COPY NO. 1

VOLUME I

PART I

DEMONSTRATION VOLUME

SNM-696 MATERIAL LICENSE RENEWAL

GENERAL ATOMIC COMPANY

SAN DIEGO SITE

July 1981

U.S. Nuclear Regulatory Commission

Docket No. 70-734

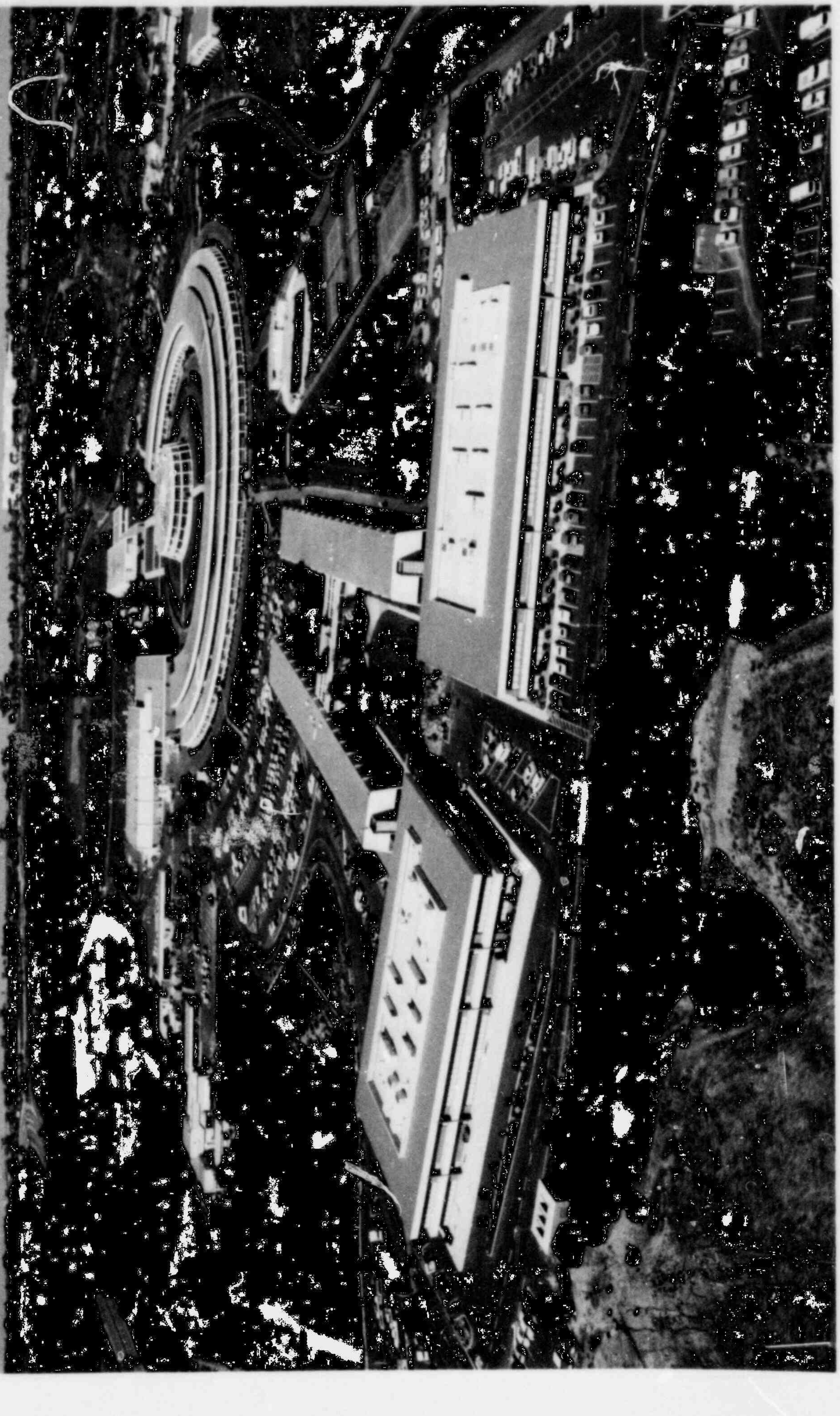


TABLE OF CONTENTS

FIGURES

TABLES

INTRODUCTION

This renewal application is filed by General Atomic Company (GAC), hereinafter referred to as the Licensee, covering its San Diego operations for a special nuclear material license to acquire, deliver, receive, possess, use, and transfer special nuclear material in compliance with the regulations of Title 10 Code of Federal Regulations Part 70. This application is for renewal of SNM-696. The application is presented in two parts: (1) Part I, Materials License Renewal - Demonstration, and (2) Part II, Materials License Renewal - License Specifications.

Part I, the "Demonstration" document, contains descriptive material, including general information about the applicant, a description of the site, and a discussion under "Present Operations" of current activities involved in the use of special nuclear material. The associated current radiological, nuclear, and materials safeguards policies and procedures are included in the remaining sections of the Demonstration document, with an analysis of postulated accidents and their activity release consequences.

Part II, the document containing "License Specification," describes the principal criteria and minimum capabilities and qualifications required by the license for facilities, equipment, and personnel, and defines the mandatory administrative and technical procedures to be used by the licensee for nuclear, radiological, and materials safeguards. These license conditions are requirements of the license under which activities shall be conducted, and they are subject to change only after prior authorization from the USNRC. Included in Part II are specifications of material license limits and authorized activities.

1. GENERAL INFORMATION

General Atomic Company, the licensee, hereby requests renewal of License SNM-696, Docket 70-734. This application is for a special nuclear materials license covering the GAC facilities at San Diego, California. A renewal of 10 years is requested.

The licensee is General Atomic Company, a California partnership, with headquarters located at 10955 John Jay Hopkins Drive, San Diego, California 92138. Under this license, the licensee operates the facilities located at 10955 John Jay Hopkins Drive, and 11220 Flintkote Avenue, San Diego, California 92138. Small amounts of SNM may be possessed, under the licensee's agreement state license, at other locations.

The licensee's partners are Gulf Oil Corporation and Scallop Nuclear, Inc., respectively Pennsylvania and Delaware corporations, whose addresses are:

Gulf Oil Corporation
Gulf Building
Pittsburgh, Pennsylvania 15230

and

Scallop Nuclear, Inc.
One Rockefeller Plaza
New York, New York 10020

The partnership conducts its business principally at San Diego, California. It is not owned, controlled or dominated by an alien, a foreign corporation, or foreign government within the meaning of the Atomic Energy Act of 1954, as amended, and of NRC's regulations.

The representatives to the Partnership Committee, the principal officers, and certain other executives of the licensee are as follows:

PARTNERSHIP COMMITTEE

Representatives of Gulf Oil Corporation

Name	Address	Citizenship
P. E. Holloway Senior Vice President	Gulf Oil Corporation P.O. Box 1166 Pittsburgh, PA 15230	USA
F. R. O'Hara Associate General Counsel	Gulf Oil Corporation P.O. Box 1166 Pittsburgh, PA 15230	USA

Representatives of Scallop Nuclear

H. L. Beckers	Scallop Nuclear Inc. 30 Carel van Bylandtlaan The Hague	The Netherlands
M. E. Lorenzo President & Director	Scallop Nuclear Inc. 1 Rockefeller Plaza New York, NY 10020	USA

Representatives of General Atomic Company

H. M. Agnew President	10955 John Jay Hopkins Drive San Diego, CA 92138	USA
W. C. Gallaway Executive Vice President	10955 John Jay Hopkins Drive San Diego, CA 92138	USA
D. Van Hilten Executive Vice President	10955 John Jay Hopkins Drive San Diego, CA 92138	The Netherlands

PRINCIPAL OFFICERS OF GAC

Name	Title	Address	Citizenship
H. M. Agnew	President	10955 John Jay Hopkins Dr. San Diego, California 92138	USA
W. C. Gallaway	Exec. Vice Pres.	10955 John Jay Hopkins Dr. San Diego, California 92138	USA
D. van Hilten	Exec. Vice Pres.	10955 John Jay Hopkins Dr. San Diego, California 92138	The Netherlands
C. L. Rickard	Exec. Vice Pres.	10955 John Jay Hopkins Dr. San Diego, California 92138	USA

OTHER EXECUTIVES

J. P. Hogan	Senior Counsel	10955 John Jay Hopkins Dr. San Diego, California 92138	USA
H. C. House	Vice President Finance & Administrative Services	10955 John Jay Hopkins Dr. San Diego, California 92138	USA

1.1 DESCRIPTION OF LICENSED ACTIVITIES

The licensee at its San Diego site has been engaged for a number of years in both government and privately-sponsored research and development operations involving use of special nuclear material (SNM).

Activities cover the conduct of both pure and applied research and development and fabrication of fuel materials in the nuclear energy and related fields. These activities are performed in various facilities described in Section 2.7, Part I. Details of present operations are covered in Section 3, Part I.

The main activity involving SNM pertains to the High-Temperature Gas-Cooled Reactor (HTGR) system. The HTGR system involves the application of research, investigations of high-temperature materials, design and fabrication of reactor system components, and the development and fabrication of highly enriched nuclear fuel elements. In the production of HTGR fuel elements, pyrolytic carbon coated uranium, thorium, and uranium-thorium dicarbide or oxide particles are prepared, made into compacts, and assembled and sealed into specially designed graphite blocks.

The TRIGA research reactor systems involve the design, development, fabrication, and installation of research reactors and their fuel elements.

Other activities using SNM include direct conversion research and development (thermoelectric), irradiation services of varying types involving physics research, activation analysis, and other research and development efforts.

A small amount of SNM is contained in various sources, such as Pu-Be sources, and employed throughout the site for research and development purposes. Specific LA-1 building laboratories and the Hot Cell are authorized to perform work with unencapsulated Pu bearing samples. Pu may also be stored in fireproof safes, vaults or vault-type rooms.

Specific uses of SNM are subject to review and approval prior to commencement of operations. Section 3, Part II, describes these uses.

1.2 ORGANIZATION

1.2.1 General Atomic Co.

General Atomic Company (GAC) is a Gulf Oil Corporation and Scallop Nuclear, Inc. partnership Company with headquarters in San Diego, California. Fig. I 1.2-1 shows this basic company structure and the relationship of units possessing or controlling SNM.

1.2.2 Operating Organizations

The organizations that carry out most of the activities under this license are Special Products, TRIGA reactors, Engineering and Technology, and HTGR Fuel operations divisions. These organizations are shown in Figure I 1.2-1, Section 3, "Present Operations." Part I discusses work being performed by the licensee at the present time. The following sections define some of the organizational units performing that work.

1.2.2.1 Engineering and Technology

The Engineering and Technology division has the responsibility to develop the technology necessary to specify the fuel, core configuration, core composition, reflector, burnable poison, control poison and shielding materials, graphite, and control and poison materials for use in the HTGR. The Applied Science organization is responsible for research and development activities on fuel and materials of all types. Associated laboratories are used in a variety of research activities generally directed toward development of HTGR and TRIGA reactor technology. Hot cell activity normally encompasses evaluation of irradiated test specimens. This division also maintains TRIGA reactors used for training and research. A staff of nuclear physicists, engineers and metallurgists perform reactor analyses and evaluations of HTGR fuel cycle technology.

1.2.2.2 HTGR Fuel Operations Division

This organization is charged with fabrication of fuel for HTGR cores and for management of the HTGR fuel fabrication facilities.

1.2.2.3 Special Products

The Electronic Systems organization of Special Products undertakes contractual responsibilities and investigations in development of detectors and electronic systems primarily for nuclear reactors of all types. They manufacture radiation and environmental monitoring equipment for power reactors as well as TRIGA reactor control instrumentation.

The Component Manufacturing organization manufactures a wide variety of nuclear components including reactor components, radioactive material shipping packages, etc.

1.2.2.4 TRIGA Reactor Division

This organization develops and manufactures fuel for the TRIGA reactors manufactured and sold by GAC. Other work includes the developing, fabrication, and marketing of the TRIGA line of nuclear research reactors.

1.2.3 Radioactive Materials Management Organizations

The functions involved in radioactive materials management include criticality safety, radiological safety, nuclear materials accountability and control safeguards and licensing administration and security. The following organizations are responsible for one or more functional controls over source, SNM, and other radioactive materials and radiation producing machines. Their relationship within the GAC organization is shown in Fig. I 1.2-2.

1.2.3.1 Nuclear Material Control Division

As shown in Fig. I 1.2-2, Nuclear Material Control Division (NMCD) reports to the office of the President, GAC. The NMCD provides over-all management of nuclear materials licenses and related controls at GAC. Reporting to the Director, NMCD are the following functional organizations:

Health Physics
Nuclear Safety
Licensing Administration
Nuclear Materials Management

The responsibilities of NMCD are established in a written policy statement approved by the President, GAC, and incorporated into the GAC policies and Procedures Manual. These responsibilities include the direction and implementation of policies and procedures governing the use of SNM at GAC.

1.2.3.1.1 Health Physics

Health Physics assures compliance with radiological safety standards and provides various services such as personnel monitoring, dose rate measurement, radioactive material detection and assay, air and water sampling, external radiation and airborne contamination alarm system, and effluent monitoring. Health Physics operates a fully equipped laboratory and counting room and a survey instrument repair and calibration facility. The functions of Health Physics in review and approval of new work (and changes thereto) are presented in Section 3, Part II. The staff of Health Physics is organized into the following three groups:

1. Operations - The Operations group performs surveys of work areas, special surveys for control of operations involving radiation exposures to personnel, and repair and calibration of instrumentation. Individual Health Physics Technicians are assigned to specific work areas to inspect operations and to advise personnel concerning radiation safety.

2. Laboratory and Counting Room - The Laboratory and Counting Room group performs measurements on the samples obtained in area surveys, environmental surveys, and the bioassay program.

3. Records and Reports - The Records and Reports group is responsible for management of records for personnel monitoring, the bioassay, in-vivo total body and lung counting programs, the meteorological program, and special projects.

1.2.3.1.2 Nuclear Safety

Nuclear Safety provides routine review and approval of proposed activities in which significant neutron multiplication is a possibility. Detailed functions of this group are presented in Section 3, Part II.

Nuclear Safety reviews activities involving source and special nuclear material to assure the nuclear safety of such activities. Nuclear

Safety reviews and/or develops company policy, criteria and procedure affecting the safe handling and storage of such materials. The verification of inventory LEMUF results and analysis is also accomplished by Nuclear Safety.

1.2.3.1.3 Licensing Administration

Licensing Administration administers licenses, providing coordination and final preparation of license applications, amendments, and correspondence with the federal and state licensing agencies for licenses administered by NMCD. This group secures appropriate internal reviews, maintains the central files, and makes appropriate distribution of these licenses for the company. All related correspondence is issued over the signature of the Licensing Administrator.

1.2.3.1.4 Nuclear Materials Management

Nuclear Materials Management administers the program of SNM accountability and control. The Manager, NMM develops, implements, and enforces the SNM control procedures and manages the overall system of SNM control. The specific functions fulfilled by NMM are presented in Section 3, Part II. NMM maintains complete, detailed records of SNM on hand by project and location of material. NMM has physical custody of all of the SNM in the storage areas under its control.

1.2.3.1.5 Security

This organization, which reports to Employee Relations, as shown in Fig. I 1.2-2, provides extensive security measures to prevent the unauthorized access to SNM and to provide the appropriate industrial security. The security function includes the following: (1) maintenance of a Security Office and a guard/watchman force, (2) physical protection of controlled areas, protected areas, and material access areas, as required, (3) provision for fire and intrusion alarms and communication systems, (4) establishment of security inspection procedures, and (5) assuring adequacy of physical protection of SNM in the various vaults and processing areas.

1.2.4 Advisory and Audit Functions

1.2.4.1 Criticality and Radiation Committee

The Criticality and Radiation Safety Committee (CRSC) provides advice, reviews and audits for activities involving radioactive materials and radiation-producing machines. In addition, CRSC reviews the policies and criteria governing these activities as they relate to radiological safety and nuclear safety, and will also review specified operations before implementation as may be covered by the criteria. License conditions applicable to CRSC are presented in Section 3, Part II. The committee typically consists of members qualified in nuclear physics, health physics, chemistry, engineering, and metallurgy. The Office of the President appoints the members and selects the Chairman and Secretary. Subcommittees are appointed by the CRSC Chairman as necessary. The Secretary maintains the official files of the Committee's actions and meetings. CRSC reports to the Office of the President, and is fully independent of the various operating groups. The committee's audits are conducted at least once each year and each such audit includes the activities of NMCD. Reports of CRSC activities are prepared for top management.

1.2.5 Administrative Procedures

The administrative procedures used by the licensee to assure radiological and nuclear safety, are presented in Section 3, Part II of the SNM-696 renewal application. The basis for this assurance is a consistent pattern of organizational responsibilities and a set of manuals and procedures used as day-to-day guides.

1.3 PERSONNEL AND TRAINING

1.3.1 Personnel

As of March 1981, the staff of the licensee comprised approximately 2077 people, of whom about 205 have doctorate degrees, approximately 261 have master degrees, and about 518 hold bachelor degrees. The personnel at the San Diego site are experienced in the technical and scientific fields necessary to support a broad range of nuclear research, development, design, and production operations.

When activities involving radioactive material or radiation-producing machines are contemplated, close scrutiny is made of the responsible individual(s) who will be directing such efforts.

Resumes of some of the management personnel in the area of nuclear operations and control are given below.

Mr. Harry N. Wellhouser, Director, Nuclear Materials Control Division

B. S. Chemical Engineering, Gonzaga University, Spokane, Washington, 1948

Post Graduate Work, University of California at Berkeley, Berkeley, California 1949-1950

Registered Professional Engineer (California)

Mr. Wellhouser has been with the licensee for more than 22 years. Prior to his current position he was, for three years, Manager, Component Engineering Department having the technical and administrative responsibilities for the design and testing of all of the major components in the High Temperature Gas-Cooled Reactor. These components included the main and auxillary helium circulators; Control Rod Drive Mechanisms, fuel handling machinery Prestressed Concrete Reactor Vessel wire winding machine, auxillary heat exchangers and the steam generators. Subsequent to this position he was plant superintendent for manufacturing supervising the manufacture of the first Fort St. Vrain Core and miscellaneous reactor components. Prior to his manufacturing position he was Assistant Project Manager for Fort St. Vrain Nuclear Power Station having the responsibility for the delivery of the Fort St. Vrain fuel, liaison with the AEC on all project matters and coordinated the San Diego engineering operations with the site construction. Prior to this position he was, for six years, associated with the Maritime Gas-Cooled Reactor Program in various technical capacities, and Assistant Project Manager of the Experimental Beryllium Oxide Reactor program.

Prior to joining General Atomic in 1959 he was three years with the AEC San Francisco Operations Office as Chief, Reactor Programs Branch and six and a half years with the Naval Radiological Defense Laboratory studying the effects of nuclear weapons, particularly the contamination/decontamination characteristics and contamination control.

Mr. Dwight C. Pound, Manager, Nuclear Safety

B. A. (Physics), University of California, Berkeley, 1948.
Registered Professional Engineer (California)

Mr. Pound joined the staff in 1959. He was a major contributor in the design, construction, and operation of the HTGR Critical Facility and was Deputy Physicist-in-Charge at the facility. This critical assembly consisted of a fuel blanket region which provided spectra-matched neutron flux to drive a central experimental reactor core simulation region. He was also a participant in the design and construction of the NUROC Critical Facility. He was later Physicist-in-Charge of the Modified HTGR Critical Facility. This involved a complete redesign of the older HTGR Critical Assembly to permit operation over a much wider neutron energy spectrum for determining the nuclear parameters of a range of HTGR-type geometries. Because of his knowledge of electronics, electro-hydraulic, and mechanical systems, he spent 5 years in charge of the development of the company's geophysical seismic sources and associated electronic systems. He is holder or coholder of 3 patents in geophysics and electronics. He has been Principal Investigator for numerous contracts involving development, design, and application of highly specialized transducers and instrumentation systems, particularly in the areas of shock, pressure, temperature, radiation, and ablation as applied to underground nuclear testing. Mr. Pound was formerly Chairman of the GAC Criticality Safeguards Committee and is now Manager of Nuclear Safety, NMCD.

From 1957 to 1959, with General Dynamics/Astronautics, Mr. Pound was Lead Systems Engineer for launch controls and consoles on the Atlas Missile Program. This work included primary design responsibility for all R&D test controls and operational launch control consoles and for integration of the various electrical and electronic launch control subsystems.

From 1948 to 1957, with General Electric at Richland, Washington, Mr. Pound helped set up and operate a program and laboratory for determining reactor physics parameters through the use of subcritical assemblies. He was the task leader in neutron-diffusion-length determinations in graphite moderators. He made studies of neutron detection, measurement, and analysis and designed and developed a number of ion chambers, fission counters, and specialized electronic circuits. He also worked on all phases of reactor safety and control instrumentation and set the criteria for and was the plant consultant in these areas for the Hanford production reactors.

Mr. Frank O. Bold, Manager, Health Physics

B. S. (Plant Pathology), University of California, 1957.
Registered Safety Engineer (California)

Mr. Bold joined the staff in 1959 as a Health Physicist for the Mark I TRIGA, Mark F TRIGA, and MGCR Critical Facility. In his next assignment as Supervisor, Health Physics Operations, he was responsible for personnel monitoring, environmental surveillance, facility design review, and engineering problems related to health physics. Mr. Bold was also a member of the TRIGA Trainiing Staff; his duties included writing the Radiological Safety Section of the TRIGA Training Manual and instructing trainees in the radiological safety aspects of TRIGA reactor operations. Mr. Bold became Manager of Health Physics Services in 1962 and Director of Health Physics Services for Gulf Oil Corporation in 1969. He is Radiological Advisor for the ERDA Radiological Assistance Team No. 3.

From 1956 to 1959, Mr. Bold was a Health Physicist for Atomics International. His responsibilities included working in the Hot Chemistry area and with the KEWB and WBNS Reactors. He was the Shift Health Physicist at the 20-MW Sodium Graphite Reactor Experiment (SRE) for 1-1/2 years. As Health Physics Coordinator for SRE, his next assignment, Mr. Bold was responsible for coordinating activities among Shift Health Physicists, the Reactor Operations Group, and the SRE Hot Cell. His next assignment was as Health Physics Coordinator for the Components Development Hot Cell; his responsibilities included establishing the Health Physics Program for the Hot Cell.

Mr. Kenneth C. Duffy, Manager, Nuclear Materials Management

B. S. (Mathematics), Franklin College, Indiana, 1950.

Mr. Duffy joined the company in 1963 as Manager of Nuclear Materials Management (NMM). His responsibilities include developing, revising, implementing, and enforcing the nuclear materials control and safeguards procedures. He also manages the overall system of nuclear material control including shipping, receiving, storage, waste processing, inventory, accountability records and reports, and surveillance of the special nuclear materials measurement system. Mr. Duffy maintains liaison regarding nuclear materials safeguards and control with other licensees, regulatory agencies, and all divisions and departments within the company. He was one of the first managers to be "certified" by the Institute of Nuclear Materials Management and is currently a member of the certification board.

From 1957 to 1963, Mr. Duffy was Nuclear Materials Manager for Metals & Controls Nuclear, Attleboro, Massachusetts, engaged in commercial and naval reactor fuel fabrication. He was responsible for managing, developing, revising, implementing, and enforcing the nuclear material control and safeguards procedures.

Between 1950 and 1957, Mr. Duffy was with Argonne National Laboratory where he worked in the Special Materials Division as Division Representative for the Metallurgy Fabrication and Reactor Areas and as Assistant Physical Control Manager for the division, supervising several area representatives.

Mr. William R. Mowry, Manager, Licensing Administration

B.S. (Applied Physics - Nuclear Option) San Diego State University, 1968

Registered Professional Engineer (California)

Mr. Mowry joined the company in 1959 as a Research and Development Technician on the HTGR Critical reactor project within the Experimental Physics Department. He was responsible for development of the reactor's fuel fabrication processes and supervised its manufacture. He also assisted in the reactor's operations throughout its experimental program. He later was assigned to other activities involving various GAC experimental reactors or radiation facilities as well as serving on the Peach Bottom HTGR power plant start-up physics crew. Here he was responsible for designing and maintaining the special instrumentation and controls system used in the reactor start-up and low power test program. Following the program's satisfactory completion, Mr. Mowry served as a Technical Consultant from GAC to the Armed Forces Radiobiological Research Institute. Mr. Mowry joined NMCD in 1972, became Manager, Licensing Administration, in 1976, and serves in a technical legal interface with government regulatory agencies.

From 1954-1959, with General Dynamics/Convair, Mr. Mowry was responsible for devising and using test equipment and procedures to accomplish the performance, environmental and reliability testing of aircraft and missile components and systems.

Prior experiences were with the U.S. Navy (1950-1954) as an Interior Communications Technician and Hoover Cleaner Co. (1949-50) as a production tool jig and fixture maker.

Dr. William L. Whittemore, Chairman, Criticality & Radiation Safety Committee

A. B. (Physics) Colby College, 1945.

A. M. (Physics) Harvard University, 1946.

Ph.D. (Physics) Harvard University, 1948.

Dr. Whittemore, who joined the company in 1957, is Physicist-in-Charge and Manager of the TRIGA Reactors Facility, with responsibility for the operation of the facility to provide irradiation services for customers, but also the conduct of R&D efforts including the development of advanced TRIGA concepts. He is also Manager of the TRIGA training program, which he has conducted for some 150 United States and foreign reactor operators. From 1957 and 1968, he headed a group engaged in neutron scattering measurements, using the Electron Linear Accelerator (LINAC), as well as reactor neutron sources. More recently, he has also been in charge of a group working to develop neutron radiography.

From 1948 to 1957, Dr. Whittemore was on the staff of the Department of Physics at Brookhaven National Laboratory, working primarily in the fields of cosmic-ray and high-energy particle physics. During 1951-52, he was also visiting professor at Harvard University.

Dr. Whittemore has published extensively. His work in the high-energy field has resulted in about 20 publications. In the fields of neutron inelastic scattering and TRIGA development research, he has published, singly and jointly, more than 40 papers. He is coinventor of a system to utilize reactor neutrons with much higher efficiency to study thermal neutron inelastic scattering. He has recently published a number of papers on his work in the field of neutron radiography, including its applications to medical problems.

Mr. John T. Iles, Manager, Security Department

Mr. Iles has been with the licensee for more than 25 years and during this time he has been in charge of the Security Department. He has administered the company's security programs for classified projects under government contracts involving AEC, DOD and NASA.

He was a security supervisor with the Atomic Energy Commission at the Los Alamos Scientific Laboratory for eight and one-half years. He attended the AEC's security school at Kirtland AFB, and the Army's security supervisor's course at Fort Gordon, Georgia. He also attended the Comprehensive Asset Security Course conducted by the American Society for Industrial Security Institute of Learning. He has been a regional vice president and chairman of the San Diego Chapter of the American Society for Industrial Security. He is a member of the Steering Committee and past chairman of Research Security Administrators, an organization consisting of senior security managers of research and industrial facilities throughout California.

1.3.2 Training

1.3.2.1 Radiological Safety

A training course in radiological safety is required for all employees who expect to handle special nuclear material. This course is also required for all supervisory personnel who have subordinates engaged in these activities. The Radiological Safety Course covers measurement units, biological effects, limiting exposure to external radiation, prevention of internal exposure, use of protective clothing and monitoring devices, radiation safety rules and policies, concept of criticality, emergency procedures, use of survey instruments, and governmental regulations. The course is presented by lectures and demonstrations with the use of selected films. In addition to the course, which requires a final examination, periodic instruction is given to employees by Health Physics personnel whenever rules change or a particular radiation safety problem arises.

1.3.2.2 Fuel Production Training

In addition to completion of the radiological training course (Section 1.3.2.1), operating personnel in fuel production activities are given supplemental training. The employee is indoctrinated in the radiological and criticality hazards and special material controls associated with the use of uranium and thorium. Administrative procedures are reviewed and alarm systems are demonstrated. After working under close supervision for a few months, the employee is required to attend a nuclear safety review course covering safety criteria, licensing, the significance of control devices and records, and the like. After satisfactory demonstration of awareness, competence, and reliability, an employee may take on greater responsibility.

1.3.2.3 Evacuation

Evacuation drills are conducted periodically to familiarize employees with evacuation procedures. Corrective action, if necessary, is taken.

1.3.2.4 Fire Brigade Training

Fire brigade members participate in training classes or drills monthly. Training sessions emphasize familiarity with the names, arrangements, and special features of buildings and the location and use of fire fighting equipment. First aid training and films emphasize the use of resuscitators and self-contained breathing apparatus. Classes of fires, extinguisher use, general fire fighting techniques, and rescue and salvage operations are reviewed in training supplemented by films. Periodic wet drills and hot drills are held with actual practice in use of equipment.

