.

The nitrogen oxide, if suddenly released to the 7000 liter volume of the SCB, will raise the pressure by 1.7/7000 = 0.025%, or about .003 psi (.08 inches WC). Thus, this event would reduce the nominal differential pressure of 0.25 inches water column (WC) by about 0.08 inches WC, leaving the SCB about 0.17 inch WC negative with respect to Zone 2A. The nominal pressure differential would be reestablished in about 120 milliseconds, since the nominal SCB flow rate is 30 cfm (14 liters/sec). It would require the instantaneous release of 5 moles of gas to overcome the SCB pressure differential with respect to Zone 2A, even without considering the mitigative effects of the ventilation flow. Thus, the SCB integrity is not challenged by the pressure consequences of this event. Further, even if the SCB pressure differential were reversed for a short period of time (seconds), there would be insufficient time for any significant migration of contaminants before the pressure differential is reestablished. Thus, there would be no significant consequences of such an event.

In the case of the liquid contents of the target, a spill tray exists at each processing station, so many leaks or spills of the liquid contents will be readily contained and easily cleaned up. In the event of target leakage while the target is pressurized, the potential exists for acidic process liquid to be driven by the target internal pressure, which would spray acidic liquid on components inside the SCB. This acidic liquid could damage other components, such as the in-box charcoal filter and the manipulator boots. The charcoal filter is contained in a stainless steel housing, so it is somewhat protected, reducing the likelihood of damage. In the event of acidic interaction with the charcoal, it's effectiveness in trapping iodine would be reduced, however the degree of degradation would be dependant on the details of the interaction and therefore has considerable uncertainty. For this reason, the in-box charcoal filter is not relied upon to mitigate any abnormal or accident scenario. Degradation of the in-box charcoal filter has no effect on the evaluation of DBA consequences. The polyethylene manipulator boots are resistant to acidic attack, however they will have tears and holes as a normal consequence of manipulator operation. Failure or degradation of the manipulator boots would have the effect of increasing the SCB leakage area, which would increase the leakage airflow. This would be offset somewhat by the SCB pressure control device, which would tend to close to maintain SCB differential pressure. Even with complete failure of the manipulator boots, the SCB pressure would be maintained negative with respect to Zone 2, so any flow in the event of boot failure would be from Zone 2 into the SCB. Failure of the manipulator boots has no effect on the evaluation of DBA consequences. Thus, the presence or quantity of acid in the SCB, and it's confinement in intended containers, has no impact on DBA consequence evaluation.

In most circumstances, a spill event involving targets would only involve a single target. The processing of targets is rigorously governed by procedure and production oversight. The probability of the contents of multiple targets being simultaneously released decreases with the number of targets so involved, due to physical constraints and the independence of processing operations.

Process spills may occur due to mechanical failures and/or human failures. Failures of targets due to mechanical defects would generally be considered independent events, since each target is independently subjected to QC processes, and any such failure would be quickly evaluated to ascertain whether or not there exists a problem which would affect production reliability. The likelihood of mechanical failures involving multiple targets would be the multiplicative probability of a single event. With these events generally assessed to occur at rates of 0.001 or less (see Section 3E.1.2), the simultaneous failure of multiple targets due to mechanical failures are extremely unlikely or incredible events.

Process spills at separate process stations due to human error would generally be considered to be independent events. If the errors are independent, the likelihood of multiple failures would be the multiplicative probability of a single failure. With a human error likelihood on the order of 1%, the probability of two simultaneous errors would be on the order of 10^{-4}. Also, evaluations of process errors would be accomplished which would tend to reduce repetitive errors. There is greater potential for multiple targets being subjected to the same error if targets were being simultaneously processed in the same SCB by the same operators. However, it will be physically impossible to have multiple targets at exactly the same state of processing in a single SCB, since only a single set of processing equipment will exist in each SCB. It may be possible, but very unlikely, to have more than one target containing fission products in liquid solution due to the fact that targets can only be introduced into the Zone 2A processing area at a rate of about one per hour and the time required for initial processing (that time up to the trapping of iodine) is also about one hour. Additionally, only one target heating fixture exists in each SCB, so only one target can be simultaneously subjected to the dissolution process in each SCB. It is much more likely that multiple targets will be processed multiple SCBs rather than in a single SCB. This is reinforced by the fact that concerns for radiation damage to the shielding windows will exist with more than one target simultaneously in-process in each SCB. Thus, it is extremely unlikely that multiple targets will be simultaneously processed in a single SCB, and the likelihood of multiple target events is essentially the multiplicative likelihood of independent events. As stated above, then, for a process spill this likelihood is of the order of 10^{-4} for events involving two targets, and extremely unlikely for events involving three or more targets.

The consideration of up to six targets is based on the daily processing rate representative of 100% of U.S. demand for Mo-99. Since residual materials are typically solidified each day, it would be unrealistic to consider more than six targets to be at risk at the same time. While it could be conservatively assumed that all spill events involve a maximum of 6 targets, the stated likelihoods are considered more realistic, and are probably conservative.

Volatile elements released to the SCB volume would be drawn into the ventilation system and would be passed through charcoal and HEPA filters, which will mitigate the release to the environment. Dose consequences in this SAR for scenarios with fully functional filters are calculated based on a HEPA filter efficiency of 0.99, and a charcoal removal efficiency for halogens of 0.95. Consideration of degradation or failure of the filters has also been evaluated. Since the filters are passive components, there is a high likelihood that they will be present and perform their intended safety function. Routine periodic inspection and maintenance of these filters will provide confidence that the filters are in place and functional. Other information, including system flow rates and pressure differential trends, changes in fan motor current, radiation measurement readings of filter frames, and comparisons of stack monitor results over time provide additional indicators of filter performance. Evaluations of the likelihood of filter degradation have been studied and documented (Lee, 1979). The complete absence or total failure of a filter is a very unlikely event and has been conservatively estimated at 0.001 per demand. The potential for degradation of the filter that reduces it's efficiency is more likely and is conservatively estimated at 0.09 per demand for a removal efficiency of 95%. Although these evaluations were accomplished for HEPA filters, the mechanisms that would cause a complete loss of filtration would be similar (human error) for charcoal filters, so the likelihood of complete filter failure should be about the same for both types of filters. Charcoal filters are probably more susceptible to degradation than HEPA filters, so a filter efficiency of 50% rather than 95% will be assumed at a likelihood of 0.09 per demand for these filters.

For each accident scenario, the circumstances that could initiate or affect the scenario are examined using event tree analyses. To build the event tree for the spill scenario, each of the five events identified above which comprise the spill sequence are linked and examined in a systematic manner based on whether or not the event occurs in a normal or abnormal manner. This defines a number of unique sequences that comprise the event tree shown in Figure 3E.2-2. Each of the unique sequences is then described to provide an understanding of the physical actions that make up the sequence to serve as a basis for probability evaluation. The likelihood of each specific outcome is determined by evaluating the likelihood of the events that make up the sequence. Similarly, the consequences of each outcome are dependent on the effect of potential mitigative actions that are or are not invoked in the sequence. In addition to mitigative actions that could occur during progression of the accident sequence, the effects of ventilation system filters will mitigate releases which occur within the HCF. The potential for these filters to mitigate accidents are generally independent of the progression of the accident sequence (i.e. no credible accidents which are initiated with a release of significant quantities of hazardous materials in the HCF will also render the filters ineffective (e.g. fires)).

Sequence Description:

Sequence A: Nominal processing of a target. No release to SCB except in event where subsequent operator handling damages target or tree, or improperly connects tree to iodine trap, releasing volatile contents.

Sequence B: Operator attaches processing tree to target properly; The target is installed intact in the heater; The target is heated nominally but the target tube, gauge or septum ruptures, releasing target volatiles to the SCB. (Septum rupture probability is much greater than target or gauge failure.)

Sequence C: Operator attaches processing tree to target properly (or detects and corrects an improper attachment); The target is installed intact in the heater; the target overheats due to malfunction of the heater; the operator detects the condition and removes power and the target and septum remain intact. There is no release to SCB except in event where subsequent operator handling damages target or tree, or improperly connects tree to iodine trap, releasing volatile contents.

Target processing tree is attached and sealed properly	Operator detects & corrects faulty seal	Target is heated nominally	Operator takes Corrective action	Septum, gauge, and target tube remain intact	Sequence
Yes	n/a (also, same as No/Yes)	Yes	n/a	Yes	A
				No	B
		No	Yes	Yes	C
				No	D
			No	Yes	E
				No	F
No	No	n/a	Yes	n/a	G
			No	n/a	H
	Yes	n/a	n/a	n/a	I
	Yes	see above	see above	See above	Same as A-F

Figure 3E.2-2 Event Tree for Process Spill in SCB

Sequence D: Operator attaches processing tree to target properly (or detects and corrects an improper attachment); The target is installed intact in the heater; the target overheats due to malfunction of the heater; the operator detects the condition and removes power but the target septum (failure probability is dominated by septum, rupture probability is dependent on the degree of overheat and subsequent pressurization; the septum will fail above 200 psi) ruptures; target volatiles are released to SCB; acid may or may not be released (no significant difference in release consequences, only in cleanup; unless acid is directed at and renders the in-box filter ineffective); operator action has no effect on release (there is some potential that operator could reduce SCB flow to mitigate release by trapping more iodine in the in-box filter).

Sequence E: Operator attaches processing tree to target properly; The target is installed intact in the heater; the target overheats due to malfunction of the heater (controller failure, improper set-point, etc) ; operator fails to take corrective action but the target and septum remain intact. There is no release to SCB except in event where subsequent operator handling damages target or tree, or improperly connects tree to iodine trap, releasing volatile contents.

Sequence F: Operator attaches processing tree to target properly; The target is installed intact in the heater; the target overheats due to malfunction of the heater (controller failure, improper set-point, etc) ; operator fails to take corrective action and the septum ruptures, releasing target volatiles to the SCB. As in D, acid release and subsequent operator action have no impact on release.

Sequence G: Operator incorrectly attaches processing tree to target such that it leaks, or damages the tree during handling; Operator fails to detect the condition of the target and subjects the target to heating; Operator detects the condition during heating and takes action to reduce heat and reseal the target (depending on size of leak, target pressure would be the most significant indicator; alternative indicator would be liquid leaking from target); with rate dependent on the size of the leak, volatiles and possibly acid are vented from the target; the release would likely be mitigated but the degree to which it would be mitigated would be difficult to quantify; venting, somewhat depending on the degree, would probably preclude rupture of the septum.

