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Preliminary Safety Analysis Report for the Gamma Irradiation Facility

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PRELIMINARY SAFETY ANALYSIS REPORT

for the

GAMMA IRRADIATION FACILITY

at the

Sandia National Laboratories, Albuquerque
Albuquerque, New Mexico

March 1, 1995

ABSTRACT

This report documents the safety analysis work performed for the Gamma Irradiation Facility (GIF) at Sandia National Laboratories (SNL), Albuquerque, New Mexico. The GIF is a new facility to be constructed at Sandia's Technical Area V, and combines the sources and capabilities of two existing irradiation facilities at the Laboratories. The analysis and content of this document meets the safety analysis report requirements of DOE Order 5480.23, "Nuclear Safety Analysis Reports." The characteristics of the facility, the site, and the operations are described and the hazards associated with operation of the facility are examined to evaluate the overall safety. A graded approach technique is employed in determining the level of detail for the analysis and documentation of the hazards associated with the facility. The analysis shows that there will be no off-site impact from operation of the GIF and that the facility can be safely operated to minimize the hazards to personnel at the site. The report concludes that operation of the GIF at SNL, presents an acceptable risk to health and safety of personnel on-site, off-site, and to the general public. .

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1. EXECUTIVE SUMMARY

1.1 General Introductory Information

Sandia National Laboratories (SNL), Albuquerque, New Mexico, is a major research and development laboratory owned by the U.S. Department of Energy and operated by Martin Marietta Corporation.[1.1] SNL's primary missions and established responsibilities are nuclear weapons development, energy and environmental programs, and work for other government agencies. As part of these missions, simulation testing of weapon components and energy related hardware are essential tasks to satisfying program requirements. One element of this testing is the simulation of ionizing radiation damage with high energy photons emitted from radioactive gamma ray sources (such as ^{60}Co). For this purpose, SNL is proposing to build a new Gamma Irradiation Facility (GIF) in Technical Area V (TA-V). This Preliminary Safety Analysis Report (PSAR) addresses the safety aspects of the proposed GIF.

SNL has neutron and gamma simulation facilities located at TA-V, a remote site on the Kirtland Air Force Base approximately 5000 meters from the main population area of the Laboratories (Chapter 3 contains details and maps for this location). The Annular Core Pulsed Reactor (ACRR), Sandia Pulsed Reactor (SPR), Hot Cell Facility (HCF), and an existing Gamma Irradiation Facility are all located within TA-V. These facilities are essential for providing high-fidelity simulation of nuclear radiation environments for warhead and component testing. In response to previous safety reviews, Sandia has established the goal of limiting functions inside TA-V to only those associated with operation of the nuclear facilities and with the preparation of experiments for these facilities. To satisfy this goal, Sandia is proposing limiting the occupancy in TA-V to facility operations personnel and consolidating the Laboratories large gamma irradiation sources to a single structure at TA-V. These goals are articulated in two priorities of Sandia's Environmental, Safety, and Health (ES&H) Long-Range Plan as follows:

1. Relocation of personnel who are not directly involved with nuclear facility operations or handling of Special Nuclear Material (SNM) to a new building located outside the TA-V security perimeter.
2. Relocation of the existing major gamma ray sources to a common new building within the TA-V security perimeter.

The new Gamma Irradiation Facility (GIF) will consolidate the radioactive sources and experiment capabilities currently located with the existing GIF in TA-V and with the Low Intensity Cobalt Array (LICA) Facility in Technical Area-I.

This PSAR is concerned only with the new GIF. A hazard assessment has determined the GIF to be a Hazard Category 3, Non-reactor Nuclear Facility requiring a Safety Analysis Report. The GIF project has proceeded through the Title I design and the Title I design review processes and is currently ready to start Title II.[1.2] Although design information is only preliminary at this phase of the project, there is sufficient details and analysis to assure that the GIF can be constructed and operated safely.

1.2 Process Overview

The GIF provides a single structure for performing a wide diversity of gamma irradiation experiments with various test configurations and at widely different dose and dose rate levels.

The GIF is divided into two types of irradiation facilities (in-cell dry and in-pool wet) based on the type of test to be performed.

- **In-Cell Dry Irradiation:** The in-cell facilities are large, dry, shielded rooms in which irradiations are performed with a high intensity gamma-ray source located in the room. An elevator raises and lowers the source between the shielded location in the water pool and a predetermined position in the cell. Entry into the cells is through a shielded door at the end of an entry maze hallway which prevents direct radiation emission from the cell. A pneumatically lifted, movable wall is part of the large gamma cell for passage of large test units which cannot be transported through the maze. Typical irradiations performed in these facilities are at high dose rates (100 - 1000 kilorads/hr) and for short to intermediate durations lasting less than a day.

- **In-Pool Wet Irradiation:** In the in-pool facilities, radioactive sources are held in an irradiation fixture in a deep pool of water where they remain stationary. Experiments canisters containing test units are immersed in the pool and positioned in preset locations in the irradiation fixture. Typical irradiations performed in these facilities are at moderate and low dose rates (<10 kilorads/hr) and for long durations lasting days, weeks and months.

The GIF is intended for the irradiation of experiments with ionizing gamma (high energy photon) radiation. The types of experiments performed cover many disciplines as demonstrated in the following listing of experiments currently performed in existing irradiation facilities:

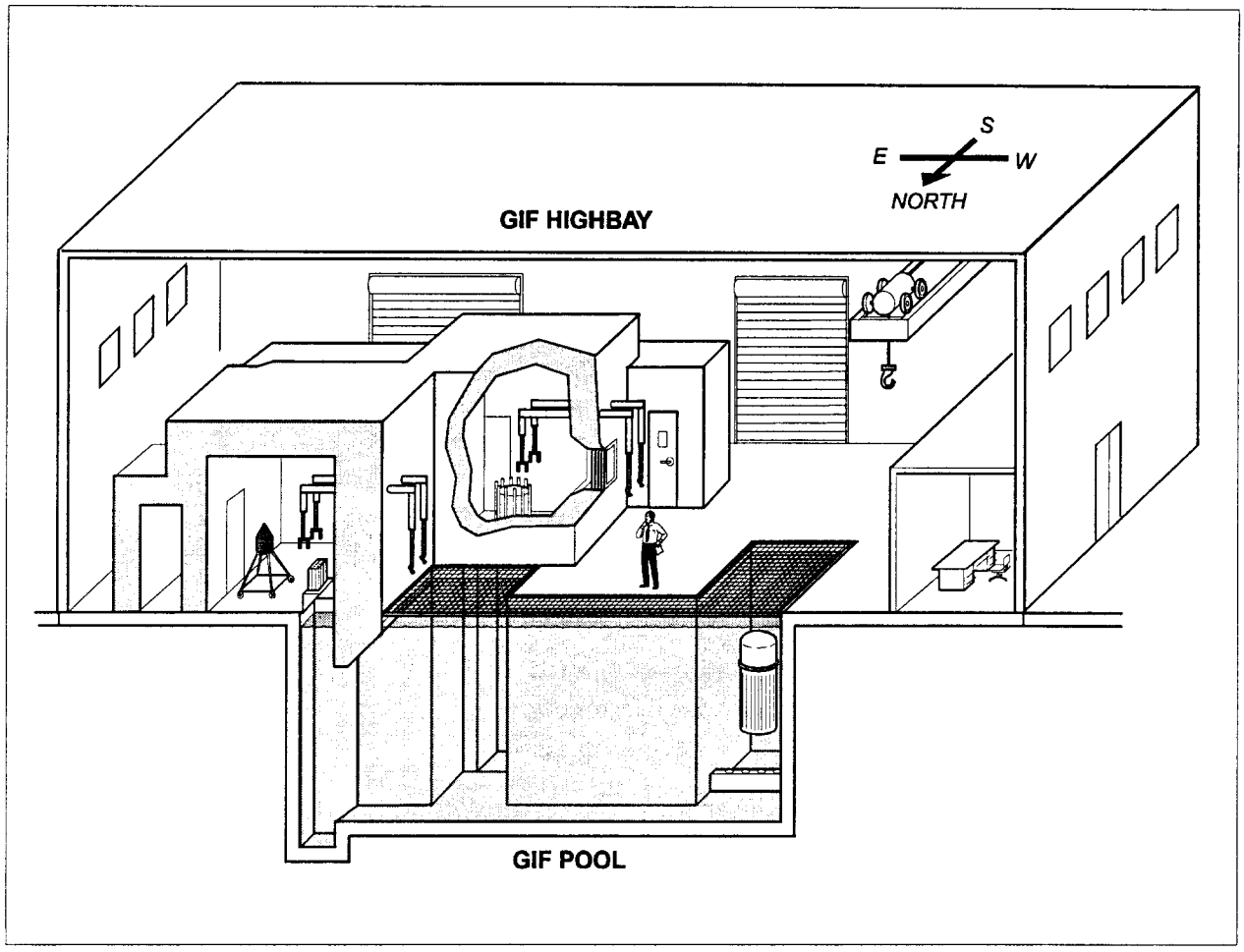
In-Cell Irradiation
- Electronic component hardness, survivability, and certification tests for military and commercial applications.
- Radiation effects on material properties.
- Radiation effects on organic materials.
- Mixed environment testing (e.g. steam and radiation, heat and radiation, etc.).

In-Pool Irradiation
- Simultaneous thermal and radiation effects studies.
- Weapon components for degradation testing.
- Material/component testing for nuclear reactor accident tests.
- Electronic component certification.

Whereas the new GIF has all of the features of the existing GIF or LICA facilities, it also has many enhanced features which make the GIF a unique irradiation facility. The GIF has three irradiation cells with one cell sufficiently large to accommodate large components (such as space vehicles or military vehicles). The following is a list of the general features and enhanced capabilities available in the GIF (also shown in Figure 1-1) :

- East Cell: 5.5 m x 9.1 m experiment cell with two source elevators and a 5.5 meter wide movable wall for access by large vehicles.
- South Cell: 3.0 m x 3.0 m irradiation cell for use with High Intensity Adjustable Cobalt Array (HIACA)for rapidly adjustable sources arrays.
- North Cell: 3.0 m x 3.0 m high fidelity cell with lead-lined walls to reduce backscatter.
- High strength radioactive sources with up to 2.4 megacuries of ^{60}Co inventory.

Figure 1-1. Cutaway View of the Gamma Irradiation Facility



- Configurable radiation sources to provide different shapes for the source array (i.e. point, planar, circular, etc.).
- Shielded windows for experiment observation during irradiation.
- Remote manipulators for experiment or source handling.
- In-pool irradiation fixtures for different experiment configurations.
- Steam room for thermal cycling following radiation exposures.
- Overhead traveling cranes with ~10 and ~5 metric ton hook capacities for source handling and shield cask movement.
- GIF operations offices and experimenter offices and labs.

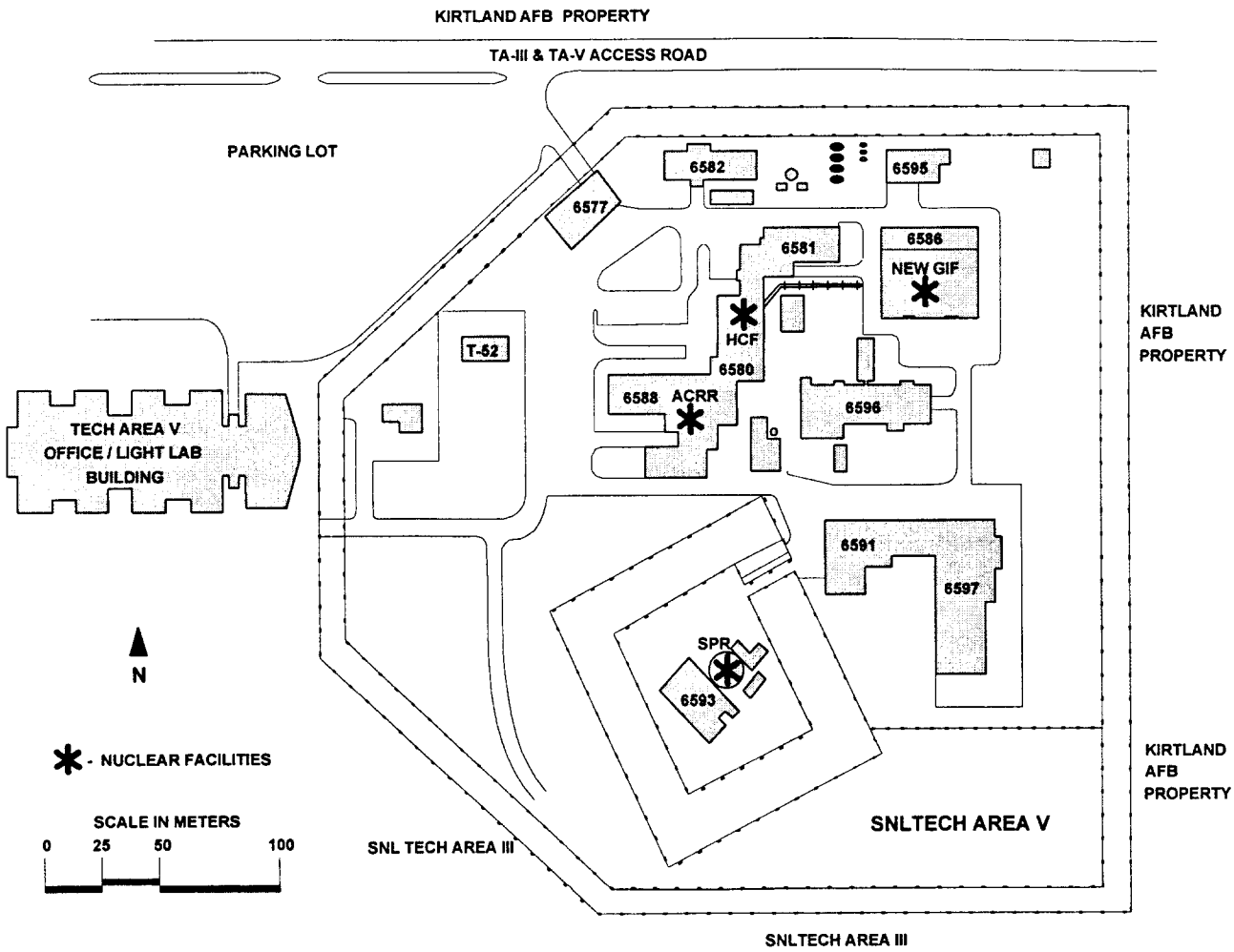
1.3 Facility Overview

The new GIF building (see Figure 1-2) is a single-story structure located in the northeast quadrant of TA-V inside of the TA-V security perimeter as described in Chapter 3. The structure consists of a central high bay with a ancillary low bay. The high bay houses three concrete test cells and a basically "H"-shaped pool with a depth of 5.5 meters. The pool can store up to 2.4 megacuries of ^{60}Co or an equivalent thermal source (40 kilowatts) of other gamma-ray sources. The sources are in the form of pins and can be shared between the in-cell irradiation facilities (one leg of the "H") and the in-pool irradiation facilities (the other leg of the

H"). Ancillary spaces in the high bay include offices, setup/light laboratories, and rest rooms. The adjacent low bay contains the support equipment for the GIF: steam room for experiments, mechanical room for water treatment and ventilation systems, and electrical room for all power distribution. The building high bay area totals approximately 1060 gross sq. meters with an additional 290 gross sq. meters in the adjacent low bay. For space utilization and optimization, some changes in the building floor plan are anticipated in the Title-II process.

The new GIF consolidates several existing SNL gamma sources into a single facility. The proposed facility will include sources relocated from the existing GIF, which is a two cell dry irradiator located in the ACRR reactor high-bay in TA-V. The relocation satisfies the following objectives: 1) relieves congestion around both the GIF and the ACRR, 2) reduces the potential for exposure of operating staff to radiation, 3) facilitates personnel evacuation in an emergency, and 4) frees space adjacent to the ACRR for experimental work. The new GIF will also include gamma sources relocated from the LICA, which is located in Sandia's TA-I. This consolidates gamma irradiation sources in a single dedicated facility in a remote area, reducing the potential for radiation exposure of non-operations personnel. It provides a modern facility to satisfy Sandia's continued need for high intensity gamma environment testing for the foreseeable future.

Figure 1-2. Location of the GIF in Sandia's TA-V



1.4 Identification of Agents and Contractors

The GIF design and construction project is directed and coordinated by a project leader from Sandia's Facilities Development Center. The project leader coordinates all activities within SNL and to outside agents and contractors. Within SNL, the project leader normally consults and obtains assistance from the following internal organizations:

- Corporate Construction Program Office
- Construction Management Department
- Facilities Planning Program Department
- Maintenance Management Department
- Security Requirements and Planning Department
- Safety and Environmental Engineering Department
- Utility Systems Department
- Site Utilities Engineering Department
- Human Factors Department or Representative
- Customer Funded Program Department
- Maintenance Operations Department-Area I
- Facilities Engineering Department
- Architectural and Interior Design Department
- Health Physics Department
- Chemical Waste Department
- Radioactive and Mixed Waste Department
- Pollution Prevention Department.
- Communications Department
- Environmental Restoration and Impact Department
- Crane and Hoist Maintenance Team
- User Operations Department
- User Safety Department
- Maintenance Operations Department-Area II, IV and KAFB
- Maintenance Operations Department-Area III, V, and Coyote Test Field
- Risk Management and National Environment Pollution Act Documentation Department

Under the direction of project leader, the Phase I design was contracted to Smith, Hinchman & Grylls/Southwest. Other outside agencies involved in the design and review process are Professional Loss Control, Inc. (for fire hazards analysis), VEL, Inc. (for value engineering), and Stone and Webster, Inc. (for review of design features and safety documentation). These agencies interface with Sandia organizations at various phases of the design, documentation and review process as shown in Figure 1-3.

1.5 Summary of Significant Site Characteristics

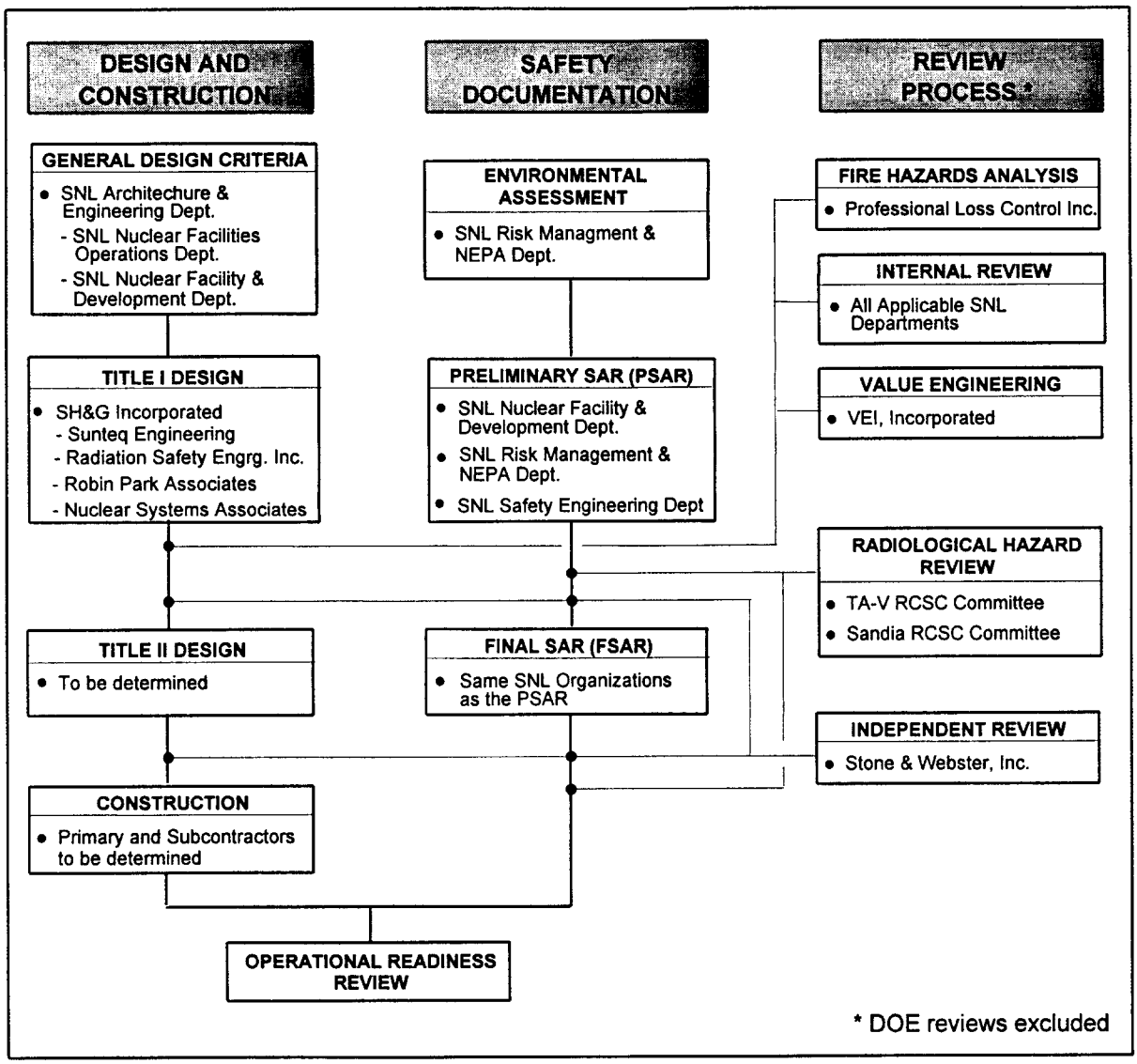
The Gamma Irradiation Facility (GIF) is located in the Technical Area V (TA-V) complex at Sandia National Laboratories/New Mexico (SNL/NM). TA-V has served as the site for Sandia's nuclear facilities for over thirty years. As shown in Figure 1-2, the current nuclear facilities in TA-V include: the Annular Core Research Reactor (ACRR), Sandia Pulsed Reactors (SPR II/SPR III), and the Hot Cell Facility. In addition to these major activities, small research laboratories, machine shops, plant support facilities, and offices for operational personnel are located throughout the area. The SNL/NM facilities are located on Kirtland Air Force Base (KAFB), Albuquerque, New Mexico.

In this PSAR, the GIF site and TA-V complex are evaluated in the following areas:

- Geography and demography (location, site, population, and regional land/water use)
- Nearby facilities and transportation routes
- Meteorology
- Surface and subsurface hydrology
- Geology and seismology
- Site characteristics affecting facility construction and operation

The conclusion of the site evaluation is that the TA-V complex is well suited for the site of the GIF. No concerns or problems were identified with the site. The siting of the GIF should have no adverse affects on the environment. The operation of the GIF in TA-V does not pose a significant risk to on-site workers and does not pose a credible risk to the general public.

Figure 1-3. Agents and Contractors during the GIF Design/Construction Process



1.6 Hazard Classification of Facility/Operation

A hazard assessment has been completed for the new facility. This work culminated in a "Safety Documentation Determination" form being approved by DOE/KAO on December 12, 1992.[1.3] This form defines the GIF as a Hazard Category 3, Non-Reactor Nuclear Facility and requires a SAR for the facility.

An Environmental Assessment has been prepared and is currently in the review process.[1.4] The Environmental Assessment emphasizes that the GIF consolidates Sandia's high intensity gamma sources into a single, dedicated facility located in the remote TA-V. In addition, the facility will be designed, built, and operated to satisfy current DOE orders and regulations. These features reduce the potential for accidental high radiation exposure to operating personnel and reduce the unnecessary risk to the general public.

1.7 Summary Normal Operations, Abnormal Conditions, and Accidents

The new GIF incorporates the sources and test facilities from two existing SNL irradiation facilities: the current GIF in TA-V (in operation since 1962), and the LICA Facility in TA-I (in operation since 1982). The experience gained during the 42 total years of the safe operation of these two facilities serves as the foundation for determining and analyzing the new GIF design and planned operations. Anticipated conditions are determined for normal and abnormal operation of the GIF along with the expected consequences from accidents.

For the accident analysis, the "graded approach", as specified in DOE Order 5480.23, is employed to identify the analysis and documentation requirements for accidents.[1.5] Because the GIF has a Category 3 hazard classification, the accident analysis is a qualitative assessment of the overall risk. Based on guidance from DOE-STD-1027, a methodology for performing a qualitative assessment was developed.[1.6] This methodology is similar to a probabilistic risk assessment in which the probability of an accident sequence and the unmitigated consequences are postulated. Based on these elements, the methodology identifies the minimum number and type of safety-related features required to assure that the overall risk is low for each anticipated accident sequence.

The postulated accidents cover natural phenomena, operational accidents, and those factors external to the GIF. The matrix of accidents are grouped into 12 accident categories. A total of 37 sequences were analyzed which were initiated by 45 separate causes. This matrix provides the basis for identifying the five safety-related systems necessary for safe operation of the facility. The term "safety-related" systems is used throughout the PSAR to identify engineered safety features; which have the function of providing only worker safety (described in Section 4.3). No engineered safety features were identified which could significantly affect co-located workers, the public, or the environment. These systems, along with their primary safety functions and type of function, are shown in Table 1-1. Only one system, the source cladding, prevents the dispersal of radioactive material. Other safety-related systems primarily prevent inadvertent radiation exposure of the GIF facility personnel. Consistent with the GIF's Hazard Category 3 classification, no system is required to protect other site workers, the public, or the environment.

Table 1-1. Safety-Related Systems for the GIF

Engineered Safety Feature	Primary Safety Function	Type of Function
1. Source cladding	Containment of radioactive material	Passive
2. Water pool	Radiation shielding	Passive
3. Irradiation cell shield	Radiation shielding	Passive
4. Elevator power interrupt	Access control	Active
5. Radiation monitoring system	Detection of radiation conditions	Active

1.8 Guide to the PSAR

This Preliminary SAR is being written to comply with DOE Order 5480.23.[1.5] The order introduces the concept of "graded approach" to proportion SAR requirements for analysis and documentation commensurate with the following three considerations: (1) magnitude of hazards addressed, (2) complexity of the facility and safety systems, and (3) stage of the facility life cycle. As noted in the DOE Order 5480.23, the "preliminary" stage of a facility in design warrants a less detailed safety analysis process; however the order is not explicit in its requirements for the content for a Preliminary SAR. Therefore, explicit requirements for a PSAR are adopted from DOE/AL Order 5481.1B and applied to the new format as specified in Order 5480.23. Based on DOE/AL Order 5481.1B, the topics/chapters to be addressed in a preliminary version of a Safety Analysis Report are the following:[1.7]

1) Introduction
2) Summary/Conclusion
3) Site Description and Assessment
4) Description of Facility
5) Description of Operations
6) System Risk Analysis
7) Accident Analysis

These chapters and their contents were cross-referenced to the Order 5480.23 topics and content. Based on the cross-reference, Table 1-2 presents a listing of the chapters in this PSAR and their required level of detail. For each chapter the terms "Complete" or 'Not Applicable" designate the amount of information presented in this report. For a particular chapter, "Complete" implies that analysis, design, and specification have been completed and the documentation presented in the PSAR is as detailed as possible at this point in the design process. "Not Applicable" implies that the material is not required in this PSAR, and therefore presentation of this material will be forthcoming in the Final Safety Analysis Report for the GIF.

1 .9 Conclusions

The design of the proposed GIF satisfies all of its intended functions. The GIF replaces two existing irradiation facilities and consolidates their operations into a single, dedicated facility in a remote area. The design, analysis, construction and planned operation of the GIF are in compliance with the current DOE orders, guidance, and standards applicable to the facility. The accident analysis has verified the Hazard Category 3 classification for the GIF -- the facility only has the potential to significantly affect the facility personnel, but does not have the potential to significantly affect other site workers, the public, or the environment. This PSAR, and the supporting analysis, demonstrates that the GIF can be operated safely within the constraints presented in this document

Table 1-2. Level of Detail for Chapters in the GIF PSAR

Chapter	Title	Corresponding DOE-STD-3009 Chapter	Level of Detail
1	Executive Summary	1/2	Complete
2	Applicable Statutes, Rules, and Orders	4	Complete
3	Site Characteristics	3	Complete
4	Description of Facility and Operations	4/5	Complete
5	Hazard Analysis and Classification of the Facility	5	Complete
6	Principal Health and Safety Criteria	4	Complete
7	Waste Management	10	Not Applicable
8	Inadvertent Criticality Protection	11	Not Applicable
9	Radiation Protection	10/11	Not Applicable
10	Hazardous Material Protection	10/11	Not Applicable
11	Analysis of Normal, Abnormal and Accident Conditions	5/6/7	Complete
12	Management, Organization, & Institutional Safety Provisions	9/10	Not Applicable
13	Procedures and Training	16	Not Applicable
14	Human Factors	None	Not Applicable
15	Initial Testing, In-service Surveillance. and Maintenance	9	Not Applicable
16	Derivation of Technical Safety Requirements	8	Not Applicable
17	Conduct of Operations	17	Not Applicable
18	Quality Assurance	9	Not Applicable
19	Emergency Preparedness	15	Not Applicable
20	Facility Decontamination and Decommissioning	14	Not Applicable

1.10 References

1.1 Contract to Operate Sandia National Laboratories for the DOE, Contract Number DE-RP04-93AL8500, Signed with Martin Marietta Corporation, effective October 1, 1993.

1.2 Technology Support Center Title I Submission, prepared by Smith, Hinchman & Grylls/Southwest, Inc. 1-6-93.

1.3 "Safety Documentation Determination for the GIF" form approved by DOE/KAO; December 12, 1993.

1.4 "Environmental Assessment - Technology Support Center", Sandia National Laboratories, 9-30-92.

1.5 DOE Order 5480.23 "Nuclear Safety Analysis Reports" (effective 4-30-92).

1.6 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, 12-92.

1.7 DOE 5481.1B "Safety Analysis and Review Systems". AL version 1-27-88.

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2. Applicable Statutes, Rules, and Orders

2.1 DOE Orders and Other Departmental Requirements

The 5480-series of DOE Orders specify the requirements for DOE-owned reactor and nonreactor nuclear facilities. The GIF is identified as a nonreactor nuclear facility; therefore, many of the requirements for a reactor facility are not applicable to the GIF. In the following presentation of orders, requirements, codes and standards applicable to the GIF, no distinction is made between applicable and non-applicable requirements in the documents. In most cases, clear delineation between applicability to reactor and nonreactor nuclear facilities is identified in the statutes. In those cases where clarification on applicability is necessary, corresponding sections of the PSAR will detail specific applicability of the requirement to the relevant system, component, and process.

2.1.1 DOE Orders

Paragraph 4.6.3(d) of Attachment I of DOE Order 5480.23 requires that the SAR identify and demonstrate compliance with applicable statutes, rules, and Departmental Orders. Overall, the SAR will be reviewed against the relevant sections of the following Orders issued by the DOE and the DOE Albuquerque Operations Office:

DOE Order 1300.2A, "Department of Energy Standards Program" (July 19, 1992)
DOE Order 1540.2, "Hazardous Material for Transport - Administrative Procedures" (December 19, 1988).
DOE Order 4700.1, "Project Management System" (June 2, 1992).
DOE Order 5000.3B, "Unusual Occurrence and Procedures of Operations Information " (July 2, 1993).
DOE Order 5400.1, "General Environmental Protection Program" (June 29, 1990).
DOE Order 5400.2A. "Environmental Compliance Issue Coordination" (January 7, 1993).
DOE Order 5400.3. "Hazardous and Radioactive Mixed Waste Program" (February 22, 1989).
DOE Order 5400.4, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements" (October 6, 1989).
DOE Order 5400.5, "Radiation Protection of the Public and Environment" (January 7, 1993).
DOE Order 5440.1E. "National Environmental Policy Act Compliance Program" (November 10, 1992).
DOE Order 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes" (July 9, 1985).
DOE Order 5480.4, "Environmental Protection, Safety, and Health Protection Standards" (January 7, 1993).
DOE Order 5480.5, "Safety of Nuclear Facilities" (September 9, 1986).
DOE Order 5480.7A, "Fire Protection" (February 17, 1993).
DOE Order 5480.10, "Contractor Industrial Hygiene Program" (June 26, 1985).
DOE Order 5480.11, "Radiation Protection for Occupational Workers" (June 17, 1992).
DOE Order 5480.15, "Department of Energy Laboratory Accreditation Program for Personnel Dosimetry" (December 12, 1987).

DOE Order 5480.17, "Site Safety Representatives" (October 10, 1988).
DOE Order 5480.19, "Conduct of Operation" (May 18, 1992)
DOE Order 5480.20, "Personnel Selection, Qualification, Training and Staffing Requirements for Non-reactor Nuclear Facilities" (June 19, 1991).
DOE Order 5480.21, "Unreviewed Safety Questions" (December 24, 1991).
DOE Order 5480.22, "Technical Safety Requirements" (September 15, 1992).
DOE Order 5480.23, "Nuclear Safety Analysis Reports" (April 10, 1992).
DOE Order 5480.24, "Nuclear Criticality Safety" (August 12, 1992).
DOE Order 5480.31, "Startup and Restart of Nuclear Facilities" (September 14, 1993).
DOE Order 5481.1B, "Safety Analysis and Review System" (September 23, 1986).
DOE Order 5483.1A, "Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities" (June 22, 1983).
DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (October 17, 1990).
DOE Order 5500.1B, "Emergency Management System" (February 27, 1992).
DOE Order 5500.2B, "Emergency Categories, Classes, and Notification and Reporting Requirements" (February 27, 1992).
DOE Order 5500.3A, "Planning and Preparedness for Operational Emergencies" (February 27, 1992).
DOE Order 5530.1A, "Accident Response Group" (September 20, 1991).
DOE Order 5700.6C, "Quality Assurance" (August 21, 1991).
DOE Order 5820.2A, "Radioactive Waste Management" (September 26, 1988).
DOE Order 6430.1A, "General Design Criteria" (April 6, 1989).
DOE/AL Order AL5400.2A, "Environmental Compliance Issue Coordination" (August 13, 1993).
DOE/AL Order AL5440.1D, "National Environmental Policy Act Compliance Program" (March 19, 1992).
DOE/AL Order AL5480 5, "Safety of Nuclear Facilities" (August 17, 1987).
DOE/AL Order AL5480.11, "Radiation Protection for Occupational Workers" (June 4, 1992).
DOE/AL Order AL5480.31, "Startup and Restart of AL Facilities, Activities, and Operations" (January 28, 1994).
DOE/AL Order AL5481.1B, "Safety, Analysis and Review System" (January 27, 1988).

2.1.2 Other DOE Regulations and Guidelines

Relevant sections of this SAR should be reviewed against additional DOE regulations and guidelines as follows:

SEN-15-90, "National Environmental Policy Act" (February 5, 1990).

SEN-35-91, "Nuclear Safety Policy" (September 9, 1991).

Executive Order 12088. Federal Compliance with Pollution Control Standards. DOE Radiation Standards For Protection of the Public in the Vicinity of DOE Facilities. (William A. Vaughn, Memorandum, August 5, 1985).

N5400.10, "Sealed Radioactive Source Accountability" (December 11, 1992).

N5480.6, "Radiological Control" (June 17, 1992).

N480.7, "Imposition of Proposed Nuclear Safety Requirements." (January 7, 1993).

N5480.8, "Radiological Health and Safety Policy" (June 8, 1993).

DOE Standard 1027, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports" (December 1992).

2.2 Applicable Federal Rules and Regulations

Sections of this SAR address the following Federal rules and regulations:

American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices.

Clean Air Act, 1990 Amendments.

Code of Federal Regulations, 10 CFR 820, "Procedural Rules for DOE Nuclear Facilites", August 17, 1993.

Code of Federal Regulations, 10 CFR 830, "Nuclear Safety Management", March 29, 1994.

Code of Federal Regulations, 10 CFR 830.120, "Quality Assurance", April 5, 1994.

Code of Federal Regulations, 10 CFR 834, "Radiation Protection of the Public and the Environment", (Proposed Rule), March 25, 1993.

Code of Federal Regulations, 10 CFR 835, "Occupational Radiation Protection", December 14, 1993.

Code of Federal Regulations, 10 CFR 1021, "National Environmental Policy Act; Implementing Procedures and Guidelines", April 24, 1992.

Code of Federal Regulations, 10 CFR 1022, "Compliance with Floodplains/Wetlands Environmental Review Requirements".

Code of Federal Regulations, 29 CFR 1910, "Occupational Safety and Health Standards" U.S. Government Printing Office, Washington, DC, July 1, 1989.

Code of Federal Regulations, 29 CFR 1910.1200, "Hazard Communication", U.S. Government Printing Office, Washington, DC, February 1, 1989.

Code of Federal Regulations, 40 CFR 260-265, U.S. Environmental Protection Agency Regulations implementing the Resource Conservation and Recovery Act, 1989.

Code of Federal Regulations, 40 CFR 61, Subparts A and M, "National Emissions Standards for Hazardous Air Pollutants," U.S. Environmental Protection Agency, July 1, 1990.

Code of Federal Regulations, 40 CFR 302-304 Implementing the Comprehensive Environmental Resource Conservation Liability and Recovery Act (CERCLA) of 1980.

Code of Federal Regulations, 40 CFR 125 "Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)".

2.3 Applicable State and Local Statutes, Ordinances and Regulations

The New Mexico state statutes relating to ES&H protection were reviewed to identify those requirements applicable to the GIF. The following state statutes were identified as being applicable in part or in total.

From New Mexico State Laws 1978, Annotated (specifically; Chapter 74, Environmental Improvement), November 12, 1992 (Rev. 0):

1. New Mexico Air Quality Control Act
2. New Mexico Radiation Protection Act
3. New Mexico Hazardous Waste Act
4. New Mexico Radioactive and Hazardous Materials Act
5. New Mexico Emergency Management Act
6. New Mexico Hazardous Waste Feasibility Study Act
7. New Mexico Hazardous Chemicals Information Act
8. New Mexico Water quality Act
9. New Mexico Ground Water Protection Act
10. New Mexico Environmental Compliance Act
11. New Mexico Solid Waste Act

The City of Albuquerque) and County of Bernalillo ordinances relating to ES&H protection were reviewed to identify those requirements applicable to the GIF. The following local ordinances were identified as being applicable, in part or in total.

From City of Albuquerque Revised Ordinances 1974 (as amended).

City of Albuquerque Ordinances

1. Air Quality Control Board," Article XVI, Chapter 6, Health, Safety & Sanitation, April 1, 1989.
2. Chlorofluorocarbons," Article XX, Chapter 6, Health, Safety & Sanitation, April 1, 1990.
3. Sewer Use and Waste Water Control," Article IX, Chapter 8, Water, Sewer & Streets, October 1, 1990.
4. Cross-Connection Prevention and Control," Article XI, Chapter 8, Water, Sewer & Streets, January 1, 1988.
5. Water Waste, Article XIV, Chapter 8, Water, Sewer & Streets, no date.

From Bernalillo County Ordinances (as amended).

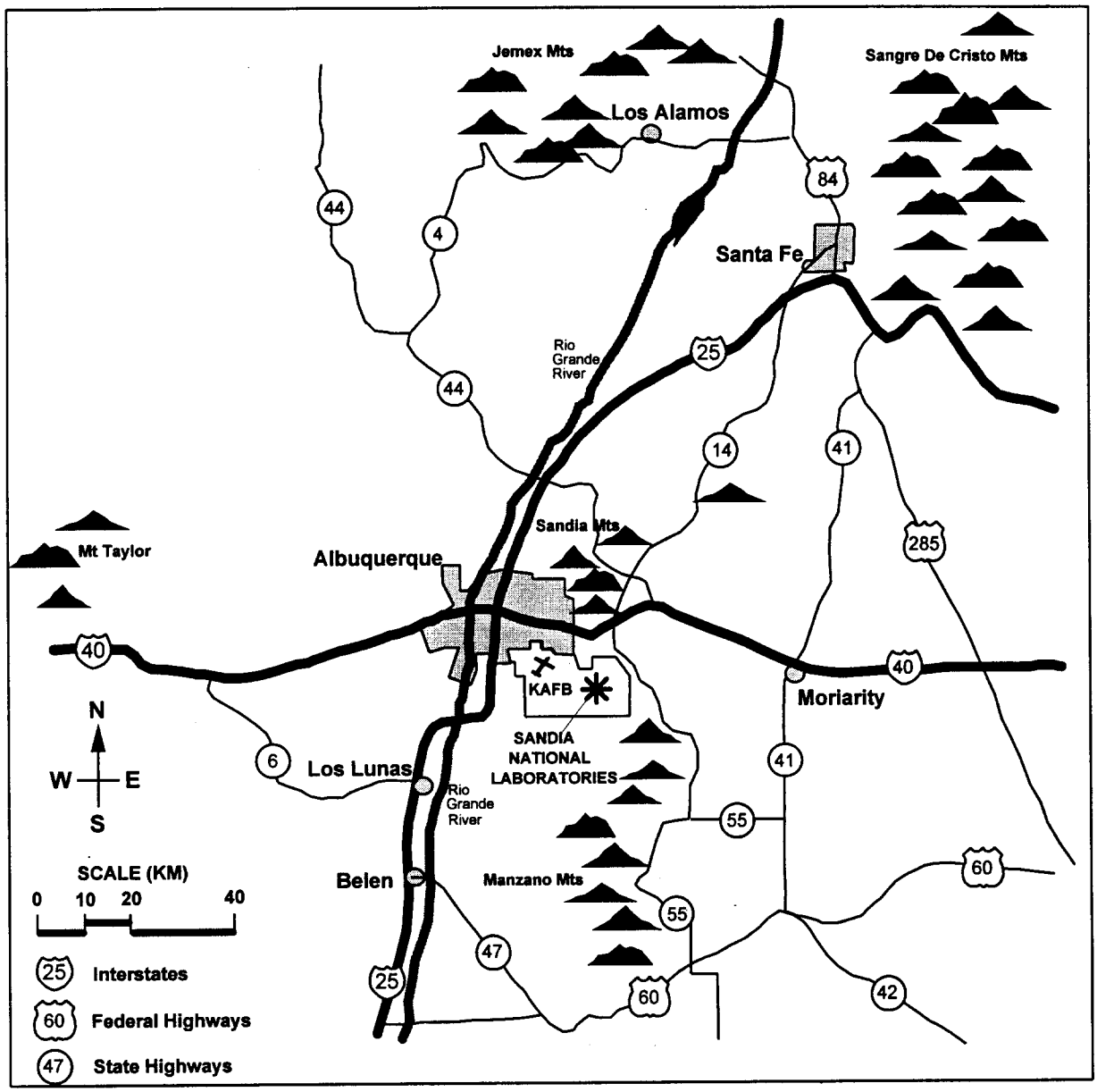
1. "Air Pollution," Ordinance No. 303, August 5, 1974.
2. "Air Quality Control/Air Pollution," Ordinance No. 88-45, no date.
3. "Bernalillo County Liquid Waste Disposal," Ordinance No. 88-1, February 4, 1988.

3. SITE CHARACTERISTICS

3.1 Geography and Demography

The Gamma Irradiation Facility (GIF) is located in the Technical Area V (TA-V) complex at Sandia National Laboratories/New Mexico (SNL/NM). Other major TA-V facilities include the Annular Core Research Reactor (ACRR), Sandia Pulsed Reactors (SPR II/SPR III), and the Hot Cell Facility. In addition to these major activities, small research laboratories, machine shops, plant support facilities, and offices for operational personnel are located throughout the area. The SNL/NM facilities are located on Kirtland Air Force Base (KAFB), a United States Air Force military reservation, immediately southeast of Albuquerque, New Mexico (Figure 3-1).

Figure 3-1. Location of Sandia National Laboratories/New Mexico



Pertinent to the discussion of the site is the definition of those areas that are under the direct jurisdiction of SNL or the USAF. Two categories of jurisdictional areas are established: KAFB Internal Area, and General Area. The KAFB Internal Area is defined as that area within the boundary of KAFB where all activities and facilities are under the direct control of either SNL or the USAF. The General Area is defined as all the contiguous area outside the KAFB boundary, including the Albuquerque International Airport, which is under the jurisdiction of local city, county, or state government authorities.

3.1.1 Location

As shown in Figure 3-1, SNL is located on the KAFB installation immediately southeast of Albuquerque, New Mexico. Major transportation services are the Albuquerque International Airport on the KAFB and Interstates 40 and 25 which cross near the base. The Sandia Mountains are northeast of KAFB and the Manzano Mountains are located to the southeast of the base. Directly to the east of SNL are the foothills which comprise the northern portion of the Manzano range.

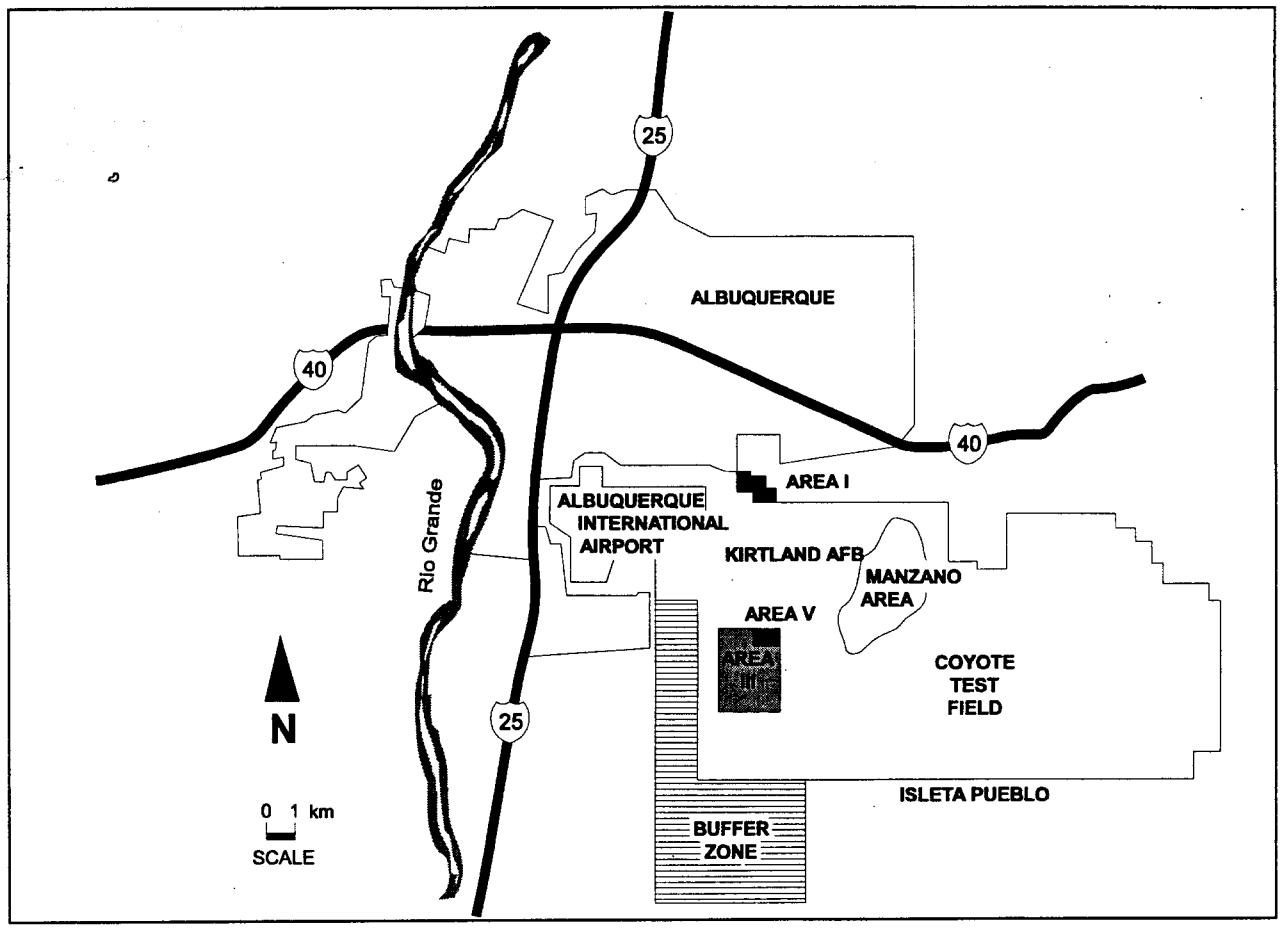
The location of SNL's technical areas with respect to the KAFB and the city of Albuquerque is shown in Figure 3-2. TA-V is located 5.4 kilometers south of Tech Area I (TA-I), which is the major SNL installation. SNL is an integral part of KAFB, which is situated in the southeast quadrant of the City of Albuquerque. The City of Albuquerque and KAFB are located in Bernalillo County. SNL Technical Area III (TA-III) is located on three sections of land adjacent to TA-V (see Figure 3-2). The main activity at TA-III is work conducted at the environmental test facilities as an integral part of the overall SNL program. Activities at TA-III normally do not have any direct effect on TA-V operations.

3.1.2 Site Description

SNL is operated by Martin Marietta Corporation for the U.S. Department of Energy (DOE). KAFB is a U.S. Air Force installation. The area in which SNL is located is administratively known as Kirtland East (KAFB East) and comprises the facilities necessary to conduct research consistent with the SNL mission. In addition to the SNL facilities, other facilities located within the KAFB East area include the U.S. DOE Albuquerque Operations office, Defense Nuclear Agency Field Command, the U.S. Air Force Operational Test and Evaluation Center, the KAFB administrative offices, the KAFB Underground Munitions Storage Center (KUMSC), and other smaller agencies. KAFB East is designated as a KAFB Internal Area.

The TA-V complex is 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 Arroyo Del Coyote, and on the south by Hell's Canyon Wash. The slope of the mesa is characterized by a consistently gradual decline toward the river. The terrain is characterized by numerous small canyons that have been cut through the mesa by drainage from the mountains.

Figure 3-2. TA-V Location within SNL and the Kirtland AFB/Albuquerque

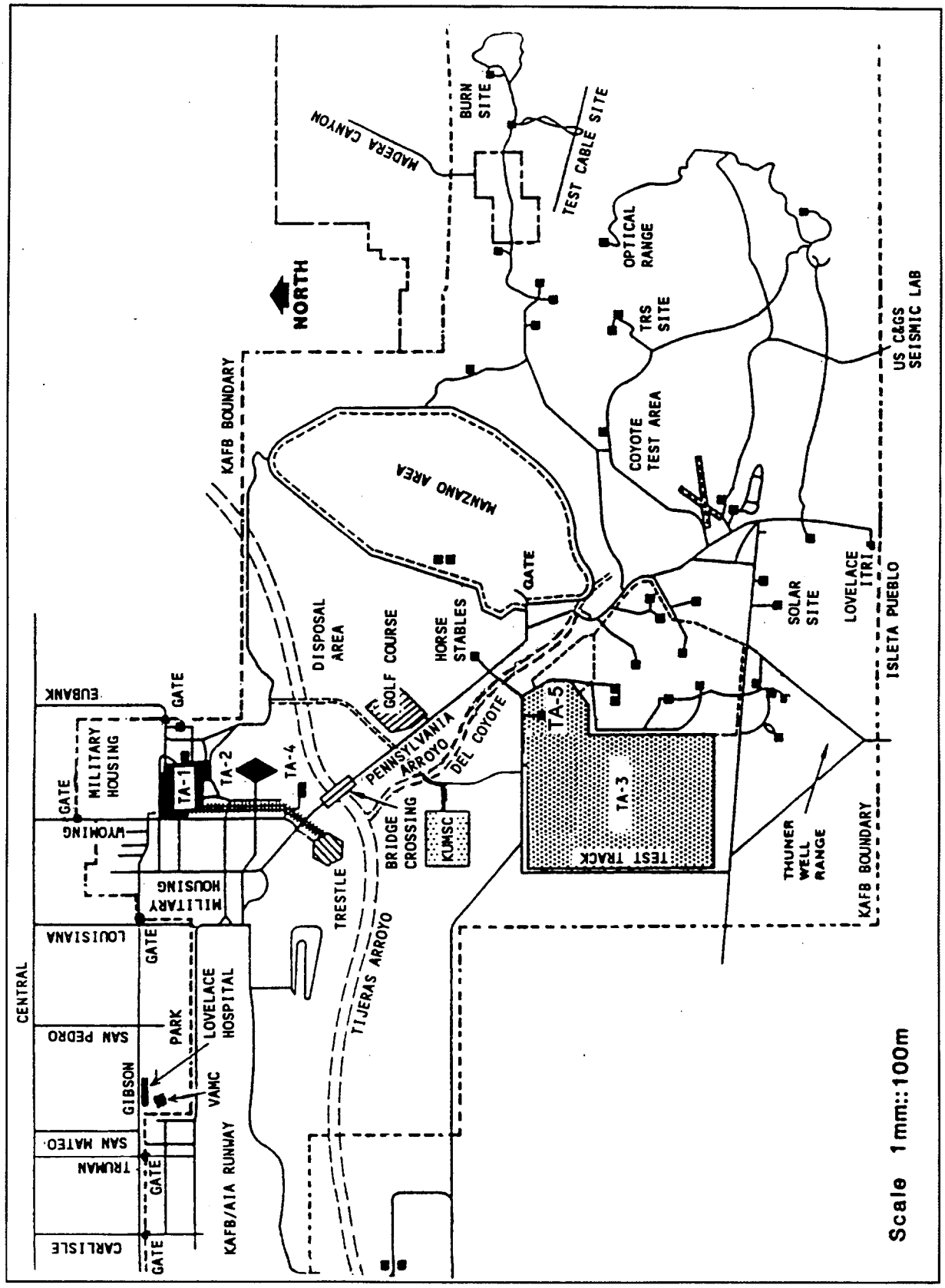


Routine access to the TA-V complex is over a paved access road connecting TA-V to the main paved road, Pennsylvania Street, which goes directly to the main facilities in TA-I. This access road crosses one small arroyo, Arroyo Del Coyote; this is normally dry, although during the rainy season the water may run deep enough to affect traffic. The only other natural event which could affect accessibility is dust storms. Normal access to the area could be restricted also by traffic accidents or military convoys which occasionally travel the main paved roads; however, urgent traffic can easily be diverted around accidents, since there is no place where the terrain can completely limit movement of traffic, and around convoys through coordination with the convoy commander. Further, the numerous dirt roads crossing the area can be used if for some reason the paved roads are blocked.

All activities in TA-V, including GIF and reactor activities, are under the administrative control of the SNL Reactor Engineering Technology Center. Direct operational responsibility for the reactors is assigned to the Reactor Applications Department (as shown in the organizational chart in Chapter 12; Management, Organization, and Institutional Safety Provisions).

Both paved and dirt roads to TA-V are usually open as shown in Figure 3-3. These roads may be closed or restricted to limited traffic under the conditions noted later in this chapter. Within TA-V there are no requirements for vehicle availability relative to GIF or reactor operations. During emergencies, personnel could leave the area on foot if necessary.

Figure 3-3. TA-V Location and Distances to Other Facilities

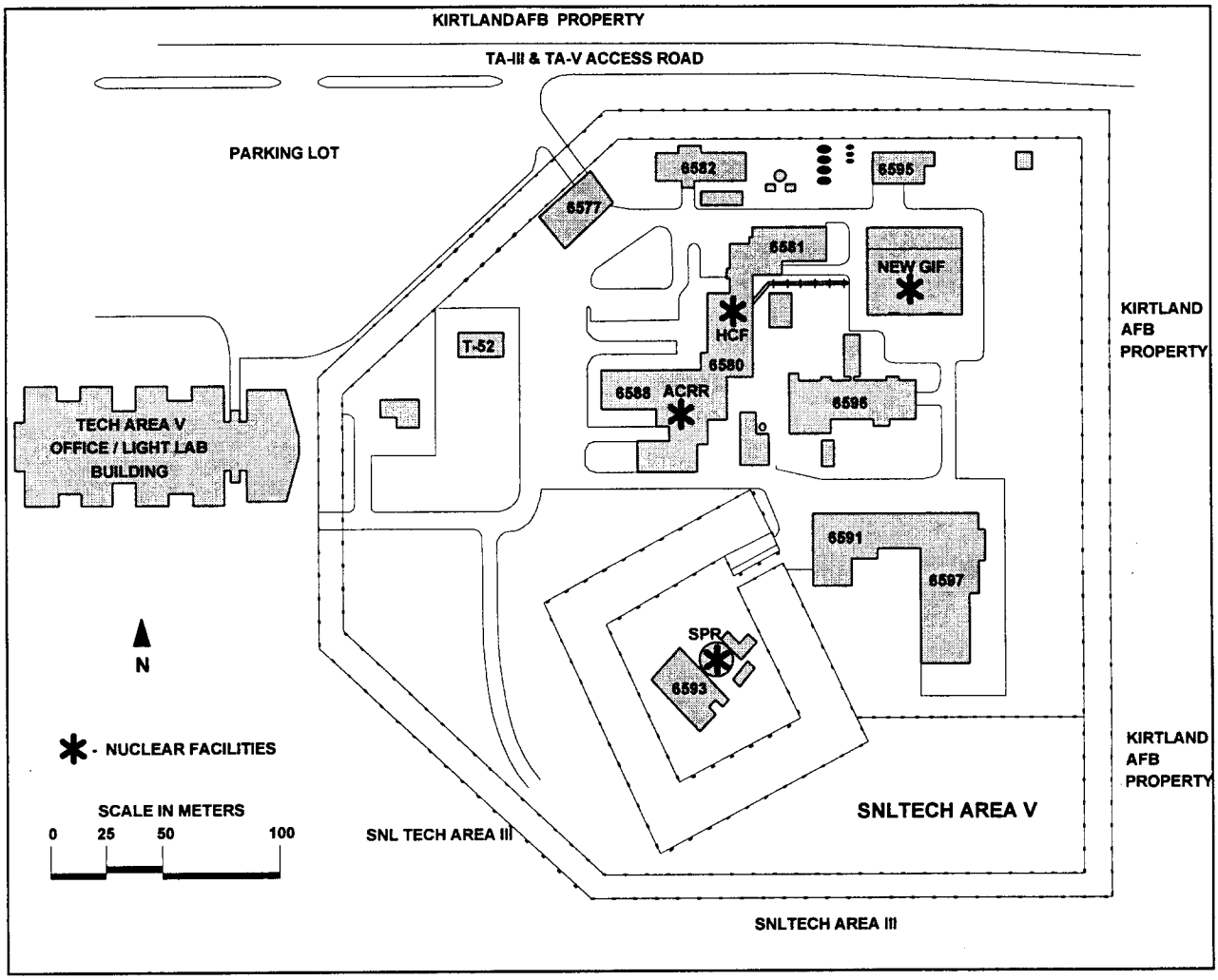


TA-V is a discrete area, completely enclosed by two standard security chain-link fences, except for the Office/Light Laboratory (O/LL) Building 6587 on the west side (Figure 3-4). All regular entries and exits to or from TA-V are through a Perimeter Access Building (PAB, Building 6577) manned by the SNL Security Force. The GIF is to be located in the northeast corner of TA-V. Other main nuclear facilities within the TA-V complex are:

- Annular Core Research Reactor (ACRR) housed in Building 6588
- Sandia Pulse Reactors II and III (SPR-II/III) housed in the KIVA
- Hot Cell Facility (HCF) housed in Building. 6580

The main technical activities are housed in Buildings 6580, 6588, 6590, 6591, and 6597. Buildings 6582 contains a large conference room and serves as the Assembly Point during emergency evacuations of TA-V. Other buildings provide laboratory and support services for the nuclear facilities in TA-V. The Office/Light Lab Building 6587 immediately to the west of TA-V houses the administrative, analytical, and experiment support personnel for the nuclear facilities. TA-V is surrounded to the west and south by Technical Area III (TA-III). To the north is the access road to TA-V. To the east and north is vacant area controlled by Kirtland AFB.

Figure 3-4. Technical Area V (TA-V (Complex)



Access to the GIF within TA-V is by asphalt covered roads routing directly east from the main TA-V entrance at Building 6577. Large paved areas adjacent to the south and west sides of the GIF provide access for experiment transports, access for source shipping transports and parking for experiment instrumentation trailers.

Control of all personnel and equipment entering or leaving TA-V is maintained at one central point, the Perimeter Access Building (PAB), which contains both personnel portals and a vehicle gate. Security Inspectors are assigned to the PAB at all times the site is open for business. Personnel control is maintained by a computer-based personnel accountability system. This provides the Security Inspectors with an up-to-date and accurate count of the total number of people in the area at all times.

During an emergency, physical access to the site required by vehicles such as fire trucks and ambulances is coordinated through the Sector Emergency Chief (assigned responsibility to the on-duty Emergency Supervisor). Ingress/egress to the TA-V complex is normally through the PAB. If use of the PAB portals or gate is not possible or practicable, there is another 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.

3.1.3 Population

3.1.3.a TA-V

Normal work activities within TA-V are scheduled for 5 days per week, Monday through Friday, 8 hours per day, 8:15 AM to 4:15 PM. The Nuclear Facilities and Diagnostics Department is responsible for GIF operations, reactor operations, and the operation of the Hot Cell Facility. This department consists of about 30 people: one department manager, and one secretary. This department is part of a total TA-V work force of about 100 people, of whom about 15 are subcontractor personnel with extended assignments at TA-V. About half of the TA-V staff are presently located in temporary buildings to the west of TA-V (the West Annex) outside the double fence. This group along with other support personnel not directly involved in the operation of the nuclear facilities in TA-V will be housed in the O/LL Building, upon its completion, outside of the TA-V security perimeter. Both of those groups are assigned access badges that automatically activate the personnel accountability system computer.

Other SNL employees with work assignments requiring them to be in TA-V are issued temporary badges that also enter them into the personnel accountability system. Approximately 40 of the temporary badges are available for issue. After completion of the O/LL building, the expected average population inside TA-V during regular working hours is from 50 to 80 persons depending on the experiment requirements at the time. All personnel are required to receive an emergency procedures briefing before being allowed unescorted access to the area within the double fence.

The PAB is under the direct control of SNL Security Inspectors around the clock, each day of the week. Other personnel in the area during non working hours will be on an overtime basis, either casual or scheduled. The number of overtime personnel normally will not exceed 40; as noted, the Security Inspector force at the PAB will know the precise number and identification of all who are in the area.

3.1.3.b KAFB Internal Areas Outside TA-V

The four major locations whose population would be of immediate interest are SNL Technical Areas I, III, and IV, and the Kirtland AFB Headquarters. The TA-I/KAFB H.q. location, shown in Figure 3-3, is about 5.5 km north of the TA-V reactor complex. It has a total population of about 10,000 persons during normal working hours and is the largest single concentration of people in the SNL/USAF complex on KAFB East. Of this number, about 7500, are SNL employees located primarily in Sandia's Technical Area I (map shown in Figure 3-5). The remainder are associated with or attached to the various military or civilian government organizations. Sandia's TA-IV is located 4.0 km north of TA-V and has a normal work day population of about 500 personnel, most of whom are SNL employees. The TA-III facilities are adjacent to TA-V on the west and south sides, and have a population that may vary between 200 to 300 at any given time due to the transient nature of the diverse testing operations for which this area exists; for the same reason, these people may be widely dispersed throughout the area.

The nearest USAF facility with a significant population is the KUMSC, situated 1.7 km NE of TA-V. This facility has a work-day force population of about 150 persons, and is equipped with its own environmental control system.

All other special areas or zones within the KAFB East complex (including military facilities) either are of low population or are located in a low meteorological probability zone (that is, a zone in which winds from the TA-V complex have a very low frequency of occurrence).

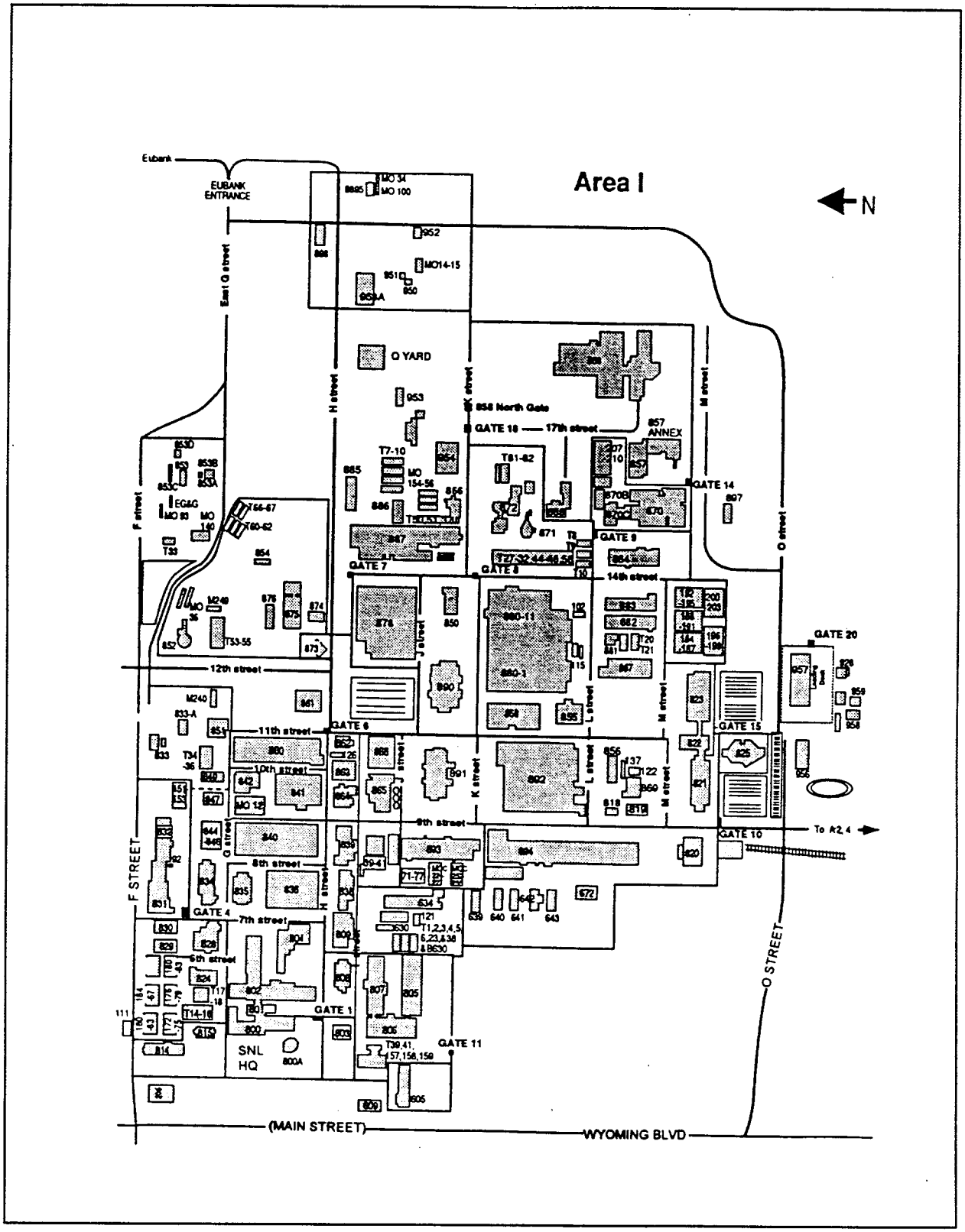
3.1.3.c General Area

All areas outside KAFB are considered to be in the General Area, since the base boundary defines the extent of the area under KAFB/SNL jurisdiction. Beyond this boundary, control is exercised by local authorities.

Within the General Area, the population centers of major concern are metropolitan Albuquerque and Santa Fe. The city of Albuquerque is adjacent to KAFB, occupying all land from the southwest quadrant clockwise through the northeast quadrant. The metropolitan area of Albuquerque (excluding the suburban communities) extends out to a maximum radius of about 12 km from the TA-V complex. As shown in Figure 3-3, the closest approach to the TA-V complex is about 5.4 km. The 1990 census showed 385,000 people within the city limits and over 480,000 in the metropolitan statistical area. Santa Fe, located 90 km northeast of the TA-V complex, had a 1990 population of 56,000 people.

Other population concentrations of concern are Los Alamos County, 100 km north, with a 1990 population of 18,000 people, and the Belen-Socorro area, 30 to 110 km south of Albuquerque. In 1990 Belen had a population of 6,500 and Socorro 8,100; both towns are situated on Interstate Highway 25.

Figure 3-5. SNL Technical Area I Map



Another zone of interest, because of the transient nature of its population, is the Albuquerque International Airport. The airport shares runways and other flight facilities with KAFB, forming an integral unit, and consists of all the private and commercial facilities located at the western-most part of the airfield complex. An exact analysis of the number of persons in the terminal and surrounding facilities is not available, but peak occupancy may be several thousand people. The airport terminal and maintenance facilities are located 9.3 km northwest of the TA-V complex. Control of this area is under the civil authorities, and the SNL Emergency, Disaster, and Mobilization Plan provides for proper and timely cooperation with those authorities.

The KAFB East/Isleta Indian land-grant boundary is 6.1 km to the south of the reactor facilities (see Figure 3-2); there are no permanent residences along the boundary. A private cattle company occupies the land bordering on that portion of the western boundary of KAFB East which is 3.1 km from TA-V. All other areas within a radius of 6.0 km are under the control of SNL except a small area immediately east of TA-I.

3.2 Nearby Industrial, Transportation, and Military Facilities

3.2.1 Location

As shown in Figure 3-2, TA-V is located within KAFB, which includes other technical SNL areas and the USAF installations. Adjacent to and physically combined with the USAF installations is the Albuquerque International Airport, in what constitutes a large joint military/commercial transportation complex.

No other commercial, industrial, or transportation facilities are within 8 km of the facilities. Several military and SNL test ranges are in the KAFB East area, but all are 1000 m or farther from the facilities. A high-speed test sled facility is located in TA-III, approximately 2.5 km from TA-V.

3.2.2 Description

On occasion, explosive devices are brought to TA-V for testing at one of the reactor facilities. Because these devices will be located in closer proximity to the reactors than the GIF, they pose no additional hazard to the GIF beyond the hazard posed to the reactor facilities. Any use of explosives associated with TA-V experiments is strictly controlled by the Technical Specifications and Standard Operating Procedures, including the Safe Operating Procedure for Tests Involving Explosive Devices at Tech Area V Reactor Facilities.[3.1.]

Similarly, with the exception of a propane tank farm on the north side, no other gas, chemicals, oil, or other hazardous materials that could affect GIF operations in the event of an incident at the storage point are stored in the proximity (within ~2 km) of TA-V. All routes used to transport hazardous materials are outside of the TA-V double fence. There are numerous improved dirt roads throughout the vicinity of TA-V, providing a variety of access and egress routes to and from the site.

3.2.3 Evaluation

Landing and takeoff patterns for the various runways at the airport facilities do not affect reactor operations. The runway of most concern relative to TA-V operations is the east-west runway. Aircraft using the east end of this runway for landing or take off can fly over the facilities if approaching or leaving the airport in a southerly direction. However, the east end of the runway is 7.0 km from TA-V, and aircraft that do fly over the area during the take off phase are already fully airborne.

Military and/or SNL test ranges are all 1.0 km or greater from TA-V, and any accidents at these sites would not directly affect reactor operations.

Accidents involving the transport of hazardous materials on routes near TA-V would not affect GIF operations within TA-V, since the surrounding area is crossed by numerous improved dirt roads. Any accident which closed a main route could not prohibit access to TA-V.

A comprehensive group of probable accident types has been reviewed for TA-V and appropriate procedures have been incorporated in the Emergency Preparedness Master Plan for SNL.

3.3 Meteorology

The general weather patterns for Albuquerque and vicinity are characteristic of high-altitude, dry continental climates.[3.2.] Average annual rainfall is approximately 208 mm (8.1 inches), 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 localized perturbations in wind patterns and inversion conditions relevant to reactor analyses.

Other interesting features of the climate are the large number of clear days and the high percentage of sunshine. Normally sunshine has been recorded for 75% or more of the hours from sunrise to sunset 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.

Relative to the TA-V and GIF operations, there are no meteorological conditions requiring special design conditions or GIF operating procedures. Because the GIF is a Category 3 nonreactor nuclear, it poses no significant potential for a release of radioactive material. Therefore, meteorological parameters are not influential on the consequences of this type of accident.

3.3.1 Temperature, Humidity, and Precipitation

The average daily range of temperatures is relatively high. Normal daily minimum temperatures for winter months are -5° to -3° C (23° F to 27° F) and for summer months 14°-19° C (57° F to 66° F). Normal daily maximum temperatures for the same periods are 8° to 11° C (46° F to 52° F) and 28° to 33° C(82° F to 91° F), respectively. Thus the approximate temperature range for both winter and summer is 14° C to 16° C (57° F to 61° F). The lowest recorded temperature was -27° C (-17° F) on January 7, 1971; the highest recorded temperature was 41° C(105° F),

reached in June and July 1980. A review of the data in the meteorological tables (Tables 3-1 through 3-4 and Figure 3-6) shows temperatures above 38° C (100° F) and below -18° C (0° F) are very rare. Similarly, average values of 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; however, June characteristically displays the most consistent low values.

The average annual rainfall for Albuquerque is just over 208 mm (8.1 inches). The lowest average monthly precipitation occurs in the winter, with less than 13 mm (0.5 inches). The highest average monthly precipitation occurs during the July-to-September period and accounts for about half of the annual amount. The summer precipitation is usually the result of highly localized heavy thundershowers which typically last an hour or less at any given location.

Maximum observed precipitation in 24 hours occurred in September 1955, when 49 mm (1.9 inches) were recorded. Since thundershowers move with the prevailing winds aloft, thundershower activity can result in considerable precipitation upland from the TA-V complex. Localized flooding may result from this concentrated activity, and water may run high in arroyos in the area. Since TA-V is situated on ground higher than the surrounding terrain, precipitation at TA-V tends to run off rather than collect in the area. Similarly, Arroyo Del Coyote to the east (see Figure 3-3) collects runoff from the mountains and diverts it from the area. Thus, normal precipitation would not cause flooding at TA-V due to run-off from the surrounding area, and the only water problem has been minor localized flooding due to rainfall within TA-V itself.