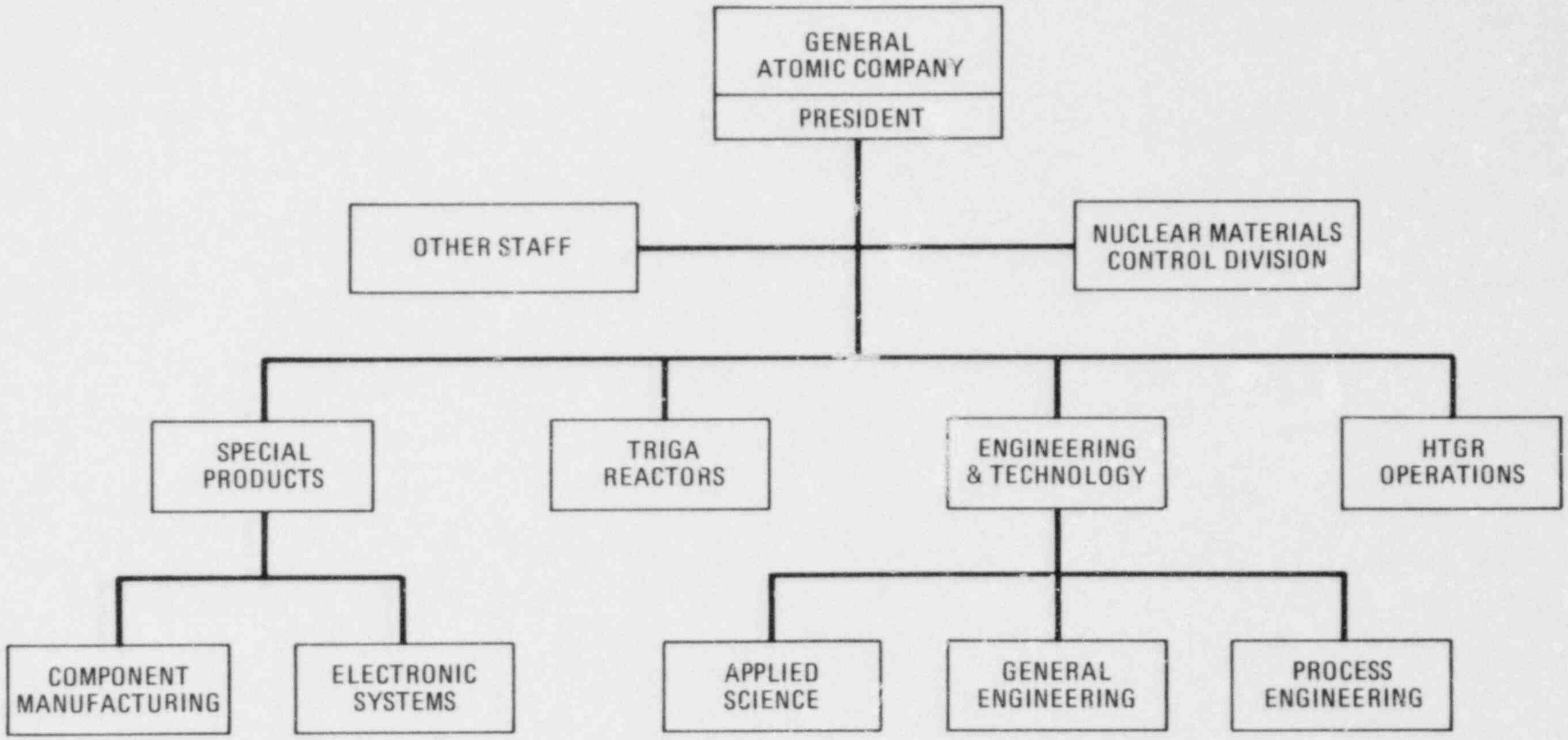


FIG. I 1.2-1 GENERAL ATOMIC COMPANY ORGANIZATION

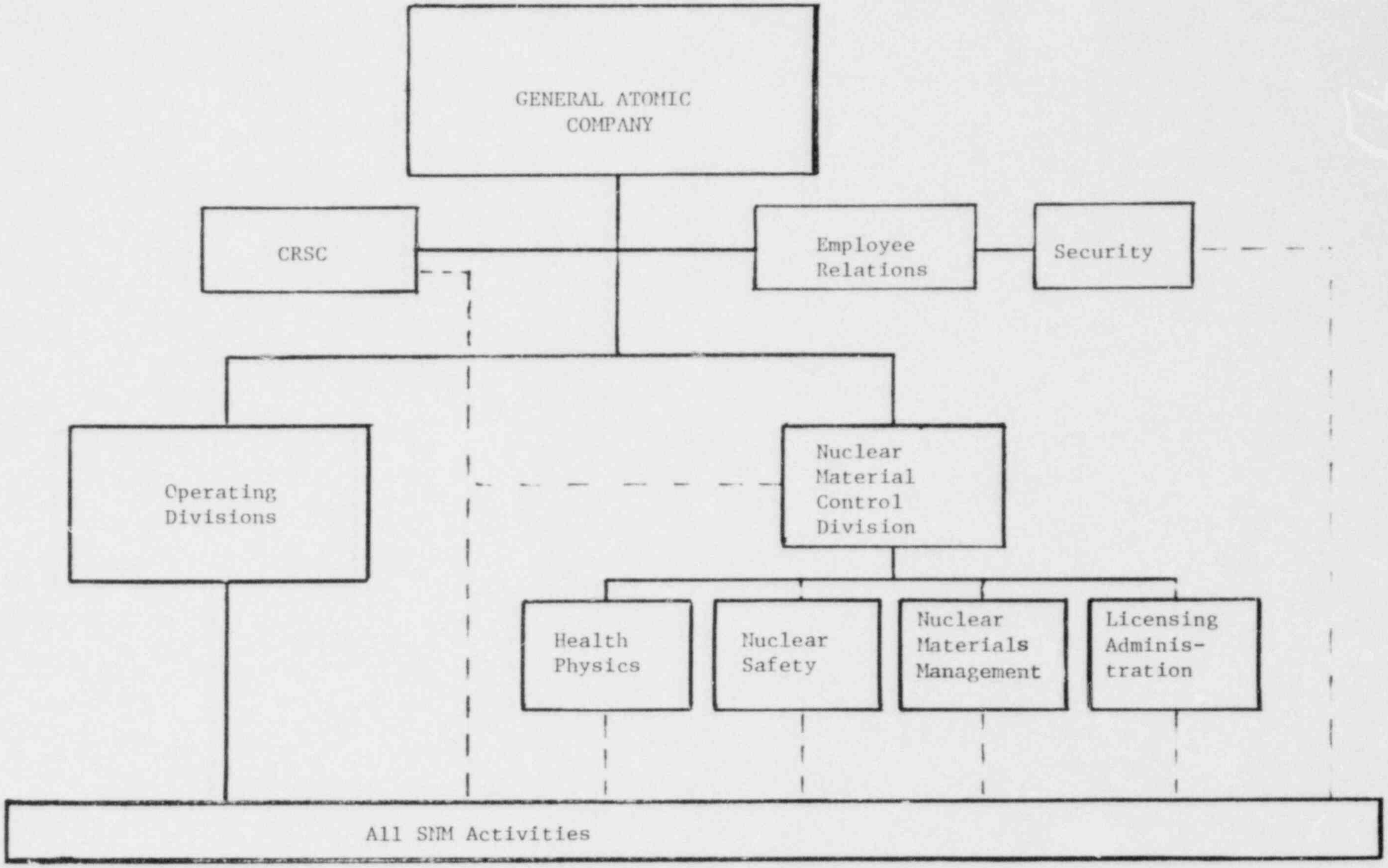


Fig. I 1.2-2. Radioactive Materials Management Organization

2. SITE DESCRIPTION*

2.1 LOCATION AND SIZE

The main site of the licensee at San Diego is located at 10955 John Jay Hopkins Drive approximately 13 miles north of downtown San Diego. This site, shown on the frontispiece, occupies approximately 360 acres. A scale map of the area surrounding the main site is shown in Figs. I 2.1-1 & -2; the heavily developed areas are shown in Fig. I 2.1-1. Fig. I 2.1-3 shows the details of the overall site building layout.

Component manufacturing and HTGR fuel production, as well as its related process development, are located in Sorrento Valley at 11220 Flintkote Avenue on property contiguous to the main site. The fuel production is in the north end of the SVA building. The process development activity is in the SVB building.

2.2 TOPOGRAPHY

The main site is on Torrey Pines Mesa about 1 mile east of the ocean at an elevation of 300 ft above sea level. The site extends into the adjacent Sorrento Valley at an elevation of between 50 and 75 ft above sea level. The mesa runs in a northerly direction paralleling the coast and rising to a height of 400 ft above sea level between the site and the ocean.

Sorrento Valley runs in a northwest direction from the east side of the main site to the ocean, intersecting the ocean at the northern end of the

---

*Details of various facilities may be found in topical documents submitted under separate covers, such as the "Environmental Appraisal Report," GA-A-13033 (revised), required "Security Plans," and the "FNMC Plan," GA-A-13248.

mesa. Sorrento Valley is about 5000 ft wide at its mouth and narrows to 1000 ft at its southern end. The valley intersects Los Penasquitos Canyon east of the main site.

2.3 METEOROLOGY

2.3.1 General Influences

The weather and climatology of Southern California are dominated by the semipermanent Pacific high-pressure system which is a feature of the planetary circulation and which oscillates back and forth during the year as the seasons change. In the summer when the Pacific high-pressure system is at its most northerly position, it blocks traveling storm and high- and low-pressure systems, resulting in almost no rain from frontal activity during the summer season. The withdrawal of the Pacific high-pressure system to its most southerly position in the winter season allows storm systems to travel further south, resulting in winter rains in Southern California.

The Pacific high-pressure system further influences atmospheric circulation by forming a temperature inversion that restricts the mixing layer for pollutants and by causing low-average wind speeds in this restricted mixing layer. The lower altitude limit of the inversion, called the inversion base, is the upper limit beyond which cloud rise is retarded. Representative temperature profiles over a period of 5 months covering summer, fall, and winter show that inversions having bases between 250 and 5000 ft altitude occurred 76% of the time. Inversion bases occurring between 1000 and 2000 ft are most common in the summer, lowering to 250 to 1000 ft in the fall and increasing to 1500 to 2500 ft or higher in the winter.

2.3.2 Winds

The prevailing winds are usually westerly, although easterly winds are almost as common during the winter months. During the day, the westerly winds developing from the Pacific high-pressure system are reinforced by the land-sea breeze, resulting in stronger average wind velocities (6.5 to 9 mph) than from the easterly land breeze (1 to 7.2 mph). The land breeze is present at night during the cold season but seldom during the warmer months. This wind is shallow, usually a few hundred feet, while the sea breeze is often 1000 ft or more. Such air flow is effectively channeled by topographical features. Wind velocity, as a function of month and direction, is shown by the wind rose for San Diego in Fig. I 2.3-1. Strong winds are infrequent, with the strongest being 51 mph from the southeast in 1944.

The micrometeorology conditions at the site are determined by the terrain roughness, local topography, wind regimes (land and sea breezes), and solar heating. The dilution of airborne contamination due to normal operating releases will be determined by the small scale turbulence in the local area in combination with the wind and mode of release (ground level or elevated). A two-tower meteorological system is used to determine the micrometeorological conditions at the site. The data from these two towers goes to recorders and computers which calculate the standard deviations of the horizontal and vertical wind variations.

2.3.3 Precipitation

The average annual rainfall in the City of San Diego is 9.78 in., but relatively wide variations in the monthly and seasonal totals take place. This is illustrated by the fact that 75% of the annual precipitation occurs from November through March. The monthly averages for the period from 1939 through 1978 are given in Table I 2.3-1. The maximum annual precipitation during the last 60 years was 24.93 in. in 1941. The maximum precipitation in any 24 hour period within a month is shown on Table I 2.3-2.

TABLE I 2.3-1

AVERAGE PRECIPITATION FROM 1939 THROUGH 1978

Period	Average Precipitation (in.)
January	1.85
February	1.89
March	1.50
April	0.70
May	0.28
June	0.05
July	0.04
August	0.09
September	0.13
October	0.42
November	0.96
December	1.87

TABLE 2.3-2

MAXIMUM PRECIPITATION IN 24 HOURS FROM 1941 TO 1979

Month	Precipitation (in.)
January (1943)	2.65
February (1971)	2.61
March (1952)	2.40
April (1965)	1.40
May (1977)	1.50
June (1972)	0.28
July (1968)	0.10
August (1977)	2.13
September (1963)	0.90
October (1941)	1.20
November (1944)	2.44
December (1945)	3.07

2.3.4 Tornado

Tornadoes on the Pacific Coast are of a low frequency and are not severe. Small tornadoes and water spouts have been reported. In the one degree square containing San Diego and its vicinity, only five tornadoes were reported between 1916 and 1971. Typical damage consisted of removing the roof from a house. There have been no reported deaths due to tornadoes in California to 1971.

2.4 GEOLOGY AND HYDROLOGY

The geology of the site is that of the coastal plains. The rocks which crop out in this area are part of a prism of sedimentary rocks of Cretaceous and Tertiary age which thin eastward and are seldom found more than 10 miles inland. They lie upon crystalline rocks which make up the Peninsular Range in central and eastern San Diego County. In the site area, the sedimentary rocks are up to 1000 ft thick. They consist of extremely well-cemented sandstones and shales of Cretaceous age below (not exposed in the site area) and firmly indurated siltstones, shales, and sandstones of Eocene age above. The sand blanket varies in thickness, with some of the region covered by marine terrace deposits of up to 30 ft in depth. The geology of the southwestern part of San Diego County is shown in Figs. I 2.4-1 and I 2.4-2.

The site lies in the Los Penasquitos drainage basin. Little water flows into Sorrento Valley except during occasional heavy rains, and it is carried off by the Los Penasquitos Creek which drains to the northwest into the Pacific Ocean.

2.5 SEISMOLOGY

The San Diego region is susceptible to earthquakes; however, since 1800 only two earthquakes have occurred with an intensity as high as VIII on the modified Mercalli Scale, one in 1800 and the other in 1894. An earthquake of intensity VIII on the modified Mercalli Scale corresponds to an acceleration of about 0.25 g with a period of 0.1 to 0.3 repeated several times. Since 1934, the epicenters of three small shocks have been located within 5 miles of the site but not in the immediate vicinity.

No mappable faults exist within the property limits. The fault nearest the property is the Rose Canyon fault (shown in Fig. I 2.4-1), which is 5 miles distance at its closest approach. Geological evidence indicates that there has been no surface displacement on the fault since early Pleistocene times, before deposition of the terrace deposits which ocver much of Torrey Pines Mesa; epicenters have been located along the fault trace, however. The second nearest fault on land is the Elsinore Fault which lies 40 miles from the site.

All buildings which contain special nucear material are designed to meet the seismic criteria specified in the Uniform Building Code (UBC) in effect at the time the buildings were constructed. The seismic parameter "C" (later designated "ZKC") used by the analyst were in accordance with the UBC in effect at the time and were dependent upon the particular type of structural component being analyzed. The magnitude of these parameters are still consistent with and meet the requirements of the UBC 1973 Edition. A summary of the buildings and seismic parameters used is given in Table I 2.5-1.

2.6 POPULATION AND LAND USE

The present population within a 1-mile radius of the main site is primarily of an industrial and university campus makeup, with an estimated

TABLE I 2.5-1

SEISMIC DESIGN

Building		Name on Plans	Construction Date	Seismic Parameter "C" (or "ZKC")	Effective Uniform Building Code (UBC)
SV-A		Metallurgic Development Bldg.	July 1961	0.133	UBC 1955 Ed.
SV-B		Light Mfg. Bldg.	Aug. 1963	0.133	UBC 1961 Ed.
L-Bldgs.	A	Science Bldg. A	Sept. 1957	0.133	UBC 1955 Ed.
	B	Science Bldg. B	Aug. 1957	0.133	UBC 1955 Ed.
	C	Science Bldg. C	Aug. 1959	0.133	UBC 1958 Ed.
Hot Cell		Torrey Pines Hot Cell	Mar. 1959	0.133, 0.200 & 1.00	UBC 1958 Ed.
ECF		Marine Gas-Cooled Reactor Critical Facility	Oct. 1961	0.133	UBC 1961 Ed.
EA-1		Experimental Area Bldg.	Sept. 1964	0.067 and 0.133	UBC 1964 Ed.
E-Bldg.		Experimental Bldg.	Feb. 1957	0.133	UBC 1955 Ed.
		Second Addition	April 1964	0.133 and 0.200	UBC 1964 Ed.
Butler		Various Vault Storage	1961 - 1963	0.067	UBC 1961 Ed.
TFF		TRIGA Fuel Fab Bldg	1975	0.133	UBC 1970 Ed.

daytime total of up to 14,500 people (about 2200 are GAC employees). The immediate vicinity of the Flintkote Avenue Facilities is zoned for industrial activity. Interstate Highway 5 is located about 1/2 mile to the east of the Component and Fuel Manufacturing Building. The location and population of nearby industrial and community facilities are shown in Figs. I 2.6-1 & -2 respectively.

Because of terrain and zoning, most future residential development will occur beyond a 2-mile radius from the site. Significant residential development is presently under way in the Mira Mesa area 5 miles east and in University City 4 miles south of the main site. Estimates of future growth indicate the area within a 5-mile radius could have a population of 250,000 by 1995.

The majority of the present population to the north is in a series of small, unincorporated towns extending to Oceanside, 25 miles north with a population of 76,700. Escondido, 18 miles northeast of the site, has a population of 62,500. To the south is the metropolitan area of San Diego. The distance and population of surrounding communities is given in Table I 2.6-1.

TABLE I 2.6-1
POPULATION OF SURROUNDING COMMUNITIES

Community	Distance (Air Miles) and Direction	Population[a]
Del Mar	5 miles north	5,017
Los Penasquitos	8 miles northeast	19,000
Rancho Bernardo	13 miles northeast	16,100
Poway	12 miles east	32,100
Mira Mesa	6 miles east	37,500
University City	4 miles south	28,900 [b]
La Jolla	5 miles southwest	27,900
Clairemont	6 miles south	82,400

[a] Population data based on 1980 census.

[b] Includes University of California at San Diego.

2.7 FACILITIES DESCRIPTION

The following is a description of the various facilities at the San Diego site which may routinely handle SNM. Fig. I 2.1-2 is a plan view of the site. The square footage quoted for the various buildings is the total floor space enclosed within the walls.

2.7.1 Flintkote Avenue Facilities

2.7.1.1 Component and Fuel Manufacturing Building (SV-A) (106,380 ft^2)

Located at 11220 Flintkote Avenue in Sorrento Valley north of the main complex, the Component and Fuel Manufacturing Building contains offices, shops, and an area used for fuel and component fabrication. The building is 460 ft long and 120 ft wide with about two-thirds of the building of high bay construction. The east section of the building is divided into two floors for offices, a protective clothing change room, a laboratory, store rooms, and a cafeteria. Nonrelated activities carried out in the facility include a machine shop, a sheet metal shop, and an assembly area for mechanical parts. Approximately one-half of the building area is devoted to fuel fabrication activities. The fuel fabrication area is bounded by two outside walls, a masonry wall and a structural steel wall, which separate it from other non-fuel operations areas and activities. Access to the fuel fabrication area is restricted to limit access to authorized personnel, to control SNM, to maintain control and monitoring of personnel, and to prevent the spread of contamination. A separate ventilation system is maintained for facilities and areas involved in SNM processing.

2.7.1.2 HTGR Fuel Production Process Development Building (SV-B) (15,200 ft^2)

Process development, pilot scale operations, and specialized fabrication work related to fuel production are conducted in a building adjacent to and north of the SVA Building. Process development is carried out in the east half of the building. Grinding, machining, and polishing operations of other non-SNM is located in the southwest corner of the building. The remainder of the building is devoted to offices and other pilot scale activities.

2.7.2 Main Site

2.7.2.1 Laboratory Building (119,370 ft^2)

The Laboratory Building contains laboratories, offices, shops, and low-level caves for work with low-level activity. Most of the research activities in metallurgy, chemistry, and experimental physics are conducted in this building. One set of laboratories is used for the fabrication, inspection and testing of isotope fueled thermoelectric generators.

2.7.2.2 Hot Cell Facility (6950 ft^2)

The Hot Cell Facility is equipped to perform a wide range of investigations of the physical, metallurgical, and chemical properties of irradiated specimens, including examinations of full-size power reactor fuel elements. The facility includes a high-level cell with three operating stations capable of handling activity levels of up to one million Ci of 1 MeV gamma, an adjacent low-level cell that can be used separately or in conjunction with the high-level cell, and a metallography cell equipped to provide complete metallurgical investigations including micro-, macro-, and stereo-photography. Supporting areas include a service gallery, physical test room, machine shop, manipulator repair, decontamination room, and an X-ray room.

2.7.2.3 TRIGA Reactors Building (6730 ft^2)

Located north of the Laboratory Building, the TRIGA Reactors Building provides an area for diversified experimental and irradiation studies using the inherently-safe TRIGA Mark I, Mark F, and Mark III reactor facilities. Included within the building are associated reactor control consoles, a low-level counting room, a small shop, a neutron beam tube room, and administrative offices. Specific uses of SNM in this area generally are governed by the terms of Utilization Facility Licenses R-38 and R-67; however, SNM that is not within the reactor pools is under this license.

2.7.2.4 Experimental Area Building I (4710 ft^2)

This building consists of laboratories and offices for work which requires the close support of the research reactors. There are about 1100 ft^2 of the total area located in a nearby underground bunker which houses a high-level chemistry lab and associated storage. The facility is used mainly for radiochemical analysis work.

2.7.2.5 TRIGA Fuel Fabrication Building (7500 ft^2)

The TRIGA fuel fabrication building, approximately 60 ft x 125 ft, is constructed of reinforced concrete prefabricated panels of about 7-1/2 in. thick for the walls. The roof is prestressed concrete approximately 4 in. thick. The building contains storage vaults, drum storage area, operations associated offices, locker and restrooms, as well as the fuel fabrication areas. The building has two truck roll-up doors and a personnel door, as well as an appropriate number of emergency exits to meet industrial safety requirements. The building has on one end a pad providing outside space for a bottled gas farm, liquid nitrogen storage tank, air-conditioning units, high-efficiency air filter plenum and blowers, etc., which require routine servicing by persons not needed in material access areas.

2.7.2.6 Waste Processing Facility (61,000 ft^2)

This area is located 1000 ft east of the Hot Cell Facility. Included in the area are a service building and various storage areas. Adjacent to this facility are evaporation ponds that occupy approximately 4800 ft^2 and a site for an incinerator (now dismantled) for contaminated waste. The waste processing facility is also equipped with a trash shredder and a compactor. Combining these capabilities allows the radioactive waste volume to be reduced to its lowest practical limit.

2.7.2.7 Experimental Critical Facility Buildings (13800 ft^2)

This facility is comprised of two buildings located within a fenced area. The two buildings are a reactor building and an assembly building. They are presently used for experiments with radiation sources/machines and the storage of source and limited SNM within suitable containers.

The two buildings are subjected to the appropriate controls to minimize the possibility of uncontrolled spread or release of radioactivity to other areas and prevent unauthorized exposure to radiation.

2.7.2.8 Experimental Building (45,000 ft^2)

This building houses offices, engineering and metallurgical, as well as chemical pilot plant activities. The major activity involving the use of SNM is the chemical pilot plant activity. The metallurgical and chemical pilot plant work areas are subjected to the appropriate controls to minimize the possibility of uncontrolled spread or release of radioactivity to other areas. The support personnel for these activities utilize a fraction of the offices available. The other offices are used by such groups as the Fusion Project, General Engineering, etc.

2.8 UTILITIES AND SERVICES

2.8.1 Utilities

Gas and Electricity

Commercial quantities of gas and electricity are supplied by San Diego Gas and Electric Company.

Emergency and Auxiliary Power

The Security Office, located in the Administration Building, has an auxiliary power system which automatically engages in case of a power failure. The auxiliary power system is rated at 10 kW(e).

In the event of a power failure in the Component and Fuel Manufacturing Building, an Onan Electric Plant automatically becomes energized within 3 seconds and is capable of producing 75 kW(e) of rated electric power thereafter to designated components. The electric plant, which is tested weekly, has a propane-fueled engine/generator unit. The auxiliary power unit supplies emergency power to criticality, fire, and security alarms, as well as to equipment cooling systems. In addition, wet-celled, battery-powered emergency lights are located strategically throughout the facility to illuminate evacuation routes and equipment that may require surveillance during power outages.

Sewerage Systems

Sewer service is supplied by the City of San Diego Department of Utilities. Sewage released from the licensee's facilties at the San Diego site is processed at the Point Loma Sewage Treatment Plant.

Hold-up tanks are provided, and routine samples of facility influent and effluent waters are taken (see Section 4.5, Part I).

Water

Water is supplied by the City of San Diego Department of Utilities.

2.8.2 Fire and Police Protection

The Northern Division of the San Diego Police and Fire Department is located 2 miles southeast of the main site. Local authorities have been instructed on operations involving SNM at the licensee's facilities.

The licensee maintains a volunteer fire brigade of about 30 members. There is a full time staff of 3 people. Periodic drills are conducted covering the use of equipment and fire fighting techniques. (See Section 1.3.2, Training.)

2.8.3 Security

Extensive security measures consistent with 10 CFR Part 73 requirements are provided by the licensee to prevent the unauthorized removal of SNM and to provide appropriate industrial security. An 8-ft-high chain link security perimeter fence, topped by three strands of barbed wire, surrounds the main San Diego facilities, and access is controlled by a 24-hour, 7-day/week guard station at the main entrance. The total guard force consists of 39 men; a portion of them, including a shift Security Supervisor, is on duty at all times, 7 days/week. The Security Supervisor's office is located in the Administration Building, just off the main lobby. All main site fire, security, and criticality alarms are connected to this office. The Flintkote Avenue site, Sorrento Valley, is protected under a separate Category I Physical Protection Plan. The Security Supervisor has at his disposal a two-way FM radio for communication with guards, fire protection, health physics, and medical personnel. During nonworking hours, the premises are patrolled by guards. SNM storage areas are designated as material access areas within the meaning and intent of 10 CFR Part 73, "Physical Protection of Special Nuclear Material," with all such areas equipped with motion detection alarm systems, including back-up auxiliary power.

The buildings at the Flintkote Avenue site are controlled access areas which are surrounded by an 8-ft-high chain link security perimeter fence topped by a 3-strand barbed wire outrigger. Access to these areas is controlled by two guard stations. One station is located in the Component and Fuel Manufacturing Building lobby, and the other is at a point on the east perimeter fence, between the Component and Fuel Manufacturing Building and the HTGR Fuel Production Process Development Building (Fig. I 3.1-7). All alarm systems in this area are connected to the central security station located in the lobby of the Component and Fuel Manufacturing Building.

All material access areas and protected areas are inspected at least quarterly by a Security Department Supervisor. Action to correct deficiencies cited is promptly initiated. Intrusion alarm systems and detection devices are tested and inspected in accordance with statement in the GAC security plans.

FIG. I 2.1
MAP OF SUR

-1
ROUNDING AREA

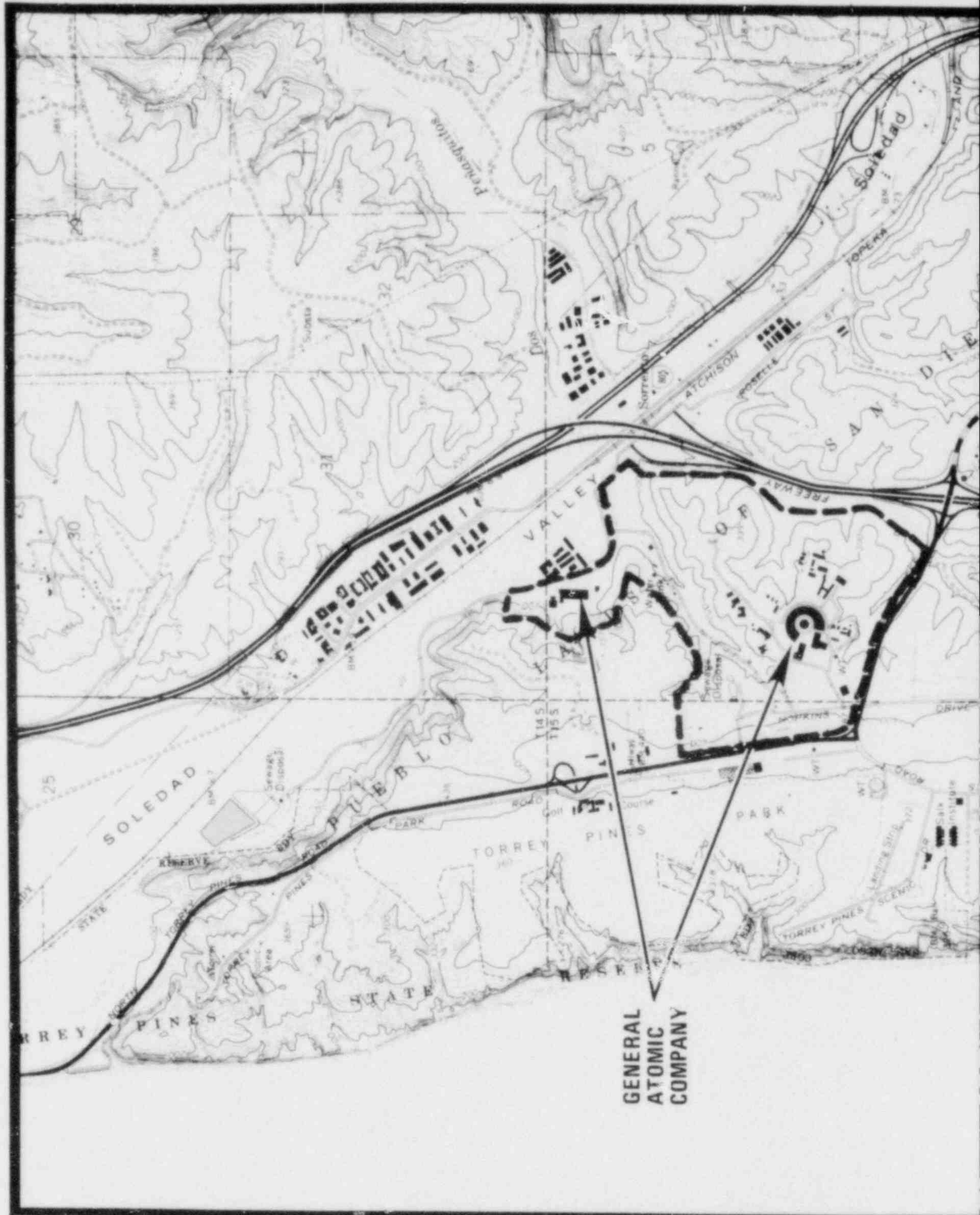

GENERAL
ATOMIC
COMPANY
SOLEDAD
VALLEY
PUEBLO
TORREY PINES
STATE
PARK
FREEWAY
ATCHISON
Soledad
Sorrento
Golf Course