Sequence H: Same as G except that operator does not detect venting and/or takes no corrective action. Complete volatile inventory would eventually be released to SCB.

Sequence I: Operator incorrectly attaches processing tree to target such that it leaks, or damages the tree during handling; operator detects condition of target and corrects the condition prior to continuing operations. Some release of volatile FP's which have been evolved by the introduction of acid into the target will occur. Available quantity of these volatiles may be difficult to ascertain, and the amount released would be dependent on the size and duration of the leak prior to its detection and correction. Once operations continue, the events would follow the event tree for a properly sealed target (Sequences A-F).

3E.2.2 Probability Assessment

Based on an understanding of the physical actions that comprise the event sequences and individual actions, the probability of accomplishing each of the actions in the intended manner or in an unintended manner are assessed. These assessments are based on operations experience, engineering judgment, and on industrial safety data that exists for similar events. For the spill events, these assessments are as follows:

1. Improperly sealed or damaged target. Since this operation is accomplished remotely and the operator has few aids to ascertain proper sealing, this may occur with frequency estimated to be .05 per demand.
2. Operator detects and corrects faulty seal. Detection depends upon the state of processing. Prior to addition of acid, there are few means to detect such a condition. The operator might notice a looseness of the fitting. Once acid is added, pressure indications become a significant means of detection, with high likelihood (0.9) that a leak would be detected.
3. Target overheat would require a heater malfunction caused either by a controller failure (.0001 per demand [hr]) or perhaps by an improper set point (very low once system has been used).
4. Operator action to an overheated target is highly likely due to specific training and operator attention during this phase of processing (.99).
5. Spontaneous septum rupture under nominal conditions is unlikely (.001). Pressure buildup under nominal conditions is limited by the quantities of reactants. Also, there are no operator interactions with the target/septum during heating. The septum design has been tested to determine the point at which rupture occurs, and the operating pressure is well below this value. Rupture under conditions of uncorrected target overheat is highly likely (1).

These probabilities are combined appropriately for each event tree sequence, providing a basis for an overall probability assessment for each sequence, and an assignment to a frequency bin defined in the SAR. This is accomplished in the following probability table, Table 3E.2-1.

Table 3E.2-1. Frequency of Occurrence for Each Sequence of the Event Tree Analysis Diagram for a Process Material Spill.

Branch	Events /yr	Target Sealed	Detection, Correction	Overheat	Operator Action	Target Intact	Freq.	Freq Bin	Result
A	1500	.95	1	1	1	1	1425	I	Nominal
B	1500	.95	1	1	1	.001	1.4	I	Release to SCB
C	1500	.95	1	.0001	.99	1	0.14	II	Nominal
D	1500	.95	1	.0001	.99	.001	1.4E-4	III	Release to SCB
E	1500	.95	1	.0001	.01	1	1.4E-3	III	Safe
F	1500	.95	1	.0001	.01	1	1.4E-3	III	Release to SCB
G	1500	.05	.1	1	.99	1	7.5	I	Mitigated Release
H	1500	.05	.1	1	.01	1	.075	II	Release to SCB
I	1500	.05	.9	1	1	1	68	I	Nominal

These probabilities are then compared to the frequency bins assigned during the development of the hazard tables for the SAR, and any changes to the previous hazard assessment are considered in the development of the SAR and in evaluating any changes to SSC's or to operational procedures or limitations.

3E.2.3 Effects of Ventilation System Filters

In addition to assessing the probability of release to the SCB, the potential for mitigation of the release by ventilation system filters should be considered. For releases to the SCB's, two charcoal filters and one HEPA filter exist in series in the ventilation system. Each filter is assumed to be either fully operational (O), degraded (D), or failed (F). Thus, there are 27 potential filter configuration combinations. However, since two identical charcoal filters exist, there are only 18 unique combinations. If the potential for failure of each filter is considered to be an independent event, the likelihood of each combination of filter configurations is calculated as summarized in Table 3E.2-2:

Table 3E.2-2 Filter Configuration Evaluation

Configuration	Charcoal 1	Charcoal 2	HEPA 1	Likelihood
1	O	O	O	.754
2	O	D	O	.15
3	O	F	O	1.6E-3
4	D	D	O	.0074
5	D	F	O	1.6E-4
6	F	F	O	1.8E-6
7	O	O	D	.074
8	O	O	F	8.3E-4
9	O	D	D	1.5E-2
10	O	D	F	1.6E-4
11	O	F	D	1.6E-4
12	O	F	F	1.8E-6
13	D	D	D	7E-4
14	D	D	F	1.6E-5
15	D	F	D	1.6E-5
16	D	F	F	1.8E-7
17	F	F	D	1.8E-7
18	F	F	F	1E-9

Based on this assessment, all filters would be fully functional in an accident scenario most of the time (75%). An additional 22% of the time, a single charcoal or a single HEPA filter would be assumed to be operating with reduced efficiency, 2% of the time at least one charcoal filter is fully functional with the other filters operating in a degraded mode. Thus, scenarios where two charcoal filters are degraded or where filters would be assumed to be totally failed will occur less than 1% of the time, and scenarios where more than one filter is failed are very to extremely unlikely.

Based on the radiological inventory of isotope targets described in Chapter 3, the consequences at the exclusion boundary for the following filter configurations have been calculated:

Scenario	Consequences (1 Target, mr)
1. All filters functional (75%)	3.2
2. One degraded charcoal filter (15%)	4.8
3. Degraded HEPA filter only (7.4%)	12.4
4. One degraded filter of each type (1.5%)	14
5. One failed charcoal filter (0.2%)	6.5
6. One failed HEPA filter (0.1%)	231
7. No mitigation (all filters failed)	301

This assessment provides a basis for understanding the likelihood of a range of potential accident consequences evaluated in this SAR.

3E.3 Fire in a Process SCB

This internally initiated DBA is a potential fire in a process SCB. Limited quantities of combustible material are present in extraction SCBs during processing. Additionally, ignition sources, primarily electrical, also exist and are active during processing. Thus, the potential exists for a fire during processing of an irradiated target.

3E.3.1 Fire in a Process SCB Scenario Development

This internally initiated DBA is a potential fire in a process SCB. The potential for SCB fire was examined by using event tree analysis methodology. The isotope production process steps and equipment in each type of SCB were examined for potential ignition sources and combustible material. The isotope production process combustible material and ignition sources are summarized in Table 3E.3-1 below. The process SCBs with the greatest potential for a fire and the greatest readily available radioactive inventory are SCBs used for the extraction and separation of isotope products. The extraction SCBs have ignition sources and combustible material due to the nature of the process steps and equipment required. Isotope target radioactive material in the extraction SCBs can be in a liquid form with the volatile halogen and noble gas fission products in a readily releasable form. The SCBs used for product purification and packaging as well as for waste storage packaging have some combustible material but reduced ignition sources. Product purification SCBs will contain only a small fraction of the fission products and they will be in relatively non-volatile liquid forms. The waste storage packaging SCB has only solidified process liquid residue in the waste containers. For these reasons, a fire in an extraction SCB will be considered in this DBA analysis as having the worst case potential consequences.

The causes and preventive features for a fire in an extraction SCB were examined in preparation of the DBA accident scenario. Mitigative features inherent in the SCB structure and HCF ventilation system will limit the spread of fire to other SCBs and mitigate the dose to the public. The heavy steel box construction should be an effective firewall to prevent spread of fire to other SCBs. The limited quantities of combustibles in the SCB will limit the duration and extent of the fire, even if it burns to completion. The physical form of the liquid process solution will also mitigate the dose to the public somewhat, since the fire will not volatilize a large fraction of the fission products in the liquid solution. The identified initiating events for this scenario are electrical wiring short/overheat or ignition of combustible material directly by touching the heating element of the electrical target heater.

Two potential DBA fire scenarios were developed. The first was fire in the electrical wiring caused by a short/overheat of the target hot air heat gun, target rotator, or waste container tumbler followed by an operator error of not detecting the overheat and shutting off power. Power isolation is accomplished by pulling a plug from an outlet immediately outside the SCB window. Power isolation could prevent a fire of other combustible material if the short or overheat condition were detected promptly so operator detection and isolation is the second event in the analysis. The event tree analysis for this scenario considered the number of hours that this equipment would normally operate in a year and the probability of overheat/short per hour of operation. Operating hours were based on the number of targets processed per day per extraction SCB in normal operation and the number of hours per target that the two pieces of equipment would operate.

Table 3E.3-1. Isotope Production Process Combustible Material and Ignition Sources.

Type of Combustible Material of Ignition Source	Amount in SCB During Processing
Extraction SCBs	
Combustible Material	
Plastic Syringes	
2 each 60 cc, 39 gram	78 gram
16 each 20 cc, 15 gram	240 gram
2 each 5 cc, 5.5 gram	11 gram
6 each 3 cc, <5 gram	30 gram
Total	~360 gram
Benchkote, 25 x 40 cm, spill tray liner	2 sheets
Wire insulation on target heater	-----
Wire insulation on waste canister tumbler	-----
Rubber septums on process glassware(4 cc ea.)	12 septums
Rubber septums on target T-section (4 cc ea.)	1 septum
Charcoal in C-vents, 7 each 6 cc	-----
Ignition Sources	
110V, 1500W electrical target heater (wiring and heating element	-----
110V waste canister tumbler	-----
Purification SCBs	
Combustible Material	
Plastic Syringes	
1 each 60 cc, 39 gram	39 gram
3 each 20 cc, 15 gram	45 gram
1 each 5 cc, 5.5 gram	5.5 gram
1 each 3 cc, <5 gram	<5 gram
Total	~95 gram
Benchkote, 25 x 40 cm, spill tray liner	2 sheets
Polyethylene product bottle (175 ml capacity)	~20 gram
Charcoal in C-vents, 7 each 6 cc	-----
Charcoal in fritted columns (3 each 20 cc)	-----
Ignition Sources	
110V electrical outlets	-----
Waste Storage Packaging SCB	
Combustible Material	
Combined process materials for the extraction and purification SCBs, in SCB and associated, attached waste barrel	-----

The second potential DBA fire scenario involved the failure of the heating element housing followed by an operator error to allow combustible material to touch the exposed heating element. Both events were required to initiate a fire in the event tree analysis. The frequencies per year for such an accident developed in the event tree analysis for both scenarios agreed with the frequency for an extraction SCB fire as assessed in the hazard evaluation.