Table 3-1a. Meteorological Data, Albuquerque, New Mexico
Normals, Means, and Extremes from 1940 through 1991

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE, F													
Normals													
- Daily Maximum	47.2	52.9	60.7	70.6	79.9	90.6	92.8	89.4	83.0	71.7	57.2	48.0	70.3
- Daily Minimum	22.3	25.9	31.7	39.5	48.6	58.4	64.7	54.9	54.9	43.1	30.7	42.1	42.1
- Monthly	34.8	39.4	46.2	55.1	64.3	74.5	78.8	69.0	69.0	57.4	44.0	56.2	56.2
Extremes													
- Record Highest	69	76	85	89	98	105	105	101	100	91	77	72	105
- Year	1971	1986	1971	1989	1951	1980	1980	1979	1979	1979	1975	1958	6/80
- Record Lowest	-17	-5	8	19	28	40	52	52	37	21	-7	-7	-17
- Year	1971	1951	1948	1980	1975	1980	1985	1968	1971	1991	1976	1990	1/71
DEGREE DAYS, BASE 65 F													
Heating	936	717	583	302	81	0	0	0	12	242	630	911	4414
Cooling	0	0	0	0	59	285	428	344	132	6	0	0	1254
% POSSIBLE SUNSHINE	72	73	73	77	80	83	76	75	79	79	77	72	76
MEAN SKY COVER (tenths)													
Sunrise - Sunset	4.8	5.0	5.1	4.6	4.2	3.4	4.5	4.4	3.6	3.5	4.0	4.6	4.3
MEAN NUMBER OF DAYS													
- Clear (Sunrise - Sunset)	13.1	11.1	11.4	12.7	14.5	17.5	12.0	13.4	16.6	17.3	15.1	13.9	168.6
- Partly Cloudy	7.7	7.7	9.8	9.4	10.3	8.6	14.3	12.5	7.8	7.8	7.7	7.4	110.8
- Cloudy (Sunrise - Sunset)	10.3	9.5	9.8	7.9	6.2	3.9	4.8	5.1	5.6	5.9	7.2	9.7	85.8
Precipitation >= 0.01	4.0	4.0	4.6	3.4	4.3	3.9	8.8	9.5	5.7	4.8	3.4	4.3	60.7
Snow, Ice, Pellets, Hail >1.0"	1.0	0.9	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.9	4.2
Thunderstorms	0.1	0.3	0.9	1.6	3.9	5.1	11.1	10.8	4.7	2.3	0.6	0.2	41.3
Heavy fog (Visibility =< ¼ mile)	1.1	0.9	0.6	0.2	0.0	0.0	0.1	0.0	0.1	0.3	0.6	1.5	5.6
Temperature, F													
- Max (90 and above)	0.0	0.0	0.0	0.0	2.6	17.1	23.0	15.9	3.8	0.1	0.0	0.0	62.6
- Max (32 and below)	2.3	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.8	5.1
- Min (32 and below)	28.9	22.7	15.9	4.5	0.2	0.0	0.0	0.0	0.0	2.1	16.2	28.5	118.9
- Min (0 and below)	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.6
AVG. STA PRESSURE, mb	838.9	837.9	835.0	835.7	835.8	838.1	840.4	840.7	840.2	840.0	838.8	839.2	838.5
RELATIVE HUMUDITY, %													
Hour 05 (local time)	70	65	56	49	47	46	60	66	62	62	65	70	60
Hour 11	50	44	34	26	25	24	34	40	40	38	42	50	37
Hour 17	40	32	24	19	18	18	27	30	31	29	36	43	29
Hour 23	61	53	43	35	34	33	48	53	52	49	55	61	48
PRECIPITATION, inches													
Water Equivalent													
- Normal	0.41	0.40	0.52	0.40	0.46	0.51	1.30	1.51	0.85	0.86	0.38	0.52	8.12
- Maximum Monthly	1.32	1.42	2.18	1.97	3.07	2.57	3.33	3.30	2.63	3.08	1.93	1.85	3.33
- Year	1978	1948	1973	1942	1941	1986	1968	1967	1988	1972	1991	1959	4.68
- Minimum Monthly	T	T	T	T	T	T	0.08	T	T	0.00	0.00	0.00	0.00
- Year	1970	1984	1966	1991	1945	1975	1980	1962	1957	1952	1949	1981	12/81
- Maximum in 24 hours	0.87	0.51	1.11	1.66	1.14	1.64	1.77	1.75	1.92	1.80	1.67	1.35	1.92
- Year	1962	1981	1973	1969	1969	1952	1961	1980	1955	1969	1991	1958	9/55
Snow, Ice, Pellets, Hail													
- Maximum Monthly	9.5	10.3	13.9	8.1	1.0	T	T	0.0	T	3.2	9.3	14.7	14.7
- Year	1973	1986	1973	1973	1979	1990	1990		1971	1986	1940	1959	12/59
- Maximum in 24 hours	5.1	6.0	10.7	10.9	1.0	T	T	0.0	T	3.2	5.5	14.2	14.2
- Year	1973	1986	1973	1988	1979	1990	1999		1971	1986	1946	1958	12/58
WIND, mph													
Mean Speed	8.1	8.9	10.1	11.0	10.6	10.0	9.1	8.2	8.6	8.3	8.0	7.7	9.0
Prevailing Direction	N	N	SE	S	S	S	SE	SE	SE	SE	N	N	SE
Fastest Observed in 1 min													
- Direction	09	09	19	17	28	16	36	27	25	10	27	0.9	09
- Speed	52	40	49	46	46	40	52	41	40	38	48	47	52
- Year	1990	1989	1991	1985	1986	1991	1990	1990	1985	1991	1988	1987	1/90
Peak Gust													
- Direction	E	W	SW	E	SW	E	N	E	W	NW	W	E	SW
- Speed	70	63	77	64	70	67	72	63	61	51	63	71	77
- Year	1990	1984	1991	1990	1991	1986	1990	1989	1985	1986	1988	1987	3/91

NOTE: T = Trace

Table 3-1b. Meteorological Data, Albuquerque, New Mexico
Normals, Means, and Extremes for 1991

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
TEMPERATURE, F													
Averages													
- Daily Maximum	46.0	58.7	59.9	71.8	81.7	88.4	89.9	88.0	80.5	74.6	54.9	47.0	70.1
- Daily Minimum	25.3	30.4	32.2	40.1	49.3	58.3	63.8	62.9	55.6	44.5	31.8	27.6	43.5
- Monthly	35.7	44.6	46.1	56.0	65.5	73.4	76.9	75.5	68.1	59.6	43.4	37.3	56.8
- Monthly Dewpoint	19.4	19.6	18.1	14.5	22.1	39.4	50.5	53.6	46.1	29.4	25.7	24.6	30.3
Extremes													
- Highest	54	66	72	83	91	101	99	95	93	86	70	58	101
- Date	5	22	24	6	19	25	7	22	3	3	7	8	6/25
- Lowest	18	19	20	26	37	46	58	59	49	19	19	18	18
- Date	31	1	8	13	5	3	27	18	21	31	3	3	12/3
DEGREE DAYS, BASE 65 F													
Heating	903	563	581	263	60	12	0	0	21	188	645	851	4087
Cooling	0	0	0	0	87	269	375	331	120	25	0	0	1207
% POSSIBLE SUNSHINE	62	79	73	88	88	84	74	69	68	84	69	56	75
MEAN SKY COVER (tenths)													
Sunrise - Sunset	4.5	5.5	5.5	3.0	3.1	4.6	5.1	5.1	5.0	3.2	4.4	5.8	4.6
Midnight - Midnight	4.3	4.6	5.0	2.7	2.7	4.3	5.3	5.2	4.7	2.8	4.2	5.3	4.6
NUMBER OF DAYS													
Sunrise - Sunset													
- Clear	16	8	8	20	18	14	9	10	14	16	14	11	158
- Partly Cloudy	5	8	11	7	8	8	15	16	5	11	9	3	106
- Cloudy	10	12	12	3	5	8	7	5	11	4	7	17	101
Precipitation >= 0.01 inch	6	1	5	0	3	6	11	9	5	2	5	10	63
Snow, Ice, Pellets, Hail >1.0 "	0	0	0	0	0	0	0	0	0	1	1	1	3
Thunderstorms	0	1	0	0	4	6	12	6	6	0	1	0	36
Heavy Fog (visibility=< ¼ mile)	0	0	0	0	0	0	0	0	0	0	0	4	4
Temperature, F													
- Max (90 and above)	0	0	0	0	2	16	17	15	2	0	0	0	52
- Max (32 and below)	1	0	0	0	0	0	0	0	0	0	0	1	2
- Min (32 and below)	27	20	18	5	0	0	0	0	0	4	19	26	119
- Min (0 and below)	0	0	0	0	0	0	0	0	0	0	0	0	0
AVG. STA. PRESSURE, mb	838.8	839.8	833.7	834.1	834.9	837.6	840.8	842.2	841.5	838.8	839.1	840.3	838.5
RELATIVE HUMIDITY, %													
Hour 05 (local time)	70	57	53	34	36	55	64	72	68	53	68	76	59
Hour 11	50	35	32	19	19	28	37	43	44	31	45	57	37
Hour 17	44	24	26	11	14	23	30	33	32	22	41	54	30
Hour 23	62	44	40	21	23	39	51	61	57	42	62	71	48
PRECIPITATION, inches													
Water Equivalent													
- Total	0.60	0.06	0.14	T	1.14	0.65	2.63	1.26	1.43	0.26	1.93	1.49	11.59
- Greatest (24 h)	0.22	0.06	0.07	T	1.02	0.31	1.23	0.54	0.76	0.26	1.67	0.56	1.67
- Date	6	28	PM-1	26	20/1	10/1	24	2/3	5/6	30/1	15/6	11	Nov
Snow, Pellets, Ice, Hail													
- Total	0.9	T	0.8	T	0.0	0.0	0.0	0.0	0.0	2.5	1.5	2.1	7.8
- Greatest (24 h)	0.9	T	0.7	T	0.0	0.0	0.0	0.0	0.0	2.5	1.1	1.3	2.5
- Date	21	18	30	26						30/1	16	30/1	Oct
WIND, mph													
Resultant													
- Direction	001	005	245	267	198	176	113	129	113	144	074	024	198
- Speed	4.9	2.5	4.3	5.0	4.6	1.7	2.9	1.3	3.0	1.4	0.8	2.3	0.2
Average Speed	8.7	9.2	11.2	11.2	12.1	9.5	8.3	6.3	7.4	8.5	9.3	6.9	9.1
Fastest Observed in 1 min													
- Direction	09	08	19	23	18	16	09	09	10	10	09	09	19
- Speed	29	29	49	40	37	40	38	26	32	38	40	30	49
- Date	20	24	26	11	11	5	3	13	18	30	30	20	3/26
Peak Gust													
- Direction	E	E	SW	SW	SW	S	E	E	E	E	E	E	SW
- Speed	39	41	77	61	70	52	56	43	41	49	58	46	77
- Date	20	24	26	11	14	5	3	13	30	30	30	20	3/26

NOTE: T = Trace

Table 3-2. Meteorological Data, Albuquerque, New Mexico Precipitation, 1960-1991 (inches)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1960	0.34	0.38	0.44	0.19	0.71	0.91	0.47	0.78	0.56	2.88	0.07	0.39	8.12
1961	0.23	0.10	0.61	0.73	0.01	0.11	2.70	1.69	1.09	0.47	0.48	0.65	8.87
1962	1.01	0.11	0.18	0.07	0.01	0.19	1.24	T	0.71	0.75	0.61	0.51	5.39
1963	0.29	0.24	0.55	0.14	0.03	0.11	1.43	3.00	0.63	0.76	0.29	T	7.47
1964	0.07	1.12	0.13	0.61	0.35	T	1.87	0.98	1.57	0.04	0.21	0.49	7.44
1965	0.47	0.60	0.49	0.49	0.19	0.99	1.65	0.61	1.18	0.89	0.33	1.42	9.31
1966	0.42	0.30	T	0.04	0.02	1.66	0.61	1.06	1.04	0.54	0.09	0.01	6.81
1967	0.01	0.44	0.25	T	0.04	1.71	3.33	3.30	0.79	0.18	0.15	0.56	8.04
1968	0.01	0.98	1.48	0.51	0.99	0.05	0.94	1/49	0.30	0.12	0.59	0.82	10.67
1969	0.08	0.34	0.41	1.76	1.31	0.59	1.22	0.95	1.08	2.37	0.01	0.72	10.56
1970	T	0.27	0.42	0.05	0.33	0.40	1.05	2.24	0.79	0.25	0.08	0.23	6.28
1971	0.27	0.21	0.03	0.78	0.16	0.02	1.00	0.87	1.44	1.15	0.67	1.40	8.50
1972	0.12	0.12	0.08	T	0.18	0.55	1.80	2.93	1.00	3.08	0.69	0.36	10.11
1973	0.85	0.33	2.18	0.91	0.66	1.37	2.40	1.19	1.13	0.35	0.08	0.-3	10.88
1974	0.88	0.11	0.85	0.14	0.01	0.22	1.43	0.79	1.58	1.96	0.38	0.51	9.83
1975	0.26	0.99	0.95	0.10	0.66	T	1.32	1.40	1.66	T	0.28	0.28	8.01
1976	0.00	0.40	0.09	0.31	0.82	0.60	0.69	0.73	0.45	0.03	0.24	0.20	5.19
1977	0.88	0.23	0.63	1.07	0.10	0.04	0.24	2.28	0.78	0.76	0.42	0.13	7.91
1978	1.32	1.02	0.54	0.05	0.69	1.05	0.80	2.49	0.59	1.22	1.00	0.76	10.97
1979	1.07	0.62	0.14	0.24	2.48	1.02	0.08	1.53	0.40	0.27	0.91	0.87	10.35
1980	0.87	0.58	0.60	0.60	0.56	0.01	1.07	2.61	1.83	0.09	0.30	0.74	8.87
1981	0.05	0.67	0.80	0.30	0.53	0.35	1.32	2.68	0.41	1.43	0.37	0.00	7.66
1982	0.32	0.20	0.84	0.05	0.52	0.09	0.55	1.09	1.34	0.26	0.60	0.78	7.41
1983	1.10	0.71	0.61	0.02	0.32	1.21	1.13	0.27	0.91	1.20	0.44	0.42	7.76
1984	0.33	T	0.62	0.50	0.16	0.48	1.16	2.70	1.13	3.04	0.63	1.36	12.08
1985	0.49	0.54	0.70	1.69	1.12	0.53	1.51	0.49	1.51	2.15	0.19	0.16	10.75
1986	0.22	1.01	0.17	0.33	1.11	2.57	0.91	2.26	0.53	1.54	1.29	0.44	12.98
1987	0.66	0.61	0.07	1.00	0.58	0.13	2.26	2.98	0.20	0.44	0.42	0.34	8.34
1988	0.15	0.07	0.85	1.42	0.62	1.25	1.51	3.29	2.63	0.32	0.22	0.03	13.11
1989	0.57	0.35	0.48	T	0.01	0.02	2.33	0.48	0.31	0.97	T	0.28	4.99
1990	0.21	0.49	0.41	1.71	0.45	0.27	2.36	1.79	0.96	0.15	0.86	0.59	10.25
1991	0.60	0.06	0.14	T	1.14	0.65	2.63	1.26	1.43	0.26	1.93	1.49	11.59
Mean	0.40	0.38	0.45	0.55	0.63	0.60	1.39	1.39	0.93	0.85	0.41	0.45	8.43

NOTE: T = Trace

Table 3-3. Meteorological Data, Albuquerque, New Mexico Snowfall, 1960-1991 (inches)

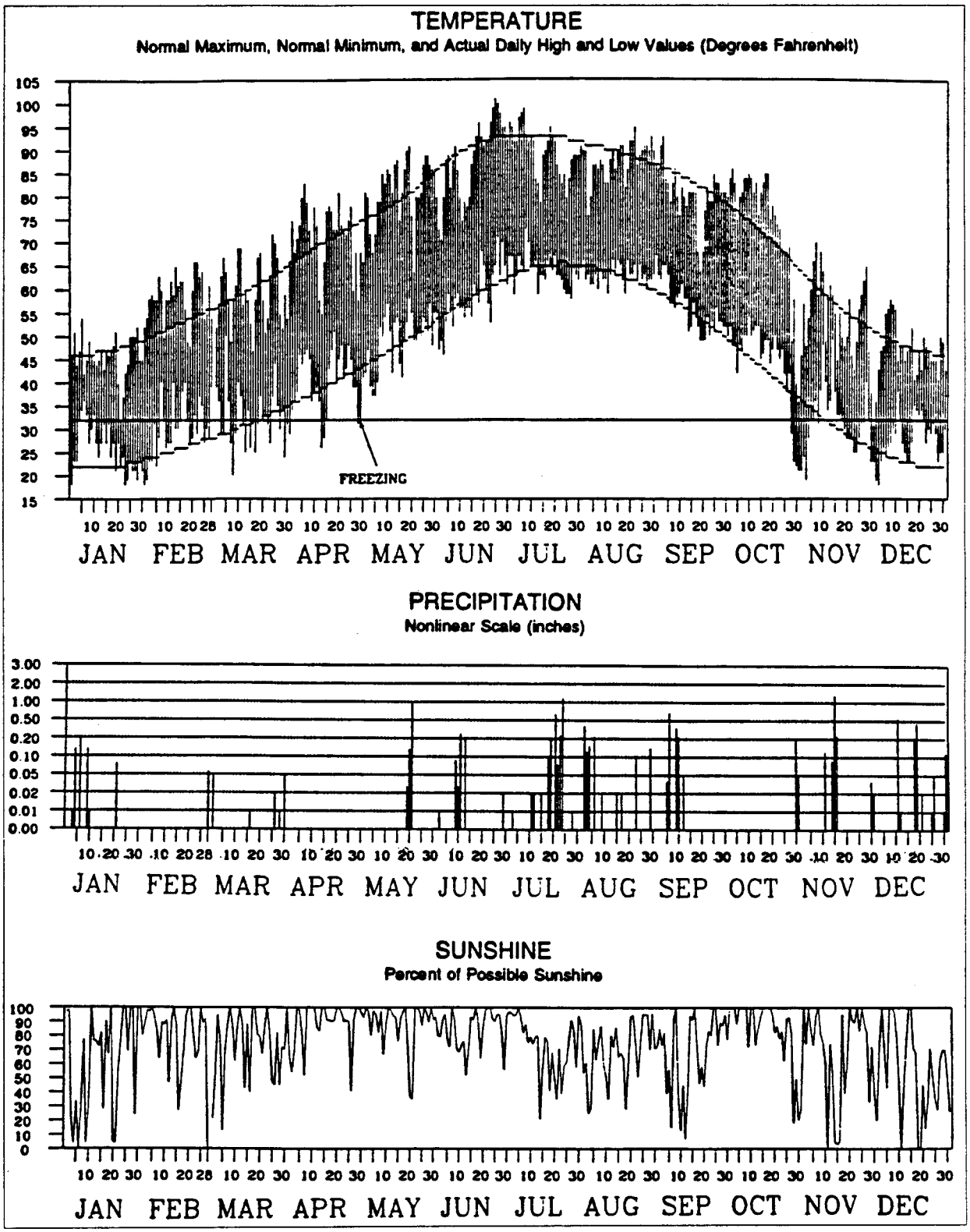
Season	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1960-61	0.0	0.0	0.0	0.0	0.0		0.6	0.4	3.0	T	0.0	0.0	6.5
1961-62	0.0	0.0	0.0	T	3.4	2.5	4.0	T	0.2	0.0	0.0	0.0	10.0
1962-63	0.0	0.0	0.0	0.0	T	2.4	2.5	0.8	2.5	0.0	0.0	0.0	6.8
1963-64	0.0	0.0	0.0	0.0	T	1.0	0.5	8.2	1.3	T	0.0	0.0	10.0
1964-65	0.0	0.0	0.0	0.0	T	T	1.4	3.6	T	T	0.0	0.0	5.3
1965-66	0.0	0.0	0.0	0.0	T	0.3	5.4	1.0	0.0	T	0.0	0.0	9.4
1966-67	0.0	0.0	0.0	0.0	T	3.0	T	1.0	1.1	T	0.0	0.0	2:1
1967-68	0.0	0.0	0.0	0.2	1.0	T	T	2.0	1.4	T	0.0	0.0	7.4
1968-69	0.0	0.0	0.0	0.0	T	2.8	T	1.8	5.5	T	0.0	0.0	14.7
1969-70	0.0	0.0	0.0	0.0	T	7.4	T	2.7	3.3	0.0	0.0	0.0	7.1
1970-71	0.0	0.0	0.0	0.5	T	1.1	3.0	2.3	0.5	T	0.0	0.0	6.8
1971-72	0.0	0.0	T	T	T	0.5	1.2	1.1	0.0	T	0.0	0.0	9.1
1972-73	0.0	0.0	0.0	T	2.9	6.8	9.5	1.8	13.9	8.1	0.0	0.0	37.4
1973-74	0.0	0.0	0.0	0.3	0.6	1.2	9..3	0.6	2.0	0.0	0.0	0.0	12.9
1974-75	0.0	0.0	0.0	0.0	T	0.1	0.9	6.7	3.8	0.2	0.0	0.0	16.5
1975-76	0.0	0.0	0.0	0.0	0.2	4.9	0.0	T	0.5	0.2	0.0	0.0	3.8
1976-77	0.0	0.0	0.0	T	2.4	1.2	8.4	1.4	2.3	2.6	0.0	0.0	18.3
1977-78	0.0	0.0	0.0	0.0	0.0	T	6.0	3.4	2.0	0.0	0.1	0.0	11.5
1978-79	0.0	0.0	0.0	0.0	T	1.0	2.6	6.0	T	0.5	1.0	0.0	11.1
1979-80	0.0	0.0	0.0	0.9	0.8	2.7	T	0.9	3.1	T	T	0.0	8.4
1980-81	0.0	0.0	0.0	T	2.8	7.4	0.5	2.6	0.9	T	0.0	0.0	14.2
1981-82	0.0	0.0	0.0	0.0	0.0	0.0	3.6	1.2	0.7	T	0.0	0.0	5.5
1982-83	0.0	0.0	0.0	0.0	0.9	3.3	7.3	4.2	1.0	T	T	0.0	16.7
1983-84	0.0	0.0	0.0	0.0	0.8	0.8	4.1	T	0.1	3.0	0.0	0.0	8.8
1984-85	0.0	0.0	0.0	T	T	3.4	2.0	2.9	0.6	0.0	0.0	0.0	8.9
1985-86	0.0	0.0	0.0	0.0	0.7	0.9	2.9	10.3	0.3	0.0	T	0.0	15.1
1986-87	0.0	0.0	0.0	3.2	0.6	0.2	4.9	4.9	0.2	2.2	0.0	0.0	16.2
1987-88	0.0	0.0	0.0	0.0	1.1	1.7	1.2	T	7.9	4.2	0.0	0.0	16.1
1988-89	0.0	0.0	0.0	0.0	1.7	0.3	3.4	3.2	3.1	0.0	0.0	0.0	11.7
1989-90	0.0	0.0	0.0	0.0	T	2.5	1.8	4.8	T	0.3	0.0	T	9.4
1990-91	T	0.0	0.0	0.0	2.2	6.3	0.9	T	0.8	T	0.0	0.0	10.2
1991-	0.0	0.0	0.0	2.5	1.5	2.1							
Mean	0.0	0.0	T	0.1	1.1	2.5	2.5	2.2	1.9	0.8	T	0.0	11.1

NOTE: T = Trace

Table 3-4. Meteorological Data, Albuquerque, New Mexico
Average Temperature (degrees F)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVG
1960	33.0	36.5	49.9	57.9	64.7	76.6	78.7	78.4	71.8	56.5	46.5	33.9	57.1
1961	33.9	40.6	47.0	54.5	65.9	75.8	76.7	75.2	65.6	56.8	40.3	34.1	55.5
1962	31.6	42.3	41.2	58.1	64.1	72.7	76.3	77.6	69.4	58.1	46.9	36.9	56.3
1963	29.4	40.5	45.2	57.7	68.0	74.6	81.4	75.9	72.5	61.5	45.7	34.8	57.3
1964	30.0	29.1	41.5	51.7	65.8	73.6	78.2	76.8	69.3	59.4	43.7	35.5	54.5
1965	38.8	39.4	44.6	54.8	61.7	69.4	77.9	75.4	66.6	58.0	48.4	35.8	55.9
1966	30.1	33.2	45.6	54.6	67.2	72.8	79.8	75.7	68.4	56.8	46.7	34.3	55.4
1967	33.2	40.5	52.0	57.8	63.8	71.5	79.2	74.5	68.4	58.2	46.1	32.4	56.5
1968	36.8	43.3	46.7	53.4	62.7	75.2	76.1	72.4	68.0	58.3	42.8	30.0	55.5
1969	38.0	38.5	41.1	57.4	66.2	73.6	80.2	79.0	70.0	53.8	41.4	39.1	56.6
1970	34.5	42.8	44.1	52.5	66.2	72.7	79.6	77.8	67.5	52.6	44.5	36.4	56.0
1971	33.6	38.9	47.7	53.3	61.7	73.8	78.1	73.9	66.4	53.8	45.2	31.9	54.8
1972	36.1	42.5	53.6	56.9	64.0	73.7	78.6	74.1	68.1	57.6	40.1	35.0	56.7
1973	31.8	35.9	45.1	50.2	62.7	73.5	78.4	78.0	67.5	56.4	44.6	34.0	54.8
1974	33.6	37.9	52.8	56.4	68.5	80.1	77.0	72.7	66.1	58.1	45.0	32.0	56.7
1975	30.8	38.0	45.0	49.9	61.0	73.0	76.8	76.1	66.3	56.5	42.6	35.6	54.3
1976	33.2	43.3	44.3	54.6	62.8	73.4	77.0	75.0	68.0	53.1	40.6	33.0	54.9
1977	29.8	40.7	43.2	56.5	64.2	75.5	78.6	77.4	69.4	58.9	46.4	34.4	56.8
1978	36.8	39.3	50.2.	57.7	60.5	75.5	81.6	75.5	69.1	60.3	47.5	34.3	57.4
1979	32..9	41.1	48.4	56.9	63.7	73.3	80.6	77.1	72.3	61.5	41.0	37.7	57.2
1980	40.2	44.2	46.1.	52.1	61.1	77.2	82.7	77.4	69.9	54.5	43.5	40.5	57.4
1981	38.0	42.9	46.2	59.0	64.5	77.0	79.8	76.4	69.7	55.7	47.0	40.5	58.0
1982	35.9	39.4	47.4	56.1	63.0	74.8	79.1	77.4	69.5	54.8	42.9	34.4	56.2
1983	35.0	39.7	46.9	50.2	63.0	73.4	80.2	79.4	73.4	58.3	45.1	36.7	56.8
1984	34.1	40.1	46.8	52.8	69.9	73.6	78.9	75.7	68.8	51.6	43.7	35.6	56.0
1985	33.8	38.3	46.5	57.4	64.0	74.1	77.1	76.6	65.9	57.5	45.4	37.6	56.3
1986	41.3	43.0	50.9	56.5	63.7	72.7	74.7	76.0	66.5	54.6	42.0	36.3	56.5
1987	32.3	39.2	43.7	54.8	62.8	73.0	77.8	74.7	68.8	61.3	45.2	35.3	55.7
1988	34.6	43.9	47.0	55.1	64.3	74.4	78.1	75.0	66.3	61.1	45.4	33.9	56.6
1989	35.5	41.9	52.8	61.4	68.8	75.6	78.6	74.3	69.4	56.7	46.4	35.1	58.0
Mean	34.6	39.7	46.5	54.9	63.8	73.5	77.4	75.3	68.4	56.8	44.0	35.3	55.9
Max	47.1	53.0	60.9	70.0	79.0	89.0	91.3	88.8	82.2	71.0	57.5	47.6	69.8
Min	22.1	26.4	32.1	39.8	48.6	56.0	63.5	81.8	54.6	42.6	30.4	23.0	41.9

Figure 3-6. Meteorological Data: Albuquerque Daily Data for Year 1991



3.3.2 Wind Data

Meteorological records for the TA-V site have been compiled by the Test Operations Control Division 7251 and published in tabular form.[3.3.] These data, compiled for inversion and all-occurrence conditions, were accumulated from a network of eight meteorological towers at selected positions around the TA-V complex, referred to as SMILE (Sandia Meteorological Instrumentation Logging Equipment) System. Sensors on all eight towers were located at the 3.7-m and 30.5-m levels, except one tower near the airport runway which was reduced to 15.25 m. In addition, the tower in TA-III, which is closest to the TA-V complex, had sensors at the 61-m and 91-m levels. Each tower was instrumented with sensors for true wind direction, windspeed in knots, temperature in degrees Fahrenheit, and percent relative humidity. All information was automatically recorded at a central station for a period of 10 years, 1961 through 1970. Although the SMILE system is no longer in service, some meteorological data are still recorded from a few selected levels on different towers. The data in Table 3-5 compiled to statistically present meteorological data from records for Tower 1 and 4. Tower 1 is located in TA-III, Tower 4 in TA-I; therefore, the statistical information from these towers covers the two points of concern: the nuclear facility area and the nearest large concentration of people.

Current wind information for the TA-V complex is obtained from several wind direction and speed indicators mounted atop structures within TA-V. Thus, in the event of an accident involving one of the nuclear facilities in TA-V, information is readily available as to which direction the plume will travel.

This data is presented for general information on the wind conditions at TA-V. Since the GIF does not have the potential for significant off-site consequences, a more complete discussion of wind inversions, wind roses, and diffusion parameters is not warranted. For additional information, this data is available in the SAR's for the TA-V reactors and Hot Cell Facility.[3.4., 3.5.]

Table 3-5. Percentage Frequency of Inversion Occurrence and Nighttime Wind Speed

	Nighttime	Total	Time Surface Wind < 3.1
Winter	82	48	58
Spring	70	32	40
Summer	71	30	46
Fall	76	41	48

3.3.3 Tornadoes

Tornado occurrences in the state of New Mexico vary from a mean annual frequency of 0.2 to a maximum of 1.1.[3.6] 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 two tornadoes have been reported in over a 20-year span. These occurred within the center of the City of Albuquerque in the years 1985 and 1987 and are officially listed in the climatological records of the National Weather Service as "small tornadoes." Damage was very light and no official wind readings are denoted.

In addition, one funnel cloud has been observed in the same 20 year period. This was reported in the Four Hills area of Albuquerque about 6 km to the north of the TA-V site on KAFB East, but it was not observed to touch down and accordingly it did not cause any (reported) damage. Based on the climatological records available, Albuquerque can be classified as a region of low 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 do not occur together under the necessary conditions.

3.4 Hydrology

The Albuquerque area is drained by the Rio Grande with a flow that is generally southward at an average flow rate of 898 x 10^6 m^3/year. Total annual pumpage in the area has been 123 x 10^6 m^3 or more in recent years from about 300 large-discharge municipal, industrial, and irrigation wells and about 1000 small-discharge wells. Pumpage from the area water sources is expected to increase to over 271 x 10^6 m^3/year by the end of the century.[3.7] At present, about one-fifth of the pumped water comes from deep wells, a figure that is expected to increase by the end of the century.

OK

3.4.1 Surface Drainage

On the western side of the Rio Grande the ground surface slope is generally southeastward and toward the river at about 9.4 to 18.9 m/km. The west drainage area is described by a zone extending westward from the river about 4.8 km and confined by a north-south trending terrace which rises about 183 m. Beyond this zone, drainage essentially follows cut terraces which parallel the river.

The eastern side, referred to as the east mesa, has a generally westerly-southwesterly ground surface slope ranging from about 47.4 m/km near the mountains to 3.8 m/km near the river. The distance between the base of the mountains and the river varies from 4.8 km in the northern part to 14.4 km in the southern part.

Topography near the TA-V complex is dominated by Tijeras Canyon, about 2.4 to 3.2 km to the north. TA-V is situated on a slight ridge of high ground that has several small drainage cuts (arroyos) through the area. One arroyo of significance is about 0.8 km east of the complex,

running south to north and emptying into Tijeras Canyon. During heavy precipitation to the east of the complex, this arroyo effectively collects runoff from the mountains and diverts surface flow away from the complex. Therefore surface flows which could affect the complex are limited to that amount collected between the complex and arroyo. The heaviest precipitation to date in this area has not produced flooding at the complex. All precipitation occurring to the north, south, and west of the complex would be drained away from the complex by the natural surface slope and therefore does not constitute a problem. Flooding at the site is extremely unlikely, and, on the basis of historical evidence, is not apt to result from natural phenomena. Similarly, there are no man-made structures which will store sufficient quantities of water to flood the site in the event of a structural failure. TA-V is approximately 152 m higher than, and 14.0 km (east) from, the Rio Grande channel.

3.4.2 Subsurface Hydrology

The major subsurface water reservoir is in the basin fill material (sand, gravel, silt, clay, and volcanic rocks of the Tertiary and Quaternary age), which has a depth of 1220 m or greater throughout most of the basin. Generally, subsurface water in the fill is not confined but is free to move with local hydraulic gradients. However, the uplifts which characterize the Lucero uplift and Sandia-Manzano mountains (see Section 3.5) do restrict the western and eastern reservoir boundaries.

The present water table in the Albuquerque area is a somewhat irregular sloping surface. Its slope on both sides of the river is toward the river, with a slightly down-valley gradient imposed such that the overall gradient is about 1.1 m/km, although local perturbations (such as caused by deep wells) can have significant effects on the gradient. On the east mesa, the present gradient is consistent with the general pattern, sloping southwesterly at about 1.1 m/km. Recharge of the subsurface reservoir is from precipitation, underground flow from adjacent areas, and seepage from streams, irrigation water, etc. The Rio Grande is the largest single source of recharge water.

The subsurface flow rates (coefficient of transmissability) which determine the recharge characteristics of the basin, as well as the pumping rates, have been found by studies conducted by the U.S. Geological Survey, in cooperation with the State Engineer of New Mexico, to be about 2480 m^3/day/meter through the gradient east of the river. Based on these results, a projected water table has been determined for the year 2000 which shows that the slope of the water table will actually reverse east of the river and have a gradient terminating at a low point about 6.4 to 9.6 km east of Albuquerque.[7] Quantitatively, this means that the water table will lower about 24.4 m or more in the area east of Albuquerque. Relative to the TA-V complex, the water table is expected to drop about 15.3 m, and the hydraulic gradient will reverse from a southwesterly direction to a northerly direction.

3.4.3 TA-V Water Supply

The TA-V water system is fed by the main KAFB East water system, which is supplied from both KAFB wells and additional water purchased from the city of Albuquerque. A single 254-mm (10-in) pipe transports water, normally by gravity feed, from TA-I to TA-III. At TA-III a system of valves, pumps, intermediate tanks, and an additional deep well forward this water, to

a large ground tank east of TA-III through a 355.6-mm (14-in) pipe. It is then ordinarily drawn from the large ground tank through the same 355.6-mm pipe to supply the water needs of TA-III and TA-V. In the event a rupture of the main 254-mm line from TA-I, the large ground tank will continue to provide water without interruption. The deep well and an intermediate tank at TA-III, together with the two auxiliary pumps, would be activated to provide replenishment, though at a reduced rate, of the large ground tank water supply. Another large elevated tank at TA-III would supply emergency water in the event of a break in the 355.6-mm line between the large ground tank and TA-III/TA-V. Pumping requirements of the deep well pump are compatible with the subsurface reservoir recharge capabilities as indicated by the fact that the level of the water table has dropped only a few meters since the pump was installed; therefore, lowering of the water table is not expected to have any significant effect on projected operation of the TA-V complex.

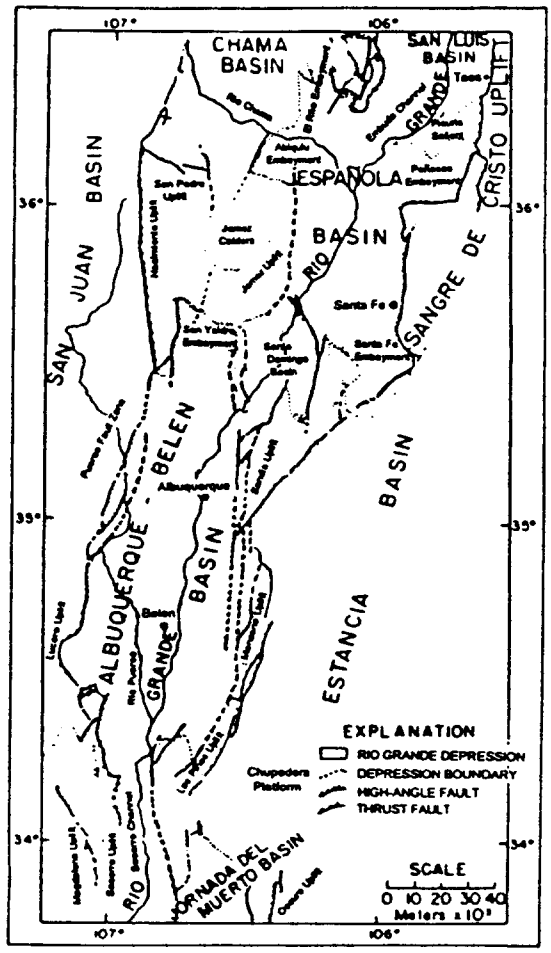
The following information on water movement under TA-V is presented for completeness of the data in this PSAR. The accident analysis in Chapter 11 demonstrates that is no credible potential for releasing contaminated water from the GIF. Five test holes drilled to depths of 9.2 to 18.4 m on the TA-V site provided samples for an analysis. Samples taken from 6.7 m below grade (the expected depth of release) to the bottom of the hole had about 1 to 3% moisture content. Grade size classification tests of these samples indicate that the moisture content of the soil is well below its specific retention (about 12%). Although it is difficult to predict how water would move through unsaturated soil, it is most likely that any water discharged on or near the surface (dry well, ponds, etc.) would be retained by the soil and never reach the water table, since additional water released to the ground in a given location would be intermittent or of such small amounts as to preclude saturation.[3.8]

3.5 Geology and Seismology

3.5.1 Geological Evaluation

The TA-V complex is situated in the eastern portion of the Albuquerque-Belen Basin as shown in Figure 3.7. This is one of the largest in a series of basins which trend to the north in the Rio Grande trough and is about 144 km long and 48 km wide.[3.9., 3.10.] It is bounded by the Sandia-Manzanita-Manzano mountains in the east, the Lucero uplift and Puerco plateau in the west, and the Nacimiento uplift in the north. The southern boundary is defined by the Socorro channel. The basin is widest in the Albuquerque area and constricted to the south and north by the San Acacia channel and the Cerrillos trend, respectively. Large-scale faulting, deepening of the basin, and tilting of the mountain zones occurred in the later Miocene times. Since then, basin deposits have been laid down in a sequence of complex layers.

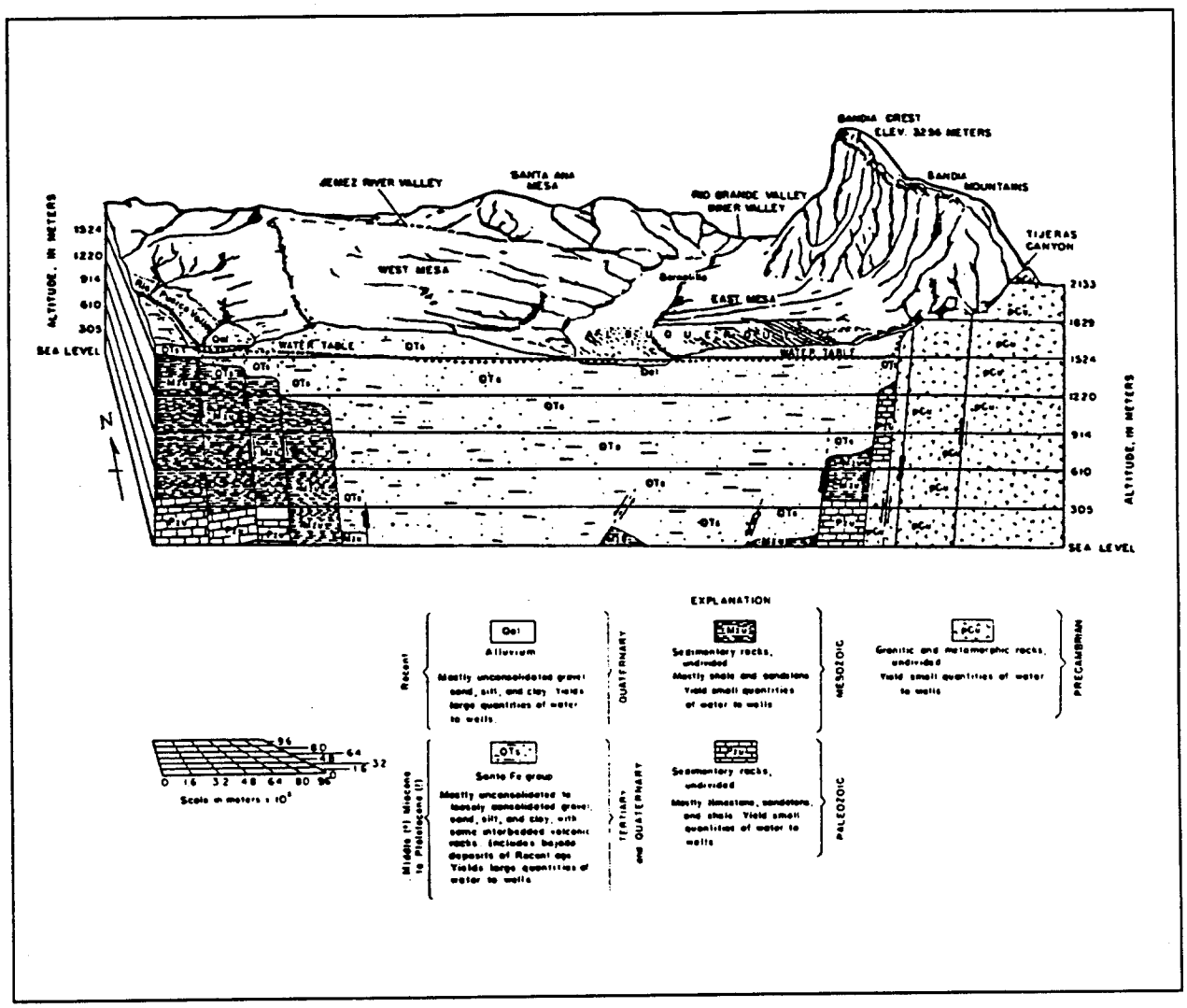
Figure 3-7. Tectonic Map of the Middle Rio Grande Depression (Modified from U.S. Geologocial Survey Map OM-157 by V.C. Kelly)



3.5.2 Basin Structure

The basin is composed of poorly consolidated Cenozoic deposits eroded from the surrounding mountain areas following the faulting and structural changes that occurred in late Miocene times.[8] Specifically, the upper part of the basin is a complex sequence of gravel, sand, silt, clay, and caliche deposits known as the Santa Fe formation. Underlying these deposits are sedimentary rocks of unknown actual thickness, but gravity and aeromagnetic mapping indicates that these rocks extend down to about 3048 m below sea level, or about 4562 m below ground level. These sedimentary rocks rest on a bed of Precambrian rocks which underlie the entire basin and then lift up to form the western plateaus and eastern mountains. The Sandia mountains are about 1524 m above the basin, giving a total difference of elevation between the Precambrian rocks in the basin and mountains of roughly 6100 m. On the west side, Precambrian rocks lie at about sea level, with sedimentary rock overlying them to a depth of about 1524 m above sea level. Figure 3.8 is a composite illustration of the basin as presently understood.

Figure 3-8. Block Diagram of an Area 85.5 x 10^6 Meters^2 Near Albuquerque, New Mexico, Showing Topography, Generalized Geology, and the Water Table in the Alluvium and the Sante Fe Group



3.5.3 Seismic History

The Albuquerque area is located in Seismic Zone 2, which by definition is a region which can be expected to receive moderate damage from earthquakes. Seismically, the Albuquerque area can be characterized as a region of high activity but relatively low magnitude and intensity. Seismic records indicate that the seismically most active segment of the Rio Grande trough in New Mexico extends southward from Albuquerque and slightly beyond Socorro (100 km). Historical evidence indicates the largest earthquake expected within this zone in a 100-year period will be of magnitude of 6 on the Richter scale.[3.11.]

The basin in which the TA-V complex is situated is bounded on the east and west by complex fault zones which generally underlie the surface but are exposed along the edges of the

mountains. Based on available information, most earthquakes recorded in New Mexico have occurred along the Rio Grande trough, with the region between Albuquerque and Socorro (96 km south) exhibiting the highest concentration (Figure 3-9) and accounting for about 90% of the recorded earthquakes between 1890 to 1960. Instrumented seismic records for New Mexico beginning in 1960 indicate the pattern of seismic activity for earthquakes of Richter magnitude 2.7 or greater has shifted and the center of activity is in the northeast quadrant of the state. There is no geological evidence for the occurrence of intensive earthquakes in the Albuquerque area within recent geologic history, although several earthquakes centered near Albuquerque during the last 20 years have recorded Richter magnitudes of 2.7 or greater.

In general, geological evidence indicates that the area has been relatively stable for a long period of time, perhaps as great as thousands of years, and that strong earthquakes have not affected the area within the last 300 years.

Available information[3.9, 3.10, 3.11, 3.12.] indicates that since 1855 about 600 earthquakes have occurred in New Mexico. Of this number, about 90% have originated in a narrow belt in the Rio Grande trough between Albuquerque and Socorro, and shocks have been felt in at least 30 different years.

Seismic activity has been characterized by five noteworthy aspects: (1) the earthquakes occur in swarms, (2) the frequency has a nocturnal maximum, (3) the annual frequency is highest during the July-December period, (4) strong shocks are frequently felt, and (5) the earthquake-affected area is usually small. Specific items of interest related to these aspects are the facts that maximum seismicity is coincident with maximum precipitation and that affected areas usually range from less than 7770 to about 18,100 km^2.

Tables 3-6 and 3-7 list all earthquakes that have been recorded or felt at Albuquerque. The intensity indicated is for Albuquerque unless noted otherwise. Examination of the information reveals that within the Albuquerque-Socorro belt, most of the earthquakes have occurred in and around Socorro. Since 1890, twelve shocks of Richter magnitude of 5 or greater have been recorded in this belt, with eight felt most intensely at Socorro and one at Bernardo; the remaining three were most severe at or near Albuquerque.[3.12.]

Available records for the earthquake which occurred November 28, 1970, show that the frequency range of vibration was about 13 Hz to 20 Hz during the major duration of the shock.[13] The Richter magnitude of this earthquake, deter mined to be 3.8, appears to be an upper limit for the average expected earthquake; consequently, the associated frequency is probably representative of this magnitude. Since the TA-V site is situated on an alluvium plane, the coupling to the major shock area was probably very good, and attenuation of the shock effect was characteristic of this type of geologic structure; therefore it is significant to note that no damage was observed at TA-V. Further, the proximity of the earthquake epicenter (in the west mesa) provides a good basis of comparison and evaluation of expected earthquake activity, since this epicenter is within the region in which activity that would affect TA-V is expected to occur.

Figure 3-9. Map of West Central New Mexico Showing Locations of Earthquakes Detected by Seismographs from January 1, 1962 to June 30, 1964

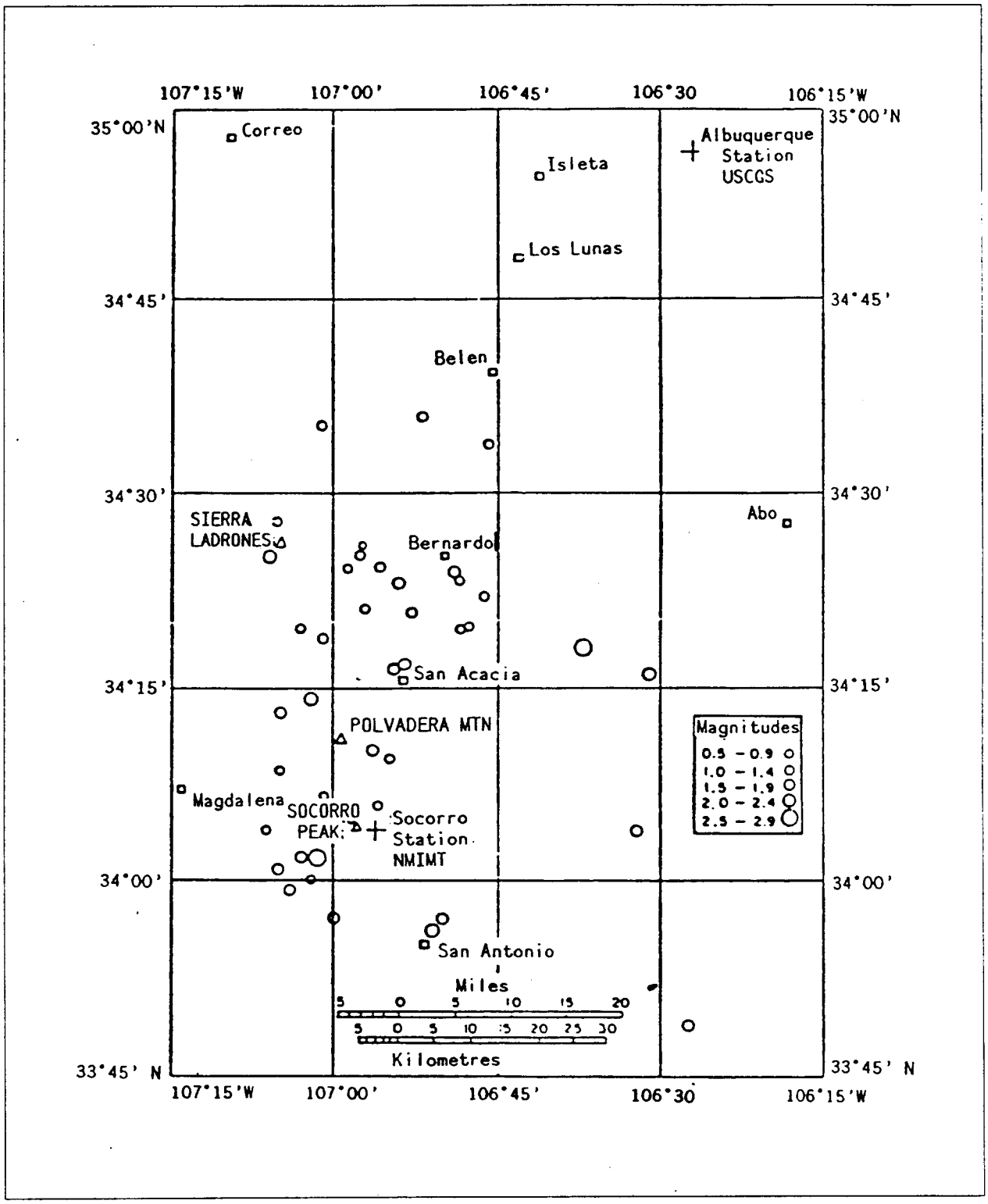


Table 3-6. Location of Non-Instrumentally Detected Earthquakes in New Mexico, 1868-1959

Year	Date	Vicinity	Latitude (° N)	Longitude (° W)	Intensity: Modified Mercalli
1869	Apr 18	Socorro	34	107	VII
1879	Unknown	Socorro	34	107	
1886	July 6	Socorro	34	107	V
1893	Apr 8	Belen	34.8	106.8	VII
	July 12	NM	35	106.4	V-VI
	Sept 7	Los Lunas	34.7	106.6	VII
1895	Oct 7	NM	35.5	106.7	V
	Oct 31	Socorro	34	107	VI
1897	Unknown	Socorro	34	107	VI
1904	Jan 19-Sept 10	Socorro	34	107	V-VI
1906	July 12	Socorro	34	107	VII
	July 16	Socorro	34	107	VIII
	Nov 15	Socorro (+ after shocks)	34	107	VII-VIII
1913	July 18	Socorro	34	107	
	Dec 5	AZ-NM	34.1	106.8	
1918	May	Cerrillos	35.5	106.6	VII
1919	Jan 31	Socorro	34	107	IV-V
	Feb 1	Socorro	34	107	V
1924	Aug 12	NM	36	104.5	V
1931	Jan 27	Albuquerque			III
	Feb 3	Albuquerque			V
	Feb	Albuquerque	35	106	VI-VII
	Apr 7	Socorro			slight
1934	Jan 7	Socorro	34	107	V

Table 3-6. Location of Non-Instrumentally Detected Earthquakes in New Mexico, 1868-1959 (Continued)

Year	Date	Vicinity	Latitude (° N)	Longitude (° W)	Intensity: Modified Mercalli
1930	Mar 23	Albuquerque			slight
	Dec 3	Albuquerque	35	106	V-VI
	Dec 4	Albuquerque			slight
	May 6	Silver City	32.7	108.2	V
1935	Jan 17	Socorro	34	107	
	Feb 20	Bernardo	34.5	106.8	VI
	Dec 12-20	Belen (earthquake swarm)	34.8	106.8	V-VI
1936	Sept 9	Albuquerque			IV-V
	Sept 11	Albuquerque			III
1938	Apr 15	Albuquerque			slight
	Apr 16	Albuquerque			slight
	Sept 17	AZ-NM border	33.2	108.6	VI
	Sept 19	AZ-NM border	33.2	108.6	V
	Sept 29	AZ-NM border	33.2	108.6	V
	Oct 31	AZ-NM border	33.2	108.6	V-VI
	Nov 2	Silver City			
1941	Aug 4	Socorro			
1947	Nov 6	Sandia Mountains		VI	
1949	May 23	East Vaughn	34.6	105.2	VI
1952	Aug 3	Cimarron	36.5	105.0	V
	Aug 17	Los Alamos	35.5	106.2	V
1955	Aug 12	Santa Fe	30.2	104.6	V
1956	Apr 25	Sandia Mountains		slight	

Table 3-7. Location of Instrumentally Detected Earthquakes in New Mexico, 1959-1986 (Richter-Magnitude of 2.7 or Greater)

Year	Date	Time-UTC	Latitude (° N)	Longitude (° W)	Nearest Town	Intensity Richter scale	Intensity Modified Mercalli scale
1960	Jul 22	15:49:30.0	34.4	106.9	Bernardo	3.3	
	Jul 23	14:15:26	34.4	106.8	Bernardo	3.8	VI
1961	Jul 3	07:06:16.5	34.2	106.9	Socorro		VI
1962	Jan 3	23:29:54.2	35.2	103.8	Tucumcari	3.0	
	Jun 14	07:27:55.8	35.6	106.9	San Ysidro	2.8	
1963	Feb 22	07:02:08.1	32.4	107.0	Las Cruces	2.9	
	Feb 22	07:53:17.7	32.4	107.0	Las Cruces	2.8	
	Jun 6	08:05:32.6	36.7	104.4	Raton	3.7	
	Aug 19	00:08:23.4	32.45	107.1	Las Cruces	2.9	
	Dec 19	16:47:29.6	35.1	104.3	Santa Rosa	3.6	
1965	Feb 3	11:33:10.5					IV
	Apr 10	07:00:55	34.0	107.1	Magdelena	2.7	IV
	Jul 28	03:52:06	33.9	106.8	San Antonio	3.0	
	Jul 28	04:38:53	33.9	106.8	San Antonio	2.7	
	Dec 22	03:33:31.5	34.15	106.9	Socorro		IV
	Dec 22	04:04:53.0	34.15	106.9	Socorro		IV
1966	Jan 23	01:56:38.0	37.0	106.9	Dulce (severe damage)		VII
	May 19	00:26:44	36.0	107.2	Dulce		
1967	Jan 16	18:14:36	34.5	107.1	Bernardo	3.6	
	Sep 29	03:52:46	32.2	107.0	Las Cruces	3.6	
1969	Jan 30	05:17:37.8	34.3	106.9	Bernardo		V
	May 12	08:26:18.7	31.8	106.4	El Paso, TX	3.4	
	May 12	08:49:16.3	31.8	106.4	El Paso, TX	3.3	
	July 4	14:43:34.0	36.1	106.1	San Juan Pueblo, CO		IV
1970	Jan 12	11:21:15.4	36.1	103.2	Stead	3.5	VI
	Nov 28	06:40:11.6	35.0	106.7	Albuquerque	3.8	VI

Table 3-7. Location of Instrumentally Detected Earthquakes in New Mexico, 1959-1986 (Richter Magnitude of 2.7 or Greater) (continued)

Year	Date	Time-UTC	Latitude (° N)	Longitude (° W)	Nearest Town	Intensity Richter scale	Intensity Modified Mercalli scale
1971	Jan 4	07:39:06.7	35.0	106.7	Albuquerque	4.7	VII
	Feb 18	11:28:13.7	36.2	105.7	Picuris Pueblo		
	Apr 28	11:36:52.7	35.8	106.6	Jemez Springs		
	Dec 6	05:18:13.7	36.1	106.3	Abiquiu	3.2	
1973	Mar 17	07:43:05.5	36.1	106.2	Abiquiu		
	Sep 22	23:38:35.8	34.5	107.0	Bernardo	3.1	
	Nov 14	07:56:28.8	35.9	106.6	Jemez Springs		
	Dec 24	02:20:14.7	35.3	107.6	San Mateo	4.1	
1974	Nov 28	03:35:20.5	32.3	104.1	Loving	3.7	
1975	Jun 28	07:20:30.4	34.8	106.9	Los Lunas		
	Dec 3	20:12:22.8	32.8	108.7	Cliff	3.9	V
1976	Jan 5	06:23:32.9	35.8	108.3	Gallup	4.6	VI
	Apr 6	18:09:00.2	33.9	106.0	Carrizozo	2.7	
1979	Oct 20	21:05:34.0	33.9	106.7	San Antonio	2.9	
	Oct 25	22:12:08.7	34.1	107.1	Socorro	3.0	
1980	Mar 22	00:49:12.5	34.6	105.9	Willard	3.4	
1981	May 9	12:35:50.8	33.9	107.0	Socorro	3.1	
1982	May 18	06:00:08.5	34.2	106.9	Lemitar	2.8	
	May 18	06:08:38.4	34.2	106.9	Lemitar	2.8	
	May 24	06:32:51.7	34.2	106.9	Lemitar	2.9	
	Sep 20	03:55:17.2	33.9	107.1	Socorro	2.9	
1983	Mar 2	23:22:19.2	34.3	106.7	Polvadera	4.1	
	Sep 20	03:55:20.1	34.0	107.0	Socorro	3.0	
1984	Aug 26	02:19:54.0	34.3	106.8	Bernardo	2.9	
1985	Aug 16	14:56:52.0	34.1	106.8	Lemitar	4.1	
1986	Aug 27	18:06:56.4	35.2	105.1	Las Vegas	3.0	

(Source: U.S. Geological Survey Earthquake Data Base System, Denver, CO, 1987)

3.5.4 Fault Zones

The entire length of the Rio Grande trough is characterized by complex fault zones along the trough boundaries. As shown in Figure 3-8, the faults are generally characterized by major lines of discontinuity which define large segments (or blocks) of substructure that have shifted with respect to each other. Further, most of the faults lie along the base of the mountains (geologically referred to as uplifts in this area) on both sides 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 of 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. Two zones of faulting on the west slope of the Sandia-Manzano mountains have been identified, one of which is significant to TA-V. The Hubble Springs fault zone extends along the base of the mountains, beginning north of Albuquerque and extending south of the TA-V complex. This fault is important to TA-V because it is the closest, passing about 800 m east of the complex on a north-south line. This fault has been active as recently as 1931-35, when earth movement along it resulted in stoppage of the water flow from these springs.

3.5.5 Zone Classification

The Albuquerque area has been classified as a Seismic Zone 2, which is defined as a zone frequently subject to moderate structural damage. This classification may be described as a Modified-Mercalli Intensity of VII to VIII, with ground acceleration that ranges from about 0.06 g to 0.22 g. If the Gutenberg-Richter relationship is used[3.14], the values above correspond to a magnitude range of about 5 or 6. All available observed and recorded data indicate that these values are representative of the New Mexico region in general and, relative to the Albuquerque area, most likely represent an upper limit.

3.6 Special Features

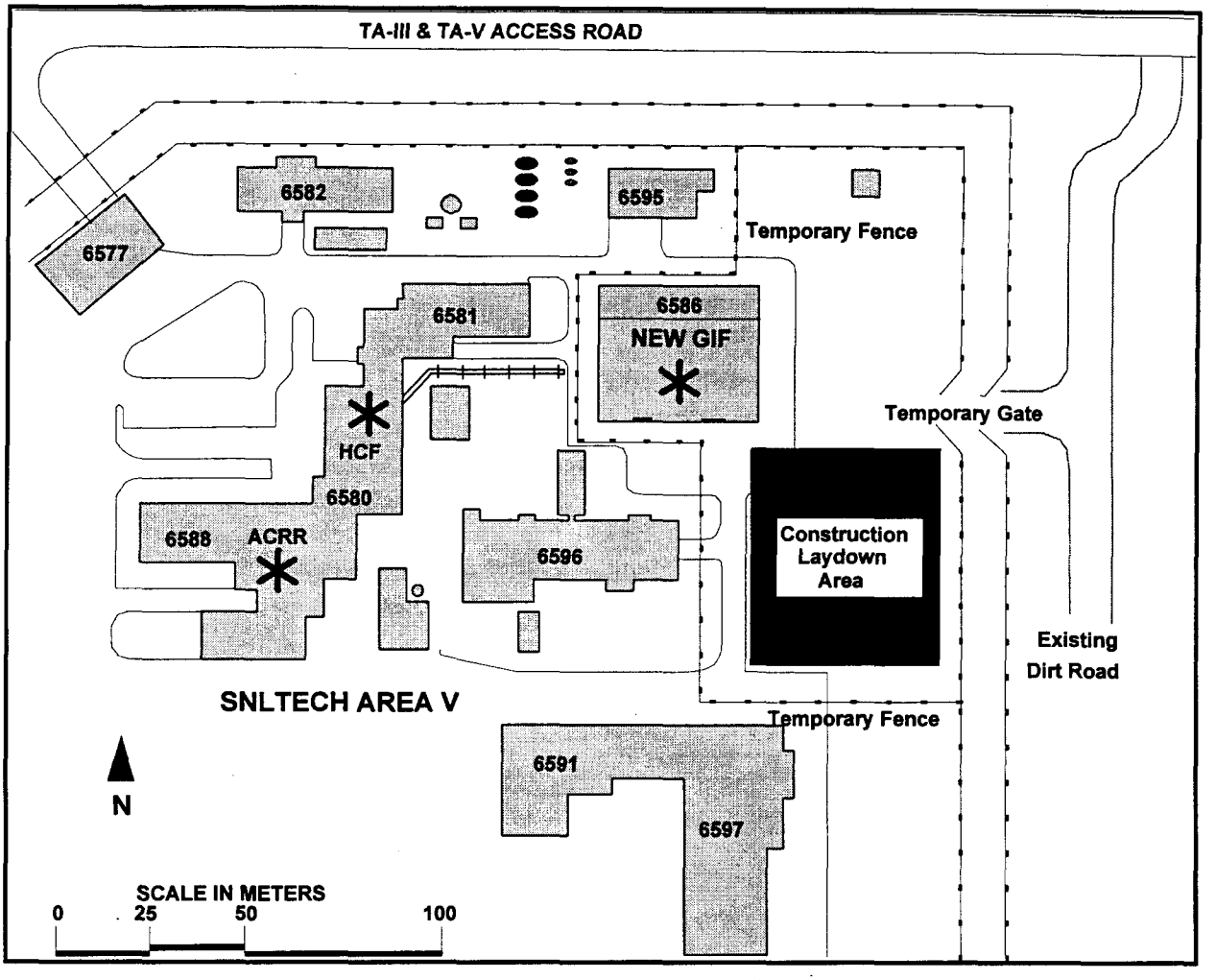
Sandia National Laboratories has operated nuclear facilities at TA-V since 1961. A total of eight reactors have been operated at the site with four currently licensed to operate. TA-V currently has a Gamma Irradiation Facility which has operated since 1962. This facility shares the high bay in Building 6588 with the Annular Core Research Reactor. Sources from this existing GIF will be used to operate the new GIF, as discussed in this PSAR. These sources will be relocated to the new GIF using shipping casks and transported solely on TA-V site roads.

3.7 Site Characteristics Affecting Facility Construction and Operation

During construction, the TA-V security perimeter will be temporarily modified to provide construction contractors easy access to the GIF construction area as shown in Figure 3-10.

Construction vehicle access to the site is proposed utilizing an existing dirt road paralleling the east side of TA-V. The dirt road connects to the paved TA-III & TA-V Access Road. The figure shows a temporary gate to be added to the TA-V security fences. The construction area inside the gate will be separated from the rest of TA-V by a single chain link fence. Current plans call for the construction site to be accessible during working hours and closed during non-working hours. This is accomplished by opening the dual security perimeter fences and providing surveillance of the temporary fence which surrounds the construction area. If necessary, the construction area can be cleared of all construction personnel. Additional laydown areas for equipment and materials are located in TA-III adjacent to TA-V. Following completion of construction and prior to initiating operation of the GIF, the TA-V security perimeter will be returned to its original configuration.

Figure 3-10. GIF Construction and Additional Laydown Areas



3.8 References

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4. DESCRIPTION OF FACILITY AND OPERATIONS

4.1 Facility Functional Description

The Gamma Irradiation Facility provides a single structure for performing a wide variety of gamma irradiation experiments with different test configurations, dose rates, and dose levels. The GIF is divided into two types of experiment irradiation facilities:

- **In-Cell Dry Irradiation:** The in-cell facilities are dry, shielded rooms in which irradiations are performed with a high intensity gamma-ray source. When irradiations are not being performed, the radioactive source is stored in a deep water pool below the cell and personnel may access the inside of the cell by way of a shield door and maze hallway. Typical irradiations performed in these facilities are at high dose rates (on the order of Mrad/hr at <1 meter from the source) and for durations lasting up to a few days.

- **In-Pool Wet Irradiation:** For the in-pool facilities, radioactive sources are held in a submerged irradiation fixture at the bottom of a deep pool of water. Experiment canisters, which contain test units, are immersed in the pool and positioned in preset locations in the irradiation fixture. Typical irradiations performed in these facilities are at moderate and low dose rates (<10 krads/hr) and for durations lasting days, weeks, and months.

The new GIF building (see Figure 4-1) is a single-story structure located inside the TA-V security perimeter as described in Chapter 3. It is comprised of a central high-bay laboratory with low-bay equipment rooms. The high-bay laboratory houses three concrete test cells and a basically "H"-shaped pool with a depth of 5.5 meters. The pool can store up to 1.2 megacuries of ^{60}Co or an equivalent thermal source (20 kilowatts) of other gamma-ray sources. The sources are in the form of pins and can be shared between the in-cell irradiation facilities (one leg of the "H") and the in-pool irradiation facilities (the other leg of the "H"). Ancillary spaces in the high bay include offices, setup/light laboratories, and rest rooms. The adjacent low bay contains the support equipment for the GIF: electrical room for all power distribution, steam room for experiment steam supply, and mechanical room for water treatment and ventilation systems.

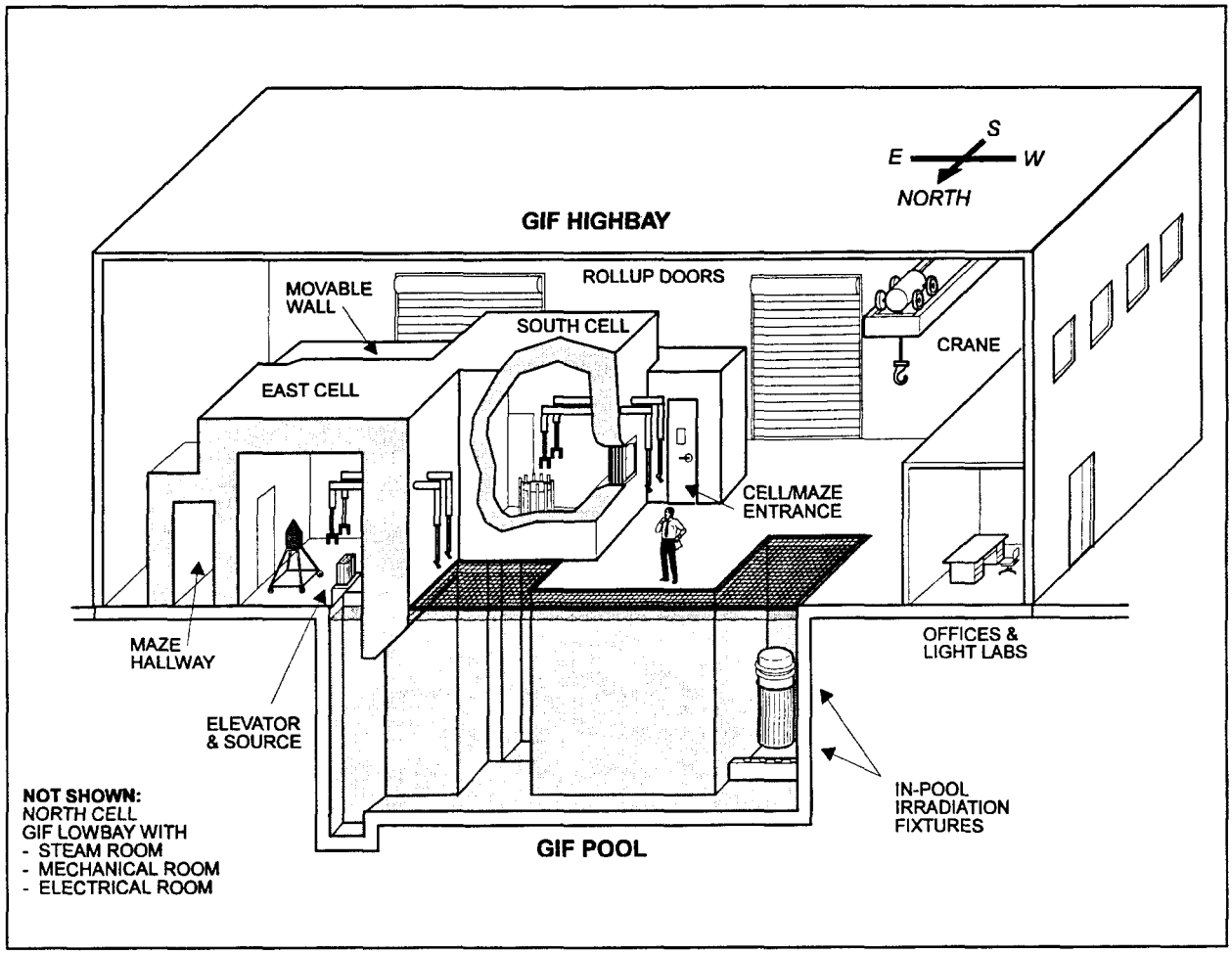
4.2 Principal Processes

The primary process performed in the GIF is irradiations of a variety of experiments with high energy gamma radiation. Types of experiments performed in the previous GIF and the LICA facilities cover numerous disciplines and components as demonstrated in the following lists:

In-Cell Irradiations:

- Electronic component hardness, survivability, and certification tests for military and commercial applications.
- Radiation effects on material properties.
- Radiation effects on organic materials (such as food or sludge irradiation).
- Hazardous waste destruction
- Mixed environment testing (e.g. steam and radiation, heat and radiation, etc.).

Figure 4-1. Layout of the Gamma Irradiation Facility



In-Pool Irradiations:

- Simultaneous thermal and radiation effects studies
- Weapon components for degradation testing
- Material/component testing for nuclear reactor accident tests
- Electronic component certification

The new GIF has several enhanced experiment capabilities. One of these is the sharing of a single facility, support systems, and radioactive sources between the in-cell and in-pool irradiation facilities. For the in-cell facilities, a large cell is included with a movable wall to provide access and irradiation of large components such as space vehicles or military vehicles. The in-pool facility enhancements include a new steam loop in one room of the GIF low bay for performing post-irradiation environmental tests.

The goal in each experiment, either in-cell or in-pool irradiation, is to accurately simulate a radiation environment to satisfy specific conditions desired for an experiment. This requires that custom experiment facilities, which are intended for specific irradiation functions, be incorporated into the design of the GIF as follows:

- Configurable radiation sources to provide different shapes for the source array (i.e. point, planar, circular, etc.).
- Configurable radiation source with rapid flux changes (HIACA) - High Intensity Adjustable Cobalt Array.
- High fidelity irradiation capability with reduced backscatter radiation.
- Simultaneous thermal and radiation.
- Shield windows for experiment observation during irradiation.
- Remote manipulators for experiment or source handling.

In addition, many general support features have been designed into the GIF for operator convenience and experiment support including the following.

- A 9 ton overhead traveling crane for source handling and cask movement with 7.6-m clear height to crane hook.
- General GIF operations offices with one office space for experimenters.
- Mechanical room for water and HVAC systems including the supply/exhaust air to irradiation cells.
- Pool filtration system with isolated resin beds with outside access in case of radioactive contamination.
- Electrical room with all electrical distribution panels.

The collection of all of these features into a single structure makes the GIF a unique irradiation facility with a wide range of experimental capabilities.

4.2.1 In-Cell Dry Irradiation Facilities

The in-cell facilities are characterized by dry shielded rooms (cells) in which irradiations are performed with a high intensity gamma-ray source. Figure 4-1 depicts irradiations being performed in two cells -- the large east cell and the smaller south cell. When irradiations are not being performed, the radioactive source is stored in the deep water pool under the cell. Elevators raise and lower sources between the pool floor and a predetermined position in the cell. When a test is not in progress, the inside of cell is accessible by way of shield door and maze hallway. During this time, the GIF operator and/or experimenters can enter a cell in order to set up test units and connect instrumentation. Following completion of the setup, the cell is cleared of personnel, the door is closed/secured, and the source is raised for a preset amount of time. Typical irradiations performed in the cells are at high dose rates (~ Mrad/hr at <1 meter from the source) and durations lasting up to a few days.

Figure 4-1 shows cutaways of two of the three irradiation cells. The three cells are different sizes and contain different features for specific experiment functions as follows:

1. East Cell: 5.5 m x 9.1 m experiment cell with two source elevators and a 5.5-m wide movable wall for access by large vehicles.
2. South Cell: 3.0 m x 3.0 m irradiation cell for use with (HIACA) High Intensity Adjustable Cobalt Array.
3. North Cell: 3.0 m x 3.0 m high fidelity irradiation cell with lead lined walls to reduce backscatter.

In addition, the following features enhance the capabilities of the dry irradiation cells:

- Maze hallway in each cell to provide simple, safe entry into cells and quick, undeniable egress from the cells.
- A complete source elevator system to lift sources from pool into cells with programmable timed termination of the run.
- Shielded windows in each cell for viewing the source raising/lowering, and for observing the test component during irradiations.
- Manipulators in each cell for performing source or experiment handling while the source is raised.
- Rails on the pool floor for easy transfer of source carts.

4.2.2 In-Pool Wet Irradiation Facilities

The in-pool wet irradiations are performed in the west side of the GIF. Figure 4.1 shows the location of in-pool irradiation fixtures at the bottom of a west portion of the GIF pool. The source-experiment geometry is arranged by positioning radioactive pins and test canisters in the irradiation fixture. Positions are mapped for flux levels for different configurations of the source array and test canisters. Because only experiment canisters are moved between the submerged irradiation fixture and the high bay, radiation sources are never brought to the surface. Test units are pre-configured in experiment canisters and often sealed for dryness with instrumentation leads routed to the surface for monitoring the test.

The in-pool irradiation fixtures are custom designed to specific source and test canister configurations. Most of the fixtures are voided of water to provide an unshielded path between the source and the test unit. Some test fixtures which are currently available are identified below. These are discussed in detail in Section 4.6.2.

1. Two linear arrays consisting of fixed ^{60}Co pins for low flux, long time irradiations with a planar source array.
2. Circular array for a near symmetrical, uniform irradiations.
3. High Intensity Cobalt Array (HICA) fixture for high dose rate irradiations of a medium size canister.
4. Two large chamber cobalt fixtures for symmetrical or planar irradiations of a large experiment chamber.

Additional fixtures may be built to match specific experiment needs. Air is available for cooling experiment canisters if necessary. Since ozone is generated, an exhaust header connected to the cell exhaust system is available for purging the experiment canisters. Air supply, exhaust purge, and instrumentation/power lines are routed around the perimeter of the pool in a covered trench.

4.3 Engineered Safety Features

The GIF accident analysis (Chapter 11) is used as the basis for identifying safety-related systems and administrative controls necessary to operate the GIF safely. The identification of the engineered safety features (ESF's) for the GIF is not straight forward. This is because most definitions and regulations in Division 1300 of DOE Order 6430.1a are directed towards facilities

that process radioactive materials -- the GIF merely uses solid, sealed radioactive sources for providing high-energy gamma photons.[4.1] As noted in Chapter 6, none of the twenty special facilities under Division 1300 of the Order apply to the GIF and only the general nuclear facility criteria are applicable. Because the GIF is a Category 3 hazard classification, it has no credible accident sequences which adversely effect the public, environment, or on-site personnel. Applying these conditions to the Order's strict definitions of ESF, safety class items, and safety classes is ambiguous. Therefore, the single term "Safety-Related System" (SRS) is used in this PSAR to identify any safety-related feature which satisfies the definition of an engineered safety feature or safety class item. The three levels of safety classes are not distinguished nor used in this PSAR.