FIG. I 2.1-2
MAP OF SITE & SURROUNDING AREA

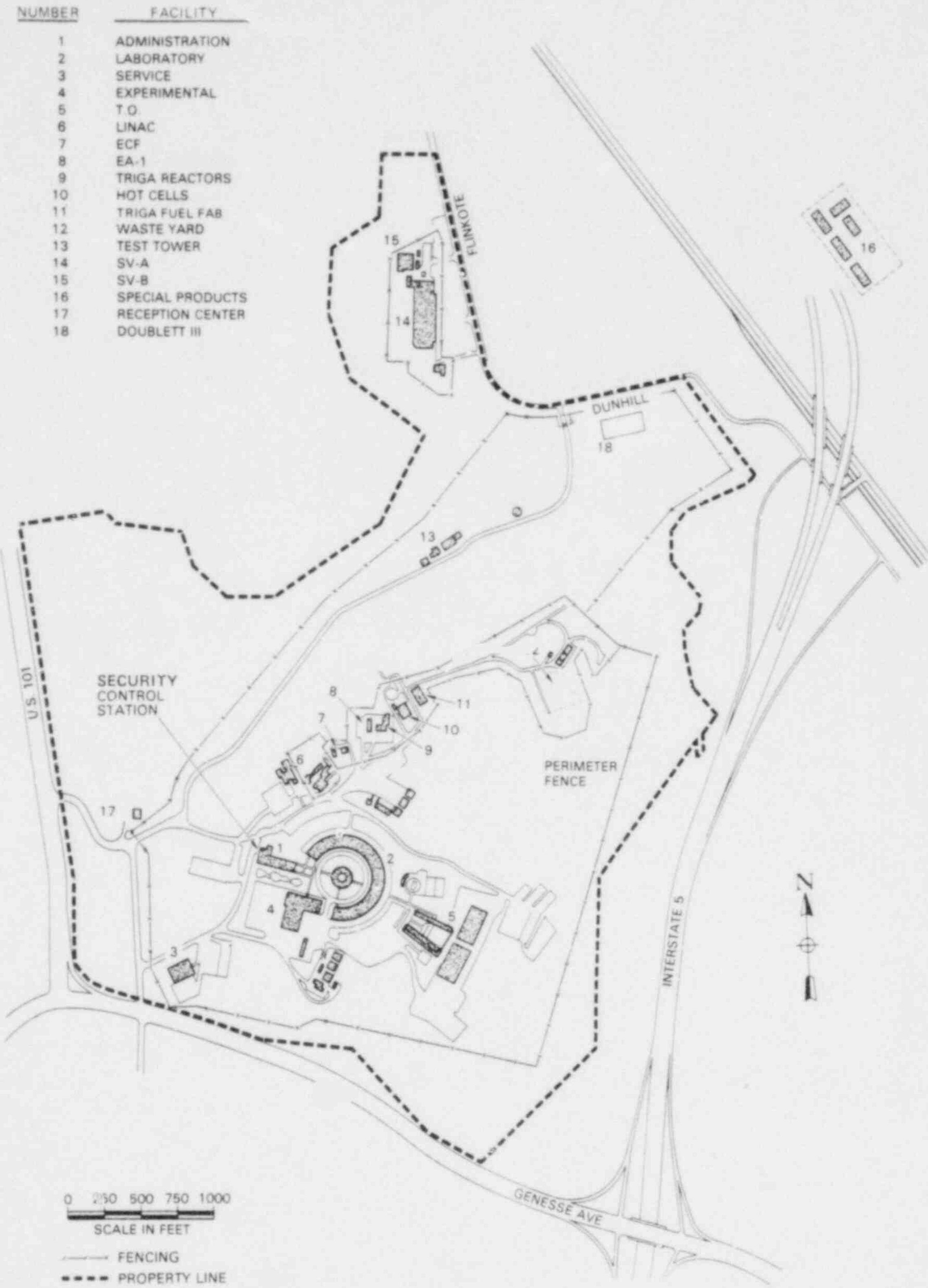


Fig. I 2.1-3 Plan View of Site

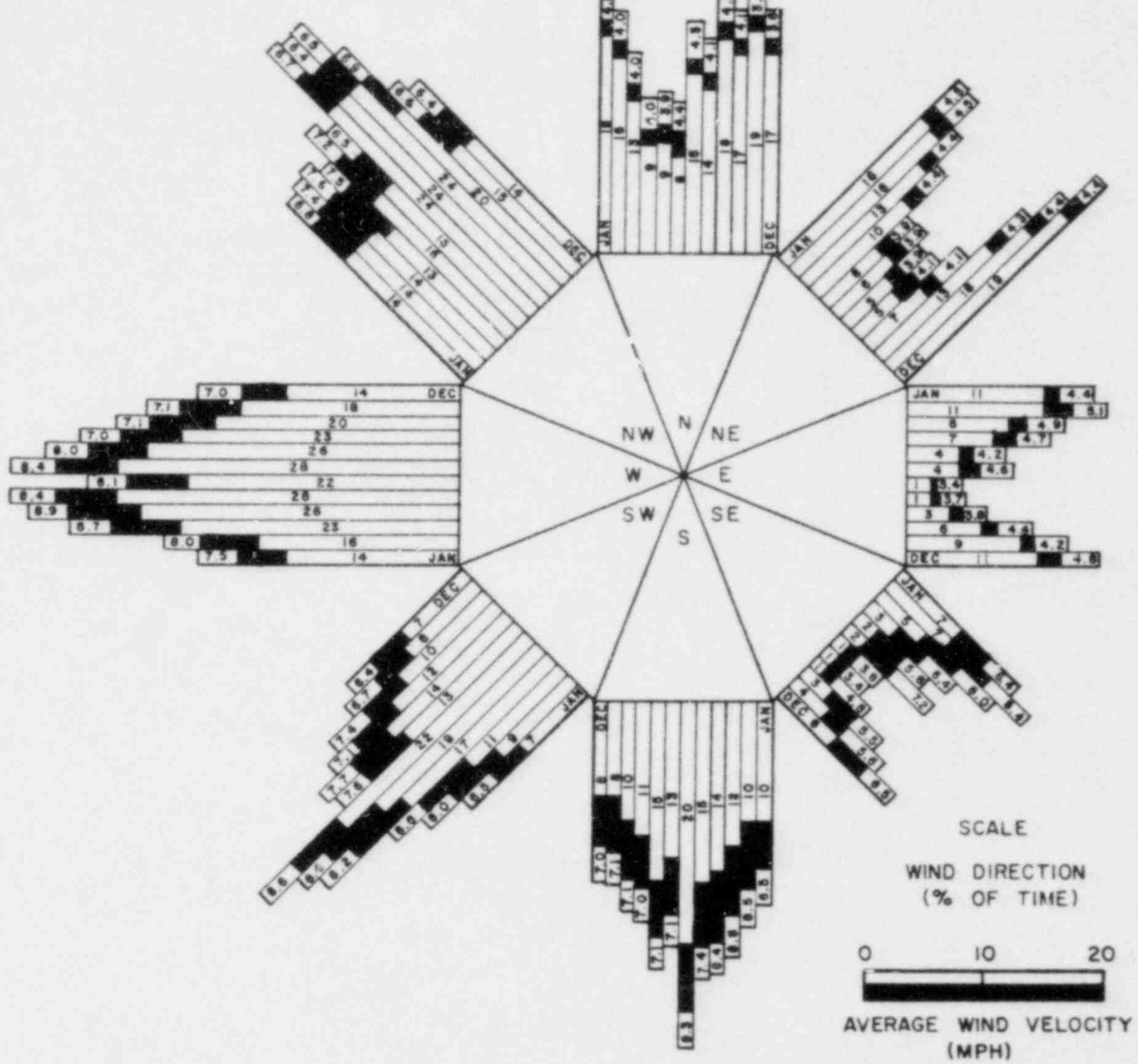


Fig. I 2.3-1 Typical wind rose for San Diego

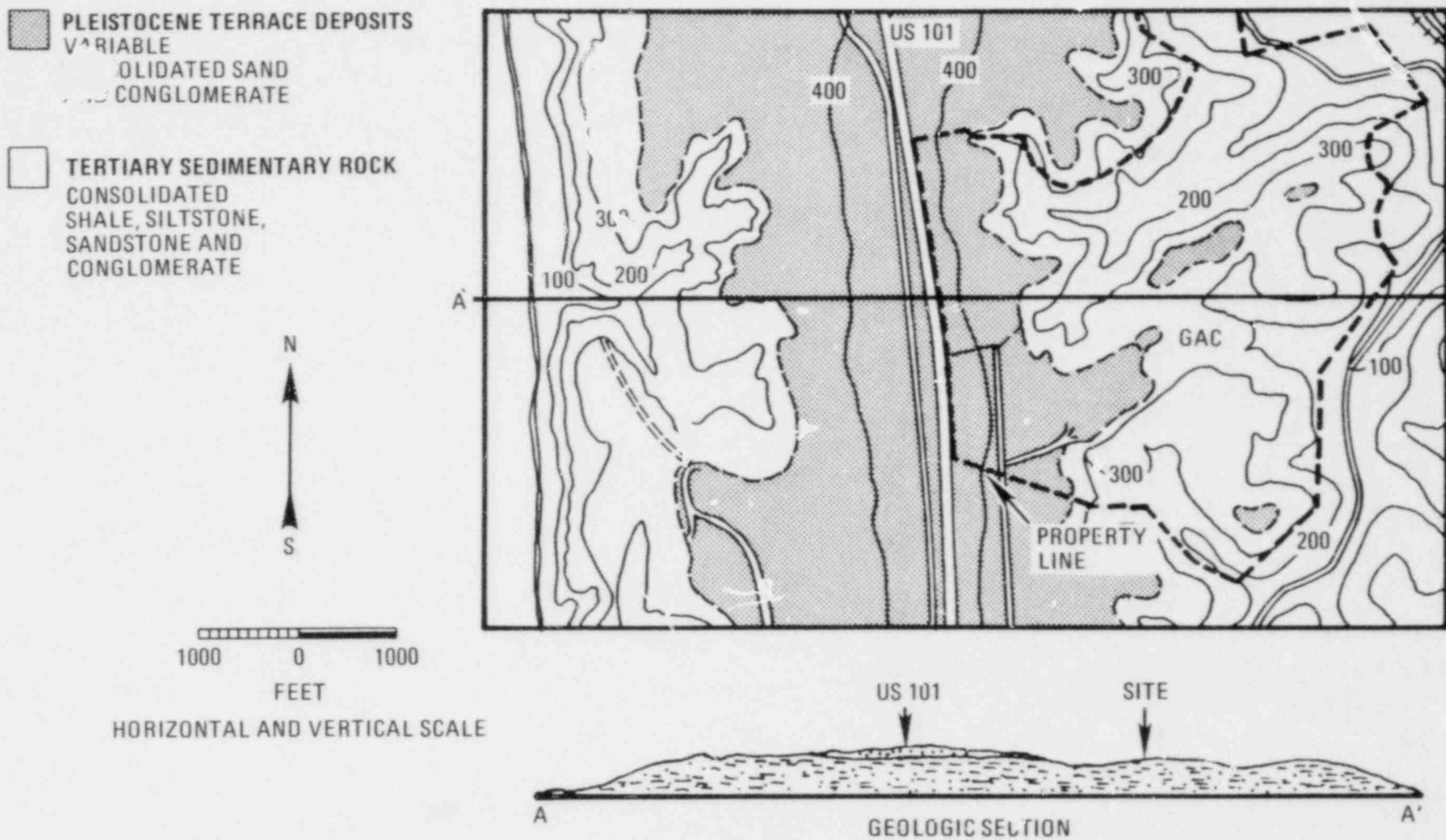


Fig. I 2.4-1 Geology of the main site

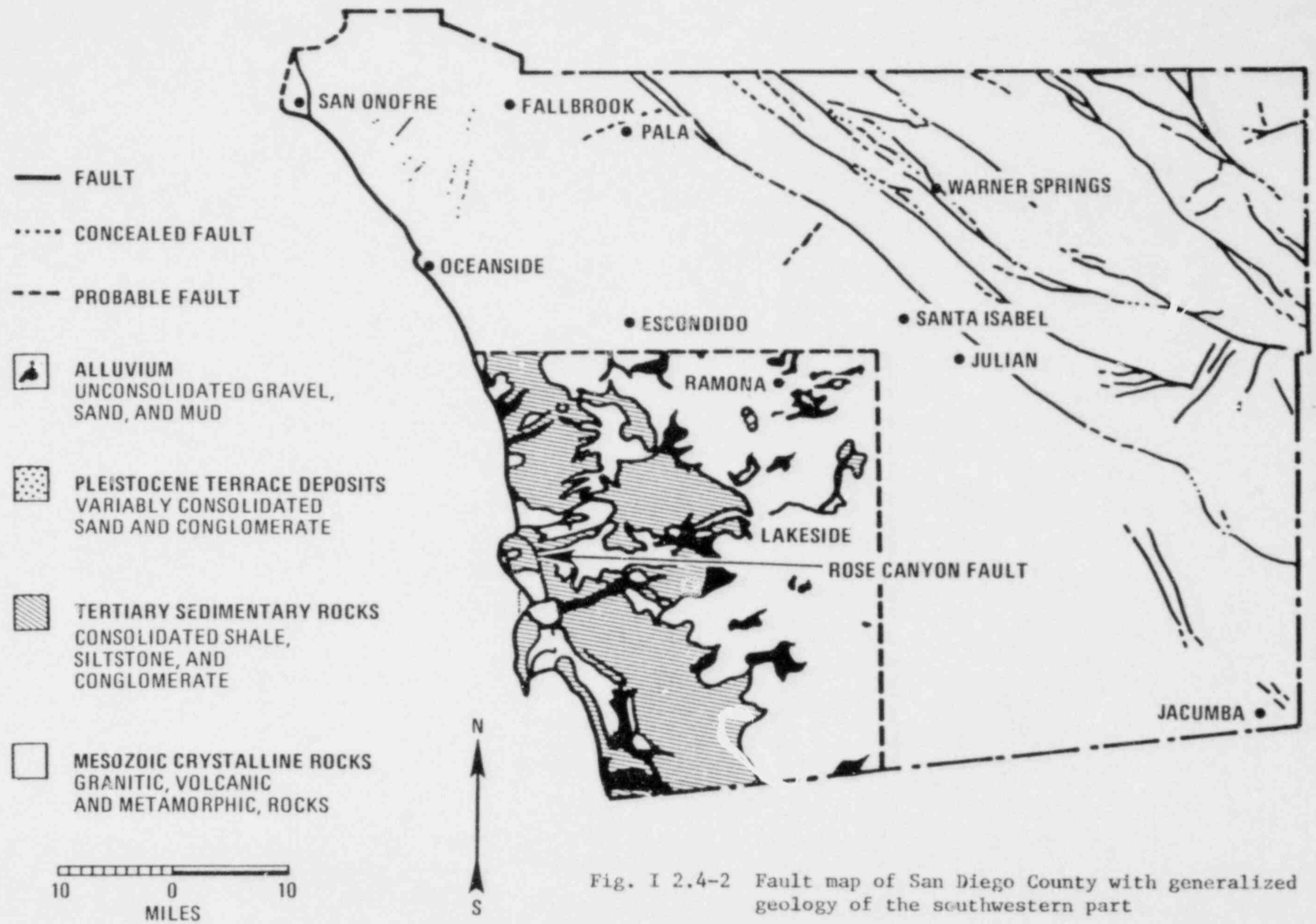
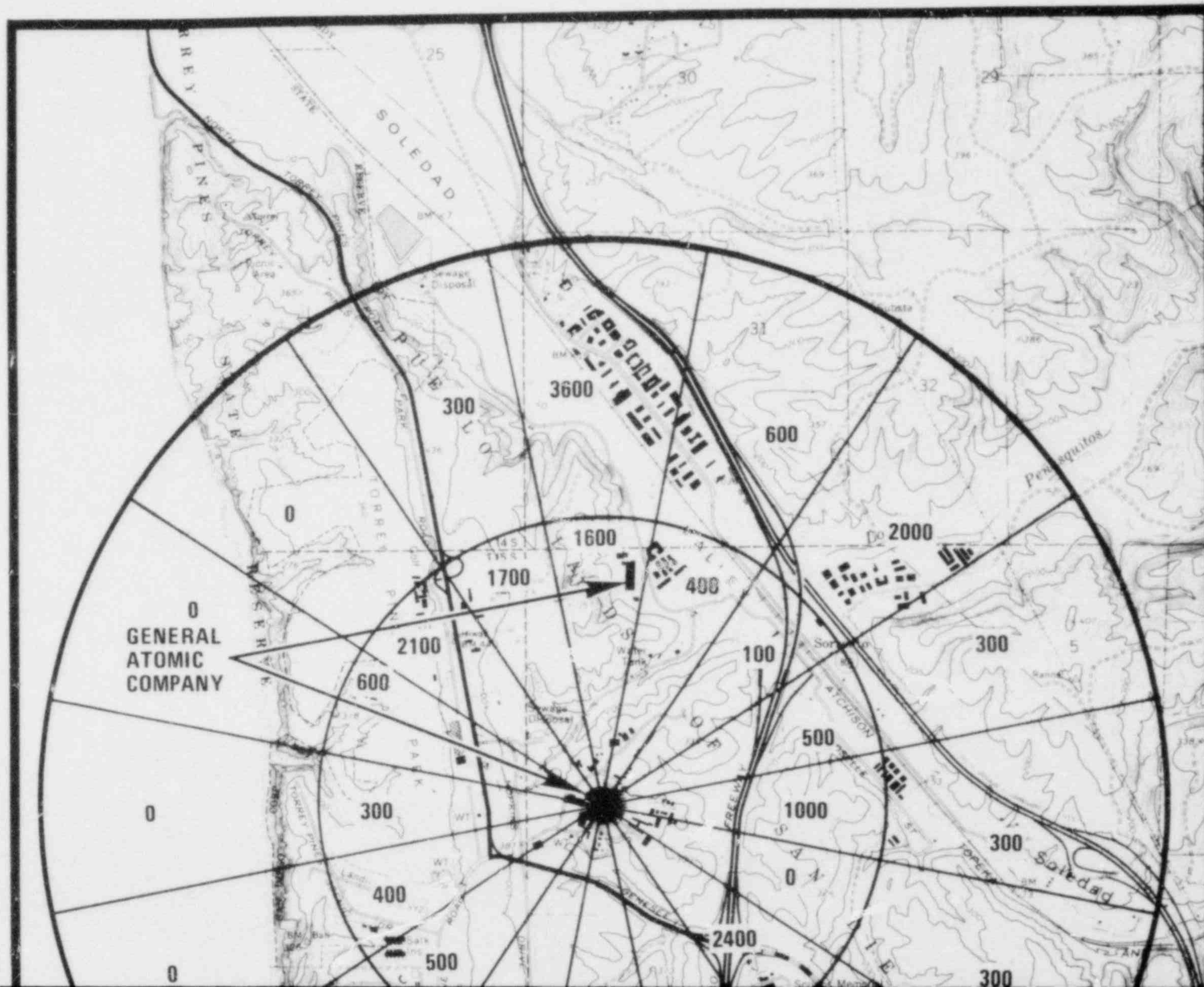


Fig. I 2.4-2 Fault map of San Diego County with generalized geology of the southwestern part


GENERAL
ATOMIC
COMPANY
3600
1600
1700
2100
600
2000
300
500
1000
100
400
2400
0
SOLEDAD
PUEBLO
TORREY PINES
STATE
PARK
ATCHISON
TOPEKA
Soledad
Penasquitos

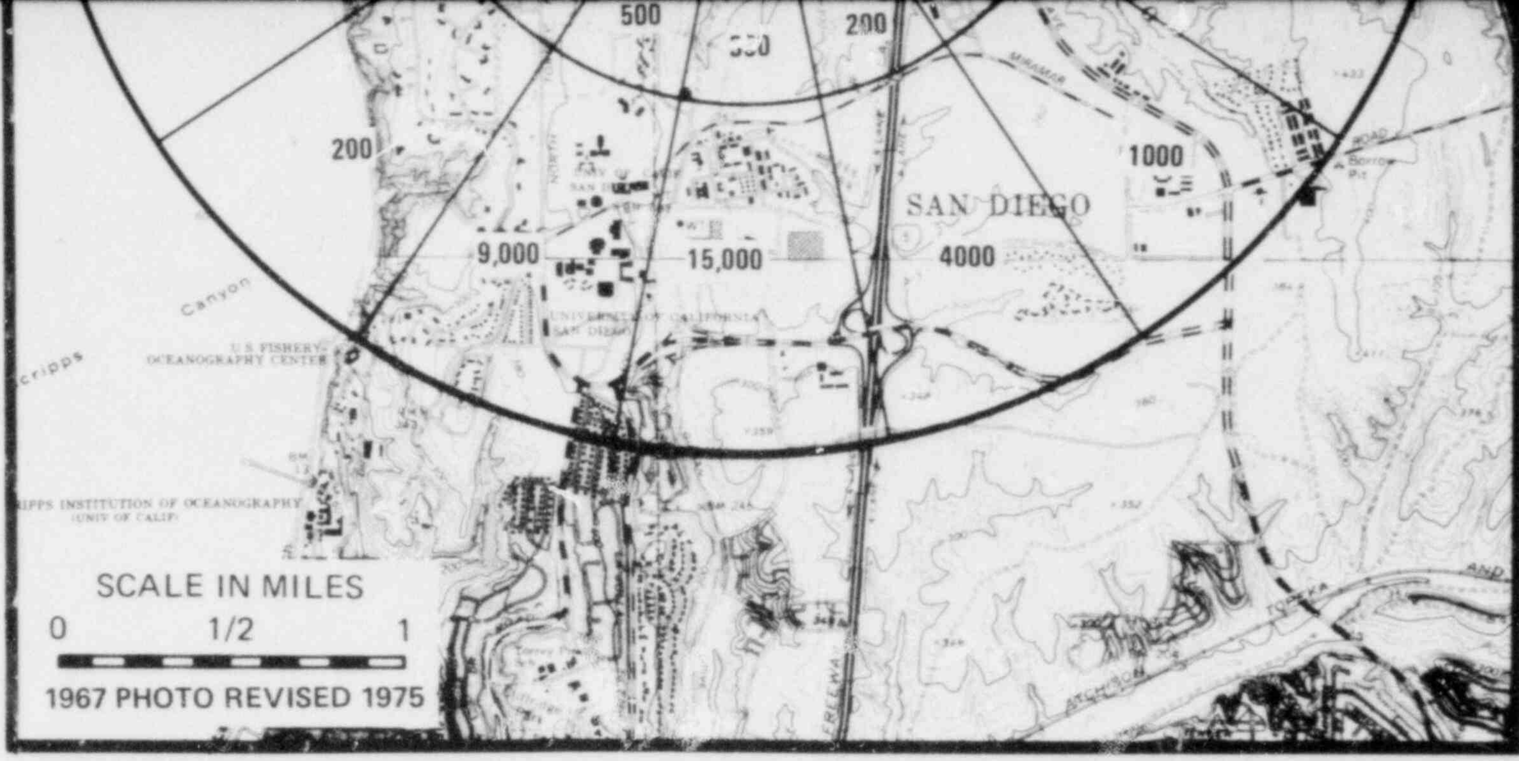
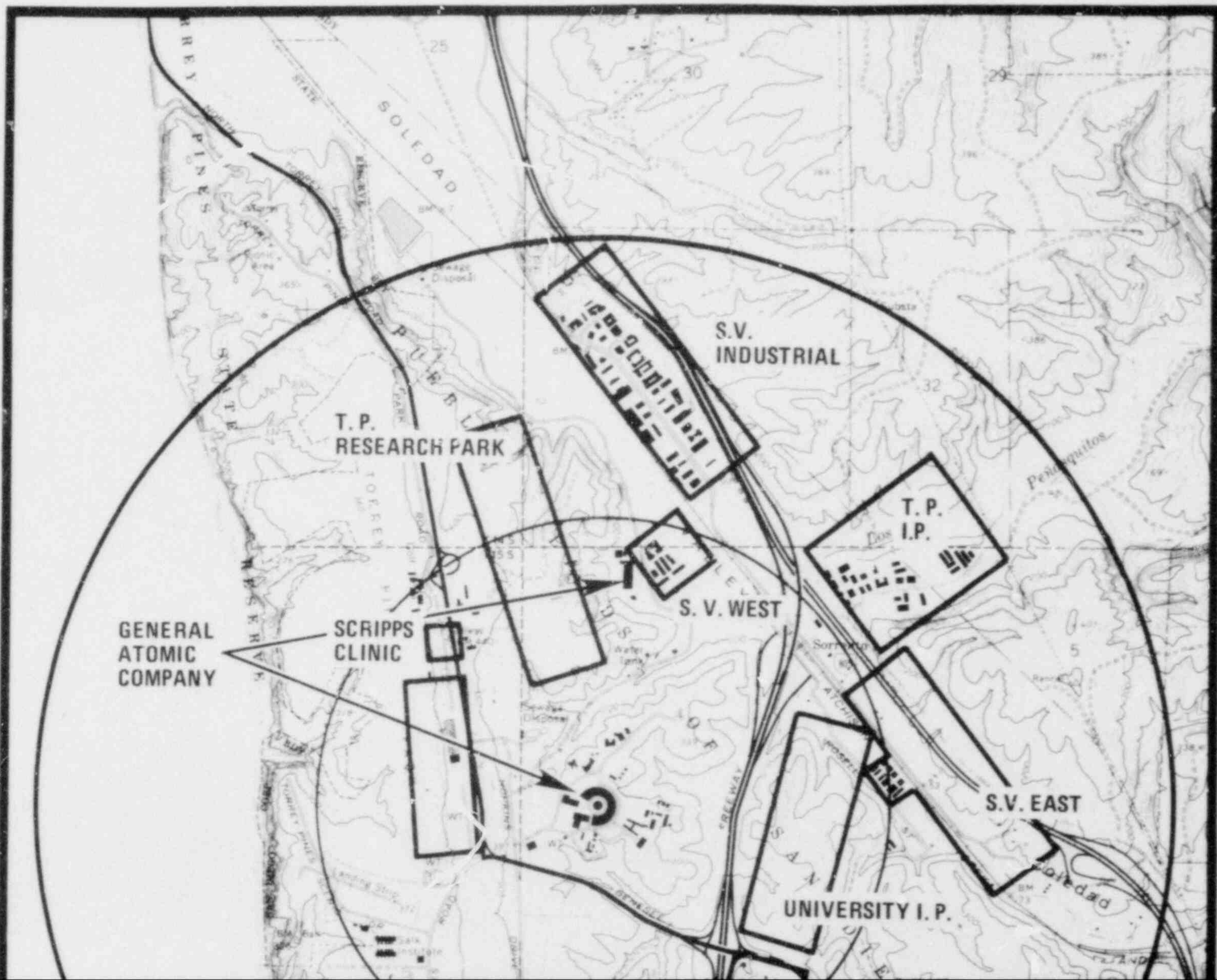


FIG. 1 2.6-1
POPULATION WITHIN 2 MILES OF MAIN SITE


S.V.
INDUSTRIAL
T. P.
RESEARCH PARK
T. P.
I.P.
S. V. WEST
GENERAL
ATOMIC
COMPANY
SCRIPPS
CLINIC
S.V. EAST
UNIVERSITY I. P.
SOLEDAD

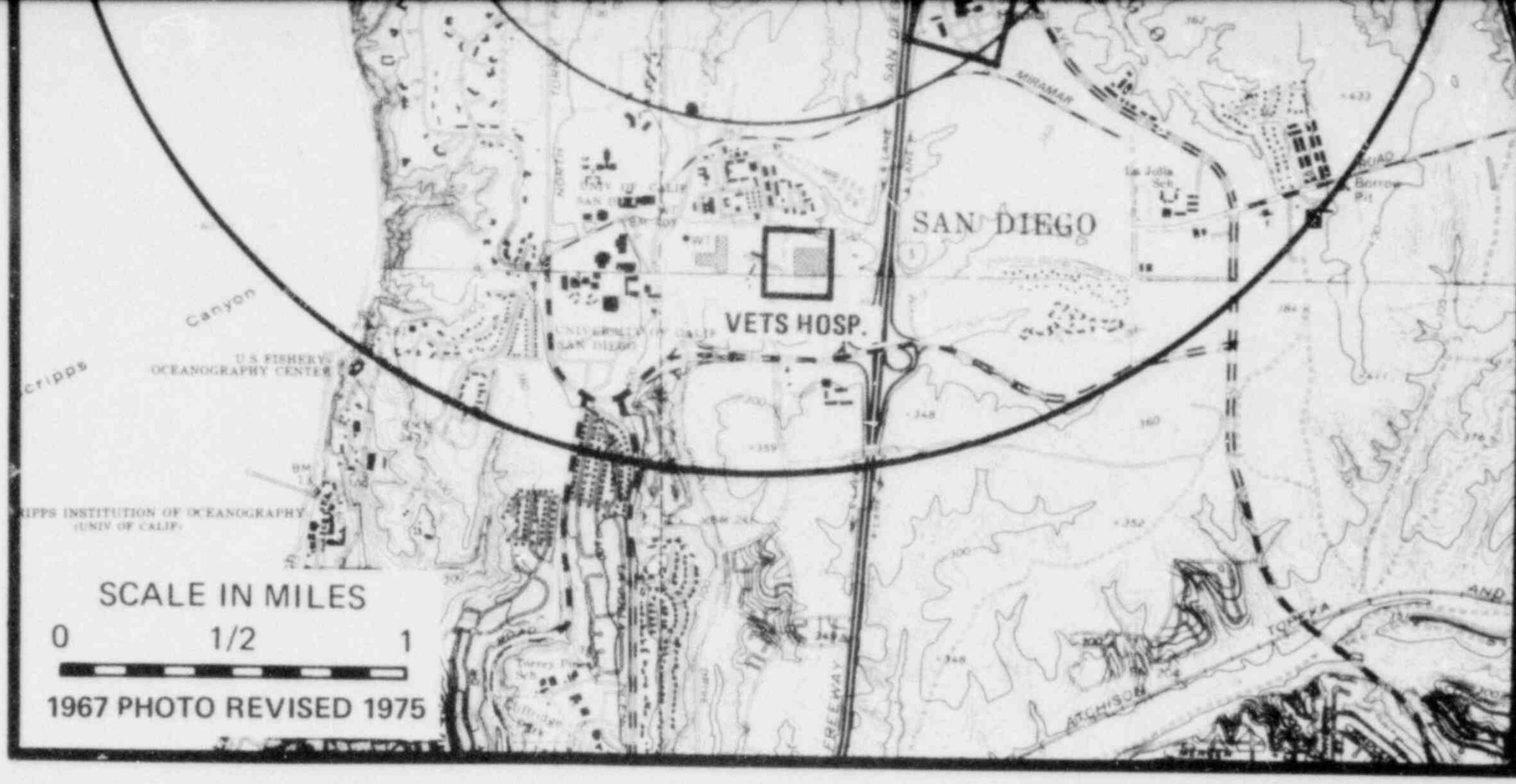


FIG. I 2.6-2
MAP SHOWING NEARBY INDUSTRIAL COMPLEXES

3. PRESENT OPERATIONS

The operations described in this section include the receiving, transfer, use, storage, shipping, fabrication, research and development, and other related activities that involve special nuclear mater ·l (SNM).

Nuclear and radiological safety aspects are discussed under the operation descriptions as applicable.

Materials safeguards for these operations are in compliance with the criteria established under Section 9, Part II, Specifications, of this renewal application.

The physical protection of SNM operations are in accordance with the criteria set forth in Section 9, Part II, Specifications. The criteria are employed in the use, storage, and transit of SNM subject to this license.