In both of the two potential extraction SCB fire scenarios, the ignition sources were assumed to ignite a combustible material fire. The burning material was assumed to envelop the liquid dissolution cocktail in the glass bottle or target during or following UO_2 dissolution to release the volatile and nonvolatile radioactive material. The fire may also damage the box charcoal and HEPA filters, rendering then ineffective. No credit was taken for limiting the duration and extent of the fire in the SCB. Thus, the fire was assumed to have the conservative worst case consequences in releasing radioactive material to the SCB and Zone 1 ventilation systems.

Event tree analysis was used to analyze the accident sequence and to evaluate the accident frequency as suggested in (DOE 1997) and (Mahn et al. 1995). Figure 3E.3-1 presents the event tree using the two accident progression sequences developed previously.

The outcomes of the event tree analysis in Figure 3E.3-1 are shown as four sequences. The outcomes represent the following detailed accident occurrence scenarios.

Sequence A: Safe condition and no further fire of combustible material. Prompt detection by operator has prevented further short/overheat ignition of a larger fire. Process containers are not breached and radiological material is not released.

Sequence B: Operator does not detect the short/overheat in time to remove power and prevent a combustible material fire that is assumed to breach process containers and release radiological material (Hazard Event CP-6).

Sequence C: Safe condition and no fire of combustible material. Operator detects the broken or missing heat gun housing segment and prevents the heating element from contacting and igniting combustible material.

Sequence D: Operator does not detect the broken or missing heat gun housing segment and does not prevent the heating element from contacting and igniting combustible material. An ensuing combustible material fire is assumed to breach process containers and release radiological material (Hazard Event CP-6).

Electrical wiring short/overheat in the target hot air heat gun, target rotator, or waste container tumbler	Operator promptly detects short/overheat and removes power	Sequence
Yes	Yes	A
	No	B

The target hot air heat gun housing fails and exposes the heating element	Operator detects broken or missing housing and prevents combustible material contact	Sequence
Yes	Yes	C
	No	D

Figure 3E.3-1 Event Tree Analysis for a Fire in a Process SCB.

3E.3.2 Probability Assessment

The target processing operation will occur 6 times per day, 5 days per week, and 50 weeks per year for a total of 1500 times per year. Failure probabilities for the various initiating events, operator response, system operation, and barrier resistance in the event tree analysis are as follows:

1. An electrical wiring short to ground is expected to occur 0.0000003 times per hour of operation. The combined operation time of the target hot air heat gun, target rotator, and the waste container tumbler is one hour per target. The overheated wiring and fire results from the electrical short (page A6, DOE 1996).
2. Operator detection and response to an unsafe condition such as shorted and overheated wiring in equipment or a broken or missing segment of equipment housing is a response to a compelling indication. Not to detect and respond is an error of omission. Such operator errors are expected to occur 0.01 times per demand or target.
3. Failure of a mechanical joint that holds on a segment of the heat gun housing or a grill covering the heating element is expected to occur 0.0000002 times per hour of operation. The operation time for the target hot air heat gun is conservatively chosen to be one hour per target. If actual operation time per target is less than one hour, housing failures are expected to occur less often (page A8, DOE 1996).

The frequency of each operational outcome or sequence for the event tree of Figure 3E.3-1 has been calculated for the process material spill as shown in Table 3E.3-2 below. Sequences B and D correspond to hazard event CP-6 of the hazard analysis from Appendix 3C. The assessed event frequency per year for hazard event CP-6 was also frequency bin IV so the event tree analysis confirms the frequency assessment of the hazard analysis. The equipment failure rates for HCF equipment may be higher. If failure rates were ten times higher than used in the analysis (Table 3E.3-2), the event tree analysis frequency bins would not change for any outcome. Failure rates would have to be almost 100 times higher to cause a change in the event tree analysis frequency bins.

Table 3E.3-2. Frequency of Occurrence for Each Sequence of the Event Tree Analysis Diagram for Fire in a Process SCB.

Branch	Targets /year	Operating Hours/ Target	Equipment Failures/ hour	Unsafe Condition Detection & Action	Freq.	Freq. Bin	Result
A	1500	1	0.0000003	0.99	4.5E-4	III	Safe, fire stopped
B	1500	1	0.0000003	0.01	4.5E-6	IV	Fire ignited and volatiles released
C	1500	1	0.0000002	0.99	3.0E-4	III	Safe, fire averted
D	1500	1	0.0000002	0.01	3.0E-6	IV	Fire ignited and volatiles released

3E.4 Hydrogen Combustion in the Elevator Pit

Solidified process residuals, including up to 12 stainless steel containers of solidified waste containing the majority of fission products, are temporarily stored in the elevator pit in 55 gallon barrels. The barrels are stored in the pit to reduce the duty cycle on the Room 109 shielding door. Up to six barrels of waste will physically fit in the pit volume, but it is currently anticipated that no more than five will be in the pit at any one time. Once four barrels are accumulated, they will normally be placed on a waste cart and moved into Room 109. At maximum production rates, a barrel will be filled every two days, and four barrels will be filled in about two weeks. Storage of five barrels in the pit is considered in the event that movement of four barrels into Room 109 cannot be immediately accommodated due to the production schedule. Hydrogen will be generated by the radiolysis of water in the solidified waste (Bodette 1996). The rate of generation decreases from about two liters per waste container per day immediately after solidification to about 0.1 liter per day within 60 days. Hydrogen will be vented from the waste containers into the barrel. The barrel is also vented, so hydrogen generated in the barrel will be released into the surrounding environment.

The Zone 2A elevator pit and Room 109 are the only two areas in the HCF where waste will be accumulated. By the time that the waste is moved into Room 109, the hydrogen generation rate is sufficiently low as to preclude accumulation to flammable levels. In the elevator pit, a flow of nitrogen of approximately 0.07 cubic feet per minute (cfm) will be provided to the bottom of the pit to sweep out both hydrogen and oxygen, which will reduce the likelihood of hydrogen combustion due to depleted levels of both combustion constituents. The normal ventilation flow that will exist in Zone 2A will also preclude any buildup in that area.

3E.4.1 Hydrogen Combustion Scenario Development

The potential for hydrogen combustion in the elevator pit was examined by using event tree methodology. The sequence is initiated by the presence of an ignition source. Such a source exists in the elevator pit in the form of the hydraulic lift limit switch, which would close contacts if the lift were lowered to the bottom of the pit. It is assumed that if this switch is activated, and if oxygen levels are sufficient, all free hydrogen at or above a concentration of 4% that exists in the pit would be ignited.

If the nitrogen flow is present, hydrogen and oxygen will be continually swept out of the pit and flammable levels of hydrogen and oxygen are precluded. Even in the event of loss of nitrogen flow, the oxygen levels in the pit would be severely depleted, and there is no continuous mechanism to reestablish oxygen levels significantly. Additionally, the maximum hydrogen concentration is limited by the generation rate and diffusion of hydrogen from the pit into Zone 2A. Maximum hydrogen concentrations with five intact barrels of waste in the event of a loss of nitrogen flow are calculated to be about 2% (Mitchell and Naegeli, 1999). Thus, buildup of a flammable atmosphere requires both the failure of one or more barrel boundaries as well as a mechanism to reintroduce oxygen into the pit. Thus, the combustion of hydrogen in the elevator pit is highly unlikely, even in the event of failure of nitrogen flow and the presence of an ignition source.

In the unlikely event that combustible levels of hydrogen and oxygen are ignited in the pit, the potential release of energy and subsequent pressure and temperature excursions can be quantitatively assessed. Assuming leakage and combustion of the contents of an entire barrel (65 liters of hydrogen at STP), approximately 800 kilojoules (kJ) of energy would be released.

This energy would heat the pit atmosphere about 300°C, assuming an adiabatic combustion process with no cooling by pit surfaces, and would approximately double the pit pressure under this conservative assumption. It is possible, depending on the permeability of the lid on the pit, that the lid could be damaged in the pressure transient. The hot gases would subsequently be vented into Zone 2A, where mixing and cooling would take place, which would mitigate the pressure transient in Zone 2A. Additionally, water condensation would occur on pit or Zone 2A surfaces. The maximum pressure rise in Zone 2A is calculated to be less than 0.08 psi, or about 2 inches WC. This pressure transient would be overcome by normal Zone 2A ventilation flow within about 50 milliseconds (msec), and the pressure gradient would be reestablished. A minor pressure transient in Zone 2A would be possible, but the heating and expansion of the pit atmosphere would not be sufficient to move any of the barrels out of the pit. The energy released in these events of up to 820 kJ is not sufficient to affect any of the metallic or glass materials in the pit, nor would it cause the release of fission products from the solidified waste contained in the steel waste containers.

Event tree analysis was used to analyze the accident sequence and to evaluate the accident frequency as suggested in (DOE 1997) and (Mahn et al. 1995). Figure 3E.4-1 presents the event tree using the accident progression sequence developed previously. The outcomes of the event tree analysis are shown as five sequences. The outcomes represent the following detailed accident occurrence scenarios.

Sequence A: The limit switch at the bottom of the pit provides the only ignition source in the elevator pit. Thus, presence of an ignition source requires that the elevator be lowered to engage the switch. This is not planned, and would be an inadvertent action. If the nitrogen is flowing at the minimum planned rate, it will sweep both hydrogen and oxygen out of the pit. The vented barrels are intact, which limits the rate at which hydrogen is released into the pit. This precludes the presence of flammable levels of hydrogen. No combustion occurs.

Sequence B: The ignition source occurs due to inadvertent lowering of the elevator. However, nitrogen flow maintains hydrogen and oxygen levels below combustible levels, even in the event of a barrel failure that could release up to 65 liters of hydrogen into the pit in a short period of time (2.6% of the pit free volume). No combustion is possible.

Sequence C: The ignition source occurs due to inadvertent lowering of the elevator, and nitrogen flow has ceased. The barrels are intact, which limits the rate at which hydrogen is released into the pit, precluding the buildup of hydrogen to flammable levels. No combustion occurs.

Presence of Ignition source	Nitrogen Flow	Intact Barrels	Presence of Oxygen	Sequence
Yes	Yes	Yes	n/a	A
		No	n/a	B
	No	Yes	n/a	C
		No	Yes	D
			No	E

Figure 3E.4-1. Hydrogen Combustion Event Tree.