4.3.1 ESF Identification

Engineered safety features are defined in DOE Order 6430.1A as:

> "Systems or design characteristics that are provided to prevent or mitigate the potential consequences of postulated design basis accidents. An engineered safety feature system is a safety class system. "

DOE Order 6430.1A further defines safety class items as:

> "Systems, components, and structures, including portions of process systems, whose failure could adversely affect the environment or the safety and health of the public. Specifically, safety class items are those systems, components, and structures with the following characteristics:
>
> 1. Those whose failure would produce exposure consequences that would exceed the guidelines in Section 1300-1.4, Guidance on Limiting Exposure of the Public, at the site boundary or nearest point of public access.
> 2. Those required to maintain operating parameters within the safety limits specified in the OSRs during normal operations and anticipated operational occurrences.
> 3. Those required for nuclear criticality safety.
> 4. Those required to monitor the release of radioactive materials to the environment during and after a DBA.
> 5. Those required to achieve and maintain the facility in a safe shutdown condition.
> 6. Those that control the safety class items described above."

Characteristics 1, 3, and 4 have no applicability to the GIF because the facility is a Category 3 hazard classification with no fissile material. Characteristics 2, 5, and 6 are the most applicable. Based on the above definitions and the accident analysis in Chapter 11, Table 4-1 identifies the five GIF systems which are determined to be safety-related systems (ESF's and safety class items). For each SRS, the primary safety function and type of function is defined. Passive systems are those features which are inherent to the design, always functional, and require no external stimulus or power source to be effective. Active systems are those features which are not always in effect but become effective after receiving an external stimulus -- active systems usually require electrical power to respond.

Table 4-1. Safety-Related Systems (SRS's) for the GIF

Safety-Related Systems	Primary Safety Function	Type of Function
1. Source cladding	Containment of radioactive material	Passive
2. Water pool	Radiation shielding	Passive
3. Irradiation cell shield	Radiation shielding	Passive
4. Elevator power interrupt	Access control	Active
5. Radiation monitoring system	Detection of radiation conditions	Active

Although other systems/subsystems assist operators in performing tasks, these five systems are the only hardware systems which are required to prevent and mitigate the consequences of all postulated DBAs to a low overall risk. This determination also assumes strict adherence to the administrative controls, as stipulated in the basis for TSRs to be presented in the FSAR. Other systems may provide additional backup functions which parallel the safety functions performed by the SRS's.

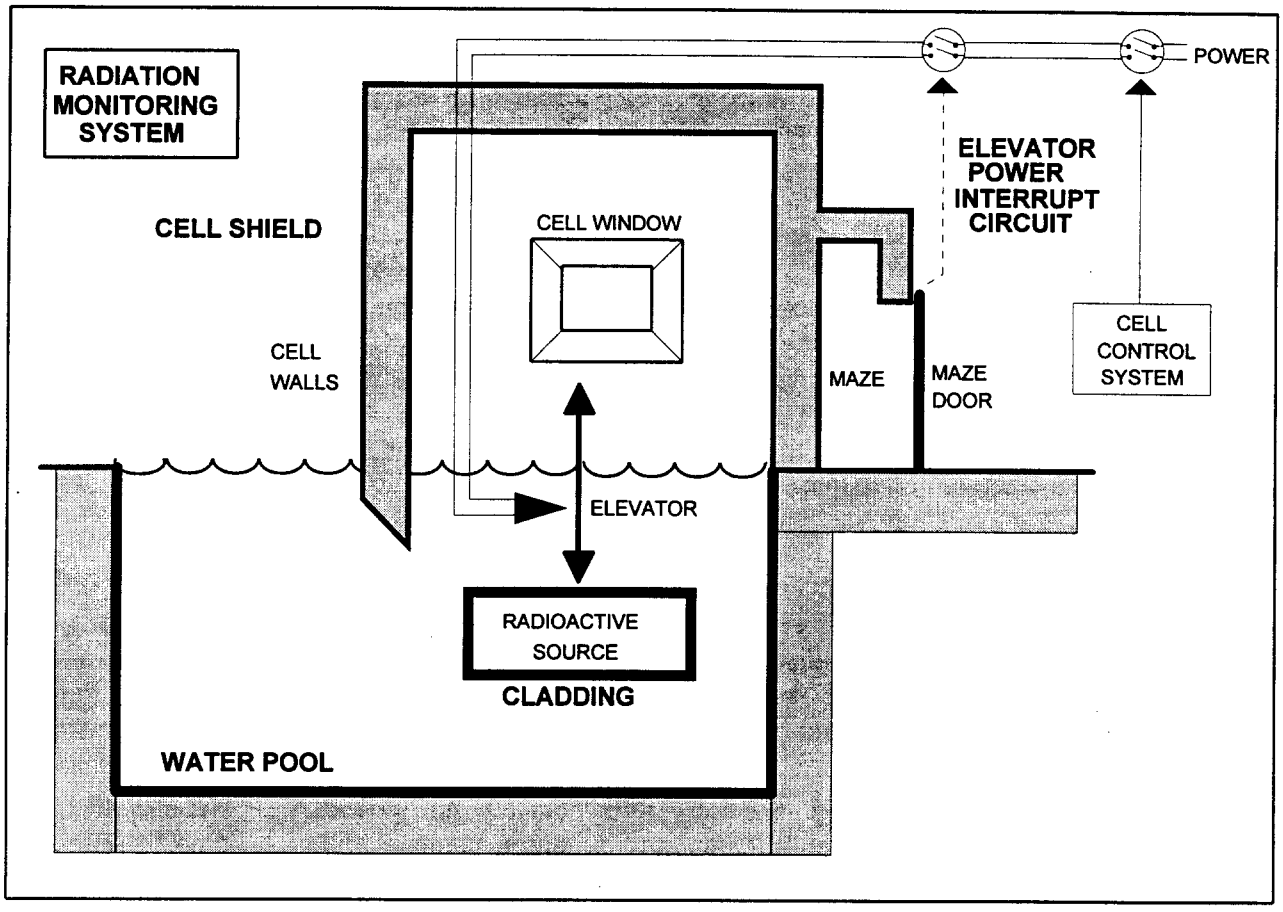
4.3.2 SRS Justification

Figure 4-2 depicts the safety-related systems and their interrelations for the GIF in a boundary-type representation. The five safety-related systems (cladding, water pool, cell shield, elevator power interrupt, and radiation monitoring system) are represented in the figure. Although the cell control system is shown in the figure, it is not safety-related but rather is the means by which the source is moved from one SRS to another SRS. The functions of all SRS's and interrelation to other systems are discussed in detail to justify their selection as safety-related systems.

The source cladding represents the primary boundary that seals the radioactive material and prevents its dispersion. All cladding on new sources will meet rigorous qualification and leak testing as described in a Section 4.4.1. Existing sources, although constructed and tested to rigid specification, are not documented as satisfying the most recently acceptable criteria. Most of sources in the existing GIF are ^{60}Co in the form of non-soluble metal; therefore, failure of the cladding would result in a very slow release process due mostly to erosion of the metal matrix. No liquid or gaseous sources are permitted in the GIF.

The GIF water pool represents the primary radiation shield when the sources are in the pool. This includes when the sources are not being used, when being used in the in-pool irradiation facilities, when in storage, when being moved in the pool, or when loaded/unloaded into transport casks. The only time the pool is not the primary radiation shield is when sources are elevated into the irradiation cells. The pool water is not required to cool the pins. This is because the source strengths are not sufficiently high to be concerned about internal power and the high energy photons penetrate over long distances therefore spreading their energy deposition. The pool water does heat up as a result of attenuating the energetic photons, and this heat is dissipated by two passive modes: evaporation to the GIF high bay and conduction to the ground. The pool can attain a temperature of up 50° C with 2.4 Mcuries of ^{60}Co.

Figure 4-2. Safety-Related Systems for the GIF



The irradiation cell represents the primary radiation shield when the sources are raised into a cell. The cell shield is comprised of the walls, floor, ceiling, door, and window. The cell shield does not act as a confinement boundary because no contamination is postulated within a cell - the cladding is the primary containment boundary along with the requirement that the source must be a solid. Strict limits on the energy sources, flammable materials, and chemicals allowed in experiments assure that the experiment cannot cause a breach of the source cladding integrity. If a mechanical failure were to occur that would distribute source pins, they would stay in the cell and radioactive material would not be dispersed in the facility or environment.

Access control is the safety function most important in assuring that an inadvertent radiation exposure of operations personnel does not occur in a cell. The basic premise of access control is that a cell shall never be entered with the source up, and the source shall never be capable to be raised with the cell accessible to entry. This is accomplished by assuring that power to the elevator drive is directly interrupted whenever the cell door is opened regardless of the status of the Cell Control System (CCS). The interrupt is accomplished by relays on each leg of the elevator drive power. Power to hold the relays closed is supplied by limit switches physically located at the door. For the large east cell, limit switches are also located on the movable wall to assure its closure whenever the source elevators are up. This elevator power interrupt subsystem represents a simple, positive, testable circuit for assuring proper access

control to the cells. Although shown in Figure 4-2 for completeness, the CCS is not part of this safety-related system for access control.

The radiation monitoring system is the safety-related system which can mitigate the consequences of any accident sequence with the potential for an inadvertent radiation exposure. Radiation cannot be sensed physiologically and, therefore, the radiation monitoring system is a necessity in ~~a~~ccessing the presence of a radiation hazard. Remote Area Monitors (RAMs) monitoring radiation in the cell give the primary indication that a source is exposed. RAMs in the pool area continuously monitor the pool surface and, in particular, during source handling operations. A RAM monitoring the recirculation loop demineralizer bed indicates if pool contamination occurred with the most likely cause being cladding failure. ~~A RAM monitoring the cell exhaust system senses if airborne radioactive material has been released in the cells~~. This may by the extremely unlikely event of an experiment failure detrimentally affecting the integrity of the source pin cladding and then dispersing the source material. The cell exhaust RAM sends an alarm signal to the cell ventilation control system which immediately closes dampers to all cells; therefore confining the release to the affected cell.

4.3.3 SRS Requirements

As detailed in Section 4.3.1, all safety-related systems are safety class items, and this definition has been applied to all SRS's and safety-related components for the GIF. To determine the requirements on the safety-related systems, Section 1300-3 of DOE Order 6430.1A states that safety class items shall be:[4.1.]

> "designed, fabricated, erected, and tested to standards and quality commensurate with the hazards and potential consequences associated with both the facility and the role of each component, system, and structure in mitigating the consequences of DBAs."

Compliance to this criteria is implemented in the design, procurement, construction and inspection of GIF ~~safety class items~~ safety-related systems. The criteria states that standards and quality shall be "commensurate with the hazards and potential consequences". Since the GIF is a Hazard Category 3 facility, it only has the potential risk for adverse affects to facility personnel and poses no significant hazard to site personnel, the public or the environment. This fact serves the basis for determining how each safety class requirement in Order 6430.1A is implemented for the safety-related systems of the GIF. Chapter 6, Appendix A contains a detailed listing of the compliance to the design criteria requirements. Table 4-2 summarizes those general requirements ~~applying to~~ where any all safety class items. In the table, comments are presented which justify the implementation of a specific requirement for GIF. Because of the low hazard category of the GIF, strict compliance to each requirement is not necessary. However, each requirement is implemented to the extent possible or a suitable alternative is justified. A number of compliance items are inherent to the GIF design process, which is described in the SNL Facilities Development Center Design Manual.[4.2.]

Table 4-2. Safety Class Criteria, Requirements, and Implementation Summarized from DOE Order 6430.1A

Criteria	General Requirement	Implementation on the GIF
General	Safety class items shall be subject to appropriately higher quality design, fabrication, and industrial test standards and codes.	The GIF facility is identified as Level 2 classification for design, construction and inspection purposes as per the Sandia Facilities "Design Manual", which is based on applicable criteria in DOE Orders 4700.1, 5700.6C, and 6430.1A. As such, the whole facility, and in particular the safety-related systems, are designed, built, and inspected to a high quality level. Through quality programs, nuclear standards, detailed inspections, and testing; the safety class items receive more rigorous attention consistent with their safety function.
ASME Boiler and Pressure Vessel Code	Safety class items shall be designed to the ASME Boiler and Pressure Vessel Code (Section III, Class II) or to other comparable safety-related codes and standards that are appropriate for the system.	The only water system which serves as a safety-related system is the GIF pool. The pool is not required for cooling or containment of hazardous material; it only serves as a radiation shield. Therefore, requirements of the ASME B&PV Code are not implemented for the pool. However since the pool is a safety-related system , it is being built and inspected to the SNL Level 2 quality assurance procedures.
Quality Assurance	The design of systems, components and structures that are not safety class items shall, as a minimum, be subject to conventional industrial design standards, codes, and quality standards. Failure of these items shall not adversely affect the environment or the safety and health of the public. In addition, their failure shall not prevent safety class items from performing their required functions.	The GIF facility is identified as an SNL Level 2 classification for design, construction and inspection purposes as per the Sandia Facilities "Design Manual", which is based on applicable criteria in DOE Orders 4700.1, 5700.6C, and 6430.1A. As such, the whole facility is designed, built, and inspected to a high quality level. Under no circumstances (normal operation or accident conditions) has the failure of non safety-related system been postulated to adversely affect the environment or the safety and health of the public. or prevent safety-related systems from performing their required functions.
Single Failure Criterion and Redundancy	The design shall ensure that a single failure does not result in the loss of capability of a safety class system to accomplish its required safety functions. To protect against single failures, the design shall include appropriate redundancy and shall consider diversity to minimize the possibility of concurrent common-mode failures of redundant items.	As part of the accident analysis, all safety-related systems were assessed to determine if single failures could severely affect the intended safety function. Throughout the GIF design process, the emphasis has been on designing safety features that are passive in functionality. This assures that the highest reliability systems prevent and mitigate the consequences accidents. Where single failure could affect the functionality of a safety-related system, a redundant feature is added to assure that overall safety is not compromised. Diversity and the avoidance of common-mode failures are two of the main concerns in selecting the type and functionality of redundant features.
Equipment Environment Considerations	Safety class items shall be designed to withstand the effects of, and be compatible with, the environmental conditions associated with operation, maintenance, shutdown, testing, and accidents. The environmental capability of equipment shall be demonstrated by appropriate testing, analysis, and operating experience, or other methods that can be supported by auditable documentation, or a combination of these methods.	All passive and active safety-related systems are designed to withstand the effects of environmental conditions postulated for normal operation and accident conditions. Passive safety-related systems are designed with large safety margins for the environmental conditions expected for the Albuquerque, NM area. Prior operating experience with sealed gamma sources, water pools, and irradiation shields in SNL TA-V have demonstrated the integrity of these passive safety-related systems. Radiation monitoring systems similar to the planned system for the GIF have been operated extensively at the other nuclear facilities at SNL TA-V. The RAMS used for the radiation monitoring system are qualified by the manufacturer. The elevator power interrupt circuit is designed to use simple, rugged, highly reliable electrical components. No addition environmental testing other than stated in this table is planned for the GIF safety-related systems.

Table 4-2 (continued). Safety Class Criteria, Requirements, and Implementation

Criteria	General Requirement	Implementation on the GIF
Environmental Qualification of Equipment	Equipment qualification shall provide assurance that safety class items will be capable of performing required safety functions under DBA conditions. The qualification shall demonstrate that the equipment can at least perform for the period of time that its safety functions are required.	All passive and active safety-related systems are design with large margins to withstand the effects of environmental conditions postulated for normal operation and accident conditions. All new source cladding and radiation monitoring systems are qualified by the manufacturers. Because of their design margins and ruggedness, no environmental qualification is planned for the GIF pool, irradiation cell shields or the elevator power interrupt circuits.
Equipment Operability Qualification	Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of the system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where such data have been documented and validated.	The three safety-related systems which must survive a DBE are all passive systems: the source cladding, the GIF pool, and the irradiation cell shields. With these three systems functional, no active system is required to maintain the facility in a safe condition. The source cladding is qualified by the manufacturer -- additional sources to be acquired for the GIF will satisfy ANSI N43.6. Dynamic analysis has been performed for the GIF pool and the irradiation cell shields. Because of the large design margins , no specific tests are planned to qualify the these two safety-related features for a DBE.
Maintenance	Safety class items shall be designed to allow inspection, maintenance, and testing to ensure their continued functioning, readiness for operation, and accuracy.	Safety-related systems are designed for inspection and testing on a daily basis prior to each day of planned operation. Radioactive material containment by the source cladding is continuously monitored by the a RAM on the recirculation loop demineralizer. The GIF pool level is alarmed and the makeup flow is compared the evaporation. The irradiation cells are visually inspected on a daily basis prior to each day of planned operation. The elevator power interrupt circuit and the radiation monitoring system are tested on a daily basis prior to each day of planned operation.
	The design of equipment that must be located within confinement systems shall allow for inplace maintenance or replacement.	The only GIF system that confines or contains the radioactive materials is the source cladding, which provides a sealed containment boundary. There are no maintenance or replacement required within the cladding. Other safety-related systems are fully accessible for maintenance, repair or replacement.
Testing	The design shall include provisions for periodic testing of monitoring, surveillance, and alarm systems. In addition, the design shall provide the capability to test periodically, under simulated emergency conditions, safety class items that are required to function under emergency conditions.	Safety-related systems are designed to be inspected and/or tested on a daily basis prior to each day of planned operation. Critical alarms on the pool level, the elevator power interrupt circuit, and the radiation monitoring system are tested daily.
	All systems for which credit is taken to meet the accidental release criteria shall be in-place testable in terms of pressure, filtration or removal efficiency, alarm capability, leak resistance, and the like. Safety class items shall be designed to be testable on a regular schedule.	No GIF safety class system is required to meet accidental release criteria. The GIF is a hazard category 3 facility which has no significant affect on the public, environment or other site personnel. Safety-related systems only serve to protect the GIF operations staff, experimenters and other personnel in the facility.
	The facility design shall allow for routine in-place testing of HEPA filtration systems.	No HEPA filtration systems are design for the GIF since no credible accident was postulated which could disperse the radioactive sources into the cell exhaust and/or building HVAC system.

4.3.4 Safety Classification of GIF Systems

Table 4-3 lists all GIF systems and subsystems. The table identifies the safety classification of each system and subsystem and identifies the correspondence between systems and their respective subsystems. The table also states the subsections in which the systems are described in this chapter with the following basic order: 1) Section 4.4: safety-related systems, 2) Section 4.5: non-safety related support systems, and 3) Section 4.6: miscellaneous support systems.

Table 4-3. Identification of GIF System/Subsystem Safety Classification

System/Subsystem	Safety Classification	Section
Sealed Sources	Safety-Related System	4.4.1
GIF Pool	Safety-Related System	4.4.2
Irradiation Cell Shield	Safety-Related System	4.4.3
Elevator Power Interrupt	Safety-Related System	4.4.4
Radiation Monitoring System	Safety-Related System	4.4.5
GIF Site and Building	Support System	4.5.1
Site	Site Access and Support	4.5.1.a
Building Structure	Support Subsystem	4.5.1.b
Building Layout	Support Subsystem	4.5.1.c
Ventilation Systems	Support System	4.5.2
Cell Exhaust Subsystem	Support Subsystem	4.5.2.a
Building HVAC	Support Subsystem	4.5.2.b
Water Systems	Support System	4.5.3
Pool Water Recirculation Loop	Support Subsystem	4.5.3.a
Pool Water Makeup Subsystem	Support Subsystem	4.5.3.b
Pool Overflow and Building Drains	Support Subsystem	4.5.3.c
Cell Control Systems	Support System	4.5.4
Cell Control Subsystem	Support Subsystem	4.5.4.a
Elevator Drive Subsystem	Support Subsystem	4.5.4.b
Emergency and Intrusion System	Support System	4.5.6
Electrical Systems	Support System	4.5.7
In-Cell Irradiation Fixtures	Misc. Support System	4.6.1
In-Pool Irradiation Fixtures	Misc. Support System	4.6.2
Source Handling Tools	Misc. Support System	4.6.3
Crane	Misc. Support System	4.6.4
Steam System	Misc. Support System	4.6.5

4.4 Safety-Related Systems

As noted in Section 4.3, safety-related systems are those preventive and mitigative features necessary to assure the safety of GIF personnel. There are no credible accident sequences which significantly effect the public, environment, or other on-site personnel. For this reason, the term safety-related system is used in the PSAR to encompass engineered safety features and safety class items. With all safety-related systems functional, the GIF can be operated and shutdown safely during all normal operations and postulated accident sequences. This section describes the five safety-related systems: 1) sealed sources, 2) the GIF pool, 3) irradiation cells, 4) elevator power interrupt circuits, and 5) the radiation monitoring system.

4.4.1 Sealed Sources

The radioactive sources to be used in the GIF are all sealed sources. Sealing involves cladding the radioactive material into cylindrical-sheathed pins with welded end caps. Normally, stainless steel is used as cladding due to its high strength and corrosion resistance in water. The GIF sources can be different radioactive nuclides. All of the existing sources are ^{60}Co in the form of a nonsoluble metal. New ^{60}Co sources will also be nonsoluble metal and doubly encapsulated. Sources of other isotopes will also be a solid and doubly encapsulated. The type and intensity of the radioactive material may vary provided the following five restrictions are satisfied:

1) The sources are sealed with a low corrosion material such that no radioactive material is intentionally in contact with the pool water.
2) The radioactive source is not a gas or liquid.
3) The sources do not exceed the Category 3 inventory limits in DOE STD-1027 Appendix A.[4.3.]
4) The sources do not contain fissile materials.
5) The total source heat load does not exceed 40 kilowatts as described in Chapter 11.

The GIF is a new facility that will combine the functions and sources of two current SNL facilities: the existing GIF and the LICA. Radioactive sources from these two facilities are planned to be transferred to the new GIF when it becomes operational. An inventory of sources, strengths, and present usage has been performed for the existing sources and is contained in Table 4-4. The total source strength for the five batches of pins is currently (as of March 1, 1995) equal to almost 157 kilocuries. This is below the DOE STD-1027 maximum limit of 190 kilocuries for unsealed ^{60}Co sources. Although all sources are sealed and no detectable leaks have ever occurred at the existing GIF or LICA facilities, SNL does not have documentation that specifies these sources as being qualified to ANSI 43.6.[4.4.] Without such documentation, these sources are not excluded from the total inventory as stipulated in DOE STD-1027. All new sources to be acquired for the GIF will be tested as specified either by the DOT in 49 CFR 173.436 or by ANSI N43.6 "Sealed Radioactive Source, Categorization".[4.5]

Table 4-4. Source Inventory for Transfer to the New GIF

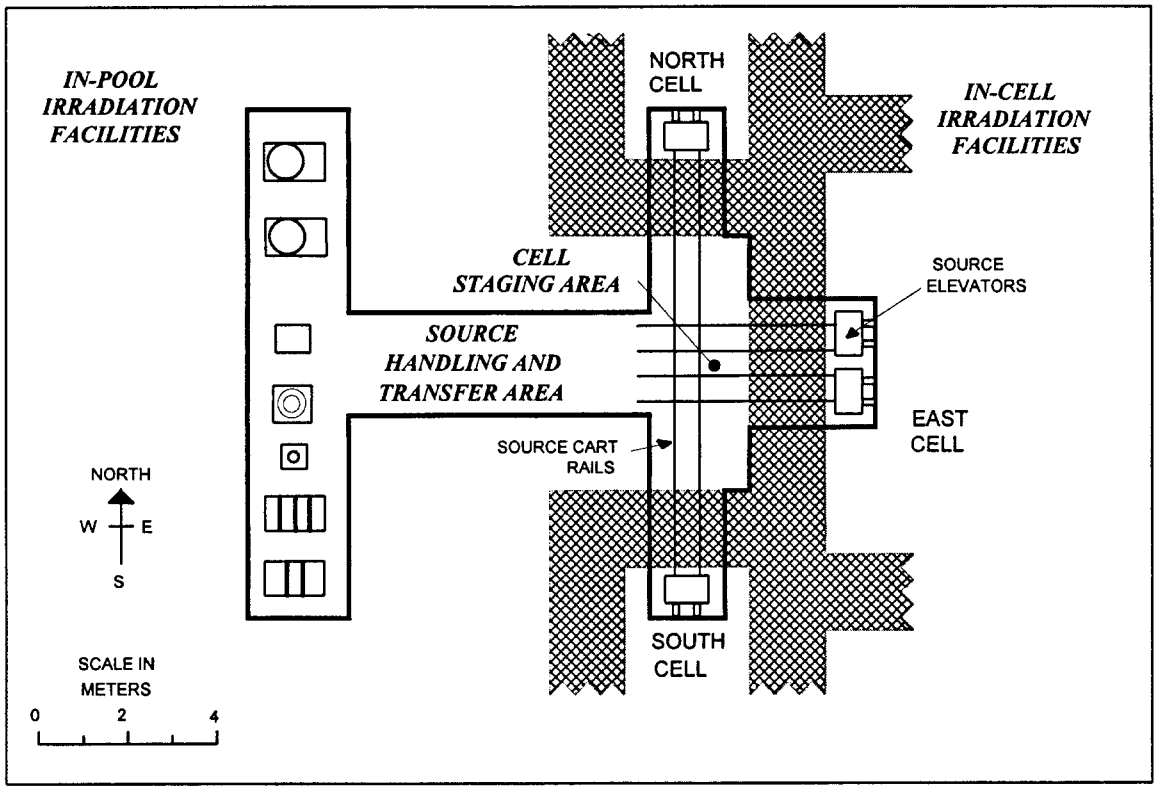
Batch	Facility	Source Type	# of Pins	Strength (3/1/95) Curies	Current Usage
1	Existing GIF	^{60}Co	64	56,648	North GIF
2	Existing GIF	^{60}Co	16	43,373	South GIF, HIACA, 24"
3	Existing GIF	^{60}Co	10	13,891	Rectangular Cobalt Array
4	LICA	^{60}Co	32	36,160	Chamber Array 24"
5	LICA	^{60}Co	93	6,858	Low Intensity Array 12"
Total			215	156,931	

The top end caps of the source pins are notched to allow attachment of a lifting tool. The configuration of the notch and the design of the tool vary depending on the manufacture of the pins. The source handling tools are nominally 7 meters tall, designed to be used by one person, and include a remote release mechanism as part of the operator end. A general purpose tool is available for picking a pin up that may have dropped on the pool floor. Custom tools may be required for specific handling operations or in case of abnormal condition (e.g. stuck pin, etc). The procedures and administrative controls for source handling are discussed in Chapter 11.

4.4.2 GIF Pool

The GIF pool contains demineralized water and exists primarily to provide radiation shielding for the submerged radioactive sources. The pool consists of a 5.5-m deep, reinforced concrete, steel-lined pool in the basic shape of an "H". Figure 4-3 shows a plan view of the pool (Figures 4-1 and 4-4 show cutaway elevation views of the pool). The pool traverses 16.3 m in the east-west direction and approximately 12.3 m in the north-south direction. The width of the pool is ~2.4 m. The east leg of the "H" comprises the in-cell irradiation facilities where four elevators raise source carts from the pool floor to the inside of the cells. Rails along the bottom of the pool provide a means for manually rolling carts between the elevators and the staging area common to all the cells. The west leg of the "H" comprises the in-pool irradiation facilities with numerous irradiation fixtures at the pool bottom. The cross-bar of the "H" represents the source handling and transfer area where shield casks can be submerged for source loading and unloading operations. The total surface area of the pool is 81.0 square meters with 69.9 square meters exposed. The total water volume in the pool is 420 cubic meters (120,000 gallons).

Figure 4-3. GIF Pool Plan View



The design and construction of the pool is consistent with its designation as a safety-related system. The walls and floor of the pool are constructed of .3-m thick reinforced cast-in-place concrete supported by spread footings. A 0.5 cm thick stainless steel liner consisting of large seam-welded plates lines the inside of the pool. In the source handling area a thick steel platform is provided for holding shield casks. To accommodate the load, the floor of the pool has the capacity to support a 14 ton (30,000 lbs.) load distributed over a 1 m x 1 m area. The pool top is a floor level with a small (~ 10 cm high) curb extending above floor level around the perimeter of the pool. Penetrations through the pool liner consists of the few necessary for the water recirculation loop. There are no penetrations in the liner below 1 m from the top of the pool.

4.4.3 Irradiation Cell Shields

The irradiation cells consist of large, dry, shielded rooms in which irradiations are performed using radioactive sources raised from the pool below the cells. The irradiation cells are not a containment boundary nor a confinement barrier. They serve as the primary radiation shield when sources are being used for performing irradiations in the cells. Figures 4-4 and 4-5 show the cell floorplan and a cutaway elevation view, respectively. Figure 4-4 also identifies the main features of each cell; in particular, those features associated with access to a cell.

Figure 4-4. GIF Irradiation Cells Plan View

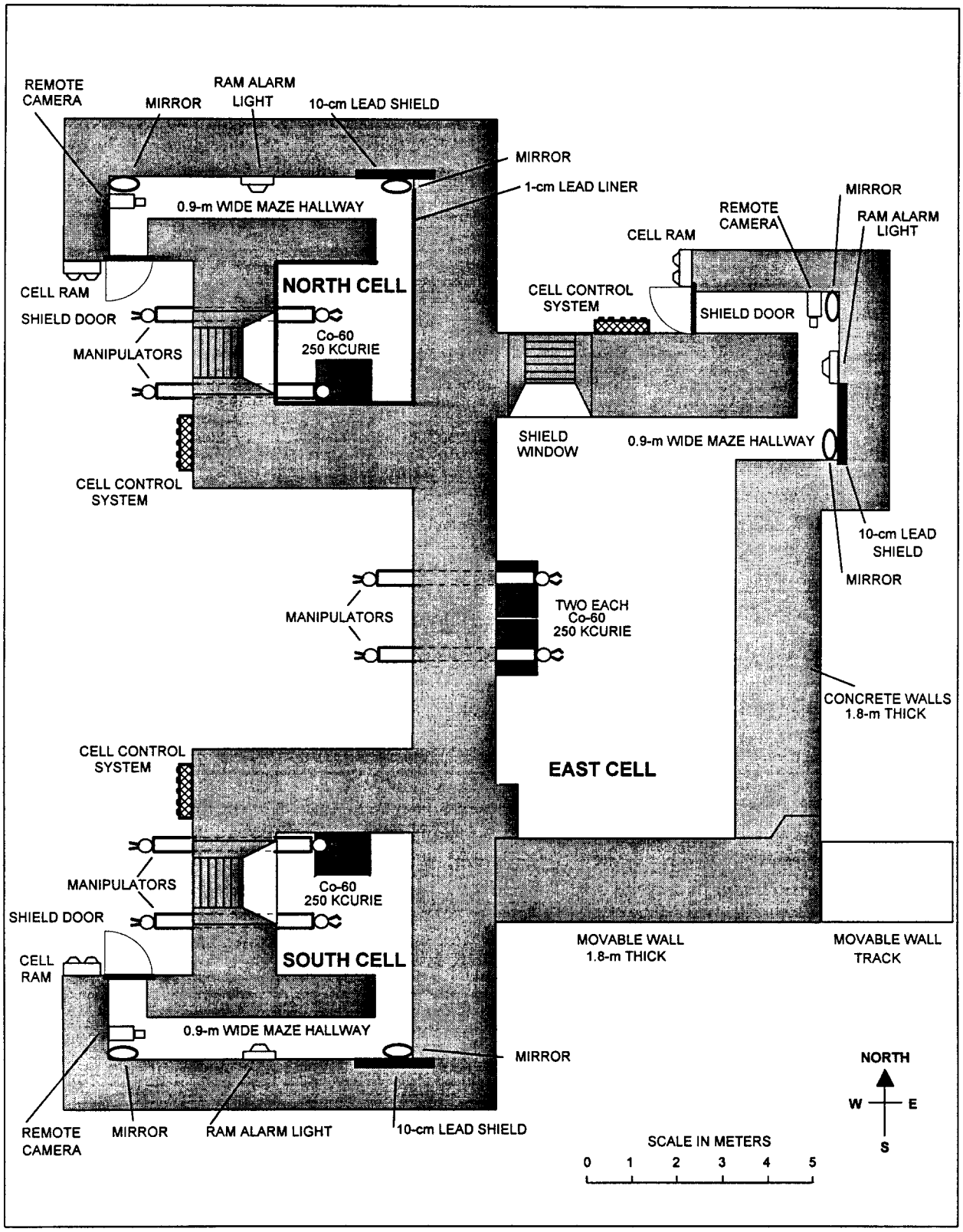
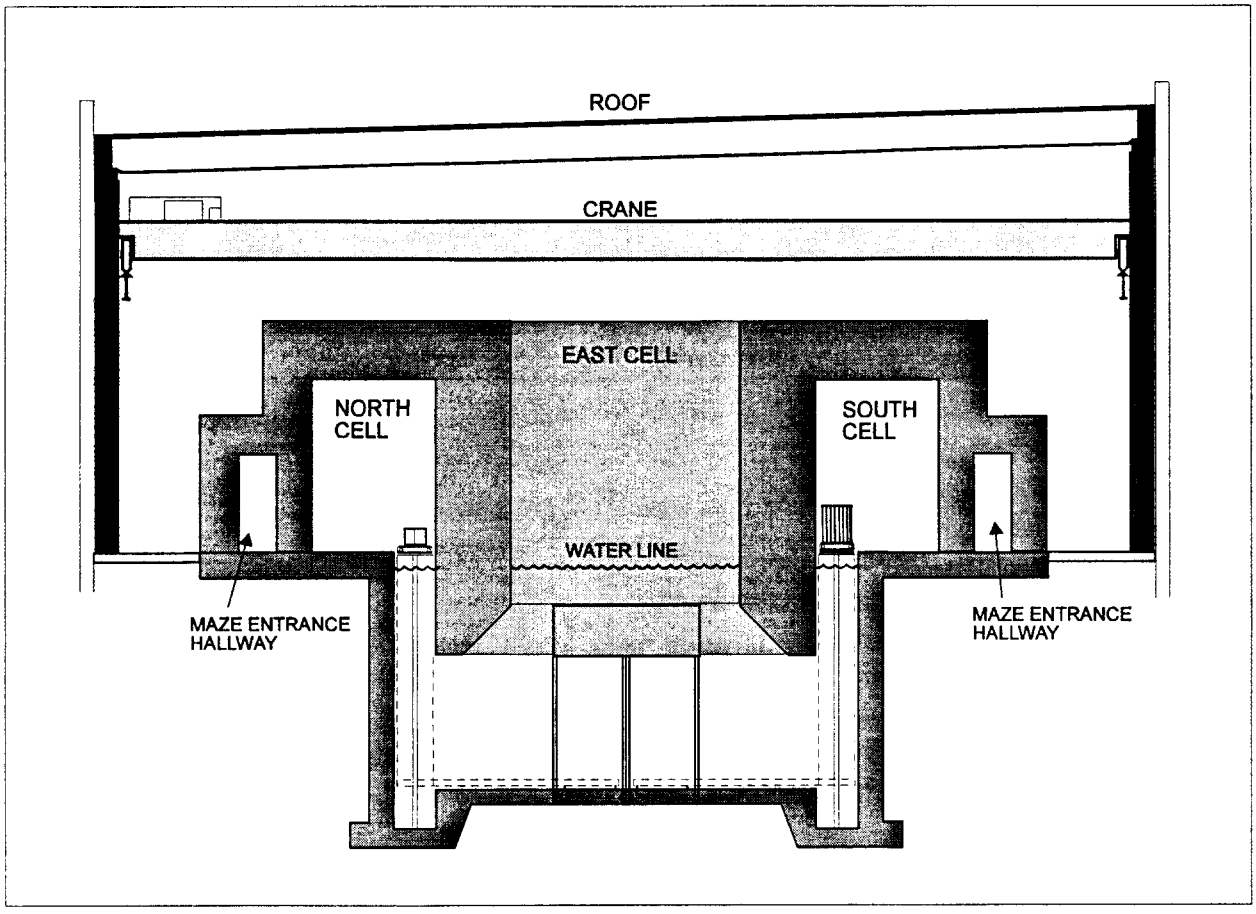


Figure 4-5. Cutaway Elevation View the North and South Irradiation Cells



The cells are designed and equipped to provide the maximum flexibility in performing a wide diversity of experiments. The cells have large floor areas and high ceilings for setting up experiments of different sizes and configurations. The east cell has the largest floor area and includes a movable wall for vehicle and large experiment access. The thick concrete walls fully shield the GIF high bay from the radioactive sources, and are designed to limit the dose rate at the outside of the walls to 1 mrem/hr. Each cell has a maze for entering the cell, window for viewing the sources and experiments, remote manipulators for handling experiments, elevators for raising/lowering sources, and a Cell Control System for controlling/monitoring cell functions.

All cells have a 4.3 m inside height with 1.8 meter thick reinforced concrete walls and 1.4 m thick reinforce concrete ceiling. The cells have different floor sizes depending on their use:

1. East Cell: 5.5 m x 9.1 m for large experiments.
2. South Cell: 3.0 m x 3.0 m for the High Intensity Adjustable Cobalt Array.
3. North Cell: 3.0 m x 3.0 m for high fidelity irradiation experiments.

The cell shields are constructed in a single unit consisting of reinforced standard concrete with no expansion joints. Due to the massive size of the cells, the wall foundations are supported on concrete columns which extend down approximately 6 m below the high bay floor to the undisturbed soil and rock below the pool floor level. Special care is employed in pouring the concrete in the cell walls and roof to achieve a consolidated block without "voids" and low

porosity. The location and types of cold joints are specifically selected to avoid any non-uniformities in high stress or high radiation areas.

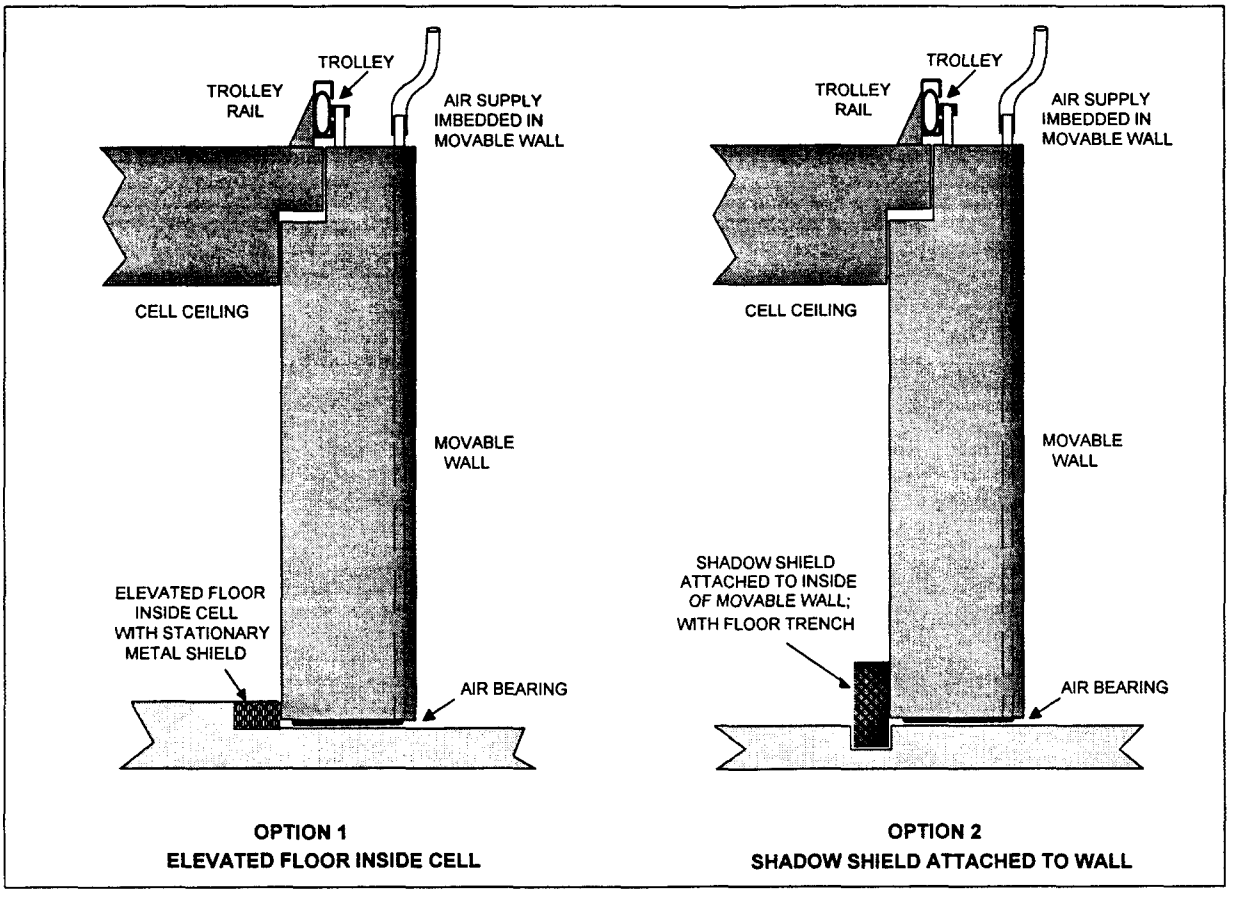
When tests are not being performed, the inside of a cell is accessible by way of a serpentine maze. The maze entrance provides a simple means of personnel access into a cell and an undeniable egress route out of the cell. Planviews of the maze hallways are shown in Figures 4-4 and 4-5. The maze hallway is enclosed by the 0.9-m thick interior concrete wall and a 1.1-m thick exterior concrete wall. The ceiling throughout the maze hallway is 2.4-m high and has a thickness of 1.1 m. The maze entrance is located at the control area for the cell where all the cell activities can be monitored. The maze is deliberately tortuous requiring direct radiation from the source to undergo a minimum of two right angle turns before impinging on the cell door. Each right angle turn reduces both the intensity and the average energy of the reflected radiation as demonstrated in calculations presented in Chapter 11. Most radiation undergoes many more scatters and, therefore, radiation doses inside the door to the maze are significantly (on the order of 10,000 times) reduced from those inside the cell. Even so reduced, radiation intensities at the maze entrance are still sufficiently high to necessitate the door provide radiation shielding.

At the maze entrance is a 0.9-m wide, 2.4-m high shield door containing ~1 cm thickness lead plate with a total weight of ~200 kg. The hinged door overlaps the door frame to prevent radiation escape. The door is specially designed and fabricated for radiation service. A shield window is included in the door to provide visibility of portions of the maze hallway. The handle of the door is physically lockable from the outside with the key being the same one used to activate the elevator drive permit in the Cell Control System. The door provides break-out capability from the inside for anyone to exit through the door in case of an emergency. The door frame has a physical stop to prevent the door from being closed until a reset is activated. The procedure for entering and exiting a cell, including interlocks and administrative controls, is described in Chapter 11.

The large east cell includes a movable south wall to provide access for large vehicles. Two options are currently being considered for the movable wall as shown in Figure 4-6. The wall is 1.8-m thick, 7.3-m long and 5.6-m high and weighs approximately 170 metric tons. In both options the wall is moved by raising the structure via air bearings located under the wall and then pulling the supported wall with a pneumatically-powered chain/sprocket drive. The bearings are comprised of 4 individual, circular (1.2-m diameter), rubberized, flat (~2-cm thick when inflated) tubes similar in appearance to bicycle inner tubes. The bearings are inflated by compressed air at a pressure of 50 to 60 psig. This pressure excerted throughout the encircled area of the bearing supplies the necessary force to lift the door. A trolley at the top of the cell guides the wall along a rail when being moved. The trolley does not supply any lift on the door but is only intended to guide and center the wall. Individual, lockable controls on the east and west corners of the wall provide for opening and closing the wall, respectively. The movable wall has serpentined interfaces with the cell walls, ceiling and floor to prevent radiation streaming as shown in Figures 4-4 and 4-6. Two options are being consider for the floor -- a raised cell floor or a shadow shield attached to the wall. Final selection of the option employed will be determined after development with manufacturers of air bearings.

Each cell contains a radiation shielding window for viewing the irradiation process. As shown in Figure 4-7, the windows consist of multiple, leaded-glass panes which are optically-coupled

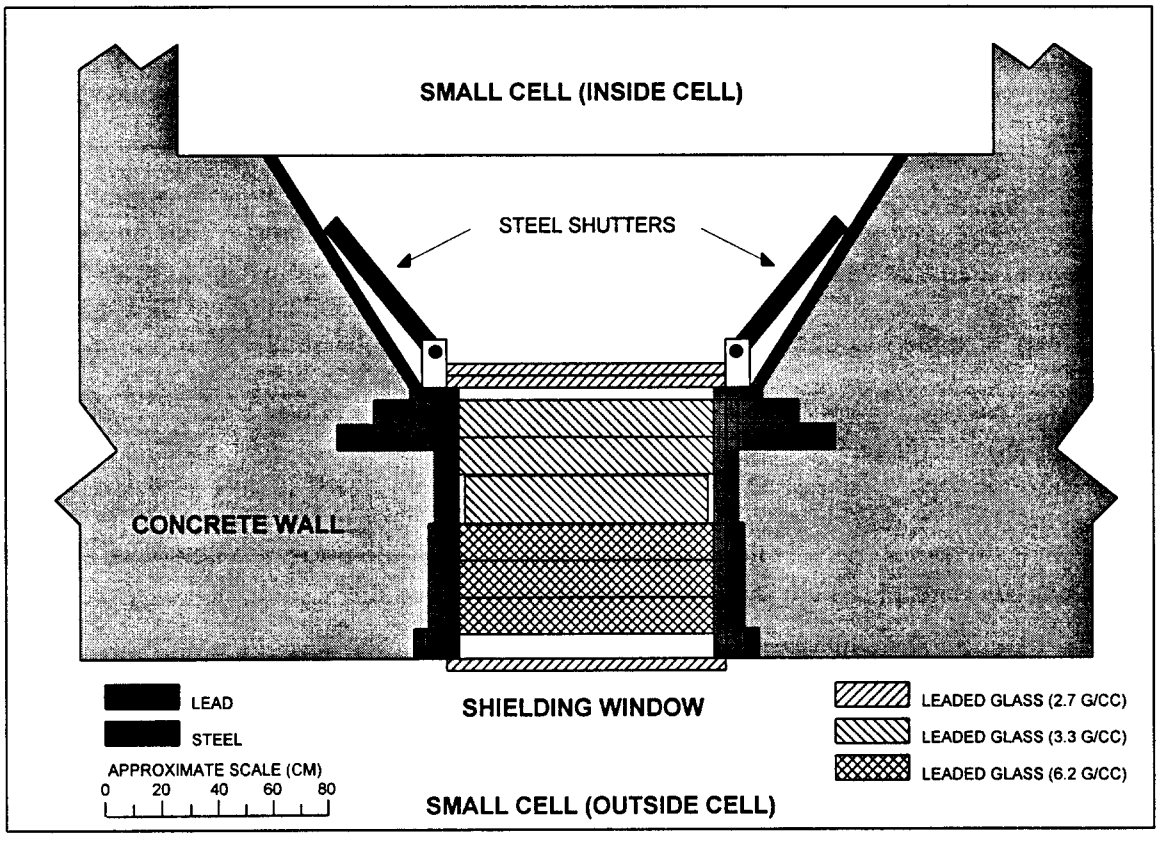
Figure 4-6. Design Options for Movable Wall



by a transparent oil . The radiation attenuation is provided almost entirely by the leaded glass -- the oil provides essentially no shielding. The glass densities (which are indicative of the lead content) vary for the window panes and are staggered so that the higher density panes are on the outside of the window. The dimensions of the viewing area is 0.61 m high and 0.79 m wide. The total thickness of the window glass is 0.89 m for the small cells and 1.04 m for the large cell. As shown in Figure 4-7, the window is mounted flush in the cell wall (thickness 1.8 m) on the outside and is recessed on the inside. The recess is flared to allow a wider field of view of the inside of the cell. The window frames are specially designed and augmented with steel and lead to prevent radiation streaming around the reduced thickness portion of the wall. The radiation shielding windows for the smaller north and south cells use glass panes from the existing GIF. This glass is to be removed, refurbished, enlarged and installed in new frames. The glass for the large east cell is new. The total radiation attenuation provided by a shielding window is equivalent to the attenuation through the 1.9-m thick concrete wall.

On the inside of each shielding window is a 5-cm thick steel swinging shutter. The shutter reduces the radiation dose to the window glass, thereby reducing "yellowing" of the glass and extending the window lifetime. The shutter is not required to reduce radiation received by personnel outside of the cell since this dose rate is acceptable with the window alone. The shutters should be closed whenever the source does not need to be visually monitored. (i.e., when being raised or lowered).

Figure 4-7. Cutaway View of the Radiation Shielding Windows for Small Cells



The cell shield walls contain a number of penetrations for specific purposes. There are several serpentined pass throughs in the control area for experiment power and instrumentation cables. Locked shield plugs fill the outside of these pass throughs when not in use. The remote manipulators penetrate the walls at ~4 m above floor level. The manipulators contain shielding to avoid radiation streaming; however, due to there construction, it is not possible to block all ports. Some local dose rates are expected to be high at this height above the floor. There are other pass throughs in the shield wall for power cables, light cables, signal wires and elevator drive cables. In each case these pass throughs are either serpentined, not directly in line with the source, at a high elevation, plugged, shadow shielded or any combination of these techniques to reduce the radiation streaming.

4.4.4 Elevator Power Interrupt Subsystem

Access control is the safety function most important in assuring that an inadvertent radiation exposure of operations personnel does not occur in a cell. The purpose of access control is to assure that a cell shall never be entered with the source up; and conversely, that the source shall never be able to be raised while the cell is accessible to personnel entry. The GIF has a number of administrative, keylock, control and interlock features designed to perform in part the access control function. However, the elevator power interrupt circuit is the single, simple, reliable, testable circuit which performs its function in a highly reliable mode. Figure 4-2 illustrates the simplicity of this circuit. The safety function is provided as follows:

- If all other features were assumed ineffective and entry were forced into a cell while the source is raised, the elevator and source would drop and remove the radiation hazard. An ozone hazard may still exist; however, this would not be lethal and it would be sensed in an increasing level as one enters through the maze.

- By breaking power to the elevator drive motor whenever the door is open, the elevators can never be raised while the cells are open to entry. This prevents raising a source while personnel are in the cell. The door is physically prevented from being closed until satisfactorily completing an administrative procedure which includes sweeping the cell and resetting the closure mechanism.

The interrupt circuit is redundant; interrupting both sides of the power to the DC motor on the elevator drive. The coil side of the fail-open relay contains two limit switches in series to provide redundancy. The limit switches are physically mounted to the door frame and are closed whenever the door is closed. The power for this circuit is supplied by the cell control system (CCS) power supply. If the CCS is de-energized or a loss of power is sensed, the elevator power interrupt circuit will also be opened.

Each cell contains an elevator power interrupt circuit with most of the circuitry enclosed in the CCS cabinet for that cell. The east cell, which includes a movable wall for accessing the cell, includes two addition limit switches in the coil-side circuit of the relay. The switches are mounted to the stationary cell walls to sense movable wall closure.

4.4.5 Radiation Monitoring System

The radiation monitoring system is designed to detect the presence of ionizing radiation and alert personnel within the facility if radiation levels reach hazardous levels. This system is not designed to protect the general public or the environment outside the facility since no accidents are postulated which can affect either. The system consists of Remote Area Monitors (RAM's) and portable radiation detectors. Due to the absence of particulates or radioactive gasses, no Continuous Air Monitors (CAMs) are provided in this facility. Body counters or contamination detectors are not normally required because no exposed sources are used at the GIF.

The GIF RAMs are deployed to give full coverage of specific operational areas. Table 4-5 presents numbers of RAMs, locations and alarm functions for ten GIF RAMs. Three RAMs are dedicated to the pool area to give full coverage of the pool particularly for source handling and experiment handling operations. One RAM is dedicated to each cell, with the detector located between the cell and hallway. This RAM indicates that a cell is safe for entry. The sensitivity of this unit is set so that if a single pin were to remain in the cell after the source is lowered, the alarm would still be activated. These RAMs send a trip signal to the cell control system (CCS). Another RAM is deployed outside of the movable wall with the detector located where the wall would first open to the cell. One RAM has a detector submerged underwater and senses if the HIACA is in its raised position. This RAM also sends a trip signal to the CCS for the HIACA cell (the south cell). A final RAM is deployed on the GIF pool recirculation loop. This RAM monitors radiation from the demineralizer, which would be the most likely point where radioactive contaminants in the pool would concentrate. An alarm on this RAM would most likely indicate cladding failure of one or more of the source pins.

All RAMs are commercially available, ionization chamber types with sensitivity to photons above a preset energy level. Typical ranges are 5 orders of magnitude with the lowest range at 1 millirem/hr. Colored lights on the units indicate functional failure and trip of a preset alarm level. An audible signal is normally associated with the alarm trip. Units monitoring the inside of the cells and the pool underwater do not have audible alarms since they normally achieve a alarm trip with sources in the raised positions. Each unit includes a self-contained battery backup power supply that lasts for a minimum of two hours. For the required GIF RAM's, remote readouts and alarm indications are provided at the TA-V health physics office and the TA-V emergency command center. This allows remote evaluation and response planning to hazardous conditions during emergencies. The RAM's and alarms components are selected to be fail safe, in their most likely failure modes. Redundancy is provided by the number of RAM's.

Portable and handheld radiation detectors are used during specific operations such as entering a cell after an irradiation and source handling. For entering a cell, "chirpee's" are usually used. A chirpee is a pocket-sized radiation detector which produces an audible beep for approximately each tenth of millirem of accumulated dose. Based on the frequency of beeps, the wearer is alerted to the radiation dose rate present.

Table 4-5. GIF RAMs Description, Location, and Alarms

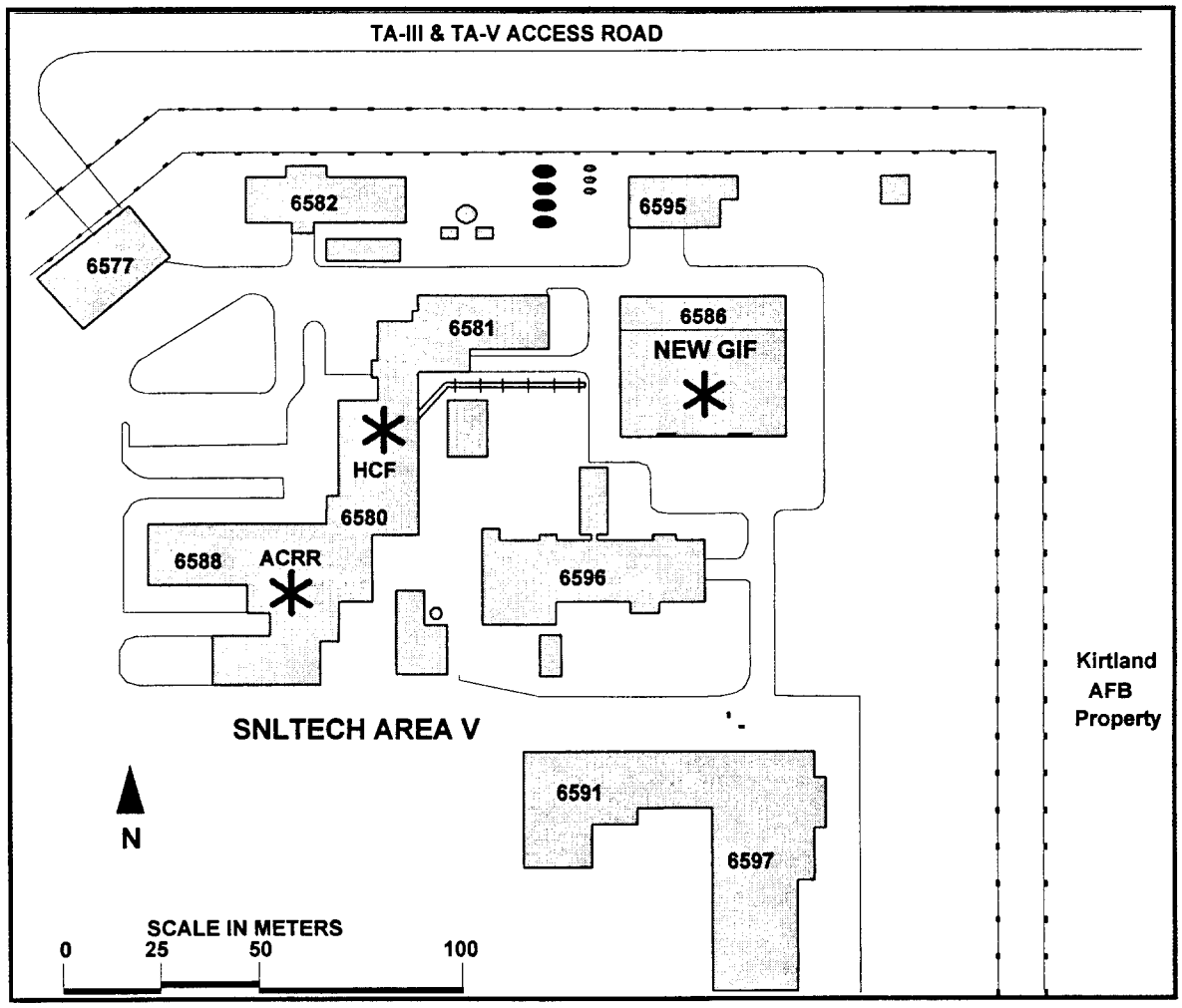
RAM Description	Number of Units	Detector Location and Monitored Area	Alarm and Other Functions
GIF pool	2	Vicinity of GIF pool, monitors dose rate in high bay near pool surface	Audible and visual on high dose rate
Cell maze monitor	1 per cell 3 total	Detector in maze hallway, electronic unit at cell control area	No alarm function, drives cell beacon in maze when source raised and provides CCS interlock
East cell movable wall	1	Immediately outside of movable wall	Audible and visual on high dose rate
Underwater (HIACA)	1	Submerged ~ 1 meter underwater at cell where HIACA used.	No alarm function, provides interlock to CCS if HIACA raised
Recirculation loop	1	Demineralizer on the recirculation loop	Audible and visual on high dose rate

4.5 Non-Safety-Related Support Systems

4.5.1 GIF Site

The GIF, which is identified as Building 6586, is located in the Northeast corner of Technical Area V (TA-V) in an area currently undeveloped (see Figure 4-8). The size and location of the building requires removal of some small storage buildings originally located northeast of Building 6596. The area west and south of the GIF are paved to connect with the existing road. A minimum slope is provided to assure drainage of the paved areas into arroyo to the east of the paved areas. A maximum cross slope is maintained in consideration of the source and instrument trailers which have access to the south and west sides of the GIF. All pavement is asphalt.

Figure 4-8. Northeast Corner of TA-V with GIF



Major personnel access to the GIF is the west side of the building. A canopy and service walk are located on the west side of the building. Parking and vehicle access to the overhead roll-up doors is located on the south side of Building 6586. A large asphalt pad is provided on the south side of the building to accommodate monitoring trailers to be parked next to the building and electronically connected to experimentation equipment inside. Some minor utility removal/relocation is required at the GIF site during construction.

4.5.2 Building Structures

The function of the GIF building (high bay and low bay) is to provide weather-tight structure for the purpose of performing irradiation experiments. The building does not serve as either a containment boundary or confinement barrier to the release of radioactive contamination. The building does not have any effect on the integrity and functioning of the three safety-related system -- the source cladding, water pool and shielded cells. The walls and roof do not serve as radiation shields and their attenuation effects are not considered in the analysis of radiation doses. Consistent with these functions, the requirements on the GIF building are simply those imposed on any DOE-owned industrial structure.

The layout and structure of the GIF building are based on the extensive 40-plus years of experience that SNL has acquired in operating two existing irradiation facilities. The high bay and low bay floorplans are arranged to maintain separability of functions while, at the same time, provide for sharing of the main resources of the facility.

4.5.2.a. Building Layout

The GIF building external view and internal layout are shown in Figures 4-9 and 4-10, respectively. The structure consists of two single-story sections of different heights: the GIF high bay, which contains the pool and cells, is approximately 11.6 meters high and the low bay, which contains the support system rooms, is 4.9 m high. The high bay has a length (east-west wall) of 39.6 m and a width (north-south wall) of 26.8 m. The low bay has a length (east-west wall) of 39.6 m and a width (north-south wall) of 7.3 m. Building areas total approximately 1340 gross square meters with 1060 m^2 in the highbay and 290 m^2 in the low bay.

The highbay is arranged into three regions: the in-cell irradiation facilities in the east side of the room, the in-pool irradiation facilities in the west side, and the offices/laboratories along the west wall

The irradiation cells and wet irradiation facility are located in a high bay space served by a 10 metric ton (10-ton) traveling overhead crane. The structure is precast concrete columns and beams with full height precast concrete wall panels The offices/instrumentation laboratory areas are located in the high bay, within a low ceiling steel stud and drywall construction at the west end of the building. Mechanical, electrical, and steam rooms are located in the GIF lowbay , a single story masonry and steel structure outside the high bay along the north side of the building.

4.5.2.b Structural, Mechanical and Finishes

The GIF high bay structure consists of precast concrete columns and beams with precast double tee roof beams. The exterior walls are non-load bearing precast panels 8-feet wide, 10 - inches thick and 38-feet high. The masonry is finished with a sealer/stain. The precast panels are finished with an acrylic polymer finish. The GIF highbay has a series of square aluminum framed windows (as shown in Figure 4-9) set in east, north and west walls to provide high "clerestory" lighting inside.

The GIF lowbay is constructed of concrete masonry bearing walls with steel beam and metal deck roof. The masonry walls at the low bay and the precast concrete wall panels are supported on cast-in-place concrete beams and on straight shaft drilled concrete piers ~0.6 m in diameter.

The slab on grade leading to the east - west pool is designed for an large, cask-bearing truck. The slab on grade leading into the large cell and the floor of the large cell is designed for a 120,000 pound vehicle load.

The specifications for the construction materials used in the GIF are defined in the Title I and Title II designs. These specifications are as follows:

<u>Reinforcing</u>
Deformed bars, ASTM A615, grade 60 for #5 and larger
Deformed bars, ASTM A615, grade 40 for #4 and smaller

<u>Prestressed Concrete Beams and Tees</u>
Designed, fabricated, transported and erected per latest PCI and ACI Codes

<u>Reinforced Masonry</u>
Uniform Building Code
Hollow unit concrete masonry units (average density between 85 psf and 115 psf),
ASTM C90, Grade N, Type 1, F'm = 1350 psi
Mortar is Type S, 1800 psi at 28-days.
Grout has a compressive strength of 2000 psi at 28-days.

<u>Structural Steel</u>
"Manual of Steel Construction", AISC 9th Edition.
Structural Steel ASTM A36, Fy = 36,000 psi
Structural Bolts ASTM 325N
Welding per AWS Standards, E70 electrodes.
Steel Deck, ASTM A446, Grade A with zinc coating per ASTM A525, G60.

The finishes on all surfaces are intended to comply with Division 0900 of DOE Order 6430.1A. The basic requirement that "where contamination can occur, washable or strippable finishes shall be used on walls, floors, and ceilings." Although contamination is not anticipated at the facility,

Figure 4-9. Elevation Views of GIF Building

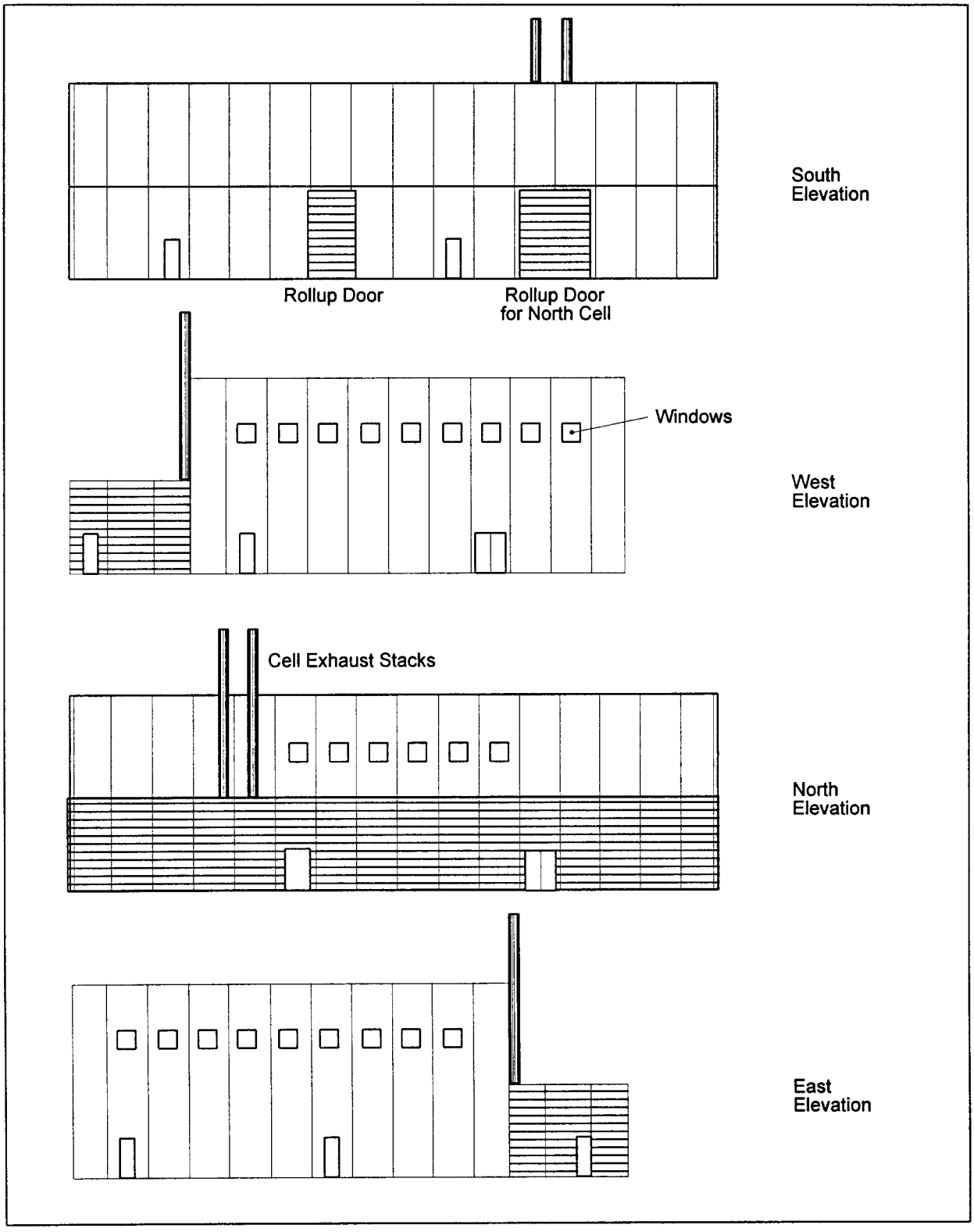
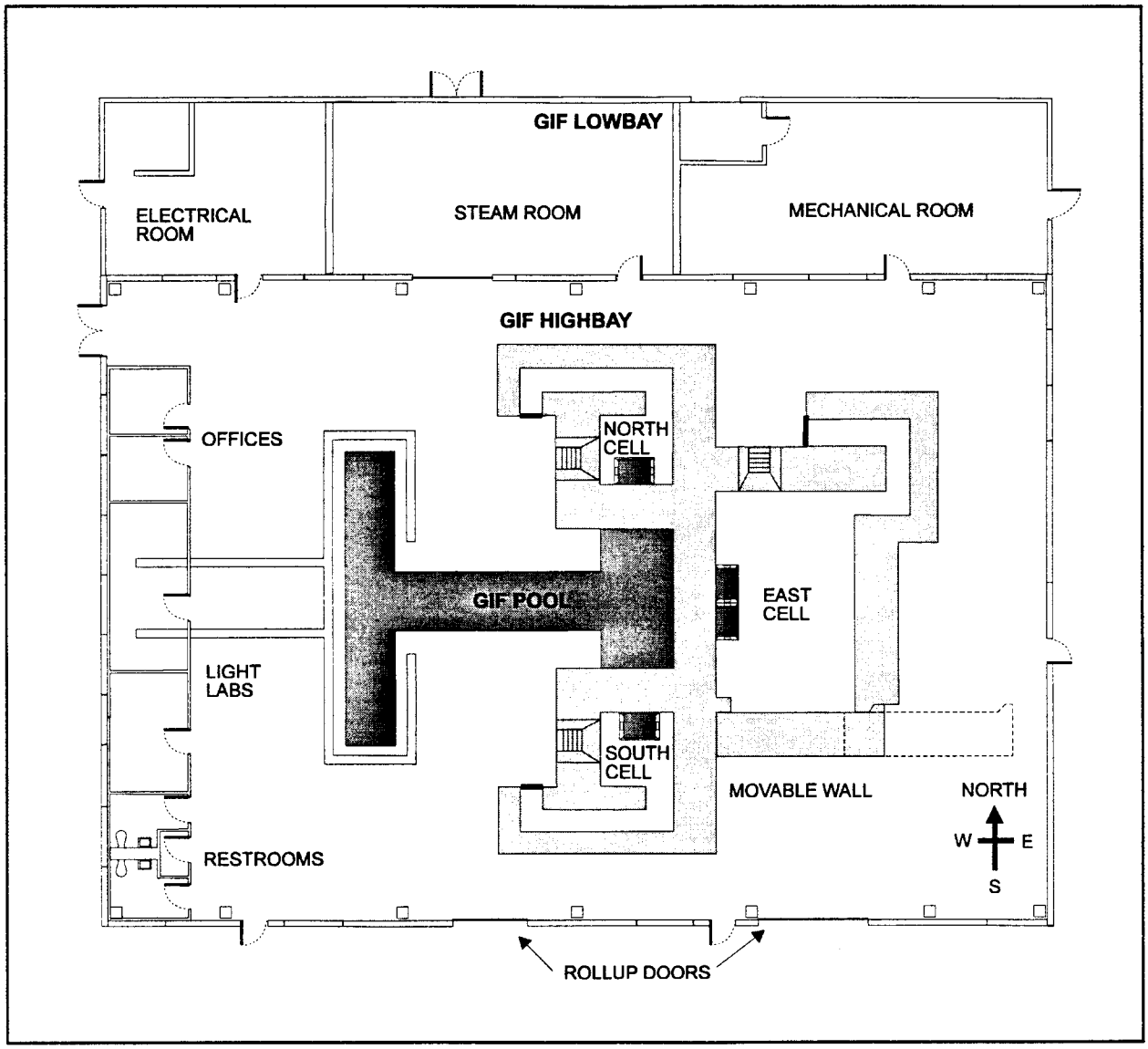


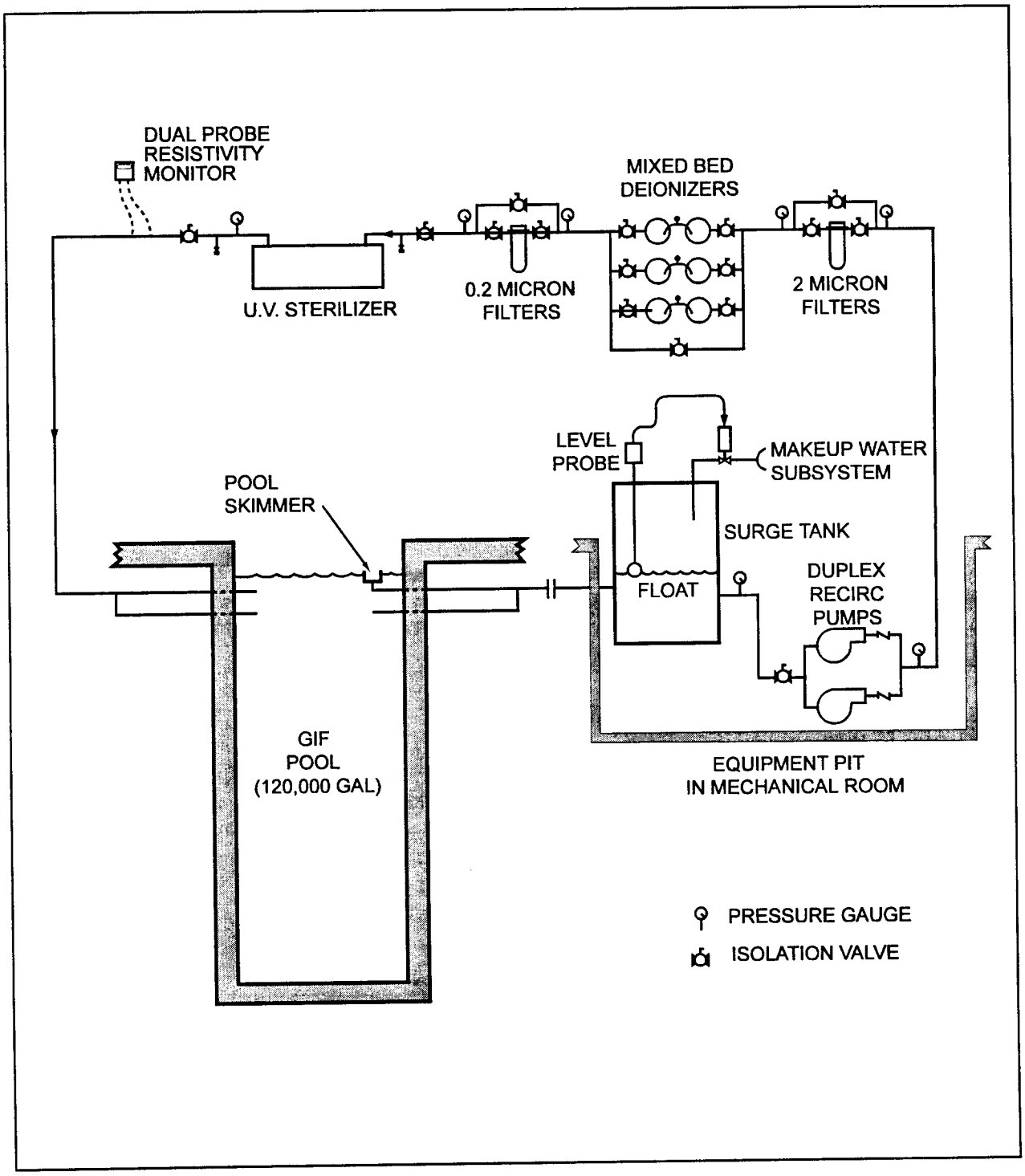
Figure 4-10. Layout of the Gamma Irradiation Facility



the following finishes for the GIF structures complies with this criteria:

Walls - painted concrete on CMU.
Floors - sealed concrete
Ceilings high bay - painted concrete or painted exposed steel deck
Interior office/laboratory spaces - painted gypsum wall board
Office floors - vinyl tile
Office, labs, toilet - acoustic tile.
Windows - aluminum frames with reflective 1/4-inch glass.
Doors - hollow metal doors and frames throughout - painted Insulated metal roll-up
Overhead doors - power operated - painted.
Exterior - acrylic polymer stucco finish and masonry sealer/stain.

Figure 4-13. GIF Pool Water Recirculation Loop



4.5.4.c. Water Supply, Pool Overflow, and Building Drains

Domestic water is provided to the GIF from a connection to TA-V site water piping. Two backflow preventers separate the domestic and non-potable water systems. Domestic water serves facility plumbing fixtures, non-freeze wall hydrants located around the building and evaporative coolers. Domestic hot water is provided by a 160-liter gas water heater. The non-potable system supplies water to the GIF pool make-up subsystem and the experiment steam system.