3.2 RECEIVING SPECIAL NUCLEAR MATERIAL

Upon receipt of a package containing SNM, receiving personnel immediately notify Health Physics and NMM. Health Physics personnel assure that the packaged contents are surveyed for radiation and contamination and verify the absence of surface contamination. NMM takes charge of the packages transport to an evaluation room where the SNM is unpackaged, evaluated and prepared for storage. Verification of all SNM material receipts is the responsibility of NMM. If upon receipt at receiving any radioactive contamination or package damage exists special attention is warranted. Such package unloading and unpackaging is done under the guidance of Health Physics.

Shipping containers remain sealed until they are unloaded. The package contents are verified against data furnished by the supplier concerning the SNM content, chemical composition, and package gross, tare, and net weights, as appropriate. The procedures and methods applied to the opening for sampling and contents verification are described in detail in the licensee's Fundamental Nuclear Material Control Plan.

Temporary storage of incoming and outgoing SNM is permitted in suitable, locked areas, provided that the material is stored in primary shipping containers approved pursuant to 10 CFR Part 71, "Packaging of Radioactive Material for Transport," storage is in an array no more reactive than permitted in 10 CFR Part 71, taking into account other SNM in the storage area, and the requirements of the Physical Protection Plan are met.

The evaluation room is a work room provided with work benches and weighing equipment. A laboratory fume hood is available for material handling and is connected to the ventilation system which contains a high-efficiency particulate air filter.

3.2.1 Nuclear Safety

The nuclear safety of this operation is ensured by adherence to shipping container and storage criteria until the containers are opened one at a time; the contents are removed to the evaluation hood or to storage. Hood safety is based on the mass and/or geometry limits of the individual SNM package, since the conetents of only one package at a time are permitted within the evaluation hood. Storage nuclear safety is discussed in Section 3.3.

3.2.2 Radiological Safety

Radiological safety is based upon conducting operations in an approved enclosure after the materials are removed from their shipping containers. Any suspect shipping container and all containers of plutonium are checked for outside surface contamination prior to opening, and the inside of the lid is checked immediately upon removal.

3.2.3 Criticality Alarms

The requirements of 10 CFR 70.24 for criticality alarms monitoring the temporary storage of SNM in sealed shipping containers loaded on their vehicles pursuant to 10 CFR Part 71 are exempted. The nuclear safety of the shipping containers during transportation has been demonstrated in the application for NRC approval. The conditions prevailing during temporary storage are entirely analogous to those prevailing during transport by common carrier when no criticality alarms are required.

3.3 STORAGE

SNM is stored in vault-type rooms and protected areas specifically designated for this use only. Most of the storage is under the direct control of trained and authorized NMM personnel, and access is restricted to authorized personnel. Storage areas are constructed and equipped to meet NRC regulations.

The storage locations active at the present time and listed in the order of discussion herein are:

NMM Central Storage Facility
By-Products Storage Building in the Waste Yard
Hot Cell Storage Yard
Irradiated TRIGA Element Storage at the Waste Yard
NMM Central Storage Yard

3.3.1 NMM Central Storage Facility

Facility Description

The NMM Central Storage Facility is located in the south end of the TRIGA Building which is within the main site, adjacent to and east of the Hot Cell. The building also contains the TRIGA Fuel Fabrication Facility which is described in a separate section. The NMM Central Storage Facility is divided into two SNM storage areas; the drum storage and a vault-type storage room. The NMM vault-type room adjoins the TRIGA Fuel Fabrication Facility storage room. The two main facilities, i.e., the TRIGA Fuel Fabrication and NMM central Storage, have separate access control through use of separate entry doors in the building lobby.

The overall building is designed with an outside equipment pad area which contains the HEPA Filter & Blower System and other building services thereby eliminating unnecessary access to the material access areas by the supply and service persons.

The overall ventilation system for the building consists of several independent blower systems. One system of exhaust blowers provides exhaust for the storage areas to assure proper air flow and negative pressure differential. Building exhausts are equipped with high-efficiency air filters and air sampling equipment.

The construction of the entire building is primarily of concrete; either prestressed or reinforced. The walls are nominally 7-in.-thick, reinforced concrete. The exterior doors are of heavy gauge metal, meeting the requirements of 10 CFR 73. The roof is of prestressed concrete beams over which a concrete slab is poured and is sloped sufficiently to eliminate the possibility of water pooling.

3.3.1.1 NMM Vault-Type Storage Room

This room is used for the general storage of SNM materials that are not currently required in the various operational MBAs and production facilities. The room area is constructed with 1-ft-thick walls of 140 lb/ft^3 concrete. Five such parallel walls define and provide nuclear isolation between four aisles. The SNM is stored in a 40 ft long planar array on one wall of each aisle. A movable partition meeting the requirements of 10 CFR 73 is provided to permit adjustment of the material access area boundaries since the area is shared between two facilities. The northern part is used for storage by the TRIGA Fuel Fabrication Faciltiy and is further discussed in Section 3.7. The southern part, currently two of the four aisles, constitutes the NMM Vault-Type Storage Room.

3.3.1.1.1 Materials Storage

The Vault-Type Room is designed for storing a variety of materials, including R&D materials and materials generated by the fuel manufacturing processes. Consequently, a general set of storage rules governs storage in the room. The most useful storage geometry takes the form of defined bins in an overall rack. The horizontal spacing is 16 in. center-to-center, 8 in. surface-to-surface. The vertical spacing is 18 in. center-to-center. The spacing is assured by fixed shelves and spacers. Storage is in compliance with one of the following criteria:

1. Uranium materials may be stored in containers of 1-gallon volume or less limited to contents of 3.6 kg U-235 or less. The individual units are standard Type B in Section 5.5, Part I, and are justified nuclearly safe therein. The array of units is standard Type G in Section 5.5, Part I and the nuclear safety is justified therein.

2. Unmoderated or moderated metal, alloy, or compounds may be stored in closed containers limited to 2.4 kg of plutonium in a 2.4 liter volume or 1.3 kg of U-233 in a 1.3 liter volume. These limits are standard Type D in Section 5.5, Part I, and are justified nuclearly safe therein. The array of units is standard Type H in Section 5.5, Part I and the nuclear safety is justified therein.

Plane arrays based upon area density or thickness are also used. In each case metal fixtures are used to assure the specified conditions are maintained. Storage is in compliance with one of the following criteria.

3. Moderated SNM may be stored in isolated plane arrays not to exceed an average of 0.160 kg of U-235 per foot square of aspect area. The maximum allowable subcrit unit is limited to 250 g U-235. This limit is standard Type E in Section 5.5, Part I and is justified nuclearly safe therein.

4. SNM may be stored in a flat plane configuration, parallel to a storage wall, as long as the thickness of the plane is not greater than: 1.5 in. and the uranium concentration is not greater than 0.4 kg U-235 per liter of array volume. From Fig. I 5.4-4, the safe thickness for an infinite slab is 1.5 in. for uranium concentration up to 0.4 kg U-235 per liter.

The 12 in. concrete walls between the parallel aisles act both as reflectors and as nuclear isolation. The effects of concrete as a reflector is discussed in standard limit Type G in Section 5.5, Part I. The nuclear isolation effects of concrete walls are discussed in Section 3.1.3.2, nuclear safety of the SV-A Tunnel Storage where the effect on reactivity of two or more parallel arrays with concrete between is presented. It is shown in Section 3.1.3.2 that increasing thicknesses of intervening concrete from 8 in. to 12 in. reduces the interaction between two parallel storage arrays. The nuclear safety of four parallel storage arrays with nominal 8 in. concrete isolation is also shown in Section 3.1.3.2. It follows that the NMM Vault-Type Storage Room with 12 in thick walls is less reactive than the 8 in. wall system of Section 3.1.3.2 and its nuclear safety is adequately assured.

3.3.1.1.2 Radiological Safety

All materials for storage are in closed containers that are free of wipeable surface contamination prior to admission to the storage area. Materials that cannot meet this criterion are placed within plastic bags to prevent the spread of contamination. No materials processing is permitted within the storage areas other than sampling for analysis or splitting of a package of material. These operations are restricted to an approved hood and are limited to handling the contents of a single storage location at any one time.

3.3.1.2 Drum Storage Area

The drum storage area is a room of about 33 x 60 ft dimension for the storage of 55-gallon drums, each containing up to 350 g of U-235 or SNM contained in authorized shipping containers. The drum storage area and the shipping container storage area are isolated from each other by 16-in. thick, 140 lb/ft^3 concrete in the form of movable blocks.

Storage of SNM in this area is governed by the following limitations:

Limitation A - Storage in Shipping Containers

1. SNM materials in approved DOT, NRC or DOE shipping containers may be stored in separate, isolated areas provided each such area does not exceed a transport index of 50 or does not exceed an appropriate quantity authorized by fissile Class III shipping criteria.

Limitation B -

1. Material is stored in 55-gallon drums; in each drum the maximum U-235 content is 350 g. Plutonium and U-233 may not be stored in this area

2. Drums in the storage area must be in a single horizontal plane array.

3. Drums are stored in an upright position only.

4. Each drum is closed with a bolted locking ring.

5. Each drum in the storage area has a serial number painted on it for identification. Written records of the identity and quantity of material, by drum serial number, are maintained.

The nuclear safety of Limitation A is based upon the shipping container approvals and Specification 7.4(5) in Part II.

The nuclear safety of Limitation B is based upon the 350 g per container and the plane array of containers. This limit is standard Type F in Section 5.5, Part I, and is justif · nuclearly safe therein.

3.3.1.3 Evaluation Room

A room adjacent to the drum storage area and within the material access area is used for the sampling and evaluation of receipts, shipments and stored items. The room is equipped with a balance and a hood connected to the building HEPA filter and exhaust system.

There are two general purpose modes of operation for handling SNM in the Evaluation Room Hood.

Case I. Total U-235 content of the SNM is less than 350 g.

There is no limit on the size, shape, or number of containers in the Hood.

Case II. Total U-235 content of the SNM is greater than 350 g.

Containers must be 1 gallon or less and must be separated by 12 inches surface to surface. Separation is to be enforced by marked container locations or fixtures that maintain separation.

The nuclear safety of Case I is based on standard limit Type A, and Case II is based on standard limit Type B, both in Section 5.5, Part I.

Containers of materials being handled in the facility are temporarily held in a storage rack secured to the isolation wall in the facility entry passageway. This rack provides 16 inch center-to-center, 8-inch surface-to-surface horizontal spacing and 18 inch center-to-center vertical spacing of containers. The use of this rack is limited to storage criteria 1 and 2 as set forth in section 3.3.1.1.1 on page I 3-104. Nuclear isolation is provided from the adjacent Vault-type Room by a 12 inch concrete wall. Isolation from the drum and shipping container areas is assured by isolation walls and/or distance.

3.3.2 ECF Storage FAcility

The ECF Storage Facility is located in two buildings that formerly housed an experimental reactor. The operating license for this reactor has been terminated. This facility is no longer utilized; it is retained here to preserve documentation of the special storage array that was used.

The facility is comprised of two buildings. The buildings, shown in Fig. I 3.3-1 and I 3.3-2, respectively, are a reactor building and an assembly building. The facility layout, including the protected area, is shown in Fig. I 3.3-3.

The reactor building consists of a 2 ft thick concrete shielded cell and an entry foyer. The shielded exposure cell is 27 ft wide x 42 ft long x 23 ft high. The foyer is 27 ft long x 12 ft wide. The roof is a series of 24 in. reinforced concrete beams. Access to the cell is through two 1/2 in. thick steel bulkhead doors, or through a large shield plug in one wall. One of the bulkhead doors is an emergency exit only with no access from the outside. Cell access via the other door or the shield plug must be gained through the foyer. Access to the foyer is via a large metal roll-up door or a metal clad personnel door. These accesses are locked. The building floor plan is shown in Fig. I 3.3-1.

The assembly building consists of a metal building 20 ft wide x 26.5 ft long x 8 ft high. The building has a concrete slab floor. The building floor plan is shown in Fig. I 3.3-2.

For purposes of SNM storage the facility is considered to be three separate storage areas; the assembly building, the reactor cell and the reactor building foyer. Each of these is nuclearly isolated from the other. The assembly building is isolated by distance and the intervening shield wall isolates the reactor cell and the foyer.

The reactor cell has been designed to house fast and intermediate neutron spectrum critical assemblies. For this reason it does not have a means of water supply. The location of the structure is near the edge of a small canyon and any runoff water drains freely away from the building.

3.3.2.1 Storage Criteria

Several types of authorized SNM storage are utilized as discussed below. Each ECF storage area may be used for only one type of storage at a time. Due to the nuclear isolation, a different type of storage may be used in different areas except that Type 3 storage, HTGR fuel materials in 55-gallon barrels is restricted to use in the two reactor building areas due to the necessity to restrict the use of water.

Type 1. FSV-3 Shipping Container

HTGR fuel elements loaded in FSV-3 shipping containers may be stored in plane arrays and stacked no more than three high.

Type 2. Barrels - General

Special nuclear material may be stored in 55-gallon or larger capacity metal barrels. Each barrel will be limited to 350 g U-235. Barrels may be placed in a side-by-side arrangement forming single plane arrays.

Type 3. Barrels - HTGR Fuel Materials

HTGR type fuel materials may be stored in 55-gallon or larger metal barrels double stacked in a plane array subject to the limitations given below.

a. Each barrel is limited to 350 g U-235 in HTGR process/product type materials.

b. All fuel materials shall also contain thorium at Th/U-235 ratio of 3.3552 or greater.

c. Only fuel materials such as particles, rods and certain process scrap may be stored. Specifically bulk waste, such as wipes and paper, may not be so stored.

d. The total array shall be limited to 23 by 14 by 2 units or smaller.

e. The container shall be steel barrels, 55 gallon or larger.

f. Each unit in the array shall be allocated a space equivalent to a cuboid 22.345 in. square by 32.695 in. high or larger.

g. The storage area shall be within a building. The space utilized shall be free of a piped water supply and shall be posted that introduction of water is forbidden.

3.3.2.2 Nuclear Safety Analysis

The nuclear safety of the loaded FSV-3 shipping containers in storage (Type 1) is assured by limitation of the plane array to not more than three layers. A detailed analysis of this array, described in Ref. 3.3-1, assumed the FSV-3 containers to be loaded with 1.5 kg or fully enriched uranium and 11.3 kg of thorium per element/container. The containers were taken to be in closest packing array geometry. Both diffusion and transport calculations using broad group cross sections were made. The analyses indicate a k_{eff} of 0.731 for an infinite planar array of the containers stacked 3 high, and a k_{eff} of 0.877 for a flooded array that is infinite in all three directions.

The nuclear safety of the Type 2, barrels-general, storage array is based upon standard limit Type F, Section 5.5, Part I, and is justified nuclearly safe therein.

The nuclear safety of the Barrel - HTGR Fuel Materials (Type 3) has been determined by a series of calculations as outlined below. Because of the restriction to HTGR materials, credit can be taken for neutron absorption by Th-232. The nominal Th-232/U-235 ratio is taken as that of the lowest ratio particles that are produced, 3.3552. The bulk of the materials requiring storage are fuel rods, composed of a mixture of fissile and fertile particles, with Th/U ratios up to 20. In addition, the barrels contain carbon and possibly some water -- at least in the region where the uranium is localized (the "fuel" region). The densities of the materials in the fuel region have been tabulated in Table I 3.3-1 along with the densities of the metal container and the water reflector. Optimum moderation (H/U-235 = 100, 500) by hydrogen has been assumed.

TABLE I 3.3-1
MATERIAL COMPOSITION

	Isotope	Atom Density, Ratio or Mass
A.	Fuel Region	
	H^{1}	H/U-235 = 100, 500
	O^{16}	H/O = 2
	C^{12}	C/U-235 = 335
	Th-232	Th/U-235 = 3.3552
	U-234 (0.8%)	3 grams
	U-235 (93.2%)	350 grams
	U-238 (6.0%)	22.5 grams
B.	Metal Container	
	Fe^{56}	8.48×10^{-2} atoms/barn-cm
C.	Water Reflector	
	H^{1}	6.70×10^{-2} atoms/barn-cm
	O^{16}	3.35×10^{-2} atoms/barn-cm

The dimensions of a single barrel are given in Table I 3.3-2. Since the outside diameter of a barrel is at least 56.7563 cm and the lateral dimensiona of the storage room are 27 ft x 42 ft, the maximum planar array is 22.56 x 14.50 barrels. Thus, consideration of a 23 x 14 x 2 array will yield results which are conservative when applied to two-layered arrays which can actually be stored in the building, when structural interferences which restrict the space utilization are considered. Further, conservatism is provided by the fact that the top reflector is 17 ft away rather than being close coupled as assumed in the model.

TABLE I 3.3-2
BARREL GEOMETRY

A.	Inner Dimensions	
	Diameter	56.515 cm
	Height	82.8675
B.	Metal Thickness	
	Sides	0.12065 cm
	Ends	0.088392 cm

Description of the Model

The 23 x 14 x 2 array has been modeled as a cubical array with the barrels in close contact in all three directions. Water reflection of the array was modeled by including a layer greater than 20 cm thick tightly surrounding all 6 sides. In addition, consideration was given to full density water between the barrels. Fig. I 3.3-4 shows a partial schematic of the array geometry.

The model for the individual barrels is shown in Fig. I 3.3-5. Three coaxial cylinders were defined which corresponded to the fuel, inner barrel and metal container regions. The height and diameter of the inner cylinder (the fuel) were allowed to vary, subject to the obvious constraint that they could not exceed the inner dimensions of the barrel. Credit was taken for the effect of gravity in that the fuel region was required to be in contact with the bottom of the barrel. The space between the fuel region and metal container was assumed to be a vacuum ("void").

Analysis

The effective neutron multiplications for the arrays that were studied were calculated with the KENO computer code (Ref. 3.3-2). Cross-sections used in the calculations were generated using the MICROX spectrum code (Ref. 3.3-3). Specifically, 18-group* modified P1 transport cross-sections were generated for cylindrical fuel regions whose material densities were defined by the criteria in Table I 3.3-1 and by fixed total volumes for the fuel region. These total volumes are listed in Table I 3.3-3. The maximum and intermediate volumes in this table [illegible] those for the whole barrel and for a cylinder with the same diam[illegible] [illegible] a height of 1 ft. The minimum volumes were determined such that the water in the fuel mixture was at maximum density (at the given H/U-235 ratio).

TABLE I 3.3-3
TOTAL VOLUMES OF FUEL REGIONS

H/U-235 Ratio	Minimum	Intermediate	Maximum
100	1.35 liters	76.5 liters	207.9 liters
500	6.71 liters	76.5 liters	207.9 liters

*The energies of the 18 groups are given in Section 5, Table I 5.3-2.

Using the appropriate MICROX cross-sections, the following k_{eff} calculations were made:

a. Arrays with full water moderation between the barrels; H/U-235 ratios of 100 and 500; all three fuel region volumes (the diameter of the fuel region in this case was equal to the inner diameter of the barrel).

b. Arrays with no water moderation between the barrels; H/U-235 = 500; all three fuel region volumes (diameter of fuel region equal to inner barrel diameter).

c. Arrays with no water moderation between the barrels; H/U-235 = 500; fuel region volume of 6.71 liters; in this case the diameter of the fuel region was allowed to be less than the inner barrel diameter.

In addition to these, calculations were made for a homogenous water reflected slab whose dimensions were the same as the 23 x 14 x 2 array and for a single bare cylinder with height equal to diameter at maximum water density. Both of these were at H/U-235 = 500. The latter calculation was for comparison with the results of a 1-dimensional transport calculation performed with the DTFX code (Ref. 3.3-4 and 3.3-5).

Results

The results of calculations A, B and C described in the preceding section are given in Tables I 3.3-4, I 3. and I 3.3-6 respectively. In these tables, is the statistical standard deviaiton of the results and reflects generation to generation variation in the calculated k_{eff}. For comparison with these, the KENO calculcation of the water reflected slab yielded a k_{eff} of 0.44 ± 0.1. The results of the single barrel calculations are listed in Table I 3.3-7. The agreement between the DTFX and KENO values for the bare sphere are very good.

TABLE I 3.3-4
K_{EFF} FOR ARRAY WITH FULL WATER MODERATION BETWEEN BARRELS

H/U-235	Volume of Fuel Region (Liters)	k_{eff}	
100	1.35	0.24	0.011
	76.5	0.25	0.017
	207.9	0.25	0.007
500	6.71	0.34	0.005
	207.9	0.28	0.008

TABLE I 3.3-5
K_{EFF} FOR ARRAY WITH NO WATER MODERATION BETWEEN BARRELS

H/U-235	Volume of Fuel Region (Liters)	k_{eff}	
500	6.71	0.43	0.007
	76.5	0.41	0.008
	207.9	0.36	0.008

TABLE I 3.3-6
REDUCED DIAMETER ARRAYS

H/U-235	Diameter (cm)	Height (cm)	k_{eff}	
500	56.515	2.675	0.43	0.007
	37.676	6.002	0.58	0.011
	24.703	14.00	0.80	0.016
	20.443	20.443	0.85	0.011
	16.74	30.48	0.80	0.010
	10.15	82.8675	0.56	0.011

TABLE I 3.3-7
K_{EFF} FOR SINGLE BARRELS

A. KENO Calculations for Water Reflected, Full Diameter Geometries

H/U-235	Volume of Fuel Region (Liters)	k_{eff}
100	1.35	0.16
	207.9	0.11

B. KENO and DTFX Calculations for Bare, Reduced Diameter Geometries

H/U-235	Volume of Fuel Region (Liters)	k_{eff} (DTFX)	k_{eff} (KENO)
50	6.71	0.69	0.72 ± 0.0126

(Height = Diameter = 20.443 cm)

Conclusions

Several conclusions can be drawn from the results of Tables I. 3.3-4 through I 3.3-6.

From the first table, it is apparent that H/U-235 = 500 is the more reactive of the two moderation ratios. Thus, this value has been used in the other calculations. From the results in Tables I 3.3-4 and I 3.3-5, it is clear that full water moderation between the barrels actually lowers the reactivity of the array. This might have been expected in light of the optimum moderation in the fuel regions and the large volumes between the barrels. It is not safe to assume, however, that water between the barrels at less than full densities is less reactive than when no water is present. Another conclusion that can be drawn from the tables is that the array is much less reactive when the fuel region is smeared over a large volume than when it is at its minimum volume. This effect is due to the greatly reduced leakages and U-235 densities, and suggests that the interaction between the barrels is not the dominating factor. A good example for comparison with these smeared cases is the low k_{eff} of the homogenous water reflected slab (0.44). The densities for the slab were the same as those for the V = 207.9 liter cylinder.

The criticality safety of the array is established by the results in Table I 3.3-6. This data is plotted in Fig. I 3.3-6 and shows the strong peaking at 0.85 for the case in which the fuel regions have equal heights and diameters. From Table I 3.3-7, the k_{eff} of the single bare fuel region itself is 0.7, so the array is not much more reactive than the single container. It should be pointed out that under the assumption of no moderation between the barrels, moving the barrels farther apart will give a lower k_{eff} for the array.

3.3.2.3 Radiological Safety

Criticality alarms are provided for all three storage areas at the facility. Radiological safety is assured by only handling closed containers.

3.3.3 By-Products Building in the Waste Yard

This storage facility is a metal butler-type building with a concrete floor. It is approximately 20 ft by 20 ft. Although it is primarily for by-products, various types of SNM (principally irradiated materials) are also stored in this area.

This storage facility is secured by a changeable combination padlock and is within the chain link security fence which surrounds the Waste Yard. Gates in the fence are secured by locks keyed to the Gulf security system. The criticality alarm system is a part of the alarm system serving the Waste Yard.

Four types of storage are provided for SNM and are described as follows:

Lazy Susans

This storage comprises six cylindrical tubes approximately 24 in. in diameter which are located along the north wall of the storage area. These tubes extend 8 ft above and below ground level. When not in use, these tubes are stored in the down position. Mounted on each tube are three circular shelves approximately 24 in. in diameter and vertically spaced 17 in. apart. Containers of material are placed on these shelves for storage.

Barrel Storage

High-radiation level barrels may be stored in four below-ground-level cylindrical concrete line holes. These holes are 30 in. in diameter, extending 11 ft 4 in. below the floor and separated from each other by approximately 10 in. edge-to-edge. Each hole has a removable plug of solid concrete 30 in. thick.

Storage Shelves

Along the west wall of the building are two shelves, each 20 ft in length. One shelf is 10 in. deep and 15 in. wide and the other is 37 in. deep and 10 in. wide. Both shelves are constructed of concrete with 10-in.-thick concrete lips across their fronts for personnel shielding.

Floor Storage

Occasionally, materials are stored on the floor. However, this arrangement is used only for materials, such as sources, that can be stored in shipping containers that provide adequate personnel shielding.

3.3.3.1 Materials Storage

Storage in the lazy susans and on the storage shelves is in accordance with the criteria that govern storage in the NMM Vault-Type Storage Room at the Central Storage Facility. Each barrel storage position is limited to 350 g of U-235, 220 g of plutonium, or 250 g of U-233. The U-235 limit is the same as a Type A in Section 5.5, Part I for individual units and Type F for arrays involving only U-235. The plutonium and U-233 limits are based on the minima in the curves of Figs. I 5.4-5 and I 5.4-8. Interaction calculations are required when containers of Pu and/or U-233 are stored on the floor.

3.3.3.2 Radiological Safety

Only closed containers of materials can be handled in this room. The only hazard is gamma radiation from radioactive materials.

3.3.4 Hot Cell Storage Yard

This is a specially secured, posted, alarmed, and doubly fenced area located within the Guard Station 2 controlled area and is immediately adjacent to the Hot Cell Facility and under the control of the facility staff. The area is used for storing irradiated material and SNM contained within either approved shipping containers or within other types of shielding and/or containers that are used solely within the confines of the main site.

3.3.4.1 Materials Storage

A maximum of 5 kg of SNM may be stored in this area. Storage geometries are no more reactive than those approved for the shipping containers and/or arrays.

3.3.4.2 Radiological Safety

The materials stored are highly radioactive. Adequate shielding is used to reduce the radiation level at the inner fence to less than 100 mRems/hr, and the fence is posted as a "High Radiation Area." An alarm on the gate leading into this area turns on a flashing warning light in the area and warns areas manned on a 24-hour basis (the Hot Cell Facility Office and the central security office). The Hot Cell Yard is a controlled area with physical barriers with radiation area posting. The level at this barrier is less than 2 mRems/hr, 100 mRems/7 days, and 500 mRems/yr.

3.3.5 Irradiated TRIGA Element Storage at the Waste Yard

This storage facility may contain irradiated uranium-zirconium fuel elements in two kinds of storage. The area is roughly rectangular, about 80 ft by 100 ft, and its nearest point is about 1000 ft east of the TRIGA Reactors Building. It is enclosed by an 8-ft-high chain link fence with a locked gate. The area is adjacent to the Waste Yard and is provided with a criticality alarm that is a part of the Waste Yard system.

3.3.5.1 Materials Storage

In the area, up to a maximum of 650 g of U-235 in the form of uranium-zirconium fuel elements may be stored in each of the containers employed; these are standard 55-gallon metal drums with axially centered 8-in. iron pipes (which may be lined with lead for radiation control) with the annuli filled with magnetite ore. Drum lids are a conventional type with gaskets and clamping bands. Under the lids and resting upon the pipe tops are lead shields approximately 16 $in.^2$ and 2 in. thick. Drums are stored in a single plane array, isolated from all other stored U-235.

A detailed criticality analysis was performed on the drum storage using the GGC-5 spectrum code and the 1DFX discrete ordinates transport code described in Section 5, Part I, Nuclear Safety. Nine energy group cross sections were used; these cross sections were averaged over a 500/1 H/U-235 water-uranium spectrum. The model described in Table I 3.3-8 was utilized.

TABLE I 3.3-8
TRIGA DRUM STORAGE MODEL CYLINDRICAL GEOMETRY

Radius (cm)	0.0	10.16	10.98	28.57	28.73
Region	1	2	3	4	
Material	Fuel, H_2O	Iron	Magnetite, H_2O	Iron	
Number density (atoms/barn-cm)					
H	$6.83x10^{-2}$	-	-		
O	$1.35x10^{-2}$	-	$2.42x10^{-2}$	-	
Fe		$8.41x10^{-2}$	$1.82x10^{-2}$	$8.41x10^{-2}$	
U-235	$7.26x10^{-4}$	-	-	-	
U-238	$5.05x10^{-5}$	-	-	-	

Height (cm): H = 38.50, $\tilde{H}$ = 43.56 (height plus reflector savings)

Boundary conditions: Left: $\Delta\phi = 0$ (symmetry)

Right: $\Delta\phi = 0$ (to model infinite plane array of drums)

$k_{eff} = 0.83$

This model represents 17 fresh TRIGA fuel elements containing a total of 650 g of U-235. The central pipe is fully flooded and homogenized, which results in an H/U-235 ratio of 430, very close to optimum. Fully enriched uranium was assumed, although the standard TRIGA element contains 20% enriched fuel, and the TRIGA-FLIP fuel is 70% enriched with a heavy load of erbium poison. The magnetite ore shielding material was assumed to be dry which results in maximum interaction with the surrounding drums.

This conservative model was found to be significantly subcritical with a k_{eff} of 0.83. Further calculations were performed to study the effect of enrichment changes and changes in the magnetite water content, the effect of stacking the drums vertically, and the effect of packing all the drums with the maximum number of rods they will hold (21 rods, 830 g U-235).

The results of these calculations are shown in Table I 3.3-9.

TABLE I 3.3-9
TRIGA DRUM STORAGE k_{eff} VALUES

Case	U-235 (g/drum)	Enrichment (%)	Description	k_{eff}
1	650	93.5	Infinite plane array, dry magnetite	0.83
2	650	20.0	Infinite plane array, dry magnetite	0.78
3	650	93.5	Single drum, dry magnetite	0.78
4	650	93.5	Infinite array, wet magnetite	0.80
5	650	93.5	Infinite array, dry magnetite stacked 2 high	0.89
6	650	93.5	Infinite array, dry magnetite stacked infinitely high	0.91
7	830	93.5	Infinite array, dry magnetite drum packed full	0.95

Optimum moderation in central pipe used for all cases.

The conclusions drawn from this study show that the drum storage facility exhibits no criticality hazard. The maximum possible multiplication under normal operations, using a conservative model, is subcritical with a keff of 0.83. Even if the drums were accidentally stacked vertically or if they were accidentally loaded to maximum capacity, no criticality hazard would exist.