Sequence D: The ignition source occurs due to inadvertent lowering of the elevator, and nitrogen flow has ceased. One or more barrels have ruptured, releasing up to 65 liters of hydrogen into the pit volume over a short period of time. If the nitrogen flow has been off for a sufficient period of time, actions such as barrel movement could cause mixing of Zone 2A atmosphere into the pit (data indicates that this does not occur readily). With the resulting build up of oxygen levels in the pit, any hydrogen at concentrations above 4% in the presence of sufficient oxygen could be ignited. The stoichiometric combustion of 65 liters of hydrogen would release 820 kJ into the pit, causing a pressure transient that would vent about 85 cubic feet of gases into Zone 2A. This would produce a minor pressure transient in Zone 2A of less than 2 inches WC which would dissipate in much less than one second. No release of fission products would occur.

Sequence E: The ignition source occurs due to inadvertent lowering of the elevator, and nitrogen flow has ceased. One or more barrels have ruptured, releasing up to 65 liters of hydrogen into the pit volume over a short period of time. If the nitrogen flow has not been off for a significant period or there has been only poor mixing between Zone 2A and the pit atmosphere (expected), then oxygen levels in the pit would be insufficient to support combustion.

3E.4.2 Probability Assessment

Failure probabilities for the various initiating events, operator response, system operation, and barrier resistance in the event tree analysis are as follows:

1. Operator inadvertently lowers elevator pit to lower limit. Placing a barrel requires raising the elevator such that the top barrel is at floor level to place a new barrel at the top of the stack, and then lowering the stack of barrels until the top barrel is 50 to 100 centimeters (cm) below floor level. With five barrels in the pit, the elevator is approximately 60 cm above the lower limit. Allowing the elevator to continue down past the desired level and on to the lower limit would require significant inattention. Estimated probability per demand: 0.02 to 0.1.
2. Nitrogen flow. The nitrogen will be provided by boil off from the cold trap in SCB 1. Maintenance of nitrogen to this cold trap is an important NESHAPS function to retain noble gases and will be subject to operational surveillance. There are no valves or active mechanisms in the vent line to restrict this boil off, so the probability that nitrogen will be vented into the pit is high, estimated at 0.99.
3. Intact barrels. "Intact barrels" is defined to mean that the barrels are not catastrophically breached. The barrels are normally vented, so the effect of minor cracks or pits would be no different than the vent, i.e. the hydrogen is still released from the barrel by the driving pressure due to hydrogen evolution, since diffusion through small openings would be a small driving force. The probability of a catastrophically breached barrel is small, conservatively estimated at 0.01.
4. Oxygen mixing. Measurements in the elevator pit have shown that the pit atmosphere does not mix significantly with Zone 2A atmosphere. With the normal presence of nitrogen flow, the oxygen levels in the pit will be totally depleted. Thus, significant mixing of the pit atmosphere with Zone 2A would be required to raise oxygen levels to the 10% or more required to support combustion. Operation of the elevator will provide some mixing. Lowering the elevator into the pit with additional barrels for temporary storage will expel some of the atmosphere from the pit (potentially hydrogen). In this case, very little oxygen will mix into the very top of the pit from the air above. When the elevator is raised to remove barrels from the pit or lift barrels to floor level to accept a new barrel, air could be drawn

deeper into the elevator shaft to replace the volume of the raised barrels. If barrels are merely raised to floor level to accept a new barrel, no or very little outside air is needed to replace the volume of barrels since no barrels are removed from the pit. Significant replacement air from outside of the pit will be required only if barrels are actually removed from the pit. In this case, oxygen mixing into the pit could be more extensive. Thus, extensive mixing of oxygen into the elevator pit could only occur when the barrels are removed from the pit for movement to Room 109 each two-week period. That movement would be the eleventh movement operation of the elevator for the two-week period. Thus, the probability of oxygen mixing is estimated for this evaluation at 0.10, although this is probably a conservative overestimate.

The frequency of each operational outcome or sequence for the event tree of Figure 3E-4 has been calculated as shown in Table 3E.4-1 below. The hazard analysis event corresponding to hydrogen combustion in the elevator pit is hazard event WE-4 of Appendix 3C. Event WE-4 frequency of occurrence was assessed as frequency bin IV. Sequence D also has a calculated frequency bin of IV so the event tree analysis is consistent with the hazard evaluation in assessed frequency of occurrence.

Table 3E.4-1. Frequency of Occurrence for Each Sequence of the Event Tree Analysis Diagram for Hydrogen Combustion in the Elevator Pit

Branch	Events /year	Ignition Source	N_2 Flow	Intact Barrels	Oxygen Mixing	Freq.	Freq. Bin	Result
A	26	0.1	0.99	0.99	n/a	2.6	I	Benign
B	26	0.1	0.99	0.01	n/a	0.026	II	Benign
C	26	0.1	0.01	0.99	n/a	0.026	II	Benign
D	26	0.1	0.01	0.01	0.1	0.000026	IV	Pit venting
E	26	0.1	0.01	0.01	0.9	0.00023	III	Benign

3E.5 Failure of the Ventilation System (Loss of Off-Site Power)

Loss of off-site power is an anticipated abnormal external event. Although system reliability has been improved recently by several system upgrades, loss of off-site power has been experienced in the past. The site has experienced 32 unscheduled outages during the 10 year period 1977-1986, with an average duration of 1.75 hours and 24 outages during the 14 year period from 1984 through 1997, with an average duration of about 3 hours. Average time without power in both instances amounts to about 5 hours per year. Such power outages can be expected to continue to occur in the future. In the event of loss of off-site power, a diesel generator is available to provide power for lighting, ventilation systems and other HCF functions as deemed appropriate.

3E.5.1 Loss of Off-Site Power Scenario Development

The sequence of events which follows as a result of loss of off-site power as an initiating event were examined using event tree methodology. Initially, loss of power will result in the cessation of all equipment requiring power. This includes all lighting, ventilation components, control systems, monitors, instrumentation, etc. Normally, the loss of power will cause the standby diesel generator to automatically start and supply power to designated systems. If this occurs, work could resume to place the facility in a safe configuration, following the assessment of the situation by HCF management. If the backup system also fails, the facility would be evacuated and all systems would remain inoperative. The facility would be left in whatever physical state it was in at the time of the loss of power and could include the presence of in-process radiological materials at processing stations. The DBA sequence progression following loss of off-site power would depend on the state that existed at the time. For purposes of radiological evaluation, four different situations are examined.

1. Most of the time (i.e. at times other than during active isotope processing) process stations will contain only residual quantities of radiological materials.
2. During normal operations, isotope processing will be in-progress a significant fraction of the time, however the amount of radiological materials available for release are limited by the quantity and form of the material in process
3. Occasionally, abnormal processing events are anticipated which would cause the volatile inventory at a process station to be elevated.
4. Normally, the process SCB would contain all of the above possible radiological inventories at process stations. They would be drawn into the ventilation system, and trapped on ventilation system filters. If the SCB failed, or a pre-existing failure was undetected, the radiological inventory could be released directly into Zone 2A.

Each of the above scenarios may be present at the time of loss of off-site power. The likelihood of each scenario can be estimated and is independent of the likelihood of loss of power. The potential consequences of each scenario can also be examined based on the inventory available for transport.

In the event of complete loss of ventilation flow in the HCF, contaminants will be transported by diffusion from regions of high contamination to regions of lower contamination. This diffusion will occur through gaps, penetrations and crevices that exist in HCF systems and structures. Two of the known transport paths are the airlock doors and the Zone 2A air supply duct. Both of these paths have double closures, but each has finite flow areas even when closed. Manipulator penetrations of Zone 2A are effectively sealed by the boot, which will exist on each manipulator. Similarly, each of the lighting penetrations through the shield wall has a contamination seal at the outer boundary, which is accessible during operations. Diffusion that might occur under a scenario where failure of these seals is postulated can be evaluated. SCB integrity is ascertained before installation, and can be affirmed during operation by observing behavior of pressure differentials during operation.

The Zone 1 exhaust will remain open in the event of loss of power, and because of its direct connection to the TA-V stack, a minimum negative pressure would be expected to be maintained in Zone 1, even in the event of loss of ventilation flow. Thus there is a tendency for the Zone 1 air to be drawn through the exhaust line and filtered before it is released. This effect has not been considered or credited in the analyses described below.

Event tree analysis was used to analyze the accident sequence and to evaluate the accident frequency as suggested in (DOE 1997) and (Mahn et al. 1995). Figure 3E.5-1 presents the event tree using the accident progression sequence developed previously.

The outcomes of the event tree analysis in Figure 3E.5-1 are shown as eight sequences. The outcomes represent the following detailed accident occurrence scenarios.

Sequence A: This is the normal operational state. The consequences of potential failures of confinement boundaries under these conditions are evaluated in other DBA's

Sequence B: In the event of loss of off-site power, the backup diesel generator will automatically start and pickup designated facility loads. In general, important facility functions would remain available. In these circumstances, operations staff would be trained to secure operations in progress and consult with facility management as to any operations that should continue.

Sequence C: This scenario results from the loss of both off-site and on-site power. If a target is in process and both the target and SCB are intact, gradual diffusion of residual quantities of contaminants (<1% of target volatile inventory) inside the SCB into Zone 2A and subsequently into Zone 2 could occur.

Off-site Power Available	Backup on-site power available	Target in-process	Intact SCB	Intact Target	Sequence
Yes	n/a	Yes	n/a	n/a	A
No	Yes	Yes	n/a	n/a	B
	No	Yes	Yes	Yes	C
				No	D
			No	Yes	E
				No	F
		No	Yes	Yes	G
			No	n/a	H

Figure 3E.5-1. Loss of Power DBA Event Tree.

Sequence D: This scenario assumes that the total loss of power occurs simultaneously with failure of a target during processing, at the time that the inventory is most volatile. In this case, the contents of the SCB at the time of loss of power are 100% of the volatile inventory of the target.

Sequence E: In this sequence, the SCB is assumed to be failed at the time of loss of power. With an intact target, limited quantities (<1%) of volatile nuclides are available for release, but are dispersed rapidly within Zone 2A.

Sequence F: This scenario assumes a failure of the target confinement, at the time the inventory is most volatile, coincident with power failure, either simultaneous with or preceded by SCB failure. The entire target, volatile nuclide inventory is assumed to be released to Zone 2A for subsequent diffusion into Zone 2.

Sequence G: This scenario results when the power failures occur at a time when a target is not being processed, but the SCB is intact. In this case the low residual SCB inventory would be available for diffusion. The resulting consequences are bounded by Sequence C, probably by more than an order of magnitude.

Sequence H: This scenario results when the power failures occur at a time when a target is not being processed, with a failed SCB. The resulting consequences are bounded by Sequence E, probably by more than an order of magnitude.