Sanitary waste from conventional plumbing fixtures will be grouped into a domestic sanitary waste system and connected to the site sanitary waste system, while waste from the steam equipment room and the pool water treatment equipment room will be served by a separate waste system routed to outside of the building and valved for future connection to Area V waste water holding tanks.

The GIF pool along with the recirculation loop are the only subsystems which have the potential for contamination. Therefore drains from these subsystems are directed to the TA-V Liquid Effluent Control System (LECS). The drain for the pool is the pool overflow. The overflow standing pipe is set at a level (with margin) above the normal pool level, but below the level where water could overflow the pool curb.

The LECS contains large-volume tanks which can hold water temporarily while it is sampled. If free of contamination the water is released to the sanitary sewer system. Since there is no potential for radioactive contamination in the high bay or low bay, the building floor drains are directly routed to the sanitary sewer system.

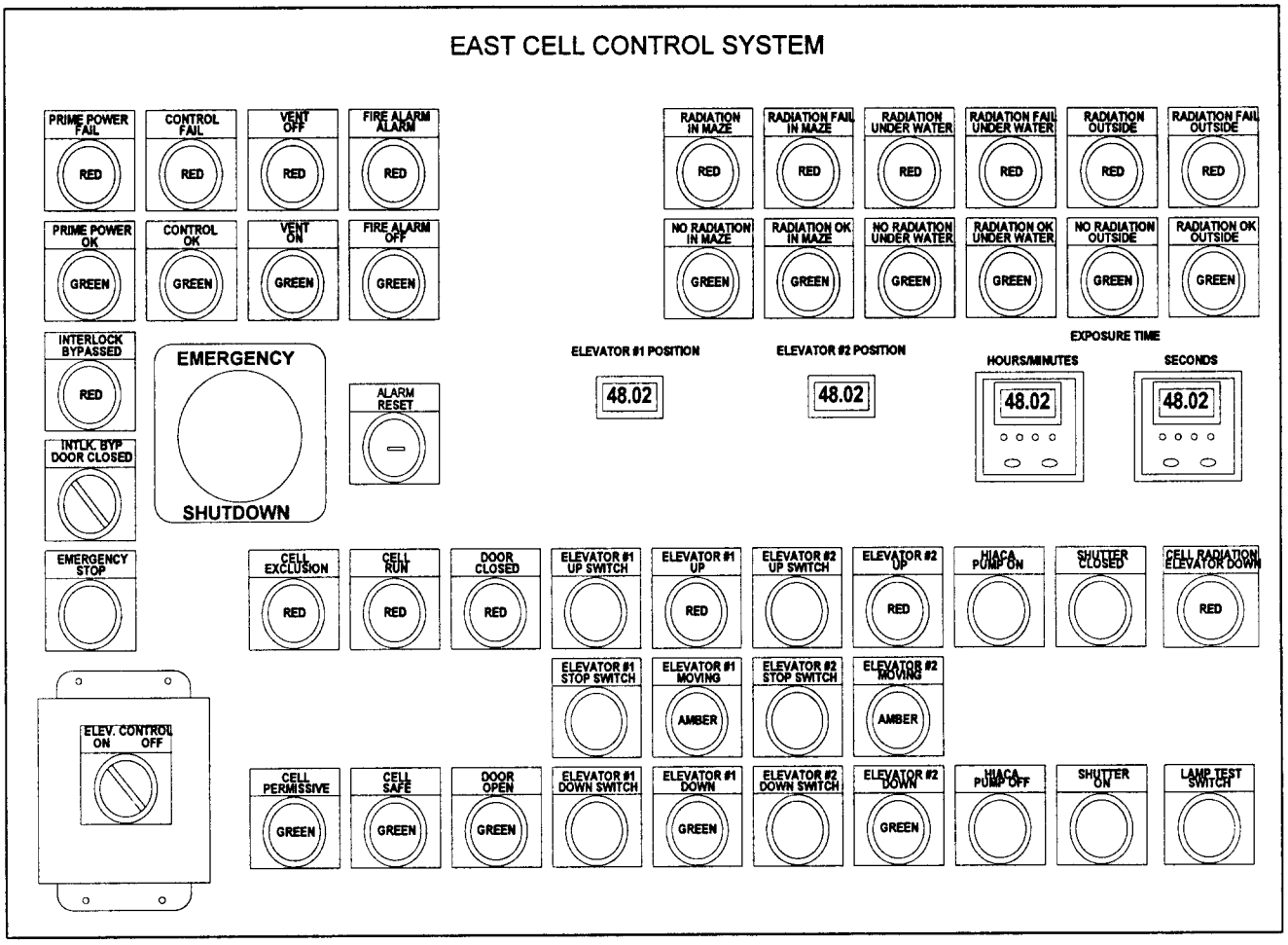
4.5.5 Irradiation Cell Control Systems

Two subsystems are required for the operation of small (north and south) irradiation cells: the cell control subsystem (CCS) and the elevator drive subsystem. For the large (east) cell, these subsystems and the movable wall controls are included in the overall control system for the cell. The in-pool irradiation facilities require no dedicated control system. As previously discussed in this chapter, none of these systems/subsystems provide a safety function but rather assist the operator in performing an irradiation. The accident analysis in Chapter 11 demonstrates that no failure of the cell control systems can impact the safety of the facility.

4.5.4.a Cell Control Subsystem

All controls and interlocks for the operation of the GIF irradiation cells are consolidated into one cell control subsystem (CCS) for each cell. The CCS is a programmable logic controller with a memory resident program to assure all conditions are satisfied prior to performing an irradiation. The interlocks and trips in the CCS serve as a backup to assure that administrative controls and procedures are followed in sequence. Figure 4-14 shows the front panel of the CCS for the large (east) cell with two elevator drives. There is one CCS with front panel for each cell located in the cell control area between the window and the maze entrance to the cell (as shown in Figure 4-4). This provides the operator with visibility of all of the important functions for operating a cell -- the source, cell entrance and cell control subsystem.

Figure 4-14. Cell Control Subsystem Operating Panel



The functional logic, alarms, interlocks, and layout of the cell control system is designed based on standards ANSI N43.10, "Safe Design and Use of Panoramic, Wet Source Storage Gamma Irradiators (Category IV)" and NCRP Report No. 88, "Radiation Alarms and Access Control Systems".[4.9., 4.10.] Because of the potential for doses greater than 100 rem, the GIF level of hazard as defined in the NCRP Report No. 88 is 'Extreme'. This hazard level implies the use of the comprehensive access control and alarm systems. The access control function is provided by the simple, reliable elevator power interrupt (a safety-related system discussed earlier in this chapter). The alarms are incorporated in the cell control subsystem and the radiation monitoring system.

The primary function of the CCS is to consolidate all interlocks, most alarms, and most elevator controls into a single control unit. The CCS includes the visible and audible alarms for warning personnel of an impending hazard. It also includes some access control functions which are similar to the preventive feature provided by the elevator power interrupt. These features represent only backup functions and do not make the CCS a safety-related system. The CCS panel contains warning lights, audible alarms, run/safe switches, and emergency stop switches. The panel is arranged for easy assessment of permissive conditions, normal operation, and abnormal conditions. Functional logic is included to provide detection of other cell conditions

(such as pressure differential trip). This logic also provides for monitoring the functionality of the components of the system.

Redundancy in alarm and interlocks is desirable to provide a level of safety commensurate with the hazards involved. Since the CCS is not an safety-related system, redundancy is not required; however, redundancy has been implemented where feasible. In general, interlock switches and alarms are doubled to provide redundancy. Interlocks are normally open (fail open) and must be closed for operation. The CCS front panel lights follow a standard color convention. Lights indicating permissive entry or safe condition are green, and lights indicating exclusion or hazard are red. Yellow or amber lights are used to indicate movement or a changing status. Paired lights provide redundancy and immediate indication of a burned out bulb.

The main interlocks for each cell are redundant. The elevator drive permissive requires closure of two switches in series in each door for operation. They are also designed to be fail safe. The CCS logic requires a prescribed sequence of steps to prepare a cell for an irradiation. Opening of an interlock out of sequence requires repeating the start up procedure, including searching of the cell. Bypassing the interlocks is only possible with a separate key, accessible to authorized personnel. This bypass is to be used only for preapproved procedures for specific maintenance/repair operations, such as working on an empty elevator in the cell. A timer in the bypass circuitry is incorporated to limit the duration of the bypass action.

Access to the inside of the irradiation cells is required on a routine basis to set up and retrieve experiments. The access control function is intended to keep personnel out of cells when there exists a hazardous environment; that is, when the sources are raised. This access control function is performed by the elevator power interrupt circuit and backed up by the cell RAM's. External indication is provided that a cell is being used for irradiation and entry is not permitted. The indication is performed by the exclusion warning light at the door. A flashing beacon in the maze is activated by the maze RAM and visible through the door window to attract attention when a cell is in use or a high dose exists in the maze.

Control over the sequence of operation for a cell irradiation is provided by a single key. This key is used to: 1) reset the cell-search switch in the cell, 2) reset the run-permissive switches in the maze, 3) lock the maze entrance door, and 4) activate the CCS. After the cell has been searched, the cell-search keyswitch is activated. This allows the operator a preset time (expected to be about one minute) to exit the cell resetting the two run-permissive keyswitches on his way out through the maze. After the door is closed and locked with the key, the operator moves to the CCS at the respective cell window. With the key, the operator activates the elevator control acknowledging that the cell is clear and the irradiation may start. From this panel, the operator can raise and lower the source elevators. The operation of this panel requires the successful completion of the key reset and lock sequence. This key is retained captive in the control console while the source is raised into the cell. Removing the key from the CCS panel assures that the source is down

The detailed procedure for performing an irradiation in a cell along with alarms and interlocks is described in Table 4-6. Administrative procedures backed up by the CCS interlock sequencing assure that the cell is clear before an irradiation can begin and that the cell cannot be entered until the irradiation is complete (with allowed time for ozone purging).

Table 4-6. Typical Operating Sequence for Cell Control Subsystem (CCS)

1. Cell and experiment being prepared for an irradiation.
   a) Experimenters and/or operators are present in cell preparing test units for irradiation.
   b) Cell maze door is open and cell is accessible.
   c) Cell interior lights are on.

2. Cell cleared.
   a) Experiment preparation complete.
   b) GIF operator announces impending irradiation.
   c) Operator assures that cell cleared of all individuals by a physical search.
   d) Operator again announces and turn off and on interior lights.

3. Activation of the cell search complete key switch (note: key is not captive in this position).
   a) Turns off the cell accessible light at the cell door.
   b) Turns on the cell exclusion light at the door.
   c) Starts a timer for the start up process.
   d) Activates a visible and audible signal in the cell warning of impending operation.

4. Close the run/permissive keyswitches through the maze (uses the same key used for activation the cell search keyswitch)
   a) Closed in specific order. This verifies that a search of the cell was made and last egress being conducted.
   b) Run/permissive switches are reset to safe whenever any interlock is activated or the cell door opened.
   c) Cell safe light goes out, cell run light comes on.

5. Close and Lock Door.
   a) The door open light goes out
   b) Then the door closed light illuminates.
   c) The maze door is then locked on the outside with the same key.

6. Operator moves to the cell control console and activates the cell control system within the preset time after the cell search keyswitch was set. (this time interval is expected to be about 60 sec).
   a) The key remains captive in the cell console as long as sources are exposed. A locking cover prevents removal of the key for maintenance of accountability.
   b) A 20 second delay is provided before sources start to be raised into cell. Visible and audible alarms in the cell activate during this 20 second period.
   c) An Emergency Stop switch in the cell will immediately lower the elevator and sound an alarm horn on the cell control panel.
   d) An Emergency Stop switch on the cell control panel also will immediately lower the elevator.

7. The source elevator may be raised by the operator if the following conditions are met: the door interlocks show the door is closed and latched, the RAM monitoring the inside of the maze is functional, the RAM monitor underwater (for the HIACA cell) is functional, and the ventilation system is providing negative cell pressure.
   a) An audible oscillating alarm in the cell sounds as the source elevator transits between the fully shielded position, and the fully exposed position.
   b) The elevator may be stopped at any position along it's travel, by pressing the 'Stop' button. Raising or lowering of the elevator may be resumed by pressing the appropriate control button.
   c) Lights on the control panels indicate the position of the elevator. In addition, a position read out from the elevator drive subsystem is displayed on the CCS panel.

8. Certain conditions will cause the source to automatically lower and become shielded as follows:
   a) Removal of the key used to activate the cell control system.
   b) Opening of the maze door for all cells and the movable wall for the large cell.
   c) Detection of heat and/or smoke in the cell exhaust. The fire alarm system is zoned to provide individual indications to each cell control system for the associated cell.
   d) Failure of the primary electrical power for more than 10 seconds.
   e) Failure of the RAM monitoring the maze and cell.
   f) Loss of ventilation to cell as detected by the pressure differential.

Table 4-6 (continued). Typical Operating Sequence for Cell Control Subsystem (CCS)

9. Activation of any interlock causes the cell control system to resets and requires reopening of the cell to determine the cause of the interlock activation, and re-initiation of the search and closure procedure described earlier.

10. At the end of the specified exposure, the elevator automatically lowers back into the pool.
    a) For timed exposure, the timers are set to lower the source at the end of the preset time. Electronic timers with a memory are provided to maintain the elapsed exposure time in the event of an interrupted exposure. The timers are started and stopped by the upper limit switches on the elevators. Desired exposure time is set into the two timers, one for 99 hours 59 min., the other for 99.99 sec. This provides exposure time of 100 hours with a resolution of 0.01 seconds.
    b) The elevator down button lowers the elevator regardless of any other condition of the panel switches. This includes the elevator control "ON-OFF" switch, as well as the settings of any timers.

11. To provide time for ozone purging of the cell, a timer starts when the elevator reaches the fully down position.

12. The cell RAM is active during the entire radiation process. The sensitivity of the RAM is set such that it is tripped when the source is present and when one or more pins are detected. The tripped RAM does not allow the door to be unlocked and opened from the outside.

13. The cell maze door may be opened if the following conditions are satisfied.
    a) The cell radiation detector and the radiation detector under the pool surface are not failed and are indicating no radiation.
    b) The source elevator is at the bottom.
    c) The ozone delay timer has expired.

14. The cell control system is disabled by turning off, and removing, the key.
    a) The permissive access lights are turned back on.

The cell control system does not require backup power. A small UPS is provided for each CCS to assure that the source has attained its full-down storage position when facility power is interrupted for more than ten seconds. It is protected from intentional or inadvertent tampering. The CCS programmable logic controllers is enclosed in a locked cabinet immediately behind and below the CCS front panel (one per cell). Locking covers are provided over the operating panels in a similar manner to limit access to only qualified operators. The wiring and other components will be installed in conduits and other protective enclosures to prevent damage or tampering. A locking cover provides over the elevator "ON-OFF" switch to provide for physical security of the key when it is left in the panel during extended exposures.

For servicing, certain CCS functions may be bypassed. The key is different from the key used to activate the cell control system. The bypass key will be administratively controlled by the line management.

4.5.4.b Elevator Drive Subsystem

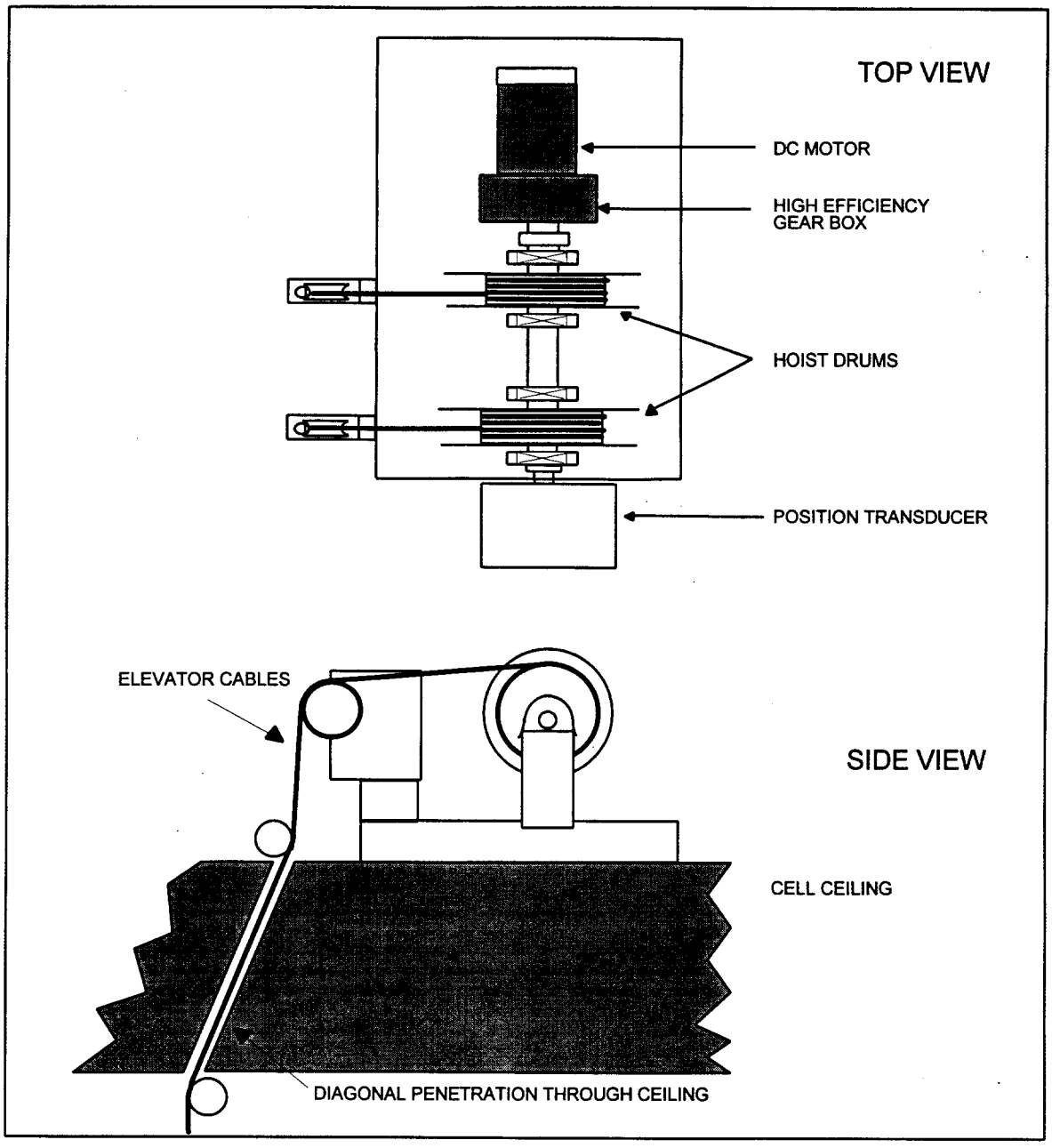
An illustration of the source elevator drive subsystem is shown on Figure 4-15. There is one drive for each small cell and two drives for the large cell. Two 1.0-cm stainless steel cables lift the elevator platform that carries the source cart. The cables run up to the ceiling of the cell where they are turned 30 degrees from vertical by pulleys mounted on the ceiling. Each cable runs through a 1.9-cm inside-diameter tube through the roof at that angle. The change in direction is necessary to reduce radiation streaming. On top of the cell each cable is turned back to vertical by another pulley and then turned horizontally by a swivel pulley. Each cable is wound up on a separate grooved drum. The final pulley swivels so the cable will track the grooves in the drum. The drums are mounted on a common shaft; therefore, the cables move at the same speed and the same distance. Although the cables through the ceiling are turned off vertical to avoid a direct radiation path from the sources, there may be some additional shielding required and the final design will be determined in Title 2 design. The whole drive unit is less than .8 m in height, well below the crane bridge.

The design load capacity of an elevator drive is 1140 kg (2500 lbs.). The cart and elevator mass is about 360 kg (800 lbs), therefore, the source and source fixture mass can be up to 680 kg (1500 lbs). The lifting speed is about 7 cm/s. The mechanical lifting components have a safety factor of five. In the small cells the elevator stops ascension at the floor level. The vertical travel distance from full-down to full-up position is approximately 6.1 meters. In the large cell the two side-by-side elevators drive subsystems are independent of each other and stop at 61 cm above the floor level. In the cell control system, these two elevators can be driven at the same time to allow their simultaneous ascension into a cell.

For normal raising and lowering, the elevators are driven by a DC motor and gear box (as shown in Figure 4-10). The motor is powered by a regenerative DC motor controller. The regenerative type is employed because the controller must absorb power during descent of the platform to control speed. To allow back driving of the elevator, the gearing between the motor and the drums is reversible. The gear box is a three stage helical type. The forward efficiency of the gears is 98% per stage. The efficiency in the reverse direction is above 90%. As a consequence the gearing can not hold the elevator above the full-down mechanical stop. In normal operation the platform is held by a solenoid operated brake on the motor shaft.

The elevator drive subsystem satisfies the special requirement that the elevator drop from any raised position in the case of a power failure that lasts more than ten seconds. Upon loss of power, a spring releases the solenoid brake and the platform descends. In order to delay this action for ten seconds, the brake power is supplied by an UPS. If the building power is not restored in ten seconds, the UPS power is removed from the brake and the source elevator drops. The drive subsystem is designed to control the descent and thereby prevent free fall of the sources. A power absorbing resistor is employed along with the permanent magnet field of the DC motor. The motor leads are switched from the controller to the resistor when the raised position is reached and the brake is set so as to be ready in case of power failure. The descending platform drives the motor backwards, which then acts as a generator pumping power into a fixed resistor. This action effectively causes dynamic braking of the platform. The platform moves down at a constant speed depending on the size of the resistor and the weight on the platform. The resistor is sized so that the elevator moves down at 7 cm/s when there is a full load on the platform. With lighter loads, the elevator moves down more slowly.

Figure 4-15. Elevator Drive Subsystem



The motor controller provides several additional useful features. One is speed control. The speeds can be controlled from near zero to 100% by the operator and/or by being switched automatically by the position sensing system. For example, the approach to the final position of the elevator can be done at a reduced speed. Another feature is torque limiting to minimize the chance of source damage. The controller can be adjusted so that the motor torque cannot exceed the preset limit, such as 125% of full load. Other features include controlled acceleration and deceleration which can be employed if applicable experiments.

The drive system includes two different types of position sensors -- an electronic limit switch and a rotary limit switch. The electronic limit switch, which is coupled to the drum drive shaft, is

a geared assembly of two electromagnetic position transducers (resolvers) that produce a unique signal for any shaft position regardless of the multiple turns. No turns counting is involved that would be lost when the power is off, hence, the instrument is an absolute fail-safe position transducer. Multiple limit points can be set in addition to ends-of-travel, such as slow-down points or different stops. From this sensor, the elevation position is displayed on the CCS front panel in engineering units (centimeters). The other position sensor is a worm-geared rotary limit switch. This unit contains two conventional limit switches that can be set up to trip at the limits of travel. These are used as a back-up for the resolver system.

The drive also includes an assembly that detects a slack cable condition. This unit is used to stop the drive in case some obstacle is hit during lowering. It is also used in conjunction with the position sensor to verify that the elevator is fully down.

Each elevator is a cantilevered platform, which glides along two vertical rails on a linear roller bearing. The rails are attached to the pool walls and run from the pool bottom to the floor of the cell. For the large cell the rails extend into the cell ~.6 m. Throughout the vertical travel, the rails maintain the elevator centered with respect to the opening in the floor of the cell. The rails for the elevators in the large cell include a supporting structure tied to the pool walls. In case of failure of electronic limit switches, each rail has a mechanical stop just above the full-up position to prevent the drive from pulling the elevator above the rails.

The lifting cables are routed to the back of the elevator to about 10 cm from the wall. This is to avoid interference with the cell manipulators. The cable lifting points on the elevator platform are near the wall which produce some off-center torque's on the rollers. The rollers are rated to accept the torque.

The elevator is accurately guided into place at the bottom of the pool by a pair of tapered dowel pins. This makes the rails on the elevator align with the rails on the pool bottom so the source cart can be easily rolled on and off the elevator.

4.5.6 Emergency and Intrusion Systems

This GIF is inside of the Technical Area V boundary which includes evacuation and fire alarm systems to support all of the nuclear facilities at the site. Evacuation alarms and fire alarms are connected to one TA-V alarm bell/enunciator system with the response procedure being identical for both alarms -- that being immediately evacuate all personnel to command and assembly points. Conditions detected within the GIF may require activation of the TA-V fire/evacuation alarm.

4.5.6.a Fire Protection

The GIF building is protected by a wet pipe sprinkler system designed and installed per NFPA requirements, SNL and DOE Design Criteria and all applicable codes. The fire alarm system is manufactured by Honeywell in order to interface with the existing SNL fire alarm system. The main indicator panel is located at the main entrance to the high bay.

The sprinkler system includes an automatic fire department alarm connection activated by the Honeywell panel. In addition to the switches inside the building the DGP receives signals from two sprinkler risers with alarm check valves and flow switches extending up the exterior of the

building. One of the risers serves the high bay and the second riser serves the low bay equipment rooms.

The fire alarm system is a zoned system with manual pull stations, heat detectors, water flow switches, tamper switches, visual devices, and bells. The manual pull stations are located at all exit doors. The heat detectors are located within the spaces of the building. The water flow and tamper switches are located on the fire sprinkler system. The bells are located throughout the building to provide adequate audible signal at any point within the building to satisfy American Disability Act requirements. The GIF fire alarm system is interfaced the TA-V fire/evacuation system which in turn is interfaced with the Kirtland Air Force Base Fire Department over telephone lines.

The fire alarm system is also interfaced with a mechanical system to activate the high bay smoke removal system. The high bay evaporative coolers and the exhaust fans are controlled to operate in a smoke removal mode upon receiving a signal from the building fire alarm panel. In the smoke removal mode, the exhaust fans and the interlocked evaporative coolers run at high speed. A switch enables the fire department to activate the smoke removal mode manually. Applicable codes do not require a smoke removal system for the low bay.

4.5.6.b Intrusion Alarm Systems

The GIF is located inside the TA-V perimeter which provides a very high level of security and access control for all of the nuclear facilities in TA-V. The TA-V perimeter consists of two standard security chain-link fences with a Perimeter Access Building (PAB) for personnel and vehicle access to the facilities.

The GIF intrusion alarm system consists of magnetic door switches on all exterior doors with signals supplied to multiplexer cabinets. The multiplexer is connected to a security command center. The intrusion system is active during all non-working hours including weekends.

4.5.7 Electrical Systems

The electrical design is based on the SNL, DOE, and IEEE design criteria. The design also satisfies the DOE Energy Conservation Manual. No GIF components require power to maintain the facility in a safe shutdown condition. The radiation protection and control system components that require some operation during loss of power are supplied by individual UPS and battery backups to extend operation through short power outages. All systems and subsystems are power fail-safe with active components returning to safe configurations on loss of power.

4.5.7.a Electrical Supply

Power to the GIF is supplied from two substations (Substation 6 and 17) outside of the TA-V. The underground power ducts extend from the Office/Light Lab Building (6556) outside of the area, through the PIDAS utility penetration at the west side of Area V, routed north of the 6580/88, and turned south to a pad-mounted transformer at the GIF. Power feeds from both Substation 6 and 17 with a manual switch over at the GIF. Should power be lost on one transformer, the building power can be switched to the second primary feed

4.5.7.b Lighting

The high bay interior lighting consists of fluorescent lights and metal halide lamps. Energy saving fluorescent lamps operated with electronic ballasts are used as the main fluorescent lighting source in the high bay, office areas and the low bay equipment rooms. Metal halide lamps operated with ballasts are used for the illumination of main high bay areas and the irradiation cells. The metal halide lamps operate within sealed industrial bulbs. The bulbs contain a quartz lamp for automatic restrike during a momentary power outage and are also be used for emergency lighting during an extended power outage. The high bay is illuminated to a level of 50 candles, offices to a level of 70 candles and the irradiation cells to a level of 100 candles.

Interior lighting is controlled by switches at the entrances to the space with exception of the irradiation cells where the lighting is controlled in the cell and at the cell control area.

Exterior lighting is provided for security. Sodium lamps operated with ballasts are used as the lighting source for all of the GIF exterior. The building perimeter is illuminated to a minimum of 0.2 candles.

Lighting for in the GIF pool is provided by stationary and movable sealed-beam underwater lamps. In-pool lighting is used during source handling/transfer operations and is normally off to minimize algae growth.

4.5.7.c Power Receptacles

The GIF high bay, low bay, offices and irradiation cells contain general-purpose power receptacles. All electrical power in the vicinity of water (GIF pool, pool water systems, and building exterior are equipped with ground fault interrupt (GFI) type receptacles. A number of 20 ampere, 120 volt duplex receptacles are provided throughout the building

One 20 ampere, 208 volt, single phase and one 20 ampere, 208 volt, three phase receptacle are provided in each irradiation cell. A 5 KVA of 20 ampere, 120 volt duplex receptacle is provided at the control area for each irradiation cell .

4.5.7.d Power Panels

Power distribution panels for the GIF are located in the electrical equipment room. A 1200 ampere, 277/480 volt, three phase switchboard with a main circuit breaker supplies all power to other power panels. The switchboard is equipped with ampere and volt meters. In general, 277/480 volt panelboards are used for fluorescent lighting and other loads requiring 480 volts while 120/208 volt panelboards are used for receptacles and loads requiring 208 volts.

The mechanical equipment are also served from the switchboards located in the electrical equipment room. Motors for mechanical systems have local motor control centers.

4.6 Miscellaneous Support Systems

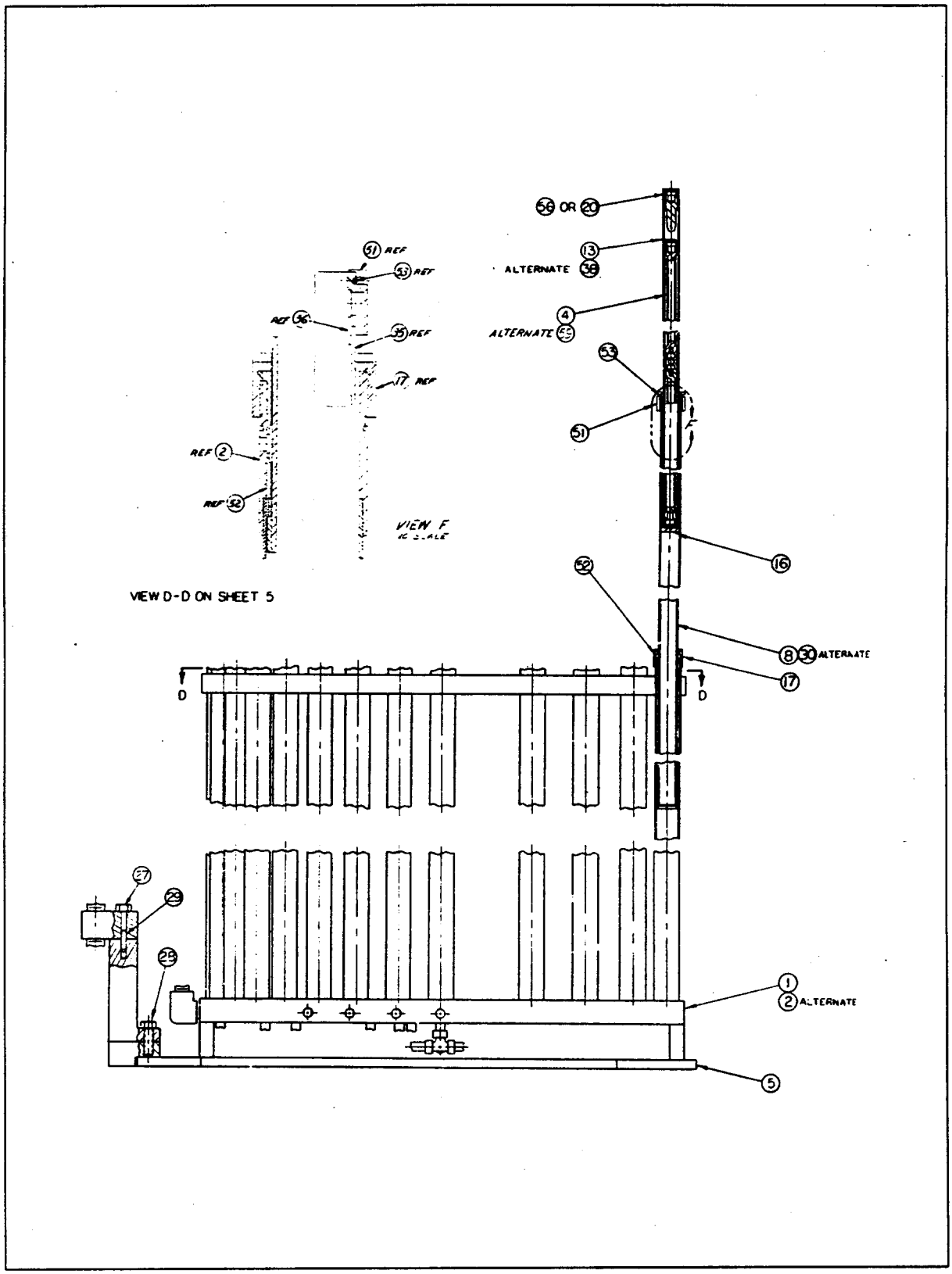
4.6.1 In-Cell Irradiation Fixtures

Sources for the irradiation cells are provided in a number of intensities and configurations. The intensity is determined by the number of pins in a fixture, their original strength, and the amount of decay (that is; the age of the pins). Based on design of the cell walls, sources for the dry irradiation cells are limited to a maximum of 250 kilocuries per fixture. This assures that no more than 250 kilocuries can be raised into the small cells (one elevator each) and 500 kilocuries into the large cell (two elevators).

The normal dry irradiation process consists of source pins held in a fixture, which is attached to a cart, and raised into the cell on the elevator. The fixture, which holds the pins, is available in a number of configurations including: a rectangular array, a circular array, a circular ring, a rectangular ring , and a planar array with movable wings which can be preset at various angles. Normally, source pins remain in a single fixture for extended times (~10 years) until the cobalt decays beyond usefulness or a new fixture configuration is required. Fixtures in use at the existing GIF will be transferred to the new GIF. New fixtures will be made as new sources pins are obtained. All new fixture designs are reviewed by the RCSC and approved by line management.

The High Intensity Adjustable Cobalt Array (HIACA) is a special fixture which allows changes in source intensity and configuration during a single irradiation test. Figure 4-16 shows an illustration of the HIACA. With the HIACA positioned just below the water surface in the cells, up to 8 banks of 4 pins are hydraulically raised into the cell at 90 degree circular intervals. The hydraulic system is supplied by pool water with pressure relief and leakage returned to the pool. The pins are fully contained in stainless tubes which provide the vertical motion. The HIACA has been in use on the existing GIF for almost 10 years. It will be relocated to the new GIF's south cell.

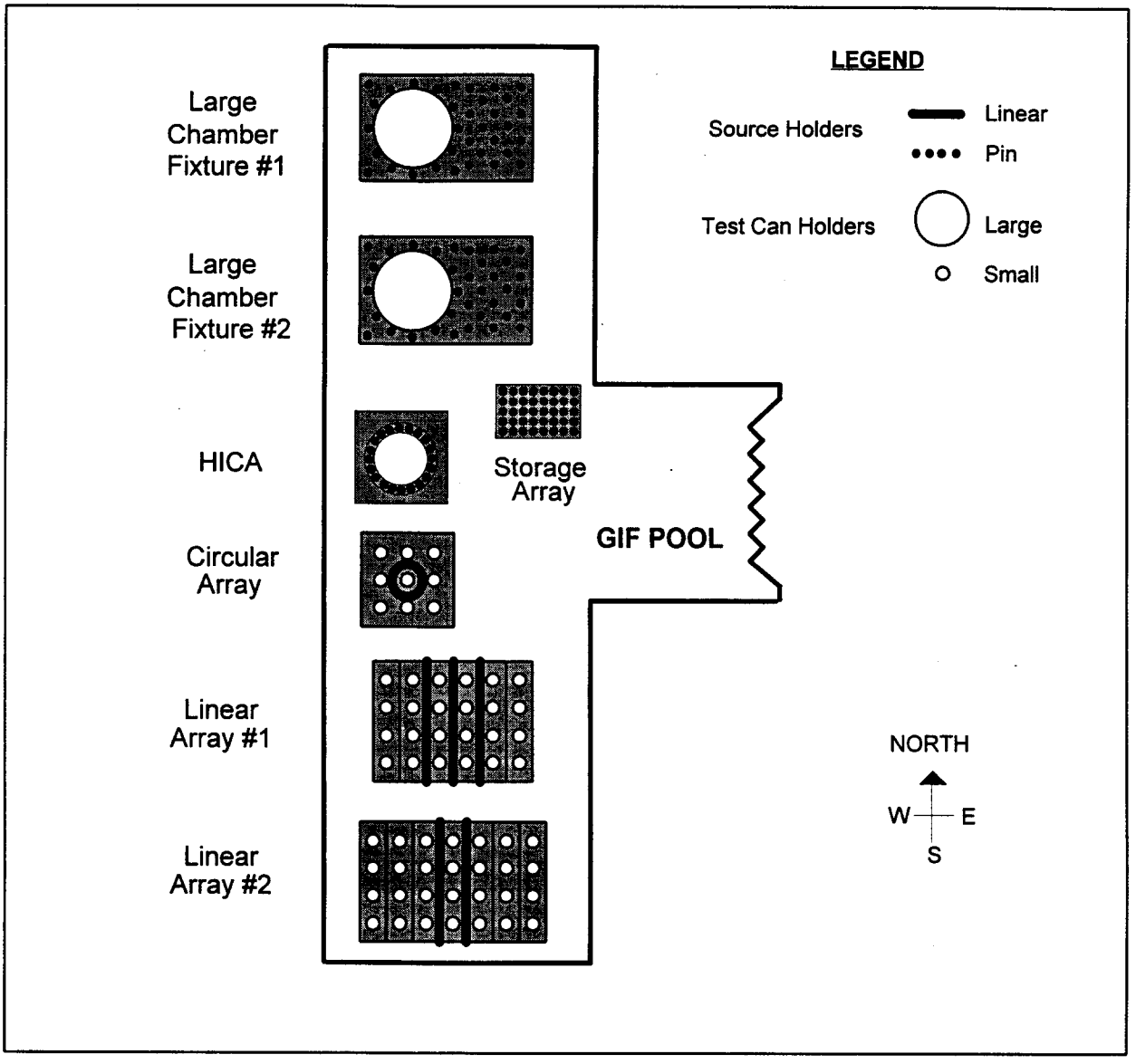
Figure 4-16. High Intensity Adjustable Cobalt Array (HIACA)



4.6.2 In-Pool Irradiation Fixtures

The in-pool wet irradiations are performed at the east side of the GIF pool. Figure 4-17 shows a possible arrangement for the in-pool irradiation fixtures at the bottom of a pool. The fixtures are configurable by positioning radioactive pins in the irradiation source holders. Experiments canisters containing test units are immersed in the pool and positioned in test canister holders in the irradiation fixture. Positions are mapped for flux levels for different configurations of the source array and test canisters. Because only experiment canisters are moved between the submerged irradiation fixture and the pool surface, radiation sources are never brought to the surface. Test units are preconfigured in experiment canisters and often sealed for dryness with instrumentation leads routed to the surface for monitoring the test.

Figure 4-17. In-Pool Irradiation Fixtures



Air is available for purging the experiment canister if necessary. Air supply, exhaust purge, and instrumentation/power lines are routed through the perimeter cable trench which goes around the pool and over to the a laboratory area, where experiment monitoring and data acquisition can be performed.

The in-pool irradiation fixtures are custom designed to specific source and test canister configurations. Figure 4-12 shows the following six test fixtures currently available for the in-pool irradiation facility; additional fixtures may be built to match specific experiment needs.

1. Two linear arrays consisting of fixed Co-60 pins for low flux, long time irradiations with a planar source array.
2. Circular array for a near symmetrical, uniform irradiation.
3. High Intensity Cobalt Array (HICA) fixture for high dose rate irradiations of medium size canister.
4. Two large chamber cobalt fixtures for symmetrical or planar irradiations of large experiment chamber.

4.6.3 Cranes

An overhead bridge crane spans the entire GIF high bay. The direction of the bridge travel is east and west and the trolley travels north and south. The crane rail beams are supported on haunches on the cast-in-place concrete columns and have lateral steel bracing on each side of the high bay. Two hooks are available on the trolley both with a 7.6-m lift capability:

- 9 metric ton (10 ton) primary crane intended mostly for shipping casks or other extremely heavy objects
- 4.5 metric ton (5 ton) auxiliary hoist mostly intended for handling large experiment canister in the pool and high bay.

A 5-ton building jib crane may be located on the roof of the GIF high bay (to be determined in the Title-2 design phase).

Housed within the high bay area will be a 10-ton bridge crane with a 25 foot hook height and with a 5-ton auxiliary hoist. The bridge crane will span the width of the building and will run the entire length of the building stopping at the last bay at the west end. There will be a 5-ton monorail in the small cell on the south side with removable track.

4.6.4 Source Handling Tools

The source handling tools consist of a number of custom, specialized tools used primarily to seize pins and move source carts underwater near the pool floor. The tools are all long (~ 7 meters) and made of light metal -- usually aluminum. The upper end caps of source pins are notched to allow seizure and release of the pin with a remote handling tool. The tools are customized for the particular batch of source pins. The tools will contain vent and drain holes to assure there is no radiation streaming through a voided tube to the surface.

4.6.5 Steam System

The existing LICA facility contains a steam system that is used to conduct environmental testing of reactor containment components. A similar steam system is provided in the new GIF. The steam system is a stand alone experiment facility that is fully housed in the GIF low bay steam equipment room. After an irradiation in the in-pool facilities of the GIF, irradiation canisters containing the test units are removed from the pool and moved to the steam room. Using the steam system, test units are subject to hot pressurized-steam environments similar to those postulated for a large PWR/LWR accident. The steam testing is performed in the steam equipment room.

The preliminary steam system design is shown in Figure 4-18. The system includes two 8 horsepower electrode type stainless-steel steam boilers rated at 250 psig, a boiler feed water system, a blowdown and feed system, a nitrogen system, an electric-powered super heater and an accumulator. All pressure vessels are ASME stamped and the entire system complies with Sandia's pressure safety program.

The steam system is controlled with a dedicated programmable logic controller (PLC) that has the following control functions:

1) Lead/Lag operation of boilers
2) Automatic switch over of duplex DI water system
3) Nitrogen gas injection
4) Control of solenoid shut-off valves
5) Modulating of electronic pressure reducing valves
6) Monitoring of steam pressure and temperature
7) Accumulator fill
8) Lead/Lag operation of feed water pumps
9) Superheater control.

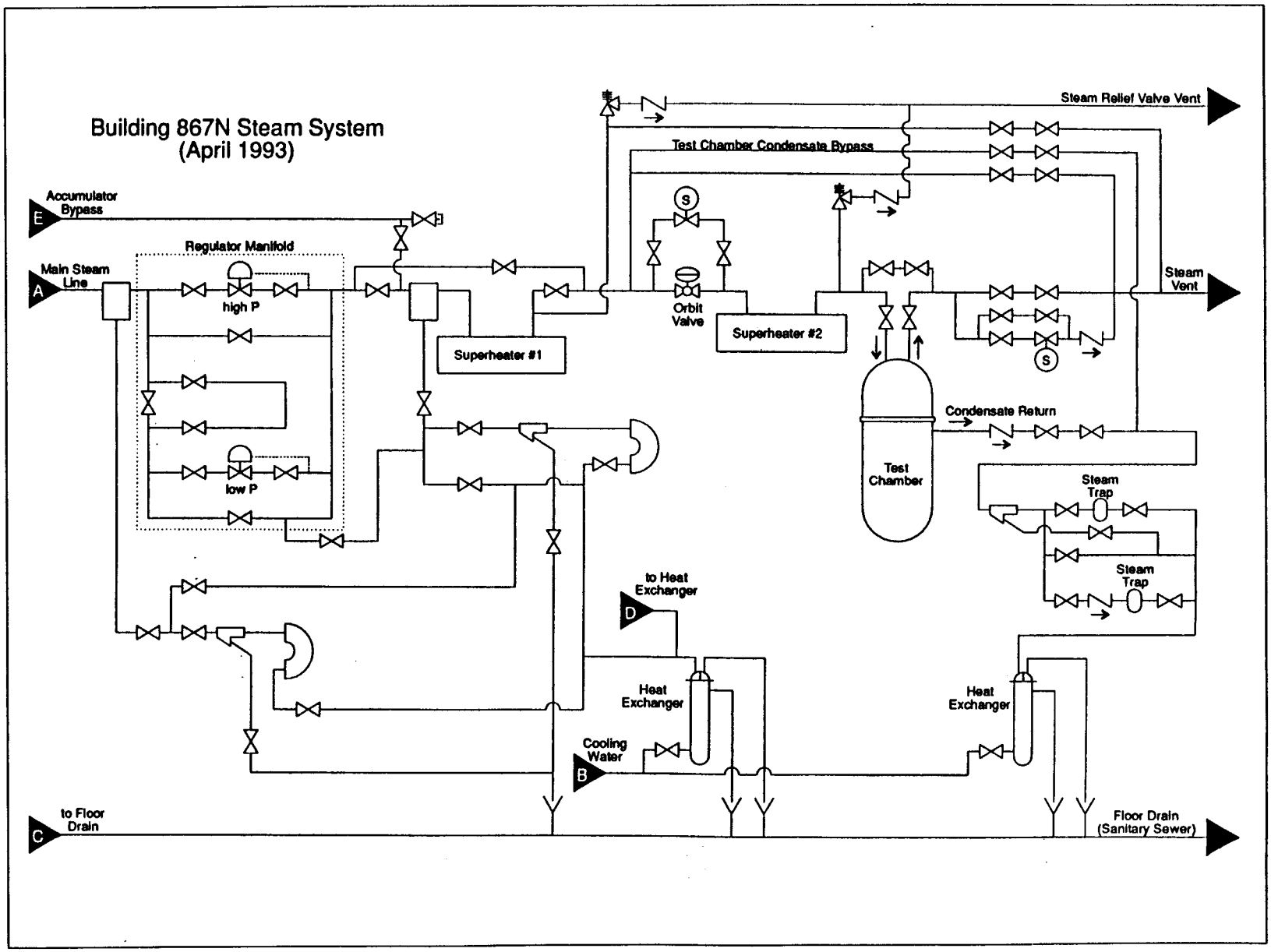
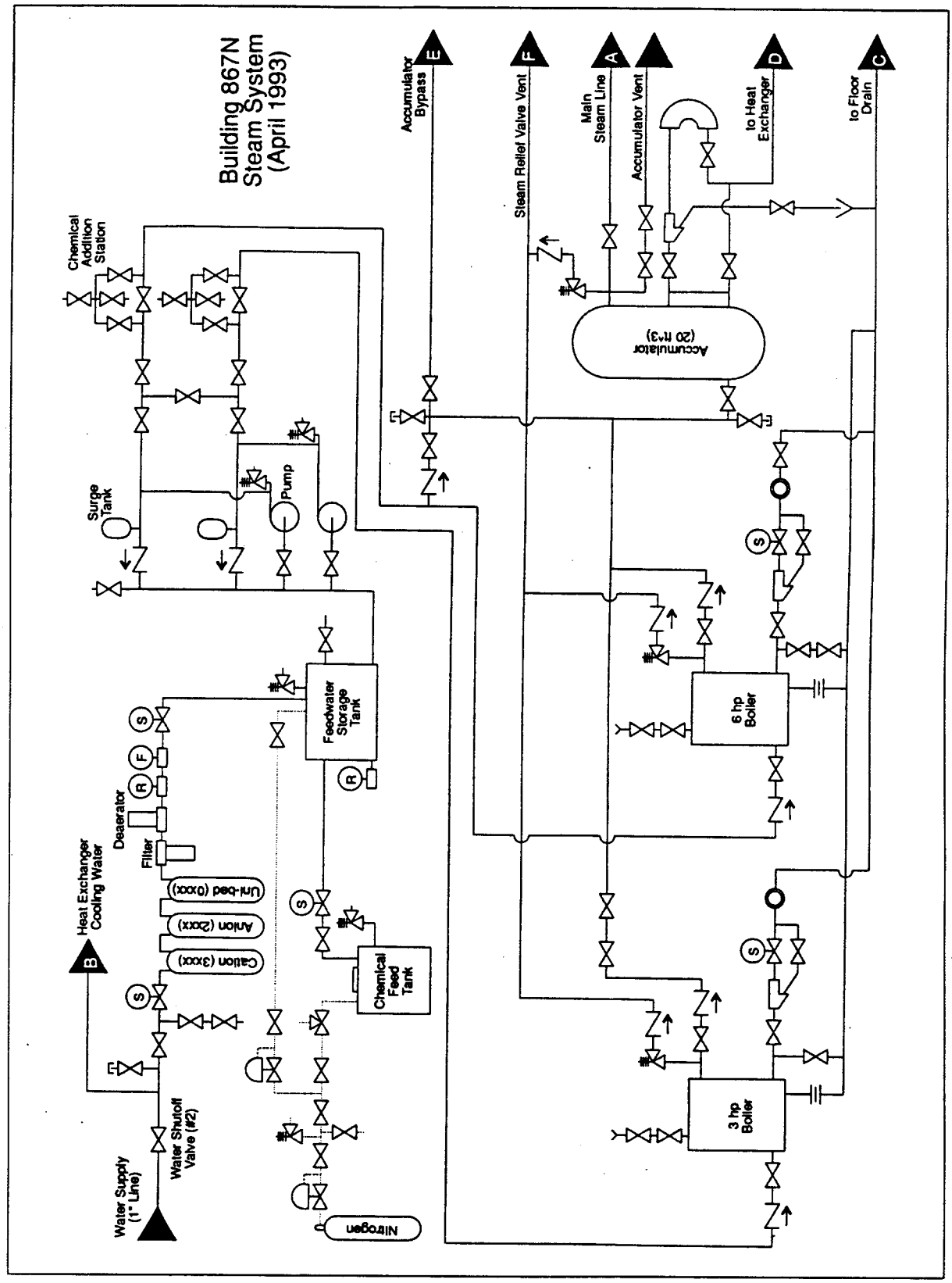


Figure 4-18. Preliminary Steam Supply Subsystem

Figure 4-18 (continued). Preliminary Steam Supply Subsystem



4.7 References

4.1 6430.1A, United States Department of Energy General Design Criteria, April 6, 1989.

4.2 SNL Facilities Development Center Design Manual.

4.3 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, December, 1992.

4.4. ANSI N43.6, "Sealed Radioactive Source, Categorization".

4.5. Code of Federal Regulation; 49 CFR 173.436 "Research and Special Programs Administration, DOT"; 12-31-91 Edition.

4.6. LEC's Title II Design March 1993

4.7 Internal Memorandum to J. W. Bryson, 6521; from K. R. Boldt, 6523, subject: "Evaluation of GIF and ACRR Evaporation Rates"; 3/1/93.

4.8 Internal Memorandum to J. W. Bryson, 6521; from K. R. Boldt, 6523; subject: "Further Analysis of GIF Evaporation Rates"; 4/1/93.

4.9 ANSI N43.10-1984, "Safe Design and Use of Panoramic, Wet Source Storage Gamma Irradiators (Category IV)"; American National Standards Institute Subcommittee N43-3.4; Approved March 13, 1984.

4.10 NCRP Report No. 88, "Radiation Alarms and Access Control Systems"; National Council of Radiation Protection and Measurements; December 30, 1986.

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5. HAZARD ANALYSIS AND CLASSIFICATION OF THE FACILITY

This chapter describes the hazard analysis and classification process used in designating the GIF as a Hazard Category 3 nonreactor nuclear facility. This process is identical for all nuclear facilities at SNL (reactor and nonreactor), and has been demonstrated to be an effective means for determining hazard classification of these facilities.

5.1 Hazard Classification Methodology

5.1.1 Regulatory Guidance

In accordance with DOE 5480.23, the hazard classification for nuclear facilities is based on the inventory of materials, the material form, and the potential energy sources involved in postulated bounding accident scenarios.[5.1] Guidance in applying these criteria is provided in DOE-STD-1027, wherein the category of facility may be determined by comparing nuclear inventories to the thresholds presented in Attachment 1, Table 2 of the guidance.[5.2] According to this guidance, sealed sources meeting the criteria set in ANSI standard N43.6 may be excluded from this inventory, as may radioactive inventory stored in containers meeting certain DOT criteria.[5.3, 5.4]

5.1.2 Sandia Procedure

Facilities are classified according to nuclear vs. non-nuclear status, and the category is set for nuclear facilities according to DOE criteria as described above. The proposed classification is formally submitted to the Kirtland Area Office (KAO) of the DOE by Sandia's Risk Management Department. A "Safety Documentation Determination (SDD) Form" (see Attachment 5-A) accompanies the proposed classification. If in concurrence with the proposed classification, the KAO either returns the form with an authorizing signature or fails to communicate disagreement within 180 days, Sandia then develops safety documentation appropriate to the level of hazard presented by the facility. Attachment 5-A shows the SDD form for GIF which identifies the facility as a Category 3 Nonreactor Nuclear Facility requiring a SAR as safety documentation.

5.2 Description of Typical Operations

The proposed GIF has two types of irradiation facilities (dry, irradiation cells and wet, in-pool facilities). The dry cells consist of three concrete-walled, rooms. The ^{60}Co sources used in the cells are stored in a 5.5 meter deep pool of water below the cells. To perform an irradiation, the sources are raised out of the pool and into the cells by elevators. Up to 0.25 megacuries of ^{60}Co may be raised into the small north and south cells, and 0.50 megacuries into the large east cells. Materials irradiated in the cells consist mainly of weapon components and hardware for use in space vehicles and nuclear reactors.

In the wet irradiation side of the pool, test materials are sealed in unpressurized vessels of various sizes, lowered into the pool, and inserted into irradiation fixtures which also hold the radioactive sources. The material consists mainly of cabling and similar components studied for effects of irradiation on integrity of nuclear reactor hardware. After irradiation and removal from the pool, some test vessels are transferred to the steam room, a small room adjacent to

the high bay, which houses a boiler and apparatus for applying pressurized steam to the material in the sealed vessel. The vessel is not pressurized while being irradiated in the GIF pool.

5.3 Hazard Identification and Characterization

In the GIF high-intensity radioactive sources for the dry and wet irradiation facilities are stored in a large, deep water pool. The primary hazard is from large quantities of radioactive materials in the form of sealed sources. Although the source term is large, the form, usage and storage conditions for this material are such that the facility presents only a low contamination hazard. Based DOE Order 6430.1A criteria, the facility is designed to limit worker radiation exposure to less than 1 rem per year. Because of the excellent radiation shielding provided by the GIF pool, little dose is attributable to sources which are stored in the pool and almost all of the expected dose arises while sources are raised into the cells.

As described in more detail in Chapters 4 and 11, the primary containment and/or confinement boundary for radioactive material at the GIF is the source cladding. All sources are sealed in cladding and no handling of unencapsulated sources is proposed. Also, the radioactive material is in a solid form -- no gaseous or liquid sources are permitted at the GIF. Therefore, the cladding provides a sufficient barrier to prevent the dispersal of the radioactive material. To protect the cladding integrity, strict administrative controls are placed on source handling and movement, cladding environmental conditions (such as water purity), and experiment energy sources.

The GIF pool primarily serves as a radiation shield for sources. The pool does not serve as an active cooling system nor confinement boundary. Up to 2.4 megacuries of ^{60}Co as multiple sealed sources (pins) are stored in an 5.5-m deep water pool. If the cobalt inventory is reduced, the pool may also contain other radioactive sources based on the total thermal power as described in Chapter 11. The source limit is for the overall pool and does not imply any proportioning between the dry or wet irradiation facilities. For the dry irradiation portion of the facility, the sources are raised out of the pool and into shielded cells for exposure of the test units. All activities for the wet irradiators, including source movement and exposure of test material, occur under water.

While sources are raised in the cells, radiation shielding is provided by the 1.8-m thick cell walls composed of commercial-grade concrete. The irradiation cell represents the primary radiation shield when the sources are raised. Access control assures that an inadvertent radiation exposure of operations personnel does not occur in a cell, where dose rates can attain 10 krad/min. The basic premise of access control is that a cell shall never be entered with the source elevator up, and the elevator shall not have power available with the cell accessible to entry. The system to assure access control is independent of the cell control system. The cell doors are always closed and locked during irradiations. If administrative controls fail and the door forcibly opened, a power interrupt circuit would directly break power to the elevator and the source would drop into the pool. For the large east cell, a similar circuit is applied to the movable wall to assure its closure whenever the source elevators are up. This elevator power interrupt subsystem represents a simple, positive, testable circuit for assuring proper access control to the cells.

Chemical hazards within the GIF are minimal. Storage of flammable or toxic chemicals in greater than laboratory quantities is not normally performed. Laboratory quantities of some flammable or toxic chemicals will be stored for experiments to be performed in the wet irradiation facilities and the steam subsystem. The primary chemicals to be used are oils, grease, small amounts of solvents for cleaning and soldering compounds. There is negligable potential for worker exposures to any compounds at levels approaching the TLV (Threshold Limit Value), so there are no plans for chemical bioassay.

Test units introduced into the GIF may contain additional hazardous materials, such as chemicals, explosives, radioactive substances, electrical systems and thermal energy sources. However, these materials are typically contained within weapons, military hardware, nuclear reactor components or systems connected with the space program. Such units are engineered to resist extreme environments. Catastrophic failure resulting in release of hazardous material is unlikely. Because of the strict limits on experiments, catastrophic failure resulting in the breach of the radioactive source cladding is extremely unlikely.

Test materials for the wet irradiation facilities consist mainly of cabling, electric wires and similar materials destined for use in nuclear reactors. The potential for worker exposure to toxic material is negligible.

5.4 Facility Segmentation

The GIF houses two independent operations in the wet and dry irradiator facilities. However, the two operations are contiguous and the sources are stored within the same pool. Therefore, segmentation is not justifiable.

5.5 Worst-Case Release Fractions and Source Terms

The radioactivity contained within the GIF could pose a serious hazard to workers in the immediate vicinity in the unlikely event that all administrative controls and engineered safety features fail. However, sources do not pose "significant on-site and off-site consequences" to workers outside the facility, the public or the environment because there are no known energy sources which could degrade the passive containment within the facility. A worst case fire would occur inside a cell with sources present. The fire would be contained by the cell, which will be constructed of highly fire-resistant material, in accordance with DOE Order 6430.1A.[5.5] Upon activation of the local fire alarm system, the source will drop back into the pool, and the ventilation system will shut down. A fire would not compromise the integrity of the source cladding because the amounts of flammables and/or combustibles in the cells is limited.

In the unlikely case of cladding failure, contamination of pool water could occur. The leak would be immediately detected by the RAM monitoring the recirculation loop demineralizer. The leaking source would be ascertained and removed from the pool or isolated in a separate container. The GIF will not be intentionally operated with a leaking source or contaminated pool. Procedures will be developed to respond to various circumstances when a cladding failure is suspected.

5.6 Worst-Case Consequence Analysis

For the reasons summarized above, there is negligible potential for the source terms within the GIF to impact workers outside of the facility, the public or the environment. The worst case consequence involves worker fatality within the facility due to exposure to ionizing radiation assuming failure of the multiple levels of preventive, detection, and mitigation features.

5.7 Facility Hazard Classification

As described above, the guidance for applying the graded approach to 5480.23 (DOE-STD-1027-92) indicates that sources meeting certain DOE and ANSI standards would not be considered for categorization purposes. This is consistent with federal regulation treatment of licensing handling of by-product material (10 CFR 30).[5.6] Up to 190 kilocuries of ^{60}Co and 89 kilocuries of ^{137}Cs will be allowed into the GIF without certification that the sources meet one or both of these standards. Additional sources will have this certification. The 190 kilocuries amounts place the GIF below the Category 2 threshold quantities for radioactive material.

Based on the lack of energy sources sufficient to disperse the radioactive inventory, the GIF has been determined to be a Category 3 non-reactor nuclear facility. This classification has been submitted to DOE/KAO and approved, as witnessed by the SDD form in Attachment 5-A.

Based on the control systems not being totally passive, the GIF is assumed to be moderately complex facility. The primary containment consists of a simple passive barrier -- the source cladding. Radiation shielding is provided by the GIF pool and irradiation cell shields, which are also passive barriers. The importance of access controls in assuring worker safety dictate a more thorough review consistent with a greater degree of complexity.

5.8 References

5.1 DOE Order 5480.23, Nuclear Safety Analysis Reports, April 10, 1992.

5.2 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, December 1992.

5.3 ANSI N43.6 ,Sealed Radioactive Sources, Categorization.

5.4 49 CFR 173.469 Department of Transportation.

5.5 6430.1A, United States Department of Energy General Design Criteria, April 6, 1989.

5.6 10 CFR 30, Rules of General Applicability to Domestic Licensing of Byproduct Material, August 15, 1991 (amended).

Attachment 5-A. Safety Documentation Determination (SDD) Correspondence

Sandia National Laboratories
Albuquerque, New Mexico

date: November 12, 1992

to: Allan Herrbach, DOE/KAO

from: A.O. Bendure, 7731

Subject: Safety Documentation Determination for the Technology Support Center, Gamma Irradiation Facility, TAV, SNL, Albuquerque.

The GIF safety documentation determination had been previously approved using the DOE Order 5481.1B guidance (Low Hazard, Non-Reactor Nuclear, SAR). However, DOE Order 5480.23 has been released and Department 7731 felt it appropriate to re-submit the safety documentation determination form against the 5480.23 criteria.

The Risk Management Department at SNL, New Mexico therefore recommends the following hazard classification, facility/project designation and safety documentation:

Hazard Class	Facility/Project Designation	Safety Documentation
Cat 3	Non-Reactor Nuclear	SAR

Please provide your concurrence/recommendation by completing the attached DOE Safety Documentation Determination Form, and returning the completed and signed form to me at your earliest convenience. The previous SDD (which was based on 548.1.B criteria) is attached for your reference.

Copy to:

7731 L.J. Dalton
7731 Z. Banda

DOE SAFETY DOCUMENTATION DETERMINATION FORM

PROJECT/ACTIVITY TITLE: Technology Support Center, Gamma Irradiation Facility

PROJECT/ACTIVITY NUMBER: LI0292-2 **PROGRAM OFFICE:** Defense Programs

CONTRACTOR: Sandia National Laboratory, New Mexico **CONTRACTOR CONTACT:** T. Schmidt, 6450

A. BRIEF PROJECT/ACTIVITY DESCRIPTION: Include category (new facility, modification, maintenance, experiment, test, etc.) location, schedule cost, etc. Attach additional sheets if necessary.

See Attached

B. SAFETY AND ENVIRONMENTAL CONCERNS: Will the project either during construction or operation, use, store, have emissions/impacts in the following entities? Provide brief explanations where appropriate. If the proposed project represents a commitment to a course of action that would ultimately require a positive response to one or more of the questions below, identify question numbers and provide explanation.

SAFETY CONCERNS	YES NO	ENVIRONMENTAL CONCERNS	YES NO
s1. Radioactive materials handling/ storage	YES	e1. Radioactive waste or mixed waste	YES
s2. Toxic chemical/material handling/ storage	NO	e2. Hazardous wastes, asbestos, or chemicals	NO
s3. Explosives handled, stored or processed	YES	e3. Wildlife, archaeological, cultural resources	NO
s4. Potentially explosive materials handled or stored	NO	e4. Pesticide/herbicide use	NO
s5. Highly flammable material stored or processed	NO	e5. Air Emissions (Radioactive/Toxic Chemical)	YES
s6. Are accelerators or sealed sources to be utilized in the project	YES	e6. Water use/diversion	NO
s7. High Worker noise level impacts during construction or operation of the proposed project			
s8. Are lasers to be used or in the proposed action			
s9. Will workers or the public be exposed to non-routine industrial hazards			

PROVIDE DETAILED EXPLANATIONS AND QUALIFICATIONS OF SPECIFIC "YES" RESPONSES

NUMBER	EXPLANATION
s1,s3	See Attached
s6	
e1,e5	See Attached

C. HAZARD CLASSIFICATION

Cat 3 — Haz. Class.

5480.23 — Doe/Order ref.:

D. FACILITY/PROJECT DESIGNATION

Non-Reactor Nuclear (Non-nuclear, Non-reactor Nuclear, Reactor Nuclear)

E. KAO SAFETY DOCUMENTATION DETERMINATION

SAR (None, SA, SAR)

KAO APPROVAL SIGNATURE: Allan M Hembach

TITLE: Safety Spec

DATE: 12/8/92

6. PRINCIPAL HEALTH AND SAFETY CRITERIA

This chapter identifies DOE Orders, codes, and standards providing health and safety criteria that are being used in designing the GIF facility. The GIF is identified as a non-reactor nuclear facility; therefore, many of the requirements for a reactor facility are not applicable to the GIF. In the following presentation of criteria, no distinction is made between applicable and nonapplicable requirements within the documents. In most cases, clear delineation between applicability to reactor and nonreactor nuclear facilities is identified in the statutes. In those cases where clarification on applicability is necessary, corresponding sections of the PSAR will detail specific applicability of the requirement to the relevant system, component and process.

6.1 Safety Criteria for Structures, Systems and Components

6.1.1 General Design Criteria

DOE Order 6430.1A establishes general design requirements for building acquisition, new facilities, and facility additions and alterations.[6.1] The GIF is designed to meet all applicable requirements of DOE Order 6430.1A, with the exceptions listed below. The GIF facility is also designed to meet the 1991 Uniform Building Code (UBC) requirements for Seismic Risk Zone 2B and ASCE7-88 for minimum design loads, excluding seismic loads.[6.2] The requirements of the DOE, "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards," UCRL-15910, as dictated by DOE Order 5480.28, will be used where they are more stringent than the UBC and ANSI requirements.[6.3, 6.4] The requirements listed in Division 13, sections 1304-1328, were determined not to apply because the GIF does not meet any of the categorical facility descriptions.

Table 6A-1 of this chapter details the applicability of and compliance status with specific 6430.1A criteria to the GIF. In Table 6A-1, the Comparison to the Criteria for the GIF design is detailed as to satisfying, not satisfying, or not applicable to each requirement in the criteria. Many of the nonapplicable requirements simply were not pertinent to a gamma irradiation facility. In some cases, exceptions to criteria were due to the unique requirements incumbent upon a dry irradiation operation. Table 6-1 summarizes the latter exceptions to the criteria of 6430.1A for the GIF design, together with justification for the exceptions.

6.1.2. Safety Criteria for Structures, Systems and Components.

6.1.2.a. Radiation Protection

Designs of structures for mitigating the effect of ionizing radiation, such as shielding, are guided by criteria for limiting radiation exposure to workers. Conformance to these criteria in design and construction is assured by the analysis of potential radiation exposure in the new GIF, presented in Chapter 4 of the PSAR and by Facility Engineering's Facilities Development Center Quality Assurance Program.[6.5] In the operational phase, Sandia's Radiation Protection programs will monitor conformance of the facility to the dose limitation criteria. Implementation of these programs at the GIF will be completely described in the GIF FSAR.

TABLE 6-1. EXCEPTIONS TO 6430.1A CRITERIA IN THE GIF DESIGN

CRITERIA	SOURCE	STATUS IN GIF DESIGN
All normal routes of egress shall have adequate space for personnel circulation and be directed through exits that contain monitoring stations.	0110-99.0.1 General Architectural and Special Design Requirements. Paragraph 3	The maze entrances to the GIF cells are purposely narrow to minimize radiation streaming. Obstacles preventing personnel circulation will be administratively limited. The radiation hazard is from sealed gamma sources. There is no potential for personnel to incur external contamination; therefore monitoring stations are not necessary .
At least two exits shall be provided in rooms where hazardous materials are handled.	0110-99.0.4 Building Layout, Paragraph 7	The cells have only one exit door. However, the sources are raised into the cells only after personnel have vacated. Introduction of another port would increase the potential for exposure of personnel to ionizing radiation.
Safety Analysis shall comply with DOE Order 5481.1B	1300-2 Safety Analysis	Safety Analysis complies with DOE Order 5480.23. Content requirements for a "Preliminary" SAR were adopted from DOE Order 5481.1B.
Designs that ease cut-up, dismantlement, removal and packaging of contaminated equipment from the facility (e.g. removal and dismantlement of gloveboxes, air filtration equipment, large tanks, vessels, equipment and ductwork). Use of modular radiation shielding in lieu of or in addition to monolithic shielding walls	1300-11.2 Decommissioning	Major items of concern during decommissioning will be the cells and the pool, both of which will constitute significant dismantling challenges. However, use of modular units would compromise the safety and reliability of the units.
Automatic water sprinkler coverage shall be provided throughout the facility except in areas where nuclear criticality or other hazards specifically preclude its use or where Halon systems are required to reduce equipment damage.	1530-99.0 Nuclear Facilities General Paragraph 18	Cells are not equipped with a sprinkler system because of the difficulty of maintaining function under- high levels of ionizing radiation and because there is no potential for a fire to spread out side of the cell. Sprinkler system designed to provide a "curtain" immediately past the cell door.

The criteria for maximum permissible radiation worker exposure and for application of ALARA principles is found in the following documents. The applicability of these criteria in design of DOE facilities is confirmed by DOE order 6430.1A, as detailed in Table 6A.

- ICRP Report No. 26 (Use of weighting factors). [6.6]
- DOE 5400 series limits for public exposure following DBA.
- DOE 5480.11, giving occupational external exposure limits. [6.7]
- Sandia's "Radiation Protection Procedures Manual" and "Radiation Control Manual" which are the Laboratory's implementation of 10 CFR 835, "Occupational Radiation Protection" [6.8, 6.9, 6.10]

The following is a list of other standards and criteria applicable to structural components used as radiation shielding in the GIF. These standards are required by DOE order 6430.1A and UBC1991. Adherence to these criteria is insured by the Facility Engineering Quality Assurance Program, which is completely described in the FSAR.

- Concrete radiation shielding - ANS 6.4, ACI 6.4.2 and ANS 6.4.2
- Lead Federal Specification 00-L-201FGMDE Con.

The following DOE orders are applicable to the operation of the GIF. The methods for implementation of these orders at the GIF will be completely described and referenced in the FSAR.

- DOE Order 5480.20 [6.11]
- Sandia's "Radiation Protection Procedures Manual" and "Radiation Control Manual" which are the Laboratory's implementation of 10 CFR 835, "Occupational Radiation Protection".
- DOE Order 5480.5 [6.12]

6.1.2.b Criticality

Criteria pertinent to criticality issues were not applicable to the GIF because fissile material is not to be used or stored at the facility. As described in Chapter 4 of the PSAR, procedures for handling any test units that introduce fissile material into the GIF must be reviewed and approved by the TA-V Radiological and Criticality Safety Committee.[6.13] The RCSC evaluates criticality issues using DOE Order 5480.24, Nuclear Criticality Safety. This Order also references applicable sections of ANSI/ANS Series-8 Standards.

6.1.2.c Fire Protection

The primary DOE order delineating fire protection requirements is 5480.7A.[6.14] Other criteria are listed by DOE order 6430.1A, as detailed in Table 6A-1. Conformance to these criteria is assured by the Facility Engineering Quality Assurance Program and by Sandia's Fire Protection program. The implementation of these programs at the GIF will be completely described in the FSAR. Also, Sandia Fire Protection Engineers are included in all phases of design, in

Operation Readiness Review and in the operational phase for the GIF. Criteria for fire protection systems include:

- DOE Order 5480.7A, Fire Protection
- NFPA 80A (Building Exterior)
- NFPA 101 (Distance from exit of 75 feet, design of Emergency Lighting)
- NFPA 80 (Fire doors, frames and hardware).
- NFPA 13 (Occupancy, water pressure)
- NFPA 13 (Sprinkler systems)
- NFPA 71, NFPA 72 (A-H) (Fire detection and alarm devices)
- NFPA 24 (Water mains)
- NFPA 20 (Fire Pumps)

6.1.2.d Emergency Preparedness

Requirements for emergency preparedness at DOE facilities are set by DOE orders 5500.IB, for the general emergency management requirements, 5500.2B, which specifies format and contents of emergency plans and procedures, and 5500.3A, requiring the preparation of a Hazard Assessment Document for DOE facilities.[6.15, 6.16, 6.17] The general emergency preparedness program for Technical Area V is in compliance with these requirements. Conformance to these criteria is ensured by Sandia's Emergency Preparedness program, as described for the GIF in the forthcoming FSAR.

Specific standards are set by 6430.1A for the components of the standby and emergency systems. Conformance to these criteria has been demonstrated for the general emergency response system in Tech Area V. Implementation for the GIF is insured by Facility Engineering's Quality Assurance program and by Sandia's Emergency Preparedness Program, as detailed in the FSAR. DOE order 6430.1A specifies NFPA and IEEE standards to be met for standby and emergency systems as follows:

- NFPA 101
- NFPA 110
- NFPA 37
- NFPA 70
- IEEE 446

6.1.2.e. Safety Documentation

The safety documentation requirements for DOE nuclear facilities are given in DOE Order 5480.23 with guidance provided in DOE-STD-1027.[6.18, 6.19] Neither document defines the desired content of a PSAR. Therefore, the guidance for content for the GIF PSAR has been taken from 5481.1B, with cross-comparison of chapter content from 5480.23. TSR requirements are delineated in DOE Order 5480.22. The bases for the GIF TSRs are forthcoming in the FSAR. Other requirements for safety documentation, such as Preliminary Hazard Assessments and Standard Operating Procedures are set by Sandia's ES&H manual and apply to operations of a facility. The appropriate documentation for operation of the facility will be completely described in the GIF FSAR and will be assessed as part of the Operational Readiness Review for the GIF.

6.1.2.f Environment

The primary requirement to assess the impact of the GIF on the environment is set by DOE Order 5440.1E and is met by the GIF Environmental Assessment.[6.20]

DOE Orders governing design of DOE facilities with reference to the environment include: 5480.4, the Directive on Radiation Protection of the Public and the Environment in the DOE 5400 series, the Directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series and DOE Order 4700.1, Chapter V. Most of these criteria are not applicable to the GIF because, as a Category 3 nuclear facility, the GIF has no potential for off-site impact, and no radioactive or hazardous effluents will be released to the environment as a result of operations. Criteria pertinent to environmental protection are delineated in Table 6A-1 including details of applicability to the GIF.

The handling and disposal of chemical and hazardous waste is regulated by DOE Orders 1540.2, 5400.1, 5400.2A, 5400.3, 5480.3, 5482.1, 5820.2A and New Mexico Hazardous Waste Management Regulations (HWMR-5). [6.21, 6.22, 6.23, 6.24]

Sandia has specific policies and programs to ensure compliance with hazardous waste and other environmental laws. Requirements for facility owners to insure compliance with Sandia policy, DOE orders and Federal, State and Local Laws are described in Sandia's ES&H manual. Sandia's Process Waste Assessment is used to implement waste minimization and to estimate air and water effluents from individual processes. Specifics on implementation of these programs at the GIF are forthcoming in the FSAR.

The GIF design and operation will also comply with the Federal, State and Local Laws concerning air and water effluents and waste listed in Chapter 2 of the PSAR.