3.3.5.2 Radiological Safety

Radiological safety of this storage yard is based upon the double containment of the irradiated fuel (intact fuel element jackets and capped pipe sections), the shielded containers or storage positions, and the 8-ft fence an' locked gate. The radiation at the point of closest approach is less than 100 mRems/hr, and the fence is posted as a "High Radiation Area."

3.3.6 NMM Central Storage Yard

The NMM Central Storage Yard is an area, about 70 ft. square, enclosed by an 8-ft-high chain link fence with a locked gate. It is located to the north of the building housing the TRIGA Fabrication Facility and the NMM Central Storage Facility. A criticality alarm system is provided per Part II, Section 4.2.1.4, Criticality Alarm System.

SNM may be stored in a plane array of 55-gallon barrels or larger capacity containers. Each container will be limited to a maximum of 350 g of U-235. The individual containers are nuclearly safe on the basis that they are the same as standard limit Type A and the array of containers is safe on the basis of standard limit Type F, Section 5.5.

REFERENCES

3.3-1 "Nuclear Safety Summary of Fuel Rod Production," Amendment to SNM-696, AEC Docket No. 70-734, October 9, 1970.

3.3-2 G. E., Whitesides, N. F., Cross, "KENO - A multigroup Monte Carlo Criticality Program," Union Carbide Corporation - Nuclear Division, Report Number CTC-5, September 10, 1969.

3.3-3 P., Walti, P., Koch, "MICROX - A Two-Region Flux Spectrum Code for the Efficient Calculation of Group Cross-Sections," Gulf-GA-A10827, Gulf General Atomic, 1972.

3.3-4 K. D. Lathrop, "DTF-IV, a FORTRAN-IV Program for Solving the Multigroup Transport Equation with Anisotropic Scattering," Los Alamos Scientific Laboratory, Report Number LA-3373, July 5, 1965.

3.3-5 D. Mathews, "DTFX Code Input Instructions," November 2, 1973.

3.3-6 H. C. Paxton, et al., "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233," USAEC Report TID-7028. Los Alamos Scientific Laboratory and Oak Ridge National Laboratory, June 1964.

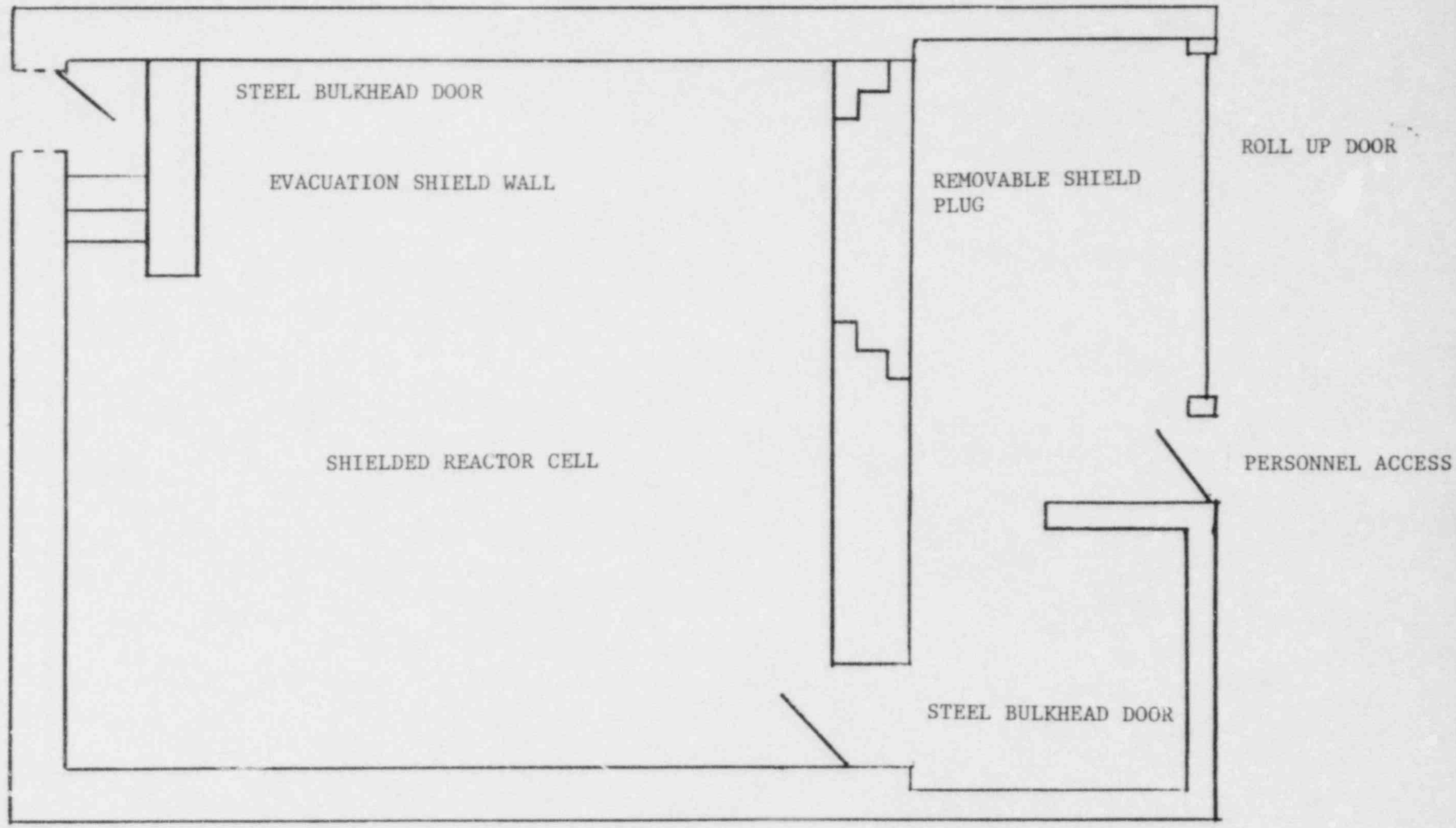


Fig. I 3.3-1 ECF REACTOR BUILDING PLAN VIEW

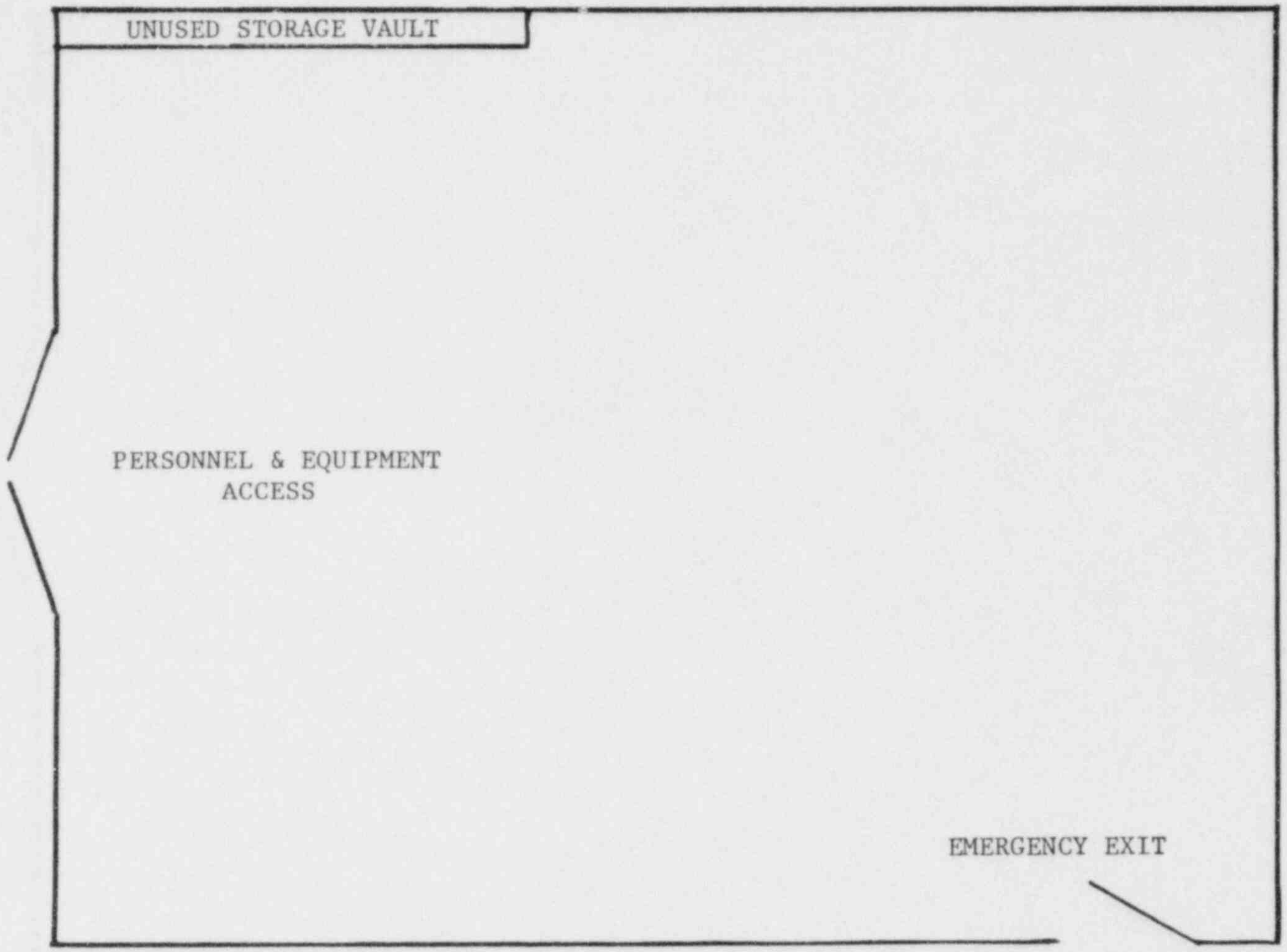


Fig. I 3.3-2 ECF ASSEMBLY BUILDING FLOOR PLAN

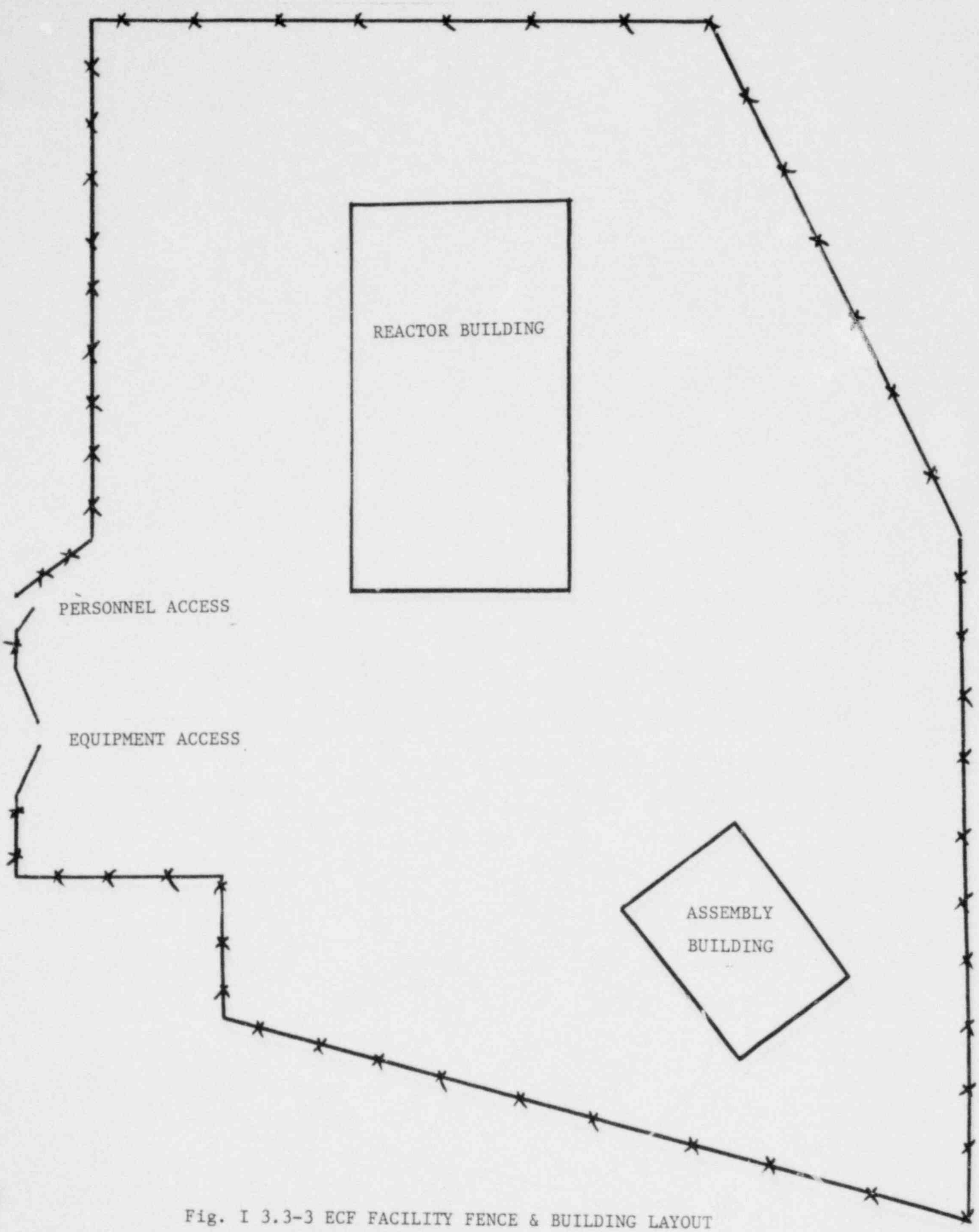


Fig. I 3.3-3 ECF FACILITY FENCE & BUILDING LAYOUT

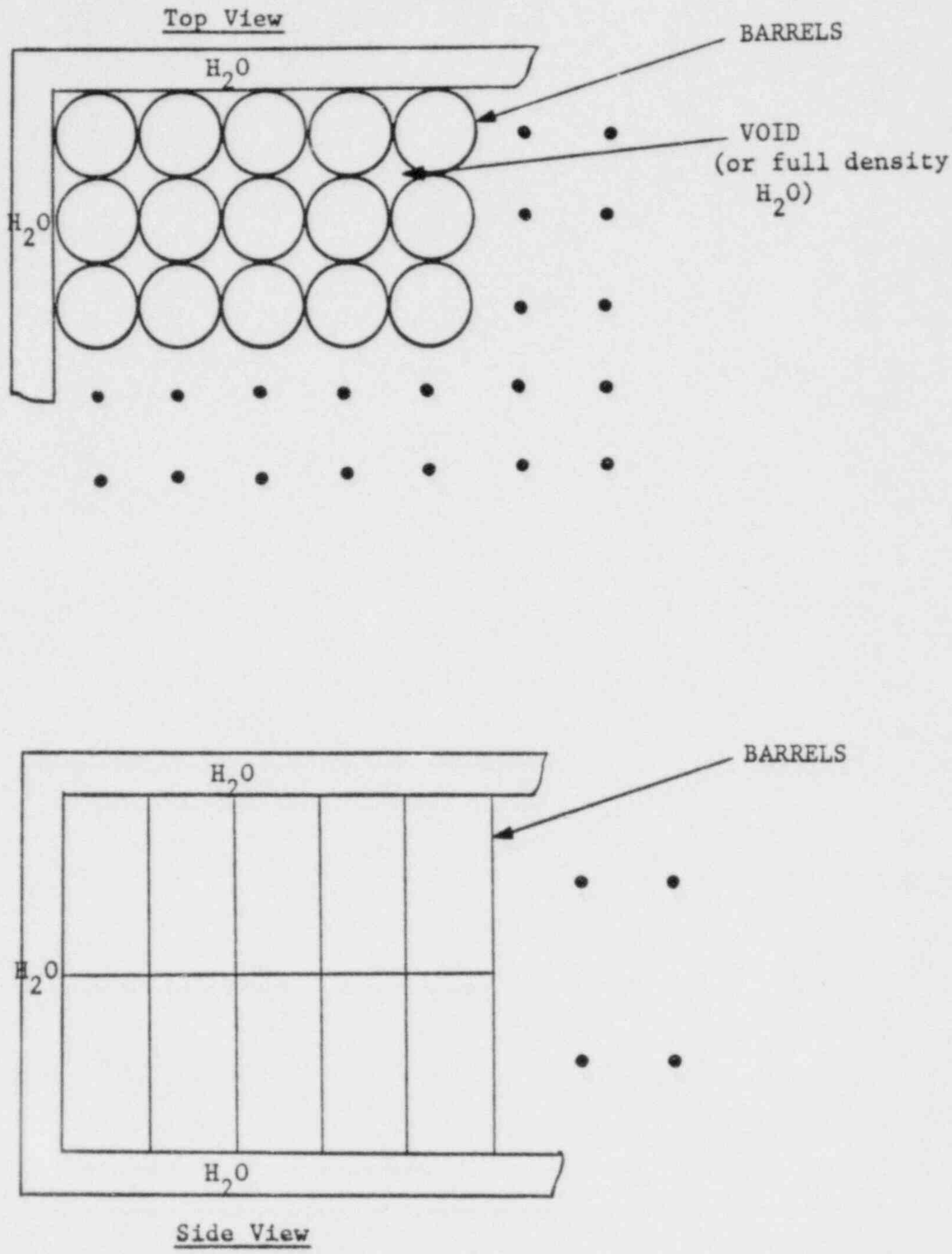


Fig. I 3.3-4 GEOMETRY FOR 23 X 14 X 2 BARREL ARRAY

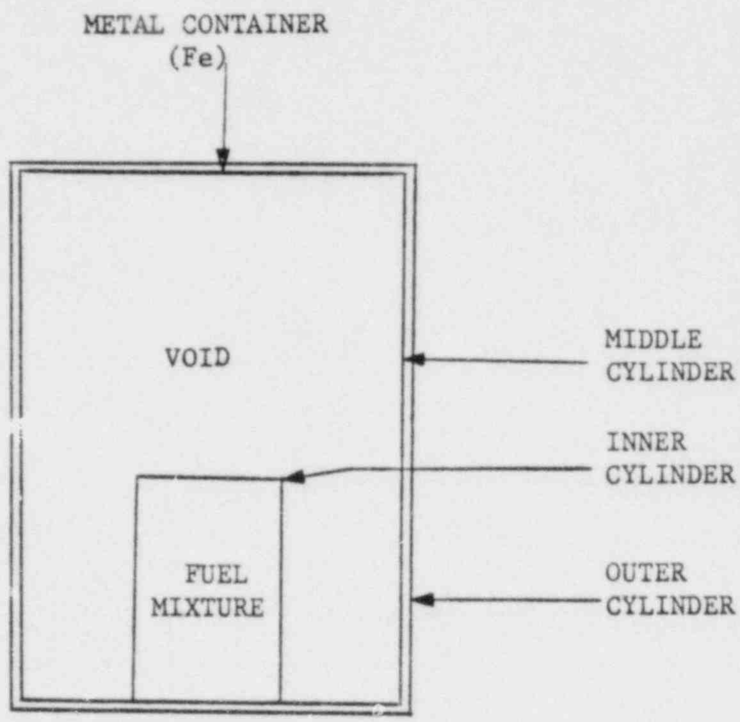


Fig. I 3.3-5 INDIVUDUAL BARREL GEOMETRY

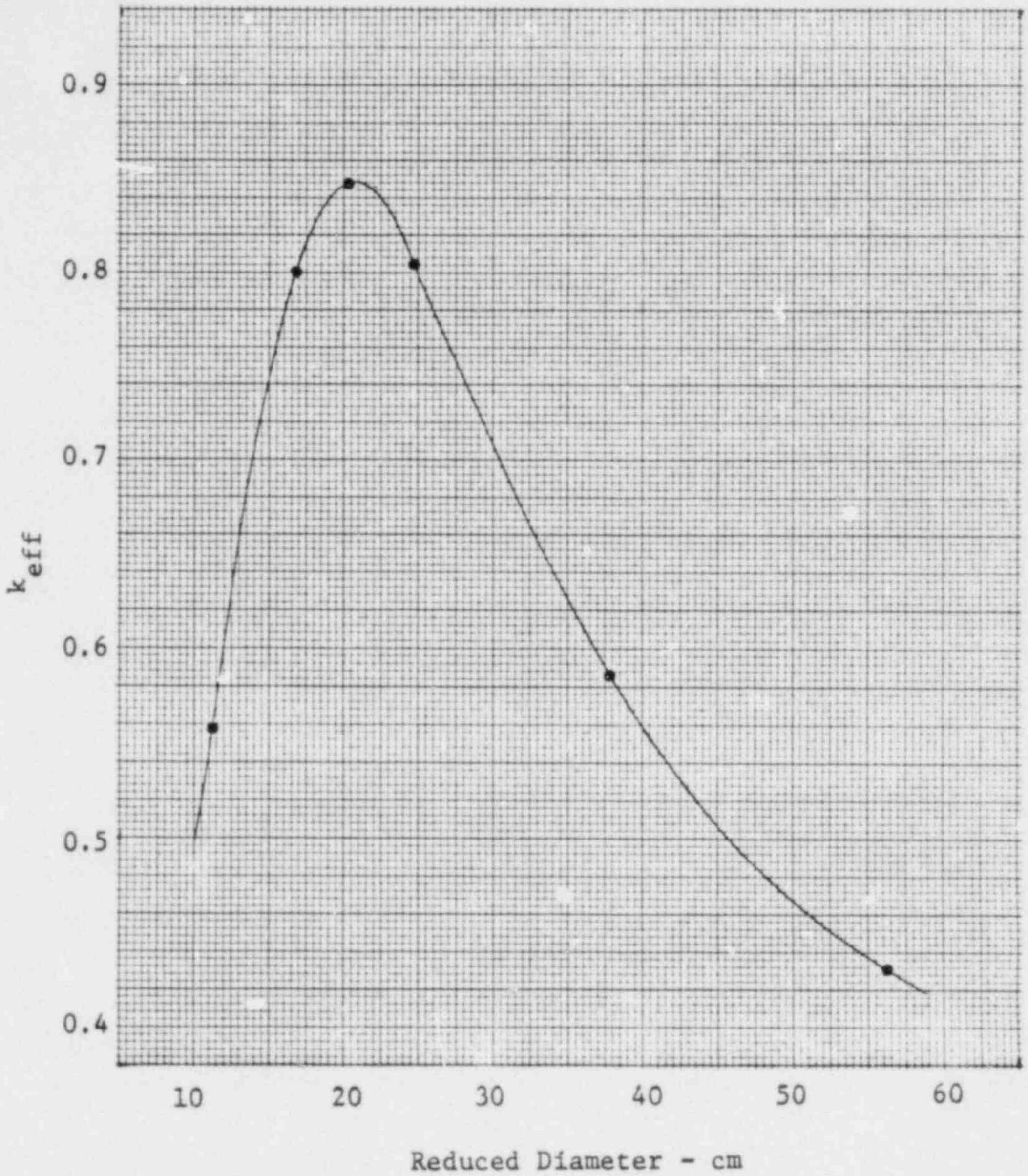


Fig. I 3.3-6 Plot of Reduced Diameter Versus k_{eff} of Array

3.4 LABORATORY OPERATIONS

The laboratory operations include a wide spectrum of small-scale physical, metallurgical, chemical, and engineering investigations utilizing SNM, predominantly U-235. These efforts are characterised by performance of experiments by skilled scientific personnel within defined locations, usually a laboratory room. Work in this class is usually conducted in the Laboratory Building and the Experimental Area Building I (EA-I).

These operations have typically included but are not limited to the following efforts using SNM:

1. Detailed metallurgical tests of unirradiated samples containing SNM.

2. Metallurgical examination and chemical analysis of up to 1 Ci of irradiated material containing SNM.

3. Investigation of U-235 hexafluoride -- uranium oxide conversion using less than 500 g of U-235 in enriched uranium on a laboratory scale.

4. Laboratory scale process development for making compacts, particles, and fuel rods containing U-235 and U-233.

5. Development of process control and quality control techniques.

6. Laboratory fabrication and assembly of special reactor test fuel elements.

7. Radiochemical research.

8. Routine chemical analysis.

The safety of these operations is assured by adherence to formal review and approval procedures (see Part II). Every new or changed operation involving SNM must be defined, undergo review and approval, and have a Material Balance Area (MBA) established. These procedures ensure that the operations have been properly planed; that adequate equipment in the form of hoods, fire protection, waste collection, etc., is provided; that personnel have adequate training and experience; and that planned operations are in full compliance with all applicable licenses.

Special nuclear materials in these operations are generally controlled by mass limits. The MBA log book for the operation provides the means of enforcing and auditing adherence to these limits. The possession limit under each MBA is the mass limit authorized; in addition, a throughput limit is often established, depending on the nature of the operations. When a throughput limit is reached, a special review and inspection is made and, generally, the laboratory and its associated waste lines and duct work must be surveyed to ensure that there is no significant holdup within the space; the MBA book is then zeroed out for throughput, and operations may be resumed. Periodic audit ensures that the MBA books are properly maintained, that limits are not exceeded, and that operations are safely conducted.

In terms of SNM criticality safety, laboratory operations are divided into four classes, all based on mass limits. Progressive degrees of control become applicable as the allowable mass in a given laboratory increases. In terms of U-235, the basic level of control is 350 g or less. Operations below this level are quite safe, and a minimum number of controls are necessary. The next level is 500 g or less, which requires controls to prevent exceeding the mass limit. A level of over 500 g but less than 740 g adds the requirement for nuclear isolation (no SNM in adjacent laboratories, or other means of isolation). The first two classes of laboratory operations based on mass limits are listed under the exemption from criticality monitors.

The last class of laboratory operation is one in which highly limited laboratory-scale processes may be carried out at several defined stations. Each station is limited to 350 g of U-235, must have acceptable integrity, and must retain the SNM under accident conditions. In this case, the MBA covers the entire laboratory and may possess over 740 g; however, a log must be maintained on each station to permit auditing and to ensure that the individual 350 g limit is not exceeded. The documentation required to obtain authorization to perform the work must contain physical descriptions of each station, including processes to be performed and means of containment. Also, an acceptable analysis of the nuclear interaction of the various stations must be included. The operating organization must also assign an individual who assures nuclear safety, conducts routine inspections, and advises his management of the nuclear safety control status. The throughput limits in this case apply to the laboratory as a whole, and SNM measurements with statistical control are required.

The criteria for radiological safety with any radioactive material are contained in the Radiological Safety Guide. These criteria must be met in obtaining a Work Authorization. Section 4 of the Specification Volume has been modified to incorporate the criteria.

3.4.1 Nuclear Safety

Laboratory Operation Class One

The mass limits of class one are 350 g U-235, 250 g of U-233, 220 g of Pu-239 (encapsulated), or 220 g of combined SNM within a space defined by walls. These limits are based on Fig. I 5.4-1 and Table 5I 7.4-1, Part II which demonstrate nuclear safety under all conditions of moderation, reflection, and double batching. The physical limits provided by the walls of the space provide adequate isolation.

Laboratory Operation Class Two

The mass limits of class two are 500 g of U-235, 300 g of U-233, 250 g of Pu-239 (encapsulated), or 250 g of combined SNM within a space defined by walls. The laboratory is prevented from exceeding its limits by the controlling of SNM issuance to the MBA. The laboratory must be a controlled access area as defined in 10 CFR 73. These limits are justified by the following analysis of the interaction with similar material in adjacent laboratories.

Interaction between laboratories involving the general limit of 500 g U-235, 300 g U-233, 250 g Pu-239, or 250 g combined SNM is controlled by spacing: no more than two stations may be considered as not isolated by 12 ft or 9 ft including two 5.5-in. concrete block walls. When considering the two stations that can be separated by less than the above distance, such as adjacent laboratories separated by only the intervening wall, the calculations below demonstrate the safety of the two stations.

A detailed criticality analysis was performed to determine the effect of interaction between two laboratory batches of SNM through a laboratory wall. The laboratory batches each consisted of 500 g of 93.5% enriched U-235, 300 g of pure U-233, or 250 g of pure Pu-239. The situation studied was the simultaneous placement of two optimally moderated, fully reflected batches of SNM directly against opposite sides of a 4-in. gypsum board laboratory wall.

The GGC-5 zero-dimension spectrum code, described in Section 5, Part I, was used to average nine energy group cross sections over spectra corresponding to the most reactive degree of water moderation. This most reactive degree of moderation corresponds to the critical mass curve minimum. From Figs. 8, 27, and 34 of TID-7028,* the critical mass minima correspond to water moderation characterized by the hydrogen-to-SNM atom density ratios in Table I 3.4-1.

TABLE I 3.4-1
OPTIMUM MODERATION

SNM	U-235	U-233	Pu-239
H/U or H/Pu	500	430	885
Batch size (g)	500	300	250

The 1DFX discrete ordinates one-dimension transport theory code, also described in Section 5, Part I, was used to determine the multiplication of the system. The model used was developed as described below. The most reactive single unit is a sphere. The size and one-group diffusion theory

---

*Paxton, H. C., et al., "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233," USAEC Report TID-7028, Los Alamos Scientific Laboratory and Oak Ridge National Laboratory, June 1964.

geometric buckling for laboratory batches of optimally moderated SNM in the shape of a sphere were calculated. By maintaining constant geometric buckling, the size of equally reactive or nuclearly equivalent cubes of the same materials was calculated (see Table I 3.4-2).

TABLE I 3.4-2

SPHERE-CUBE EQUIVALENTS

SNM	U-235	U-233	Pu-239
H/U or H/Pu	500	430	885
Batch size (g)	500	300	250
Sphere radius (cm)	13.19	10.61	12.58
Equivalent cube edge size (cm)	22.85	18.37	21.78
Equivalent cube fuel mass (g)	620	373	310

To verify the accuracy of this simple conversion, the multiplications for the two U-235 systems described above were calculated using 1DFX. Nine energy groups were used with S4 quadrature and P1 scattering. The multiplication for 500 g of U-235 in a fully water reflected sphere at an H/U ratio of 500 was found to differ from that of the nuclearly equivalent, fully reflected 620 g cube by less than 0.4%. Thus, the two systems are indeed nuclearly equivalent.

These nuclearly equivalent systems were then used to determine interaction effects. A 1DFX model, shown in Fig. I 3.4-1, was used. Full water reflection on all sides not up against the wall was assumed. Optimal moderation was used: H/U-235 = 500, H/U-233 = 430, and H/Pu-239 = 885. The transverse dimensions were increased by twice the reflector savings for an infinite water reflector to account for reflection on all sides of the units.