3E.5.2 Probability Assessment

Failure probabilities for the various initiating events, operator response, system operation, and barrier resistance in the event tree analysis are as follows:

1. Loss of off-site power: A probability of loss of off-site power of 3 times per year is supported by the data from 1977 to 1997.
2. Availability of on-site backup power: 0.01/demand (Mahn et al. 1995)
3. Target in process: At maximum rates, 1500 targets would be processed per year. During processing, the constituents are in a volatile state for about one hour for each target. Thus, volatile constituents are available 1500 hours per year. For an 8760-hour year, this results in volatile constituents being available 17% of the time.
4. SCB: The SCB is a passive confinement, fabricated principally of stainless steel. Sealed glass windows and other sealed penetrations exist as part of the SCB boundary. A failure rate of 0.001 is assumed for this passive component. Since the operator continually monitors the SCB pressure differential, this may be a conservative estimate, i.e. suspect SCBs would be taken out of service. (Mahn et al. 1995, Table 5)
5. Target: Failure of the target confinement boundary has been evaluated in the spill scenario to occur approximately 0.2 percent of the time.

The frequency of each operational outcome or sequence for the event tree of Figure 3E-7 has been calculated as shown in Table 3E.5-1. The frequencies calculated in the event tree analysis compare well with the assessed frequency bins of hazard event CP-12 for a ventilation system confinement failure. The frequency bin for event CP-12 was III as compared to frequency bins of II to V. CP-12 did not assess differing prior conditions or coincident volatile material releases as evaluated in the event tree analysis.

Table 3E.5-1. Frequency of Occurrence for Each Sequence of the Event Tree Analysis Diagram for a Loss of Off-Site Power, Ventilation System Failure.

Branch	Events /year	On-site Power	Target In-process	SCB	Target	Freq	Freq Bin	Result
A	n/a	n/a	n/a			1500	I	Safe
B	3	.99	.17	.999	.998	0.5	II	Safe
C	3	.01	.17	.999	.998	.005	III	Neg. Cont.
D	3	.01	.17	.999	.002	1E-5	IV	Minor Cont.
E	3	.01	.17	.001	.998	5E-6	IV	Minor Cont.
F	3	.01	.17	.001	.002	1E-8	V	HCF Cont.
G	3	.01	.83	.999	1	.025	II	Neg. Cont.
H	3	.01	.83	.001	1	2.5E-5	IV	Neg. Cont.

3E.6 Fire in a HCF Radioactive Material Storage Area

This internally initiated DBA is a potential fire in a radioactive material storage area that is associated with the HCF. Limited quantities of combustible material are present in some of the radioactive material storage areas. Additionally, ignition sources, primarily electrical, also exist and are active in some of the radioactive material storage areas. Thus, the potential exists for a fire in some of the radioactive material storage areas.

3E.6.1 Fire in a Storage Area Scenario Development

This internally initiated DBA is a potential fire in a radioactive material storage area. The potential for a radioactive material storage area fire was examined by using event tree analysis methodology.

The radioactive material storage areas and the material in storage were examined for potential ignition sources and combustible material. See Appendix 3D for more information.

- The principal combustible material collocated with radioactive material in storage consists of wood, cardboard, paper, and plastic temporary packaging materials of varying amounts.
- Ignition sources are provided principally by the electrical lighting and the systems for heating, ventilation, and cooling (HVAC) in some of the radioactive material storage areas. Forklifts are used for moving material for storage so they present a limited additional ignition source and combustible material due to forklift energy sources and fuel. Some forklifts are electric so no fuel is present.
- Radioactive material in the radioactive material storage areas is mostly in solid form but can be in a liquid or resin form with appropriate spill control pallets. The radioactive material stored is mostly activated equipment, irradiated experiments, residue from water purification systems (radioactive resin), and other associated materials that are being stored for possible reuse or eventual disposal as waste.

The monorail storage hole radioactive material storage areas have no ignition sources and usually no combustible material. While spontaneous combustion is theoretically possible in the monorail storage holes, the limited volume available for combustibles and the combination of radiation shielding plug and weather cover sealing the hole make a fire caused by spontaneous combustion unlikely. Due to the separated and sealed nature of the monorail storage holes, no fire suppression systems are installed.

Building 6596 and Building 6597 high bay radioactive material storage areas have the ignition sources and combustible material listed above. Because people work in those areas to perform storage, packaging, and other operations, wet pipe sprinkler fire suppression systems are installed. In addition, appropriate portable fire extinguishers are available for local use by personnel. When people are present in these radioactive material storage areas, the ignition sources of lighting and HVAC systems are most active but some reduced lighting and HVAC system operation can be expected after working hours.

Due to the absence of both combustible material and ignition sources in the monorail storage holes, only fires in Building 6596 and Building 6597 high bay radioactive material storage areas will be considered.

The causes and preventive features for a fire in a radioactive material storage area were examined for the DBA accident scenario. The identified initiating events for this scenario are electrical wiring short or overheat in lighting or HVAC circuits that ignites combustible packaging material present in the area. The subsequent fire is assumed to affect all of the radioactive material in storage and to cause a release through vents or doors in the facility. Thus, the scenario is a conservative upper bound to the radioactive material at risk to fire that should provide a conservative bound to consequences for the public. The detailed progression of the fire from ignition to involvement of all of the radioactive material was not analyzed nor were the methods of airborne release of the material or its escape from the building structure. Forklift caused fires were not considered since they could only occur during the relatively brief times that a forklift is used in the radioactive material storage areas.

Features for fire prevention were the mechanical properties of some metal material containers and radioactive material form to prevent or reduce the release, and smoke detectors and sprinkler fire suppression systems to prevent or delay ignition of combustible materials. In addition, administrative operating procedures, hazardous material handling training and packaging requirements could also help prevent or mitigate a fire caused by an electrical wiring short or overheat.

Mitigative features for this DBA are inherent in the distance to the site exclusion area boundary. In addition, low or zero ventilation rates from the HVAC system exhausts may reduce the amount of radioactive material escaping the building for airborne release.

It should be noted that the consequences of this internally initiated fire, involving all of the radioactive material in a radioactive material storage area, are the same or greater than a fire in a radioactive material storage area caused by external events.

Since there are multiple radioactive material storage areas, the question of facility segmentation should be addressed. According to DOE-STD-1027-92, Attachment 1, "The concept of independent facility segments should be applied where facility features preclude bringing material together or causing harmful interaction from a common severe phenomenon." Thus, a fire in a radioactive material storage area can be evaluated independently (or the area segmented) if that fire will not affect the radioactive material in another radioactive material storage area, the HCF in the basement of Building 6580, or some other nuclear facility in TA-V. All of the radioactive material storage areas are located in physically separated buildings or separate sealed holes and not in the same building as another nuclear facility. Therefore, they can all be segmented and fires in each radioactive material storage area can be treated separately. The only exception to this segmentation would be for radioactive material storage areas in the same building or adjacent to a location that contains radiological material in quantities below the hazard category 3 threshold levels. Then, the physical separation of the building walls and other features should be assessed to evaluate whether a fire in the radioactive material storage area could affect and involve the adjacent radiological material.

The radioactive material storage areas in Building 6596 are not assumed to be segmented from the other parts of Building 6596 for this fire DBA. Three locations in Building 6596 may contain radiological material in excess of hazard category 3 threshold quantities. Those locations are the Building 6596 east and west high bays and the Building 6596 chapel, a high roof side room addition to Building 6596. The east and west high bays of Building 6596 are connected by a cut out in the wall for a ceiling crane so a fire could propagate from one side of the wall to the other. Likewise, the wall and door between the east high bay and the chapel are not rated as fire barriers so a fire could propagate from the east high bay to the chapel. Thus, the radiological material in all of Building 6596 must be considered for the source term in this DBA. An administrative control procedure is required to ensure that the total of all radioactive material located in all parts of Building 6596 does not exceed the hazard category 2 thresholds since the Building 6596 radioactive material storage areas cannot be segmented.

The DBA fire scenario was an electrical wiring short or overheats that caused an electrical fire. Then the fire spread to combustible packaging material and spread to involve all of the radioactive material in storage. Power isolation could prevent a fire of combustible material other than the electrical wiring if the short or overheat condition were detected promptly by an operator or isolated by an automatic circuit protection device (circuit breaker). To investigate fire termination by power isolation, the event tree analysis for this DBA considered three scenario variations:

- Electrical wiring short or overheats that caused an electrical fire and then spread to combustible packaging material to involve all of the radioactive material in storage.
- Electrical wiring short or overheats that caused an electrical fire and then spread to combustible packaging material to involve all of the radioactive material in storage. Possible spread to other combustible material halted by circuit breaker power isolation.
- Electrical wiring short or overheats that caused an electrical fire and then spread to combustible packaging material to involve all of the radioactive material in storage. Possible spread to other combustible material halted by operator detection and manual power isolation. An operator is present only part of the time and some lights remain on at all times to present an electrical short or overheat hazard.

In all of these scenario variations, the fire suppression system composed of a wet pipe sprinkler system could limit fire progression and possibly the extent of the release. As the sensor that starts the sprinkler water flow is passive and located near the high ceiling level, The sprinkler system may not start promptly to suppress the fire. In that case it will be more of a mitigation feature than a prevention feature so it was not included in the event tree analysis of radioactive material release.

Event tree analysis was used to analyze the accident sequence and to evaluate the accident frequency as suggested in (DOE 1997) and (Mahn et al. 1995). Figure 3E.6-1 presents the event tree using the accident progression sequences developed previously.

Electrical wiring short or overheat in lights or HVAC	**Circuit breaker promptly detects short and removes power**	**Operator promptly detects short or overheat and removes power**	**Sequence**
Yes	Yes	N/A	A
	No	N/A	B
		Yes	C
		No	D

Figure 3E.6-1. Event Tree Analysis for a Fire in a Radioactive Material Storage Area.

The outcomes of the event tree analysis in Figure 3E.6-1 are shown as four sequences. The outcomes represent the following detailed accident occurrence scenarios.

Sequence A: Safe condition and no further fire of combustible material. Prompt detection and a power removal by the automatic circuit breaker has prevented further short or overheats ignition of a larger fire. Radiological material is not involved in the fire and released.

Sequence B: The automatic circuit breaker does not detect the short or overheat and remove power to prevent a combustible material fire that is assumed to involve stored material and release the radiological material (Hazard Event RS-1). This sequence applies while no operator is present in the facility.