6.1.2.g Health and Safety

General ventilation requirements for DOE facilities are specified in DOE Order 6430.1A and include the following:

- ASHRAE Systems Handbooks
- ACGIH "Industrial Ventilation (1992) ASHRAE "Applications" (1991)
- Work Space Management Standards
- Indoor Ventilation Air Requirements as set by ASHRAE Standard 62

The primary DOE Order setting other health and safety requirements at DOE facilities is 5480.10.[6.25] Additionally, Sandia facilities operate in compliance with Federal laws and industry standards as listed below. Requirements for facility owners and operators insuring compliance with these standards are detailed in Sandia's ES&H manual.[6.26] Complete implementation of safety and health programs for the GIF will be described in the FSAR.

- DOE Order 5480.10
- DOE Order 5483.1A
- Code of Federal Regulations 29 CFR 1910
- Code of Federal Regulations 41 CFR 101-17
- American Conference of Governmental Industrial Hygienist: Threshold Limit Values

(most current version).

6.1.2.h Energy Conservation

DOE Order 6430.1A requires that DOE facilities be built to the following standards, in terms of energy conservation. Conformance to these standards is insured by the Quality Assurance Program of Facility Engineering, completely described in the FSAR for the GIF.

- ASHRAE Standard-90
- DOE Energy Conservation Manual

6.1.2.i Building and Systems Structural Components:

The following standards for building structural components are specifically required by DOE Order 6430.1A. These are identified in Table 6A-1. Conformance to these criteria is insured by the Quality Assurance Program of Facility Engineering, to be completely described in the FSAR for the GIF.

(a) Foundation:

- NSI A58.1 (Live Loads, Wind load design)-Now ASCE 7-88.
- ACI 318 (Foundation)
- DOE Order 5483.1A
- DOE Order 5480.10

(b) Concrete:

- ACI 207.1 R-87 (SWEC)
- ACI 318 (or 349 SWEC)
- 40 CFR 249
- CI SP-4
- ACI 207.1 R87 (for movable wall)

(c) Masonry

- ASTM C90 (SWEC)
- ASTM C 330 (aggregates)

(d) Steel

- Manual of Steel Construction, AISC 9th Edition
- Structural Steel ASTM A36
- Structural Bolts ASTM 325N
- Steel Deck, ASTM A446, Grade A with zinc coating per ASTM A525, G60

(e) Plumbing and Piping

- NSPC, ASHRAE Handbooks and ASHRAE Standard 90
- Pipe fittings: ASTM D2513

- Pipe - ASTM D2513
- Water piping ASTM D1785 and ASME B31.3
- Sanitary Sewer ASTM D2665
- Steam piping - ASME B31.1
- Above Ground Piping ASTM A53
- Compressed air systems: ASTM B88
- Ductwork - SMACNA HVAC Air Duct Leakage Test Manual, HVAC Duct Construction Standards, NFPA 45, NFPA 91

(f) Fixtures

- FSWW-p-541

(g) Electrical

- NFPA 70-1990, "National Electric Safety Code."
- IEEE 493
- IEEE 242
- IEEE C37
- IEEE 142 (grounding)
- IEEE 437 (Grounding Connections)
- Safety Class Systems - IEEE 379 and 384 (redundancy and separation criteria)

(h) Lightning Protection

- UL 96A
- ANSI/ASME NQA-I.

(i) Exterior Communications and Alarm Systems.

- DOE 5632, Section 1670
- NFPA 72A,72B, 72C, 72D, 72E, 72F, 72G, 72H
- ANSI N2.3 (evacuation Alarms)
- NCRP Report No. 88 "Radiation Alarms and Access Control Systems"

(j) Industrial

- ASME boiler and Pressure Vessel Code (safety class items)
- Overhead Cranes CMAA-70 and ASME B30.2 (SWEC)
- Equipment rooms - room temperature does not exceed NEMA equipment ratings
- Motors- NEMA MG-I
- Hoists: all specifications of Electric Hoist Manufacturers Association

6.1.2.j. Decontamination and Decommissioning

For D&D considerations, designs must be consistent with the requirements of DOE 5820.2A.[6.27] A detailed description of how D&D considerations are incorporated in the design and operation of the GIF are to be provided in the FSAR.

6.1.2.k. Occupancy

The occupancy of the GIF be in accordance with the following criteria, as specified by DOE Order 6430.1A:

- NFPA 13

Operation will be preceded by an Operational Readiness Review in accordance with:

- DOE Order 5480.31 Startup and Restart of Nuclear Facilities
- DOE/AL Order AL5480.31 Startup and Restart of AL Facilities, Activities, and Operations

6.2 Natural Phenomena Design Criteria

The requirements of the DOE, "Design and Evaluation Guidelines Department of Energy Facilities Subjected to Natural Phenomena Hazards," UCRL-15910, and its corresponding supporting documents will be met for each of the natural phenomena events to be evaluated and designed for: (i.e. UCRL-53582, Seismic: UCRL-53526, Extreme Wind: UCRL-15746 Flood) will be used where they are more stringent than the UBS and ANSI requirements.

6.2.1 Wind Criteria

Design for extreme wind was based on UCRL-15910. From this document and using site-specific data, wind loading is based on 81 miles per hour wind speed, exposure C, and importance factor of 1.07. Winds of this magnitude are very rare. According to site-specific data, winds greater than 25 mph have a frequency of less than 3%.

6.2.2 Tornado Criteria

Not applicable to this region. Albuquerque is classified as a region of low tornado occurrence with an annual frequency of .1 or less.

6.2.3 Snow and/or Ice Criteria

Using site-specific data and UCRL-15910, criteria for snow and/or ice was 6 psf. This criteria is considered conservative because the climate of the region is generally mild. On the average, less than one day a year sees temperatures less than 0° F. Snowfall rarely remains more than 24 hours. Average annual snowfall is 14.7 inches.

6.2.4 Flood Criteria

In accordance with UCRL-15910, and site-specific data and supporting documents, the criteria is based on a hundred year flood of 5-inches of rainfall per hour. Although the climate is generally dry, with average annual precipitation near 8 inches, half of the average annual precipitation occurs as brief but heavy thunderstorms from July through September. Temporary

flood conditions are not unusual following heavy thundershowers. This criteria is considered conservative because Tech Area V is not within the 100 year flood plain.

6.2.5 Subsurface Hydrostatic Criteria

The subsurface hydrostatic criteria will be based on site-specific data included as part of the Title II requirements for the GIF.

6.2.6 Missile Criteria

Missile criteria are provided for protection against missiles generated because of internal events, events near the site, and natural phenomena. In accordance with UCRL-15910, missile criteria are not required for the GIF because it is a low hazard facility.

6.2.7 Seismic Criteria

The Albuquerque area is located in seismic risk Zone 2b, which by definition is a region that can be expected to receive moderate damage from earthquakes. In accordance with UCRL-53582, seismic evaluation uses a maximum ground acceleration of 0.22g.

6.2.8 Ashfall Volcanic Criteria

Not applicable

6.3 Dynamic Effects Design Criteria

Evaluation of maximum spectral acceleration is used in the low period region as required for low hazard facilities.

6.4 References

6.1 DOE Order 6430.1A, General Design Criteria, April 6, 1989.
6.2 1991 Uniform Building Code (UBC).
6.3 UCRL-15910, Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards.
6.4 DOE Order 5480.28, "Natural Phenomena Hazards Mitigation" January 15, 1993.
6.5 "Design Manual", SNL Facilities Development Center, March 1, 1993
6.6 ICRP Report No. 26.
6.7 DOE Order 5480.11, " Radiation Protection for Occupational Workers", June 17, 1992.
6.8 Code of Federal Regulations, 10 CFR 835, "Occupational Radiation Protection", December 14, 1993.
6.9 Sandia ES&H Manual Supplement "Radiation Protection Procedures Manual" MN471016, Issue A, December 20, 1994.
6.10 Sandia ES&H Manual Supplement "Radiation Control Manual" MN471015, Issue A, January 27, 1995.
6.11 DOE Order 5480.20, " Personnel Selection, Qualification, Training and Staffing Requirements for Non-reactor Nuclear Facilities" June 19, 1991.

6.12 DOE Order 5400.5, Radiation Protection of the Public and the Environment, including Change 2, January 7, 1993.
6.13 "Charter for the TA-V Radiation and Criticality Safety Committee", SNL internal controlled document, 6512-RCSC-01 (Issue B), approved May 27, 1993.
6.14 DOE Order 5480.7A, " Fire Protection", February 17, 1993.
6.15 DOE Order 5500.1B, "Emergency Management System", February 27, 1992.
6.16 DOE Order 5500.2B, "Emergency Categories, Classes, and Notification and Reporting Requirements", February 27, 1992.
6.17 DOE Order 5500.3A, "Planning and Preparedness for Operational Emergencies".
6.18 DOE Order 5480.23, "Nuclear Safety Analysis Reports" , April 10, 1992.
6.19 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, December 1992.
6.20 DOE Order 5440.1E, "National Environmental Policy Act Compliance Program", November 10, 1992.
6.21 DOE Order 5400.1, "General Environmental Protection Program", June 6, 1990.
6.22 DOE Order 5400.2A. "Environmental Compliance Issue Coordination", January 7, 1993.
6.23 DOE Order 5400.3. "Hazardous and Radioactive Mixed Waste Program".
6.24 DOE Order 5480.3, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes", July 9, 1985.
6.25 DOE Order 5480.10, "Contractor Industrial Hygiene Program", June 26, 1985.
6.26 "ES&H Manual", Sandia National Laboratories, MN471001, most recent issue April 23, 1993.
6.27 DOE Order 5820.2A, Radioactive Waste Management.

Table 6A-1. GIF Comparison to Criteria (DOE 6430.1A)

This Appendix provides a detailed comparison of the GIF design to the criteria set in DOE order 6430.1A. The table includes:

- reference to specific sections within 6430.1A for each criteria,
- quote from 6430.1A describing the criteria,
- assessment as to whether the criteria is (**S**) satisfied, (**NS**) not satisfied, or (**NA**) not applicable
- comments on how the criteria is met or justification for other responses.

SECTION	TITLE/CRITERIA	S	NS	NA	COMMENT
Division 0100	**General Requirements**				
0101	Criteria Purpose and Applications				
0101-1	General These criteria provide mandatory, minimal acceptable requirements for facility design. The predominant model building code in the region shall govern on issues not covered in these criteria.	X			According to criteria set in UBC , 1991, overall facility is classified as B2, while the cells are H7.
0101-4	Handicapped Provisions	X			In accordance with Uniform Federal Accessibility act, the building is accessible to handicaps. Due to the potential for rapid emergency evacuation, the cells are not.
0101-6	Regulatory Requirements This section lists the regulatory requirements cited in these criteria.	X			Documented in Chapter 6 of the PSAR.
0101-9	Reference Standards and Guides	X			Documented in Chapter 6 of the PSAR.
0110	Architectural and Special Design Requirements	X			Documented in Chapter 6 of the PSAR.
0110-1	Design, Programmatic, and Operating Requirements				
0110-1.1	General				
0110-1.1.1	Design Designs shall produce facilities that are straightforward and business-like. Designs must respond to user needs but reflect responsible use of public funds. Design shall be defensible in scope, cost & appearance.	X			Value Engineering report.
0110-1.1.2	Programming Programming studies shall include consideration of functional requirements of the activities to be housed to determine the amount of space provided in facility. The design criteria document shall make program and operating requirements explicit in compliance with DOE 4700.1.	X			Included in Title II requirements and in Value Engineering report.
0110-1.2	System Integration When two or more services/systems are to be incorporated into a facility or complex, these systems shall be considered to determine if they can be integrated and identify the most cost-effective level of systems integration: telecommunications, lighting controls, HVAC control, energy management system, security and alarm, closed-circuit television, vertical transportation controls, fire detection and alarm, and public address system.	X			Systems include pool, spaces, HVAC, power and all shared services.
0110.1.3	Emergency Planning Emergency planning requirements, including provision of storage space of emergency equipment, shall be considered early in conceptual design to ensure that facility features provide from evacuation and other emergency requirements and that facility emergency plans are coordinated with the overall plant-complex emergency plan.	X			Considered in PSAR.
0110-2	Alternate Designs	X			Addressed in Environmental Assessment and Value Engineering Study.

SECTION	TITLE CRITERIA	S	N	K	COMMENT
0110-3	Flexibility Flexibility is a major design requirement for all facilities except those with highly specialized functions. Even in special facilities, the design shall, to the maximum extent practicable, provide sufficient flexibility to accommodate for programmatic changes or operational modifications.	X			Maximum flexibility and capability provided for unknown array of experiments.
0110-5	Health and Safety	X			
0110-5.2	Safety Analysis All DOE facilities shall be evaluated for potential risks to the operators, the public, and the environment.	X			Safety documentation satisfies 5480.23 with guidance from STD-1027.
0110-5.3	Emergency Preparedness Planning Each facility that has potential on-site and off-site effects during normal or abnormal operations shall have an Emergency Plan prepared which shall be incorporated with the Site Emergency Preparedness Plan.	X			There are no significant off-site consequences; however, GIF is located with Category 2 facilities requiring EPP and Tech Area V EP, which are in place.
0110-6	Fire Protection				
0110-6.1	General				
para. 1	Facilities shall comply with the following: DOE 5480.4 Attachment 2, Section 2.C DOE 5480.7 Section 1530, Fire Protection	X			5480.7 was superseded by 5480.7A in February, 1992.
para. 2	Facilities shall also comply with 29 CFR 1926 and CFR 1910. Except as required by other sections of these criteria, NFPA 101 shall apply where 29 CFR 1926 and 29 CFR 1920 do not apply or where NFPA 101 exceeds the requirements of 29 CFR 1926 and 29 CFR 1910.			X	Facility is in compliance with 29 CFR 2910. 29 CFR 1926 is inapplicable.
para. 3	Definitions, fire resistance ratings, and types of construction shall be as contained in the UBC.	X			In Title II requirements.
para. 4	Any materials with unusual fire characteristics such as urethane foams, and any materials that develop significant quantities of toxic or other harmful products of combustion shall not be used as interior finishes or other interior applications with the approval of the cognizant DOE fire protection authority. The use of foamed plastics in construction shall be prohibited unless it fully complies with FM 1-57.	X			No foamed plastics in use.
0110-6.2	Fire Protection Design Analysis A special fire protection design analysis shall be made of each facility vital to DOE mission accomplishment. The analysis shall use time parameters established in accordance with DOE 5480.7. The analysis shall identify the special fire prevention and protection features and controls to achieve a level of fire protection for vital facilities and programs that meets or exceeds the "improved risk" level.	X			The GIF is not a facility vital or critical to the DOE mission accomplishments.
0110-6.3	Fire Resistance Ratings				
para. 1	All facilities shall be divided into areas in which the total potential fire loss to each area and its equipment does not exceed $75 million as described in DOE 5480.7. These areas shall be separated by fire walls and barriers with not less than 4-hour fire-resistance ratings. Where exceptions are necessary for reasons of operations or equipment, exception procedures shall comply with DOE 5480.7.	X			Facility value is less than $75 million.
para. 2	Adjacent occupancies of non-compatible groups shall be separated by 2-hour, or better, fire-rated walls, floors, and ceilings as required by the NFPA codes.	X			Non-compatible groups are all in separate buildings .

SECTION	TITLE / CRITERIA				COMMENT
para. 3	Wall, floor and ceiling, and roof and ceiling assemblies shall be tested and rated for their fire resistance by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Untested, unrated or unapproved assemblies shall be approved by the cognizant DOE fire protection authority before being considered for use in a DOE facility.	X			UBC Maximum Flame, Spread Class, Walls,/Ceilings. Fire Resistance Ratings per UBC Section 504.
0110-6.4	Hazardous Areas				
para. 1	Hazardous areas, such as radioactive spaces or spaces with inert atmospheres, shall have sufficient alarms and interlocks to assure that access by emergency personnel will not endanger such personnel or result in a public hazard.	X			Door controls are interlocked with source elevator. All cells are equipped with RAMS.
para. 2	The design of hazardous areas shall facilitate access by emergency personnel from the exterior and, at the same time, shall maintain any required confinement or containment using air locks or other features.	X			Emergency response does not necessitate that emergency personnel access cells.
para. 3	The design of the exteriors of facilities shall follow the recommendations of NFPA 80A. Facilities that are not separated as recommended by NFPA 80A shall have fire protection systems such as exterior sprinklers or barrier walls.	X			In Title I.
0110-7	Environmental Protection and Pollution Control The construction of all DOE facilities shall comply with the environmental protection and pollution control portions of the following: DOE 4700.1 Chapter V, DOE 5480.4, DOE 5480.1B, DOE 5440.1C.	X			See Environmental Assessment and Facilities Engineering Project Plan.
0110-9	Operation, Maintenance, Repair, and Replacement Planning and design of buildings and other structures, including their operating components and systems, shall take into account all aspects of operation and maintenance including: Equipment accessibility, Dismantling, Replacement, Repair Frequency of preventive maintenance, Inspection requirements Personnel safety, Day-to-day operation	X			Includes Human Factors. Human factors expert included in all phases of design and operation.
0110-10	Fallout shelters	X			
0110-11	Work Space Management Standards	X			41 CFR 101-17 and DOE 4300.1 are applicable.
0110-12	Energy Conservation	X			ASHRAE Standard 90 applicable. A preliminary Energy Conservation Report has been done.
0110-13	Physical Protection				
0110-13.1	General DOE security interests are to be protected from theft or diversion or special nuclear material, sabotage, loss or theft of classified matter or Government property, and other hostile acts which may cause unacceptable adverse impacts on national security, program continuity, or on the health and safety of employees, the public, or the environment.	X			The requirements of this section are met by the security provisions of SNL's Tech Area V.
0110-13.2	Access Control and Security Areas				
0110-13.2.1	General Controls shall be established to prevent unauthorized access to security areas or removal of security interests.	X			Security Provisions of SNL's Tech Area V.
0110-13.2.2	Property Protection Area Requirements Verification of the identity of persons authorized access to a limited security area shall be accomplished at the area entrance.	X			Security Provision of SNL's Tech Area V.

0110-13.2.3	Limited-Area Requirements Clearly define physical barriers shall be utilized to control, impede, or deny access, and shall effectively direct the flow of personnel and vehicles through designated portals, and allow effective searches. A means shall be provided to detect unauthorized intrusion by use of alarm systems, random patrols, or visual surveillance.	X			GIF is within the Tech. Area V Physical protection system.
0110-13.2.3	Limited-Area Requirements (continued) Adequate protective illumination shall be provided to permit or assist in detection and assessment or adversaries, reveal unauthorized persons, and, at pedestrian and vehicular entrances, to permit examination of credentials and vehicles. The protection program shall include suitable means to assess alarms and/or activities of adversaries. Measures shall be in place to prevent unauthorized visual or aural access to classified matter.	X			GIF is within the Tech. Area V Physical protection system.
0110-13.2.4	Exclusion Area Requirements An exclusion area must meet all the requirements for a limited area, except when the exclusion area is located within a larger limited area.	X			GIF is within the Tech. Area V Physical protection system.
0110-13.2.5	Protected Area, Material Access Area, and Vital Areas See Section 1300-10.2.3, Baseline Protection Requirements	X			GIF is within the Tech. Area V Physical protection system.
0110-13.3	Physical Barriers Physical barriers shall protect DOE property and facilities as follows: Barriers such as walls or fences are intended to control or impede access. Unoccupied facilities shall be locked with tamper-resistant locks.	X			GIF is within the Tech. Area V Physical protection system.
0110-13.4	Intrusion Detection Intrusion detection and assessment systems shall protect against the impact of loss or sabotage of property and facilities.	X			GIF is within the Tech. Area V Physical protection system.
0110-13.5	Communications Equipment Communications equipment shall be provided to allow effective protection.	X			GIF is within the Tech. Area V Physical protection
0110.99	Special Facilities				
0110-99.0	Nonreactor Nuclear Facilities - General				
0110-99.0.1	General				
para. 01	Unless there are specific requirements for providing office areas within the special facilities, they shall be located with other offices and common-use facilities (e.g., data computation and processing, word processing) in a centralized location. The design professional shall consider the need for safe normal and emergency access, egress, and internal traffic flow.	X			New GIF together with the TSC complex support this requirement.
para. 02	Support areas such as the health physics laboratory/office shall be located near the exit from the process area.	X			In Title I.
para. 03	The exit areas shall have adequate space for personnel circulation and egress and monitoring equipment. All normal routes of egress shall be directed through exits that contain monitoring stations.		X		The maze entrances to the GIF cells are purposely narrow to minimize radiation streaming. Obstacles preventing personnel circulation will be administratively limited. Because radioactive sources are sealed, there is negligible potential for personnel contamination.

para. 04	The type and level of hazard shall be determined for each functional area of the special facility, the attendant degree of risk established, and the possibility of cross-contamination considered. Radioactive and hazardous materials (chemicals, feed wastes, etc.) shall be segregated from each other to minimize the generation of mixed waste. Wherever possible, areas for work with radioactive or other hazardous contaminants shall be located together to simplify solutions to problems of air supply and exhaust, waste disposal, decontamination, and cross-contamination. In addition, areas where radioactive materials are used shall be designed for ease of decontamination during building usage and also for decommissioning after the building life cycle.	X			Addressed within Chapter 4 of the PSAR.
para. 05	Significant energy savings for heating and cooling may be realized, based on LCC effectiveness of energy conservation features; however, any such features shall only be incorporated where they do not compromise the safety and health of personnel.	X			Trace 600 HVAC Analysis will be Performed.
0110-99.0.2	Building Services and Distribution				
para. 01	Vertical chases shall be provided with fire cutoffs, preferably at each floor level and at the enclosing partitions, consistent with the building construction code classification.	X			Facility contains only one floor.
para. 02	To maintain the necessary degree of protection required by the particular building code classification, equipment selections shall be made from products listed by UL or other approved testing organization.	X			See Facility Engineering Project Plan.
para. 03	To ensure both the safety of personnel and the effective administration and control of special facilities, access to hazardous areas (i.e., hazardous gas storage locations and electrical power and distribution panels) shall be controlled by locked gates, doors, power panels, or other physical barriers.	X			TAV Security Perimeter meets this requirement.
para. 04	Compressed gas cylinders shall be isolated outside of the special facilities building or housed in a special hazardous materials storage room, exhausted gas cabinets, or similar types of containment.	X			Compressed gas cylinders are to be stored outside the East Wall.
para. 05	Where continuous services are required, services headers shall be looped and appropriately valved to maintain such services during routine maintenance or systems alterations.	X			Requirement for Title II.
para. 06	All piping shall be located outside hazardous areas whenever possible to reduce personnel exposure during maintenance.	X			No Piping within cells.
0110-99.03	Utilization Schedule	X			Requirement for Title II.
0110-99.0.4	Building Layout				
para. 01	The design of the facility shall include controlled access to areas of potential hazards within the facility.	X			Door interlocks.
para. 02	The facility layout shall provide for the segregation of administrative and other support personnel from operations and process activities and areas.	X			The construction of the new GIF and the TSC meet this requirement.
para. 03	The arrangement and location of process equipment and its maintenance provisions shall ensure that exposure to radiation and other hazardous materials is within the requirements of DOE 5480.11 and DOE 5480.10, respectively.	X			Insured by engineering design.
para. 04	The design shall protect workers sufficiently from hazards to ensure that workers can perform actions required during normal operations, anticipated operational occurrences and postulated DBAs.	X			Substantiated by Accident Analysis within the Safety Analysis Report.

SECTION	TITLE / CRITERIA				COMMENT
para. 05	The design shall ensure prompt, safe shutdown in emergencies and allow ready access to areas where manual corrective actions are required and to areas that contain radiation monitoring equipment.	X			Most emergencies result in lowering of the source. No scenarios have been identified that would require emergency access to the cells.
para. 06	Some exits shall be provided for emergency use only, and equipped with alarm devices and seals.	X			Some doors exiting the building will be designated as Emergency Exit Only .
para. 07	At least two exits shall be provided in rooms where hazardous materials are handled. (Exceptions for explosives facilities appear in Chapter 11, Section 2.2, of DOE/EV 06194.)		X		See Table 6.1. The High bay, Steam Room and Mechanical and Electrical rooms qualify. For the cells, the provision of a second exit would introduce additional hazards by increasing the risk of accessing the cells with the source exposed.
para. 08	In those areas where an accidental breach of a primary confinement system could expose personnel to radioactive material, a distance of 75 feet as measured by the method in the NFPA 101 shall be the maximum travel distance to ensure that personnel can exit through the next confinement barrier. This barrier is the partition separating two different air zones, the area of refuge being on the upstream side of the barrier.	X			Exits exist within 75 feet of the cells. For the smaller cells, the door to the maize will be openable from the inside.
para. 09	The assured airflow through the barrier shall be in the direction opposite of exit travel.	X			Cells are maintained at negative pressure with respect to the environment.
para. 10	The facility design shall provide space to accommodate all planned activities, operations, and maintenance (e.g., processing, research and development, scrap and waste handling, sample analysis, shipping and receiving, and material staging required for equipment installation and modifications).	X			Ample space is provided.
para. 11	The design shall minimize the hazard of handling flammable and other hazardous materials.	X			Quantities of flammables within GIF will be limited. Other than manipulation of the sources within the pool, handling of radiological material is all automated.
para. 12	In addition to the usual industrial safety features required in a nuclear facility, the design shall also include the following safety features, as appropriate: - Layout of the facility shall provide specific control and isolation, if possible, of quantities of flammable, toxic, and explosive gases, chemicals, and other hazardous materials admitted to the facility. - The provision of additional space shall be considered for temporary shielding in the event radiation levels are higher than anticipated.	X			There is ample room for additional shielding.
para. 13	Storage areas (or vaults) shall be located in light of the hazards of materials stored (e.g., radiation and criticality or nuclear materials), fire-fighting capabilities, and contamination control.	X			The only radiological storage is within the pool. Quantities of other hazardous material are limited. Small quantities of flammables will be stored within flammable storage cabinets.
para. 14	All corridors and door openings shall meet NFPA 101 or more stringent requirements based on the hazards of materials to be handled or operations to be performed, as established by the cognizant DOE Health and Safety authority.			X	This requirement does not apply to the cells because no hazardous material will be present when the cell is occupied.
para. 15	Where room doors open into corridors, frames shall be recessed to prevent the open doors from encroaching on clear corridor spaces.	X			Requirement for Title II.

SECTION	TITLE / CRITERIA	[illegible]	[illegible]	[illegible]	COMMENTS
0110-99.05	Interior Walls and Partitions Fixed partitions shall be provided for corridors and office space unless movable partitions are functionally and economically justified and satisfy fire safety and other health and safety requirements	X			In Title I.
0110-99.0.6	Fire Resistance Development of the DBF shall include consideration of conditions that may exist during normal operations and special situations (e.g., during periods of decontamination, renovation, modification, repair, and maintenance). The structural shell surrounding the critical areas and their supporting members shall remain standing and continue to act as a confinement structure during the DBF under conditions of failure of any fire suppression system not designed as a safety class item.	X			Fire Hazard Analysis.
0110-99.0.6	Fire Resistance (continued) Fire resistance of this shell shall be attained by an integral part of the structure (concrete slabs, walls, beams, and columns) and not be a composite assembly (membrane fireproofing). In no event shall the fire resistance rating be less than two-hours under conditions of failure of any fire suppression system not designed as a safety class item. Penetrations in this shell shall incorporate, as a minimum, protection against DBF exposures unless greater protection is required by other sections of these criteria.	X			Fire Hazard Analysis.
0110-99-0.7	Loss Limitations The design shall provide sufficient structural integrity, fire resistance, compartmentalization, detection, and extinguishing systems and alarms to generally limit property loss from any single DBA (excluding earthquake and tornadoes) to less than $1 million for those special facilities in which safety systems are provided and function properly, and to less than $25 million where safety systems do not function properly.	X			Fire Hazard Analysis
0110-99.0.8	Personnel and Public Safety				
para. 01	The design of special facilities shall reduce the consequences of normal and DBA events by incorporating ALARA design concepts. Occupancy time, spacing, remote handling equipment, and shielding shall be considered.	X			Considered in PSAR.
para. 02	Automatic monitoring and alarm devices shall be provided (where required by the form and potential hazard of the material being handled or stored) to detect the presence of significant levels or increases of radioactivity and, if feasible, any other hazardous materials, either released in the special facility or escaping from it. (Where monitoring devices are not available for specific contaminants, sampling devices shall be substituted and be evaluated on a frequency sufficient to detect release levels of interest.)	X			Applies to cells, high bay and mechanical room equipped with RAMS. Requirements detailed within the PSAR.
para. 03	Cautionary systems or interlocks shall prevent inadvertent entry into hazardous areas. All safety alarm systems shall enunciate inside of the special facility so as to identify hazardous areas.	X			Applies to door interlocks, the requirements for which are described in detail in the PSAR. As described in Title I, safety alarm systems in compliance.
para. 04	The need for visual alarm devices within the special facility, in addition to audible alarm devices, shall be considered.	X			Visual and audible alarm devices used.
para. 05	Where alarms can preclude or minimize exposures outside of the facility, they shall be provided (such as criticality alarms or evacuation alarms).	X			Criticality alarms NA. Evacuation alarms are provided.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 06	Proper consideration shall also be given to chemical toxicity protection, as well as radiation protection. As an example, for unirradiated enriched uranium, under postulated accident conditions, chemical toxicity exposure will often be the controlling factor.	X			Chemical toxicity protection provided against ozone.
0110-99.2	Emergency Preparedness Facilities			X	No Emergency Preparedness Facilities.
0110-99.7	Occupational Health Facilities			X	No Occupational Health Facilities.
0110-99.8	Telecommunications, Alarm , and ADP Centers and Radio Repeater Stations			X	No Stations.
0110-99.9	Vaults and Vault-Type Rooms for Storage of Classified Matter			X	No Vaults
0110-99.10	Secure Conference Rooms			X	No Secure Conference Rooms.
0110-99.11	Secure Offices			X	No Secure Offices.
0111	Structural Design Requirements				
0111-1	General				
para. 01	Materials, framing systems, and details shall be compatible with the following: - Clear space and span requirements - Serviceability requirements - Applicable fire protection classification - Structural design loads for the specific facility and location.	X			In Title I.
para. 02	The structural design drawings shall indicate design criteria, structural materials and their strengths with applicable materials standards, the design loads including loads that can occur during construction, and the allowable foundation loads that were used in the design.	X			In Title I drawing.
0111-2	Loads				
0111-2.1	General Requirements Structures and their elements shall be designed for the loads prescribed in these criteria.	X			In either Title I or requirement for Title II.
0111-2.2	Dead Loads				
0111-2.2.1	General				
para. 01	Dead loads are loads that remain permanently in place. They shall include the weights of all permanent materials and equipment, including the structure's own weight, supported in, or on, a structure.	X			Requirement for Title II.
para. 02	Load calculations shall include an allowance for any loadings anticipated to be added at a later date. Initially assumed loads shall be revised so that the final design reflects the configuration shown on the drawings.	X			Requirement for Title II.
0111-2.2.3	Service Equipment Design dead loads shall include the weight of all permanent service equipment.	X			Requirement for Title II.
0111-2.2.4	Allowance for Partition Loads. The minimum allowance for weights of partitions, where partitions are likely to be rearranged or relocated shall be as follows: - For partition weights of 150 psf or less, an equivalent uniform dead load of 20 psf shall be used. - For partition weights above 150 psf, actual linear loads shall be used. - Partitions that are likely to be rearranged or relocated should be calculated as live loads for load factor design.			X	Doors are not partitions.
0111-2.3	Live Loads				

SECTION	TITLE - CRITERIA	S	N	K	COMMENT
0111-2.3.1	General Live loads shall include all loads resulting from the occupancy and use of the structure, whether acting vertically down, vertically up, or laterally. Live loads shall include neither dead loads nor loads from the environment, such as wind, tornado, earthquake, thermal forces, earth pressure, and fluid pressure.	X			Requirement for Title II.
0111-2.3.2	Buildings and Other Structures Live loads for buildings and other structures shall be those produced by the intended use or occupancy. In no case shall they be less than the minimum uniform load or concentrated load stipulated in ANSI A58.1. Live loads on roofs shall be as stipulated in ANSI A58.1. They shall include the minimum roof live loads or the snow loads and snow drifts or possible rain loads stipulated therein, whichever produces the more severe effect.	X			ANSI A58.1 has been upgraded to ASCE/ANSI 70-88.
0111-2.4	Wind Loads				
0111-2.4.1	General The structural frame and exterior components of all buildings, signs, tanks, towers, and other exposed structures shall be designed to resist pressures due to wind assumed to act from any direction.	X			In Title I.
0111-2.4.2	Buildings and Other Structures				
para. 01	Wind load design for buildings and other structures shall be determined in accordance with procedures in ANSI A58.1 with the basic wind speed being obtained from UCRL 15910.	X			ANSI A58.1 has been upgraded to ASCE/ANSI 70-88. See Title I.
para. 02	The basic wind speed shall be derived from DOE site-specific hazard model studies summarized in UCRL 53526, Rev. 1. If site-specific hazard model studies are not available, a hazard model shall be developed that is consistent with the approach used in UCRL 53526, Rev. 1.	X			In Title I.
para. 03	The basic wind speeds for any specific site shall be determined following the procedures in UCRL 15910, except that Exposure "C" should be used for all construction unless it can be shown that the necessary permanent shielding will be provided by natural terrain (not including shielding from trees or adjacent buildings).	X			In Title I.
para. 04	To determine the design wind loads, all factors and coefficients stipulated in ANSI A58.1 shall be applied to the site-specific basic wind speeds. Building additions shall be designed as part of a totally new building without regard to shielding from the original building and without regard to lesser wind resistance for which the original building may have been designed.	X			Used ASCE 7-88: formerly ANSI 58.1.
0111-2.5	Tornado Loads				
para. 1	The basic wind speed and missile parameters shall be derived from DOE site-specific hazard models studies summarized in UCRL 53526, Rev. 1. If site-specific hazard model studies are not available, a model shall be developed consistent with the approach used in UCRL 53526, Rev. 1.			X	GIF is not a facility vital or critical to the DOE mission accomplishments.
para. 2	Structures other than critical facilities need design for tornado loading.			X	Albuquerque is an area of low tornado frequency.
para. 3	Facilities for radioactive material handling, processing, or storage, and other facilities having high value or vital importance to DOE programs that are classified as critical facilities, shall require special tornado loading criteria as stipulated in Section 0111-99.0, Nonreactor Nuclear Facilities - General.			X	GIF is not a facility vital or critical to the DOE mission accomplishments.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0111-2.6	Internal Shock and Blast Loads Building structures (excluding explosive facilities) that house operations that may release energy from rupture of equipment or explosions, either inadvertently or purposely (such as testing), shall be designed to control the resulting internal shock pressure loads per applicable criteria.	X			The only energy system which could cause a blast load is the steam subsystem for wet irradiation experiments. The system will be designed and constructed to satisfy industry standards for pressurized steam.
0111-2.7	Earthquake Loads				
0111-2.7.1	Buildings and Other Structures				
para. 01	The basic seismic parameters shall be derived from DOE site-specific hazard model studies summarized in UCRL 53582.	X			In Title I.
para. 02	Earthquake load design for buildings and other structures shall be determined in accordance with the procedures contained in UBC and UCRL 15910.	X			In Title I.
para. 03	For critical facilities, the provisions and design procedures of TM 5-809-10.1 shall be used.			X	GIF is not a critical facility.
para. 04	Facilities for radioactive material handling, processing, or storage, and other facilities having high value or vital importance to DOE programs that are classified as critical facilities shall require application of dynamic analysis in determining structural requirements for earthquake loading as stipulated in Section 0111-99.0, Nonreactor Nuclear Facilities - General.			X	GIF is not a critical facility.
para. 05	An independent review of the seismic design shall be made for facilities and buildings where a seismic event can have a potential risk to operator lives, to public safety, or of large economic loss. The review shall be made in two stages, the first at the end of preliminary design and the second before final design is complete. For additional guidance on independent reviews, see LBL-9143 and UCRL 15910.	X			Stone and Webster provide independent review.
0111-2.8	Other loads for buildings and other structures.				
0111-2.8.1	Vibratory loadings				
para. 01	Equipment supports shall be designed to avoid resonance resulting from harmony between the natural frequency of the structure and operating frequency of reciprocating or rotating equipment support on structure.			X	No routine vibratory loading.
para. 02	The operating frequency of supported equipment shall be determined from manufacturer's data prior to completion of structural design.			X	No applicable supported equipment.
para. 03	Resonance shall be prevented by designing equipment supports to reduce the dynamic transmission of the applied load to as low a level as can be economically achieved in the design.			X	No dynamic transmission expected from applied loads.
0111-2.8.2	Earth and Groundwater Pressures Every foundation wall or other wall serving as a retaining structure shall be designed to resist, in addition to the vertical loads acting on it, the incident lateral earth pressures and surcharges, plus hydrostatic pressures corresponding to the maximum probably groundwater level. Retaining walls shall be designed for earth pressures and potential groundwater levels producing highest stresses or overturning moments.	X			In Title I.
0111-2.8.3	Fluid and Gas Pressure The design of components of buildings and other structures shall include the effects of fluid and gas pressures, both internal and external.	X			Requirement for Title II.
0111-2.8.4	Thermal Forces The design of structures shall include the effects of stresses and movements resulting from variations in temperature.	X			Requirement for Title II.

SECTION	TITLE / CRITERIA				COMMENT
0111-2.8.5	Creep and Shrinkage Forces Concrete and masonry structures shall be investigated for stresses and deformations induced by creep and shrinkage.	X			Requirement for Title II.
0111-2.10	Combination of Loads and Design Requirements for Buildings and Other Structures. Combination of Loads, allowable stresses, and strength requirements for buildings and other structures shall be as stipulated in the UBC, except as otherwise indicated in 0111-99, Special Facilities.	X			Requirement for Title II.
0111-3	Structural Systems for Buildings and Other Structures				
0111-3.1	Framing Structural systems shall be designed for ductile modes of failure to the extent feasible.	X			Requirement for Title II.
0111-3.2	Floors Excessive loads or equipment subject to vibrations shall be supported by separate pads isolated from the rest of the floor slab with flexible joints.	X			Applicable to shielding door. Requirement for Title II.
0111-3.3	Control Joints Control joints shall be designed and placed in such a manner as to avoid structural distress and uncontrolled cracking from thermal expansion and contraction, concrete shrinkage, and movements due to wind and earthquake forces.	X			Requirement for Title II.
0111-3.4	Foundations				
0111-3.4.1	General Requirements The provisions of the UBC shall be the minimum requirements for foundations design.	X			Requirement for Title II.
0111-3.4.2	Foundation Vibrations Analysis of foundation vibrations, design to avoid resonance, and vibration and shock isolation, where required, shall be in accordance with Chapter 1 of DM-7.03.	X			Requirement for Title II.
0111-99	Special Facilities				
0111-99.0	Nonreactor Nuclear Facilities - General				
0111-99.0.1	General				
para. 01	Special facility structures that need not be designed to withstand severe natural phenomena or man-made events shall be designed to the requirements in Section 0111-2, Loads.	X			Requirement for Title II.
para. 02	Safety class items required to function during or following severe natural phenomena shall not be prevented from performing their required safety functions by the failure of components, systems, or structures that are not designed to the severe natural phenomena criteria.	X			Applies to cladding, cells and pool. Requirement addressed in PSAR.
para. 03	Safety class structures shall be protected against dynamic effects, including effects of wind-driven missile and discharging fluids, that may result from natural phenomena, accidents at nearby facilities, including military installations and transportation facilities, equipment failure, and similar events and conditions inside and outside the facility.	X			Test cells are the main drivers of this requirement: Usage is low and effects of wind-driven missiles do not require analysis.
para. 04	The design bases for such events shall take into account their historic frequency and severity in the region of the site and the potential risk to the environment or the health and safety of the public.	X			In Title I. Requirement addressed in PSAR.
para. 05	Facilities containing plutonium, other radioactive material, or other material that would be likely to produce significant health or safety hazards shall be evaluated as to the degree of risk, as necessary.	X			Evaluated in PSAR.

SECTION	TITLE / CRITERIA	S	A	N	COMMENT
para. 06	Many buildings are subject to future additional ceiling-roof equipment loadings. In planning and designing buildings for special facilities, construction shall be given to providing for a future 10 to 20 psf additional structural loading.			X	Dedicated use: no modifications are planned; however consideration will be given to allowing for additional loads -- particularly on the low bay roof.
para. 07	Where floor-mounted special facilities equipment will have a commonality of use, it shall be centrally located with respect to special facilities operations. Floor loadings and location of equipment and projections of future additional equipment requirements and their floor loadings shall be considered and provided for in structural planning and design.	X			Addressed in Title I. and requirement for Title II.
para. 08	In addition, safety class confinement barriers (barriers whose continued integrity is shown by a safety analysis to be required following severe natural phenomena, including the DBE, and man-made events) shall be designed to withstand secondary events as well as primary events. Potential secondary events might be fire, explosion, or nuclear criticality caused by the DBE.	X			Fire Hazard Analysis.
para. 09	In no case shall the total combustible loading located in a fire area exceed the fire resistance rating of the area enclosure. This shall be documented in a fire risk analysis.	X			Fire Hazard Analysis.
0111-99.0.2	Tornado and Extreme Wind				
para. 01	Determination of Design Basis Tornado DOE site-specific hazard model studies summarized in UCRL 53526, Rev. 1, shall be used to select the DBT and extreme wind characteristics for the design of structures. If site-specific hazard model studies are not available, a hazard model shall be developed consistent with the approach used in UCRL 15910. In applying UCRL 53526, Rev. 1, specific guidance on relating frequency of occurrence to facility hazard levels shall be obtained from UCRL 15910.			X	Albuquerque is classified as a region of low tornado occurrence, with an annual frequency of 0.1 or less.
para. 02	Tornado Analysis In designing for tornado or extreme wind resistance: - The tornado rotational speed shall be appropriately combined with the transitional speed. - Resulting loads from rate of pressure drop, taking into consideration any pressure equalization due to permissible venting, shall be combined with velocity-induced pressure loads as stipulated in UCRL 15910. - UCRL 53526, Rev. 1, provides the characteristics of typical potential tornado-generated missiles. Additional missiles may be identified from review of on-site sources and possible missiles that could be borne to the site by a tornado. Both small high-velocity missiles and massive low-velocity missiles shall be considered separately in terms of penetration, perforation, or crushing effects. The horizontal and vertical velocities of the missiles shall be combined in the design. - The minimum wind speed used shall be 70 mph. Loads resulting from the DBT shall be assumed capable of occurring at any time. However, for design purposes, DBT loads need not be assumed to occur simultaneously with other severe site-related events such as an earthquake, fire, or floor, except where the simultaneous occurrence is related (e.g., fire from lighting of other wind-related causes).			X	Albuquerque is classified as a region of low tornado occurrence, with an annual frequency of 0.1 or less.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0111-99.0.3	Floods The design loads from flooding shall comply with UCRL 15910. In calculating design loads from flooding, a conservative approach shall be taken to ensure that the loads used in the design are as follows: - Greater than the maximum historic levels recorded for the site - No less than the probable maximum flood (PMFL)	X			Requirement met by berms. Requirements in Fire Hazard Analysis.
0111-99.0.4	Earthquakes				
para. 01	General The systems, components, and structures that shall be designed to meet these special facility criteria shall be identified through a written evaluation (see Section 0111-99.0.1, General).	X			Addressed in PSAR.
	Such systems, components, and structures shall be designed to provide their passive or active functions as required by the SAR in accord with their designated safety classes.	X			Addressed in PSAR.
para. 03	Site-specific seismic parameters shall be determined for a DBE. The SSE shall be equivalent to the DBE.	X			Addressed in PSAR and In Title I.
para. 04	New seismic design, including additions or modifications to existing structures, shall be reviewed by a qualified, independent organization. This review must include evaluation of the design approach, the lateral force resisting system, and the design detailing, per UCRL-15910. TM-5-809-10 can be used for design detail guidance.	X			Stone and Webster Evaluation.
para. 05	Earthquake Occurrence The DBE shall be assumed capable of occurring at any time, except that the simultaneous occurrence with any other limiting site-related event such as a tornado, fire, or flood need not be considered for design purposes, except where the joint occurrence is casually related (e.g., fire or flood).	X			Addressed in PSAR.
para. 06	Determination of DBE. To determine the DBE, site-specific earthquake hazard models and response spectra given in UCRL 53582, Rev. 1, shall be used to select the appropriate seismic ground acceleration. Design guidance in UCRL 15910 shall be used in applying UCRL 53582, Rev. 1. The DBE shall be defined by design response spectra, appropriate for the site, or by acceleration time histories, representative of the anticipated ground motions.	X			Site-specific data was used as described in PSAR.
para. 07	Seismic Analysis The adequacy of systems, components, and structures to withstand a seismic event shall be verified by a dynamic analysis, except where it can be demonstrated that the use of a simplified approach, such as static load method, component testing, or a combination of testing and analysis provides assurance of adequate seismic design.	X			Requirement for Title II.
para. 08	The ratio of vertical-to-horizontal acceleration shall be two-thirds, unless site-specific data justify use of a different ratio.	X			In Title I and requirement for Title II.
0111-99.0.5	Aircraft Unless the safety analysis can demonstrate that the risk from an aircraft crashing into the facility is acceptable, potential aircraft crashes shall be considered among the spectrum of man-made missiles that confinement structures shall be designed to withstand or against which they shall be protected.	X			Addressed in Preliminary Safety Analysis Report.

0111-99.0.6	Nearby Explosions and Externally Generated Missiles The potential effects of a major explosion at a nearby facility or transportation route shall be considered among the spectrum of external blast effects and missiles that confinement structures shall be designed to withstand or against which they shall be protected.	X			Addressed in Preliminary Safety Analysis Report.
0111-99.0.7	Explosion, Internal Pressurization, Criticality, and Other DBA Causes The probable consequences of DBAs involving internally generated missiles or blast effects shall be considered. Such DBAs typically involve failure of high-speed rotating machinery, cranes, experimental facilities, high-energy fluid system components, or explosives. Structures required to function following such accidents shall be designed to withstand DBAs.	X			Requirement for analysis met in PSAR. Due to the substantial structure of the cells and the pool, the consequences are negligible.
para. 01	Load Combinations Safety class structures and structural members shall be designed to resist the appropriate load combinations provided in UCRL 15910.	X			In Title I and requirement for Title II.
para. 02	Concrete Structures Concrete structures and structural members for safety class concrete structures shall meet the design and construction requirements of ACI 349 for new construction or original (or equivalent) codes for existing construction providing the margin of safety of the overall facility is maintained.	X			In Title I for ACI 318.-89.
0140	Quality Assurance				
para. 01	Facility design shall be conducted under QA requirements to ensure that the established program and project quality objectives are satisfied. A QA program shall be developed and implemented in compliance with DOE 5700.68 and using the elements of DOE 4700.1 and ANS ANSI/ASME NQA-1.	X			See QA Chapter of FSAR. During design and construction, the QA requirements are satisfied by the Facilities Development Center based on requirements in DOE Orders 4700.1 and 5700.6C
para. 02	Control mechanisms shall be established to ensure that: (1) design inputs are correctly translated into design documents in a timely manner; (2) organizational and physical interfaces are identified and controlled; (3) changes to design are controlled in a manner commensurate with the original design; (4) the design is independently verified to be adequate; (5) documentation and records of the design and design verification process are maintained in accordance with the QA program.	X			See QA Chapter of FSAR. During design and construction, the QA requirements are satisfied by the Facilities Development Center based on requirements in DOE Orders 4700.1 and 5700.6C.
para. 03	QA program shall include quality control functions in the following areas: - The design will satisfy program and project requirements. - The prepared drawings and construction specifications adequately incorporate QA, design, and codes and standards requirements and are available in a timely manner. - Tests, reviews, or inspections confirm adequacy of design and quality of construction and manufactured components, where appropriate. - Lock and tag systems are provided for turnover acceptance, maintenance, and system outages.	X			See QA Chapter of FSAR and TA-V nuclear program. During design and construction, the QA requirements are satisfied by the Facilities Development Center based on requirements in DOE Orders 4700.1 and 5700.6C
para. 04	As a part of the QA program, architectural and engineering portions of design should be closely coordinated and functionally analyzed during the conceptual, preliminary (Title I), and detailed (Title II) design phases to avoid conflicts that could result in costly changes during construction. Prior to initiating Title I and Title II design, QA requirements shall be established for the project systems, subsystems, and components. The following shall be determined: What the facility is to accomplish, Range of operating conditions, Required degree of reliability, Intended useful life, and How it can be maintained, repaired, or replaced.	X			See QA Chapter of FSAR. During design and construction, the QA requirements are satisfied by the Facilities Development Center based on requirements in DOE Orders 4700.1 and 5700.6C

SECTION	TITLE / CRITERIA	E	N	D	COMMENT
para. 05	Provisions shall be made for review and checking design calculations, drawings, and construction specifications by qualified personnel other than those responsible for the original design.	X			See QA Chapter of FSAR.
para. 06	Deviations from specified standards shall be identified and procedures established to ensure their control.	X			See QA Chapter of FSAR.
para. 07	To the extent practicable, and particularly in the case of innovative design, the design should be independently reviewed by competent consultants in construction or manufacturing techniques to confirm the practicability of construction or manufacture.	X			See QA Chapter of FSAR.
Division 0200	**Site and Civil Engineering**				
0200	Site Development				
0200-1	Facility Siting				
0200-1.1	General				
para. 01	The selection of sites for new facilities shall comply with DOE 4300.18. A site development plan shall be used to locate new facilities on existing or new sites to assure effective site utilization and to preclude future conflicts between existing and new facilities.	X			The new GIF is part of Sandia's Site Development Plan.
para. 02	During site selection for new facilities the following conditions and requirements shall be considered: - Programmatic and operating efficiency - Natural topographic and geologic conditions - Existing cultural, historic, and archeological resources - Endemic plant and animal species - Existence of known RCRA and/or CERCLA sites - Special siting requirements for facilities containing, using, or processing hazardous material - Health, safety and environmental protection requirements - Indoor air quality impacts (e.g., presence of radon in foundation soils, building materials that off-gas irritating chemical vapors and the need to "bake out" new buildings prior to occupancy). - Hazardous operations and consequences of potential accidents in adjacent facilities - Natural hazards including seismic activity, wind, hurricane, tornado, flood, hail, volcanic ash, lightning and snow. - Wave action within any natural or man-made body of water (in accordance with CERC Shore Protection Manual) - Physical protection requirements - Security and safeguard requirements - Adequacy of existing or planned support and service facilities, including utilities, roads, and parking areas - Interrelationships between facilities and aesthetic compatibility - Energy conservation requirements - Impact of site selection	X			Most of these requirements are met by the Environmental Assessment for the GIF. Others, such as physical protection and security and safeguard requirements are considered as part of Sandia Site Development Plan.
para. 03	Location analysis performed during the preparation of CDRs shall consider but not be limited to these same criteria. The NEPA/DOE 5440.1C require the preparation of an environmental assessment prior to the initiation of a government action that may significantly affect the environment. These requirements shall be considered in facility siting.	X			Met by the GIF Environmental Assessment.
0200-1.2	Radiological Siting Requirements				

para. 01	For those facilities in which radioactive materials are processed, used, or stored, or those facilities that incorporate radiation-producing machines, the acceptability of the site shall be evaluated in terms of potential radiological consequences.	X			Met by GIF Environmental Assessment and addressed in the PSAR.
para. 02	Radiation dose to an off-site individual receiving maximum exposure shall be evaluated.	X			Calculated in PSAR.
para. 03	Dose shall be calculated and compared to the dose guidelines established below. Comparisons shall be based on a 50-year committed effective dose-equivalent.	X			Calculated in PSAR.
para. 04	The off-site individual receiving the maximum dose shall be assumed to be located at the point of highest concentration (or highest exposure rate) outside the boundary controlled by the site.	X			Calculated in PSAR.
para. 05	Meteorological conditions used in dose calculations shall be representative of unfavorable dispersion, determined by comparing the 0.5 percent dispersion factors (X/Q) for each sector to the 5-percent overall site X/Q and selecting the highest value.	X			Calculated in PSAR.
para. 06	Consideration shall be given to on-site individuals. Prudent measures associated with the radiological protection of on-site personnel and in conjunction with the on-site emergency response planning, as required through implementation of DOE 5500.3, shall be incorporated into the design and siting of a new facility.	X			Calculated in PSAR.
para. 07	Information on the siting evaluation, including the models, parameters, and assumptions used in the dose calculations shall be documented for use in the facility's SAR and emergency response plans.	X			Addressed in GIF's Environmental Assessment and utilized in the PSAR. There are no dose calculations in the PSAR.
0200-1.3	Radiological Siting Guidelines				
para. 1	The maximum calculated dose shall not exceed 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated by using the ICRP Report No. 26 weighting of factors.	X			No credible off-site impacts identified. The sitings requirements of DOE Order 5480.3 will be complied.
para. 2	When calculating these doses, degraded performance of ESF and administrative controls shall be assumed unless they can be clearly shown to be unaffected by the accident (capable of performing their safety function) by proper design, installation, testing, and maintenance according to prescribed standards.	X			No credible off-site impacts identified.
0200-2	Building Location	X			
0200-99	Special Facilities				
0200-99.01	General	X			
0200-99.0.2	Other Facilities and Operations The potential hazards from other on-site facilities and off-site sources of hazards that could affect the safe operation of the special facility shall be considered.	X			Considered in PSAR.
0200-99.0.3	Services The design of utility services shall provide reliability consistent with operational requirements, the value of in-process product, and the potential hazard for identifiable probable conditions. Utility systems essential to the support of safety class items shall be designed as safety class items.	X			Electrical systems and water makeup are not safety class items.
0200-99.0.4	Meteorology				

SECTION	TITLE / CRITERIA	[illegible]	[illegible]	[illegible]	COMMENT
para. 1	Available meteorological data shall be considered to identify conditions that may influence the design and operation of the facility. Meteorological data to be considered shall include expected annual ranges and distributions of the following variable. wind direction and speed, atmospheric stability, temperature atmospheric water vapor, mean joint temperature and specific humidity	X			In Title I and considered in the PSAR.
para. 2	As a minimum, at least one year of valid meteorological data shall be used to properly develop estimated joint frequency distributions of wind speed and stability conditions. These data shall be used to eliminate the dispersal of effluents under normal and accident conditions.	X			Met by both Title I and PSAR.
0200-99.0.5	Hydrology Site studies shall be performed to determine ground water levels, flood runoff, drainage, and other hydrological characteristics that could influence the design or operation of the facility. The hydrological studies shall include the following: - Flooding (probably maximum flood, 100-year flood, 25-year flood, flash flooding, flood due to tsunamis, flooding due to dam failures, flooding due to ice jams) - Ground water levels - Tsunamis - Dam failures and breaches (including seismically induced dam failures) - Ice loadings from water bodies - Potential transport or radioactive and chemical contaminants in surface water and in groundwater.	X			Flooding addressed in Environmental Assessment of the GIF and as part of Title I. GIF location is not part of the 100 year flood plain.
0200-99.0.6	Seismology Studies shall be performed to determine site features such as ground failure under dynamic loading, surface faulting, liquefaction, vibratory ground motion, and site amplification that could influence the design or operation of the facility.	X			Results of study documented in Construction Package for Title II.
0200-99.8	Telecommunications, Alarms, ADP Centers, & Radio Repeater Stations	X			Requirement for Title II.
0201	Subsurface Investigations	X			Requirement for Title II.
0202	Surveying	X			Requirement for Title II.
0203	Utilities Within Easements or Corridors	X			Requirement for Title II.
0205	Demolition, Decontamination, and Decommissioning				Requirement for Title II.
0205.1	Demolition Demolition plans shall ensure that remaining buildings, trees, and environmental resources are protected.	X			Assured as part of Sandia's demolition procedures.
0205-2	Decontamination and Decommissioning Facilities where radioactive or other hazardous contaminating materials will be used or will result from facility operation shall be designed to limit dispersion and simplify periodic decontamination and ultimate facility decommissioning and disposal or reuse. Requirements are provided in Section 1300-11, Decontamination and Decommissioning.	X			Addressed in SAR.
0210	Site Preparation	X			Requirement for Title II.
0214	Dewatering	X			Requirement for Title II.
0215	Shoring and Underpinning	X			Requirement for Title II.
0220	Earthwork	X			Requirement for Title II.
0235	Building Foundations				Requirement for Title II.

SECTION	TITLE / CONTENT	R	P	N	REQUIREMENT
0235-1	General Building foundations shall be designed in accordance with the requirements of the UBC and ACI 318.	X			Requirement for Title II.
0235-2	Foundation Design Criteria	X			Requirement for Title II.
0235-3	Concrete Concrete for building foundations shall be designed in accordance with Section 0330, Cast-In-Place Concrete.	X			Requirement for Title II.
0235-8	Equipment Foundations Heavy, vibration-producing equipment, such as high-pressure air compressors, chillers, fire pumps and engine/generator sets, shall have separate, isolated foundations.	X			Requirement for Title II.
0245	Railroad Design	X			Requirement for Title II.
0250	Paving and Surfacing	X			Requirement for Title II.
0256	Airports and Heliports	X			Requirement for Title II.
0260	Piped Utility Materials	X			Requirement for Title II.
0260-1	Coverage	X			Requirement for Title II.
0260-2	Exterior Utilities	X			Requirement for Title II.
para. 1	All water mains, supplying fire protection systems, fire hydrants, etc., shall be treated as fire mains and installed in accordance with NFPA 24.	X			Requirement for Title II.
para. 2	Water storage facilities shall comply with NFPA 22.	X			Requirement for Title II.
para. 3	Gas distribution shall comply with local codes and requirements. Fuel gas shall comply with NFPA 54. Liquefied petroleum gas shall comply with NFPA 58.	X			Requirement for Title II.
0262	Corrosion Control	X			Requirement for Title II.
0266	Water Distribution Systems				
0266-1	General Cross-connections between domestic and industrial or irrigation distribution systems are prohibited.	X			Requirement for Title II.
0266-2	Regulatory Review Domestic water conveyed within distribution systems that serve DOE facilities shall comply with the applicable SDWA, 40CFR141, 10CFR142 requirements and with all other State, regional, and local requirements. The radionuclide content of these drinking water systems shall comply with the requirements of the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.	X			Requirement for Title II.
0266-3	Planning for Water Distribution Systems	X			Requirement for Title II.
0266-4	System Design Considerations				
para. 01	Domestic water distribution systems that also serve fire protection requirements shall be designed to satisfy fire flow requirements plus 50 percent of the average domestic requirements plus any industrial or process demands that cannot be reduced during a fire.	X			Requirement for Title II.
para. 02	Each fire hydrant within the distribution system must be capable of delivering 1000 gpm at a residual pressure of not less than 100 psi.	X			Requirement for Title II.
para. 03	Where domestic water distribution systems are to serve internal fire protection systems (i.e., sprinklers or foam systems), adequate residual pressures shall be maintained for proper operation of such fire protection systems.	X			Requirement for Title II.
para. 04	Fire hydrant branches (from main to hydrant) shall be not less than 6 inches in diameter and no longer than 300 feet.	X			Requirement for Title II.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 05	A gate valve shall be installed within each fire hydrant branch to facilitate maintenance.	X			Requirement for Title II.
para. 06	Water mains shall have a minimum pressure rating of 150 psi.	X			Requirement for Title II.
para. 07	Water distribution systems shall be designed to maintain a normal operating pressure range of 40 psi to 100 psi (at ground level) in distribution mains and building service lines.	X			Requirement for Title II.
para. 08	Fire hydrants shall be installed at a maximum spacing of 400 feet. Fire hydrants shall not be located more than 300 feet from the buildings to be protected.	X			Requirement for Title II.
para. 09	Each building shall be protected by a minimum of two hydrants.	X			Requirement for Title II.
0267	Industrial Water Treatment	X			The Liquid Effluent Control System (LECS) for TA-V satisfies montoring requirements.
0270	Sanitary Wastewater Collection and Stormwater Management Systems	X			Addressed in GIF EA.
0273	Water Pollution Controls	X			Addressed in GIF EA
0273-1	General				
0273-4	Selection of Sanitary Wastewater Treatment and Disposal Methods	X			Addressed in GIF EA
0273-99	Special Facilities				
0273-99.0	Nonreactor Facilities - General There shall be no interconnection among storm water systems, the sanitary waste system and radioactive or other hazardous material handling areas. The sanitary waste system at each facility shall be monitored or sampled and analyzed (e.g., alpha emitters) for radioactivity unless the site sanitary treatment system is monitored. In addition, there shall be no interconnections between the potable water system, the sanitary waste system, and process systems.	X			Requirement fulfilled by LECS, as described in the EA. Requirement to contain pool overflow fulfilled by sloping floors to the pool. Other cross-contamination prevented by a trench outside of the door.
0275	Industrial Wastewater Treatment			X	The Liquid Effluent Control System (LECS) for TA-V satisfies montoring requirements.
0276	Construction in Floodplains or on Wetlands			X	Not in floodplains or on wetlands.
0278	Power and Lighting	X			Requirement for Title II.
0279	Exterior Communications and Alarm Systems. The design professional shall coordinate exterior communications and alarm systems as follows: - Intrusion alarm and fire alarm systems shall comply with the DOE 5632 series, Section 1670, Exterior Communications and Alarm Systems, NFPA 72A, NFPA 72B, NFPA 72C, HFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, and NFPA 72H.	X			Requirement for Title II.
0280	Site Improvements	X			Requirement for Title II.
0281	Vehicular and Pedestrian Circulation	X			Requirement for Title II.
0283	Physical Protection	X			Requirement for Title II.
0283-1	General Application of physical protection systems to meet site safeguards and security requirements shall be documented and justified in Headquarters-approved MSSAs. Physical protection system design should use a graduated approach.	X			TAV in general goes beyond these requirements because of the presence of SNM.

SECTION	TITLE - CRITERIA	S	M	N	COMMENT
0283-2	Physical Protection Planning Physical protection requirements shall be considered during site selection for new facilities. Physical protection system designs shall comply with the DOE 5632 series and shall be coordinated with the responsible security administrator or his designee. Approval of the recommended physical protection system shall be obtained from the DOE Safeguards and Security Coordinator. These features shall be documented in the SSSP or other corresponding planning documents.	X			TAV in general goes beyond these requirements because of the presence of SNM.
0283-3	Permanent Security Fencing	X			Fulfilled by Tech Area V perimeter.
0283-4	Patrol Roads and Walkways	X			Fulfilled by Tech Area V security system.
0283-5	Gates, Entry Control Points, Vehicle Barriers	X			Fulfilled by Tech Area V security system.
0283-6	Security Inspector Posts and Guard Towers	X			Fulfilled by Tech Area V security system.
0283-7	Lighting	X			Fulfilled by Tech Area V security system.
0285	Solid Waste Systems				
0285-1.1	General Management of hazardous solid waste shall comply with 40 CFR 264 and Subtitle C of the RCRA.	X			Addressed in GIF EA and in PSAR.
0285-99	Special Facilities				
0285-99.0	Nonreactor Nuclear Facilities - General. Design of special facilities shall include adequate provisions for the safe collection, packaging, inventory, storage, and loading for transport of solid waste that is contaminated with radioactive material. These provisions shall include allocation of adequate space for sorting and safe temporary storage of solid waste, equipment for assay of the waste, and facilities for volume reduction appropriate to the types of quantities of solid waste to be produced. All packages containing contaminated solid waste shall be appropriately monitored, both before being moved to temporary storage locations and before being loaded for transport to a disposal site. Nuclear criticality safety shall be considered in the design of radioactive solid waste facilities.	X			Addressed in GIF EA and in PSAR.
0290	Landscaping	X			Requirement for Title II.
0291	Irrigation Systems	X			Requirement for Title II.
Division 0300	**Concrete**				
0301	General Requirements Concrete materials, design, and construction for buildings and other structures shall comply with ACI 318 and 40CFR249.	X			In Title I.
0310	Concrete Formwork Concrete construction formwork shall comply with ACI 347 & ACI SP-4.	X			In Title I.
0320	Concrete Reinforcement	X			In Title I.
0330	Cast In-Place Concrete	X			In Title I.
0340	Precast Concrete	X			In Title I.
0350	Cementitious Decks for Buildings	X			In Title I.
0370	Repair and Restoration of Concrete Structures	X			In Title I.
0380	Mass Concrete	X			In Title I.
0400	**Masonry**	X			In Title I.
0500	**Metals**	X			In Title I.
0600	**Wood and Plastics**	X			In Title I.
0700	**Thermal and Moisture Protection**	X			In Title I.
0727	Firestopping				
para. 1	Firestopping shall comply with NFPA 101, Chapter 6.	X			Requirement for Title II.

SECTION	PARAGRAPH				COMMENT
para. 2	Firestopping materials and assemblies shall be tested for their fire resistance and listed by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Unrated and unapproved assemblies shall be tested and approved before being considered for use in a DOE facility.	X			Requirement for Title II.
para. 3	Where fire-rated assemblies (walls, floor-ceilings, roof ceilings) are either partially or fully penetrated by pipes, ducts, conduits, or other building elements, firestopping material shall be placed in and around the penetrations to maintain the fire resistance rating of the assembly.	X			Requirement for Title II.
0800	**Doors and Windows**				
0800-1.1	General Frequently used doors shall have a vision panel except where privacy, security, or fire safety requirements preclude installation.	X			Requirement for Title II.
0800-1.2	Fire Protection Fire doors, frames, and hardware shall be either tested and listed by UL or nationally accredited testing laboratories or approved by FM or similar national insurance organizations. Fire doors, frames, and hardware shall be installed with label attached in accordance with NFPA 80.	X			Requirement for Title II.
0800-2	Windows	X			Requirement for Title II.
0810	Metal Doors and Frames	X			Requirement for Title II.
0820	Wood and Plastic Doors	X			Requirement for Title II.
0830	Special Doors	X			Requirement for Title II.
0833	Coiling Doors Exterior overhead rolling metal curtain doors shall be weather-stripped.	X			Requirement for Title II.
0836	Sectional Overhead Doors	X			Requirement for Title II.
0839	Screen and Storm Doors	X			Requirement for Title II.
0850	Metal Windows	X			Requirement for Title II.
0860	Wood and Plastic Windows	X			Requirement for Title II.
0870	Hardware	X			Requirement for Title II.
0880	Glazing	X			Requirement for Title II.
Division 0900	**Finishes**	X			Requirement for Title II.
Division 1000	**Specialties**	X			Requirement for Title II.
Division 1100	**Equipment**				
1100	General				
1161	Enclosures, Hoods, and Gloveboxes			X	This section is not applicable because the GIF cells do not satisfy the definition of enclosures.
1161-1	General Considerations				
para. 1	The design objective shall be to keep exposure of the plant personnel to airborne contamination and shall implement ALARA concepts as practical to minimize operator exposures. The enclosure system, including its internal and external support structures, shall be designed to withstand the effects of normal operating conditions and the environment. Also, DBAs such as fire, explosion, criticality, and natural phenomena shall be considered in the design of the enclosure. Enclosure stability during a seismic event shall be based on the seismic parameters described in Section 0111-99.0.4, Earthquakes.			X	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para.2	Where practical and without penetrating the enclosure, all equipment components not functionally required to operate directly in the presence of radioactive materials shall be located outside the enclosure. All equipment that must be located within the enclosure shall be designed to allow for in place maintenance and/or replacement.			X	
para. 3	The design and operation of support and protection systems, such as fire protection, shall not promote the failure of the enclosure system integrity or the loss of confinement.			X	
1161-2	Construction				
para. 01	Noncombustible or fire-resistant materials shall be used for enclosures and, to the maximum extent practicable, for required radiation shielding.			X	
para. 02	In no case shall the total combustible loading in a fire area exceed the fire resistance rating of the structural envelope (see Section 0110-99.0.6, Fire Resistance). This shall be documented in a fire risk analysis.			X	
para. 03	Enclosures (except open-face hoods) shall be designed with the objective of being leak-tight. In conjunction with their ventilation systems, all enclosures shall be capable of maintaining confinement (i.e., negative pressure with respect to the surrounding operating area). Without their associated ventilation systems, enclosures shall be designed with appropriate physical features to provide an essentially leak-tight confinement (except open-face hoods, which shall provide filtered confinement) for the contaminants they handle.			X	
para. 04	Viewing windows in enclosures shall be as small as practicable.			X	
para. 05	The windows shall be constructed on noncombustible or approved fire-resistant materials as specified in Section 0727, Firestopping.			X	
para. 06	Window design shall be such that it will enable replacement with minimum risk of releasing contamination to the working area.			X	
para. 07	The selection of appropriate window material shall be based on specific process, combustible loading, and radiological safety considerations.			X	
para. 08	Glove ports shall have flexible gloves attached to allow operating personnel access to all interior surfaces and equipment.			X	There are no glove boxes.
para. 09	They shall be designed to allow replacement of gloves without losing contamination control and with minimum exposure to the operator.			X	There are no glove boxes.
para. 10	When gloves are not in place, a noncombustible shield or cover for each glove port shall be provided.			X	There are no glove boxes.
para. 11	To reduce migration of contamination, closure devices or permanent seals shall be provided on entrances and exits of piping, ducts, or conduits penetrating confinement barriers.			X	
para. 12	Such closures or seals shall have an integrity equal to or greater than the barrier itself.			X	
para. 13	Where pertinent to safety, the enclosure design shall consider the heat generation in the enclosure. Structural support shall be provided to accommodate any anticipated loading resulting from shielding.			X	
para. 14	Discrete work stations or process areas shall be separated from each other by a barrier designed to prevent the spread of fire based on safety analysis review.			X	
para. 15	Generally, the fire barriers within and between enclosures will be normally closed. Where operations require that the fire barrier be in the open position, it shall automatically close upon activation of the fire detection system or by release of a fusible device.			X	

SECTION	TITLE/CRITERIA	S	N	I	COMMENT
para. 16	Design of the enclosure system shall allow automatic closure of the fire barrier without loss of confinement, without degradation of the enclosure system's integrity, and without injury to personnel.			X	
para. 17	The fire barrier shall be capable of being opened or closed manually from the exterior and interior of the enclosure.			X	
1161-3	Fire Protection				
para. 01	When an automatic fire suppression system is mandatory and protection against loss from fire originating within the enclosure system is required, a highly reliable, fast-acting system shall be provided.			X	
para. 02	Where automatic systems are not required, fire detection shall be installed.			X	
para. 03	Provisions shall also be made for manual fire suppression where deemed necessary.			X	
para. 04	Fire detection systems shall be integrated with any central alarm location and any associated automatic fire suppression systems.			X	
1161-4	Ventilation				
para. 01	A ventilation system shall be installed on all enclosure systems to maintain minimum negative pressure differential of 0.3 in. of water inside the enclosure (except open-face hoods) with respect to operating area.			X	
para. 02	Open-face hoods shall be ventilated such that flow from the operating area into the hood is maintained.			X	
para. 03	Safety class items of the ventilation system shall be supplied with emergency power.			X	
para. 04	Failure of any single component or control function shall not compromise minimum adequate ventilation.			X	
para. 05	Perchloric acid fume exhaust systems shall comply with NFPA 45, Chapter 6.			X	
para. 06	HEPA filters shall be provided at the interface of the enclosure outlet and the ventilation system to minimize the contamination of ductwork and at the enclosure inlet to prevent movement of contamination within the enclosure to the operating area in the event of a flow reversal.			X	
para. 07	The system shall be designed to automatically ensure adequate inflow of air through a credible breach in the enclosure system.			X	
para. 08	Minimum inward air velocity shall be 125 plus or minus 25 linear ft/min or as determined from guidance provided in the ACGIH Industrial Ventilation Manual.			X	
para. 09	The design of the enclosure ventilation flow pattern shall minimize the spread of fire, and fire screens shall be provided where necessary.			X	
para. 10	For enclosures where overpressurization is possible, a system shall be provided to ensure that confinement is not breached.			X	
para. 11	Small enclosure systems with positive-pressure supplied gases shall have positive-acting, pressure-relief devices (connected into the exhaust system) to prevent pressurization of the enclosure.			X	

SECTION	TITLE, CRITERIA				COMMENT
para. 12	Hood faces shall not be located within 10 ft. of the closest air supply or exhaust point. Hoods shall not be located in or along normal traffic routes. An open-faced hood shall be designed and located to provide a minimum air velocity of 125 plus or minus 25 linear ft/min over the hood face area. A hood should not be used in a location where room air currents of > 50 linear ft/min at the face of the hood will disrupt uniform air entrance. All open-face hoods shall be designed to provide appropriate face velocity to ensure capture of contaminants in the hood exhaust (see the ACGIH Industrial Ventilation Manual). Exhaust air from a hood shall not be recirculated to occupied areas.			X	
1161-5	Operational Compatibility Shielding, shape, size, and any other pertinent design criteria for all enclosures, gloveboxes, conveyor tunnels, hoods, and process equipment should be coordinated with operations requirements to ensure continuity and performance of operations; and by the Safeguards and Security Group (function) to ensure that SNN control and accountability considerations have been considered along with other DOE physical protection requirements.			X	
Division 1200	**Furnishings**				
1201	General Furnishings shall be designed and constructed to exclude or prevent the escape of emissions from volatile organic compounds, such as formaldehyde, and combinations of volatile organic compounds that have been determined to be a health hazard.	X			Requirement for occupancy.
1230	Manufactured Casework The design of manufactured casework for use with radioactive materials shall consider radioactive shielding requirements.	X			Shielding requirements have been considered, as documented by the PSAR.
1250	Window Treatment	X			Part of Title II requirements.
1260	Furniture and Accessories	X			Part of Title II requirements.
1260-99	Special Facilities				
1260-99.1	Laboratory Facilities (Including Hot Laboratories) In laboratories handling radioactive materials, the weight of shielding material to be placed on bench tops and hoods shall be considered in specifying bases and cabinets.			X	No shielding is to be placed on bench tops and hoods.
Division 1300	**Special Facilities**				
1300	General Requirements				
1300-1.3	Objectives Protection of employees within the facility and at nearby facilities shall be a requirement in all aspects of the design. For mixed-use facilities, such as those combining PPHFs and PSFs, the design of either part of that facility shall not jeopardize the safety requirements of the other.	X			The construction of the new GIF will result in eliminating mixed use.
1300-1.4	Guidance on Limiting Exposure of the Public				
1300-1.4.1	General The confinement of hazardous materials produced, processed, or stored in special facilities shall be designed to minimize dose to a maximally exposed member of the public.	X			The design to meet this requirement is documented in the PSAR.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300-1.4.2	Accidental Releases Releases of hazardous materials postulated to occur as the result of DBAs shall be limited by designing facilities such that at least one confinement system remains fully functional following any credible DBA (i.e., unfiltered/unmitigated releases of hazardous levels of such materials shall not be allowed following such accidents). Facility design shall provide attenuation features for postulated accidents (up to and including DBAs) that preclude off-site releases that would cause doses in excess of the DOE 5400 series limits for public exposure.	X			Documented in the PSAR.
1300-1.4.3	Routine Releases The annual dose resulting from postulated, planned, or expected releases from the proposed facility shall be considered in combination with the annual doses resulting from planned or expected releases from other facilities at the same site. The sum of the doses from the site shall be limited according to DOE Radiation Standards of Protection of the Public in the Vicinity of DOE Facilities or subsequent guidance included in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.	X			No routine releases expected.
1300-1.4.4	Monitoring of Releases Releases shall be monitored in accordance with the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series.	X			Note: RAMS on pool demineralizers.
1300-2	Safety Analysis Safety Analysis shall comply with DOE 5481.1B. See also Section 0110-5.2, Safety Analysis.		X		DOE Order 5480.23 supersedes 5481.1b.
1300-3.1	General Special facility components, systems, and structures shall be designed, fabricated, erected, and tested to standards and quality commensurate with the hazards and potential consequences associated with both the facility and the role of each component system, and structure in mitigating the consequences of DBAs.	X			Design aspect is documented in the PSAR. Testing program will be detailed in the FSAR.
1300-3.2	Safety Class Items				
para. 1	Safety class items shall be subject to the appropriately higher-quality design, fabrication, and industrial test standards and codes specified in Section 0106, Regulatory Requirements, and Section 0109, Reference Standards and Guides, to increase the reliability of the item and allow credit to be taken for its capabilities in a safety analysis. Safety class items shall be designed to the ASME boiler and Pressure Vessel Code (Section III, Class II) or to other comparable safety-related codes and standards that are appropriate for the system being designed.	X			Safety significant items include the cladding, pool and cells. Design requirements are set by commitments in the PSAR. Special testing will be included as part of the installation of the pool (including leak testing) and as part of the ORR.
para. 2	The design of systems, components and structures that are not safety class items shall, as a minimum, be subject to conventional industrial design standards, codes, and quality standards. Failure of these items shall not adversely affect the environment or the safety and health of the public. In addition, their failure shall not prevent safety class items from performing their required functions.	X			Documented in Chapter 6 of the PSAR. Interaction of other systems with safety class items is analyzed in the PSAR.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300-3.3	Single Failure Criterion and Redundancy The design shall ensure that a single failure does not result in the loss of capability of a safety class system to accomplish its required safety functions. To protect against single failures, the design shall include appropriate redundancy and shall consider diversity to minimize the possibility of concurrent common-made failures of redundant items.	X			Design requirements of cladding, pool and cells documented in the PSAR.
1300-3.4	Equipment Environment Considerations				
1300-3.4.1	General Safety class items shall be designed to withstand the effects of, and be compatible with, the environmental conditions associated with operation, maintenance, shutdown, testing, and accidents.	X			Criteria addressed in the PSAR.
1300-3.4.2	Environmental Qualification of Equipment Equipment qualification shall provide assurance that safety class items will be capable of performing required safety functions under DBA conditions. The qualification shall demonstrate that the equipment can at least perform for the period of time that its safety functions are required. Temperature, pressure, and humidity environments shall be based on the most severe postulated accident affecting the particular item. The postulated environment shall reflect an environment that considers both radiological composition (e.g., elements, isotopics, total radioactivity) and chemical composition (e.g., abrasives, acids, smoke, caustic vapors) or all material physical forms likely to affect the equipment.	X			Criteria addressed in the PSAR.
1300-3.4.3	Equipment Operability Qualification Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of fluid system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE. Seismic experience data may be used as an alternative to testing or dynamic analysis where such data have been documented and validated.	X			Incorporated in FSAR and ORR for the GIF.
1300-3.5	Maintenance				
para. 1	The design shall consider the maintainability factors peculiar to the specific equipment to be used in the facility. Facility design shall provide for routine maintenance, repair, or replacement of equipment subject to failure.	X			Addressed in the PSAR. Details of maintenance contained in the FSAR.
para. 2	Safety class items shall be designed to allow inspection, maintenance, and testing to ensure their continued functioning, readiness for operation, and accuracy. Ancillary equipment, such as pumps, blowers, motors, compressors, gear trains, and controls, shall be located in an area least likely to be contaminated.	X			Addressed in the PSAR. Details contained in the FSAR. No ancillary equipment will be located in an area where contamination is a potential.
para. 3	The design of equipment that must be located within confinement systems shall allow for in-place maintenance or replacement.	X			Applies to elevator in cells. Cells will not be functioning as confinement system when personnel are inside.
para. 4	The capability shall be provided for the maintenance of contaminated equipment that cannot be repaired in place. This capability shall include the necessary provisions for confinement, ventilation, and waste control.	X			Criteria applies to demineralizer resins.
para. 5	The design of all process equipment shall include features to minimize self-contamination of the equipment, piping, and confinement areas. The design of process equipment shall also include features to minimize the spread of contamination out of local areas.	X			Demineralizer acts to remove contamination from secondary confinement. .
1300-3.6	Testing				

para. 1	The design shall include provisions for periodic testing of monitoring, surveillance, and alarm systems. In addition, the design shall provide the capability to test periodically, under simulated emergency conditions, safety class items that are required to function under emergency conditions.	X			Preliminary requirements for a testing program are discussed in the PSAR. Testing will be detailed in the FSAR.
para. 2	All systems for which credit is taken to meet the criteria of Section 1300-1.4.2, Accidental Releases, shall be in-place testable in terms of pressure, filtration or removal efficiency, alarm capability, leak resistance, and the like. Safety class items shall be designed to be testable on a regular schedule.	X			Systems for prevention of accidental releases include cladding, pool and cells. Requirements for testing of these systems is described in the PSAR and details will be given in the FSAR.
para. 3	The facility design shall allow for routine in-place testing of HEPA filtration systems as outlined by ASME N510.			X	No HEPA filtration systems.
1300-4	Nuclear Criticality Safety				
para. 01	An assessment of a design shall be made as early as practical to determine if the potential for nuclear criticality exists.			X	No SNM is to be used or stored in the GIF except where present in test items and when reviewed by the Tech Area V RCSC
para. 02	When such potential exists, the design of nuclear criticality control provisions, including equipment and procedures, shall meet, as a minimum, the requirements of DOE Order 5480.5 and the ANS 8 series on Nuclear Criticality Safety.	X			Tech Area V has a review committee (Radiation and Criticality Safety Committee) for assessing criticality compliance of tests and experiments involving SNM.
para. 03	Nuclear criticality safety shall be achieved by exercising control over both the quantity and distribution of all fissile materials and other materials capable of sustaining a chain reaction, and over the quantities, distributions and nuclear properties of all other materials with which the fissile materials and other materials capable of sustaining a chain reaction are associated.			X	
para. 04	The design shall ensure that material shall not be displaced or allowed to accumulate to form a critical mass in the event of an internal or external accident.			X	
para. 05	The design shall emphasize geometrically favorable compartments or spacing to minimize reliance on administrative control, and shall prevent the unsafe accumulation of moderator or reflection materials (e.g., water from a fire sprinkler system).			X	
para. 06	Also, heating or cooling jackets in the safe dimension of geometrically safe vessels shall preclude a leak in the jacket that causes an increase in the system's reactivity.			X	
para. 07	Process designs shall incorporate sufficient factors of safety so that a least two unlikely and independent concurrent changes must occur in process conditions before a criticality accident is possible.			X	
para. 08	Structures, systems, and components that provide nuclear criticality safety shall be designed as safety class systems and be capable of performing their criticality safety functions during and following design basis accidents and events.			X	
para. 09	A criticality monitoring and alarm system (gamma and/or neutron) shall be provided where necessary to meet the requirements of DOE Order 5480.5 and ANS 8.3.			X	
para. 10	Nuclear criticality safety shall be controlled, in decreasing priority, by geometric spacing, density and/or mass limitation, fixed neutron absorber, soluble neutron absorber, and administrative control.			X	

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 11	The design of the facility shall emphasize engineered safeguards and shall not rely strictly on administrative controls.			X	
para. 12	Process systems shall be designed to prevent the carryover of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas.			X	
para. 13	A system of positive control and backflow prevention, such as air gaps (siphon breakers) shall be used to prevent inadvertent transfer of fissile material and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers.			X	
para. 14	Locations where a potential critical mass could occur in the event of accidental flooding by water from fire protection systems shall be protected by geometrically favorable curbed areas or collection systems.			X	
para. 15	Where frequency estimates for a specific operation at a specific location shows the frequency of a criticality accident to exceed 10 per year, the combination of shield design and facility layout shall minimize radiation doses to adjacent work stations and exit routes.			X	
para. 16	Egress routes shall be provided that take into account the locations where postulated criticality accidents would normally be expected to occur. For facilities where the design cannot avoid evacuation through areas of potentially high exposure, the use of additional shielding in such areas shall be considered.			X	
para. 17	All barriers along egress routes shall be designed to allow crash existing of evacuating personnel (i.e., operator safety should take priority over security concerns).			X	
1300-5	Source and Special Nuclear Material The criteria of ANSI N16.1 shall apply. In-process source or SNM shall be stored in storage containers to be approved by facility management, and simple physical barriers shall be used to segregate materials and provide a level of confinement and safety consistent with the hazard of the material.			X	No SNM Storage. Same as 1300-4.
1300-6	Radiation Protection				
1300-6.1	General Special facilities shall be designed to minimize personnel exposures to external and internal radiological hazards, provide adequate radiation monitoring and alarm systems, and provide adequate space for health physics activities. Primary radiation protection shall be provided by the use of engineered controls (e.g., confinement, ventilation, remote handling, equipment layout and shielding); secondary radiation protection shall be provided by administrative control. ALARA concepts shall be applied to minimize exposures where cost-effective.	X			Design of facility to meet goals defined by RAD Con manual and by ALARA principals is documented in the PSAR. Primary protection is provided by engineered controls.
1300-6.2	Shielding Design				
para. 1	The shielding design basis shall be to limit the maximum exposure to an individual worker to one-fifth the design goals for occupational external exposure limits specified in DOE 5480-11. Within this design basis, personnel exposures shall be maintained ALARA. Specifically, the shielding shall be designed with the objective of limiting the total EDE to less than 1 rem per year to workers, based on their predicted exposure time in the normally occupied area. The EDE shall be the sum of all contributing external penetrating radiation (gamma and neutron). In addition, appropriate shielding shall be installed, if necessary, to minimize nonpenetrating external radiation exposures to the skin and lens of the eye of the worker.	X			Design of facility to meet goals defined by RAD Con manual and by ALARA principals is documented in the PSAR. Primary protection is provided by engineered controls.