Although the most reactive shape for a single unit, in rectangular geometry, is cubic, this is not necessarily true for two interacting units. If the shape is made more flat against the wall, neutron leakage is increased, reducing k_{eff}, but interaction between the two units is increased, which acts to raise k_{eff}. To determine the most reactive shape, a series of 1DFX calculations was run with different shapes for a 620-g batch of U-235 against each side of the laboratory wall. The results of these calculations, shown in Fig. I 3.4-2, reveal that the most reactive shape corresponds to an aspect ratio of 0.86; that is, the unit thickness is 0.86 times the two dimensions up against the wall.

The models used for the final calculations are shown in some detail in Table I 3.4-3. Using these models, 1DFX was used to calculate the system multiplication for two laboratory batches on opposite sides of a 4-in.-thick laboratory wall. The multiplications for these most reactive situations are all safely subcritical (see Table I 3.4-4).

Laboratory Operation Class Three

The mass limits of class three are 740 g of U-235, 530 g of U-233, 460 g of Pu-239 (encapsulated), or 460 g of combined SNM within a nuclearly isolated space. The physical nature of the SNM must be such that it is readily identifiable and well contained. This, together with control of SNM issuance to the MBA, makes exceeding mass limits incredible. These mass limits are justified on the basis that they are 90% of the minimum critical mass assuming optimum moderation and reflection as shown in Part II, Section 5.4. Full nuclear isolation from other SNM must be provided.

TABLE I 3.4-3
LABORATORY BATCH INTERACTION
1DFX MODEL
U-235 - SLAB GEOMETRY

Distance (cm)	0.0	5.08	27.93[a]	37.93[b]
Region	1	2	3	
Material	Wallboard and Air	Fuel and Water	Water	
Number density (atoms/barn-cm)				
H	8.044×10^{-3}	6.665×10^{-2} (c)	6.70×10^{-2}	
O	1.207×10^{-2}	3.333×10^{-2} (c)	3.35×10^{-2}	
Ca	2.011×10^{-3}	--	--	
S	2.011×10^{-3}	--	--	
U-235	--	1.333×10^{-4} (c)	--	
U-238	--	9.264×10^{-6} (c)	--	
Boundary condition $\Delta\phi = 0$ (symmetry)				$\phi = 0$ (vacuum)
Transverse dimensions - (cm) - including reflector savings		28.31[d]		

Other SNM:		U-233	Pu-239
Distance (cm)	(a)	21.70	24.78
	(b)	31.7	34.8
Fuel region density (c)	H	6.682×10^{-2}	6.692×10^{-2}
	O	3.341×10^{-2}	3.346×10^{-2}
	U-233 or Pu-239	1.551×10^{-4}	7.560×10^{-5}
Transverse distance (cm)	(d)	24.78	28.37

TABLE I 3.4-4
k_{eff} VALUES

Most Reactive Configuration

SNM	U-235	U-233	Pu-239
Batch size (g)	500	300	250
k_{eff}	0.920	0.874	0.867

Isolation by separation is provided by not permitting SNM to enter laboratories adjacent to a class three laboratory that share a common wall unless that wall meets the 12 in.-of-concrete criteria.

<u>Laboratory Operation Class Four</u>

The mass limits of class four are 350 g of U-235 per defined and documented station [illegible] 5 kg in MBA possession. U-233 and plutonium are not permissible under this rule. The safety of the individual station is justified under standard limit Type A, Section 5.5, Part I, which demonstrates the safety of the individual 350-g stations under the combined conditions of optimum moderation, reflection, and double batching.

Calculations of the interaction between the various 350-g stations must be made and documented and undergo review and approval as specified in Part II. The k_{eff} for each 350-g station shall be taken as 0.62 and the maximum allowable solid angle shall be 2.80 steradians.

3.4.2 Radiological Safety

Radiological safety of laboratory operations is based upon the utilization of control procedures and equipment meeting the specification in Section 4.1, Part II. No operation may be undertaken until the workers have been formally qualified, the radiological hazards have been defined, the proper provisions for control have been made, and the proposed operations have been reviewed and approved.

3.4.3 Criticality Alarms

All operations involving more than 500 g of U-235, 300 g of U-233, 300 g of Pu-239, or 300 g of combined SNM requires a criticality alarm which meets the specification in Section 4.2.1.4, Part II.

Exemption has been requested from the requirements of 10 CFR 70.24 for criticality alarms monitoring those operations carried out under laboratory class one limits. The mass limits of class one are 350 g U-235, 250 g of U-233, 220 g of plutonium (encapsulated), or 200 g of combined SNM within a space defined by walls.

The request is justified because of the safety provided by this very conservative, "always safe" operating limit. The nuclear safety of the mass limits is set forth in standard limit Type A in Section 5.5.1, Part I. Additional safety is provided by the requirement that only one such limit can be in the laboratory space as defined by the walls.

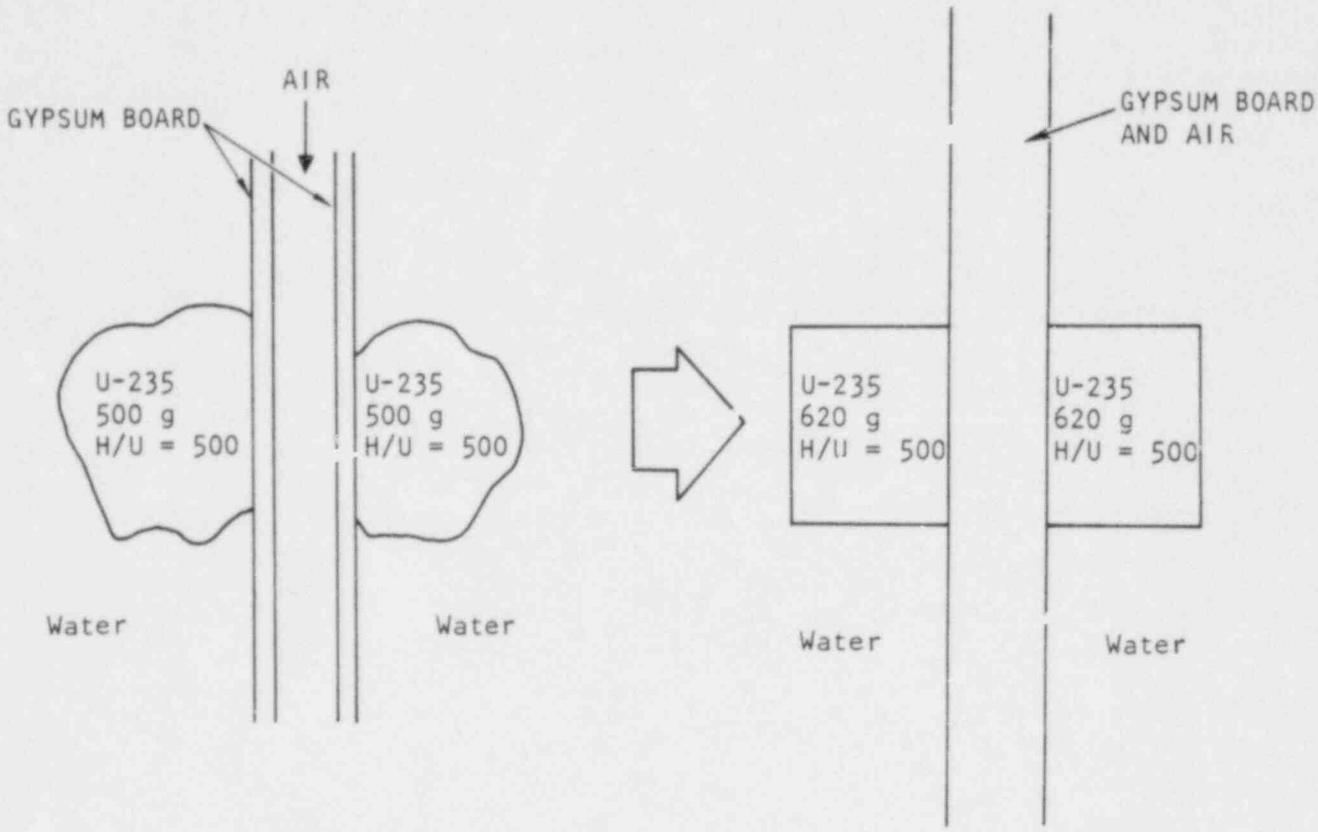


Fig. I 3.4-1. Models used

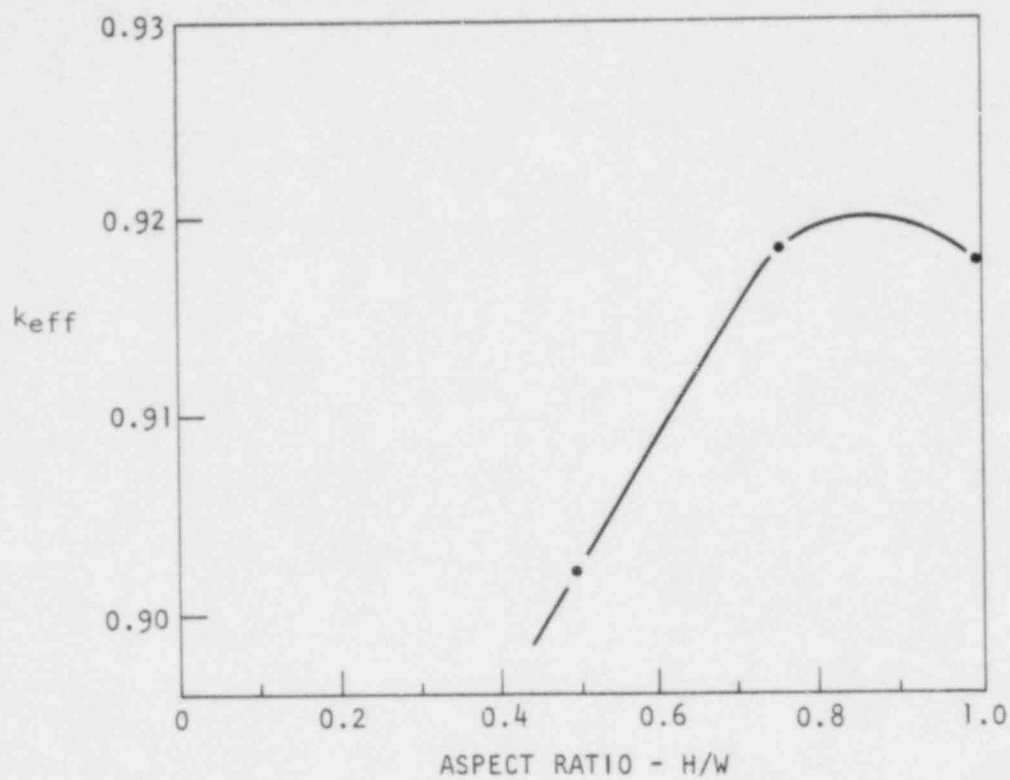


Fig. I 3.4-2. Reactivity versus aspect ratio

3.5 HOT CELL FACILITY

The Hot Cell Facility is located within a controlled area. Complete personnel access control is maintained during working hours. During off-shift hours, the facility is locked and checked at least every 4 hours by the security patrol.

The Hot Cell Building has approximately 7000 ft^2 of floor space consisting of office space, three Hot Cells, an operating gallery, and hot and cold auxiliary areas. Figures I 3.5-1 and I 3.5-2 show the plan view of the facility and details of the cells and shielding.

The high-level cell, which is the largest of the cells and which has the most shielding, is 8 ft wide, 18 ft long, and 15 ft high. The cell walls range from 42-in.-thick high-density concrete on the front and end to 60-in.-thick conventional concrete on the rear. A two-section steel door separates this cell from the adjacent low-level cell; the lower section is 21 in. thick and 11 ft high, and the upper section is 12 in. thick and 3-1/2 ft high. There are three operating stations, two on the front wall and one on the end wall, each with a viewing window and two master-slave manipulators.

The low-level cell is 10 ft long, 8-1/2 ft wide, and 15 ft high. The walls of this cell are formed by the high-level cell door, a 17-in.-thick solid steel door to the service area, a 36-in. front wall, and a 32-in. back wall of high-density concrete. The front wall has a viewing window with manipulators and various shielded access holes. There are also shielded transfer tubes connecting the low-level cell to the other two cells.

The metallography cell measures 9 ft long, 5 ft wide, and 11-1/2 ft high. The walls are made of high density concrete and range in thicness from 34 to 36 inches. Personnel access to the cell is through a 15-in.-thick solid steel sliding door to the service area. The front wall of the cell has one operating station equipped with a viewing window, manipulators, and access holes. On the corner of the cell is an operating station equipped with a stereomicroscope and remote operated specimen stage for viewing small specimens. The side wall of the cell contains a metallograph mounted in such a manner that the stage can be retracted into the cell when the instrument is in use. When not in use the instrument is retracted into the cell wall, and a lead-filled shielding door located inside the cell is closed to protect the optical and electronic components.

The operating areas of each cell are those areas in which active work is performed on irradiated material and on samples removed from that material. These areas are neutronically isolated from the locations used solely for storage of SNM-bearing materials as described below.

There are special storage wells in the cells, one in the low-level cell floor and three in the high-level cell floor. The we;;s are 12.25 in. inside diameter and 6 ft 1 in. deep with 18-5/8-in.-thick gasketed plugs. The wells are located 2 ft from the back wall of the cell and are located on 5 ft 6 in. centers. These wells may be used to store radioactive and special nuclear materials.

In addition to the small storage wells above there are two storage wells for HTGR fuel elements, one well in each cell. The well in the low-level cell is 16 ft. 4 in. deep and 2 ft 8 in. in diameter with a 2 ft 2 in. thick high density concrete plug. The center of this well is 3 ft from the back wall of the low-level cell and 33-1/4 in. from the center of the small dry well. The 10.55 in. of conventional concrete between these two wells does not provide nuclear isolation. This well will accept a FSV shipping cask. The well in the high-level cell is 11 ft 8 in. deep and 23-1/4 in. in diameter with a 20 in. thick conventional concrete plug. This well is centered between two of the small storage wells. There is 14.7 in. of conventional concrete between the fuel element well and each of the small storage wells providing nuclear isolation for these wells. This well provides storage for up to three irradiated HTGR fuel elements.

The Service Gallery, Fig. I 3.5-1, contains an array of eight storage wells for irradiated materials. The wells are recessed 6 in. below the service gallery floor. The wells are 14 ft 8 in. deep by 13.38 in. diameter. An eight inch thick lead shot filled plug caps each well. The wells are separated by a minimum of 13.52 in. of high density concrete. These wells are used to store Hot Cell specimens for future study. The radiation at the surface will be less than 100 mr per hour.

Auxiliary hot areas within the facility include the hot change room, the hot machine shop, the equipment decontamination room, storage areas for supplies, equipment, and casks, the service gallery and loading dock, and the service corridor.

The operating gallery is a normally clean area encompassing the operating faces of the cells. Work performed in this area includes remote hot cell operations, photography, and other normally clean operations.

More detailed descriptions of the facility and its operation are contained in "Safety Study for the General Atomic Hot Cell Facility."*

---

*"Safety Study for the General Atomic Hot Cell Facility," USAEC Report GA-1953, General Dynamics, Gulf General Atomic Division, January 24, 1961.

3.5.1 Process Description

The operations performed in the Hot Cell Facility can best be described as examination of by-product and fissionable materials. The largest and most highly shielded cell, the high-level cell, is used for such operations as visual examinations, photography, puncturing of specimens for gas analysis, decanning or decladding capsules or fuel elements, cutting of small samples for metallographic examinations, dissolution of small specimens, and general preparation of samples for further testing in the low-level or metallographic cell.

The low-level cell is used primarily as an interlock cell or buffer area for introducing radioactive materials into the adjacent cells and for the remote transfer of equipment into the high-level cell. Operations such as density measurements, hardness, and tensile tests on radioactively low-level specimens are performed in this area, although any of the operations performed in the high-level cell may be performed in this cell providing the shielding is adequate for the activities involved.

In the metallography cell, specimens which have been cut and transferred from the high-level cell are mounted, prepared for examination, and remotely examined and photographed.

3.5.2 Nuclear Safety

There are three modes of operation for the low-level cell and the high-level cell. The cell's operating limits are defined by the operation. These modes are as follows:

1. Miscellaneous SNM operations.

2. FSV fuel element destructive operations.

3. FSV fuel element transfer and inspection.

The operating limits for these three operations are shown in Table I 3.5-1. The operations are mutually exclusive requiring each operation to be completed and all SNM placed in storage before another type of operation begins. The normal input to the miscellaneous operations consists of material which has been irradiated in reactors and is well identified. With this identification of materials, double batching is not credible. The nuclear safety limits are 90% of the optimum geometry minimum masses given in Part II, Section 5.4, item 2c, under conditions of optimum moderation and reflection.

The nuclear safety limits for operations with FSV fuel elements is based on the detailed analysis of fuel elements in proposed storage arrays (Ref. 3.5-1). The results of the analyses are summarized in Table I 3.5-2. The calculations show the storage of fuel elements in isolated columns, rows, and a plane array of the specified separation to be nuclearly safe. Destructive operations on FSV fuel elements require assigned locations for the fuel elements and removed rods with an approved interaction calculation.

For the metallography cell (including the metallograph) Table I 3.5-1 shows the nuclear safety limits. These limits are based on Fig. I 5.4-1, and similar data from TID-7028 (Ref. 3.5-2) with the 2.3 safety factor applied, which demonstrate the safety of the stated limits under conditions of optimum moderation, reflection, and double batching combined. The more conservative assumption of double batching is made in these locations, because the materials generally consist of samples removed from larger fuel assemblies and both the identity and SNM content can be subject to uncertainty.

TABLE I 3.5-1
HOT CELL SNM INVENTORY LIMITS

Location	Miscellaneous[1] U^{233}	U^{235}	Pu^{239}	In FSV Fuel Elements gm U^{235} in Elements (or equiv.)
Total facility	530	740	460	8400 in 6
Met Cell	250	350	220	-
Low Level Cell[3]	530	740	460	2800 in 2
High Level Cell[3]	530	740	460	2800 in 2
Any small dry well*[4]	250	350	220	-
Any large dry well*[5]	-	-	-	3300 in 3
Low & High Level Cell[6]	-	-	-	8400 in 6

[1]Includes all SNM not otherwise described. It may be in any physical form.

Except for a maximum of 5 g, all Pu is in a "bred-but-unseparated" form. Where more than one fissile isotope is present, inventory limit shall be determined by the equation.

$$\frac{m\ (U^{235})}{750} + \frac{m\ (U^{233})}{530} + \frac{m\ (Pu^{239})}{460} \leq 1,$$

where m is the isotopic mass in grams based on the original unirradiated content of the materials.

[2]Includes all SNM in the form of FSV fuel elements with 1.4 kg U-235 and 11.3 kg Th-232 per element (pre-irradiation values). "In the form of" means either in intact fuel elements or fuel rods in an equivalent (less reactive) geometry.

[3]Location shall contain either miscellaneous or FSV Fuel Element SNM, but not both. Fuel elements shall be in fixtures maintaining a minimum surface to surface distance of 12 in. The products of fuel element destructive operations shall be in an assigned location.

[4]A small dry well is one less than 14" in diameter. All material will be stored in closed five-gallon containers. Small dry wells are located in: service gallery, low level cell, high level cell.

*The locations of all dry wells are shown in Fig. 3.5-2.

TABLE I 3.5-1 (continued)
HOT CELL SNM INVENTORY LIMITS

[5]A large diameter dry well is one with a diameter of more than 14". There are such dry wells in both the low and high level cells. FSV elements will be stored in closed containers.

[6]This condition applies only during transfer of fuel elements. During the time when more than two fuel elements are in the cells, all elements but one will be stored in a fixture which insures a minimum center to center distance of 20 in. between the elements. The remaining element will be in transit.

TABLE I 3.5-2
NUCLEAR SAFETY ANALYSIS OF FSV FUEL ELEMENTS

Description			k_{eff}
		One fuel Element*	0.67
1.1 kg U-235	1 ft water	Two fuel Elements, side by side	0.86
9.4 kg Th-232	Reflector	Infinite row of side by side elements	0.95
		Two fuel Elements stacked end to end	0.71
		Infinite Column of fuel elements end to end	0.74
1.4 kg U-235	Bare	One fuel Element	0.38
11.3 kg Th-232	25% of Normal Density water between blocks	Infinite Array with 20 in. center-to-center spacing, maximum reactivity	0.38

The models assume a volume of water equal to the volume of the coolant holes homogenized with the element.

*Values from Ref. 3.5-1.

When in-cell storage is open for addition or removal of samples the cell limit will not be exceeded and operations will be restricted to the one involving the storage access.

When in-cell storage for fuel elements is open for transfer or exchange of fuel elements, or equivalents, all miscellaneous SNM produced by destructive operations will be in the small storage wells.

The use of the initial loading SNM inventory is conservative because reactor fuel materials tend to lose reactivity with exposure.

The mass limits on the small dry wells shown in Table 3.5-1 provide nuclear safety. The limits are based on limiting each well to a factor of 2.3 below the minimum critical mass as given in the specifications Section 5.4, item 2c.

Inventory logs are maintained for each controlled accumulation of SNM. These records show sample identity and SNM content as well as the total SNM in each controlled area. A member of the Hot Cell technical staff is assigned responsibility for facility internal inspection and day-to-day enforcement of SNM control and logging procedures.

The concrete thickness between the storage wells in the low level cell, while substantial, is not adequate to provide nuclear isolation. An interaction calculation was made in which the small well was modeled as a maximum stack of 5 gallon containers and the cask well was modeled as three FSV fuel elements at the uppermost part of the cell. This maximizes the interactions between the two units. The small well sees 1.1151 and the large well sees 0.5974 steradians. Both are acceptable values.

3.5.3 Radiological Safety

The complete facility is designed to safely contain operations involving up to 1 x 10^6 Ci of mixed fission products. The continued safety of the operation is assured by adherence to approved procedures for handling radioactive materials and for maintaining the facility and through the formal qualification of all workers.

The high-level cell is designed to contain and shield 1 x 10^6 Ci of 1 MeV gamma radiation. The low-level and the metallography cells are each designed to 1 x 10^5 and 1 x 10^4 Ci respectively. These levels are the maximum operating limits of the various cells.

Access control within the building is assisted by the building design. The building is arranged so that the machine shop, decontamination room, service corridor, and service gallery can be operated a contamination control zone permitting maintenance, etc., without complete decontamination. The back door to the building is closed to traffic, and access to this zone, except for transfer of casks and hot waste, is through the change room. Hot and cold change facilities are provided in the change room. The operating gallery is normally clean, and access to this area is from the lobby and service corridor. The gallery can be converted into a contamination zone by securing the door to the lobby and opening the door to the service corridor.

The roof area above the building directly over the cells is chained off and marked as a high-radiation area. Signs and markings are used extensively throughout the building to identify hazardous areas.

The ventilation system is designed to that the air flow pattern is always from a clean area to a contaminated area and from ceiling to floor and is equipped with dampers and an interlock system to assure proper flow direction. Exhaust air from radioactively dirty areas passes through prefilters and high-efficiency air filters before being exhausted to the atmosphere. An "elephant trunk" system services the operating gallery, decontamination room, machine shop, X-ray room, and service corridor. This system is equipped with a cyclone separator to separate chips, dirt, and dust particles from the air before it is admitted to the main exhaust filtering system. Stack gas samples are continuously passed through monitoring equipment which has an audio and visual alarm in the facility. Table I 3.5-3 summarizes the containment and ventilation for the Hot Cell process areas.

The facility is equipped with several area radiation monitoring systems, a continuous air monitor, air flow sensing elements on the ventilation system, and hot-drain tank liquid-level sensors which are connected to audio-visual indicating panels in the operating gallery and office area to alert personnel of unsafe or changing conditions. These systems also alert the plant security force during nonworking hours.

The filter cassette, cyclone separator, fume scrubber, ventilation fans, and exhaust stack are located in a controlled access area at the north end of the building. The liquid waste tank trailers are located in another controlled access area to the north of the building. Entry into both of these areas is monitored on the audio-visual panels mentioned above.

Portable survey instruments are used throughout the area, and personnel are equipped with personal radiation detectors which give an audible indication in the presence of gamma radiation. Personnel are also required to wear film and pocket dosimeters when at the facility. Hand and foot monitors are located at entries to the facility contamination control zones.

No.	Hot Cell[1]	Material	Form	Station Enclosed	Prefilter	HEPA
1	Hi Level Cell	U, Th, Fission and By-products	Solids, Particles, Solutions and Slight Quantity of Dry Powders	x	x	x
2	Low Level Cell			x	x	x
3	Metallography			x	x	x
4	Other	Contaminated Equipment Repair	Solid & Liquid	x	Fume Scrubber	x

[1] Cells use a common HEPA filter system with no flow alarm, blower failure alarm, high particulate radiation alarm, high gas radiation alarm, fire alarm, filter loaded (ΔP) alarm. The system is continuously monitored and has a stack radiation alarm.

TABLE 3.5-3
HOT CELL PROCESS CONTAINMENT & VENTILATION

They are equipped with audio and visual indicators and have an alarm set point. Protective clothing is required in all areas of the Hot Cell with the exception of the office, lobby, operating gallery, and change room. In addition to all other safeguards, cells are entered with a second person on standby at the operating gallery side of the low-level cell window. Television and audio communications are maintained at all times when personnel are in a cell or in the service gallery area.

The handling of effluent waste from the Hot Cell Facility is conducted under the Waste Management Program at the main site. Sources of waste include all the solid radioactive waste at the Hot Cell which results from scrap generated during the normal Post Irradiation Examinations performed on test elements, capsules, thermionic cells, and similar devices. Liquid waste is made up entirely of water that has been used to decontaminate equipment to acceptable levels for performance of maintenance or is the result of washing areas within the facility to keep them at levels consistent with personnel entry. Gaseous waste consists of small amounts of fission gases that may be released from samples within the different test devices and particulate matter that may become entrained in the cell ventilation air flow.

The only waste stream from the Hot Cell Facility that is released to an unrestricted area is the air (gas) flow used to maintain the different cells at proper negative pressure conditions. This air passes through three filtering systems. Prefilters, primarily designed to remove relatively large particulate matter, are located in back of each cell with a second prefilter at the main filtering station. The air is then passed through high-efficiency air filters that have an efficiency of 99.97% for particles of 0.3 micron size. It is then released to the atmosphere from a 26-ft exhaust stack.

Liquid waste is collected in 500-gallon-size trailers located in a restricted area. Upon filling, they are transferred to the Waste Processing Facility (WPF).

TABLE I 3.5-4
IDENTITY AND CATEGORIES OF HOT CELL WASTE

Type of Waste	Physical Form	Chemical Form	Disposition
Solid	Metals, graphite plastics, paper, wipes, wood	$U-ThO_2$ Mixed fission products	Low-level to WPF[a] High-level to commercial waste disposal[b]
Liquid	Decontamination water	Mixed contaminants including fission products	Transferred to WPF[c]
Gas	Hot Cell ventilation	Particulate contaminants and small quantities of iodine and krypton	Filtered and released released to atmosphere

[a] Solid dry wastes are removed to a commercial land burial facility in metal drums or wooden boxes. Some waste materials may be compacted in drums prior to shipment.

[b] Solid high-level wastes are put into sealed metal containers and shipped inside approved shielded casks to a commercial burial site.

[c] Water is evaported in solar evaporation ponds. After evaporation, resultant pond sludge is mixed with absorbent and solidifying materials prior to removal for commercial land burial.

3.5.4 Criticality Alarms

Criticality alarm detectors are located in the operating gallery. These are shown in Fig. I 3.5-1 as Remote Area Monitoring Systems. Criticality alarms cannot be located within the cells because of the very high variable radiation levels that exist there. Exemption is therefore required from the 120 ft air equivalent location requirement in 10 CFR 70.24. The combination of shielding, criticality detectors in the gallery, continuous air monitors and audible alarm systems provides protection equivalent to that required by 10 CFR 70.24.

REFERENCES

3.5-1 "Nuclear Safety Summary of Fuel Rod Production," Amendment to SNM-696, AEC Docket No. 70-734, October 9, 1970.

3.5-2 Paxton, H. C., et al., "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233," USAEC Report TID-7028, Los Alamos Scientific Laboratory and Oak Ridge National Laboratory, June 1964.