Sequence C: Safe condition and no further fire of combustible material. The automatic circuit breaker does not detect the short or overheat and remove power. The operators present in the facility promptly detect the electrical short or overheat and remove power to prevent a combustible material fire that is assumed to involve stored material and release the radiological material.

Sequence D: The automatic circuit breaker does not detect the short or overheat and remove power. The operator present in the facility also does not promptly detect the electrical short or overheat and remove power. The result is a combustible material fire that is assumed to involve stored material and release the radiological material (Hazard Event RS-1).

3E.6.2 Probability Assessment

The radioactive material storage area is in continuous operation to store radioactive material, thus, at least some of the electrical circuits are in use for all of the 8760 hours per year. Failure probabilities for the various initiating events, operator response, system operation, and barrier resistance in the event tree analysis are as follows:

1. An electrical wiring short to ground is expected to occur 0.0000003 times per hour of operation. The continuous operation time of the radioactive material storage area is 8760 hour per year. The overheated wiring and fire results from the electrical short.
2. Failure of a circuit breaker, automatic circuit protection device is expected to occur 0.001 times per demand or electrical over current event. The amount of the additional current caused by an electrical short is not known but it is assumed to be in excess of the current required to cause the circuit breaker to remove power from the circuit.
3. Operator detection and response to an unsafe condition such as shorted and overheated wiring in equipment or a broken or missing segment of equipment housing is a response to a compelling indication. Not to detect and respond is an error of omission. Such operator errors are expected to occur 0.01 times per demand or electrical overheat. Operators are assumed to be present in the radioactive material storage area only part of the time. Eight hours per week or approximately 0.05 of the time is considered typical. Thus, the sequence C and D conditions are considered typical of the overall fire response of a radioactive material storage area.

The frequency of each operational outcome or sequence for the event tree of Figure 3E.6-1 has been calculated as shown in Table 3E.6-1 below.

Table 3E.6-1. Frequency of Occurrence for Each Sequence of the Event Tree Analysis Diagram for Fire in a Radioactive Material Storage Area.

Sequence	Operating Hours/ Year	Equipment Failures/ hour	Unsafe Condition Detection & Action	Freq.	Freq. Bin	Result
A	8760			8760	I	Safe, fire stopped
B	8760	0.0000003		2.6E-3	III	Fire started and radioactive material released
C	8760	0.0000003	1	2.6E-3	III	Safe, fire stopped
D	8760	0.0000003	0.01	2.6E-5	IV	Fire started and radioactive material released

Sequences B and D correspond to hazard event RS-1 of the hazard analysis from Appendix 3C. The assessed event frequency per year for hazard event RS-1 was frequency bin III. This agrees well with the Sequence B frequency bin of III in the event tree analysis but not with the Sequence D frequency bin of IV. Sequence D was not considered typical of the overall operation of a radioactive material storage area. The failure to detect an electrical short or overheat and remove power in Sequence D depended on an operator being present. Since operators are only present in a radiological material storage area approximately 5% of the time, this operating condition was not assessed as typical. Thus, the event tree analysis confirms the frequency assessment of the hazard analysis.

3E.7 Design Basis Earthquake

The Hot Cell Facility (HCF) was constructed to standards that are 40 years old and would not meet current seismic criteria. Some of the HCF structures and much of the installed equipment in the HCF are not expected to withstand a significant seismic event. However, modifications to the confinement structures during the 1999 upgrade did not affect the seismic integrity of these structures, which are expected to remain intact following a seismic event. The accident analysis did not take credit for any above ground structures or ventilation ducting beyond the basement confinement structures. This evaluation considers the expected response of HCF systems and structures, and the potential radiological consequences that could result, based on that response. Separate evaluations of the basement of B6580, containing the greatest hazard, and the individual radiological material storage areas will be performed. Independent of the results of the design basis earthquake (DBE), the potential consequences of equipment and/or structural failures are also evaluated for a beyond DBE (BDBE).

3E.7.1 DBE Scenario Development

There are two fundamental elements that must be assessed to evaluate the consequences of the DBE:

1. the configuration of confinement and associated equipment,

2. the source term or inventory available for release.

The evaluation of the configuration of confinement following a DBE provides an assessment of potential leakage paths for the source term to the environment. Assessment of equipment configuration bears on the leakage paths as well as on transport mechanisms in that the ventilation fans provide a driving force to remove airborne radioactive material from the facility. An assessment of the source term is essential in that it is the basis for assessing the magnitude of the potential consequences. A separate evaluation of the likelihood of each of these elements is provided, since they are independent parameters.

3E.7.1.1 Confinement Configuration

An evaluation of the confinement functions in the HCF must consider the state of the confinement structures, and the potential flow and/or leakage paths that would result in dose consequences to either on-site or off-site personnel. Two outside evaluations of the seismic performance of HCF SSCs form the basis for this DBE analysis. The first, performed by Walla Engineering Ltd in December 1998, was an evaluation of the east shield wall of Zone 2A. This wall has the greatest potential for failure in a seismic event of all of the basement concrete structural elements, since it is unrestrained at the top. The second evaluation is a qualitative assessment of several SSCs performed by Chavez-Grieves based on an on-site inspection, reported in memorandum format dated May 18, 1999.

The conclusions of these evaluations were:

1. The east shield wall, including the CMU course on top of the wall, would remain intact
2. The SCBs would likely remain intact
3. The MER structure, containing many ventilation components, would likely collapse
4. B6580 and B6581 would likely collapse
5. Filter housings in the MER would tip over and sever connections to ventilation ducting

<u>State of confinement structures</u>

Based on the Chavez-Grieves assessment, the likelihood of steel confinement box (SCB) integrity following a DBE is expected to be high (Chavez-Grieves, May 18, 1999). Further, potential openings or weak points in the SCB envelope are not likely to result in failure of the confinement function. The SCB opening to the conveyor system (hatch cover) is latched down and would likely remain in place in a DBE. There is a normal 5 square centimeter (check valve) opening in this cover to provide flow into the SCB, and there is some potential that the check ball could be displaced or wedged into an open position by debris. The water washdown lid could be displaced, but the welded stainless steel piping is a closed volume, so this opening does not provide a potential leakage path. The SCB glass alpha seal could crack due to distortion of the frame. These forces could be evaluated, but they are judged to be small relative to the strength of the glass. Even if cracked, the glass would likely remain in place in the frame, thus maintaining a confinement barrier.

The Zone 2A structural walls have been evaluated and are expected to withstand a DBE. Chavez-Grieves expressed the opinion that the airlock doors would likely remain standing in a DBE. The course of cinderblock above the east shield wall has been evaluated for seismic response and is expected to withstand a DBE (Walla, 1998). The HCF windows are contained in substantial (1 to 1.5 inch thick) steel frames cast into the concrete shield wall and would be unaffected by a DBE. Cracks, which might be created in the concrete structures as a result of the DBE, would provide leakage paths that are small relative to the normally existing leakage paths. There were no specific assessments of the ability of the Room 109 shield doors to remain functional or of their ability to remain in the up position following a DBE. Thus, there is no assurance that the doors will remain in the up position in the event of a DBE or BDBE. In the event that all three of the Room 109 shield walls lowered in a DBE, Room 109 would provide a large leakage opening to Room 101 (Zone 3).

The failure of the course of CMU above the east shield wall, as well as failure of the airlock doors, are evaluated as a beyond DBE. The airlock door opening is 8.5 feet wide and 10.3 feet high, or 88 square feet. The gap between the poured concrete wall and the HCF ceiling is about 10 inches, providing a potential opening of about 50 square feet. Some of the opening above the poured concrete wall would be filled by debris following a BDBE, reducing the effective area. Leakage through Room 109, which represents a 270 square foot opening, could also contribute to migration of contamination in a DBE.

Evaluation of Equipment and Leakage Paths

As described above, gross structural failures of confinement barriers in the basement of B6580 are not expected in a DBE but are postulated for the BDBE. Such failures could provide significant confinement leakage paths. In the event that the Room 109 shield doors lowered, the pressure of Zone 2A and room 109 would be equalized. If the ventilation system were operating, overall confinement and flow paths would not be affected, since the ventilation system would continue to draw air through Room 109 into Zone 2A and exhaust it through the filtered flow path. The flow rate through Room 109 in these circumstances exceeds the diffusion velocity of volatile specie, preventing migration of contamination out through Room 109. In the event that the ventilation system was not operating, and all shield doors were down, Room 109 provides a leakage path from Zone 2A to Room 101.

The ventilation ducting provides an intended pathway to the environment that could be breached in a DBE. Breaches in the Zone 1 ventilation piping in the basement area due to the DBE are unlikely. This piping consists of 3 and 6 inch welded stainless steel pipe. If breaches did occur with the fans operating, Zone 2 air would be drawn into the breach, diluting the SCB effluent, and likely reducing the flow drawn from the SCBs, but not significantly changing the transport of radionuclides. In the event of a complete (double ended) breach, flow from the SCB (s) would cease, and further transport would occur due only to diffusion. The effect of these potential configurations (intact, breached, or disconnected) are encompassed by this DBE evaluation.

The Zone 1 and Zone 2A filter housings, located in the Mechanical Equipment Room (MER), have been assessed by Chavez Grieves to likely tip over in a DBE. They would also be subject to debris impacts resulting from the assessment that the MER structure would likely collapse in a DBE. In either case, the displacement or rotation of the filter housing would rupture the sheet metal duct transitions, which attach the housings to the ducting. Both the housing and the welded metal ducting are significantly more robust than the transitions. Failure of the transition would separate the fan suction from the Zone 1 or Zone 2A ducting. A partial breach, if the fans were operating, would result in dilution of the effluent by an inflow of ambient (MER) air, but would not result in a significant difference in the transport path. Damage to the filter housings that would cause distortion of the housings and disruption of the filtered flow path without significantly affecting the weaker transitions is improbable.

Power to the ventilation system components in the MER is supplied by a conduit entering the MER on the inside of the west wall and routed to a power panel mounted to an internal wall. Power to the fans is supplied by conduit that is routed along the walls and in the ceiling of the MER. Failure of these conductors would be highly likely in a DBE that caused structural collapse of the MER, either at the power panel or by failure of the individual fan conductors contained in conduit.