SECTION	TITLE / CRITERIA				COMMENT
para. 2	Shielding and other radiation protection measures shall be provided for areas requiring intermittent access, such as for preventive maintenance, component changes, adjustment of systems and equipment, and so forth. The projected dose rates based on occupancy, time, and frequency of exposure shall not exceed 1 rem/yr.	X			No sources will be present in the cells when personnel access is permitted. Access to roof and top of cell will be administratively controlled to prevent inadvertent exposure.
para. 3	Concrete radiation shielding design shall comply with ANS 6.4 and ACI 349 and shall consider the material specifications of ANS 6.4.2 where it provides a critical confinement or structural function.	X			Concrete shielding in accordance with ACI 318-89, as described in Chapter 6 of the PSAR.
para. 4	Straight-line penetration of shield walls shall be avoided to prevent radiation streaming.	X			Design to prevent radiation streaming is documented in the PSAR.
1300-6.3	Hand and Forearm Protection Remote shielded operation (i.e., with remote handling equipment such as remote manipulators) shall be considered where it is anticipated that exposures to hands and forearms would approach the dose guidance in 5480.11 or where contaminated puncture wounds could occur.	X			All source handling is to be done with remote equipment.
1300-6.4	Internal Radiation Exposure The design shall ensure that occupied operating areas do not exceed the airborne concentration limits of the DOE 5480 series for normal operating conditions. In addition, to the extent practical, the concept of ALARA shall be used when designing confinement and ventilation systems to limit airborne contamination levels. The design shall ensure that respirators are not required to meet the dose limits for normal operations. Engineered controls and features shall also be provided to minimize potential inhalation of radioactive and other hazardous materials under all conditions.	X			Sources are sealed. No airborne contamination will occur during normal operating conditions.
1300-6.5	Monitoring, Warning, and Alarm Systems				
1300-6.5.1	General All radiation monitoring, alarm, and warning systems that are required to function during a loss of normal power shall be provided with an emergency UPS (internal or external on-line)unless it is demonstrated that they can tolerate a temporary loss of function without losing needed data and they are provided with standby or emergency (switched) power. Determination of the power supply type and quality shall be based on the safety classification of the monitoring system or device. The sampling motivation (vacuum) shall be installed to the same requirement.	X			RAM's have 24 hour check. All RAMs have battery backup suffficient for source to be in safe condition. There is no air sampling for radiation planned for the GIF since all sources are sealed.
1300-6.5.2	Air Monitoring and Warning Systems Air monitoring and warning systems shall be installed in work areas where hazardous materials are stored or handled and where hazardous airborne particles or vapors may be present. Air sampling heads shall be located to provide a representative sample of potential airborne radioactive materials being breathed. Air monitoring systems shall comply with ANSI N13.1.			X	RAM's are planned for all areas which will contain or potentially may contain radioactive materials. No air sampling systems will be in use.
1300-6.5.3	Personnel Monitoring and Warning Devices				
para. 01	Provisions shall be made for personnel monitoring devices, such as hand and foot counters, in the vicinity of work stations.			X	No routine contamination hazard.
para. 02	Installed monitors (supplemented with personal monitoring methods if necessary) shall be used to monitor personnel exiting an operating area through access ways.			X	No routine contamination hazard. Leaking sources are to be placed in sealed containers.
para. 03	CAMs shall be provided to detect and to alarm at prescribed airborne radioactivity levels.			X	No airborne releases of radioactive material are anticipated.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300-6.5.4	Ionizing Radiation Monitoring System Where ionizing radiation is present (due to process material, equipment, or operations), an area radiation monitoring system shall be provided to alert personnel of unexpected increases in ionizing radiation levels.	X			RAMS are planned for all areas which will contain or potentially may contain radioactive materials as described in the PSAR.
1300-6.5.5	Warning and Alarm Systems Features Warning and alarm systems shall be designed, installed, and tested to ensure they can be heard in the ambient conditions of the covered area. Evacuation alarm systems shall comply with ANSI N2.3.	X			Design of warning and alarm systems is described in the PSAR. Installation and testing will be described in the FSAR. Evacuation alarm systems are part of the Area V system and will comply with ANSI N2.3.
1300-6.5.6	Nuclear Accident Dosimetry Where there is the potential for a criticality excursion causing personnel exposures, nuclear accident dosimeters shall be provided with performance features and placement consistent with DOE 5480.11.	X			All Area V personnel are equipped with nuclear accident dosimeters. in accordance with 5480.11.
1300-6.5.7	Central Radiation Monitoring and Alarm Readout In addition to a local station alarm, radiation monitoring system (criticality alarms, CAM's, alarms associated with stack monitoring systems, and so on) shall have central (i.e., control room or radiation monitoring office) readout and alarm panels that are accessible after a DBA to evaluate internal conditions.	X			All RAMs will have readout to Health Physics office.
1300-6.6	Decontamination of Personnel Design shall provide for personnel decontamination facilities close to areas that represent sources of potential contamination	X			Showers are located in the evacuation building.
1300-6.7	Meteorological Equipment Meteorological equipment shall be provided to measure and record wind speed and direction. Consideration shall be given to the need for additional equipment to provide meteorological parameters such as humidity data and wind direction frequencies for heights related to the estimated heights at which stack effluents and cooling tower moisture will be dispersed. As necessary, special equipment for stack effluent dispersal and tracking shall be considered for installation. Central Site meteorological monitoring capability shall be considered as a substitute for individual facility monitoring.	X			Meteorological equipment is located on the C-5 roof.
1300-6.8	Change Rooms Men's and women's change rooms shall be provided for changing into and from protective clothing. These areas shall be adjacent to shower facilities. Change rooms shall be designed to ensure that clean clothing (e.g., personal clothing) and protective clothing are segregated. The design shall ensure that storage of contaminated protective clothing will control contamination so that it does not spread beyond the storage container. The change room exhaust air shall be HEPA-filtered if dispersible radionuclides are handled in the process areas it serves.			X	No protective clothing is required.
1300-6.9	Breathing Air System Breathing air supply systems shall comply with ANSI Z88.2 and 29 CFR 1910.134.			X	No breathing air systems are required.
1300-7	Confinement Systems				
1300-7.2	General				

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 01	Confinement capabilities, including confinement barriers and associated ventilation systems, shall maintain a controlled, continuous airflow pattern from the environment into the confinement building, and then from noncontaminated areas of the building to potentially contaminated areas, and then to normally contaminated areas.			X	Pool and cells are secondary confinement with the primary containment satisfied by the source cladding. To remove ozone from the cells while the source is exposed, individual ventilation systems are activated and cells are maintained at negative pressure with respect to the room.
para. 02	Engineering evaluations, trade-offs, and experience shall be used to develop a practical design that achieves confinement system objectives.	X			PSAR summarizes the engineering evaluation.
para. 03	Sufficient redundancy shall be provided in the unlikely event of a confinement system failure. At least one of the confinement systems shall be designed to ensure that it can withstand the severe natural phenomena and man-made events (see Section 0111-99.0, Nonreactor Nuclear Facilities - General), including the postulated DBSs and DBF initiated by these events, and remain functional to the extent that the guidelines of Section 1300-1.4.2, Accidental Releases, are not violated. The adequacy of the design of these confinement systems to effectively perform their required functions shall be demonstrated by the safety analysis.	X			All confinement systems will be seismically qualified. Other DBAs will not affect confinement systems. See Chapter 11 of PSAR.
para. 04	The secondary and tertiary barriers may exist in common such as a single structural envelop (e.g., walls, roof slab, floor slab), provided the barrier can withstand the effects of man-made events and DBAs including DBE, and does not contain access ways that allow the routine transfer of personnel, equipment, or material directly from the exterior of the facility.			X	No barriers exist in common.
para. 05	Design of confinement areas shall provide adequate means for decontamination of the areas prior to entry or breaching for maintenance and repair purposes.	X			Contamination of confinement areas is not a potential, with the exception of low level contamination of the pool and subsequently of the demineralizer resins. Procedures for decontamination of the pool will be detailed in the FSAR.
1300-7.3	Access Ways Special features (e.g., air locks, enclosed vestibules) shall be considered for access through confinement barriers to minimize the impact of facility access requirements on the ventilation system and to prevent the release of radioactive airborne materials. Provisions for normal and emergency equipment shall be provided in or adjacent to the access ways. Consideration shall be given to emergency lighting, paging systems, automatic access door switches, hand and foot monitors, storage for clothing and emergency equipment, warning lights, air sampling, and breathing air outlets.			X	Primary safety consideration reqarding Access through confinement barriers is to prevent access when sources are exposed and to allow rapid exit. Special features such as air locks would impede exodus.
1300-7.4	Transfer Pipe and Encasements				
para. 01	Double-walled pipes or pipes within a secondary confinement structure encasement shall be used in areas where primary pipes leave the facility.			X	Primary is totally enclosed in secondary.
para. 02	Within the facility, the use of double-walled pipe shall be considered.	X			Any underground piping associated with the pool cleanup loop will be double walled or in a piping trench where the pipes can be visually checked for leaks.
para. 03	Leakage monitoring shall be provided to detect leakage into the space between the primary pipe and the secondary confinement barrier.	X			Applied to pool. Leakage of cladding will be detected by monitoring of the demineralizer resin.
1300-8	Waste Management				

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1300-8.1	General The process systems shall minimize the production of wastes at the sources and minimize the mixing of radioactive and nonradioactive hazardous wastes. The waste management systems shall provide facilities and equipment (or incorporate existing facilities and equipment) to handle those wastes safety and effectively. Waste handling areas shall comply with the same standards of confinement and ventilation requirements commensurate with the potential for spreading contamination by the waste packages/forms handled.	X			The only radioactive waste will be expended sources. Before declaring as waste, their potential for reuse ot recycle will be assessed. Waste sources will be transported to permitted disposal facilities. The primary hazard in removing these sources is irradiation of personnel. Contamination is not a significant risk.
1300-8.3	Mixed Waste Mixed waste shall be segregated and handled separately from other types of waste in accordance with DOE 5400.3.	X			Mixed waste will be handled in accordance with Sandia's ES&H manual, as detialed in the FSAR.
1300-8.4	Waste Segregation Facility design shall provide for the segregation of hazardous wastes into compatible groups for storage in accordance with the DOE 5400 series and DOE 5480 series.	X			Will occur in accordance with Sandia's ES&H manual, as detailed in the FSAR.
1300-8.5	Spill Prevention and Control Spill prevention and control shall be considered in the design stage of the facility to minimize the possibility of accidentally releasing hazardous waste to the environment.	X			Spill prevention considerations are described in Chapter 11 of the PSAR. Primary concern is overflow of the pool, which will be prevented by an exterior berm.
1300-8.6	Approvals and Permits				
para. 01	The construction of a new facility or modification of an existing facility that either releases hazardous wastes (including airborne radioactive effluents (see 40 CFR 61, Subpart H) to the environment or manages hazardous wastes shall in most cases be approved by the EPA or authorized State agency prior to the beginning of construction. In addition to obtaining approval for construction or modification of a facility, operating permits shall also be obtained for facilities that manage hazardous wastes as specified in RCRA.			X	Documented by a FONSI for the GIF EA.
para. 02	Environmental discharges of any effluent, including hazardous and nonhazardous wastes, shall meet applicable Federal and State laws and regulations and DOE orders. The limits specified in discharge permits for these effluents shall be considered during the design of the facility.	X			Environmental discharge will be controlled/regulated by a NESHAPs permit approved by the EPA and State of New Mexico.
1300-09	Effluent Control and Monitoring				
para. 01	Hazardous effluents released to the environment (radioactive and nonradioactive) shall not exceed the limits referenced in DOE 5400.1 and the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.	X			Ozone emissions from the cells are in compliance with the limits in DOE 5400.1. The GIF facility will not release hazardous radioactive effluents to the environment.
para. 02	Emphasis shall be placed on reducing total quantities of effluents (both radioactive and nonradioactive) released to the environment.	X			Same as above
para. 03	Effluents shall comply with all applicable Federal, State, and local laws and regulations.	X			Same as above.
para. 04	During normal operations, the effluent concentrations of radionuclides measured at the site boundary shall not exceed the DCGs specified in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.	X			Same as above.
para. 05	At the point of discharge of the facility, (stack or equivalent) the effluent concentration shall not exceed the DCGs specified in DOE 5480.11.	X			Same as above.
para. 06	The guidance on radioactive protection referenced in Section 1300-1.4.3, Routine Releases, shall also apply to effluent treatment and discharge systems.	X			Same as above.

SECTION	TITLE / CRITERIA	S	N	A	COMMENT
para. 07	All effluent streams shall be sampled or monitored in accordance with the requirements of 5400.1, the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series, and the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series.	X			Same as above.
para. 08	Sampling and monitoring shall ensure adequate and accurate measurements under normal operations, anticipated operational occurrences, and DBA conditions.	X			Same as above.
para. 09	The design of the facility shall include appropriate groundwater monitoring unless a site-wide program is provided.	X			GIF will participate in the Groundwater Protection Program as part of TAV.
para. 10	This monitoring shall be designed to detect releases of contaminants to the ground or ground water.	X			Same as above.
para. 11	Groundwater protection programs shall comply with DOE 5400.1, DOE 5400.3, and the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.	X			Same as above.
1300-10	Physical Protection, Material Safeguards, and Storage of Special Nuclear Material	X			The GIF facility does not routinely handle or store SNM. However, if a test unit or experiment involves SNM, physical protection and material safeguards are available is provided by its location within the TA-V security perimeter.
1300-10.1	General	X			Same as above.
1300-10.2	Physical Protection	X			Same as above.
1300-10.3	Material Control and Accountability (MC&A) Safeguards	X			Same as above.
1300-11	Decontamination and Decommissioning				
1300-11.1	Decontamination				
para. 01	Design of the areas in a facility that may become contaminated with radioactive or other hazardous materials under normal or abnormal operating conditions shall incorporate measures to simplify future decontamination.	X			Floors of easily decontaminated materials (sealed concrete). Pool is stainless steel. However, contamination of pools, cells and other surfaces is not anticipated. Details of decontamination procedures will be described in FSAR.
para. 02	Such items as service piping, conduits, and ductwork shall be kept to a minimum in the areas and shall be arranged to facilitate decontamination.	X			Piping, conduits and ductwork is minimal in the GIF.
para. 03	Filters shall be positioned in ventilation systems in locations that minimize contamination of ductwork.			X	No HEPA filtration systems.
para. 04	Walls, ceilings, and floors shall be finished with washable or strippable coverings. If necessary, all cracks, crevices, and joints shall be caulked or sealed and finished smooth to prevent contaminated material accumulation in inaccessible areas.	X			All surfaces will be easily decontaminated. However, no routine contamination is expected in cells or pool.
1300-11.2	Decommissioning				
para. 01	Designs consistent with the program requirements of DOE 5820.2A shall be developed during the planning and design phases based on a proposed decommissioning method or a conversion method leading to other uses.	X			Program requirements of DOE 5820.2A incorporated into Title I.

Section	Criteria	Is Criteria Met			Comments
para. 02	Decommissioning of special facilities is of utmost importance. The facility design shall include features that will facilitate decontamination for future decommissioning, increase the potential for other uses, or both. In addition to the requirements of Section 0205, Demolition, Decontamination, and Decommissioning, the following design principles shall be considered for facilities handling radioactive and other hazardous materials: - Use of modular, separable confinements for radioactive and other hazardous materials to preclude contamination of fixed portions of the structure. - Materials that reduce the amount of radioactive and other hazardous materials requiring disposal and that are easily decontaminated. - Designs that ease cut-up, dismantlement, removal and packaging of contaminated equipment from the facility (e.g., removal and dismantlement of gloveboxes, air filtration equipment, large tanks, vessels, equipment and ductwork). - Use of modular radiation shielding, in lieu of or in addition to monolithic shielding walls.		X		Large radiation shield cannot be constructed in modules. However, contamination of the shielding walls is not anticipated.
1300-12	Human Factors Engineering				
1300-12.1	Coverage These criteria shall apply to new construction and retrofitting of existing facilities. Criteria shall be considered for upgrading existing facilities where cost-benefit or risk-tradeoff analyses indicate justification.	X			Human Factors expert was involved in Title I design. Details of Human Factors considerations will be presented in the FSAR.
1300-12.2	Objectives The primary objective of human factors engineering is to improve human performance through enhancements in the work environment and human-machine interfaces. To achieve this objective, human factors engineering considerations shall be included during the conceptual, preliminary, and design phases of a project.	X			Human Factors experts will have input in all phases of design and operation, as described in the FSAR.
1300-12.3	System Development				
1300-12.3.1	General The integration of human factors engineering into system development shall begin at the point when the detailed system goals and objectives have been defined.	X			Human Factors expert was involved in Title I design. Details of Human Factors considerations will be presented in the FSAR.
1300-12.3.2	Planning the Human Factors Engineering Role in System Development A human factors engineering program plan appropriate to the level of importance of a facility or system shall be developed during the system development process.	X			Human Factors experts will have input in all phases of design and operation, as described in the FSAR.
1300-12.3.3	Requirements Analyses				
para. 01	A systems requirements analysis appropriate to the level of importance of the system and the level of risk associated with system failure shall be performed as an integral part of the design process and shall include human factors engineering considerations.	X			Systems requirement analysis has been incorporated into Title I and is documented in the PSAR.
para. 02	The needs and requirements of the system user or operator shall be systematically examined as an integral part of the design process. Appropriate requirements shall be selected and analyses performed for systems that are important to safety to ensure that the public, the facility, and facility personnel risks are minimized. These analyses shall be directed primarily to the areas of human-machine function allocation and task analysis.	X			The needs and requirements of system operators has been incorporated as part of the Human Factors analysis at Title I. This analysis will continue throughout all design phases and in operational considerations.

para. 03	Decisions concerning which system functions to allocate to the human versus the machine shall be determined by analyses of system functions required, impact of error or no action on safety, and a comparison of human capabilities and equipment capabilities for the separate system functions.	X			These considerations have been incorporated as part of the Human Factors analysis at Title I. This analysis will continue throughout all design phases and in operational considerations.
para. 04	For functions allocated to an operator, there shall be a systematic analysis of those vital activity tasks that must be performed by the operator to satisfactorily complete the function, given a proposed system design, This task analysis shall develop a list of operator needs and requirements necessary for successful task completion	X			Human Factors analysis was part of Title I review. This analysis will continue throughout all design phases and in operational considerations.
1300-12.3.4	Process System Design Interfaces				
para. 01	The design or the selection of equipment to be operated and maintained by personnel shall include the application of human factors engineering criteria together with other appropriate design criteria.	X			Human factors analysis has included design or selection of equipment. This analysis will continue throughout all design phases and in operational considerations.
para. 02	These criteria shall include the list of information and control requirements developed from the task analysis. More generic human factors engineering criteria pertaining to desirable equipment characteristics, available in the form of checklists or text descriptions, shall also be consulted. Studies performed to examine special features of the system design shall be considered.	X			Criteria for equipment selection will be based on task analysis by a human factors expert. This analysis will continue throughout all design phases and will be incorporated in operational considerations.
para. 03	Design teams and design review teams shall include or have resource support available from persons knowledgeable in human factors engineering. Human factors personnel shall also be included in the system validation process.	X			Human Factors analysis by a Human Factors expert was part of Title I review. This analysis will continue throughout all design phases, operational readiness and will be incorporated in operational considerations.
1300-12.3.5	Test and Evaluation The test and evaluation phase shall focus on verifying that the system can be operated and maintained by the intended user personnel under the conditions for which it was designed. The system shall meet applicable human factors engineering design criteria.	X			Human Factors analysis by a Human Factors expert was part of Title I review. This analysis will continue throughout all design phases, operational readiness and will be incorporated in operational considerations.
1300-12.4	General Human Factors Implementation Criteria and Considerations				
1300-12.4.1	General The organization of operator movements and the arrangement and accessibility of equipment and controls in the work area shall facilitate convenient access to each system component for operation and maintenance.	X			Human Factors analysis by a Human Factors expert was part of Title I review. This analysis will continue throughout all design phases, operational readiness and will be incorporated in operational considerations.
1300-12.4.3	Environmental Considerations				
para. 01	Lighting Adequate lighting levels are necessary to ensure optimum performance in all work areas. Glare and shadowing shall be avoided.	X			Design of lighting system incorporates human factors considerations, which will be part of operational readiness review.
para. 02	Emergency Lighting Emergency lighting systems shall be provided as required by NFPA 101.	X			Emergency lighting is not required for cell, because cell will not require access during an emergency.

SECTION	TITLE / CRITERIA	S	N	X	COMMENT
para. 03	A control room emergency lighting system shall be automatically activated and immediately available for a stated minimum length of time on failure of the normal lighting system.	X			Emergency lighting of control panel area is not required because foreseeable emergencies do not require operation of controls. Emergency lighting for personnel evacuation is provided
para. 04	The emergency lighting system for vital areas shall be an electrically independent system that is not degraded by failure of normal lighting .	X			Emergency lighting for personnel evacuation is provided
para. 05	Control room emergency lighting levels shall be in accordance with NUREG 0700, Section 6.1.5.4.	X			Emergency lighting for personnel evacuation is provided.
1300-12.4.4	Component Arrangement The arrangement of controls and displays on control panel shall promote efficient use of task-related components, rapid location of any given component, and maximum operator awareness of plant conditions.	X			These considerations were part of human factors analysis in the Title I review. Results will be incorporated into Title II.
1300-12.5	Protective Equipment Personnel working in hazardous environment or who may be temporarily exposed to such hazards shall have convenient access to appropriate protective equipment including proper garments, equipment such as emergency showers and eyewashes, and other protective equipment necessary for the successful and safe completion of their work.			X	No protective clothing or equipment is required. Primary hazard is from ionizing radiation and response to emergency is evacuation for all personnel.
1300-12.4.6	Display Devices				
para. 01	Displays shall provide only the information about system status and parameter values that is needed to meet task requirements in normal, abnormal and emergency situations. Status, rather than demand information, shall be displayed for important parameters. Displays shall indicate whether they reflect demand or actual status.	X			These considerations were part of human factors analysis in the Title I review. Results will be incorporated into Title II.
para. 02	Failure of a display of any type shall be easily recognized and shall not affect equipment or system performance.	X			This consideration was part of human factors analysis in the Title I review. Results will be incorporated into Title II.
1300-12.4.7	System Controls Prioritized coding, organization of data by system and subsystem, demarcation of system and subsystem components, and removal or relocation of marginally useful data shall be used to reduce operator information overload.	X			These considerations were part of human factors analysis in the Title I review. Results will be incorporated into Title II.
	Component Controls Each control device shall provide the appropriate control capability, range, and sensitivity for necessary control settings and manipulations. Selection of a control device shall fulfill any control requirements described in the task analysis of system function.	X			These considerations were part of human factors analysis in the Title I review. Results will be incorporated into Title II.
1300-12.4.8	Warning and Annunciator Systems				
para. 01	An effective warning system shall alert personnel to a problem or abnormal condition and shall provide sufficient time to respond appropriately to the problem.	X			Warning system contains both visual and audible signals. Warning devices located wherever ionizing radiation may be present.
para. 02	Each stimulus shall be easily distinguishable from other stimuli in the same modality but it shall not be a distraction. If an alarm can be one of many similar alarms that may occur simultaneously, it shall be easy to locate.			X	In all cases, sounding of any warning device calls for immediate evacuation of all personnel.
para. 03	Any specific stimulus shall have only one meaning. False alarms and nuisance alarms shall be removed. Set point determination shall allow sufficient response time to the operator.	X			In all cases, sounding of any warning device calls for immediate evacuation of all personnel.

para. 04	Provisions shall be made for active acknowledgment and for silencing of auditory alarms after they have been acknowledged.	X			Silencing of alarms can only be done by trained personnel, who will confirm the elimination of the hazard. Administrative procedures will control the silencing of alarms.
para. 05	Provisions shall be made for maintaining personnel awareness of alarm conditions until they have been corrected or "cleared." Clearing of the alarm shall require a positive response from the assigned personnel.	X			Silencing of alarms can only be done by trained personnel, who will confirm the elimination of the hazard. Administrative procedures will control the silencing of alarms.
para. 06	Visual alarm tiles shall be grouped by function or system within panels having horizontal and vertical alphanumeric labeling for ready coordinate designation of individual tiles.	X			These considerations were part of human factors analysis in the Title I review. Results will be incorporated into Title II.
para. 07	It shall be possible to test the warning system periodically.	X			Testing of warning system will be part of TSRs.
1300-12.4.9	Communication Systems The system shall have provisions of periodic maintenance tests, instructions for the use of each system used, and procedures for handling emergency communications where applicable.	X			TSRs will provide requirements for periodic testing and calibration, and if applicable maintenance (outage intervals) for safety related items within the facility. SOPs will be developed to implement the requirements identified in the TSRs. .
1300-12.10	Maintainability The design of equipment shall incorporate the objective of efficient maintainability. The surveillance, testing, and maintenance of a system and its restoration to operational effectiveness shall be achieved at minimum cost with a minimum level of support services. UCRL-15673 shall be considered for system design.	X			Maintainability of equipment was part of Title I review by a Human Factors expert. This analysis will continue throughout all design phases, operational readiness and will be incorporated in operational considerations.
1300-12.11	Labels				
para. 1	Equipment and any parts of that equipment to be used by personnel shall be identified with appropriate labels.	X			This requirement will be part of Title II and will be assessed during Operational Readiness Review.
para. 2	The label shall indicate clearly and concisely the function and purpose of the item being label.	X			This requirement will be part of Title II and will be assessed during Operational Readiness review. Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation.
para. 3	The label information shall be easy to understand.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
para. 4	Label design shall be consistent.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.

SECTION	TITLE / CRITERIA	S	N	I	COMMENT
para. 5	Various equipment labels placed on the same or similar pieces of equipment and serving similar function shall use the same material, color, font type, relative location, to component, general format, and other configuration features to promote simplicity and avoid clutter.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
para. 6	The terminology used for equipment, procedures, and training materials shall be the same for each case.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
para. 7	Permanent labels shall be attached to the specific component or equipment in such a manner that environmental conditions or usage by personnel will not remove or destroy the label.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
para. 8	Temporary labels shall be used only when necessary and shall be controlled administratively.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
para. 9	Labeling shall be legible and conform to human visual capabilities and limitations in regard to physical characteristics such as letter and symbol size, contrast, form simplicity, spacing and stroke width.	X			Adequacy of labelling is part of Human Factors analysis, which is incorporated into all phases of design and operation. This requirement will be assessed during Operational Readiness Review.
1325	Laboratory Facilities (Including Hot Laboratories)			X	The GIF does not meet the strict definition of Laboratory Facility as defined in 6430.1A and detailed below:
1325-1	Coverage Section 1300, General Requirements shall apply. These requirements are in additions to those requirements of that section and other applicable section of these criteria, particularly those section numbered -99.0, Nonreactor Nuclear Facilities-General, and -99.1, Laboratory Facilities (Including Hot laboratories).			X	The GIF does not satisfy the definition of a "Hot Laboratory" which includes hot cells, glove boxes, or other similar enclosures; nor is the GIF used for isotope production, inspection of spent fuel, prototype processes or metallurgical testing.
1325-2	Objectives The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public.			X	
1325-3	Nuclear Criticality Safety The specific requirements for nuclear criticality safety at these facilities shall be considered on a case-by-case basis.			X	
1325-4	Confinement Systems			X	
1325-4.1	General Consideration shall be given to the installation of radioiodine adsorber units in the exhaust ventilation/off-gas system to reduce the radioiodine concentration in the effluent to the extent that the limits in the references specified in Section 1300-1.4.3, Routine Releases, are not exceeded.			X	
1325-4.2	Primary Confinement System			X	
para. 01	The integrity of the primary confinement system shall be ensured for normal operations and anticipated operational occurrences.			X	

Section	Title / Criteria				
para. 02	The primary confinement volume and isolation systems, as appropriate, shall be compartmentalized to isolate high-risk areas and to minimize the potential effects of the DBAs they are required to withstand.			X	
para. 03	The primary confinement system(s) shall be designed to operate under process conditions that prevent or minimize the probability of potential explosive chemical reactions and shall use ALARA design principles to minimize exposures.			X	
para. 04	The following requirements shall be appropriately applied in the design of a laboratory facility primary confinement system(s): - Design features for introduction and removal stations to ensure the safe introduction and removal of material and maintenance equipment to and from the primary confinement. - Separate ventilation system or off-gas treatment system with appropriate air-cleaning capability (e.g., HEPA filtration, radioiodine absorbers, scrubbers). The use of an inert gas atmosphere within the primary confinement shall be considered when handling pyrophoric material or tritium. - The ventilation and cleanup systems associated with the primary confinement shall generally not be shared with secondary and tertiary confinement systems. - The operating pressure in the primary confinement shall be negative with respect to the secondary confinement. - Tanks within the primary confinement shall vent to the off-gas treatment system - Glove boxes - Hot cells			X	
para. 05	Glove boxes shall meet the following criteria: - Corrosive gases or particles from vats, scrubbers, or similar equipment shall be neutralized prior to reaching HEPA off-gas filters. - Required exhaust flow rates (for air-ventilated glove boxes) shall have the ability to safely confine in-box contaminants where an access port is opened or a glove ruptures (minimum air velocity of 135 linear ft per minutes). - If the glove box is filled with an inert atmosphere, specific design criteria for emergencies (i.e., ruptured glove) shall be incorporated on a case-by-case basis to suit a particular situation (e.g., pyrophoric materials).			X	
1325-4.3	Secondary Confinement System			X	
para. 01	The secondary confinement systems shall remain functional for all normal operations anticipated operational occurrences, and for the DBAs it is required to withstand.			X	
para. 02	The following design requirements shall be incorporated into secondary confinement systems: - Design features to minimize the probability of the spread of potential contamination from within the laboratory facility operating areas to areas that are not normally contaminated. - The use of ventilation system separate from the primary confinement ventilation system with appropriate air-cleaning capability (e.g., HEPA filtration, radioiodine absorbers, scrubbers). - Measures to ensure that the operating pressure in the secondary confinement shall be negative with respect to the tertiary confinement.			X	
1325-4.4	Tertiary Confinement System			X	

para. 01	The following design requirements shall be incorporated into tertiary confinement systems: - Measures to ensure that the confinement building provides protection for the primary and secondary confinement barriers and for enclosed equipment against the effect of severe natural phenomena and missiles. - Measures to ensure that the tertiary confinement can withstand the effects of severe natural phenomena and man-made events, including the DBAs and DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1.4.2, Accidental Releases, are not violated. - The use of a ventilation system separate from the primary confinement ventilation system with appropriate air-cleaning capabilities, (e.g., HEPA filtration, radioiodine absorbers, scrubbers). - Measures to ensure that the operating pressure in the tertiary confinement is negative with respect to the atmosphere.			X	
para. 02	The secondary and tertiary confinement ventilation systems may be shared if safety analysis indicates that this type of design is acceptable.			X	
1325-5	Effluent Control and Monitoring			X	
1325-5.1	Radioactive Solid Waste Since hot laboratories often contain a large variety of processes within the facilities, the potential solid radioactive wastes to be processed shall be considered on a facility specific basis.			X	The GIF facility, due to the form of the radioactive material to be handled and stored within the facility (sealed or metal matrix form sources), will not process solid radioactive wastes.
1325-5.2	Radioactive Liquid Waste Since hot laboratories often contain a large variety of processes within the facilities, the potential liquid radioactive wastes to be processed shall be considered on a facility-specific basis.			X	The GIF facility will not process liquid radioactive wastes.
1325-5.3	Effluents			X	
1325-5.3.1	Airborne Effluents All exhaust outlets that may contain radiological contamination shall be provided with two monitoring systems.			X	No radioactive effluents are expected during normal operation of the facility.
1325-6	Decontamination and Decommissioning All designs shall provide for ease of decontamination.			X	
Division 1400	**Conveying Systems**				
1401	General				
para. 01	Elevators, dumb waiters, wheelchair lifts, escalators, and moving walks shall comply with: ASME A17.1, NFPA 70, ANSI C2, UBC Chapter 51 (except enclosures), 29 CFR 1926, 29 CFR 1910, UFAs, NEMAs standards, and NFPA 101 Chapter 6.			X	The GIF elevators will not transport personnel.
para. 02	Hoisting, conveying, and material handling systems and equipment for hazardous materials shall meet the requirements established by the cognizant DOE authority.	X			Criteria for hoisting, conveying and material handling systems will be part of Title II requirements.
1420	Elevators			X	The GIF elevators will not transport personnel.
1440	Lifts			X	No lifts planned for the GIF.
1460	Cranes All cranes shall be designed consistent with CMAA-70 requirements. Overhead cranes and related equipment for special facilities shall be designed and installed to the same requirements in effect in the building location in which they are installed. Cranes shall have wheel restrainers.	X			Crane design criteria will be part of Title II requirements. Installation will be assessed as part of construction inspection and Operational Readiness Review.

SECTION	TITLE - CRITERIA	C	N/S	P	COMMENT
Division 1500	**Mechanical**				
1525	Mechanical Insulation				
1525-1	Applicability				
para. 01	Insulation shall be considered for equipment, ductwork, piping, flue pipe, and breaching to minimize energy loss, to prevent condensation, and to provide safe surface temperatures.	X			Part of Title II requirements.
para. 02	All insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of not more than 25 fuel-contributed and smoke-developed ratings of not over 50 when tested using UL 723 Test Methods. Exception to the smoke-developed rating of 50 shall be made for exterior underground piping and exterior above-ground piping beyond 15 feet from buildings or individual supports (stanchions).	X			Part of Title II requirements.
para. 03	Asbestos or asbestos-containing materials shall not be used.	X			Part of Title II requirements.
1530	Fire Protection				
1530-1	General Fire protection systems shall comply with DOE Order 5480.7.	X			In Title I.
1530-2	Improved Risk Concept for Fire Protection Systems				
1530-2.1	General Fire protection design shall incorporate an "improved risk" level of fire protection as directed in DOE 5480.7 as well as Section 0110-5, Health and Safety.	X			Part of Fire Hazard Analysis.
1530-2.2	Vital Programs Fire protection design shall incorporate an "improved risk" level of fire protection as directed in DOE 5480.7 as well as Section 0110-5, Health and Safety.	;X			Part of Fire Hazard Analysis.
1530-2.3	Maximum Possible Fire Loss				
1530-2.3.1	General The "improved risk" level of protection requires that the "maximum possible fire loss" shall be the basis for determining the need to provide automatic fire suppression systems and for additional fire protection systems and features.	X			Part of Fire Hazard Analysis.
1530-2.3.2	Criterion I Whenever the maximum possible fire loss exceeds $1 million fire suppression systems shall be provided.	X			Part of Fire Hazard Analysis.
1530-2.3.3	Criterion II The need for automatic fire suppression systems shall be considered when the maximum possible fire loss is below $1 million.	X			Part of Fire Hazard Analysis.
1530-2.3.5	Criterion IV Whenever the maximum possible fire loss exceeds $25 million, the area shall be subdivided with free-standing fire rated walls or suitable redundant fire protection systems to limit the credible loss to less than $25 million even in the event the primary system fails.			X	Entire facility is worth less than $25 million.
1530-2.3.6	Criterion V The need for redundant fire protection systems or methods, or for supplementing existing redundant fire protection capability, shall be considered on a case-by-case basis when the maximum fire loss potential is below $25 million.			X	Part of Fire Hazard Analysis.
1530-3	Water Flow and Pressure Requirements for Fire Protection				

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1530-3.1	General All sprinkler or other automatic fire suppression system components shall be UL- or FM-approved for the particular application chosen.	X			Part of Title II requirements.
1530-3.2	Occupancy Hazard Classification NFPA 13 shall be used to determine Occupancy Hazard Classification for any facility. Light hazard occupancy rules are prohibited.	X			Part of Title I.
1530-3.3	Water Demands for Sprinklered Facilities				
1530-3.3.1	Schedule-Designed Sprinkler Systems For systems designed using pipe schedule methods, NFPA 13 shall be used for calculating water demand in the absence of specific requirements provided by cognizant DOE fire protection authorities based on unusual occupancies or special hazards.	X			Part of Title II requirements.
1530-3.3.2	Hydraulically Designed Sprinkler Systems NFPA 13 shall be used to determine water supply requirements for hose streams (gpm) and duration (min). For ordinary hazard occupancies and above, hose stream requirements shall be a minimum of 500 gpm regardless of the hose stream demands listed in the above references unless otherwise specified by the DOE project criteria. Determination of adequacy of water supply shall be made on the basis of actual flow test data gathered using the methods in NFPA 13, Appendix B.	X			Part of Title II requirements.
1530-3.3.3	Fire Hydrant Demand Where reliance is placed on fire department response, either for protection of unsprinklered buildings or where the fire department will serve as redundant (backup) protection, as a general rule the water supply should be adequate to supply at least 0.03 gpm per cubic foot of fuel (building and contents) in the largest fire area (for high-BTU-content fuels, convert to equivalent ordinary BTU loads). This water supply should be available at 20 psig residual pressure at the hydrants.	X			Tech Area V system is in compliance.
1530-4	Automatic Sprinkler Protection	X			Part of Title II requirements.
1530-4.1	General All sprinkler systems shall comply with NFPA 13.	X			Part of Title II requirements.
1530-4.2	Types of Sprinkler Systems	X			
1530-4.2.1	Wet Pipe Sprinkler systems shall be normally be wet pipe using pipe schedule sizes listed in NFPA 13 for ordinary installations. Hydraulic designs shall be considered for all systems. The system shall be hydraulically designed where residual pressure is marginal, water application rate is high, response time is critical, or special risks are involved.	X			Part of Title II requirements.
1530-5	Special Protection Systems	X			
1530-5.1	General Selection of a particular special suppression system shall be based on: - The effectiveness of that system or agent for the type of hazard. - The damage likely to be caused by the extinguishing agent, including cleanup and downtime.	X			Part of Fire Hazard Analysis.
1530-5.2	Types of Special Suppression Systems	X			
1530-5.2.1	Water Spray Installation of water spray systems shall comply with NFPA 15.	X			Part of Title II requirements.
1530-5.2.2	Carbon Dioxide Carbon dioxide agent quantity requirements and installation procedures shall comply with NFPA 12.			X	No CO2 systems planned.

1530-5.2.3	Dry Chemical Dry chemical systems shall comply with NFPA 17.			X	No dry chemical systems planned.
1530-5.2.4	Foam Foam systems shall comply with NFPA 11, 11A, 16, 16A, and NFPA 409.			X	No foam systems planned.
1530-5.2.5	Halon The installation of Halon 1301 systems and Halon 1211 systems shall comply with NFPA 12A and NFPA 12B, respectively.			X	No Halon systems planned.
1530-6	Standpipes and Hose Systems Installation of standpipe systems shall comply with NFPA 14.	X			Part of Title II requirements.
1530-7	Portable Fire Extinguishers Portable fire extinguishers shall comply with NFPA 10.	X			All Sandia portable fire extinguishers are in compliance.
1530-8	Fire Detection and Alarm System	X			
1530-8.1	General All fire detection and alarm devices shall have UL-listed components or be FM-approved. Devices and systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G And NFPA 72H as applicable.	X			Part of Title II requirements.
1530-8.2	Alarm Systems	X			
1530-8.2.1	General	X			
para. 01	Fire alarm systems shall have the following basic features: - Transmission of signals to the DOE facility fire department alarm center and other constantly attended locations in accordance with the appropriate NFPA Signaling Systems Standard - Local alarms for the building or zone in alarm - Trouble signals as required by the appropriate NFPA Signaling Systems Standard - Emergency battery backup for system operation - Electric supervision of all circuits as required by appropriate NFPA standard - Supervisory devices for all critical functions (valve position switches, water level, temperature) - Capability of annunciating at least three separate conditions: 1) a fire alarm, 2) a supervisory alarm, and 3) a trouble signal indicating a fault in either of the first two. Annunciation of each condition shall be separate and distinct from the other two.	X			Part of Title II requirements.
para. 02	Fire alarm systems for new DOE buildings shall be compatible with those for the DOE complex where the new building is to be located.	X			Part of Title II requirements.
1530-8.2.2	Alarm Actuating Devices - Alarms that respond to flow of water shall be provided wherever a sprinkler system is installed and shall comply with requirements of the NFPA standards for the type of signaling used. - A manual fire notification method such as manual fire alarm boxes shall be provided /located in accordance with appropriate NFPA standards. - Combined watch reporting and fire alarm systems, if used, shall be in accordance with the appropriate NFPA standards.	X			Part of Title II requirements.
1530-8.3	Automatic Fire Detection System	X			
1530-8.3.1	General Automatic fire detectors shall comply with NFPA 72E. Detector spacing shall be in accordance with NFPA 72E, Appendices A, B, and C.	X			Part of Title II requirements.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1530-8.3.4	Smoke Detectors Smoke detectors shall be installed in all areas where required by the appropriate NFPA standard or by the cognizant DOE fire protection authority. Smoke detectors shall be of a type operating on one of the principles described in NFPA 72E. Location and required spacing of smoke detectors shall be determined by the methods of NFPA 72E and its Appendix C. Spacing shall be based upon threshold fire size, fire growth rate, and ceiling height as described in these standards.	X			Part of Fire Hazard Analysis.
1530-9	Water Storage and Distribution	X			
para. 01	Wherever practical, dedicated fire water storage and distribution systems shall be used.	X			Part of Fire Hazard Analysis.
para. 02	Underground fire water mains or combined fire and domestic water mains, including valves, hydrants, and fittings, shall be installed, flushed, sterilized, and tested in accordance with NFPA 24 and Section 0260, Piped Utility Materials. Water storage tanks shall comply with NFPA 22. Fire pumps shall comply with NFPA 20. Water storage shall be sufficient to meet the density, pressure, and duration requirements of NFPA 13.	X			Tech Area V system in compliance.
para. 03	Whenever feasible, all water distribution systems shall be of the looped grid type providing two-way flow with sectional valving arranged to provide alternate water flow paths to any point in the system.	X			Part of Title II requirements.
para. 04	Fire mains (except those supplying a single hydrant or extensions of existing smaller mains) shall be at least 8 inches. Mains shall be sized to supply the largest fire demand plus the largest domestic and process demands with consideration for residual sprinkler system pressure requirements.	X			Part of Title II requirements. Area V system in compliance.
para. 05	Sprinkler supply lead-ins should be at least 6 inches, except lead-ins of 4 inches may be used for very small sprinkler systems when substantiated by hydraulic calculations. In no case shall the lead-in be smaller than the sprinkler riser.	X			Part of Title II requirements.
para. 06	Outside control valves that can be locked open shall be provided on each supply lead-in, located if possible a minimum distance of 40 feet from the building.	X			Part of Title II requirements.
para. 07	Key-operated buried valves shall not be used for sprinkler control valves. In no case shall there be more than one valve controlling a sprinkler supply lead-in.	X			Part of Title II requirements.
para. 08	All lead-ins shall be connected with the sprinkler system at the base of the riser. Alarm valves shall be located as close as practical to the building entry point.	X			Part of Title II requirements.
para. 09	Hydrants shall be provided so that hose lays from hydrants to all exterior portions of a protected building are no more than 300 feet. Hydrants shall not be closer to buildings than 50 feet.	X			Tech Area V system in compliance. GIF system part of Title II requirements.
1530-99	Special Facilities				
1530-99.0	Nuclear Facilities General				
para. 01	An assessment shall be made early in the design or modification to determine the facility structures, systems, and components that shall be protected against the effects of a DBF and explosion.	X			Part of Fire Hazard Analysis.
para. 02	A fire protection engineer or person knowledgeable in applying the principles of fire protection shall develop the fire protection system.	X			Fire Protection engineers are involved in all phases of design.

SECTION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 03	To maximize the protection against fire, the system shall contain an appropriate integration of fire prevention, detection, and suppression features.	X			Assessed by fire protection engineers, involved in all phases of design.
para. 04	Fire protection systems shall not: (1) prevent a facility from achieving and maintaining a safe shutdown condition, (2) prevent the mitigation of DBA consequences, or (3) cause an inadvertent nuclear criticality.	X			Assessed by fire protection engineers, involved in all phases of design. No SNM material is employed or stored at the GIF. -
para. 05	Total reliance shall not be placed on a single fire suppression system. Appropriate backup capability shall be provided.	X			Assessed by fire protection engineers, involved in all phases of design.
para. 06	To ensure that redundant safety class components shall be capable of performing the necessary safety functions, the facility design shall provide appropriate separation against fire, explosion, and failure of fire suppression systems.	X			Cladding, pool and cell will not be compromised by fire or explosion, as discussed in Chapter 11 of the PSAR.
para. 07	Fire protection systems, or portions of them, that must function to control effects of a DBA event (as determined by safety analysis accident scenarios) shall be designed to be functional for all conditions included in the accident scenario. This shall include both the event initial cause and its consequences.	X			Part of Fire Hazard Analysis and assessed by fire protection engineers, involved in all phases of design.
para. 08	The operation or failure of a fire protection system that interfaces with a safety class system such as a safety class water system, shall not prevent the safety class system from completing its safety functions when required.			X	Fire protection systems do not interface with safety class systems.
para. 09	Confinement systems, particularly the building structural shell and its associated ventilation systems, shall be designed with the capability of retaining the confinement function during the DBF.			X	Building is not part of confinerment.
para. 10	When the use of water sprinkler coverage is precluded because of nuclear criticality or other hazards, non-aqueous extinguishing systems (i.e., inert gas, carbon dioxide, high-expansion foam, or halogenated organics) shall be used.	X			Note: building is not part of confinement.
para. 11	Fire protection systems shall be designed so that the failure of any active component (equipment or control device) shall not disable the entire fire protection system.	X			Part of Title II requirements.
para. 12	Fire protection systems and components shall have fail safe features and audible and visual alarms for operability and trouble indications.	X			Part of Title II requirements.
para. 13	An emergency source of electric power shall be provided to operate fire protection systems. Fire protection systems shall be capable of operating during a normal power outage. The emergency power sources and the electrical distribution circuits shall have independence and testability to ensure performance of their safety functions assuming any single failure.	X			Part of Title II requirements.
para. 14	The designers of the fire protection system shall consider the fire and explosion potential of the materials being processed and the solvents used during processing. In addition, the design shall include facility-specific fire protection systems to mitigate the damage from pyrophoric and other materials that are fire hazards, (e.g., magnesium, ion exchange resins, nitrate solvent and nitrate reductions, and zirconium fuel element cladding hulls).	X			Part of Title II requirements. Facility-specific considerations are discussed in Chapter 11 of the PSAR.
para. 15	When the process uses or produces combustible gases or vapors, the design shall include features such as inert gas purging, premixing hydrogen to a nonflammable percent with inert gas, and increasing the air flow within process confinement barriers to provide the dilution required to maintain the concentration of gases below the lower limit for flammability.			X	Process does not use or produce combustible gases or vapors.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 16	Entry of air into furnaces operating with reducing gas shall be precluded by the use of inert-gas purged locks or other suitable means at the furnace entry and exit. Furnace gas shall be exhausted through a filtered exhaust system.			X	No furnaces in use.
para. 17	Process furnaces shall be provided with a system for automatically shutting off the furnace gas and purging with inert gas in the event of power failure, loss of coolant water, loss of exhaust ventilation, over temperature, or detection of hydrogen in the vicinity of the furnace.			X	No process furnaces.
para. 18	Automatic water sprinkler coverage shall be provided throughout the facility except in areas where nuclear criticality or other hazards specifically preclude its use or where Halon systems are required to reduce equipment damage.		X		Automatic sprinklers are not included in the cells because their installation, operation and potential consequences in the high radiation environment are suspect. Storage and use of combustibles and flammables in the cell are administratively limited.
para. 19	The water supply for the permanent fire protection installation shall have a minimum of two reliable, independent sources each with sufficient capacity (based on maximum demand) for fire fighting until other sources become available. Only one of these two sources shall be required to be DBE qualified.	X			Area V system is in compliance. Tie-in for GIF part of Title II requirements.
para. 20	To protect the integrity of process confinement systems, fire protection systems shall include the following features: - A fire-extinguishing system to rapidly remove heat produced by fire to prevent or minimize the pressurization of a process confinement and to rapidly extinguish a fire to minimize the loading of ventilation system filters with combustion products. - The introduction of the extinguishing agent in a way that does not result in over pressurization of the confinement barriers.			X	Fire will not compromise confinement systems, as discussed in chapter 11 of the PSAR.
para. 21	Where fire barriers are penetrated by the confinement system's ventilation ducting, fire dampers shall be appropriately used to maintain the barrier integrity. However, the closure of such dampers shall not compromise the functions of the confinement system where the loss of confinement might pose a greater threat than the spread of fire. In such cases, alternative fire protection means (e.g., duct wrapping) shall be used as a substitute for fire barrier closure. In no case shall a sprinkler system (including safety class sprinklers) be considered a fire barrier substitute.			X	Fire will not compromise confinement systems, as discussed in chapter 11 of the PSAR.
para. 22	Because of flammable or potentially flammable atmospheres, electrical installations in hazardous process locations shall be designed to preclude the introduction of any ignition source by the electrical equipment.			X	No flammable atmospheres produced.
1540	Plumbing/Service Piping				
1540-1	Plumbing				
1540.1.1	General				
para. 01	Domestic water shall be supplied by a separate service line and not be a combined fire protection and potable water service or a combined process water and potable water system within the building.	X			Part of Title II requirements.
para. 02	Plumbing shall comply with the NSPC (or other locally adopted nationally recognized plumbing code), ASHRAE Handbooks, and ASHRAE Standard 90.	X			Part of Title II requirements.
1540-1.2	Fixtures All fixtures shall comply with FS WW-P-541.	X			Part of Title II requirements.
1540-1.3	Piping				

SECTION	TITLE/CRITERIA	S	N	N	COMMENT
1540-1.3.1	Supply No lead solder shall be used for copper pipe in potable water systems. Where domestic or fire water service lines enter buildings, suitable flexibility shall be provided to protect against differential settlement or seismic activity in accordance with the NFPC or NFPA 13, respectively.	X			Part of Title II requirements.
1540-1.3.2	Drain, Waste, and Vent Underground lines shall be service weight cast iron pipe hub-type; hobbles cast iron soil pipe may be used in locations where piping is accessible.	X			Part of Title II requirements.
1540-1.5	Safety Devices				
para. 01	Tempering valves shall be the fail-safe pressure balance type.	X			Part of Title II requirements.
para. 02	As directed by project criteria, emergency showers, or combination eye-wash/showers shall be provided where corrosive or other skin or eye irritant chemicals are stored, handled, used, or dispensed. Equipment shall comply with ANSI Z358.1 and be serviced by the potable water system.			X	The chemicals to be used on the steam system iare being assessed. If corrosive chemicals are used, emergency eyewash and showers will be included. Final deterrmination will be made in Title II.
para. 04	Backflow preventers and air gaps shall be used to prevent cross-connection (contamination) or potable water supplies. Vacuum breakers (to prevent back-siphonage) shall be used only in conjunction with administrative controls.	X			Part of Title II requirements.
1540-1.6	Appurtenances	X			Part of Title II requirements.
1540-99	Special Facilities				
1540-99.0	Nonreactor Nuclear Facilities - General				
1540-99.0.1	General Cooling System Criteria These criteria and requirements are for cooling water and water supply systems including all components that transfer heat from sources in the facility to the ultimate heat sink that are classified as safety class items in accordance with Section 1300-3.2, Safety Class Items.			X	The pool does not function to cool the sources.
1540-99.0.2	Water Collection System				
para. 01	Collection systems shall be provided for water runoff such as from fire fighting activities from areas within special facilities containing radioactive material. Nuclear criticality prevention (if necessary), confinement, sampling, volume determination, and retrievability of liquids and solids shall be provided for in the design of collection systems. The size of the collection system for fire fighting water shall be based on the maximum amount of water that would be collected in fighting the DBF. The configuration of the system components shall be based on conservative assumptions as to the concentration of fissile or other materials capable of sustaining a chain reaction that might collect in the system.	X			LECS system will hold overflow from fire suppression system.
para. 02	For facilities that process, handle, or store fissile or other material capable of sustaining a chain reaction, the water runoff collection system shall be designed with the following nuclear criticality safety considerations: - The maximum material mass loading that could be in the runoff system - The most disadvantageous material concentrations, particle size, and material dispersion in the water slurry - The change in concentration of material and geometric configuration of the slurry as the particulate matter settles out of the water.			X	No SNM material employed or stored at the GIF. No potential for contamination of water runoff.
1540-99.0.3	Other Collection Systems				

SECTION	TITLE / CRITERIA	[illegible]	[illegible]	[illegible]	COMMENT
para. 01	Consideration shall be given to the collection and monitoring of radioactive and nonradioactive contaminants in natural runoff (e.g., roof drainage) and blowdowns from heating and cooling systems before discharge to the environment.			X	There exist no potential for radioactive contamination of natural runoff. Nonradiaoactive contaminants will be prevented by controlling the location and procedures for handling hazardous materials.
para. 02	Safety shower water and personnel decontamination shower water shall drain to the contaminated process wastewater system.	X			If safety showers are required, they will drain to the LECS.
1540-99.0.4	Equipment Operability Qualification Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of fluid system components, mechanical equipment, instrumentation, and electrical equipment that are required to operate during and following a DBE.	X			Testing requirements part of the TSRs.
1540-99.0.5	Water Supplies and Other Utility Service The design of each utility service or cooling water system shall consider the demands for normal operations, anticipated operational occurrences, and DBA conditions.	X			Part of Title II requirements.
1540-99.0.6	System Installation The following design features represent recommended practices for the installation of piping and valves carrying hazardous process fluids. In addition, the design professional shall consider the applicability of the criteria in R.G. 8.8 for piping systems carrying radioactive materials. - Pipe and valve locations as specified on approved drawings (not located at the discretion of the installer)			X	Although slight contamination possible in pool and recirculation loop, no hazardous process fluids are anticipated.
1540-99.0.6	System Installation (continued) - Valves designed and installed to operate in the stem-up orientation - Valves and other connections located to minimize the consequences of leaks - Block valves in pipes that enter or exit a process area Piping not embedded in concrete slabs - Pipe sleeves where piping passes through nonshielding concrete walls, floors, and roofs - Sleeves sloped to drain toward the controlled area - Space between the pipe and sleeve to be packed and sealed - Process valves not located at low points in the piping - Corrosion resistance of block valve and/or check valve and associated process piping equivalent and adequate - Welded joints rather than flanged connections wherever possible; butt-welded joints rather than socket-welded joints.			X	Although slight contamination possible in pool and recirculation loop, no hazardous process fluids are anticipated.
1550	Heating, Ventilating and Air-Conditioning Systems				
1550-1	General Sizing and Design Criteria				
1550-1.1	General Selection Procedures for HVAC Systems	X			
1550-1.2	Heat Gain and Heat Loss Calculations	X			Part of Title II requirements
1550-1.3	Heating and Air-Conditioning Equipment Sizing and Performance	X			Part of Title II requirements
1550-1.4	Use of Evaporative/Adiabatic Cooling	X			Part of Title II requirements
1550-1.5	Ventilation-Exhaust Systems Design Requirements				Part of Title II requirements
1550-1.5.1	General				

para. 01	The design professional shall select ventilation-exhaust systems for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists, and excessive heat and for the provision of fresh air to occupants.	X			Part of Title II requirements. Title II design reviewed by Industrial hygienists and other health professionals for compliance with ventilation standards.
para. 02	The use of exhaust stack(s) shall be considered to provide dispersion and preclude exhaust-to-intake return of air to this or an adjacent facility. Local weather and site conditions along with guidance found in ASHRAE Fundamentals shall be used to determine requirements.	X			Exhaust stack provided for venting of ozone.
1550-1.5.2	Outdoor Air Quality Outdoor air shall be used to provide makeup air, dilute non-toxic contaminants and provide acceptable indoor air quality in spaces served by ventilation systems. The outdoor air shall meet the quality required by ASHRAE Standard 62. DOE project criteria shall include test data on ambient air quality. If the outdoor air does not meet the ambient air quality standards for particulates, gases, or other contaminants, it shall be treated to remove particles and gases and vapors as required to meet the minimum ambient air quality standards.	X			Part of Title II requirements. Title II design reviewed by Industrial hygienists and other health professionals for compliance with ventilation standards. Local outdoor air meets ASHRAE Standard 62.
1550-1.5.3	Personnel Ventilation Air Requirements The outdoor air shall be provided in the quantities indicated for conditioned offices and other occupied spaces in ASHRAE Standard 62. Outdoor air in addition to the quantities required by ASHRAE Standard 62 shall be provided when required to balance a building's or space's exhaust air rate or to maintain the building or space under a positive pressure. Proper ventilation rates shall be demonstrated by calculating if natural ventilation or infiltration is used as the outdoor air introduction method.	X			Part of Title II requirements. Title II design reviewed by Industrial hygienists and other health professionals for compliance with ventilation standards.
1550-1.5.4	Recirculation Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to health and safety of personnel or are potentially damaging to equipment. These areas shall be 100-percent exhausted. Project criteria shall indicate other areas of non-recirculation.	X			Cells 100% exhausted when ozone is present.
1550-1.5.5	Industrial Ventilation Requirements Industrial-type facilities and laboratories shall be provided with ventilation (supply and exhaust) systems as required for heat exposure control, or dilution ventilation. Ventilation air shall be provided in the quantities required to maintain OSHA air quality limits, all the PELs established by 29 CFR 1910 and all ACGIH TLVs. Design air quantities and transport velocities shall be calculated according to the calculation methods prescribed by the ASHRAE Systems handbook, the ASHRAE Applications handbook, the ACHIG Industrial Ventilation Manual, 29 CFR 1910, and NFPA 45. Designers shall consider ASHRAE Applications Chapter 14, "Laboratories," when designing laboratories and laboratory buildings. Makeup air shall be provided in the quantities required to maintain required positive or negative room static pressure requirements and to offset local exhaust air quantities. Makeup air shall be tempered.	X			Cell ventilation system designed to eliminate harmful quantities of ozone. Test and balance of HVAC system part or occupancy.
1550-1.5.6	Local Exhaust Systems DOE project-specific criteria shall provide information on the source, quantity, and type of contaminants. Local exhaust systems shall be designed to maintain the required capture air velocities for source contaminant control.	X			Cell ventilation system designed to eliminate harmful quantities of ozone. Testing will be described in the FSAR.