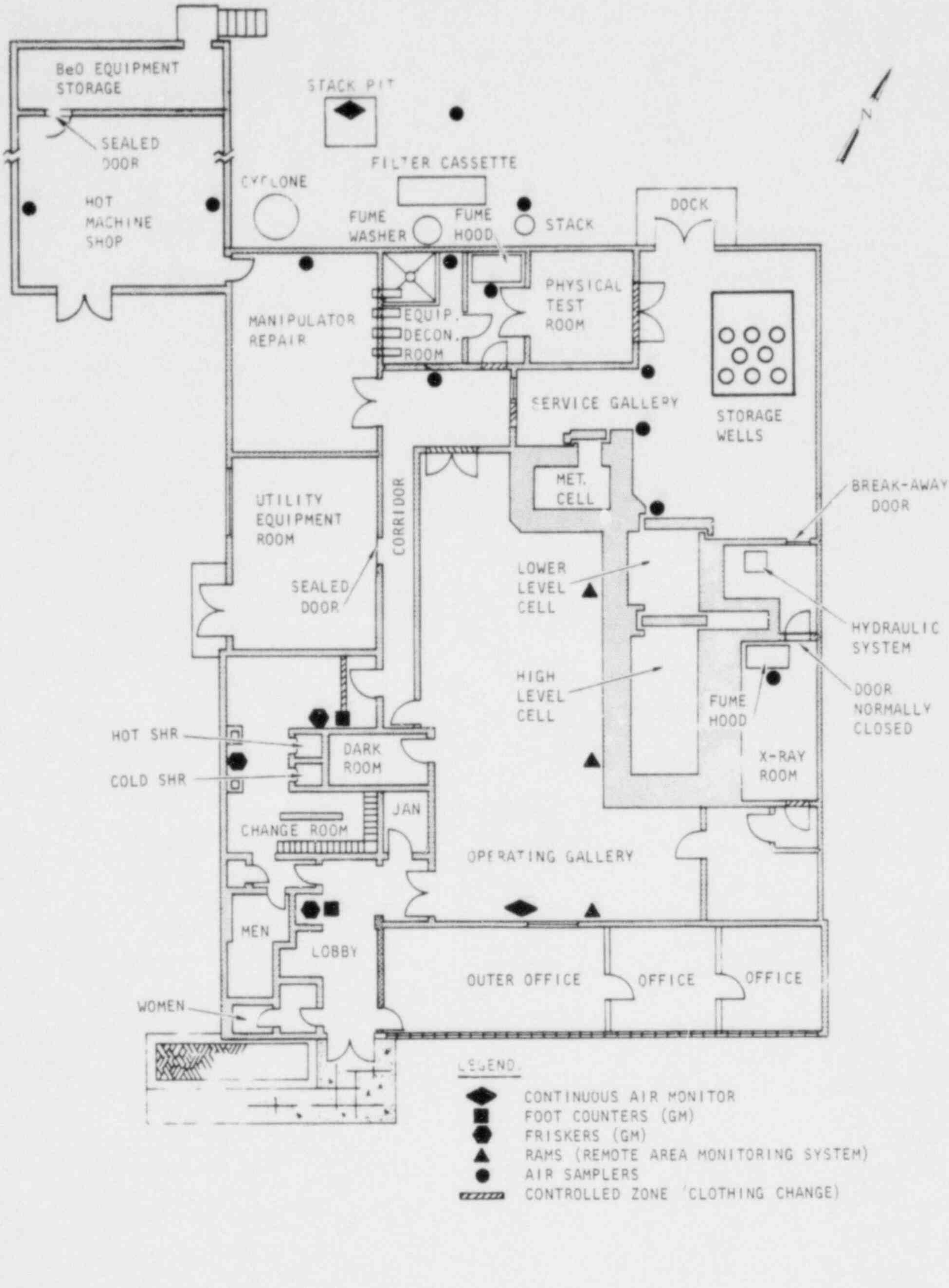


FIG. 1 3.5-1 HOT CELL FACILITY FLOOP PLAN

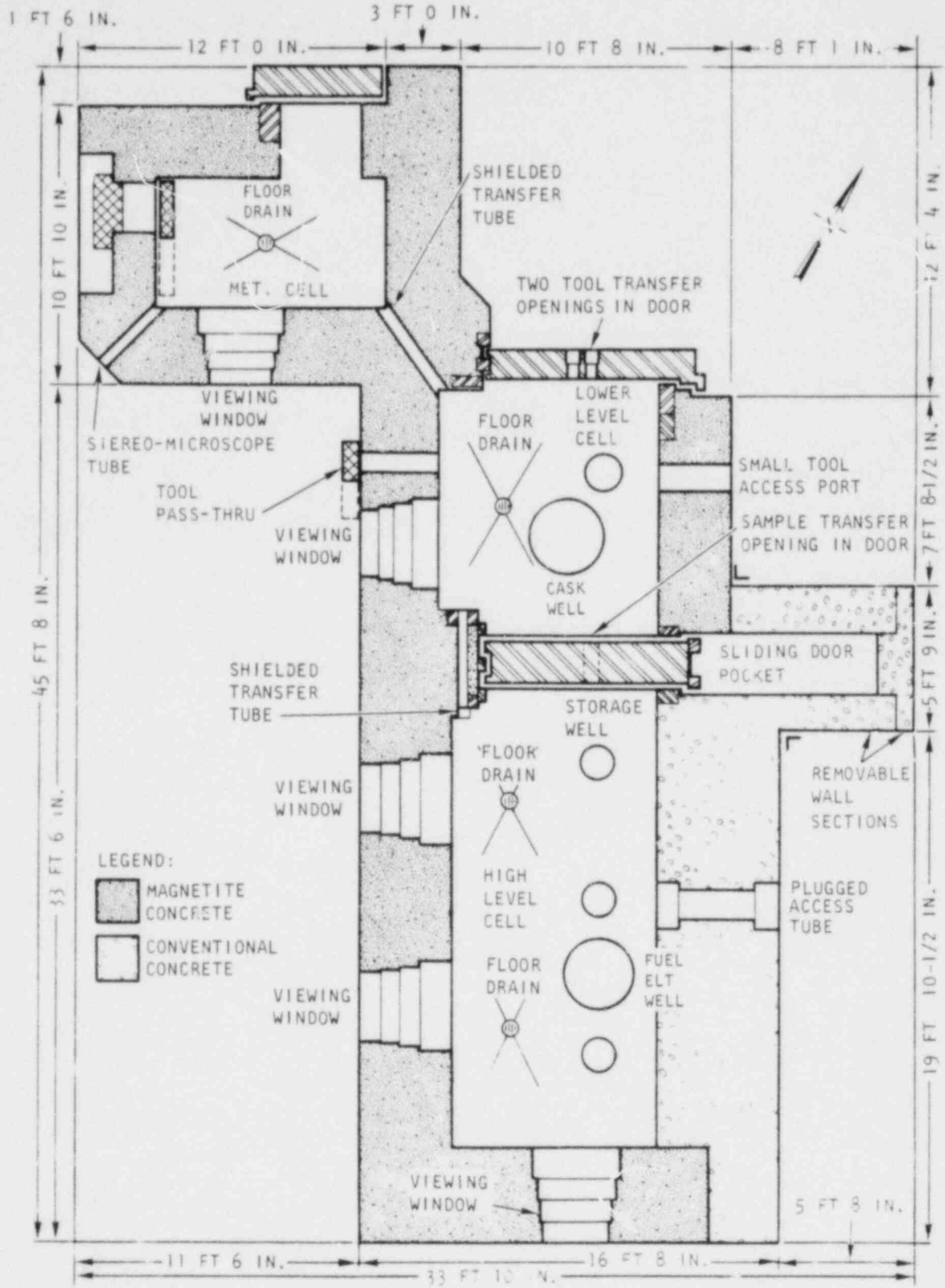


FIG. 1 3.5-2. PLAN VIEW OF THE HOT CELLS

3.6 THERMOELECTRIC GENERATORS

3.6.1 General

Thermoelectric generators containing encapsulated plutonium may be assembled in a nuclearly isolated laboratory complex. The units typically range in size from a few mw(e) to the order of 0.5 watts. The activity consists of assembling the principal components of the generator into an enclosure, performing the subsequent tests, and interim storage with eventual shipment to the customer.

Double or triple encapsulated sources of plutonium are obtained from qualified suppliers such as Los Alamos Laboratory, McDonald Douglas, Monsanto, etc. Each source will be serialized. No operations are performed on the source which could cause significant chemical or physical damage to the sources. The maximum amount of plutonium in any single source will not exceed 200 grams.

Each source used in the thermoelectric operation shall have its encapsulation designed to prevent release of the plutonium during normal use and forseeable accidents. Each encapsulation design shall have undergone the minimum temperature, pressure and crush tests stated below. Complete records of design and test data will be maintained.

Capsule Tests

Fuel capsules with simulated void volumes were exposed to the following environment: The temperature of each capsule was raised to the test temperature and held for the duration of the test. Test temperatur for the tests was 850°C. The capsules were tested up to a maximum internal pressure of 800 Atms. without failure.

Crush Test

To test the ability of the Hastelloy C capsules to withstand mechanical damage without bursting, sample capsules were crushed between steel jaws. Forces up to 4000 lbs. were applied without rupturing the capsules.

Plutonium capsules will be assembled with other generator components involving vapor degreasing, mechanical and adhesive attachment of components, in-process electrical testing, and final battery structural assembly by TIG welding.

1. Capsules are inspected on receipt.

2. Inventory control is done by storing capsules in fireproof vault or safe until used in production assembly.

3. Capsule is mechanically attached to generator components.

4. Generator structure is sealed by TIG welding.

5. Complete generator is leak checked to verify weld integrity.

6. Generator is acceptance tested to obtain electrical performance.

3.6.2 Nuclear Safety

The fuel materia. may be a composition of Pu and non-fissionable elements on materials. The SNM of any source will be limited to 200 gm of Pu (all isotopes summed). Subject to the 200 gm limit, the plutonium may be combined with non-fissionable elements or materials.

The storage and handling of the encapsulated units will '_ in a criticality safe geometry which have considered optimum moderation, flooding, etc.

3.6.3 Radiological Safety

The primary safety objectives when handling the fuel capsules will be to: assure the integrity of the encapsulated fuels, assure early detection of any contaminations, and maintain accountability of all sources. To meet these objectives the following general procedures are followed.

1. Receipt of Capsules

   a. A Health Physics Technician will be present.

   b. A wipe will be made of the entire outside surface of the shipping container. If the alpha activity is 6 pCi or less, the Health Physics Technician will release the delivery vehicle. If the alpha count is higher than 6 pCi, a survey of the delivery vehicle will be made and the vehicle decontaminated if necessary, prior to release.

   c. If there is no detectable activity on the packing material, the inside shipping container will be opened and the inside of the lid will be wiped.

   d. If the wipe of the inside of the lid over the capsules indicates alpha activity of 6 pCi or less, the capsules will be removed one at a time, and a wipe will be made over the entire surface of each capsule. If the alpha activity on the wipe is less than 10 pCi, the capsule will be considered not to be leaking.

2. Assembling Generators

   a. A Health Physics Technician will be present, as required.

   b. The capsule will be mechanically attached to the generator components.

   c. Final assembly of generator.

   d. Functional test of generator.

3. General Handling Procedures Capsules and Generators

Fuel capsules will be stored in shipping containers or in a fireproof safe. The capsules will be removed from the safe as necessary for production use.

All generator assembly and testing will be planned, conducted and monitored to preclude any effect on the integrity of the capsules. In-process wipes will be taken and checked for activity.

Assembled generators will not be removed from the assembly area until wipes are taken and checked for activity. The results of all wipes will be routinely logged and maintained for at least five years and for such longer time as the NRC regulations may require.

4. Routine Leak Tests

As a minimum, each plutonium capsule shall be tested for leakage and/or contamination at intervals not to exceed six months. In the absence of a certificate from a transferor indicating that a test has been made within six months prior to the transfer, the sealed source shall not be put into use until tested by licensee.

The test shall be capable of detecting the presence of 0.005 μCi of removable alpha contamination. The test sample shall be taken from the plutonium source or from appropriate accessible surface of the device in which the sealed source is permanently or semi-permanently mounted or stored. Records of leak test results shall be kept in units of microcuries and maintained for inspection by the Commission.

If the test reveals the presence of 0.005 μCi or more of removable alpha contamination, the licensee shall immediately withdraw the sealed source from use and shall cause it to be decontaminated or to be returned to the manufacturer. Within five days of a test which reveals 0.005 μCi or more of removable alpha contamination, a report will be made to the NRC describing the equipment involved, the test results and the corrective action taken. A copy of such report shall be sent to the Director of the nearest NRC Regional Compliance Office, listed in Appendix D of Title 10, Code of Federal Regulations, Part 20.

The thermoelectric generators will be transferred in accordance with procedures utilized to account for and control special nuclear materials, assure proper packing for transport and prevent the spread of radioactive contamination.

3.7 TRIGA FUEL FABRICATION

3.7.1 Facility Description

Uranium zirconium hydride fuel elements for TRIGA research reactors are fabricated in the TRIGA Fuel Fabrication Facility portion of the TRIGA Fuel Lab Building. This building is located within the main site, adjacent to and east of the Hot Cell as shown in Fig. I 2.1-2. The building is divided into two separate facilities consisting of the NMM Central Storage Facility and the TRIGA Fuel Fabrication Facility. The TRIGA Fuel Fabrication Facility is subdivided into two basic process storage areas. These are the TRIGA fuel process area and the TRIGA vault-type storage room. The NMM Central Storage Facility is split into two SNM storage areas; the drum storage area and the NMM vault-type storage room. The two vault-type rooms are located within a single storage area with an internal divider used to define the two separate material access areas. Separate doors are used to control entry to these areas. The two main facilities in the building have separate access control exercised through use of separate entry doors in the building lobby. These two doors are where the material access area entry and exit controls are maintained according to the 10 CFR 73 Category II facility requirements set forth in the applicable General Atomic Security Plan and the Materials and Plant Protection (safeguards) Amendment to the NRC materials license.

The NMM Central Storage Facility is further described in Section 3.3.1 section. The remainder of this section is addressed only to the TRIGA Fuel Fabrication Facility.

The building is designed with a covered outside equipment pad area which will contain the HEPA Filter & Blower System, gas bottle farm, liquid nitrogen supply dewar, etc., thereby eliminating unnecessary access to the process area by the supply and service persons. See Fig. I 3.7-2 for general building layout.

The TRIGA fuel process area is divided into separate zones which are used to define process station boundaries, equipment locations, logical grouping of process activities and assist in material handling. The zones are:

1. Metal preparation
2. Furnace area
3. Hydride area
4. Machine shop area
5. Assembly and inspection area
6. Office and locker room

Each of the zones and the contained equipment are described in more detail in the description of the Process Steps and Stations (Section 3.7.5).

The storage vault-type room area consists of 1-ft-thick walls of 140 lb/ft^3 concrete. A movable partition is provided to permit adjustment of the material access area boundaries since the storage area is shared between two facilities. The SNM is stored in planar arrays along one side of each concrete wall. The arrays are constructed of metal and meet the criteria for SNM storage given in Section 3.7.4.1.

The ventilation system for the building consists of several independent blower systems. One system conditions the air of the office spaces and is a closed system. One system provides exhaust for the storage areas. Two systems provide air exhausts for the TRIGA fuel processing area; one servicing elephant trunks and special containments while the other provides general room air exhaust. Each area of the building is assured proper air flow and negative pressure differential by the system of exhaust blowers. All the building exhausts are equipped with high-efficiency particulate air filters and continuously operated air sampling equipment. Air inlets are fitted with barometric dampers to assure proper air balance and prohibit the escape of radioactivity in the event of ventilation system shut-off or failure.

The construction of the building is primarily of concrete; either prestressed or reinforced. The walls are nominally 7-in.-thick, reinforced concrete. The exterior doors are of heavy gauge metal meeting the requirements of 10 CFR 73. The roof is of prestressed concrete beams over which a concrete slab is poured and is sloped sufficiently to eliminate the possibility of water pooling.

3.7.2. Nuclear Safety

The nuclear safety analysis of the TRIGA Fuel Fabrication uses the same methods, procedures, and assumptions that are described and verified in Section 5, Part I, of the application for renewal of materials license SNM-696. The criterion used for the safety evaluation of the units considered in this building was to perform a simple, conservative analysis with the introduction of refinements only when indicated necessary by the initial calculations. Cross sections for use in this analysis were obtained from the GAM and GATHER codes (Ref. 3.7-1) with resonance calculations performed where necessary (Ref. 3.7-2). The nine broad energy group structure defined in Section 5.3, Part I, was used for the criticality calculations. The ability of this nine-group structure to handle the variations in flux spectrum from unflooded to fully flooded assemblies is also described in Section 5.3, Part I. Cross sections were averaged over a spectrum appropriate to the problem under consideration. Conservative assumptions used in the analysis include:

1. Use of homogeneous uranium-water mixtures for all situations where fuel-water mixing was possible.

2. Interaction calculations based on optimum possible fuel-water mixing with no reflection.

3. Neglecting all absorber material present in a station except uranium, water, and zirconium.

4. Use of 93.5% enriched uranium for criticality calculations although the facility is currently limited to processing uranium or less than 20.0% enrichment.

5. Use of the most reactive geometries (i.e., spheres) unless other shapes, such as fuel rods, are fixed.

Other specific nuclear safety considerations are discussed in the individual zone or station descriptions.

3.7.3 Radiological Safety

All building operations that may generate airborne radioactivity (i.e., hydriding, machining, etc.) are conducted within closed equipment, hoods, glove boxes or are exhausted via elephant trunks. Air ducts from each of the above utilize high-efficiency particulate air filters to treat the effluent air. The filters have an operating efficiency of 99.95% for 0.3 micron particles and are of fire-resistant type and are equipped with differential pressure indicators. Each of the elephant trunks are designed for a flow of 150 ft/ min. [illegible] from the orifice plane.

Categorization of [illegible] processing wastes as to solid, liquid, or gas is presented in Table I 3.7-1. The table identifies each source, waste category, its physical and/or chemical form and gives the treatment or disposition of the wastes, except for the treated waste streams which are released to unrestricted areas. These streams are the ventilation systems and the water from the fume scrubber in the process area.

TABLE I 3.7-1
DESCRIPTION OF WASTE STREAMS

Source	Waste Category	Form	Disposition
Pickling Tank	Liquid	Spent HNO_3 + HF with dissolved U	Waste Yard[a]
Pickling Tank Ventilation	Air and gas with entrained liquids	Air with oxides of nitrogen and dissolved uranium	Released to atmosphere via fume scrubber
Pickling Tank Ventilation	Liquid	Water from fume scrubber	Released to sanitary sewer
Ventilation, melting and casting, parting, finish machining	Gases with entrained solids	Air with entrained uranium dust	Released via high-efficiency air filter
Centerless grinder	Liquid	Water with uranium	Waste Yard[c]
Vacuum system	Liquid	Oil with uranium	Waste Yard[d]
Mop water	Liquid	Water with uranium	Waste Yard[c]
Wash water	Liquid	Water with uranium	Waste Yard[c]
Trash barrels	Solid	Paper and rags with uranium	Waste Yard[b]

[a] Mixed with neutralizing agents, absorbent, and solidifying materials prior to shipment to commercial land burial.

[b] Shipped to commercial land burial facility in metal drums or wooden boxes.

[c] Evaporated in solar evaporation ponds. After evaporation, resultant pond sludge is treated as in (d).

[d] Mixed with absorbent and solidifying materials prior to shipment to commercial land burial.

The exhaust ventilation systems are provided with prefilters and high-efficiency particulate air filters to reduce the quantity of particulates and the resulting concentration of radioactivity released to the environment. The ventilation system serving the pickling station discharges through a fume scrubber employing water scrubbing to remove acid fumes.

The scrubber water having unmeasurable levels of radioactivity is blown down without in-line monitoring to the building drainage system and is subsequently discharged to the plant sewer system. The plant sewer system discharge is sampled routinely and verifies the levels as acceptably low.

Equipment to control other liquid waste consists of various containers to temporarily store the liquid wastes until transfer to the Waste Processing Facility for treatment and disposition. For such liquids handled in batches, no in-line monitoring is necessary. The fume scrubber blowdown is sampled, and having been shown to have very low activity, is directed to the building drainage system, and is subsequently discharged to the sanitary sewer without in-line monitoring. The sewer system discharge waste is sampled routinely and verifies the levels as acceptably low.

Sampling equipment for airborne radioactivity exists at the outlets of the ventilation system and at the exhaust from the fume scrubber. Samples are collected daily and the concentration of long-lived alpha and beta radioactivity is determined. Alert levels for the exhaust effluent are based on actual ooperating levels and are evaluated by the "ALARA" requirements of 10 CFR 20. The alert levels are reevaluated periodically.

All solid waste is transferred to the Waste Yard where it is packaged for removal to a land burial site by a commercial waste disposal company.

All building operations are monitored by criticality alarms installed per 10 CFR Part 70, Paragraph 70.24, which sound locally and at the secondary central security control station.

3.7.4 Storage

Within the facility, SNM is stored in various temporary arrays inside the process area and in the TRIGA vault-type room. Limits, criteria and contained materials applicable to the vault-type room are described in Section 3.7.4.1 below. The description of the individual temporary storage arrays and their limits located within the process area zones are discussed in Section 3.7.4.2, however, their interaction with other SNM locations is discussed and summarized in Section 3.7.5.

3.7.4.1 TRIGA Vault-Type Room

Storage within the facility of in-process materials generated in the manufacture of enriched U-Zr fuel elements, other than temporary storage as described in Section 3.7.4.2, is limited to the TRIGA vault-type room.

The storage area is designed for storage of a variety of material including chopped sheets (1/4-in. squares), castings (1/2 and 1-1/2 in. in diameter), broken buttons, meats (1-1/2 in. in diameter), and fuel pins 1/2 in. in diameter. This room may be used for storing research and development material, as well as material generated by the normal U-Zr fuel process.

The storage arrangement in the vault constitutes a plane array along one wall of each vault aisle. Special steel racks have been designed for each of the various types of materials to be stored. The racks are securely attached to both the floor and the ceiling of the room, and are designed to prevent the material from being dislodged and to prevent water from being retained in significant volume in any compartment.

The material stored in this vault typically consists of uranium metal, U-Zr alloy, or hydrided U-Zr alloy containing uranium enriched up to 20.0% in U-235. U-Zr fuel elements bear an inscribed identification number and the alloy material has an identification number engraved on it immediately after being parted into fuel meat lengths. Such external markings plus the special design of the storage racks, which by their dimensions are designed to accommodate only one specific type of material, ensure that each kind of material is placed in the correct location within the storage area.

Storage is maintained under one of the following criteria:

1. SNM metal, alloys, or compounds are stored in closed containers, or as processed shapes, in a plane array containing a maximum of 3.6 kg U-235 with a maximum volume of 1 gallon per unit or container, with 16-in. center-to-center spacing and 8-in. surface spacing between units or containers. Safety of this arrangement is based on standard limit Type G in Section 5.5, Part I. The safety of the individual unit is based upon standard limit Type B in Section 5.5, Part I.

2. SNM metal, alloys, or compounds are stored in isolated plane arrays of 160 g U-235 per ft^2 provided that the maximum allowable subcritical unit is limited to 250 g of U-235 and the local regional average satisfies the 160 g criteria. This is standard limit Type E in Section 5.5, Part I.

3. Material may be stored in a flat plane configuration, against the storage wall, as long as the thickness of the plane is not greater than 1.5 in. and the uranium concentration of any individual liter of volume is not greater than 0.4 kg of U-235. From Fig. I 5.4-4, Section 5, Part I, the safe thickness for an infinite slab is 1.5 in. for uranium concentration up to 0.4 kg U-235/liter of slab with full reflection assumed.

The 12-in.-thick concrete walls provide neutronic isolation from other storage locations and SNM processing areas.

3.7.4.2 In-Process Storage

Means are provided in the facility process area for the ready, yet safe storage of in-process materials such as castings, recycle scrap, and meats. This storage is in the form of steel storage racks secured to walls and as carts which offer safe portability of materials.

3.7.4.2.1 Storage Racks

Two storage racks are located in the Furnace Area and one in the Assembly Area. The storage criteria used in these three racks are the same as criteria 1 used in the vault-type room. For purposes of interaction calculations the racks are assumed to be loaded according to criteria 1, 3.6 Kg of U-235 in 1 gallon containers. The k_{eff} for this container is 0.600, as shown for standard limit type B-4 in Section 5.5, Part I. Carts may not be located closer than 5 feet from the front of the storage racks; this restricted area is marked on the floor.

3.7.4.2.2 Scrap Storage

A storage rack in the machine shop contains scrap material such as chips and turnings in 5-gallon drums. The drums are loaded to a maximum of 350 g of U-235 each and are individually safe as justified for standard limit type A, Section 5.5, Part I. The drums are 12 in. in diameter and 14 in. high. They are positioned on two shelves that are 36 in. long and separated vertically by 26 in. The containers are positioned two to a shelf with 12-in. surface-to-surface spacing in the horizontal and vertical directions. The k_{eff} for a single type-A unit for purposes of interaction is 0.62 and the maximum allowable solid angle interaction is 2.8 steradians. The solid angle intercepted at one of the four containers by the other three containers in the rack is only 0.946 steradians; hence, the rack of four containers is safe and an adequate margin remains for interaction with other equipment in the locale. Carts may not be parked closer than 2 feet from the front of the storage racks; this restricted area is marked on the floor.

3.7.4.2.3 Element Carts

Cart top storage is used throughout the TRIGA fuel process area. The interaction calculations assume that a number of typical positions are occupied. A separate interaction study has been performed which assumed carts closely coupled to and virtually surrounding many of the process stations. This study demonstrated that restrictions on cart locations are not required other than those stated in Sections 3.7.4.2.1, 3.7.4.2.2, and 3.7.4.2.5.

The basic configuration for cart top in-process storage is a plane array of fuel castings, machined meats or assembled elements. The fuel pieces are stored end-to-end in parallel 1-1/2 in. diameter cylindrical geometry. The cylinder spacing used with fuel enriched up to 93.5% U-235 is 6 in. on center. The 20% enriched meats are stored in a similar array except on 3-in. centers. Different enrichments of SNM are not in use simultaneously, and the cart top positions are appropriately blocked when higher enrichments are used.

Criticality calculations for the nuclear safety analysis were based on a 1.7/1 H/Zr content in the fuel meat; the current upper limit for fuel production is 1.65/1. Fully enriched uranium was also assumed, and criticality for safety and interaction purposes was based on infinite rather than finite fuel cylinders.

Atom densities for the fuel meat, based on 1.7/1 H/Zr and 93.5% enriched uranium, are given in Table I 3.7-2.

TABLE I 3.7-2

TRIGA FUEL MEAT ATOM DENSITIES AFTER HYDRIDING[a]

Hydrogen	0.06017 atoms/barn-cm
Zirconium	0.03539 atoms/barn-cm
U-235	0.001215 atoms/barn-cm (0.475 g/cm^3)
U-238	0.000084 atoms/barn-cm
H/U-235	50

[a] 93.5% enriched uranium and 1.7 H/U-Zr ratio (1.65 is upper limit for actual meats) are assumed.

An infinite array of infinitely long 1.5-in.-diameter cylinders of fully enriched $UZrH_{1.7}$ on 6-in. centers has a calculated k_{eff} of 0.603 when fully water flooded. The 20% enriched $UZrH_{1.7}$ fuel on 3-in. centers has a calculated k_{eff} of 0.849 when modeled as a 1.5-in.-thick infinite slab with full water flooding; the slab was assumed to be a uniform fuel-water mixture of rods plus gaps. Thus, the nuclear safety of the individual meats and those stored on cart tops is guaranteed under all accident conditions.

For the interaction calculations the multiplication factor of bare, infinitely long cylinders of fully enriched $UZrH_{1.7}$ was calculated. For a 1.5-in.-diameter cylinder, k_{eff} was 0.05. All criticality results are summarized in Table I 3.7-3.

TABLE I 3.7-3

CRITICALITY ANALYSIS SUMMARY

	k_{eff}
Infinite array of infinitely long 1.5-in.-diameter fully enriched $UZrH_{1.7}$ cylinders, fully flooded on 6-in. centers	0.603
Infinite slab of 20% enriched $UZrH_{1.7}$ plus water, 1.5 in. thick, with full water reflection representing the 1.5-in.-diameter rods on 3-in. centers	0.849
Infinitely long, 1.5-in.-diameter fully enriched $UZrH_{1.7}$ cylinder, bare	0.050

In considering interaction solid angles, two cases are considered for the cart: a central meat, which interacts only with similar meats on each side, and an edge meat, which also interacts with the hydride furnace. The cart storage arrangement for the fully enriched meat was used since this forms the most reactive case.

3.7.4.2.4 Container Carts

Cart tops are also used for transport of containers of bulk materials such as uranium metal and weighed out charges for induction casting. The basic units transported are 1 gallon containers each holding up to 3.6 Kg of U-235. Physical holders are provided to restrain the containers on the cart top to a 16-in. center-to-center, 8-in. surface-to-surface geometry. Safety of this arrangement is based on standard limit type G in Section 5.5, Part I. The safety of the individual unit is based on standard limit type B in Section 5.5, Part I.

Interaction calculations are performed by considering an individual container on the cart as interacting with the other containers and with adjacent equipment. For these purposes the cart is assumed to hold 4 containers.

3.7.4.2.5 Casting Carts

Castings resulting from the melting and casting process step are handled two at a time on a cart which has fixtures to retain the unseparated castings or molds which have not been separated from the castings. The fixtures maintain a 12-in. surface-to-surface separation between the two units.

The nuclear safety of individual mold-casting units is discussed in the description of the melting and casting process, Section 3.7.5.3. A KENO (Ref. 3.7-4) calculation has been performed to justify the nuclear safety of the individual units on the cart and to establish a reactivity value for interaction purposes.

The calculations were made on a 5 in. x 5 in. x 17.5 in. system which is the basic mold criteria. A homogeneous mixture of 1.6 Kg of U-235 in 93.2% enriched uranium and water was assumed. The maximum moderator ratio within these constraints is 117. Calculations were made using both KENO, a monte carlo code and DTFX, a one dimensional transport code. The cross sections were obtained through a MICROX calculation for 18 broad groups. Both methods yielded a flooded, unreflected k_{eff} of 0.57. Similar calculations were made at lower moderator ratios which confirmed the fully flooded case is the most reactive.

Interaction calculations are performed by considering the individual container as interacting with the other container on the cart and with adjacent equipment. The cart position study described in section 3.7.4.2.3 indicates that the allowable solid angle of interaction seen by casting carts will not be exceeded if no more than 6 carts are nested at one location.

3.7.5 Processing Steps and Stations

A flow diagram of the TRIGA fuel fabrication process is given in Fig. I 3.7-3. For convenience, the steps in the fabrication process are also listed in Table I 3.7-4. For each step the following information is given:

1. Process
2. Equipment
3. Zone
4. Maximum special nuclear material per operations (U-235 mass limit)
5. Method of transport

SNM storage in these areas is according to the criteria set forth in Section 3.7.4. Comingling of material containing uranium of different enrichments in the different areas is prevented by appropriate procedural and administrative controls.

U-235 processing step and stations are controlled to their individual limits. The material to be processed, metallic uranium or U-Zr alloy, contains uranium enriched in U-235 up to 93.5% within a minimum of 87 wt % zirconium or uranium enriched in U-235 up to 20% within a minimum of 55 wt % zirconium. While not described in the discussion of each operation, the SNM hold-up at each station is determined by a weight difference closure between input and output materials. This is an accurate method because the majority of the operations are mechanical in nature and are performed on metallic materials. The closure is performed frequently such as for each cart load of material processed through a lathe. The materials are taken to one of the weighing stations (discussed in the rest of this section) and weighed. A material balance book is maintained for each applicable station to record this material closure.