The CMU buildings, B6580 and B6581, were assessed by Chavez Grieves to collapse in a DBE. Since the ventilation ducting between the MER and the HCF stack is routed alongside and over these buildings, breaching of the ductwork between the MER and the stack is highly likely in a DBE. Since this would result in an undesirable configuration in that it bypasses the HEPA filter at the base of the stack and thus results in an unfiltered ground release, it will be conservatively assumed to occur in a DBE. For this reason, evaluation of the HEPA filter and response of the stack are not relevant and are not evaluated in the DBE.

Since the Zone 1 and Zone 2A fans are connected to the ducting and are not anchored in the MER, significant displacement of the fans in a DBE would result in distortion and/or breaching of the ducting. Partial breaching would allow dilution, if it occurred upstream of the fan, and exhaust of potentially contaminated air into the MER if it occurred downstream of the fan. The former would have little effect on transport mechanisms unless the fan were totally separated from the ducting, while the latter would not be significantly different than breaching of the ducting outside the MER, which has been conservatively assumed to occur. Thus, the structural behavior of the fans in a DBE has no impact on the DBE outcomes presented in this analysis.

<u>Confinement Configuration Probability Assessment</u>

1. Confinement structures. Based on the two seismic assessments previously referenced, these walls and SCBs are assumed to remain structurally intact in a DBE. Leakage through Room 109 will be evaluated in conjunction with the DBE, without assessing the likelihood. The consequences of gross structural failure of other elements of the confinement barriers are evaluated for the BDBE.

2. The zone 1 ducting is assessed to fail in a DBE at the transition with the filter housings. The filter housings are assessed to tip over or be knocked over in a DBE, which severs the transition joint between the housings and the ducting. The housing itself is assessed to be more structurally rigid than the transition, thus the filters will remain effective if the ducting is not breached. A failure probability of 0.9 will be assumed for this failure.

3. Loss of power to the fans is assessed to be highly likely in a DBE. A probability of 0.9 will be assumed for this likelihood.

4. Failure of the ducting beyond the MER is assumed to occur in a DBE due to structural collapse of the MER, B6580 or B6581.

Thus, the likelihood of ventilation system configurations up to the exhaust from the MER, following a DBE, is assessed as follows:

Ventilation system continues to operate normally:	0.01
Ventilation system is intact but fan is not operating:	0.09

Ventilation ducting is decoupled from fan 0.9

Even though the above assessments of ventilation system configuration likelihood are judged to be appropriate and valid, the consequences of incorrect judgments are evaluated by assuming that the components either fail or do not fail in a manner differently than that assumed in this analysis. The impact on potential outcomes for different judgments is assessed in this analysis in section 3E.7.2.

3E.7.1.2 Source Term Evaluation

The potential source term in B6580 for the DBE consists of residual radiological contamination, contaminants built up on in-box filters, the noble gas inventory in the cold trap, and any radiological materials that are in process at the time of the event. The availability of the source term for transport is dependent on the physical form of the material and the containers in which the material exists. The effect of the DBE on each of these potential source terms must be evaluated to determine expected releases. While it might appear that the significant 500,000 curie source term present in Room 109 should be a consideration for the DBE, the potential consequences associated with this source term, even in fire scenarios, have been evaluated in Section 3.4.2.4 of the SAR to be very low due to the physical form of the material. The fission products are effectively bound in solidified concrete inside stainless steel containers.

Residual Inventory

Residual contamination will exist in each SCB due to routine spills and incidental venting of gases evolved during processing. The principal contaminant (as well as the contaminant of most concern) will be iodine, due to its volatility and biological hazard. Iodine is rendered volatile during acidic dissolution of uranium dioxide containing fission products. Noble gases will be vented to and captured in a cryogenic cold trap. Those noble gases that are inadvertently released to the SCB environment will be entrained in the ventilation system flow and discharged immediately to the environment. Fission products other than noble gases and halogens remain non-volatile, will remain in acidic solution during processing, and will be solidified at the completion of each processing operation. The maximum residual SCB iodine inventory has been assessed to be 26 curies (Mitchell & Naegeli, SAR Supporting Analysis, Evaluation of Ventilation System Failure). This residual inventory is time dependant and decreases by an order of magnitude every 20 minutes, since the ventilation system will continually sweep out the SCB atmosphere and deposit entrained fission products on the in-box filters (ibid.). The "average" inventory during the one hour processing period is determined by integrating the time dependant concentration over the time period required for processing, assuming that the entire released inventory occurs at the beginning of the interval. This results in an average concentration of 0.15 of the maximum inventory, or about 4 curies of iodine (Mitchell and Naegeli, 1999). Since all four extraction SCBs can be used for initial processing, the total residual inventory in the SCBs is 16 curies of iodine, of which 2.4 curies are I-131 and 5.6 curies are I-133. The potential dose consequence at the 3000-meter exclusion area boundary that would result due to the unmitigated release of this inventory, is 0.2 mrem.

The potential inventory on in-box filters has been evaluated, and totals 40 curies of I-131, and 34 curies of I-133. (Mitchell and Naegeli, 1999). This inventory would not be directly affected (released) due to seismic loads, but is potentially releasable in a fire. Based on the limited combustible inventory, the containers in which such inventory would exist in each SCB, and the fact that ignition sources are limited to supplied electricity and electrical heaters contained in process fixtures, it is judged that a DBE would not have significant effect on the failure mechanisms that could lead to an in-box fire. It would be difficult to quantify the likelihood of a fire in the event of a DBE, and it is judged to be low, but it is likely higher than the probability of less than 10^{-5} per year assessed in the SCB fire analyses (Appendix 3E.3). Further, the likelihood of simultaneous fires in multiple SCBs, while there admittedly is a common cause factor, would still be less than the likelihood of a fire in a single SCB. For the purposes of this DBE evaluation, it will be assumed that a fire occurs with a likelihood of 0.01 in two SCBs, making the filter inventory in these SCBs available for release. This totals 80 curies of I-131 and 68 curies of I-133, which would result in dose consequences at the 3000-meter exclusion area boundary of 4.8 mrem for an unmitigated release. This also provides a basis for evaluating the potential consequences of the inventory contained in all four in-box filters in the more unlikely event that they were all subjected to a fire.

The residual inventory in Zone 2A outside of the SCBs is represented by an airborne concentration of 51 microcuries of iodine, which is the only specie with significant volatility. This inventory level represents a decontamination factor of 10,000 relative to the average contamination levels in the SCBs during processing operations, which should be readily achievable given that proper airflows are maintained in the HCF. Normal ventilation system operation will continuously sweep out airborne materials, and will provide airflow across surfaces that would tend to pick up any readily volatized material. It is likely that the airborne contamination levels will be much lower than that assumed here and that any residual contamination on Zone 2A surfaces would likely remain in place following a DBE.

The inventory in the cold trap is potentially available for release in the DBE, which could disrupt the supply of LN to the trap. While this piping may remain intact following a DBE, it will be conservatively assumed that the LN supply piping fails. Warming of the trap would vaporize the noble gases contained in the trap. If the vacuum pump were operating, the pump would discharge the contents to the Zone 1 exhaust. If, in the more likely event that the pump were not operating, the noble gases would be released, but more slowly than if they were actively pumped out. Thus, although equipment configuration would affect the timing and rate of noble gas release, it does not affect the ultimate outcome. The noble gas inventory, based on maximum processing rates, has been assessed to approach an equilibrium value of 33,000 curies of Xe-133 within about 30 days (Mitchell and Naegeli, 1999). The dose consequence at the 3000 m. exclusion area boundary, which would result in the event of the unmitigated release of this entire inventory, is 3.4 mrem.

<u>In-Process Inventory</u>

The material in-process inventory is that of a maximally irradiated target. The hazard analysis considered the effects of NPH phenomena in assessing the likelihood of target failure. No significant forces were identified that could be induced on the target as a consequence of a DBE. Thus, induced forces are small relative to the structural characteristics of the target, and the assessed likelihood for spontaneous failure of a target of 0.001 is appropriate and valid for the DBE. The rate of target introduction to the HCF processing SCBs is limited by the transfer system to about one per hour. Therefore, coupled with the fact that there is only one heating apparatus in each SCB for acidic dissolution of fission products, the in-process inventory potentially available for release cannot exceed that from a single target.

During the one-hour initial processing period, the entire radiological inventory is potentially available for release. Once the iodine has been collected in the iodine trap, it would not be vulnerable to DBE effects. Even if crushed, breached, and/or burned, the trap would not release the iodine, since it is chemically bound as copper iodide. Thus, for the remainder of the processing period only the residual process liquid, containing about 75% of the total fission product inventory or 14,000 curies, is available as a potential source term. This source term is present until the waste is solidified (approximately 3 hours).

Source Term Summary

The source term potentially available for release consists of the cold trap noble gas inventory, the residual contamination in each SCB, the halogen inventory built up on the in-box filters, the residual process liquid source term, and the inventory in a maximally irradiated target. The specific mix of each of these inventories in each DBE scenario varies, and is dependent on the specific release scenario under consideration. The dose consequence at the 3000-meter exclusion area boundary for each of these potential inventories is summarized in Table 3E.7-1.

Table 3E.7-1 DBE Source Term Summary

Source Term	Isotope	Inventory (Curies)	Dose Conversion Factor (Rem/Ci)	Unmitigated Dose, 3000 m (mrem)
Noble Gas	Xe-133	33000	1.03 E-7	3.4
Residual	I-131	2.4	5.3 E-5	0.13
	I-133	5.6	1.22 E-5	0.07
In-box filters	I-131	80	5.3 E-5	4.0
	I-133	68	1.22 E-5	0.8
Process Liquid	Semi-Volatile	1044	3.3 E-5	35
	Non-volatile	12,580	1.2 E-5	152
Target	Noble Gases	1865	8 E-7	1.5
	Halogens	2600	1.65 E-5	43
	Semi-Volatile	1044	3.3 E-5	35
	Non-Volatile	12, 580	1.2 E-5	152

Source term probability assessment

The residual SCB inventory and the noble gas inventory are continuously available during periods of processing. The residual SCB inventory decays rapidly after processing due to operation of the ventilation system.

The in-box filter inventory associated with two SCBs would be released in an SCB fire, which is assumed to occur with a conditional likelihood of 0.01.

Based on a processing rate of 30 targets per week, and an initial processing time of 1 hour, the likelihood of having a target in process at any given time is assessed to be 0.17.

The likelihood of spontaneous target failure in the event of a DBE, which would release to contents of the target in process to the SCB, has been assessed to be 0.001 in other DBA analysis.

The likelihood of having acidic process liquids present at any given time is assessed to be 0.54, based on a processing time of 3 hours.