SECTION	TITLE / CRITERIA	S	N	N	COMMENT
1550-1.5.7	Equipment Room Ventilation Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. DOE project criteria shall provide the space temperature limit criterion. Where mechanical ventilation cannot maintain a satisfactory environment, evaporative cooling systems or other mech cooling systems shall be provided.	X			NEMA Equipment rating part of Title II requirements.
1550-2	Heating, Ventilation, and Air-Conditioning System Selection	X			Part of Title II requirements.
1550-2.1	Central Station Cooling Equipment and Systems	X			Part of Title II requirements.
1550-2.2	Central Station Heating Equipment and Systems	X			Part of Title II requirements.
1550-2.3	Water Distribution Systems	X			Part of Title II requirements.
1550-2.4	Steam Distribution Systems All steam piping shall comply with ASME B31.1 and be a minimum of Schedule 40 black steel. Fittings, valves, and accessories shall be selected based on pipe size and temperature and pressure conditions.	X			Part of Title II requirements.
1550-2.5	Air Handling and Air Distribution Systems	X			
1550-2.5.1	General	X			
para. 01	The design professional shall consider and design air handling equipment and air distribution systems sized to optimize both initial cost and air handling system operating and maintenance costs.	X			Considered in Value Engineering report and part of Title II requirements.
para. 02	The design professional shall provide all air handling system equipment with vibration isolators and flexible ductwork connectors to minimize transmission of vibration and noise. Systems shall satisfy the NC levels recommended for various types of spaces and vibration criteria as listed in the ASHRAE handbooks.	X			All systems in compliance with ASHRAE handbooks.
para. 03	Air flow diagrams shall be developed and provided in the preliminary design phase unless waived by the DOE project criteria.	X			Part of Title I.
para. 04	Airflow velocities shall be designed to minimize settling of entrained particles as outlined in the ACGIH Industrial Ventilation Manual.			X	Entrainment of hazard particulates not a concern at the GIF.
para.05	Air handling and air distribution systems shall meet the energy conservation requirements for transport energy in ASHRAE Standard 90.	X			Part of Title II requirements.
1550-2.5.3	Fans/Motors Fans shall be designed and specified to assure stable, nonpulsing aerodynamic operation in the range of operation over varying speeds. Air handling units and fans in sizes over 1 hp shall use belt drives.	X			Part of Title II requirements.
1550-2.5.5	Air Cleaning Devices	X			
para. 01	Air cleaning equipment for duct work shall be easily removable, serviceable, and maintainable. Air cleaning equipment shall have face velocities as recommended by the filter manufacturer and design manuals recommended above to achieve maximum efficiency and minimum pressure drop.	X			Part of Title II requirements.
para. 02	Filters shall be constructed of noncombustible materials meeting the requirements for UL 900, Class I. Air filters shall be located on the suction side of fans and coils and other special locations as required for air treatment. Air-filter pressure drop gauges of the diaphragm-actuated, dial-type or inclined manometer type shall be located on other filter assemblies.	X			Part of Title II requirements.
para. 03	High-Efficiency Particulate Air Filters HEPA filter assemblies shall comply with ASME N509.			X	No HEPA filtration systems in use.
para. 04	HEPA filtration systems shall be used to minimize the release of particulate contaminants such as carcinogens, infectious agents, radioisotopes, or highly toxic materials when determined by safety analysis to be necessary.			X	

SECTION	TITLE - CRITERIA				COMMENT
para. 05	The design professional shall design for a location that facilities in-place testing of HEPA filters, with particular attention given to a plenum hardware provisions that allow for testing of the HEPA filter bank without requiring the testing personnel to enter the plenum. Utility services shall be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate testing work. In-place testing design requirements shall meet all the recommendation of UL 586, ASME N510, and ERDA 76-21. HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life			X	
para. 06	In providing, fire protection for the HEPA filters, the design shall separate prefilters or fire screens equipped with water spray sufficiently from the HEPA filters to restrict impingement of moisture on the HEPA filters.			X	
1550-2.5.6	Ductwork Systems				
para. 01	Ductwork shall be designed to meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual	X			Part of Title II requirements.
para. 02	Ductwork, accessories, and support systems shall be designed to comply with the following: - ASHRAE Fundamentals Handbook - SMACNA HVAC Duct Construction Standards - Metal and Flexible - SMACNA Fibrous Glass Duct Construction Standards - SMACNA HVAC Duct Design Manual - ACGIH Industrial Ventilation Manual - NFPA 45 - ERDA 76-21	X			Part of Title II requirements.
para. 03	Ductwork shall also be designed to comply with NFPA 90A, including specification and installation of smoke and fire dampers at fire wall penetrations and smoke pressurization/containment dampers as required for smoke pressurization/evacuation systems. Fire dampers shall not be used on exhaust system ducting if it is required to maintain confinement of hazardous materials during and after a fire event.	X			Part of Title II requirements.
para. 04	Exhaust ductwork shall comply with NFPA 91.	X			Part of Title II requirements.
para. 05	Ductwork shall be designed to resist corrosive contaminants if present.			X	Part of Title II requirements with consideration for ozone generated in the cells
1550-3	Testing, Adjusting, and Balancing	X			
1550-3.1	System Performance Tests The design professional shall specify system performance tests for mechanical air distribution and HVAC water distribution systems to verify compliance with DOE project criteria.	X			Part of Title II requirements.
1550-99.0	Nonreactor Nuclear Facilities - General				
1550-99.0.1	General Ventilation and Off-Gas Criteria				
para. 02	Ventilation systems shall be designed to provide continuous airflow pattern from the environment into the building and then from noncontaminated areas of the building to potentially contaminated areas and then to normally contaminated areas. Thus, the air flow is toward areas of higher radioactive or hazardous material contamination.	X			In Title I.
para. 03	Dampers shall be located so that cross-contamination will not occur in case of a localized release of material.			X	No cross-contamination potential.
para. 04	Ventilation system balancing shall be specified to ensure that the building air pressure is always negative with respect to the outside atmosphere.	X			Included as part of occupancy.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
para. 05	Portions of ventilation and off-gas systems that provide required functions allowing a seismic event shall be designed to be functional following a DBE.			X	Ventilation not required after a DBE - see chapter 11 of the PSAR.
para. 06	The use of downdraft ventilation within occupied process areas shall be considered as a means to reduce the potential inhalation of contamination.			X	Inhalation of contamination not a concern.
para. 07	The failure of ventilation and off-gas systems not designed as safety class systems shall not prevent other facility safety class systems from performing their required safety functions.			X	No ventilation or off-gas systems are safety class.
para. 08	Gas storage areas and process areas that use nonradioactive hazardous materials shall have ventilation systems designed to ensure that the hazardous material concentrations do not exceed the limits referenced in DOE 5480-10 and ALARA in the workplace environment.	X			Ventilation system of cells designed to eliminate ozone
para. 09	Effective loss-of-ventilation alarms shall be provided in these areas.	X			Loss of ventilation results in lowering of source and audible and visible alarms.
para. 10	Suitable off-gas stream pretreatment shall be provided upstream of the off-gas cleanup system to remove or reduce the concentration of chemicals that would adversely affect system operation.			X	No gas cleanup systems.
para. 11	Components of ventilation and off-gas systems that require electric power to perform their safety functions shall be considered safety class loads.			X	No safety class ventilation systems.
para. 12	Adequate instrumentation and controls shall be provided to assess ventilation or off-gas system performance and allow the necessary control of system operation.	X			Control panel indicates ventilation performance.
para. 13	Equipment in ventilation and off-gas systems shall be appropriately qualified to ensure reliable operation during normal operating conditions, anticipated operational occurrences, and during and following a DBE.			X	No safety class ventilation systems.
1550-99.0.2	Confinement Ventilation Systems				The confinement ventilation system is applicable only to the purging of ozone from the cells when they are in operation. Since ozone is hazardous only in high concentration, some leakage into personnel areas can be tolerated. Requirements under this section are selectively applicable for these reasons.
para. 01	The design of a confinement ventilation system shall ensure the ability to maintain desired air flow characteristics when personnel access doors or hatches are open.	X			Each cell has individual intake and exhaust dampers.
para. 02	The ventilation system design shall provide the required confinement capability under all credible circumstances with the addition of a single failure in the system.			X	
para. 03	If the maintenance of a controlled continuous confinement airflow is required, electrical equipment and components required to provide this airflow shall be supplied with safety class electric power and provided with an emergency power source.			X	
para. 04	Ventilation system balancing shall be specified to ensure that building air pressure is always negative with respect to the outside atmosphere.			X	

SECTION	TITLE CONTENT				COMMENT
para. 05	Air cleanup systems shall be provided in confinement ventilation exhaust systems to limit the release of radioactive or other hazardous material to the environment and to minimize the spread of contamination within the facility as determined by the safety analysis. The following general cleanup system requirements shall be met, as appropriate, for confinement ventilation system design:			X	All sources are sealed to prevent the release of radioactive material - no filter is required. No cleanup of ozone is performed since release rates are within EPA limits.
	- The level of radioactive material in confinement exhaust systems shall be continuously monitored. Alarms shall be provided that will annunciate in the event that activity levels above specified limits are detected in the exhaust stream.			X	All sources are sealed to prevent the release of radioactive material - no monitor is required.
	- Appropriate manual or automatic protective features (initiated by the alarm system) that prevent an uncontrolled release of radioactive material to the environment or workplace shall be provided.			X	
	- To limit on site dose and to reduce off site doses by enhancing atmospheric dispersion, elevated confinement exhaust discharge location shall ensure that the calculated consequences of normal or accidental releases shall not exceed the radiological guidance in Section 1300-1.4, Guidance on Limiting Exposure of the Public.			X	
	- An elevated stack shall be used for confinement exhaust discharge. Provisions shall be made to ensure an adequate ventilation exhaust discharge path in the event of stack failure.			X	
	- The stack shall be located so that it can not fall on the facility or an adjacent facility containing safety class items. The alternative is the construction of a stack that shall remain functional following a DBE, severe natural phenomena, and man-made events.			X	
	- Safety class air filtration units shall be designed to remain functional throughout DBAs and retain collected materials after the accident.			X	
	- Air sampling locations shall meet ACHIH/ASHRAE criteria. Sample collecting devices shall be located as close to the sampling probe as possible.			X	
	- The number of air filtration stages required for any area of a facility shall be determined by safety analysis based on the quantity and type of radioactive materials to be confined.			X	
	- Air filtration units shall be installed as close as practical to the source of contaminants to minimize the contamination of ventilation system ductwork.			X	
	- Ducts shall be sized for the transport velocities needed to convey, without settling, all particulate contaminants.			X	
	- Air filtration units shall be located and provided with appropriate radiation shielding to maintain occupational dose ALARA during operations and maintenance.			X	
	- Air filtration units shall be designed for ease of recovery of fissile material and other materials capable of sustaining a chain reaction in case of an accident as well as during normal operations.			X	
	- The cleanup system shall have installed test and measuring devices and shall facilitate monitoring operations, maintenance, and periodic inspection and testing during equipment operation or shutdown, as appropriate.			X	

SECTION	TITLE / CRITERIA	S	N	N	COMMENT
	- Where spaces, such as a control room, are to be occupied during abnormal vents, safety class filtration systems shall be provided on the air inlets to protect the occupants. As a minimum, air inlets shall be filtered to limit the loading of exhaust filters with normal atmospheric duct.			X	
	- Either HEPA filtration or fail-safe backflow prevention for process area intake ventilation systems shall be provided.			X	
	- Consideration shall be given to providing roughing filters or prefilters upstream of a HEPA filter to maximize the useful life of the HEPA filter and reduce radioactive waste volume.			X	
1550-99.0.3	Off-Gas Systems			X	No off-gas systems.
1555	Central Plant Heat Generation/Distribution	X			Part of Title II requirements.
1565	Refrigeration	X			Part of Title II requirements.
1574	Cryogenic Systems			X	No cryogenic systems.
1589	Air Pollution Control				
1589-1	General These criteria shall be applied to the control, treatment, and subsequent disposal of all airborne and gaseous wastes to assure compliance with the following: - DOE 5400.1 - DOE 5440.1C. - DOE 5480.4 - Federal, State and local standards including restrictions on sulfur content of fuel and other requirements specifically related to the control of air pollutants, as referred to in Executive Order 12088.	X			The compliance to these orders will be assessed as part of Title-II for ozone releases only. No radioactive discharges are anticipated.
1589-2	Improved Risk Concept At a minimum, facility confinement systems, including filters and ventilation systems, shall comply with the "improved risk" criteria defined in DOE 5480.7 and shall preclude off-site release of greater than TLV amounts of toxic materials during the maximum credible fire loss conditions.			X	There is only source confinement; no facility confinement.
1589-3	Planning for Air Pollution Control	X			The generation and release of ozone will comply with the requireements of applicable EPA and DOE regulations.
1589-4	Combustion Process Installations			X	No combustion processes.
1589-5	Refuse Disposal Facilities			X	No refuse disposal facilities.
1589-5.1	Incinerators			X	No incinerators.
1589-5.2	Off-Site Disposal	X			Off-site disposal facilities may be used dependent on the decision by the Kirtland Air Force Bases on the use of their on-site disposal facility will be used.
1589-5.3	Landfill and Dumping	X			Off-site disposal facilities may be used dependent on the decision by the Kirtland Air Force Bases on the use of their on-site disposal facility will be used.
1589-99	Special Facilities				
1589-99.0	Nonreactor Nuclear Facilities - General				
1589-99.0.1	Radioactive Airborne Effluents			X	

para. 01	All airborne effluents from confinement areas shall be exhausted through a ventilation system designed to remove particulate material, vapors, and gases as needed to comply with the guidance provided in Section 1300-1.4.3, Routine releases, and, if other hazardous materials are additionally present, with DOE 5400.1. ALARA design principles shall be implemented to minimize effluent concentrations and quantities released for all hazardous materials.			X	No airborne effluents from confinement areas.
para. 02	All exhaust ducts (or stacks) that may contain radioactive airborne effluents shall be provided with effluent monitoring systems that are designed in accordance with the applicable requirements contained in the directive on Radioactive Protection of the Public and the Environment in the DOE 5400 series and the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series. Backup capability for monitoring systems shall be considered in the design of each system (e.g., redundant detectors, additional sample line ports, additional sampler trains, etc). Continuous stack sampling and continuous radiation detection shall be considered. Sampling systems shall be designed in accordance with ANSI N13.1 and associated appendixes to ensure representative sampling of the effluent stream. Isokinetic sampling shall be provided for effluent streams that are expected to contain particulate radionuclides. The range capability of continuous monitors shall cover from routine to potential DBA releases of radionuclides. Nuclear criticality safety shall be considered in the design of equipment used to treat and discharge radioactive airborne effluents.			X	No exhaust ducts or stacks contain radioactive airborne effluents.
1589-99.0.2	Nonradioactive Airborne Effluents For nonradioactive hazardous gaseous or airborne effluents, the point of release shall be considered the point at which the effluent exists the stack, vent, etc. Nonradioactive gaseous or airborne effluent releases shall not exceed the guidelines contained in DOE 5400.1 and shall comply with all other applicable Federal, State, and local requirements. To the extent practical, ALARA principles shall be applied to minimize adverse impacts to the public and the environment.			X	No airborne effluent releases with guidelines in DOE 5400.1.
1595	Controls				
1595-1	General				
para. 04	Control systems shall be designed to use the closed-loop feedback method of control. Open-loop systems shall not be used. Proportional-type control shall be used for all control systems; other type control systems shall be used as needed according to the degree of control required.	X			Control systems in compliance.
para. 05	Copper piping shall be used for high pressure air in inaccessible locations (plastic piping may be used if installed in conduit). Air leakage shall not exceed 5 percent of pressure in 24 hours. Transmitters shall be capable of field calibration and thermometers or pressure gauges shall be provided at transmitters. All controllers and thermostats shall be pilot-bleed type.	X			High pressure air systems will be designed as part of Title II. A large capacity pressurized air system (50 to 100 psig) is required for the pneumatically-lifted movable wall on the large cell.
1595-6	Control of Air Handling Systems	X			Part of Title II requirements.
1595-6.5	Fire and Smoke Detection and Protection Controls				
para. 01	Engineered smoke pressurization and evacuation systems shall comply with the following: - NFPA 90A - NFPA 72E - ASHRAE Manual, Design of Smoke Control Systems for Buildings - ASHRAE Systems handbook	X			Part of Title II requirements.

SECTION	[illegible]	[illegible]	[illegible]	[illegible]	COMMENT
para. 02	All air handling systems shall be provided with the smoke and fire protection controls required by NFPA 101.	X			Part of Title II requirements.
para. 03	All supply, return, relief, and exhaust air ventilation systems shall have interlock controls that interface with fire and smoke detection system controls and either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire throughout the building. These controls shall comply with NFPA 90A.	X			Part of Title II requirements.
para. 04	Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91.			X	Not applicable for ozone ventilation system, as described in Chapter 11 of the PSAR.
Division 1600	**Electrical**				
1605	Basic Electrical Materials and Methods				
1605-1	General				
para. 01	All systems shall comply with NFPA 70 and ANSI C2. Electrical systems shall be designed so that all components operate within their capacities for initial and projected loads.	X			Part of Title II requirements.
para. 02	Electrical materials and equipment shall be UL- or FM-tested, with label attached, for the purpose intended, whenever such products are available. Where there are no UL- or FM- listed products of the type, testing and certification by another nationally recognized testing agency may be acceptable.	X			Part of Title II requirements.
para. 03	On-site acceptance testing shall be required for each major electrical system. Tests shall be specified to demonstrate that each function and important parameter is implemented. Specific criteria shall be included to determine pass/fail acceptance. Tests shall be performed in the presence of a government representative. Copies of all test results shall be submitted for approval.	X			Part of Title II requirements.
1605-2	Wiring System				
1605-2.1	Raceways				
1605-2.1.1	General Raceways that penetrate fire-rated assemblies shall be noncombustible. The complete installation shall be suitable sealed to maintain the established fire ratings as defined in UL Building Materials Directory and UL 1479.	X			Part of Title II requirements.
1605-2.1.2	Electrical Metallic Tubing Electrical Metallic Tubing (EMT) shall be used to enclose circuit power conductors, alarm and signal circuits in nonhazardous and noncorrosive locations. It shall not be installed where subjected to physical damages during installation or while in service. EMT shall not be installed underground and shall not be encased in concrete. When EMT is used outdoors or in damp locations, compression type (rain tight) fittings must be used.	X			Part of Title II requirements.
1605-2.1.3	Flexible Steel Conduit Flexible steel conduit shall be used for connection to equipment subject to vibration and connection from junction boxes to recessed lighting fixtures.	X			Part of Title II requirements.
1605-2.1.4	Rigid Steel Conduit and Intermediate Conduit Rigid steel conduit or intermediate metal conduit shall be used in locations classified as hazardous by NFPA 70.	X			Part of Title II requirements.

Section	Requirements				Comment
1605-2.1.5	Aluminum Aluminum conduit shall be used for high-frequency circuits where steel will cause magnetic problems or in atmospheres where steel conduit is unsuitable. Aluminum conduit shall not be installed underground, encased in concrete, or where the atmosphere is corrosive to aluminum.			X	No aluminum conduit required.
1605-2.1.6	Nonmetallic Conduit Nonmetallic conduit shall be used only where allowed by NFPA 70.	X			Part of Title II requirements.
1605-2.1.7	Surface-Metal or Nonmetallic raceways and multi-outlet assemblies shall be used only where allowed by NFPA 70. Surface-metal raceways passing from one floor to another shall have mechanical protection to a height of 4 feet above the floor level.	X			Part of Title II requirements.
1605-2.1.8	Cable Trays The use of cable trays shall be considered for large multiple-cable applications in both interior and exterior locations.	X			Part of Title II requirements.
1605-2.2	Conductors				
1605-2.2.1	General				
para. 01	Conductors for interior electrical systems shall be copper, except that aluminum conductors size No. 4 AWG and larger may be used. Conductors for power and lighting branch circuits shall not be smaller than No. 12 AWG. No. 10 and No. 12 AWG conductors for power and lighting branch circuits shall be solid. No. 8 AWG conductors and larger shall be stranded.	X			Part of Title II requirements.
para. 02	Conductors for Class 1 remote-control and signal circuits shall be enclosed in cable and shall comply with NFPA 70. Conductors for Class 1 low-energy remote-control and signal circuits shall be not smaller than No. 18 AWG. Power and lighting conductors shall be 600-volt, Type THW, XHHW, or THWN. Conductors required to be rated 90 degrees C in accordance with NFPA 70 shall be RHH, THW, or THHN. Conductors in high-temperature areas shall be NEC Type FEP or TFE as required. Direct-burial conductors shall be Type UF, UL 493. Bonding and grounding conductors shall be ASTM B1 solid, bare copper for sizes No. 8 AWG and smaller and shall be ASTM B8 Class B stranded copper for wire size No. 6 AWG and larger.	X			Part of Title II requirements.
1605-2.2.2	Aluminum Conductor Termination The termination of aluminum conductors, the connection of aluminum terminating lugs to copper or aluminum pads, and the use of Belleville washers shall comply with IEEE 141. Setscrew termination shall be allowed for connection to approved circuit breakers. Split-bolt terminators shall not be used.			X	No aluminum conductors.
1605-2.3	Receptacles Receptacle circuits shall be provided with ground-fault circuit-interrupters as directed by NFPA 70.	X			Part of Title II requirements.
1620	Power Generation	X			Area V system in compliance.
1630	Exterior Electrical Utility Service				
1630-1	General				
1630-1.1	Load Requirements Electric service quality and reliability shall be considered in conformance with IEEE 493 to ensure that they meet the load requirements.	X			Part of Title II requirements.

SECTION	TITLE - CRITERIA	S	N	D	COMMENT
1630-1.3	Redundancy Facilities designated by the cognizant DOE authority as critical shall be served by dedicated, redundant circuits. The two services shall be separated by a 4-hour fire-rated barrier and shall be served from separate sources. In lieu of providing two separate services, a single service supplied from a loop-type transmission or distribution system having sectionalizing features may be provided when the reliability of the single service proves adequate when considered in conformance with IEEE 399 and IEEE 493.			X	GIF is not a critical facility.
1630-2	Supply Equipment and Facilities				
1630-2.1	General Exterior electrical systems shall be designed and constructed with regard to existing electrical system construction in adjacent areas. Design shall be coordinated with the utility company. Relying shall comply with IEEE 242, and switchgear shall comply to IEEE C37 series.	X			Part of Title II requirements.
1630-2.2	Power Supply Lines	X			Area V system in compliance.
1630-2.3	Substations and Switching Stations	X			Area V system in compliance.
1630-3	Power Supply for Exterior Lighting	X			Area V system in compliance.
1630-4	Power Supply for Buildings	X			Area V system in compliance.
1630-5	Lightning Protection				
para. 01	Lightning protection systems shall comply with NFPA 78. Lightning protection systems shall be considered for buildings containing facilities for the use, processing, and storage of radioactive, explosive, and similarly hazardous materials; for buildings over 50 feet in height; and for buildings containing valuable equipment. A risk assessment using the guide in Appendix I of NFPA 78 shall be made of these buildings to determine the risk of loss due to lightning.	X			In Title I.
para. 02	Electric power and communication services to all buildings and facilities and to underground power cables, where connected by overhead power distribution lines, shall have lightning and surge protection.	X			Area V system in compliance.
1639	Grounding				
1639-1	General Grounding systems shall comply with NFPA 70 and IEEE 142. A separate ground conductor shall be used. Raceway systems shall not be used as ground path.	X			Part of Title II requirements.
1639-2	Substation and Switching Station Grounding Substation and switching station grounding systems shall comply with IEEE. Grounding connections shall comply with IEEE 837.	X			Part of Title II requirements.
1639-3	Fence Grounding Permanent fence grounding shall comply with ANSI C2.			X	No Fence grounding required.
1639-4	Isolated Ground Systems Isolated ground systems may be required to meet special instrumentation or other equipment needs. Such ground systems shall be clearly identified, protected against improper usage, and installed in conformance with NFPA 70.			X	No isolated ground systems required.
1640	Interior Electrical Systems				

Section	Requirement				Comment
1640-1.4	Power System Reliability Power system reliability consideration shall comply with IEEE 493 to ensure continual power supply to systems and equipment designated as critical by the cognizant DOE authority. The need for multiple transformer-switchgear service equipment, to ensure power supply continuity within the facility during scheduled or emergency equipment outages, shall also be considered.			X	GIF is not a critical facility.
1640-1.5	Power Quality Requirements Sensitive electrical equipment (data processing equipment) shall be isolated as needed for protection. Uninterruptible power systems, motor-generator sets, or power conditioners may be used for isolation.			X	No isolated electrical systems required.
1640-1.6	System Protection System protection shall comply with IEEE 242. For specialized research and development facilities, protection of equipment and systems shall comply with DOE/EV 0051/1.	X			Part of Title II requirements.
1640-1.7	Ground-Fault Protection Ground-fault protection shall comply with NFPA 70. See also Section 1605-2.3, Receptacles.	X			Part of Title II requirements.
1640-1.8	Neutral Conductors The neutral conductor for electric discharge lighting and for data processing and other similar equipment shall be sized in accordance with NFPA 70. Calculations shall include harmonic current.	X			Part of Title II requirements.
1640-2	Service Equipment and Facilities				
1640-2.1	General Interior electrical systems shall comply with NFPA 70. Switchgear criteria shall comply with IEEE C37 series.	X			Part of Title II requirements.
1640-2.3	Transformers Interior service transformer installations shall comply with NFPA 70. Transformer protection and appurtenances shall comply with IEEE C37.91. Transformer installation shall comply with FM 5-4/14-8.	X			Part of Title II requirements.
1640-2.4	Motors Motors shall comply with NEMA MG-1, except that hermetic refrigerant motor compressors shall comply with UL 984.	X			Part of Title II requirements.
1640-2.5	Motor Control Control equipment shall comply with NEMA ICS standards and UL 508.	X			Part of Title II requirements.
1640-3	Power Service for Security, Communications, and Alarm Systems				
1640-3.1	General Electrical power distribution systems shall be filtered to reduce emanation of detectable electromagnetic signals to acceptable levels as directed by the DOE telecommunications and security personnel. Installations shall comply with DOE 5300.2B, DOE 53000.3B, and DOE 5300.4B.	X			Part of Title II requirements.
1640-3.2	Primary Power Supply Normal primary power for protective alarm and communications systems shall come directly from the on-site power distribution system or, in case of isolated facilities, shall come directly from the public utility. Where several power sources are available, the most reliable source shall be used.	X			Area V system in compliance.
1640-3.3	Standby or Emergency Power Supply Standby or emergency power supply for security, com, and alarm systems shall be provided in accordance with Section 1660, Special Systems.	X			Area V system in compliance.
1655	Interior Lighting				

SECTION	TITLE - CRITERIA	S	N S	N A	COMMENT
1655-1	General Exit and emergency lighting systems shall comply with NFPA 101 and NFPA 110.	X			Part of Title II requirements.
1655-3	Fixtures Fixtures shall have diffusers and lenses constructed of noncombustible materials.	X			Part of Title II requirements.
1660	Special Systems				
1660-1	General				
para. 01	Standby and emergency systems shall serve loads set forth in NFPA 110. Additional standby or emergency systems shall be provided to support systems or equipment components whose operating continuity is determined to be vital by the cognizant DOE authority for protection of health, life, property, and safeguards and security systems. Safety Class 1 items shall be provided with emergency power.	X			Area V system in compliance.
para. 02	Operational standby systems shall be provided for production process operations in cases where the cognizant DOE authority determines that the process will become unstable on loss of power or that a severe monetary loss will result.			X	No production processes will occur within the GIF.
para. 03	Uninterruptible power shall be provided for equipment that cannot sustain functions through the momentary power loss that occurs when an alternate power source comes on line and picks up the load. See Section 1660-3, Uninterruptible Power Systems.	X			Uninterruptible power to RAMs and in cells controls for monitoring shut-down.
para. 04	Emergency power shall be provided for protective alarm and communications systems as dictated by the system requirements. Switch-over to emergency power shall be automatic on failure of the primary power source and shall be indicated on an annunciator panel. The annunciator shall be located in an occupied area and shall indicate any problems with the emergency system. Definition of "emergency systems," "legally required standby systems," and "Optional standby systems" shall be in accordance with NFPA 70.	X			Area V system in compliance. GIF system part of Title II requirements.
para. 05	Emergency power equipment areas shall be ventilated to exhaust hazardous gases (if applicable) and to maintain satisfactory ambient temperatures for equipment operation or personnel access.	X			Area V system in compliance. GIF system part of Title II requirements.
para. 06	Emergency or standby power service shall service fire alarm, security alarm, and supervisory sensing devices designated essential by the cognizant DOE authority.	X			Area V system in compliance.
1660-2	Emergency Power Systems				
para. 01	Emergency power systems shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446.	X			Area V system in compliance. GIF system part of Title II requirements.
para. 02	Emergency power systems shall be capable of maintaining full operation of emergency load for the full time period specified by the cognizant DOE authority (nominally, a minimum of 24 hours). Such power sources shall have the necessary built-in features to facilitate operational testing on a periodic basis to verify their readiness.	X			Part of Title II requirements.
para. 03	Where emergency generators are required for loads of 25 kVA and smaller, gasoline or LPG engines may be used. For loads greater than 25 kVA, diesel engines shall generally be used.	X			Area V system in compliance.
para. 04	Application of diesel engines shall comply with FCC Technical Report No. 69.	X			Area V system in compliance.

SECTION	TITLE - CRITERIA	S	N	D	COMMENT
para. 05	Batteries, when required shall be rechargeable and shall be kept fully charged at all times when primary power is available. The charger shall automatically switch from float to fast charge rate at a preset drop in DC bus voltage. The charger shall be furnished with a capacity to charge the battery from a fully discharged state to not less than 85 percent of the rated ampere-hour capacity within 24 to 72 hours. See IEEE 308.	X			Part of Title II requirements.
para. 06	Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. More stringent emergency power requirements shall be identified by the cognizant DOE authority on a case-by-case basis.	X			Part of Title II requirements.
1660-3	Uninterruptible Power Systems Uninterruptible power supplies shall be provided for those loads requiring guaranteed continuous power. Applications of UPSs shall comply with IEEE, 446, as modified by the cognizant DOE authority. UPS installations may be Safety Class 1, (Seismic Category I functional) or standby type dependent on the classification of the loads served.	X			Part of Title II requirements.
1660-99.0	Nonreactor Nuclear Facilities - General				
1660-99.0.1	Safety Class (Emergency) Electrical Systems			X	No safety class electrical systems.
para. 01	For safety class items that require electric power to perform their safety functions, the design shall provide safety class emergency electric power systems (AC, DC, and their distribution systems).			X	
para. 02	The design shall define the type, capacity, performance characteristics, and features of the safety class electric systems, including generator and batteries, required to meet safety class system needs.			X	
para. 03	Safety class electric systems shall be provided with suitable redundancy and separation to ensure that adequate capacity and capability are available with the addition of a single failure.			X	
para. 04	Redundant safety class electric systems shall be physically protected or separated to prevent a common external event from causing a failure of the redundant systems. IEEE 379 and 384 shall be used as redundancy and separation criteria.			X	
para. 05	The connection of loads that do not require safety class power to safety class buses shall be minimized.			X	
para. 06	Where such loads must be connected to a safety class electric power system, the loads shall be provided with suitable separation or devices that will prevent failures from affecting the safety class electric system.			X	
para. 07	Testing or a combination of testing and analysis shall be the preferred method of demonstrating the operability of instrumentation and electrical equipment that are required to operate during and following a DBE.			X	
para. 08	The capability to periodically test safety class electric systems to verify system performance shall be provided.			X	
1660-99.0.2	Protection System and Instrumentation and Controls				
para. 02	A protection system shall provide automatic initiation of protective actions that require rapid response and automatic control of interlocks that prevent unsafe operator actions.	X			The elevator power interrupt system for each cell is in compliance.
para. 03	Protection systems shall be designed to sense potentially hazardous conditions and to initiate actions to ensure that specific acceptable design limits are not exceeded as a result of anticipated operational occurrences.	X			Source lowered under potential hazardous conditions.

SECTION	TITLE / DESCRIPTION	[illegible]	[illegible]	[illegible]	COMMENT
para. 04	The protection system shall automatically activate safety class systems and components that are required to ensure the safety of operating personnel and the public. It shall provide audible and visual indication of system status. Automatically initiated protective actions shall be provided with a manually initiated backup.			X	Safety class systems are all passive. Audible and visual indication of system status provided.
para. 05	The design of the protection system shall provide suitable redundancy and diversity to ensure that safety functions can be completed, when required, and that no single failure will result in the loss of the protective functions. The protection system shall be designed to fail in a safe state following a component or channel failure or loss of power (e.g., control air or electric power).	X			System fails in a safety state.
para. 06	Safety class instrumentation shall sense abnormal conditions affecting safety and subsequently provide an alarm, e.g., low differential pressure between HVAC zones, criticality monitoring.			X	No safety class instrumentation.
para. 07	Safety class instrumentation and control systems shall provide audible and visual alarms so that the operator can take timely corrective actions to ensure the safety of operating personnel and the public.			X	No safety class instrumentation.
para. 08	The safety class instrumentation shall be designed to monitor safety related variable and safety class systems over expected ranges for normal operation, anticipated operational occurrences, DBA conditions, and for safe shutdown. Safety class controls shall be provided when they are necessary to control these variables.			X	No safety class instrumentation.
para. 09	The design of safety class instrumentation and controls shall provide suitable redundancy and diversity to ensure that safety functions can be completed, when required, and that no single failure will result in the loss of the protective functions. The safety class instrumentation and controls shall fail in a safe state following a component or channel failure or loss of power (e.g., control air, electric power).			X	No safety class instrumentation.
1660-99.03	*Qualification* Protection and safety class instrumentation and control equipment shall be qualified to the environmental qualification requirements in Section 1300-3.4, Equipment Environmental Considerations.			X	No safety class instrumentation.
1660-99.0.4	Separation and Physical Protection				
para. 01	Redundant protection system and safety class instrument channels shall be physically protected or separated to prevent a common external event or failure of one channel in causing failure in redundant channel.			X	No safety class instrumentation.
para. 02	The safety class protection system and safety class instrumentation and control system shall be appropriately separated or isolated from other instrumentation and control systems to the extent that a failure (e.g. electrical, control air) in these other systems will not degrade the safety class systems to the extent that they are unable to perform their necessary safety functions.			X	No safety class instrumentation.
1660-99.0.5	Test and Calibration The design of protection system and safety class instrumentation and control systems shall provide for the periodic in-place testing and calibration of instrument channels and interlocks. The design shall allow periodic testing of protection functions to determine whether failure or loss of redundancy may have occurred.			X	No safety class instrumentation.

SECTION	TITLE CRITERIA				COMMENTS
1660-99.0.6	Power Sources An analysis shall be made to determine power requirements for safe shutdown of the process. Safety class electric power or a safety class control air system shall be provided unless adequate system performance including fail safe shutdown can be demonstrated when conventional power sources are used.			X	No safety class systems to which requirement applies.
1660-99.0.7	Control areas Control areas or a control room shall be designed to allow occupancy and actions to be taken to operate the facility safely under normal conditions, anticipated operational occurrences, and DBA conditions, to achieve and maintain a safe shutdown condition including the remote manual initiation and control of safety functions, if used. In the event that a control area or control room is disabled, there shall be sufficient redundancy and capability to allow the facility to be placed in safe shutdown condition.	X			Control area in compliance.
1670	Exterior Communications and Alarm Systems				
1670-1	General Systems shall be designed to avoid unnecessary duplication of facilities. Joint use shall not expose the security system to damage or to unauthorized access.	X			Area V system in compliance.
1670-2	Fire Alarm and Supervisor Systems				
para. 01	Fire alarm and supervisory systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, NFPA 72H, NFPA 1221, and ANSI C2 as appropriate for location.	X			Part of Title II requirements.
para. 02	Fire alarm cables installed in underground ducts shall be distinctly marked within manholes and handholds that are shared with other communications cables and shall be kept physically separated from all power conductors.	X			Part of Title II requirements.
para. 03	Exterior fire alarm pull boxes and emergency-reporting telephones shall be installed in weatherproof housings manufactured specifically for the mechanism.	X			Part of Title II requirements.
1670-3	Security Alarm and Assessment Systems				
para. 01	Devices and equipment for interiors required for SNM and storage of classified matter shall meet FS W-A-450B or equipment as approved by the cognizant DOE authority.			X	No SNM or classified matter stored.
para. 03	Protective alarm systems shall have a primary and emergency power source.	X			Area V system in compliance.
para. 04	Emergency power of protective alarm systems shall be supplied by batteries or engine-driven generators. Switchover to the emergency power shall be automatic on failure of the primary power source, and on failure of both the primary and emergency power sources a signal shall be generated to indicate an alarm condition at the monitor.	X			Area V system in compliance.
para. 05	Rechargeable batteries shall be kept fully charged or subject to automatic recharging whenever the voltage drops to a level specified by the battery manufacturer.	X			Area V system in compliance.
para. 06	Auxiliary power sources shall be capable of maintaining full operation of the alarm system for not less than 8 hours.	X			Area V system in compliance.
para. 07	Supervisory and line-tamper circuits for existing alarm systems that protect Category I or II amounts of SNM shall meet the requirements listed in this section.	X			Area V system in compliance.

SECTION	TITLE / CRITERIA	S	V	N	COMMENT
1670-4	Secure Communication Systems Secure communications systems shall comply with DOE 5300.3B, DOE 5300.4B, and the DOE 5632 series.	X			Area V system in compliance.
1671	Interior Communications and Alarm Systems				
1671-1	Planning				
1671-1.3	Hazardous Locations Telecommunications and alarm equipment and conductors shall be located outside areas subject to explosion, fire, flood, chemical fumes, excessive dust, radiation or vibration, and excessive electrical or electromagnetic noise levels. Where telecommunications and alarms services must be extended into these areas, equipment and installation shall be suitable for the hazard.	X			Telecommunications and alarm equipment outside of hazardous areas.
1671-2	Fire Alarm and Supervisory Systems Fire alarm and signaling systems shall comply with NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, and NFPA 72H.	X			Part of Title II Requirements.

11. ANALYSIS OF NORMAL, ABNORMAL, AND ACCIDENT CONDITIONS

The new Gamma Irradiation Facility incorporates the sources and test capabilities of two existing SNL irradiation facilities: the current GIF in TA-V (in operation since 1962), and the Low Intensity Cobalt Array (LICA) Facility in TA-I (in operation since 1982). Experience gained during the 42 total years of safe operation of these two facilities and conformance to industry standards serve as the foundation for determining the new GIF design and planned operation. This chapter defines the anticipated conditions for normal and abnormal operation of the GIF along with the postulated consequences from accidents.

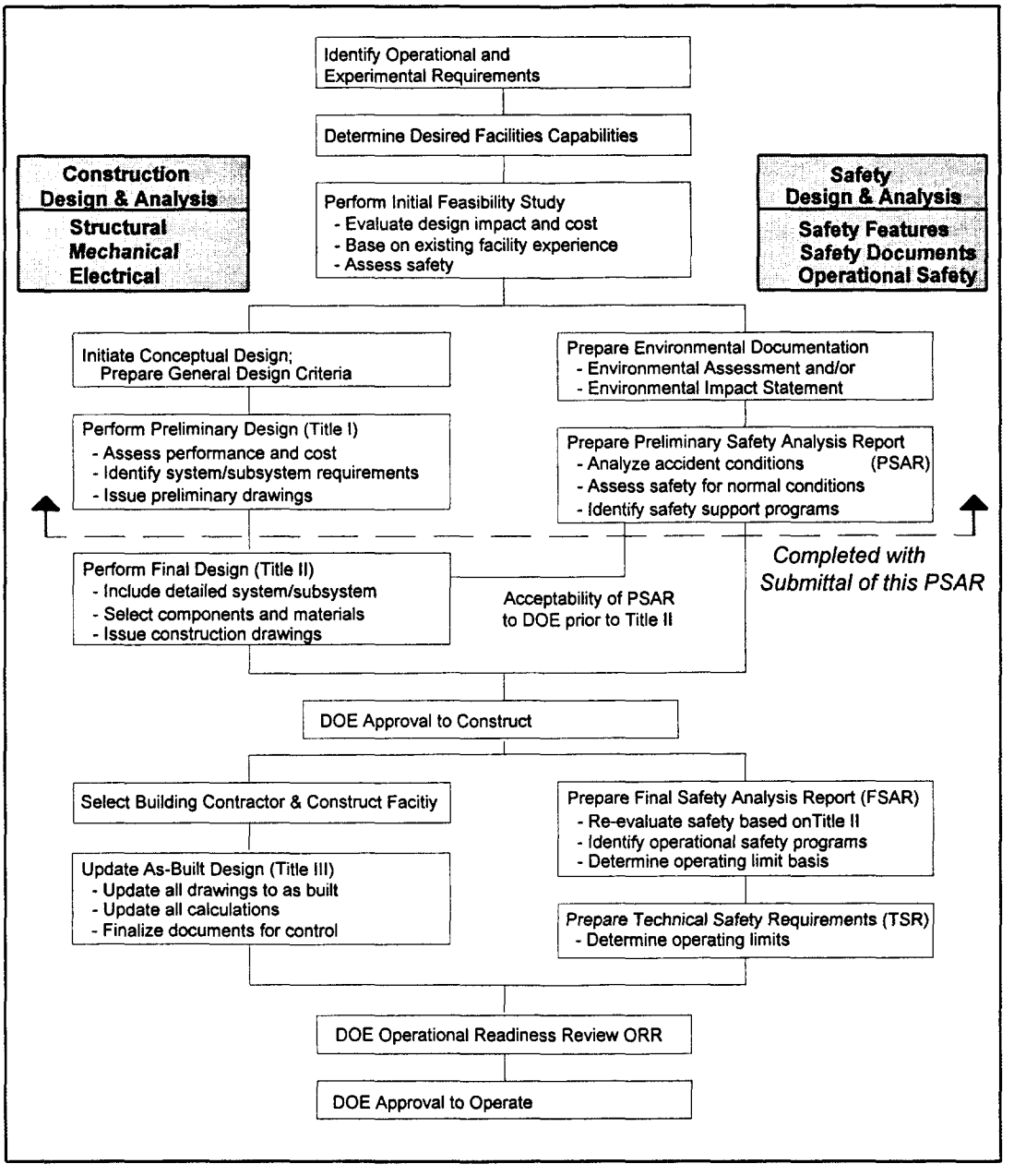
The normal ranges for GIF system, subsystem, and operational variables are presented and the resultant performance parameters are calculated. The calculations are extended beyond routine operation and continue into the abnormal regime. These ranges are used to bound normal operation and serve as part of the basis for the determination of Technical Safety Requirements for the facility.

Postulated accident sequences are also presented in this chapter. The "graded approach", as specified in DOE Order 5480.23, is employed to identify the analysis and documentation requirements for accidents.[11.1] Because the GIF is a Category 3 hazard classification, the accident analysis is a qualitative assessment of the overall risk. Based on guidance from DOE-STD-1027, a methodology for performing a qualitative assessment was developed.[11.2] This methodology is similar in approach to a probabilistic risk assessment in which the probability of an accident sequence and the unmitigated consequences are postulated. Based on these elements, the methodology identifies the minimum number and type of safety-related features required to assure that the overall risk is low for each anticipated accident sequence. The postulated accidents cover natural phenomena, operational accidents, and those external to the GIF. The matrix of accidents total 37 sequences initiated by 45 separate causes and are grouped into 12 accident categories. This matrix provides the basis for identifying the engineered safety features (discussed in Chapter 4) and required administrative controls necessary for safe operation of the facility.

11.1 Analysis Methodology for Normal Operations

The analysis of normal operation presented in this PSAR is based on the Title-I GIF design and includes some modifications, such as the maze entrances and the air-lift movable wall. Figure 11-1 depicts the two areas of the design and analysis process for the GIF: that related to construction and that related to safety. The figure illustrates the portion of the analysis completed at the time of this PSAR submittal. The analysis presented in this document includes calculations performed in three stages of the project: 1) the scoping calculations performed during the feasibility study, 2) the performance calculations completed as part of the Title-I design by SH&G, and 3) the safety calculations performed for documentation in this PSAR.[11.3] Some modifications to the GIF design may occur as the design proceeds through the Title-II stage. Based on the impact of the change to overall safety, these changes will be implemented into the safety review process either as requests to modify the PSAR or as inclusions in the FSAR.

Figure 11-1. Analysis Processes in the GIF Design/Construction



The methodology for analyzing normal operations of the GIF employs very simple analytical techniques. Although more accurate and much more complex techniques are available, there are considerable unknowns at this stage in the design process which dilute the effectiveness of performing detailed analysis. Equations are very basic in nature, with conservative values used to bound the calculated variable. When possible, solution techniques were verified and benchmarked to the existing GIF and LICA facilities.

Few computer codes were used in the analysis for this preliminary design stage; however, as more detailed analysis is required, additional codes are expected to be used. The "Monte Carlo" type code MCNP (version 4 by LANL) was used to calculate radiation dose rates in the cells and around the maze entrances to the cells.[11.4] Because of its poor statistics on deep

penetration problems, it has marginal applicability to predict dose rates through thick walls. The code Microshield (version 4 by Grove Engineering) was used for determining gamma dose rates through air, water and concrete.[11.5] This code was benchmarked to the current GIF to provide general assurance of its accuracy. The code PUTZ by Oak Ridge National Laboratories was used by an independent contractor on the Title I project design team to calculate dose rates outside of the concrete shield walls.[11.6] The general agreement of all three codes gives additional assurance that the radiation dose rate predictions and the methodology used to predict these dose rates are as sufficiently accurate as possible.

11.2 Analysis of Normal Operations

Normal operations of the GIF are assessed using the methodology described in the previous section. Analysis of normal operations is presented in sequence starting with the establishment of the desired source types and strengths for gamma irradiation and following this through to the requirements placed on major systems and subsystems. The following is representative of the sequence in which the analysis was performed and also identifies the order in which the main topics are presented in this PSAR:

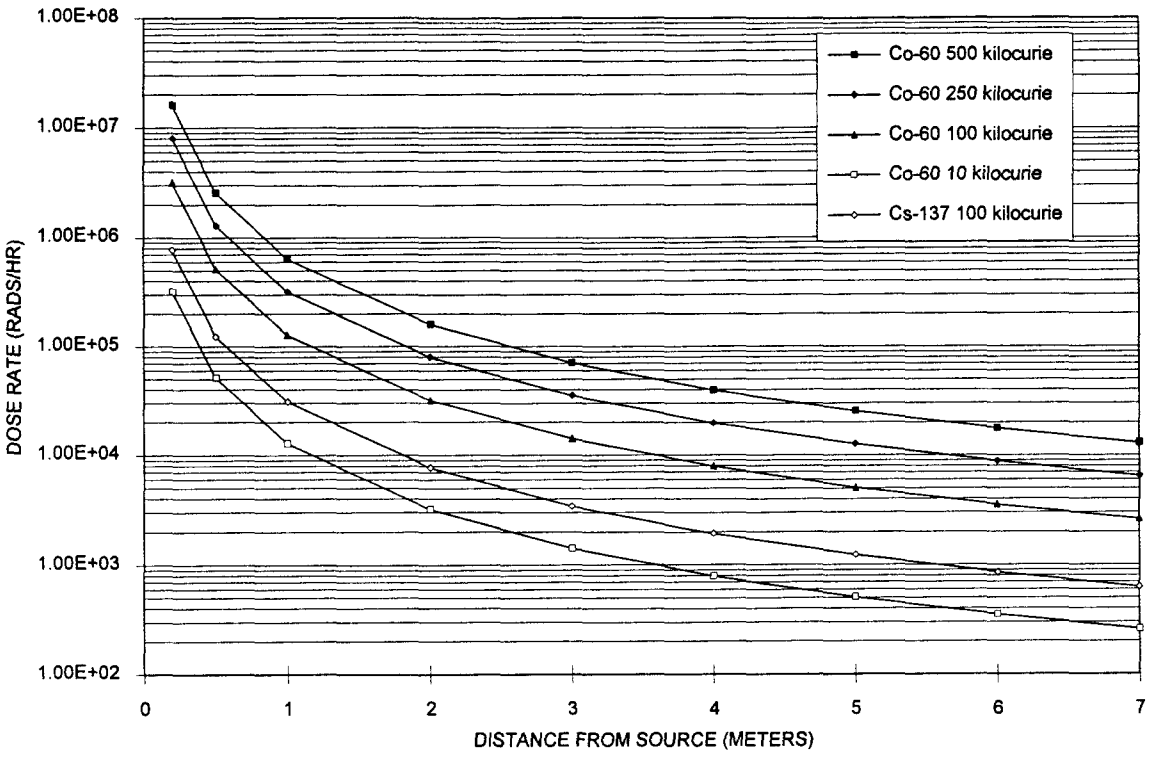
1. Gamma Irradiation for In-cell Facilities
2. Predicted Pool Cooling
3. Source Inventory
4. Radiation Dose Estimations for Personnel
    a) Source Storage in Pool
    b) Wet Irradiation Facilities
    c) Dry Irradiation Facilities
5. Ozone Generation from Wet and Dry Irradiation Facilities

For each area of analysis, the range of predictions cover normal operations with the result being the determination of the limits for normal operation. In most cases the analysis is extended beyond these limits into abnormal operation so that the consequences of operations just beyond the normal operating limits can be assessed.

11.2.1 In-Cell Irradiation Capabilities

The desired gamma irradiation capabilities for the new GIF are based on the capabilities in the existing GIF and LICA facilities and new capabilities desired for future experiments. The existing GIF routinely irradiates experiments in dry cells with ^{60}Co sources that are in the range of 50 to 100 kilocuries. In order to cover this range of experimentation and to allow for the decay of the ^{60}Co source, a design value of 250 kilocurie for each of the smaller north and south cells is established. The large east cell provides for experimentation on larger test units and therefore the design value is established at 500 kilocuries to account for the longer distances possible between the source and test unit. Figure 11-2 shows the predicted dose rates through air as a function of distance from a point source for ^{60}Co and ^{137}Cs of various sizes. The dose rate follows basically a linear relationship with the source strength and an $1/r^2$ relationship with distance from the source. These calculations were performed assuming the radioactive source is a point source.

Figure 11-2. Predicted Dose Rates for Direct Radiation in Dry Irradiation Cells



The dose rates in Figure 11-2 are what a test unit would receive directly from the source in a dry irradiation cell. At 2 meters from a 250-kilocurie ^{60}Co source, the direct dose rate is 80,000 rads/hr. However, due to reflection off of the cell walls, the actual dose received is higher. For the same size source, the reflected dose rate in a cell is ~10,000 rads/hr and is relatively independent of location. The total dose rate is therefore 90,000 rads/hr for a test unit at 2 meters from the source. The north cell (high fidelity cell) contains lead-lined walls to reduce the reflected component. For the large east cell, the total dose rate is approximately 180,000 rads/hr at 2 meters from the 500-kilocurie ^{60}Co source.

Two other dose predictions, which are of concern in assessing accident consequences, are the dose rates at 10 m and 50 m. Ten meters is the assumed distance from the pool area to the outside of the GIF building and 50 meters is the assumed distance to the site boundary. With only air shielding (no building walls), the dose rate at 10 m from ^{60}Co sources of 250 kilocuries and 10 kilocuries are 3200 rads/hr and 130 rads/hr, respectively. At 50 m from the same sources, the dose rates are 120 rads/hr and 4.7 rads/hr, respectively.

11.2.2 Predicted Pool Cooling

Radioactive sources in the GIF pool generate heat as a result of the radiation energy. Because the GIF contains sources which are primarily gamma ray emitters, most of the radiation energy is deposited in the water around the source. This is due to the long mean free path of gamma photons. Although there may be some internal attenuation of the gammas

within the radioactive source material, the inventory in a pin is limited so that no significant heating occurs in the pins. Consequently, the purpose for the water in the pool is not for cooling source pins, but rather as a radiation shield. In this capacity the water will heat up as it attenuates the radiation. Removing the heat from the pool is the topic of this section.

The GIF contains no active system associated with cooling the pool water. The radioactive sources generate power continuously; therefore, passive forms of heat removal are considered more reliable and preferable to active forms. The two types of heat rejection which are employed on the existing GIF and LICA facilities are evaporation and conduction. Evaporation is a convective process which occurs at the pool surface as pool water evaporates, removing considerable energy in the process. It is primarily a function of the pool surface area, water temperature, and air flow velocity over the surface. Conduction is a less efficient process that occurs through the pool walls to the subsurface ground around the pool. Conduction is dependent on the pool water temperature, the subsurface earth temperature, and the insulating properties of the pool walls and earth fill. Conduction to earth is a very slow process, which can be affected by long term conditions such as seasonal climate changes and yearly rainfall.

11.2.2.a. Evaporation

GIF evaporation is analyzed as an extension of an effort to determine water evaporation rates for the existing GIF and the Annular Core Research Reactor (ACRR) pools.[11.7,11.8] This serves two purposes: 1) comparing the predicted evaporation rates to experimental values gives an indication of the accuracy of the models, and 2) providing benchmarks for a better prediction of the new GIF rates. The comparison of the evaporation models to experimental values yields one obvious conclusion: there are no accurate methods for calculating absolute values of pool evaporation. Inaccuracies occur due to the assumptions used to generate the equations and/or from the assumed values of physical parameters input into the equations. The models were therefore benchmarked to the experimental values obtained from the existing GIF and ACRR pools. These pools operate at different water temperature and airflow conditions. The empirical models are then extrapolated to different parameter regimes expected for the new GIF pool. Two calculation methods are used to predict the evaporation rates compared as functions of two main variables effecting pool evaporation: pool temperature and surface air flow

METHOD 1: Evaporation studies performed by Sutton and Pasquill serve as the basis for the Clancey model.[11.9] This Clancey model is used in many accident analyses involving volatile liquids spills. The model is derived for rectangular and circular pools and benchmarked to the existing GIF and ACRR pools, respectively. The Clancey equation for rectangular pools was used for the new GIF pool:

$$E = 1.2E\text{-}10 * (M * P / T) * u^{0.78} * x^{0.89} * y$$

E = evaporation rate in (g/s)
M = molecular weight
T = water temperature (K)
P = vapor pressure at temperature (dynes/cm^2)
u = air flow speed (cm/s)
x = downwind pool dimension (cm)
y = crosswind pool dimension (cm)

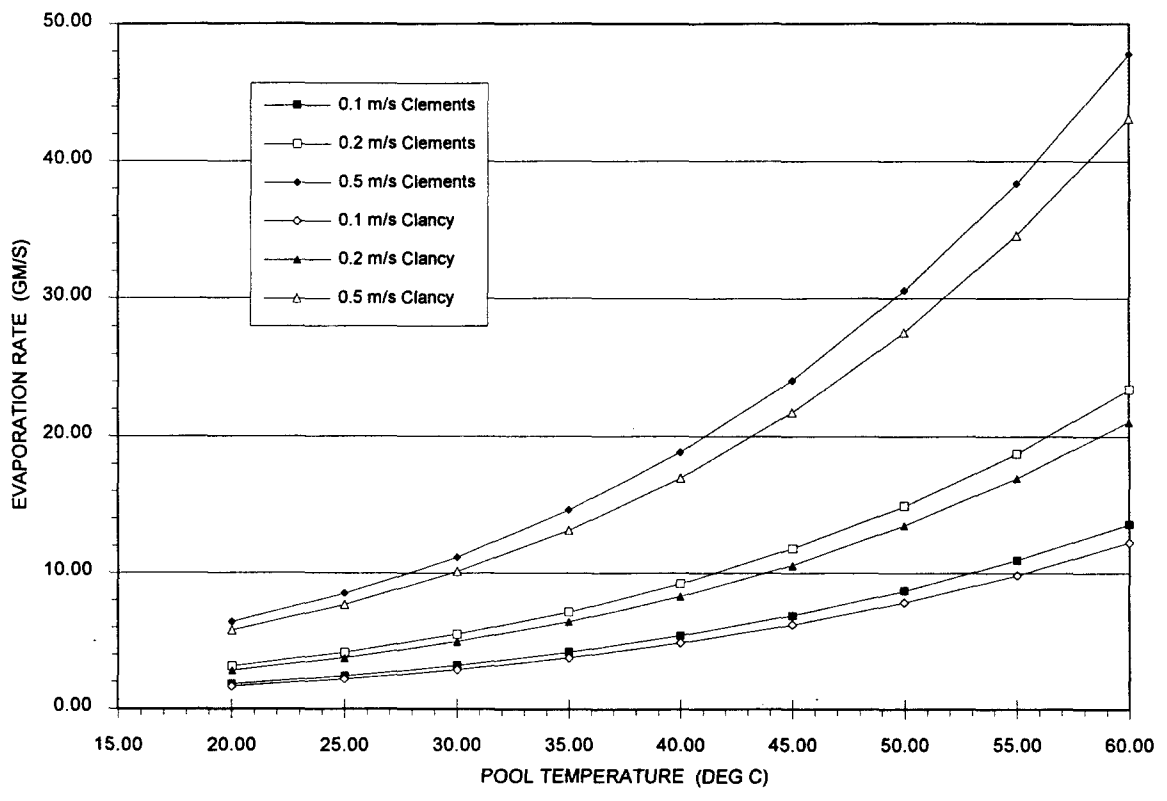
METHOD 2: The Clement evaporation model is recommended for usage by the U.S. EPA in its document "Technical Guidance for Hazard Analysis".[11.10] For the model used in this analysis, the constants in the equation have been converted to yield metric units.

$$QR = 7.89E\text{-}9 \ *(A * VP * M^{2/3} * u^{0.78}) / (T+273)$$

QR = evaporation rate in (g/s)	u = air flow speed (m/s)
M = molecular weight	A = pool area (cm^2)
T = water temperature (C)	VP = vapor pressure ($dynes/cm^2$)

Figure 11-3 shows the results for the two evaporation models as functions of pool temperature and at different surface air flow speeds. The air flow rate of 0.2 m/s is considered to be an average velocity that is realized above the GIF pool. As will be discussed later in this section, a pool temperature of 50° C is considered a practical operating level. Based on the results in Figure 11.3, the evaporation rate at this temperature is about 15 gm/sec or 54 liters/hr. This value is used to size the maximum capacity of the pool water makeup subsystem. The subsystem is sized to deliver 200 liters/hr which accounts for uncertainties in the models and assumed operating values.

Figure 11-3. Predicted Evaporation Rates for the GIF Pool



11.2.2.b. Conduction

As previously noted, conduction is the less efficient process for removing heat from the GIF pool. Conduction is dependent on the pool water temperature, the subsurface earth temperature, and the insulating properties of the pool walls and earth fill. Most of these values can not be accurately determined, but rather, must be assumed. For this reason, the conduction model used in this prediction is based on a simple one dimensional model as follows:

$$P_{cond} = A * K_c *(T_{water} - T_{soil}) / X$$

P_{cond} = conducted heat / time
A = pool wall & floor area
K_c= concrete conductivity
T_{water} = water temperature (C)
T_{soil} = soil temperature (C)
X = thickness of concrete

The conduction model is assumed to be dominated by the temperature drop through the concrete wall of the pool. The equation contains soil temperature and a value of 25° C is assumed for these calculations.

11.2.2.c. Total Heat Loss Rate

The total cooling for the GIF pool is the power lost by evaporation at the pool surface plus the power conducted through the walls and floor of the pool. Using the evaporation rates presented in Figure 11-3, the evaporation power can simply be stated as the evaporation mass rate multiplied by the heat of vaporization. Therefore the equation for total power loss from the pool is as follows:

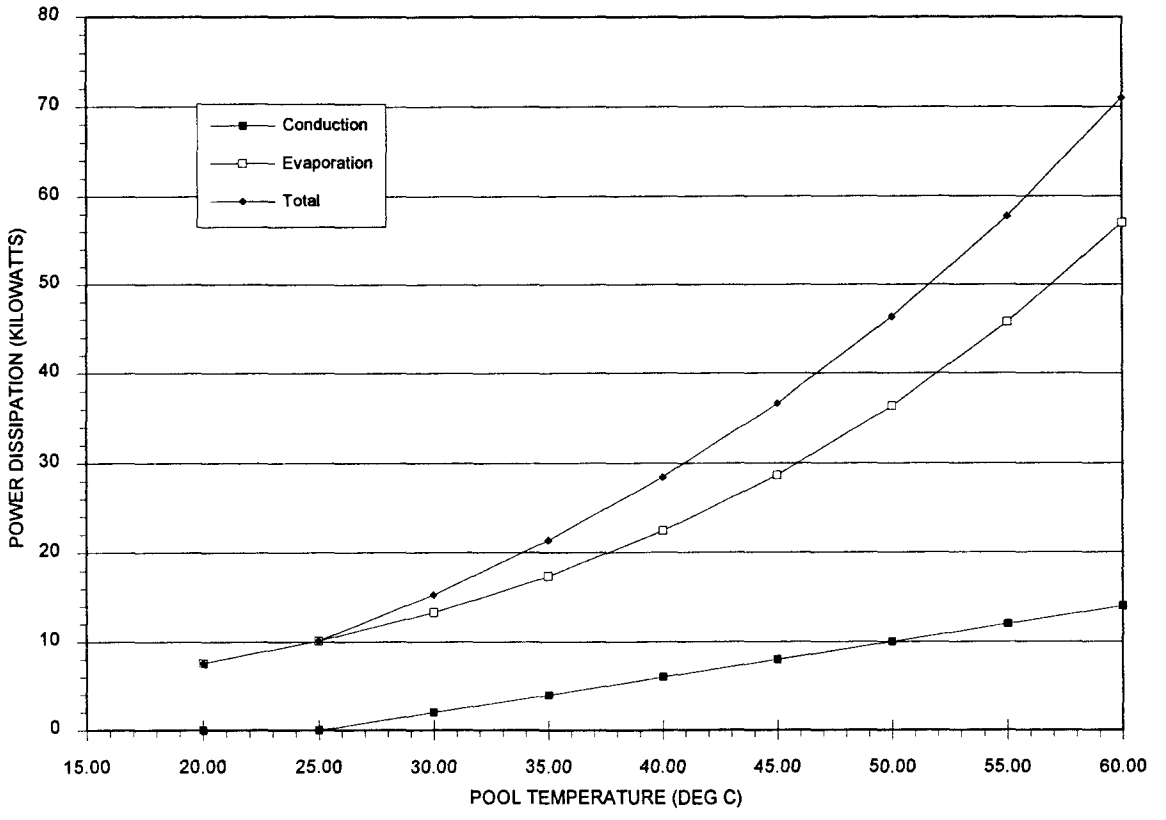
$$P_{pool} = QR_{evap} * H_{vap} + P_{cond}$$

P_{pool} = pool power loss
QR_{evap} = evaporation mass rate (assumes 0.2 m/s air flow)
H_{vap} = heat of vaporization

Figure 11-4 shows a graph of the predicted power loss for the GIF pool as a function of temperature. The power loss is presented in its individual components (conduction and evaporation) and as the total.

The maximum temperature at which the pool can be operated is limited by the resins in the pool water recirculation loop. Typical manufacturers limit for resins is 60° C. At this temperature, the resins proceed to release minerals rather than trap them. As shown in Figure 11-4, the predicted power loss at 60° C is ~70 kW. This represents the maximum allowable thermal power source for the pool. A more practical value for the nominal operating temperature of the pool is 50° C. The total power loss is approximately 46 kW for a pool temperature of 50° C.

Figure 11-4. Predicted Power Loss for the GIF Pool



11.2.3 Source Inventory

The radioactive sources used in the GIF are all sealed sources. The GIF sources can be different radioactive nuclides. Most, if not all, of the radioactive material will be ^{60}Co which is in the form of a non-soluble metal. The type and intensity of the radioactive material may vary subject to restrictions presented in the thermal analysis in this section.

Radioactive gamma-emitting sources generate heat as a result of the attenuation of the long range, energetic photons. For the GIF, this heat is deposited as a volumetric heat source in the pool water. It does not present a localized cooling concern. There may be some internal attenuation within the radioactive source material; however, due to the long range of gammas, this power source is not sufficiently large to require water cooling of the pins. In the dry irradiation cells, sources are routinely brought out of the water for extended periods with only slight increase (<10° C) in pin temperature. All sources brought into the GIF pool are subject to review by the Radiation and Criticality Safety Committee (RCSC).

The total source inventory limit for the GIF pool is determined by a number of considerations: cooling, shielding, and administrative limitations. Pool cooling is the most important issue and is described in the previous section. Shielding is also an issue; however, as will be demonstrated in Section 11.2.4, the pool depth is sufficient to shield much larger sources. Another source inventory consideration is the limitation for a Hazard Category 3 facility as described in DOE STD-1027 Appendix A.[11.11] The standard provides exclusion of sources

which satisfy testing as specified either by the DOT in 49 CFR 173.436 or by ANSI N43.6 "Sealed Radioactive Source, Categorization".[11.12, 11.13] As described in Chapter 4, approximately 180 kilocuries of existing sealed ^{60}Co sources, which are not qualified for exclusion, will be transferred to the GIF. All new sources to be acquired will be qualified to the DOT or ANSI standards; consequently, the inventory can be excluded from the DOE STD-1027 limits.

The total source inventory for the GIF pool is therefore limited by the total cooling (power loss) capability of the pool. The equation for calculating the power generated by a radioactive source is as follows:

$$P_{source} = C * (1.6e\text{-}13)(3.7e+13) * E$$

P_{source} = power (W)
C = source strength in kilocuries
E = total energy per decay in MeV

By substituting in the energies (E) for ^{60}Co and ^{137}Cs, the following power conversion values are obtained:

Nuclide	E - Energy per Decay (MeV)	P_{source} (watts per kilocurie)
^{60}Co	2.82	16.7
^{137}Cs	1.18	7.0

The calculated power based on the above conversion values are presented in Table 11-1.[11.14] For the current five batches of ^{60}Co sources, the power generated is ~2.6 kW. Assuming ~1.0 Mcuries of new ^{60}Co sources, the total power generated by all gamma sources in the new GIF will be almost 20 kW.

Table 11-1. Power Generated by GIF Gamma Sources

Batch	Facility	Source Type	# of Pins	Strength (3/1/1995) Curies	Power Generation (watts)
1	Existing GIF	^{60}Co	64	56,648	950
2	Existing GIF	^{60}Co	16	43,373	720
3	Existing GIF	^{60}Co	10	13,891	230
4	LICA	^{60}Co	32	36,160	600
5	LICA	^{60}Co	93	6,858	120
Subtotal	(Existing Sources)	all ^{60}Co	215	156,931	2,620
Subtotal	(New Sources)	^{60}Co	TBD	1,000,000	16,700
Total	(All Sources)	^{60}Co	TBD	~1,157,000	~19,300

To determine the total inventory for the GIF pool, the watt-per-kilocurie conversion factors are also used. As discussed in the previous section, a pool temperature of 50° C is considered as a nominal operating temperature. The total power loss is approximately 46 kW for convection and conduction. Allowing a margin for uncertainties in the power loss calculation (particularly the conduction component), a conservative value of 40 kW is assumed to be the power loss at a pool temperature of 50° C. Using the conversion factor for ^{60}Co, the total source inventory to generate 40 kW is 2400 kilocuries (2.4 megacuries). This provides a basis for the maximum inventory of ^{60}Co sources in the GIF pool. If other types of sources are placed in the pool, the ^{60}Co inventory is decreased accordingly, so that the total power generated by all sources does not exceed 40 kW.

11.2.4 Radiation Dose Estimations for Personnel

ALARA principals are used as the basis for determining the GIF radiation shielding design. Based on ALARA, a reasonably challenging goal of 1 rem/yr is used as the individual worker dose limitation for design purposes. This is well below the individual dose limit of 5 rem/yr and the administrative limit of 2 rem/yr as specified in the SNL RADCON Manual.[11.15] For determination of the dose rate limit for design, the following equation is used:

$$DR = D_{alara} * Q / (Hr * O * F_{use})$$

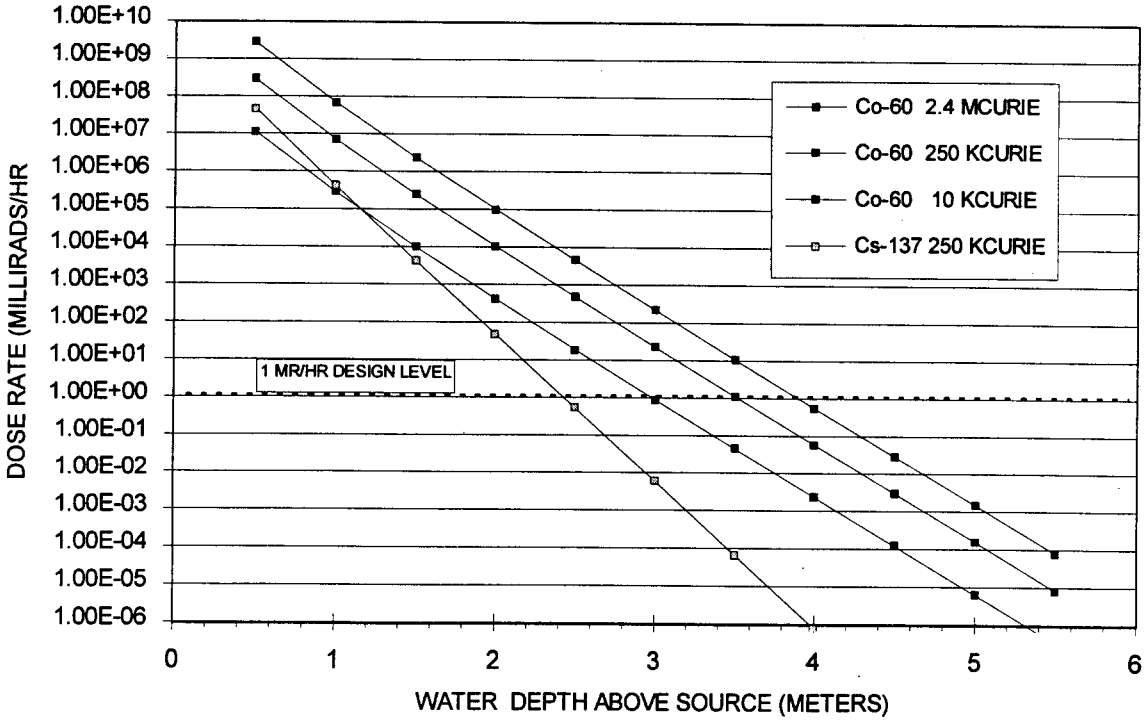
D_{alara} = 1 rem/hr
DR = dose rate (rad/hr)
Q = 1rad/1rem (biological conversion factor for gammas)
Hr = 2000 hrs (working hours per year)
O = 0.5 (occupancy of individual in the radiation area)
F_{use} = 1.0 (use factor of the facility)

From operating experience with existing gamma irradiation facilities, the assumed values for occupancy (50%) and use factor (100%) are believed to be very conservative. Based on the stated values, a dose rate of 1 millirad/hr is calculated as a GIF design criteria. Actual doses received during operation will be in full accordance with ALARA.

11.2.4.a Source Storage

In-pool source storage requires a minimum depth of water to provide adequate shielding for personnel at the pool surface. Figure 11-5 shows predictions of ^{60}Co and ^{137}Cs radiation attenuation through water as a function of pool depth.[11.16] The calculations were performed with Microshield.[11.5] The graph shows that a depth of ~4.0 meters of water is required to attenuate a 2.4-megacurie ^{60}Co point source to 1 millirad/hr. With the GIF pool depth of ~6 meters to the floor bottom, there is sufficient margin to accommodate storing the entire 2.4 megacuries above the pool floor by almost 2 meters. A more practical estimate of source storage depth is to assume that a 250 kilocurie source is stored at an elevated location such as the in-pool irradiation fixtures. Based on these conservative point source calculations, a depth of 3.5 meters would be required. If a single ^{60}Co pin (assumed equal to 10 kilocurie) were handled, a water depth of 3.0 meters is required to maintain dose rates below the 1 millirad/hr level. The ^{137}Cs curve illustrates that cesium's lower energy gamma makes it much less of a concern than ^{60}Co.

Figure 11-5. Radiation Dose Rate as a Function of Pool Depth



11.2.4.b Dry Irradiation Facilities

The "Monte Carlo" type code MCNP (version 4 by LANL) was used to calculate radiation dose rates in the cells and around the maze entrances to the cells. The code is a combined neutron and photon scattering code, with only the photon portion of the data used for GIF analysis. Because of the poor statistics for both the deep penetration and maze problems, code runs typically required 5 to 10 million photon histories to converge on a reasonably accurate dose rate. For deep penetration problems, the Microshield code (version 4 by Grove Engineering) was used for determining gamma dose rates through the concrete walls. All dose rate predictions will be mapped and verified as part of the initial testing program

Figure 11-6 shows the dose rates (in rads/hr) predicted for the cells, the cell maze, and above the cells.[11.17,11.18] The dose rate maps are presented for 1) the floor plan of the small cells with 250-kilocurie ^{60}Co sources, 2) the floor plan of the large cell with a 500-kilocurie ^{60}Co source, and 3) a vertical map of a small cell including the roof with a 250-kilocurie ^{60}Co source.

For the small cells the highest dose rate occurs on the wall immediately opposite the source. The ~0.5 millirad/hr value is about one-half of the design value, demonstrating the adequacy of the 1.83-m thick concrete walls. Dose rates through the shield windows are equivalent or better than the shielding provided by the 1.83-m thick concrete wall. The necessity of the 10-cm lead shield at the end of the maze is also demonstrated. The shield reduces the direct shine radiation impinging on the narrow portion of the maze external wall such that the dose rate on the outside of the wall is ~0.3 millirad per hour. The dose rates through the maze are discussed later.

Figure 11-6. Radiation Dose Rates for the Dry Irradiation Cells

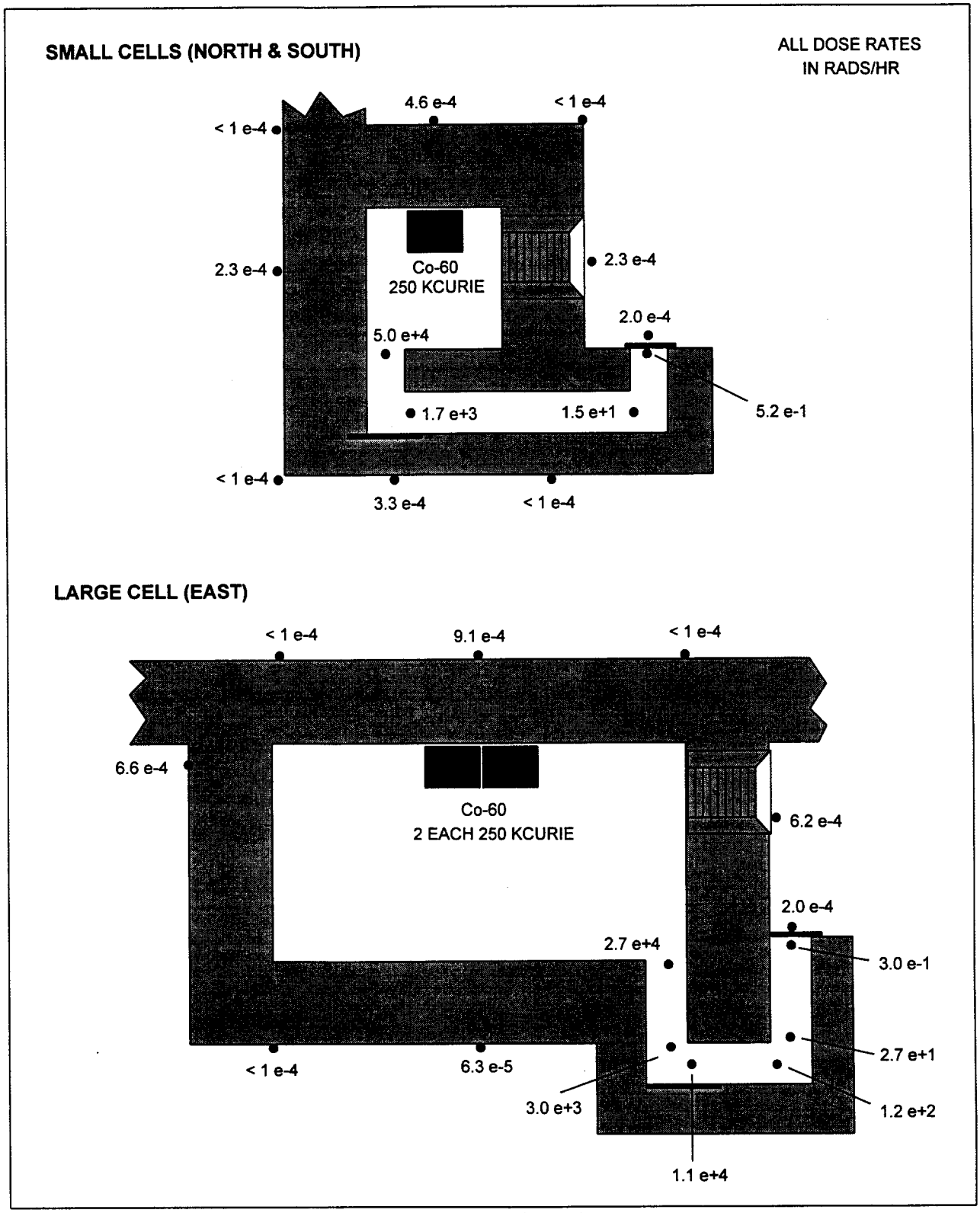
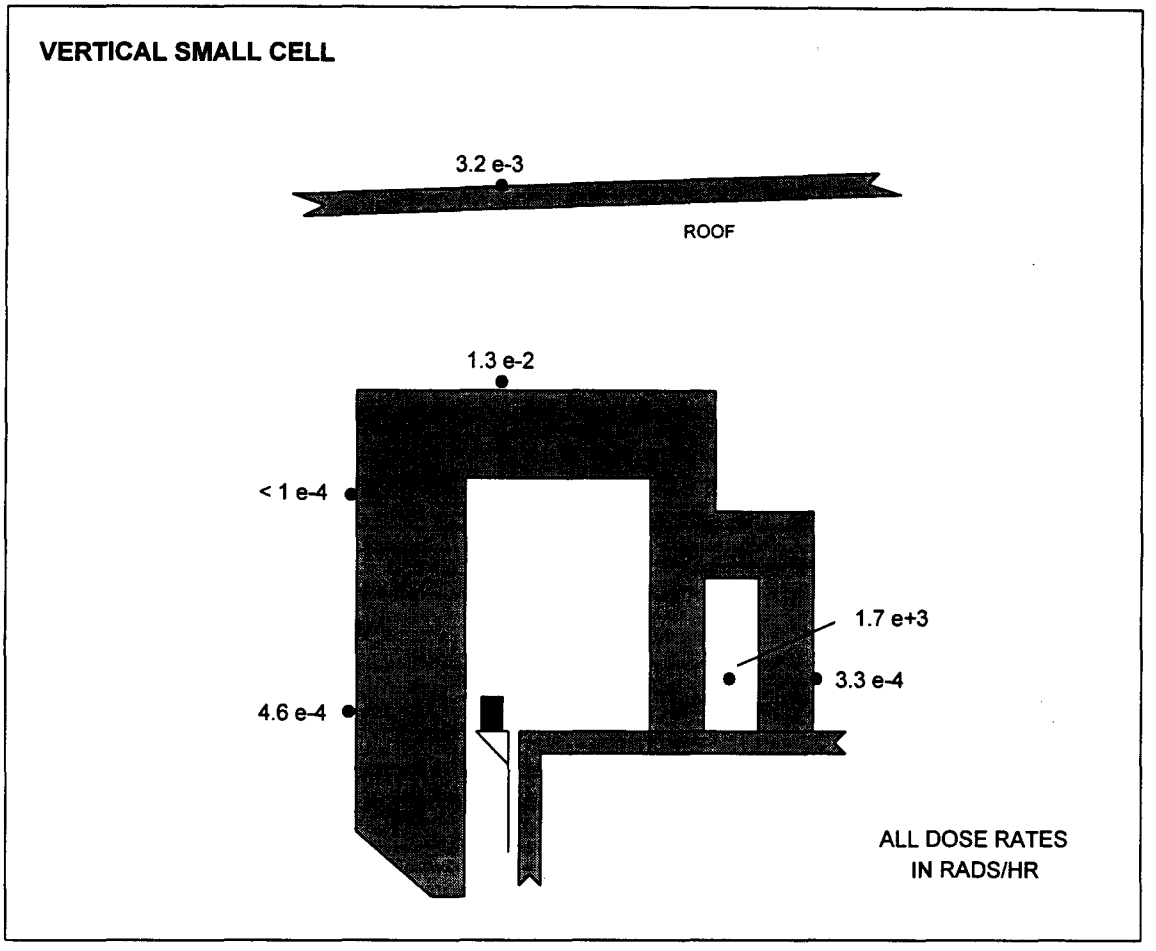


Figure 11-6 (continued). Radiation Dose Rates for the Dry Irradiation Cells



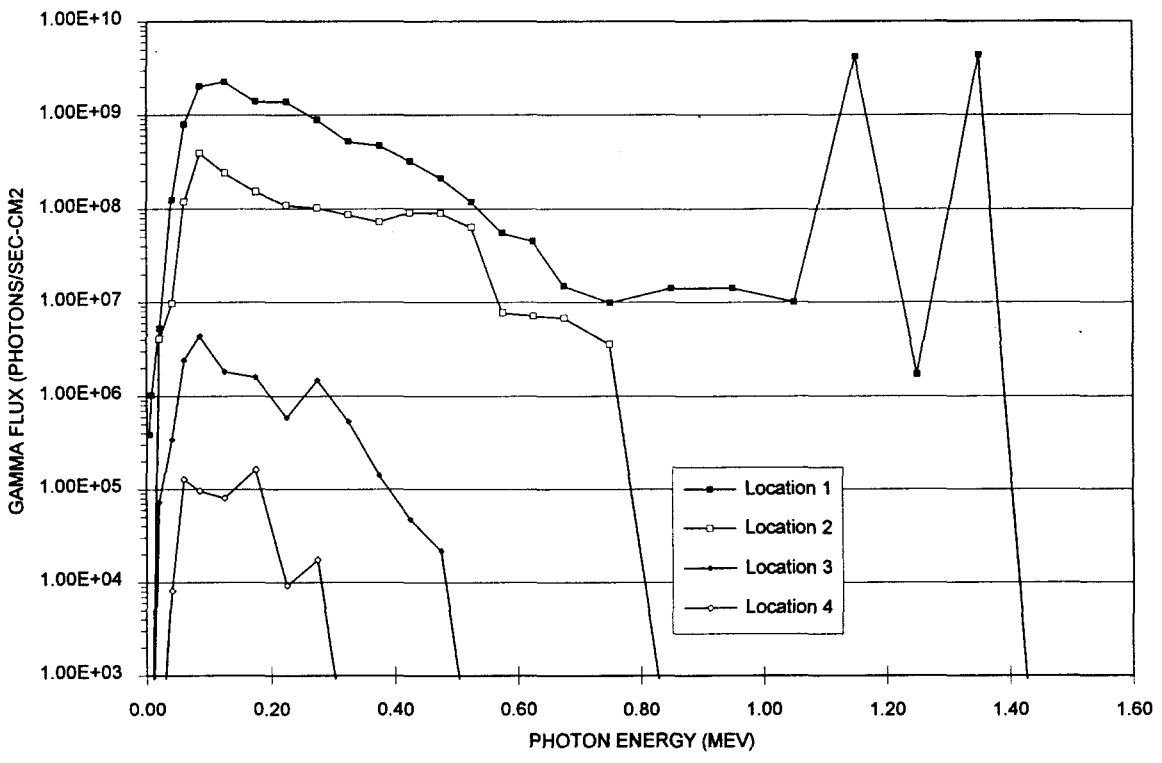
For the large cell the source is doubled to two 250-kilocurie ^{60}Co sources, as shown in the second map of Figure 11-6. The dose rate at the exterior of the wall nearest the sources is calculated to be 0.9 millirad/hr. This calculation conservatively assumes that sources are point sources in contact with the inside wall. A more realistic calculation with planar sources located at the centerline of the elevators shows the dose rate to be 0.7 millirad/hr.