The availability of the process liquid inventory is dependent on the integrity of the glass process containers. The likelihood of failure of the glass containers in the event of a DBE, has been conservatively assessed to be 0.1. This estimate is based on the fixtures and process operations used in isotope separation processes. Most of the time, the glass containers are securely held in metallic fixtures, which would preclude damage to the containers, even if the fixtures were overturned. At other times, they are subjected to manipulator operations, with some potential for being dislodged and damaged by impact.

Thus, the likelihood of having source terms of a given magnitude available for release is as follows:

Residual source term of 16 curies of iodine	0.17
In box filter inventory of 74 curies of iodine	0.01
Process liquid source term of 14,000 curies	0.054
Entire target source term of 18,400 curies	0.00017

The noble gas inventory of 33,000 curies of Xe-133 is assumed to be present and released in all scenarios. The potential source term in Zone 2A (50 microcuries of iodine) is inconsequential relative to the above source terms and will not be considered in this evaluation.

3E.7.2 Probability Assessment

The ventilation system ducting between the MER and the stack is conservatively assumed to fail in all scenarios. The potential states of the balance of the ventilation system have been assessed to occur with the following likelihood:

Ventilation system operating	.01
Ventilation system intact, fan not operating	.09
Ventilation system breached	.90

In the event that the ventilation system is operating, the contents of the SCBs would be drawn through the charcoal filters in the MER, and would be discharged at ground level at some location north of the MER. Fission products other than halogens would not be captured by the charcoal filter.

In the event that the fan is not operating or the ventilation ducting is decoupled from the fan, there is no mechanism to draw contamination out of the SCBs. Release of hazardous material under these circumstances would occur at a rate determined by diffusion. Evaluations of transport of radionuclides under these conditions (with the Room 109 shield doors in place) have been previously accomplished, and indicate that buildup of fission products in Zone 2 of the HCF several hours after the event is less than one microcurie. Transport of these fission products outside the confines of the HCF would be negligible, and dose consequences at 3000 meters would be extremely small.

In the event that the shield doors are down, a large opening exists which provides a transport path for radionuclides from Zone 2A into Room 101 (the HCF machine shop). Diffusion of iodine, the most volatile specie, has been evaluated (Mitchell and Naegeli, 1999). This analysis indicates that after 6 hours, approximately 0.1% of the Zone 2A inventory would diffuse into the machine shop through Room 109. However, since the Zone 2A residual inventory is estimated to be 51 microcuries, this results in only 0.5 microcuries diffusing into Zone 3. Even if this inventory were released directly to the atmosphere, it would result in negligible risk to the public.

Each potential ventilation system configuration (operating, non-operating, and breached) can be combined with the potential source terms of Table 3E.7-1 to derive the dose consequences shown in Table 3E.7-2 for each DBE event.

Table 3E.7-2 DBE Event Consequences

DBE Event	Source Term Description	Dose at 3000 m. (mrem)
DBE1	Operating, RST (noble gas only)	3.4
DBE2	Non-Operating, RST (noble gas only)	3.4
DBE3	Breached, RST (noble gas only)	3.4
DBE4	Operating, RST+ (noble gas + residual iodine)	3.6
DBE5	Non-Operating, RST+ (noble gas + residual iodine)	3.6
DBE6	Breached, RST+ (NG + residual I + iodine on in-box filters)	8.4
DBE7	Operating, PLST (process liquid + noble gas)	191
DBE8	Non-operating, PLST (noble gas only)	3.4
DBE9	Breached, PLST (noble gas only)	3.4
DBE10	Operating, EST (process liquid + noble gas + residual iodine)	191
DBE11	Non-operating, EST (noble gas only)	3.4
DBE12	Breached, EST (noble gas only)	3.4

Notes: RST = Residual Source Term
RST+ = Residual Source Term plus In-box Filters Source Term (SCB fire)
PLST = Process Liquid Source Term
EST = Entire Source Term

The likelihoods of occurrence of the twelve potential outcomes, given that the probability of a DBE is 0.001 per year, are summarized in Table 3E.7-3.

Table 3E.7-3 DBE Event Frequencies

DBE Event	Ventilation System Condition Likelihood	Source Term Likelihood	Overall Likelihood
DBE1	.01	.17	1.7 E-6
DBE2	.09	.17	1.5 E-5
DBE3	0.9	.17	1.5 E-4
DBE4	.01	.01	1 E-7
DBE5	.09	.01	9 E-7
DBE6	.9	.01	9 E-6
DBE7	.01	.054	5.4 E-7
DBE8	.09	.054	4.9 E-6
DBE9	0.9	.054	4.9 E-5
DBE10	.01	.00017	1.7 E-9
DBE11	.09	.00017	1.5 E-8
DBE12	0.9	.00017	1.5 E-7

These calculated frequencies and consequences are bounded by those assigned to (and in all cases are well below) process spill events in the hazard analysis prepared for this SAR.

3E.7.3 Evaluation of Alternative Assumptions

The analysis described above is in part, based on engineering judgment and professional opinion. While these judgments are appropriate and valid in applying the graded approach to assessing the safety of HCF operations, one can examine the effects on the evaluated outcomes of judgments different than those made in this analysis. Some of these assessments, and specifically the assessment of confinement barrier failures, will be accomplished in evaluation of the BDBE, and thus will not be discussed here.

If, for example, the likelihood of the filter housing overturning and breaching the ventilation ducting transition were 0.1 instead of the assumed 0.9, the likelihood of DBEs 3, 6, 9, and 12 would decrease by about an order of magnitude, while the likelihood of DBEs 1, 4, 7, and 10 would increase by an order of magnitude. The likelihood of these events, judged to have limited to no significant off-site consequences, would remain assessed to be very or extremely unlikely.

Similarly, if the failure of glass containers were certain to occur in a DBE (as opposed to the 0.1 assumed), the likelihood of DBEs 7, 8, and 9 would increase by an order of magnitude, however only DBE7 has any resulting consequences. The likelihood would be assessed to be very unlikely, and would still be bounded by other analysis presented in the SAR.

If the source term for the SCB fire in a DBE were increased from that associated with two SCBs to four SCBs, the dose consequences for DBEs 4, 5, and 6 would approximately double. Also, if the SCB fire were different than that assumed in this analysis (0.01) in the event of a DBE, the likelihood of these three DBEs would increase or decrease in direct proportion to the estimated likelihood of the fire. However, in all cases, both the overall likelihood and the potential consequences result in minimal risk.

Another area of judgment was that the charcoal filters in the MER were assumed to remain functional following a DBE based on the relative robustness of the ducting and housing structures. If this judgment were incorrect, the potential dose consequences for DBE1 would increase from 3.4 mrem to 3.6 mrem, the consequences of DBE 4 would increase from 3.6 to 8.4 mrem, and the consequences of DBE10 would increase from 192 to 235 mrem. Given the low likelihood of these events, these are not significant differences.

While additional resources could be applied to evaluate the likelihood and characteristics of ventilation system failures in more detail, the estimated magnitude of the risks would suggest that such additional evaluations are not justified, even if significant misjudgments were incorporated in this DBE analysis.

3E.7.4 DBE Evaluation of Radioactive Material Storage Areas

By DOE-STD-1027 definition, the HCF radioactive material storage areas (RMSA), since they are limited to radiological material inventories less than Hazard Category 2 thresholds, do not, by themselves, have the potential for significant off-site consequences. However, the potential release of this inventory as a contributor to the overall release can be evaluated for a perspective of the overall risk.

Based on the DOE-STD-1027 criteria and methodology, a dose consequence at 3000 meters of 44 mrem is calculated for unmitigated release of the entire maximum inventory associated with each RMSA. Material in stagnant storage would not be released due to structural loads induced by a DBE. For such a release to occur, a severe energetic event, such as a fire, would be required to provide a mechanism for dispersal of radioactive material. The likelihood of a DBE initiating a fire in an RMSA, and a deterministic evaluation of the expected release fraction in this scenario would be difficult to quantify, and is not justified given the limited dose consequences for this event.

3E.7.5 Beyond Design Basis Earthquake Evaluation

An evaluation of the response of the HCF in a Design Basis Earthquake (DBE) has been accomplished, and likelihoods of occurrence have been assessed for the configuration of confinement systems and availability of radiological inventory for release.

For the BDBE, structural degradation greater than that which would result from the DBE was postulated to occur. Additional analyses were accomplished based on larger openings in confinement barriers than were assumed for the ventilation failure analysis. As the basis for assessing the consequences, the following structural failures were assumed to occur in a BDBE, without regard to likelihood:

1. The 1-inch thick glass window in each SCB was assumed to shatter, releasing the contents of the SCBs to Zone 2A.

2. The course of CMU on top of the east shield wall of Zone 2A was assumed to completely disintegrate. This provides a 50 square foot opening between Zone 2A and Zone 2. Failure of the Room 109 shield doors as well as complete structural failure of the airlock doors was also evaluated. Each of the latter two leakage paths resulted in consequences less than those which were calculated for failure of the CMU, however the combined leakage through all three paths could result in overall releases that would be perhaps twice as large as those due to CMU failure alone.

3. In a seismic event in which the above structural degradation occurred, the continued operation of the ventilation system would be extremely unlikely, but the potential consequences of both continued operation and non-operation are evaluated.

The source terms considered were those described in the DBE evaluation, namely:

1. A normal residual source term of 4 curies of Iodine in each SCB (16 curies total), which is available with a likelihood of 0.17.

2. An additional 74 curies of iodine is present in each SCB in-box filter, and is released in the event of a simultaneous fire, which is assumed to occur in the BDBE.

3. The source term associated with a maximally irradiated target, which is available with a likelihood of 0.00017 (the failure of the metallic target is equally unaffected by the BDBE)

In the more likely event of failure of the ventilation system, the inventory contained in the SCBs is released to Zone 2A, and subsequently diffuses into Zone 2. The rate of this diffusion has been calculated and the resulting Zone 2 iodine inventory was plotted (Mitchell and Naegeli, 1999). In the most extreme case, that of simultaneous target failure and SCB fire which releases the inventory contained in the in-box filters, the Zone 2 inventory of I-131 approximates 1 curie after about 4 hours. If this source term were instantaneously flushed out of the HCF by some unspecified mechanism, the dose consequences at 3000 meters would be about 0.05 mrem.

In the less likely event of continued ventilation system operation, the source term and resulting consequences would be identical to that calculated for the same scenario in the DBE, with maximum consequences of about 200 mrem at 3000 meters.

3.E.8 References

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