The predicted dose rates above the cell are shown in the third map of Figure 11-6. Because of the reduced ceiling thickness of 1.37 meters (compared to the wall thickness of 1.83 meters), dose rates above the ceiling are higher than those around the cell. The thinner ceiling is desirable for construction purposes. With a 250-kilocurie ^{60}Co source located 1 meter above the floor, the dose rate on top of the cell ceiling is 13 millirad/hr. The reason this high value is tolerated is that access to the top of the cells will be restricted during operations. Likewise, the predicted dose rate on the roof is 3 millirad/hr; implying that some access control is also necessary for the GIF roof. The calculations do not take into consideration radiation streaming through openings that are intentionally designed into the cell ceilings such as the elevator cable and movable wall trolley. Local areas of high radiation can be exhibited at these locations. The amount of radiation streaming will be minimized by design features; however, limiting access to the cell roofs and the high bay roof will most likely be required.

The purpose of the maze is to reduce the gamma flux through the torturous corridor so that a manageable sized cell door can be used at the entrance. The path of the maze assures that any radiation impinging on the door area must undergo at least two scattering reactions before reaching the door. Figure 11-6 shows the predicted dose rates at four locations around the small cell maze: 1) the source-side entrance to the maze, 2) the corridor near the entrance, 3) the corridor near the exit, and 4) the inside surface of the maze door. From location 1 to location 4, the dose rate drops almost 5 decades from 50,000 rads/hr to 0.5 rads/hr. The door reduces the flux by another 3 decades so that the dose rate at the exterior of the door is only 0.2 millirads/hr. The required shield for the door is minimal -- approximate 0.5 cm thick lead sheet. The reason the lead thickness is small is because the photon flux circumventing the maze reduces in energy as well as intensity. With each scatter reaction the average energy of the photon flux is reduced. Figure 11-7 shows the predicted photon spectra at the four locations around the maze. The two large spectrum peaks at location 1 are the 1.17 and 1.33 meV gamma rays directly from the ^{60}Co source. The graphs clearly illustrate that the average energy, as well as the overall intensity, is decreasing as the radiation flows through the maze. As part of the Title-II design process, optimization of the maze path will be performed with the objective being to reduce the overall lead shielding required in the design.

The purpose of the dose rate predictions is to provide a basis for shield design. The source intensities stated herein are values assumed for the maximum of normal operations. Higher source levels may be employed if other controls (i.e. administrative, access control) are used to restrict personnel access to high radiation areas.

Figure 11-7. Radiation Fluxes for the Maze Hallways
(Graphs do not reflect the large statistical uncertainty for the small fluxes)



11.2.5 Ozone Generation from Wet and Dry Irradiation Facilities

The purpose for calculating ozone generation is to evaluate ventilation requirements for the GIF irradiation cells.[11.19] Ozone produced in the irradiation cells must be vented outside to atmosphere to prevent its concentration from exceeding OSHA regulations.[11.20] OSHA regulations limit ozone concentrations to 0.1 ppm (or 0.2 mg/m^3) for continuous exposure in a work environment. For short term exposure (up to 30 minutes) without irreversible health effects, the maximum permissible ozone concentration is 10 ppm (or 20 mg/m^3).

Toxic gasses are produced by radiation in the process of ionizing the component gasses of air. In addition to the generation of ozone (O_3), various forms of nitrogen oxides are also created. In the presence of water vapor the nitrogen oxides will form nitric acid. Of all toxic gasses produced, ozone production almost always is the limiting factor, primarily due to its lower limiting value (0.1 ppm), high radiolytlc yield, and chemical reactivity.[11.21]

The production rate of ozone is related to the integral dose of an irradiated air volume by a term identified as the radiolytic yield (G). G is defined as the number of molecules of ozone formed per unit of energy deposited. Experimental data suggest that radiolytlc yield of ozone in pure oxygen is around G=13 molecules per 100 eV.[11.22,11.23] In air these values are believed to be in the range of 7.4 to 10.3 molecules per 100 eV, depending on the instantaneous dose rate.[11.24,11.25] Experiments also suggest that value of G decreases with increasing dose rate, primarily due to enhanced decomposition of ozone by the higher radiation fields.

Ozone is removed from cell atmospheres either by the ventilation system or by decomposition. Ozone decomposes rapidly by two means: 1) it reacts chemically with air impurities and other materials, and 2) it decomposes by radiation. The effective decomposition time depends on room size, wall material, temperature, and impurities in the air. The decomposition time has been found to be about 60 min in a typical research installation made of concrete walls.

The ozone concentration buildup is described by the following equation (perfect mixing of the ventilation flow is assumed):

$$C(t) = M\,T\,[1 - \exp(-t_b / T)]$$

Where, C = concentration (mg/cm^3) or ppm with a linear conversion factor
t_b = buildup time (sec)
M = overall production rate of ozone (mg/m^3-sec)
T = determined by the removal process as

$$T = (T_{vent} \times T_{decomp}) / (T_{vent} + T_{decomp})$$

T_{vent} = the room volume divided by the air volume exhausted per second
T_{decomp} = decomposition time for ozone (~3600 sec)

For long buildup times, such as for the GIF, the saturation concentration C_{sat} can be expressed as:

$$C_{sat} = M\,T$$

In the case of no ventilation or low ventilation, the saturation concentration is given as:

$$C_{sat} = M \times 3600$$

The concentration of ozone at the time after the ^{60}Co source is removed from the cell can also be determined. The concentration diminishes exponentially with decay time t_d, as given by the following equation (perfect mixing of the ventilation flow is assumed):

$$C(t_d) = C_{sat} \exp(-t_d / T)$$

To determine the overall production rate (M), the source is assumed to be a point source located in a corner of the room. The local ozone production rate depends on the rate of local energy deposition, i.e. local dose rate. The local dose rate varies with distance from the source as $1/R^2$, where R is the distance from the source. Using a G value of 10, the number of molecules generated is 1.0×10^{14} molecules/cc-s. This corresponds to a volumetric mass production rate (M) approximately equal to 8 mg/m^3-s for the small cells and higher for the large cell due to the larger sources allowed in that cell .

Figures 11-8 and 11-9 show the predicted ozone concentration in the small cells for different exhaust flow rates and at the start of an irradiation and after an irradiation, respectively. Since the cells are inaccessible during an irradiation, the concentration in the cells does not need to satisfy OSHA requirements. However, the point of time at which the cell is accessible for entry is determined by the concentration graphs.

Figure 11-8. Ozone Concentration at the Start of Exposure for the Small Cells

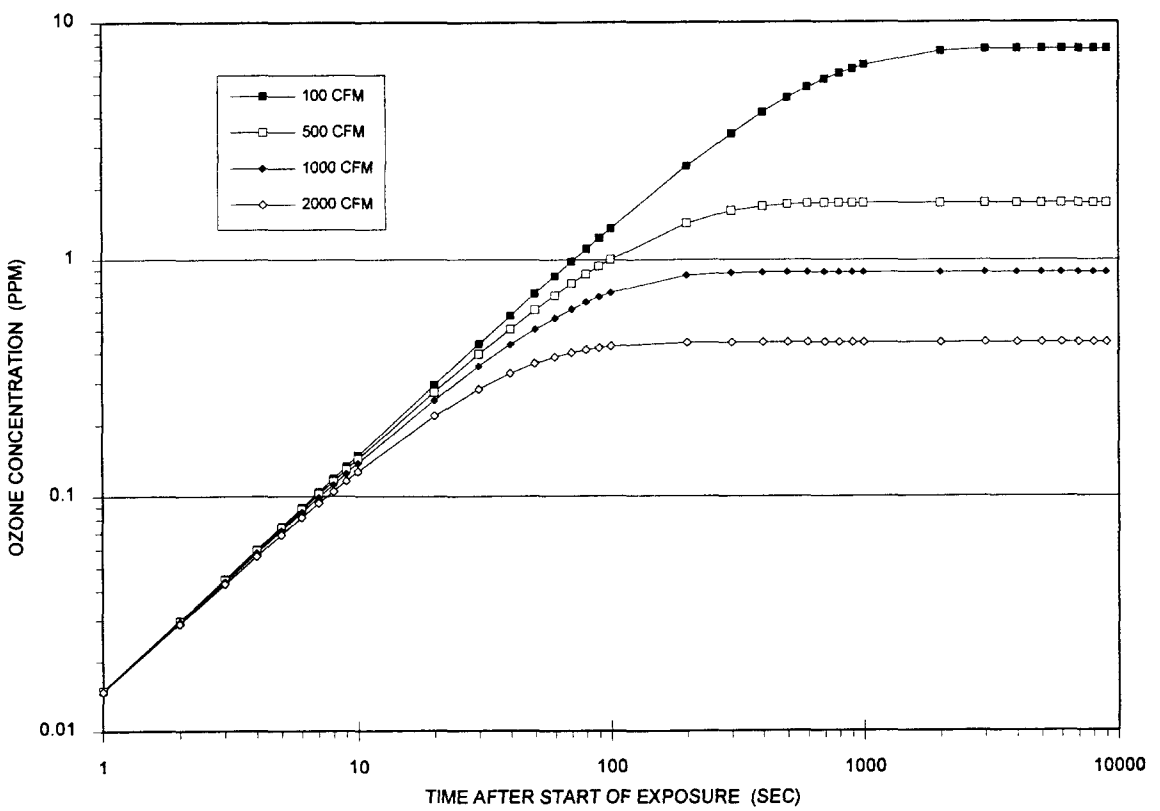


Figure 11-9. Ozone Concentration after the Termination of Exposure for the Small Cells

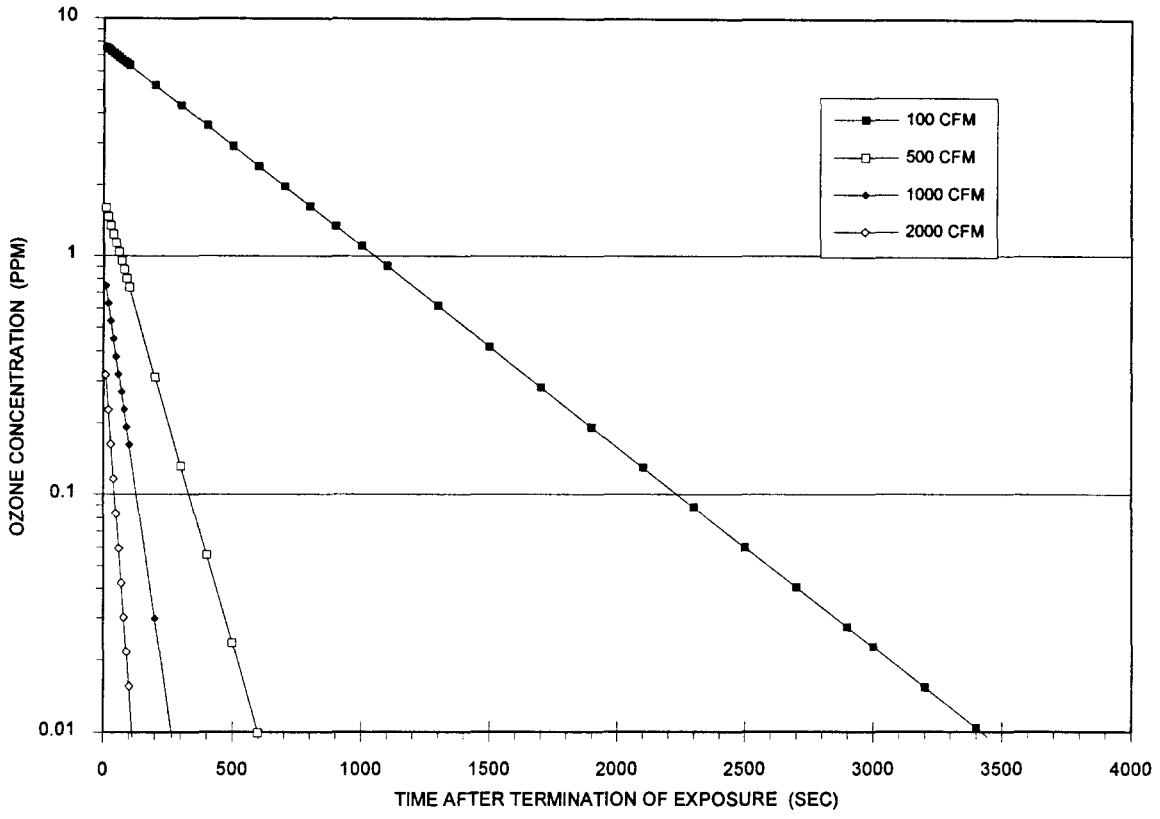


Figure 11-9 shows the ozone concentration drops below the permissible value of 0.1 ppm for a flow of 1000 cfm at ~200 seconds after termination of the irradiation. The value of 1000 cfm (28 m^3/min) corresponds to approximately 45 air changes per hour for the small cells. Allowing for margins of uncertainty, 10 minutes is the recommended time before reentry into a cell and is automatically controlled by a countdown timer in the Cell Control Subsystem (CCS). The saturation concentration value obtained for a flow rate of 1000 cfm is ~1 ppm which is a factor of 10 below the short term allowable limit as specified by OSHA requirements. If a power loss were to occur at the GIF during an irradiation process, this concentration would be the leakage source into the high bay.

11.2.5 Source Handling Operations

As discussed in Chapter 4, stationary sources are safe provided the three engineered safety features (ESF) are effective; those being source cladding, GIF water pool, and irradiation cell shields. Additional precautions must be exercised when physically handling sources because the effectiveness of each ESF can be influenced. Handling the radioactive sources involves two new concerns:

1. Moving the sources in a manner that could reduce radiation shielding provided by the pool water or the cell shields to unacceptable levels, and
2. Handling the sources in a manner that could damage the cladding or potentially put the pin in a position where the cladding could be penetrated.

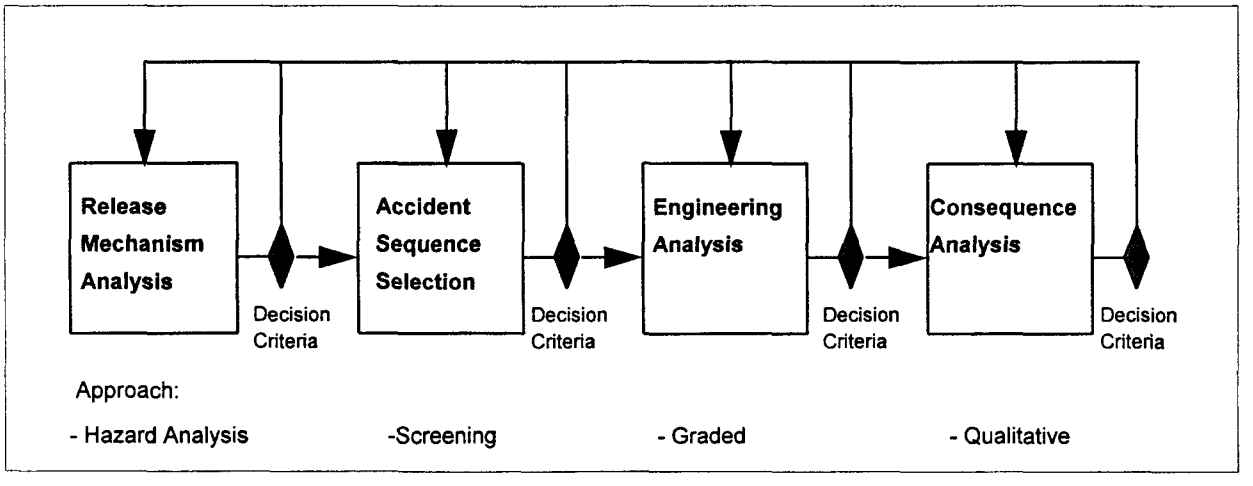
For both concerns the emphasis for safe source handling is accountable to operator training and administrative controls. Only a certified GIF Supervisor, GIF Operator, or supervised candidate-in-training is permitted to handle radioactive sources. Handling in this sense implies grasping sources, moving sources, or any operation that could cause radioactive sources to move (whether intentionally or unintentionally).

The top end-caps of the source pins are notched to allow attachment of a lifting tool. The configuration of the notch and the design of the tool vary depending on the manufacturer of the pins. The source handling tools are nominally 7 meters tall, designed to be used by one person, and include a remote release mechanism as part of the operator end. A general purpose tool is available for scooping up a pin that may have dropped to the pool floor. Custom tools may be required for specific handling operations or in case of abnormal condition (e.g. stuck pin, etc). If the source handling tools consist of hollow tubes, they contain holes to allow water fill during use. The water fill prevents radiation streaming up the tube and eliminates the possibility of the tube being buoyant.

11.3 Analysis Methodology for Abnormal and Accident Conditions

DOE Order 5480.23, and accompanying guidance in DOE-STD-1027, classify nuclear facilities and activities into three hazard categories based on the consequences for an unmitigated release of the radioactive/hazardous material. The safety documentation requirements are graded depending on the category of a nuclear facility. Category 3 is the least hazardous with the potential only for significant localized consequences and no potential for significant on-site or off-site consequences. For Category 3 facilities, the SAR accident analysis is only required to be a qualitative assessment instead of quantitative as required for the other categories. Without numerical evaluation, there are no criteria for determining if safety-related features are adequate for a given hazard. Therefore, a methodology has been developed for evaluating safety-related features of a Category 3 nonreactor nuclear facility in the absence of a quantitative analysis. This methodology has been applied to the safety analysis of the GIF.

Figure 11-10. Application of the Graded Approach to GIF Accident Sequence Analysis



According to STD-1027 guidance on the application of the graded approach, the four elements of a Category 3 safety analysis were addressed as follows (as shown in Figure 11-10):

- The release mechanisms are only focused on unique scenarios which could adversely effect the health and safety of workers in the facility.
- The accident sequence selection was completed by a checklist to ensure that a comprehensive list of potential accident conditions are qualitatively considered.
- Only a limited engineering analysis was performed to determine the effectiveness of preventative and mitigative features.
- A qualitative consequence analysis for each identified accident sequence determined the overall risk level (consequence and probability) for that accident.

Two ambiguities occurred in employing this approach directly. First, a qualitative analysis is required to demonstrate that preventive and mitigative features are incorporated to protect workers; however, no criteria are provided for assessing the adequacy of these features. Second, no guidelines are provided for ensuring a uniform designation of consequence level, probability, and overall risk level.

Therefore, a methodology has been developed which establishes a uniform set of criteria to determine requirements for safety related features depending on the severity of the consequences and the probability of occurrence for each accident sequence. As introduced in STD-1027, unmitigated consequences are categorized or binned into three levels (high, medium and low). The following definitions were used:

- High: involving a hazard to the public, environment, site worker or a potential lethal consequence to the facility workers.
- Medium: having the potential to result in an injury (usually non-lethal) to a facility worker or which can result in high radiation doses above approved limits.
- Low: potential for property damage or violation of ALARA principals.

Probabilities were quantitatively evaluated with levels based on a number of DOE orders and guides. Adhering to categories and descriptions in DOE/AL Order 5481.1B, probability levels were binned consistent with the guidance given in STD-1027 as follows:

Category	Description	Frequency per Year
High	Anticipated event during plant operation	$> 10^{-2}$
Medium	Unlikely event during plant operation	10^{-2} to 10^{-4}
Low	Extremely unlikely event	10^{-4} to 10^{-6}
Incredible	Occurrence is incredible	$< 10^{-6}$

The safety-related features for reducing the overall risk were then ranked according to the desirability/reliability in achieving accident prevention and mitigation as follows:

1. Elimination of hazard through engineering techniques
2. Redundant passive barriers
3. Passive barrier (continuously present, requiring no external stimulus to be effective)
4. Active feature (automatically or manually initiated, fail-safe and non-fail-safe)
5. Administrative control (two-person rule)
6. Administrative control (single-person compliance)

According to the ranking, the most desirable features are those that perform their intended function reliably with no external stimulus/control (e.g. passive features). The least desirable are features which rely on administrative controls and operator action to be effective. Within each rank level, other safety characteristics such as redundancy, reliability, diversity, response times and failure modes must also be considered in determining the overall effectiveness of a safety-related feature.

The minimum required number and type of safety-related features were defined for each consequence category and probability level as shown in the matrix in Table 11-2. The specified features in each bin are considered as the minimum required to reduce the accident sequence's overall risk to a low level. In implementing this process, the table is first applied to the unprevented, unmitigated accident sequence. The necessary features are identified and incorporated into the design or administrative controls. New consequence and probability levels are determined and these are reported in this document. Considerable flexibility is provided in the safety features within a bin to permit considerations for cost, manpower requirements, operational constraints, human factors, etc. This matrix was applied to all accident sequences postulated for the GIF.

Table 11-2. Minimum Safety-Related Features Necessary for Low Overall Risk Level

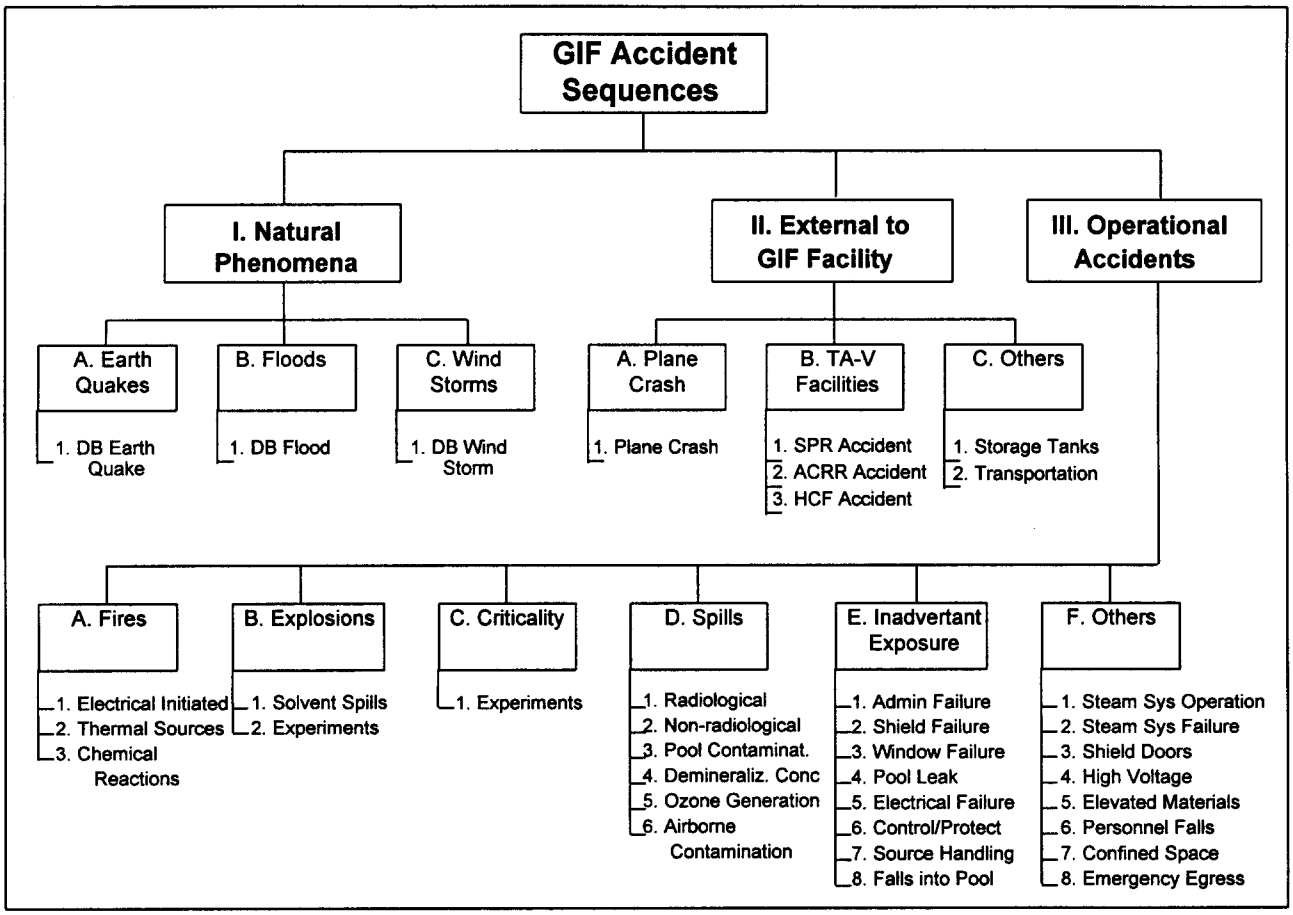
Consequence Category	Probability			
	High	Medium	Low	Incredible
High				
Potential for dose to public, hazard to site worker or release to environment	1. Eliminate Hazard or 2. Redundant Passive	1. Eliminate Hazard or 2. Redundant Passive	1. Eliminate Hazard or 2. Redundant Passive	None
Potential for accident with lethal consequence	3. Passive Barrier	3. Passive Barrier or 4. Active	3. Passive Barrier or 4. Active	None
Medium				
Potential for injurious accident or high dose above approved limits	4. Active or 5. Administrative (two-person)	6. Administrative (single-person)	6. Administrative (single-person)	None
Low				
Adherence to ALARA principals	6. Administrative (single person)	None	None	None
Potential for property damage resulting in high cost or facility downtime	6. Administrative (single person)	None	None	None

11.4 Accident Sequence Analysis

The accidents sequences analyzed for the GIF are shown in Figure 11-11. Accidents sequences are divided into three categories: I) natural phenomena occurrences, II) accidents originating external to the GIF, and III) operational accidents at the GIF. For some accidents, dissimilar initiators of different probabilities can lead to the same sequence and similar consequence. These are treated as separate accidents sequences in the analysis.

The GIF accidents are qualitatively analyzed in the Appendix Table 11.A-1. For each accident sequence; the cause, preventive features, detection method, mitigation features, and consequences are presented along with an overall assessment of the risk. The preventive and mitigative features are further divided into design and administrative features. In Table 11.A-1, Potential Impact refers the consequences of an unmitigated accident sequences. However, the reported risk level identified under Risk Determination includes these features in deter-mining the overall risk. Because the number and type of safety features incorporated into the GIF design and administrative controls are as defined in Table 11-2, either the probability level or the mitigated consequences level becomes low, and the resultant overall risk level for the accident sequence becomes low. These are the values reported under Risk Determination.

Figure 11-11. Accident Sequences Analyzed for the GIF



11.5 Summary of Results and Conclusions

The accident sequence analysis confirms that no credible accident was identified which could have a significant effect on other site workers, the public, or the environment.

The postulated accidents cover natural phenomena, operational accidents, and those factors external to the GIF. The matrix of accidents are grouped into 12 accident categories. A total of 37 sequences were analyzed which were initiated by 45 separate causes. This matrix provides the basis for identifying the five safety-related systems (that is -- the engineered safety features) necessary for safe operation of the facility. These systems, along with their primary safety functions and type of function, are shown in Table 11-3. Only one system, the source cladding, provides the containment or confinement function preventing the dispersal of radioactive material. Other safety-related systems primarily prevent inadvertent radiation exposure of the GIF facility personnel. Consistent with the GIF's Hazard Category 3 classification, no safety-related system is required to protect other site workers, the public, or the environment.

Table 11-3. Safety-Related Systems for the GIF

Engineered Safety Feature	Primary Safety Function	Type of Function
1. Source cladding	Containment of radioactive material	Passive
2. Water pool	Radiation shielding	Passive
3. Irradiation cell shield	Radiation shielding	Passive
4. Elevator power interrupt	Hazard Removal	Active
5. Radiation monitoring system	Detection of radiation conditions	Active

11.6 References

11.1 DOE Order 5480.23, Nuclear Safety Analysis Reports, 4-10-92.

11.2 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, 12-92.

11.3 SNL GIF Title I Design Submittal, Smith, Hinchman, and Gryllis / Southwest, Inc. SNL Project No 1264-90-AO1, 1-6-93.

11.4 MCNP-4 "Monte Carlo Neutron and Photon Transport Code System"; version 4 Los Alamos National Laboratory, Los Alamos, NM; June 1991.

11.5 Microshield version 4.00; Grove Engineering, Rockville MD, 20850, 5-92.

11.6 PUTZ "Point Kernal using Tank Zones"; version 2.1/PC by D.T. Ingersall, Oak Ridge National Laboratories; 10.06/91.

11.7 Internal Memorandum to J. W. Bryson, 6521; from K. R. Boldt, 6523; subject: "Evaluation of GIF and ACRR Evaporation Rates"; 3/12/93.

11.8 Internal Memorandum to J. W. Bryson, 6521; from K. R. Boldt, 6523; subject: "Further Analysis of GIF Evaporation Rates"; 4/1/93.

11.9 Clancey, V. J. "The Evaporation and Dispersion of Flammable Liquid Spillage in Chemical Process Hazards", Vol. 5, page 80.

11.10 "Technical guidance for Hazard Analysis" (DEC 1987). Reference: Clement Associates Inc, "Mathematical Models for Estimating workplace Concentration Levels - A Literature Review" EPA Contract 88-01-6065 (1981).

11.11 DOE Standard 1027, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, 12-92.

11.12 ANSI N43.6, "Sealed Radioactive Source, Categorization"

11.13. Code of Federal Regulation; 49 CFR 173.436 "Research and Special Programs Administration, DOT"; 12-31-91 Edition.

11.14 Internal SNL calculation No. 6523-KRB-93-007 on "GIF Source Inventory Determination" by K. R. Boldt, 3/1/93

11.15 ES&H Manual Supplement; "SNL Manual" MN471015; January 27, 1995.

11.16 Internal SNL calculation No. 6523-KRB-93-004 on "Gamma Dose Rate Calculations in Air and Water" by K. R. Boldt, 5/1/93

11.17 Internal SNL calculation No. 6523-KRB-93-006 on "Dose Rate Calculations for GIF Cell Walls" by K. R. Boldt, 7/17/93

11.18 Internal SNL calculation No. 6523-KRB-93-004 on "Dose Rate Calculations in GIF Cell Mazes" by P. Cooper and K. R. Boldt, 7/6/93

11.19 Calculation performed by Dasari V. Rao, SEA; "Ventilation Requirements for Gamma Irradiation Facility (GIF)"; Document # HP-TA5-002, Rev A; 4-04-92.

11.20 ACGIH; "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices"; American Committee of Governemnet Industrial Hygienist; 1992

11.21 Swanson, W. P., "Radiological Safety Aspects of the Operation of Electron Linear Accelerators", IAEA Technical Reports Series No. 188, IAEA, Vienna, 1979.

11.22 Johnson, G. R A, and Warman, J.M., "Formation of Ozone from Oxygen by the Action of Ionizing Radiations", Discuss. Faraday Soc., Vol. 37, pp. 87, 1964.

11.23 Shah, J., and Maxie, E.C., "Gamma Ray Synthesis of Ozone from Air", Int. J. Appl, Radiation Isotopes, Vol. 17, pp. 155, 1966.

11.24 Willis, C., Boyd. A.W., and Young. M.J., "Radioiysis of Air and Nitrogen-Oxygen Mixtures with Intense Pulses: Determination of a Mechanism by Comparison of Measured and Computed Yields". Can. J. Chemistry., Vol. 48, pp. 1515, 1970.

11.25 Kertesz, Z.I., and Parsons, G.F., "Ozone formation In Air Exposed to Cobalt-60 Gamma Radiation", Science. Vol. 142, pp. 1289,1963.

Chapter 11 Appendix
Table 11A-1. Analysis of GIF Accident Sequences

I.A.1: **Design Basis Earthquake** Cause - Natural phenomenon resulting in a 0.22 g ground acceleration	Design - The GIF facility is located in a moderate seismic active zone with a probability of 1.0E-3 for an earth-quake with 0.22 g ground acceleration. Administrative - None	- No detection or alarm devices are installed	Design - Building structure, cell walls and enclosure, source pool and other structures are designed to withstand a 0.22 g static acceleration and dynamic loads. - The Title I and Title II designs, are independently reviewed by internal teams and external review contractor Administrative - Operator will shutdown facility (lower all sources) upon detection of any ground movement.	Potential Impact - Safety-related features (cells, pool , and building) will survive this accident, and no radiation exposure is anticipated . - Damage may occur to non-safety-related systems and equipment . Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
I.B.1: **Design Basis Flood** Cause - Natural phenomenon resulting in a downpour of 5 inches in 1 hour.	Design - The GIF Facility and TA-V are not located in a flood plain . - No permanent or temporary water retention facilities drain into TA-V. - All structures in TA-V and surroundings that influence storm drainage in the area are designed to drain into arroyos around TA-V that eventually drain into Tijeras Canyon and the Rio Grande River. Administrative - None	- No detection or alarm devices are installed	Design - Building structure, drains, and TA-V drainage are designed to withstand a 5-inch rain storm in 1 hour. - The Title I and Title II designs, are independently reviewed by internal teams and external review contractor Administrative -None	Potential Impact - No adverse effects are expected because of the absence of flooding or severe water damage potential. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
I.C.1: **Design Basis Wind Storm** Cause - Natural phenomena resulting in an 81-mph basic wind speed	Design - None Administrative - None	- TA-V is located on the Kirtland Air Force Base which has Tornado Warning System.	Design - Building is designed to withstand the wind load - The Title I and Title II designs, are independently reviewed by internal teams and external review contractor Administrative - None	Potential Impact - Safety-related features (cells, pool , and building) will survive this accident, and no radiation exposure is anticipated. - Damage may occur to non-safety-related systems Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
II.A.1: **Airplane Crash** Cause - Airplane crash from unknown cause during takeoff or landing from KAFB/ Albuquerque Airport.	Design -None Administrative - None Information - As determined for other nuclear facilities in TA-V, the calculated probability for a plane crash into a TA-V facility is 7.5E-6 with the largest portion being general aviation (smaller airplanes).	- None	Design - GIF sources are normally stored the bottom of a 5.5-m deep pool. - If sources are raised for irradiation they are contained in a 1.8- meter thick, reinforced concrete cell. Administrative - None	Potential Impact - Although a plane crash would cause serious damage to the facility and could be injurious to personnel, it is not likely that sources, pool or the cells would be significantly damaged. Risk Determination Probability Level - Low Consequence Level - Medium Risk Level - Low
II.B.1: **TA-V Facilities - SPR Accident** which may adversely influence GIF operations. Cause - Accident at the Sandia Pulsed Reactor	Design - GIF is designed as a separate stand-alone facility that shares no structures with SPR. It shares the following utilities: electrical power, water, and liquid effluent treatment s - SPR is remotely located from the GIF with the reactor core in a shielded Kiva. SPR is a test reactor with little fission product inventory . Administrative - SPR hazardous experiments are normally performed out of hours.	- An audio alarm rings in all buildings and throughout TA-V.	Design - The TA-V fire/evacuation functions are integrated into a single area-wide alarm system. -Egress to evacuation assembly building is via outdoor route. Administrative - TA-V Emergency Plan requires all site workers to evacuate immediately on alarm to the predesignated assembly building unless prior exemption is granted.	Potential Impact - SPR is a Category 2 Nuclear Facility and has potential for significant on-site consequences. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
II.B.2: **TA-V Facilities - ACRR Accident** which may adversely influence GIF operations. Cause - Accident at the Annular Core Pulse Reactor	Design - GIF is designed as a separate stand-alone facility that shares no structures with ACRR. It shares the following utilities: electrical power, water, and liquid effluent treatment system. - ACRR is remotely located from the GIF with the reactor core underground in a 9 m deep pool. ACRR is a test reactor with little fission product inventory and only natural convection required to cool the reactor. Gaseous release from ACRR is via two 20- m high stacks. Administrative - ACRR hazardous experiments are normally performed out of hours.	- An audio alarm rings in all buildings and throughout TA-V.	Design - The TA-V fire/evacuation functions are integrated into a single area-wide alarm system. -Egress to evacuation assembly building is via outdoor route. Administrative - TA-V Emergency Plan requires all site workers to evacuate immediately on alarm to the predesignated assembly building unless prior exemption is granted.	Potential Impact - ACRR is a Category 2 Nuclear Facility and has potential for significant on-site consequences. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low
II.B.3: **TA-V Facilities - HCF Accident** which may adversely influence GIF operations. Cause - Accident at TA-V Hot Cell Facility	Design - GIF is designed as a separate stand-alone facility that shares no structures with HCF. It shares the following utilities: electrical power, water, and liquid effluent treatment system. - GIF is remotely located from the HCF with the most operations below ground level. Gaseous release from HCF is via a 34 m high stack. Administrative - HCF hazardous experiments are normally performed out of hours.	- An audio alarm rings in all buildings and throughout TA-V. - Criticality alarms at HCF can lead to activation of the TA- V fire/evacuation alarm .	Design - The TA-V fire/evacuation functions are integrated into a single area-wide alarm system. -Egress to evacuation assembly building is via outdoor route. Administrative - TA-V Emergency Plan requires immediate evacuation to the predesignated assembly building unless prior exemption is granted.	Potential Impact - HCF is a Category 2 Nonreactor Nuclear Facility and has potential for significant on-site consequence as a worst hazard. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low
II.C.1: **TA-V Propane Storage Tank Accident** which may adversely influence GIF operations Cause - Accident at TA-V Storage Tank Facilities.	Design - GIF is a separate stand-alone facility that is located remotely from the propane storage tanks in TA-V. - GIF air intake is located on the low bay roof. Administrative - None.	- An audio alarm rings in all buildings and throughout TA-V.	Design - The TA-V fire/evacuation functions are integrated into a single area-wide alarm system. -Egress to evacuation assembly building is via outdoor route. Administrative - TA-V Emergency Plan requires immediate evacuation to the predesignated assembly building unless prior exemption is granted.	Potential Impact - No hazard for GIF operations. - No damage is postulated for safety-related features (sources, cells or pool); however, some building exterior damage could occur. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low
II.C.2: **Transportation Accident** Cause - Accident involving radio-active source transport-ation and handling.	Design - Sources are brought to the facility by trucks using approved casks. - GIF has a large rollup door for truck access into the structure. - GIF has sufficient crane capacity to lift large shield casks. Administrative - Approved procedures are used for transporting & handling sources before and after transfer to the pool.	- None	Design - Radioactive source transfers to and from the GIF are monitored by the Health Physics staff. Administrative - Radioactive source transfers will be performed by procedures specifically approved for the purpose. - Sources brought into the GIF are approved by line management and reviewed by RCSC.	Potential Impact - Transport and transfer of radioactive sources to the GIF are a potential hazard because the primary shield of the pool water is not present. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Prevention Features	Detection and Indication	Mitigation Features	Consequence and Risk Determination
III.A.1: **Fires - Electrical Initiated.** Cause - Electrical short in the cell electrical systems or arcing from the electrical systems of test units.	Design - Fire-resistive characteristics will be incorporated into the irradiation cell construction. Administrative -None.	- Heat sensors are located in cell exhaust systems. - Smoke detectors are located in the high bay.	Design - Cells are constructed of extremely fire resistive material. - Sources are automatically submerged if cell heat sensor is alarmed. - The building is equipped with a wet pipe sprinkler system meeting NFPA requirements. The alarms are connected to a remote panel which constantly communicates with the KAFB base wide fire alarm system. KAFB has a full-time fire department on duty at all times and can respond to a fire within 10 minutes. - Cell ventilation is interlocked to shut down if a cell heat sensor is alarmed, but may be manually reactivated by the fire dept. Administrative - Safe Operating Procedures minimize the presence of flammable materials inside the cell. - Types and quantities of flammable materials throughout the building are strictly controlled. Combustibles are kept to a minimum. - Personnel are trained in use of fire suppression equipment.	Potential Impact - fire and smoke damage to interior of cells, to radiation detection units and other electrical systems within cells. Potentially extensive facility damage. Risk Determination Probability Level: Medium Consequence Level: Low Risk Level: Low
III.A.2: **Fires - Thermal Sources.** Cause - Ignition of combustible test material by heat from the source or heat from batteries in the test units.	Design - Extremely fire-resistive characteristics will be incorporated into the irradiation cell construction. Administrative -Thermal energy sources presenting a high hazard level must be approved by line management and reviewed by RCSC	- Smoke detectors are located within the high bay. - Heat sensors are located in the cell ventilation systems.	- Design and Administrative Mitigation Features are the same as for Sequence III.A.1 Electrical initiated fires	Potential Impact - Fire and smoke damage to interior of cells, to radiation detection units and other electrical systems within cells. Potentially extensive facility damage. Risk Determination Probability Level: Medium Consequence Level : Low Risk Level: Low
III.A.3: **Fires - Chemical Reactions** Cause - Failure of containment systems provided by test unit, allowing incompatible chemicals to mix, initiation of unexpected chemical reaction by heat generation and ignition of hydrogen due to unanticipated chemical reaction during test.	Design - Extremely fire-resistive characteristics will be incorporated into the irradiation cell construction. - Test units are usually weapons, other military equipment , nuclear reactor related material or equipment related to the space programs. These items are designed to withstand extreme environments. Administrative - Chemicals presenting a high hazard level must be approved by line management and reviewed by RCSC	- Heat sensors are located in the cell ventilation systems. - Smoke detectors are located within the high bay.	- Design and Administrative Mitigation Features are the same as for Sequence III.A.1 Electrical initiated fires	Potential Impact - Limited fire and smoke damage to interior of cells, to radiation detection units and other electrical systems within cells. Risk Determination: Probability Level: Medium Consequence Level: Low Risk Level: Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.B.1: **Explosions - Solvent Spills.** Cause - Failure of containment systems within test units allowing liquids to pool, or inappropriate handling of solvents, creating a spill during loading of test material into the cell.	Design - Test units are usually weapons, other military equipment , nuclear reactor related material or equipment related to the space programs. These items are designed to withstand extreme environments. Administrative - Liquid flammable materials other than materials contained within test units are minimized inside the GIF - Employees receive hazardous material training including spill prevention.	- Heat sensors are located in the cell ventilation systems.	Design - The cells will have 1.8-m thick reinforced concrete walls on all sides and a 1.4-m thick reinforced concrete roof. All cell walls are supported by deep concrete piers and spread footing. Windows are 3' and are covered with shutters during operation of the cell. - Source will be immediately shielded if the cell heat sensor is activated. - The ventilation system shuts down if a fire alarm system is activated, preventing the spread of radioactive material outside of the cell. Administrative - Safe Operating Procedures minimize the presence of flammable materials inside the cell. - Emergency procedures provide rapid evacuation of personnel in the event of an emergency. - A spill response team is available for emergency response.	Potential Impact - Impact damage to interior of cells, to radiation detection units and other electrical systems within cells. Contamination of cell interior, if source is damaged. Risk Determination: Probability Level: Low Consequence Level: Low Risk Level: Low
III.B.2: **Explosions - Experiments** Cause - Failure of containment systems within test units allowing ignition of explosive materials.	Design - Test units are usually weapons, other military equipment , nuclear reactor related material or equipment related to the space programs. These items are designed to withstand extreme environments. Administrative - Explosive materials are not normally used at the GIF and contained only in test units. - Explosive materials are subject to a graded level of review and approval with bench-safe explosive devices being the least hazardous. Review includes assessing the impacts of venting an explosive confinement vessel. - Employees handling explosives receive explosives training.	- Heat sensors are located in the cell ventilation systems.	Design - The cells will have 1.8-m thick reinforced concrete walls on all sides and a 1.4-m thick reinforced concrete roof. All of the cell walls will be supported by spread footing. Windows are ~1 m and covered with shutters during operation of the cell. - Source will be immediately shielded if the heat sensor is activated. - The ventilation system shuts down if a fire alarm system is activated, preventing the spread of radioactive material outside of the cell. Administrative - Safe Operating Procedures minimize the presence of flammable materials inside the cell. - Emergency procedures provide rapid evacuation of personnel in the event of an emergency. - Sandia HAZMAT team is available for emergency response.	Potential Impact - Impact damage to interior of cells, to radiation detection units and other electrical systems within cells. Dispersal of pins within cell interior where remote access may be difficult. Contamination of cell interior, if source is damaged. Risk Determination: Probability Level: Med. Consequence Level: Low Risk Level: Low
III.C.1: **Criticality Accident - Experiment** Cause - Possible criticality of experimental device being environment tested at the GIF	Design - Test units containing fissile material are engineered to prevent criticality accidents. Administrative - All units containing fissile material are handled according to the Criticality Program set in SNL's ES&H Manual. Movement of fissile material into the GIF must be properly packaged and requires prior approval of the TA-V Radiation and Criticality Safety Committee.	- RAMs - A portable criticality monitor will be brought to the facility if deemed necessary by the RCSC.	Design - None Administrative - None	Potential Impact - Criticality accident may result in worker injury or death, release to environment and severe facility damage and decontamination. Risk Determination Probability Level - Incredible Consequence Level - High Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact Risk Determination
III.D.1.a: **Spills/Releases - Radiological** Cause - Forklift penetration of test unit while loading the cell. Catastrophic failure of test unit, allowing release of radioactive material.	Design - Test units are usually weapons, other military equipment , nuclear reactor related material or equipment related to the space programs. These items are designed to withstand extreme environments and unlikely to undergo catastrophic failure. - Breaching of a sealed source is unlikely. All new sources are sealed according to ANSI N43.6, which has strict criteria for the safety margins, quality ,and ruggedness of the sealed-source cladding. - Fork lift operators receive training. Administrative - Liquid radioactive materials other than materials contained within test units are minimized inside the GIF - Employees receive hazardous material training & spill prevention.	- RAM units are located on exterior walls, within the equipment room and inside the cells. - Swipe tests	Design - Floors and walls are finished for easy cleaning. Administrative - GIF Operators handle sources according to approved procedures. - Personnel are trained in hazardous material response. A Sandia HAZMAT team is available for response to radiation accidents. - Emergency procedures provide rapid evacuation of personnel in the event of an emergency. - Health Physics staff monitors and perform swipe tests of operations with potential for radiological spill or contamination.	Potential Impact - Temporary contamination of building or cell interior. Risk Determination Probability Level: Medium Consequence Level: Low Risk Level: Low
III.D.1.b: **Spills/Releases - Radiological** Cause - Breaching of sealed source due to inappropriate handling of sources or mechanical shock and shear	Design - Liquid and gaseous radioactive materials are not used as sources at the GIF, however they may be used in test units. - Breaching of a sealed source is unlikely. All new sources are sealed according to ANSI N43.6, which has strict criteria for quality, and ruggedness of the sealed-source cladding. - All old sources are sealed units with cobalt metal source material. Administrative - Trained operators are the only personnel authorized to handle GIF sources or raise sources into a cell. - Raising sources with the elevator is visually monitored by the GIF operator.	- RAM units are located on exterior walls, within the equipment room and inside the cells. - Swipe tests	Design - Floors and walls are finished for easy cleaning. Administrative - GIF Operators handle sources according to approved procedures. - Personnel are trained in hazardous material response. A Sandia HAZMAT team is available for response to radiation accidents. - Emergency procedures provide rapid evacuation of personnel in the event of an emergency. - Health Physics staff monitors and perform swipe tests of operations with potential for radiological spill or contamination.	Potential Impact - Temporary contamination of building , pool or cell interior. Risk Determination Probability Level: High Consequence Level: Low Risk Level: Low
III.D.2: **Spills/Releases - Non-Radiological** Cause - Forklift penetration of test unit while loading the cell. Inappropriate handling of test material , catastrophic failure of test unit, allowing release of hazardous material.	Design - Test units are usually weapons, other military equipment , nuclear reactor related material or equipment related to the space programs. These items are designed to withstand extreme environments and are unlikely to undergo catastrophic failure. Administrative - No solvents or caustics are stored in the GIF. - Hazardous materials are limited to materials contained in test units and small quantities of cleaning compounds for equipment maintenance, etc. - Fork lift operators are trained; fork lifts, hoists, etc undergo routine maintenance. - Employees receive hazardous material training & spill prevention.	- Due to the small quantities of hazardous materials handled in the GIF, no workplace monitoring is done. Detection of spills relies upon observation by GIF personnel.	Design - Floors and walls are sealed concrete inside cell. Other floors are resilient tile. Administrative - Personnel are trained in hazardous material response. A Sandia HAZMAT team is available for response to hazardous material accidents. - Emergency procedures provide rapid evacuation of personnel in the event of an emergency.	Potential Impact - Temporary chemical contamination of building or cell interior. Risk Determination Probability Level: - Medium Consequence Level: - Low Risk Level: - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.D.3: **Pool Contamination** Cause - Leaking sources or contaminated shipping cask. Sources damaged by mishandling. Sources damaged by malfunctioning of elevator, hoisting equipment.	Design - Sources are all sealed. All new sources conform to ANSI and DOT standards for shipping. All old sources are sealed with source material in the form of cobalt metal. Administrative - Handling (transferring, moving, storing, etc) within the pool of any GIF sources is performed with the consent of a member of the TA-V Health Physics staff. - GIF operators receive specific training on source handling, rigging and crane operation; and are the only individuals authorized to handle sources. - Non-routine raising of GIF sources is restricted and is to be performed only by qualified GIF operations personnel with another knowledge-able individual present who is designated by the line management. When appropriate, source handling operations are rehearsed. - Sources are transferred from a approved shipping cask by remote handling apparatus under water in the shield pool. Transportation is performed in accordance with Sandia Guidelines, as well as appropriate State and Federal standards. - Cranes, hoist and rigging equip-ment undergo routine maintenance.	- RAMs located near the resins beds will alarm if elevated radiation levels are detected. - For lower levels of contamination, a semiannual sample is taken by Sandia's Health Physics organization. Sample is analyzed for low level radioactive contamination.	Design - Pumps continuously circulate the pool water through a make-up water loop containing mixed bed deionizers with pre- and post-filters. Administrative - Upon detection of radioactive contamination, personnel immediately act to identify and remove the source. Depending on the level of contamination, the demineralizing system may be allowed to de-contaminate the pool. If levels of contamination are high, the demineralizing system will be shut-off and local shielding added as required.	Potential Impact - Creation of low-level and mixed radioactive waste. Radiation exposure of personnel in violation of ALARA. Risk Determination Probability Level: High Consequence Level: Low Risk Level: Low
III.D.4: **Demineral-izer Concentration** of Pool Contamination Cause - Pool contamination from leaking source or contaminated cask which eventually is concentrated in the recirculation loop demineralizer	Design - All original GIF sources from the old GIF and LICA facilities are Co-60 metal clad in stainless steel. Leakage of contamination to the pool is a very slow process. New sources for the GIF are sealed to conform to ANSI Standards. Administrative - Sources are transferred to the GIF with approved shipping casks having predetermined levels of contamination.	- A RAM located near the demineralizer will alarm if elevated radiation levels are detected. - For lower levels of contamination, periodic water samples taken by Health Physics organization are analyzed for low level radioactive contamination. - Counting of spent resin beds for low level continuation.	Design - Operation of the pumps which normally circulate pool water through the demineralizers, will be automatically terminated upon detection of an abnormally high radiation level in the demineralizer area. Administrative - Upon detection of radioactive contamination, personnel follow approved procedures to identify y source and isolate source from the GIF pool. Depending on the level of contamination, the demineralizing system may be allowed to de-contaminate the pool. If levels of contamination are high, the demineralizing system will be shut-off.	Potential Impact - Creation of low-level radioactive waste. Radiation exposure of personnel in excess of ALARA principals. Risk Determination Probability Level: High Consequence Level: Low Risk Level: Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.D.5: **Ozone Release** Cause - Ozone generation by ionizing radiation; failure of ventilation systems; opening of cell prior to proper ventilation; failure to maintain negative pressure of GIF cells with respect to the outside. .	Design - Interlocks are equipped with a delay timer such that, after the source is lowered, the door cannot be opened until the timer expires, allowing for adequate ventilation of the cell. - The cells make-up air system will operate in a lead/lag manner such that if the lead make-up air unit fails, the lag make-up air unit fails, the lag make-up air unit will be automatically started and an alarm condition will be indicated. The supply air quantity to each cell will be an adjustable percentage of the exhaust air quantity to maintain negative pressure in the cells at all times. The make-up air units are interlocked with the exhaust system serving the cells. - The exhaust system is sized for 45 air changes per hour to quickly purge each cell. - Interlock system will not allow the source to be raised unless the ventilation system is operational. -Experimental chamber of in-pool facility is vented directly to outside. Administrative - Ventilation system undergoes routine maintenance. - Operator has visual confirmation on the control panel that the ventilation system is working and can lower the source if it is not.	- Visual and audible alarms will be activated on the control panel if the ventilation system fails to function. - Ozone is detectable by odor at .05 to .06 ppm. while the TLV is .1 ppm.	Design - Source is automatically lowered if the ventilation fails. Administrative - Response procedures are activated if the odor of ozone is detected. - Personnel are trained on the hazards of ozone exposure as part of their HAZMAT training and facility briefing.	Potential Impact - Potential for ozone release into the high bay. Respiratory symptoms of those in the affected area due to ozone exposure. Risk Determination Probability Level: High Consequence Level: Low Risk Level: Low
III.D.6: **Airborne Contamination** Cause - Failure of cladding and airborne dispersal of a radioactive source	Design - Sources are solid, not liquid or gas. - New sources are doubly contained in cladding which is designed to withstand rigorous insult. Most cladding satisfies ANSI standards. Noncomplying inventory is limited . -Source are continuously monitored for leaks into pool. - Source handling apparatus are designed to minimize damage to cladding. Administrative - Handling procedures and handling apparatus designs are reviewed by safety committee.		Design - Cell exhaust is shutdown upon detection of radioactive particulate . Administrative - Leaking sources will be detected far in advance by the pool cleanup system.	Potential Impact - Potential to release significant radioactive contamination into the interior of cell, building or atmosphere. Potential employee exposure to respirable radioactive particles. Risk Determination Probability Level - Incredible Consequence Level - High Risk Level - Low
III.E.1.a: **Administrative Failure** Cause - Inadvertent exposure due to entry onto cell roof while cells in operation	Design - Access to cell roof is restricted by locked ladder and/or posted warning signs stating that this is a radiation area. Administrative - No access is allowed to the cell roof area during testing in any cell without specific authorization from the GIF Operator and TA-V Health Physics staff.	- Visual and/or sound detection of individuals on the cell roof.	Design . - None Administrative - Authorized persons accessing the facility roof will be closely monitored by the Health Physics staff. - Unauthorized persons accessing the cell roof will be required to immediately get down and will be checked by Health Physics.	Potential Impact - Dose rate levels on the cell roof can attain up to 100 mr/hr with a 500-kCurie source. Persons entering this restricted area could receive doses at this rate. The severity of the dose would depend on the length of time present. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
III.E.1.b: **Administrative Failure** Cause - Inadvertent exposure due to entry onto facility roof while cells in operation	Design - Access to facility roof is restricted by locked ladder and/or posted warning signs stating that this is a radiation area. Administrative - No access is allowed to the facility roof area during testing in any cell without specific authorization from the GIF Operator and TA-V Health Physics staff.	- Visual and/or sound detection of individuals on the facility roof.	Design - None Administrative - Authorized persons accessing the facility roof will be closely monitored by the Health Physics staff. - Unauthorized persons accessing the facility roof will be required to immediately get down and will be checked by Health Physics and re-instructed in the applicable SNL safety procedures.	Potential Impact - Dose rate levels on the facility roof are calculated to be ~10 mr/hr with a 500-kCurie source. Persons entering this restricted area could receive doses at this rate. The severity of the dose would depend on the length of time present. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.E.1.c: **Administrative Failure** Cause - Persons remaining in cell when closing door and raising source.	Design - Interlock forces Operator to activate the "all clear" keyswitches after inspecting the cell and prior to closing the door. - Cell door has audio and visual annunciator whenever in motion. - The door moves sufficiently slow to allow time for verbal alarm. - Cell door controls are located at the opening to each cell where the Operator can view all entry and egress from the cell. Administrative - Procedures require the Operator to inspect the cell/experiment and announce intention to close cell door to all other persons. - All persons experimenting and working in the GIF cells are given instructions on the activation of the source shutdown switch and the health consequences of this accident.	- Visual and/or verbal alarm of individuals in the cell when the cell door is closing.	Design - A source elevator shutdown switch located inside the cell near the door stops the ascension of the source and prevents further ascension until physically reset by the Operator. - Source elevator controls are located near the shielded window for each cell. Administrative - Procedures require the Operator to visually monitor the inside of the cell while the source is being raised.	Potential Impact - Person remaining in the cell when the source is raised could receive lethal dose of radiation. Risk Determination Probability Level - Low Consequence Level - High Risk Level - Low
III.E.1.d: **Administrative Failure** Cause - Persons entering cell with source exposed.	Design - Interlock from cell radiation detector prevents opening the door when levels above one pin are detected. - Interlock from elevator drive prevents opening door if elevator not in down position. - Elevator tables are large and include many tapped holes for firmly mounting source support brackets. Administrative - Procedures require the Operator monitor the source ascension into the cell from the cell window. - All designs and modifications of source support brackets will be reviewed and approved by the Manager, Nuclear Facilities and Diagnostics Dept. - All source transfers into support brackets will be monitored by the Health Physics Staff.	- A RAM located in line of sight of raised sources immediately outside of the door detects and alarms on abnormally high radiation levels as the door opens.	Design -None. Administrative - The shield door will be closed by the GIF Operator if any abnormally high radiation level is detected on the RAMs located outside of the cell door. - When entering the GIF cells following an irradiation, operators and experimenters must wear a chirpy with audible sounds or use other handheld audible detector.	Potential Impact - Person in direct line of sight of unshielded source or entering a cell with a source/pin exposed will be in high radiation area Depending on the time of exposure, this can result in high to lethal dose received. Risk Determination Probability Level - Low Consequence Level - High Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.E.2.a: **Shield Wall Failure** Cause - Fracture, crack or hole in wall of any cell due to improper design, improper construction, or excessive mechanical stresses.	Design - The GIF cells are designed and built with 1.8 meter thick walls and 1.4 meter thick ceiling consisting of reinforced concrete according to ACI 318-89. - A cell shielding qualification check will be performed with a sample source following construction. Administrative - Title I and Title II design documents are independently reviewed by an internal team and external review contractor. - The GIF cells must satisfy rigorous QA requirements during construction and testing.	- Visual inspection of the radiation shield (walls and doors) prior to each days operation. - Radiation survey taken of any suspect area	Design - None Administrative - Dose rate predictions will be verified during the initial testing and qualification of the cells. -All dose rate calculations will be verified to assure accuracy of modeling. - No operations (sources raised) will be performed until the crack or hole is adequately repaired or shielded. - Any additional penetrations are reviewed by internal safety committee.	Potential Impact - May lead to local area of high radiation dose with the source raised which could overdose operations personnel or experimenter. Risk Determination Probability Level - Low Consequence Level - Med. Risk Level - Low
III.E.2.b: **Shield Wall Failure** Cause - Improper installation or removed shadow shield, shield plug, or other local shield covering a designed penetration in shield wall.	Design - Shadow shields, shield plugs or other local shields which protect personnel for a column of radiation from the cell are installed in a semi-permanent mounting arrangement to prevent easy removal. - Shields which prevent streaming of high radiation levels from the cell will be mounted with a Health Physics controlled lock arrangement. Administrative - Any removal of shadow shields, shield plugs or other local shields shall be approved by the Manager, Nuclear Facilities and Diagnostics Dept., with consultation with the GIF Operator and Health Physics staff.	- Visual inspection of the shield wall, penetrations and local shields will reveal improperly installed or removed local shields. - RAMs, Remote Area Monitors, may reveal higher than normal radiation levels.	Design - Penetrations through the shield are located at areas that are restricted during operation or not easily accessible. - Penetrations through the concrete shield are designed with a serpentine bend or not directly in the line of sight of the source. Administrative - A visual inspection of the shield wall, penetrations and local shields will be made prior to each days operation. -All dose rate calculations will be verified to assure accuracy of modeling - A GIF Operations Logbook will be maintained to record modifications to the shield integrity. - Lockout/Tagout procedures will be employed whenever a local shield plug is removed. - Dose rate predictions will be verified during the initial testing and qualification of the cells.	Potential Impact - Depending on the size of the opening, local areas of high radiation levels could exist on the outside of the shield. Risk Determination Probability Level - Low Consequence Level - Med. Risk Level - Low
III.E.3: **Window Failure** Cause - Improper installation resulting in paths of radiation streaming around the shield windows. .	Design - Shield windows are designed with multiple panels of leaded glass and transparent oil in between. Administrative - Windows are maintained and inspected by external contractor specializing in radiation shield windows. - Steel shutters, which reduce the dose to the windows, are to be used whenever visual monitoring of the cell is not necessary.	- Visual inspection of the windows is performed on a daily basis - Radiation monitors located on walls adjacent to the cells will detect if higher than background radiation levels are attained.	Design - Internal steel shutters reduce the dose rate levels that the windows and frames are exposed. Administrative - Operations will not be continued if radiation dose rates outside of the windows are higher than expected. -All dose rate calculations will be verified to assure accuracy of modeling. - A cell shielding qualification check will be performed with a sample source following construction.	Potential Impact - If radiation streaming paths exist, they will be discovered and repaired. No significant consequences are anticipated. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.E.4.a: **Pool Level Drop** Cause - Leak or rupture of the pool liner caused by poor design, improper construction, corrosion, or puncture of liner.	Design - Pool liner will consist of 6 mm stainless steel plate covering 30 cm reinforced concrete walls. - Pool water quality will be maintained to resistivity >= 1.0 megaohm - A 2 m x 2 m x 2.5 cm thick stainless plate is positioned on bottom of pool for supporting heavy shield casks. Administrative - Title I & Title II designs are reviewed by an internal teams and external review contractor.	- Disparity between measured pool makeup and expected water lost by evaporation. -RAMs located around the pool if level undergoes severe drop.	Design - A pool makeup system is capable of supplying up to ~4 liters/min which would compensate for most postulated leaks. - RAMs are located around the pool at locations to detect abnormal radiation levels. Administrative - Pool water makeup will be closely monitored to assure that entire makeup quantity is accounted for by the sum of predicted evaporation and other known losses.	Potential Impact - Radiation shielding is not compromised until the depth of water shielding above the source is less than 3 meters. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.E.4.b: **Pool Level Drop** Cause - Inadvertent drop in pool level due to siphoning or pumped removal of water.	Design - No inlets or outlets to the GIF pool exist below 1 meter below the pool surface. Administrative - Pumps are not permitted below 1 meter depth from the pool surface without specific approval from the Manager, Nuclear Facilities and Diagnostics Dept.	- Disparity between measured pool makeup and expected water lost by evaporation. -RAMs located around the pool if level undergoes severe drop.	Design - A pool makeup system is capable of supplying up to ~4 liters/min which would compensate for most postulated leaks. - RAMs are located around the pool at locations to detect abnormal radiation levels. Administrative - Pool water makeup will be closely monitored to assure that entire makeup quantity is accounted for by the sum of predicted evaporation and other known losses.	Potential Impact - Radiation shielding is not compromised until the depth of water shielding above the source is less than 3 meters. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.E.5: **Electrical Failure** Cause - Electrical failure resulting in loss of power with source raised.	Design - All control equipment associated with the operation of GIF is designed to fail in safe condition upon loss of electrical power. - Programmable logic controllers, which control/monitor the elevator and door movement, are on UPS lasting a couple of minutes after power loss to verify that the elevator returns to its down position. - Battery backup is provided for critical equipment such as emergency lighting, required RAMs, evacuation/fire alarm, etc.) Administrative - Procedures are implemented to review GIF control/drive system additions/modifications to insure power loss fail-safe conditions.	- Loss of facility power is evident from lighting conditions. - Loss of controller power is evident from warning light on panel.	Design - Raised sources are automatically lowered back into pool by gravity with damping provided by the unpowered electric motor. Administrative - During normal work hours, the GIF operator will assure that the GIF is in a safe condition (source elevator is in the down position) upon loss of electrical power.	Potential Impact - Loss of electrical power results in loss of ventilation power, particularly cell exhaust flow. Without ventilation, ozone production in the cells will continue to higher than approved levels. The ozone would need to be purged via the exhaust system before entering the cell. Lowering sources into the pool eliminates the ozone generation. Risk Determination Probability Level - High Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.E.6.a: **Cell Control System Failure** Cause - Failure of control logic allowing the elevator to raise without all prerequisites satisfied.	Design - The control system consists of a programmable logic controller for each cell. The PLC program requires that the cell clear-, door closed-, pressure differential-, etc interlocks are satisfied prior to raising source. - The PLC program is written on resident ROM's and cannot be changed without access to the PLC internals. Administrative - Procedures are implemented to review GIF control system hardware and software modifications	- None	Design - An elevator power cutoff button is located inside each cell and on each PLC that (irregardless of control logic) interrupts power to the elevator drive motor for that cell. - The elevator power is interrupted whenever the maze door is opened for that cell. Administrative - The elevator power cutoff switch for each cell will be tested prior to that days operation except for operations lasting more than a day.	Potential Impact -The potential exists for raising a source elevator without the proper operation sequence. A hazard would exist if sources were raised without the cell door closed. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.E.6.b: **Cell Control System Failure** Cause - Failure of elevator drive motor, door motor and/or controller.	Design - The control system consists of a programmable logic controller for each cell; and will have software and hardware designed using fail-safe criteria -- that is elevator fail down and cell door fail stationary. Administrative - No occupancy in the cells is allowed with the shield door closed without specific exemption for each case as approved by Manager, Nuclear Facilities and Diagnostics Department. - Procedures are implemented to review GIF control/drive system additions and modifications.	- None	Design - An elevator power cutoff button is located inside each cell and on each PLC that (irregardless of control logic) interrupts power to the elevator drive motor for that cell. Administrative - The elevator power cutoff switch for each cell will be tested prior to that days operation except for operations lasting more than a day. - Unescorted experimenters working alone in cells will be trained in the use of the power cutoff switch.	Potential Impact -The potential exists for individuals being closed in a cell or have sources raise while people occupy the cell. Exposure to a source without any shield would result in very high doses even with rapid egress. Risk Determination Probability Level - Low Consequence Level - Medium Risk Level - Low
III.E.7.a: **Source Handling Accident** Cause - Raising source manually above adequate water shield depth	Design - Source handling equipment will be specially designed considering safety, reliability, and ease of use. Administrative - All source handling involving lifting of pins will have a health physicist present in addition to the operator. No HP is necessary for transfer operations involving source carts.	- Health physicist will manually monitor handling operation involving lifting of sources.	Design - Source pins are designed to handle one at a time. Administrative - GIF operators are the only individuals authorized to handle sources in the GIF pool. - GIF operators are specifically trained on source handling procedures and response procedures for an exposed source.	Potential Impact - Sources raised too close to the pool surface or out of the pool will result in high radiation areas in vicinity of the source. This may lead to high radiation doses to personnel in the high bay. Risk Determination Probability Level - High Consequence Level - Low Risk Level - Low
III.E.7.b: **Source Handling Accident** Cause - Raising source mechanically above adequate water shield depth.	Design - Source pins are designed to handle one at a time. - Pool rigging used for sources (except for shielded casks) will be of adequate length such that the lifted object will not rise further than 7 feet below the surface with the crane in the full up position. Administrative - All source handling involving lifting of pins will have a health physicist present in addition to the operator. No HP is necessary for transfer operations involving source carts.	- Health physicist will manually monitor handling operation involving lifting of sources.	Design - The crane controls will have a separate permissive button in addition to the directional controls. Administrative - GIF operators are the only individuals authorized to handle sources. - GIF operators are specifically trained on source handling procedures.	Potential Impact - Source lifted above the pool surface can result in high radiation doses to immediate workers and a high dose rate in the vicinity of the unshielded source. Risk Determination Probability Level - Low Consequence Level - Medium Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.E.8: **Falls into Pool** Cause - Any number of conditions that cause individuals to fall into source pool.	Design - The pool will be covered by a personnel grate sufficient to support a few individuals but not a vehicle. - The pool area will be roped off or designated by signs to warn non-operations personnel. Administrative - Whenever a grate is removed to allow access to the pool, railings will be placed around the open area.	- None	Design - Grates will be segmented into smaller units to allow handling by one or two individuals Administrative - GIF operators are the only individuals authorized to remove grates from the pool top. - GIF operations involving work around the pool top will normally be monitored by the GIF operators.	Potential Impact - Depending on the depth that individual attains, a fall in the pool can result in some radiation exposure -- but not necessarily high. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.F.1: **Steam System Operation** Cause - Improper design, installation, operation or inspection of steam system for the in-pool irradiation facilities.	Design - The steam system for experiments is a separate test loop not contained in the GIF high bay. Operation of the steam loop does not affect the GIF operation. - The steam system will be designed, constructed, and operated according to Sandia's pressure safety manual. Administrative - The steam system and modifications will be reviewed by the local pressure safety advisor as to compliance to Sandia's pressure safety practices manual.	- Pressure meters and gages along with temperature monitors at saturation conditions.	Design - Pressure relief devices are contained on the steam loop to prevent the excessive pressure and energy being developed in the system. Administrative - Pressure relief devices are qualified and inspected on a periodic device.	Potential Impact - Catastrophic failure of the steam loop may result in building/equipment damage or personal injury; but, will not affect the radioactive source located in the GIF cells and pool. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.F.2: **Steam System Failure** Cause - Failure of steam system boiler, controller, instruments or other pressure boundary components.	Design - The steam system will be constructed of commercially available components designed and built for steam plant use. Administrative - The steam system and modifications will be reviewed by the local pressure safety advisor as to compliance to Sandia's pressure safety practices manual.	- Major steam leaks or destructive failure which will be visually evident.	Design - The steam system for experiments is a separate test loop contained in the GIF low bay. - Pressure relief devices are contained on the steam loop to prevent the excessive pressure and energy being developed in the system. Administrative - Pressure relief devices are qualified and inspected on a periodic device.	Potential Impact - Catastrophic failure of the steam loop may result in building/equipment damage or personal injury; but, will not affect the radioactive source located in the GIF cells and pool. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.F.3: **Cell Shield Door (Movable Wall)** Cause - Failure of movable wall drive mechanism for the large east cell.	Design - The movable wall is designed to be operated in a predetermined sequence which is programmed into the PLC's. - Movable wall drive motors are periodically inspected and maintained. - The movable wall cannot be operated without air pressure which will be deactivated during irradiations. Administrative - GIF operators are trained in the operation, functioning and power required to operate the movable wall. - Air pressure lines are bled down or valved closed to prevent actuation of the pneumatically-lifted wall.	- A pressure switch monitors if air pressure is available for the movable wall	Design - Because of its mass, the movable wall cannot be operated without air pressure and could only be moved slowly with sufficient time to perform corrective action and stop possible damage. Administrative - The air supply is locked by the GIF operator whenever the movable wall is not being operated.	Potential Impact - Movable wall operation (open or close) is not required for safety. Nonoperational drive motor would not result in an unsafe condition. Operating the drive without proper sequencing may result in property damage but not necessarily injury. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigative Features	Potential Impact and Risk Determination
III.F.4: **High Voltage** Cause - Personnel exposure to voltages greater than 50 volts due to improper design, poor equipment or incorrect installation procedure of electrical equipment.	Design - Electrical equipment is designed to applicable codes, built for specific service, and installed by licensed electricians. Administrative - Procedures to minimize exposure to high voltages (particularly around water systems) are implemented in the design cycle.	- Inspection by qualified electrical inspectors	Design - Over correct devices (fuses, circuit breakers, and/or ground fault circuit interrupters) are installed in each circuit to limit current to the device. - GFCI, installed outdoors and near the pool area will interrupt current if there is an unbalanced current to ground on either conductor. Administrative - Lockout/Tagout procedures will always be used when installing or modifying electrical circuits.	Potential Impact - Improperly installed electrical circuit may result in equipment damage, fire, injury, or death. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.F.5: **Elevated Materials** Cause - Personnel injury and/or equipment damage due to improper design, equipment or lifting procedure for heavy materials	Design - Cranes will be designed, built and installed to applicable standards. Administrative - Design standards referenced in DOE Hoisting and Rigging Manual are incorporated in the design process.	- Periodic inspection and testing will reveal equipment deficiencies	Design - Cranes will have rated capacity clearly marked. - Inspection, testing and maintenance of cranes and rigging will be performed on periodic schedule following DOE Hoisting and Rigging Manual guidelines. Administrative - Crane operators are qualified by attending crane operation, lifting, and rigging training courses.	Potential Impact - Improper crane operation, lifting or rigging most likely will lower safety margins, result in property damage, or has the potential for an injurious accident. Risk Determination Probability Level - Medium Consequence Level - Low Risk Level - Low
III.F.6: **Personnel Falls** Cause - Personnel exposure to elevated work areas, openings in floors, or platforms.	Design - All elevated platforms and openings in floors require guarding with standard railing per OSHA 1910.23 Administrative - Potential fall hazards are identified during the design process and are guarded as necessary and eliminated where feasible.	- Visual monitoring assures that possible openings in floors, or elevated platforms are guarded	Design - Standard railing consists of two rails and vertical posts with a height of 42" and the capability of supporting a person. Administrative - Procedures for insuring that rails are in place and that removed rails are returned to their proper location are implemented	Potential Impact - Depending on the height, surface hardness, and impact position, a fall can lead t o serious injury or death. Risk Determination Probability Level - Low Consequence Level - High Risk Level - Low
III.F.7: **Confined Spaces** Cause - Entry into potentially dangerous areas with limited means of egress	Design - None Administrative - Potential confined locations are identified during the design process and eliminated where feasible. The maze entry to the cells have been considered; however, competing safety rationale for their design has been justified.	- Visual inspection of confined spaces assures proper warnings are posted.	Design - Individuals entering confined spaces use equipment and precautions as specified by warning labels, procedures and/or entry permits. Administrative - Procedures for identifying and marking confined spaces are implemented. - Procedures for entry and occupancy of confined spaces will be developed.	Potential Impact - Individuals trapped in confined spaces may result in slow emergency response, injury or asphyxiation. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low

Table 11A-1 (continued). Analysis of GIF Accident Sequences

Sequence and Cause	Preventive Features	Method of Detection	Mitigation Features	Potential Impact and Risk Determination
III.F.8: **Emergency Egress** Cause - Potential exposure to fires, high radiation, hazardous material, or airborne contaminants.	Design - The facility design satisfies compliance with appropriate sections of NFPA, Life Safety Code. Administrative - None	- An audio fire/evacuation alarm rings in all buildings and throughout TA-V.	Design - The TA-V fire/evacuation functions are integrated into a single area-wide alarm system. -Egress to evacuation assembly building is via outdoor route. Administrative - TA-V Emergency Plan requires all site workers to evacuate immediately on alarm to the predesignated assembly building unless prior exemption is granted. Training for all TA-V residents and frequent visitors is provided by an TA-V Emergency Response Training Video. - Procedures and inspections assure that emergency egress routes are not blocked or disabled.	Potential Impact - Potential exists for personnel not being able evacuate hazardous condition or assemble at TA-V evacuation building in timely manner. Risk Determination Probability Level - Low Consequence Level - Low Risk Level - Low

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