TABLE I 3.7-4
.RIGA FUEL ELEMENT FABRICATION

Operation	Station No.	Description
		a. Processes b. Equipment c. Zone location d. Maximum SNM per operation e. Method of transport
Uranium Preparation	1, 3, 24	a. Rolling, annealing, chopping b. Rolling mill, vacuum furnace, shear, balance c. Metal preparation d. 10 Kg U-235 in process e. 4-wheeled cart with appropriate stainless steel pans and containers
Melt Preparation	5	a. Weighing materials and loading furnace crucibles b. Balance, containers and crucibles c. Furnace Area d. 3.6 Kg U-235 in process e. 4-wheeled cart with appropriate storage containers
Melting and Casting	6	a. Induction melting and casting b. Vacuum induction furnace, crucible mold c. Furnace Area d. 1.6 Kg U-235 in process e. 4-wheeled cart with mold and casting fixtures
Casting Extraction	7	a. Remove casting from mold and separate b. Work bench and hand tools c. Furnace Area d. 1.6 Kg U-235 in process e. 4-wheeled cart with mold and casting fixtures
Parting of Castings and Ingots	8	a. Cutting castings from hot top b. Abrasive cut off saw c. Machine shop Area d. 1.6 Kg U-235 in process e. 4-wheeled cart with mold and casting fixtures

Operation	Station No.	Description
Parting Castings	9 - 10	a. Part castings to length and diameter for hydriding b. Lathe, drill press c. Machine shop d. 1 Kg U-235 in process e. 4-wheeled cart with meat cart top
Hydriding	11, 30	a. Form $UZrH_x$ by holding meats at elevated temperature in H_2 atmosphere b. Hydriding furnace c. Hydride Area d. 3 Kg U-235 e. 4-wheeled cart with meat cart top
Centerless Grind	12	a. Finish meat to proper diameter b. Centerless grinder c. Machine shop d. 1 Kg U-235 in process e. 4-wheeled cart with meat top
Special	13 - 14	a. Machine detail in meats for special purposes b. Surface grinder, mill c. Assembly Area d. 1 Kg U-235 in process e. 4-wheeled cart with meat top
Assembly and Quality Control	15 - 02	a. Clad acceptable meats in aluminum, stainless steel, Hastelloy, or Incoloy cans; clean and/or co : clad elements b. Welding lathe, helium leak detection, inspection c. Assembly Area d. 3 Kg U-235 e. 4-wheeled cart with meat cart top
Chip Washing	21	a. Remove foreign surface contaminants prior to reprocessing b. Water c. Machine shop Area d. 350 g U-235 e. Hand carry container

Operation	Station No.	Description
Pickling	23	a. Treat scrap alloy or hydrided alloy in acid solution to remove surface oxide b. Acid solution, acid resistant dissolving pan, acid resistant storage container c. Fines burning area d. 350 g U-235 e. 4-wheeled cart
Weighing	24	a. Precision weighing at all stages of process b. Balance c. Hydride area d. 3.6 Kg U-235 e. 4-wheeled cart with appropriate top
D-2	any	a. Nonstandard process steps b. As required by process c. Any area, with approved solid angle calculation d. 350 g U-235 e. 4-wheeled cart with appropriate top
Fines Burning	2, 33, 24	a. Control burn scrap fines b. Burn furnace c. Twin shell blender d. Balance

All scrap and waste materials removed from the facility are evaluated for SNM content by gamma counting or by sampling and laboratory analysis. Gamma survey methods are used to evaluate the effectiveness of equipment cleanout and to assure that unknown SNM hold-ups do not exist. The hold-up in each piece of equipment is limited to 350 g U-235 as determined by in and out weight differences.

Station limits set forth in the detailed discussion on the stations apply to the material that is actually in process in or on the particular piece of equipment and do not reflect the material that may be present on a nearby cart awaiting processing. In each case the nuclear safety of the combined stations and carts is assured through evaluation and documentation of interaction solid angles.

Cart-top carriers designed for safe transport of material are used with a standard four-wheeled cart. The carts are used exclusively for transport of U-Zr material throughout the building. Openings in the cart tops are blocked off to permit only the limit for the type of material in process. The nuclear safety of the carts is described in Section 3.7.4.2.

In summary, the station limits, transfer cart limits, and storage limits are maintained taking into account that the uranium content and U-235 enrichment may vary with the fuel element requirements. During the production of elements of a specific enrichment level of U-235 in a given zone, all other special nuclear material is excluded from that zone.

Interaction calculations have been performed on all equipment and the associated fuel transport carts and all resultant values are well below the limiting criteria. As noted in Section 3.7.4.2.3, a separate extensive interaction study has shown that the only restrictions required on cart locations are the restricted space in front of storage racks, see Sections 3.7.4.2.1 and 3.7.4.2.2, and the restriction on casting cart nesting given in Section 3.7.4.2.5.

3.7. 1 Uranium Preparation; Stations 1, 3, 24

(Mass Limit - 10 Kg U-235)

Uranium stock material is brought to the metal preparation zone in its storage or shipping container and is limited to one container at a time. Container loadings and shapes vary. Containers up to 3.6 Kg U-235 in 1 gallon may be stored within the facility. Larger loadings of U-235 in varying containers may be received from sources outside the company. These will be stored in the NMM storage facilities and be issued at the time of use herein. The material is then weighed and placed in containers in batches ready for placing in the casting furnace. These containers are then returned to the TRIGA Vault-Type Room. All locations where operations are conducted on the uranium metal are exhausted by local elephant trunks through a high-efficiency air filter system. Any container listed for U-235 in Standard Limit-Type B, Section 5.5, Part I, may be required. The analysis for the limit B indicates that the 3.6 Kg U-235 in 1 gallon container is the most reactive, having a k_{eff} of 0.600 when fully flooded but unreflected and 0.95 fully flooded and reflected.

Uranium stock material is reduced to chips (about 1/8-in. cubes). The uranium size reduction is accomplished by cold rolling the stock pieces into a sheet about 1/8-in. thick. The average stock piece forms a sheet about 1/8 in. x 3-1/2 in. x 20 in. These pieces are placed in stainless steel pans having a maximum depth of 3/4 in. The sheets are chopped into small pieces using a shear mounted in a hood. The chopped uranium is placed in containers with a volume of 1 gallon or less. Each can contain a maximum of 3.6 Kg U-235.

This step consists of three separate stations where fissile material is under process, excluding the carts used to transport the uranium. These stations are (1) the rolling mill station, (2) the chopping machine, and (3) a weighing table. These stations are indicated in Fig. I 3.7-2. The batch processing is performed in series; therefore, fissile material will not be in all of these stations at the same time. However, for interaction purposes, it was conservatively assumed that full permissible fissile loads were present at each area.

The sheets rolled from the stock metal at Station 1, rolling mill, are about 3-1/2 by 1/8 by 20 in. These sheets are placed in 3/4-in.-deep pans. Nuclear safety at this stage is assured since the uranium is mass limited to 4 Kg and the uranium is in sheet metal form so that it cannot mix with water. Figure 8 of TID-7028 (Ref. 3.7-5) shows that 4 Kg of uranium is subcritical for any H/U-235 ratio less than 11 even with double batching and full water reflection. Water is excluded from these steps, and any possible liquid moderator is present in highly controlled conditions such as in cooling coils.

For interaction purposes k_{eff} was calculated for a bare 3-1/2 by 3/4 by 20 in. slab containing 4 Kg U-235 in the form of uranium metal. The calculated k_{eff} was 0.1 for use in interaction calculations.

The sheets are taken to Station 3 and chopped into small pieces which are collected into a 1 gallon container. No more than 3.6 Kg of U-235 are placed in any one container. These containers are then weighed into suitable charges at the weighing station for use in the subsequent melting process. The nuclear safety of the 1 gallon container with up to 3.6 Kg of U-235 is based on Standard Limit Type B in Section 5.5, Part I, as are the k_{eff} values of 0.95 when flooded and reflected and 0.600 when flooded but unreflected.

3.7.5.2 Melt Preparation, Station 5 (Mass Limit 3.6 Kg U-235)

The uranium, zirconium and other additives such as erbium to be used in the element fabrication are received from storage or other feed material preparation steps in containers limited to a volume of 1 gallon and 3.6 Kg U-235. The proper amount of uranium and zirconium are weighed and charged into the induction furnace crucible having a 5 in. diameter and a volume of 3.2 liters. Other additives may be included in the crucible or placed in a small addition hopper. The crucible is placed into the furnace. The weighing is accomplished at the weighing Station 5 within the furnace area.

The nuclear safety of this station is based on Standard Limit Type B in Section 5.5, Part I. The k_{eff} is 0.95 when flooded and reflected and 0.600 when flooded but unreflected. A spacing of at least one foot surface-to-surface is maintained between the feed container and the crucible.

3.7.5.3 Melting and Casting, Station 6 (Mass Limit 1.6 Kg U-235)

Two types of fuel rods are manufactured by the casting process. One is standard TRIGA fuel and the second is small fuel pins. The former requires casting rods slightly less than 1.5 in. in diameter and the second requires casting rods about 0.51 in. in diameter.

Melting and casting of the UZr alloy is accomplished using a vacuum induction furnace located in the furnace area at Station 6. The furnace exterior surfaces and induction coils are water cooled. The water cooling system is a limited volume, closed system. An elevated emergency cooling tank located outside the building may be manually coupled to the furnace cooling system. The furnace components are shown in Fig. I 3.7-5. The process melts the contents of the crucible, mixes them by induction, and pours the result into a cold or heated mold in the lower portion of the vacuum furnace. In an alternate mode of operation the mold is placed within the induction coil to permit remelting of the alloy within the mold and/or its cavity top. An inert gas blanket is added prior to pouring the melt. The hot molds are permitted to cool radiatively and conductively by adding an inert gas. The warm molds are removed from the furnace and allowed to air cool.

The initial step in the casting process is to melt pre-measured quantities of materials to form the desired alloy. This is cast to form an ingot approximately 3.25 in. dia and 12 in. long. The ingot is then parted into 3 segments, each about 4 inches long.

The rods are cast by placing a segment of the ingot in the top cavity of a rod mold. The segment is remelted, and the cavity channels the melted fuel into the fuel meat cavities in the lower part of the mold. Typical molds are:

Mold Type I	4 ea	1.5 in. dia. x 10.75 in. long
Mold Type II	25 ea	0.52 in. dia. x 6.5 in. long

Nuclear Safety Basis

The nuclear analysis submitted here is directed toward fabrication of any diameter rods limited only by the allowable quantity of U-235 within a geometrical constraint.

The material required for casting rods, described above, is about 12.7 Kg of alloy limited to 1.6 Kg of U-235. In the 5-in. diameter crucible, the alloy is in a single ingot contained in graphite. The alloy is poured into a mold. Alloy dimensions within the mold are constrained to a 5 in. x 5 in. x 17.5 in. parallelepiped or, alternatively, to dimensions having a less reactive, larger geometrical buckling.

Nuclear safety is assured under normal conditions by limiting the allowable amount of U-235 to a safe mass. Under normal conditions, the safety limit can be based on a dry mass limit of 10 Kg U-235. As Fig. 8 of TID-7028* (Ref. 3.7-5) shows, this mass limit is safe with allowance for accidental double batching for incidental amounts of moisture up to an atomic ratio of H/U = 2.

In the accidental event of a water leak, it would normally be immediately detectable because of a loss of vacuum, and automatic power shut-off. In the unlikely event of significant quantities of water being introduced into the furnace, safety is assured by safe geometrical dimensions for the alloy material within the molds. All alloy is constrained within equivalent to dimensions 5 in. x 5 in. x 17.5 in. Since the geometrical buckling for that water reflected parallelpiped is 0.355 cm^{-2}, then the equivalent safe cylinder diameter is 5.5 in. Applying a geometrical safety factor of 93% for the cylindrical diameter results in an equivalent critical diameter of 5.75 in., which, according to Fig. 1.A.3 of AHSB Handbook (Ref. 3.7-6), is a safe cylinder size for concentrations up to .4 Kg U-235/liter. Using Fig. 1.A.1 of the AHSB Handbook, give a critical mass of 2.4 Kg of U-235 which is 50% higher than the allowable 1.6 Kg U-235. The graphite mold designs will constrain the alloy within the dimensions 5 in. x 5 in. x 17.5 in. or less. Since the nuclear safety analysis given in this paragraph is quite general, then any alloy configuration in the graphite mold with a geometrical buckling greater than 0.355 cm^{-2} is acceptable. Since the 5 in. diameter crucible has been analyzed according to a similar argument (maximum U-235 density in the alloy -- .75 g/cc., and a 5-in. cylinder is safe up to densities greater than 1 g/cc according to Fig. 1.A.3 of Ref 3.7-6), then it too is safe.

---

*Since the quantity of graphite is approximately 7,300 g which is equivalent to a C/U-235 atomic ratio of 90, the actual critical mass is much larger as Fig. 14 of LA-3221-MS (Ref. 3.7-7) shows.

The credible, but highly unlikely, event that the graphite mold should tip, thus spilling alloy was investigated. All molds have lengths greater than the mold well diameter (15 in.) so that it is impossible for a mold to tip horizontally more than a given angle. For the maximum tip angle (25° from the horizontal), the maximum spill for the 1-1/2 in. diameter mold is 335 g of alloy per single rod mold assuming the highly unlikely condition of the alloy remaining molten. For the case of a single 4-rod mold (the worst possibility), the maximum possible spill is 1440 g of alloy or 168 g U-235. This corresponds to less than half the safe mass under the optimum moderation conditions.

To summarize then, the furnace has been found to be safe under the following accident conditions:

a. A water leak
b. Spill of metal out of the mold

In the operation of the casting furnace, a single charge of SNM is used and it resides either in the crucible or the mold. For interaction purposes the mold represents the most reactive case and it is considered as the interacting unit. The calculations described in Section 3.7.4.2.5 are used to define a k_{eff} of 0.57 for use in interaction calculations.

3.7.5.4 <u>Casting Extraction, Station 7</u> (Mass Limit 1.6 Kg U-235)

Upon reaching proper cool-down temperature the UZr alloy castings are removed from the molds by destroying the mold. The casting is separated from the mold on the furnace area work bench (Station 7). Only one loaded casting mold is permitted at this station. The ingots are prepared for machining by separating the individual ingots from each other. This requires cutting or breaking the castings from the hot top if the physical cross-section is small enough. If this is not the case, the castings are placed on the casting transfer cart and taken to Station 8. The hot top (the material in the mold top channels) residue alloy is returned to scrap storage or melt preparation.

The nuclear safety of this station has the same basis as the melting and casting process, Section 3.7.5.3. The reactivity analysis in Section 3.7.4.2.5 indicates a k_{eff} of 0.57 when the intact casting with hot top is flooded and unreflected, the value for use in interaction calculations.

3.7.5.5 Parting of Castings and Ingots, Station 8
(Mass Limit - 1.6 Kg U-235)

Castings that cannot be broken apart at Station 7 are taken to the cut-off saw, Station 8, for removal of the hot top. This unit is a liquid-cooled abrasive saw. The fuel is present in the shape of the casting. Only one casting can be cut apart at one time although two may be present on the transfer cart.

The nuclear safety of this station has the same basis as the melting and casting process, Section 3.5.9.3. The reactivity analysis in Section 3.7.4.2.5 indicates a k_{eff} of 0.57 when the intact casting with hot top is flooded and unreflected, the value for use in interaction calculations.

The waste from this operation is contaminated with the abrasive and cannot be directly reused in the manufacture process. The material is collected, evaluated for SNM content, oxidized at Station 2, and stored awaiting the accumulation of sufficient material to warrant shipment off site for recovery of the contained SNM.

3.7.5.6 Machining, Enriched U-Zr Elements, Stations 9A, 9B, 9C and 10 (Mass Limit - 1 Kg U-235)

The meats are machined and drilled in the Machine Shop. The resulting turnings and chips are collected and stored in the containers under the same conditions as described in Section 3.7.4.2.2 and recycled. After machining, the meats are inspected for surface cracks. Material transport to and from the machine shop is accomplished on four-wheeled carts with appropriate cart-top carriers.

The machining is conducted on a single casting ingot or parted meat at each lathe at Stations 9A, 9B, and 9C. In normal practice Stations 9A and 9B are used for machining 1.5-in.-diameter material and Station 9C is used for .5-in.-diameter, therefore all stations do not normally operate simultaneously. The 1.5-in.-diameter meats have a central hole drilled at the drill press, Station 10. For purposes of interaction calculations, all stations are assumed to be in operation and contain SNM simultaneously.

The nuclear safety of each station is based upon the use of a single piece of 1.5-in.-diameter material at each station. Fig. I 5.4-3 in Section 5.5, Part I, demonstrates that a single cylinder of material less than 3 in. in diameter cannot be made critical under any condition of water moderation and/or reflection. The k_{eff} for a single cylinder of $UZrH_{1.7}$ material without reflection is 0.050. This is demonstrated in Section 3.7.4.2.3.

3.7.5.7 Hydriding Furnace, Station 11

(Mass Limit - 3.0 Kg U-235)

The furnace is a 6-in. i.d. by 11-ft long Inconel tube that has 9 ft. electrically heated with external elements. The overall length of the furnace is 13 ft. It is mounted horizontally with its axis 5 ft from the floor. The furnace can contain up to five racks of elements, each rack 1-1/3-ft long, or nine racks of pins 1/2 in. x 5.5 in.

Elements are transported to and from the furnace and the associated rack loading hood, Station 30, on an appropriate cart-top carrier.

The nuclear safety of the hydride furnace is based on an analysis which considers the furnace a 6.063 in. cylinder of varying length and studying the effects of varying the distribution of a given mass of U-235. The analysis considered the reflected cylinder to be of varying height and a geometrical buckling calculation was made to determine the reactivity-equivalent sphere. The spherical critical concentration of U-235 in a homogeneous water mixture was then obtained from Fig. 9 of TID 70[illegible] (Re 3.7.5). In each case, this is the concentration which would also make the cylinder critical.

The buckling calculations used the standard relationship:

$$\left(\frac{2.405}{r_c+\delta_c}\right)^2 + \left(\frac{\pi}{h + 2\delta_c}\right)^2 = \left(\frac{\pi}{r_s + \delta_s}\right)^2$$

Where r_c = radius of cylinder

h = height of cylinder

r_s = radius of sphere

δ_c = effective extrapolation length of cylinder

δ_s = effective extrapolation length for sphere

The values of δ_c and δ_s were obtained from Fig. 3 of TID 7028.

The safety of mass controlled SNM loadings was determined by distributing a given amount of U-235 over the volume of the cylinder. The safety factor is the ratio of the critical concentration to the mass-load-limited concentration. The safety factor has a minimum in the range of 20 to 30 in. column height, and this minimum is used to set the maximum permissible loadings. The result of this calculation, shown in Fig. I 3.7-5, demonstrates the safety to the furnace under conditions of internal flooding with the additional assumptions that the contained fuel finely fragments and that the resultant metal-water mixture is confined to the most reactive configuration (a region about 25 in. long). Fig. I 3.7-5 shows that 3.0 kg of U-235 has a safety factor of 1.11 (90% of critical, a limit justified under mass control when double batch is not considered) under these highly unlikely conditions. The H/U-235 ratio at the minimum safety factor point is 90.

The foregoing has assumed that the $UZrH_{1.7}$ fuel was distributed in the most reactive form (finely divided) over the most reactive volumes. This is a highly conservative assumption because the fuel is in the form of rods held within fixtures which limit the spatial distribution. The fuel rods have a high degree of integrity which has been demonstrated by water quench from high temperatures without fracture of the rods.

The normal geometry of the fuel within the furnace is determined by a fixture which holds five rows of 1.5 in. fuel rods, or a larger number of 0.51 in. rods with an equivalent cross-sectional area. An analysis similar to the foregoing using the cross-sectional area-equivalent cylinder (3.13 in. diameter) indicates that the 3.0 kg U-235 loading has a safety factor of 10. Fig. 10 of TID-7028 indicates that a cylinder of this size cannot be made critical at U-235 densities less than 17.5 kg/l assuming 93.2% U-235 and 12 wt % U in the UZr fuel, hence the nonflooded system cannot be made critical.

Any disarrangement within the furnace of a maximum fuel charge containing 3.0 Kg of U-235 falls within and is less reactive than the flooded cylinder.

For interaction calculations, it was assumed that the five rows of fuel rods in the furnace racks were replaced by one, infinitely long $UZrH_{1.7}$ cylinder with a cross-sectional area equivalent to that of five rods. For this bare cylinder, k_{eff} was calculated to be 0.30. No additional water between the rows of fuel rods was assumed in this calculation since presence of this water would imply flooding of the complete rack including full reflection, thus shielding the fuel from interaction.

3.7.5.8 Centerless Grinding, Station 12
(Mass Limit - 1 Kg U-235)

Subsequent to hydriding, the meats are finish machined to final dimensions by use of the centerless grinder, Station 12. This is accomplished by feeding the material one piece at a time through the station.

The nuclear safety of this station is based on the same discussion as the other stations in the machine shop in Section 3.7.5.5.

The waste from this operation collects in the coolant liquid and is concentrated in a filter. The limit on waste within the station is 350 g. The accumulation is determined from differential weight measurements and is verified through gamma survey as discussed in Section 3.7.5. This waste is contaminated with the abrasive and cannot be directly reused in the manufacturing process. Treatment and disposal of this material is discussed in Section 3.7.5.18.

3.7.5.9 Special Machining, Stations 13 and 14
(Mass Limit - 1 Kg U-235)

A few of the meats require special machining to accommodate instrumentation such as thermocouples. This is done at a surface grinder, Station 13, and a milling machine, Station 14. The machining is done on a single piece of material at a time. The nuclear safety is based on the same considerations as set forth for the equipment at Stations 9 and 10, Section 3.7.5.6.

3.7.5.10 Assembly, Enriched U-ZrH Elements, Stations 15-20
(Mass Limit - 3.0 Kg U-235)

The accepted meats are inserted into aluminum, stainless steel, Hastelloy, or Incoloy tubes at Station 15 and sealed by welding at Station 16. They are then checked for leak tightness at Station 18 and 19. Finally, the elements are inspected dimensionally and visually at Station 20, and stored in the vault-type room as finished elements. Elements are processed singly during this work, other than at Station 18, and carts are used to hold the meats awaiting assembly and the assembled elements.

Station 17 is a Magnaform machine, an electro-magnetic swaging process, used to swage control rod followers to special fuel elements.

Special cluster-type fuel assemblies are sometimes made at Station 15 by assembling four finished fuel elements into a four rod square with outside dimensions of 3 in. by 3 in. These assemblies are inspected at Station 20, placed into shipping containers and removed from the facility.

Nuclear safety at Stations 16, 17, and 19 is based upon a single fuel element being in the station and the same considerations as set forth for Stations 9 and 10, Section 3.7.5.6, apply.

Nuclear safety at Stations 15 and 20 is based upon the four rod fuel assembly. The safety is demonstrated by Fig. 10 of TID-7028 (Ref. 3.7-5), which shows that the critical diameter of a 50/1 H/U-235 mixture, fully water reflected, infinitely long cylinder is 5 in. The diameter of the equivalent four-rod-cluster cylinder is 3 in.

For interaction purposes, the 3 in. x 3 in. x 15 in. four-rod cluster was replaced by a single cylinder of equivalent cross-sectional area and 15 in. long. Assuming only $UZrH_{1.7}$ and 93.5% enriched uranium in this cylinder and neglecting the clad material as an absorber, the unreflected k_{eff} was calculated as 0.25. The atom densities used in this calculation and the H/U-235 ratio are given in Table I 3.7-2.

At Station 18 a chamber is used to apply Helium gas pressure to the outside of finished fuel elements as a part of the leak detector test. The chamber is a 6-in.-diameter cylinder. This size vessel has been demonstrated in Section 3.7.5.7 to be safe for loadings of hydrided fuel containing up to 3 Kg of U-235.

The interaction calculations assume the maximum content at each station.

3.7.5.11 Chip Washing, Station 21 (Mass Limit - 350 g U-235)

Chips generated during the machining process are degreased by a hot water rinse to remove foreign surface contaminants prior to reuse. The chips are held in a 5-gallon container, 12 in. in diameter and 14 in. high, and mass limited to 350 g U-235. Drying is accomplished by drawing air through the chip container to the exhaust system.

Nuclear safety for any degree of moderation and flooding is ensured by the 350-g limit, which is less than standard limit Type A in Section 5.5, Part I. Safety in the event of double batching is also assured.

3.7.5.12 Pickling, Station 23
(Mass Limit - 350 g U-235)

Occasionally material becomes oxidized on the surface or scrap is generated that cannot be recycled. This material can be treated by acid dissolution before reuse, storage or disposal. A unit containing no more than 350 g U-235 is brought to the hood located in the fines burning area. Portions of the scrap material are taken from the container and surface pickled in a nitric - hydrofluoric acid solution. The procedure is repeated until all of the scrap material from the container is processed, until the acid solution is depleted, or until an amount of material containing up to 350 g of U-235 has been processed. When any one of the above conditions is met, the solution containing the dissolved scrap is transferred into a special acid-resistant storage container. Dissolved material from more than one scrap unit may be accumulated in the solution storage container, but the mass limit of the solution storage container is 350 g of U-235.

Since the dissolver is mass limited to 350 g of U-235, its nuclear safety is based on standard limit Type A in Section 5.5, Part I. Criticality safety of the scrap dissolver storage containers is also assured by the 350 g U-235 mass limit.

3.7.5.13 Weighing, Station 24
(Mass Limit - 3.6 Kg U-235)

A weighing balance is located at Station 24 in the hydride area. This station is normally used to weigh single fuel meats, but it may also be used to weigh containers. Nuclear safety is justified on the same basis as Stations 4 and 5 in Sections 3.7.5.1 and 3.7.5.2.

3.7.5.14 <u>D-2 Type Stations</u>

(Mass Limit - 350 g U-235)

General operating stations called D-2 type are periodically required within the TRIGA Fuel Fabrication Facility to accommodate nonstandard operations that affect special fuel element fabrication. The nuclear safety of the D-2 type station is based upon the limit of 350 g of U-235 at each of the subject stations. This quantity is Standard Limit Type A in Section 5.5, Part I. The criteria for the stations are: they may be located in a fuel processing area provided that (1) the solid angle produced by the addition to the D-2 station does not exceed the allowable total solid angle of any interacting station, (2) the total solid angle seen by the D-2 station does not exceed 2.50 steradians which is based upon a k_{eff} of 0.650 for the 350 g U-235 mass limit, and (3) all of the D-2 type stations will be documented and shall be approved by the Fuels Quality Assurance Division.

3.7.5.15 <u>Patterson-Kelly Twin Shell Blender, Station 26</u>

(Mass limit 350 g U-235 or any mass of oxide ash from the controlled burning of UZr alloy containing less than 11 wt% U-235).

The V-blender is formed of two 5.5" i.d. type 304 stainless steel tubes joined to form a 90° elbow. The V-blender rotates about an axis forming an isosceles triangle with the axis of the two tubes. The volume contained in the V-blender is 6.035 liters.

For operation under the 350 g U-235 limit the nuclear safety of the V-blender is justified under Standard Limit Type A, Section 5.5, Part I.

For operation with oxide ash from the controlled burning of UZr alloy, the nuclear safety is based on analysis. The analysis considered the V-blender to be a sphere of equivalent volume filled with a homogeneous mixture of the oxides formed by stoichiometric oxidation of UZr alloy containing 11.2 wt % U-235 to ZrO_2 and UO_2. Calculations using the DTFX transport code with 18 broad group cross sections generated by the MICROX spectrum code were made for H/U-235 ratios from 500 to 25 and for bare and reflected spheres (Ref. 3.7-8, 3.7-9). Conservatism is built into the calculation by the assumption of spherical geometry, consideration of a reference maximum reactivity alloy, the use of crystalline densities for the oxides, and the assumption of homogeneous mixing of the oxide and contained water. The results of the calculation are shown in Fig. I 3.7-6. The maximum k_{eff} in the two cases is as follows:

Unreflected k_{eff} = 0.67 for H/U-235 = 200, 0.104 kg/ℓ U-235

Reflected k_{eff} = 0.88 for H/U-235 = 150, 0.130 kg/ℓ U-235

3.7.5.16 <u>Hydride Boat Hood, Station 30</u>
(Mass Limit - 3.0 Kg U-235)

A hood is located in the hydride area for use in loading and unloading the fixtures (boats) used in the hydride furnace. Each of these boats is up to 5.5 inches OD by 12 inches long. They are held in two parallel cylindrical rows, each up to 4 feet long, within the hood. A metal fixture is provided to assure a 12-inch, surface-to-surface separation of the two fueled cylinders. Fuel meats are moved to and from the station on standard move carts, and are handled singly between the cart and the boats in the hood.

The nuclear safety of the station is based upon the 3.0 Kg U-235 limit and the 5.5-inch outer diameter of the fixtures. Figures I 5.4-25 and I 5.4-29 show that this configuration and loading has a minimum safety factor of 2.3 when fully water-moderated and reflected. This occurs when the material is concentrated in a cylinder about 32 inches long. Any other distribution of the fuel within the cylinder has a greater safety factor. Hence the safety of the system is demonstrated.

The reactivity of the system is obtained from an analysis based on the fact that the area of the envelope of the hexagonal fueled area within the fixture (19.339 sq. in.) is less than the area of a 5-inch cylinder (19.635 sq. in.) and the neutron leakage of a hexagonal shape is larger than that of a cylindrical shape. For this reason the bare and reflected reactivities for 5-inch cylinders 0.58 and 0.95 may be assumed for each of the two locations in the hood.

3.7.5.17 Waste Barrel Storage Area, Station 31
(Mass Limit - 235 per barrel)

Marked areas may be established for the holding of scrap and waste barrels prior to removal from the facility. Each area will be designated for a fixed maximum number of 55-gallon barrels. Each barrel may contain up to 225 gms of U-235. The barrels are to be upright, in a single stacked plane array.

The highest area density is realized in a triangular close packed array of barrels. A typical 55-gallon barrel is 22.5 inches in diameter and occupies 2.637 sq. ft. in such a close packed array. If the barrel contains the 225 gm limit of U-235, the equivalent SNM area density is 85.3 gms U-235 per sq. ft. The nuclear safety of this type of station is, therefore, based on Standard Limit Type E in Section 5.5, Part I. The maximum area density is less than 160 gms U-235 per sq. ft. and the maximum unit is less than 250 gms U-235. The applicable k_{eff} are therefore 0.71 reflected and 0.55 bare.

Interaction calculations shall be made on each waste barrel storage area that is established. These calculations shall be used to establish the minimum distance that SNM move carts may be spaced away from the array.

3.7.5.18 Fines Furnace, Station 2 (alt.)
(Mass Limit - 350 g U-235)

The fine UZr scrap resulting from various operations is burned to oxide at Station 2. This burning is carried out at regulated temperatures using a controlled flow of an N_2/O_2 gas mixture. The material to be burned is generally in the form of damp, bulk fines or as filters loaded with fines.

A 500 gal. tank connected to the end of the furnace tube is isolated from the tube by a rupture disc. In the unlikely case of an overpressure in the furnace tube, the rupture disc will break, releasing the pressure to the expansion tank. Both the tank and furnace tube have been designed and constructed to the intent of the applicable ASME pressure vessel code for a 200 psi working pressure. They have been approved by a pressure vessel inspector for the State of California. Normal furnace exhaust is through the by-pass line around the rupture disc and into the expansion tank. The expansion tank outlet is connected to the building exhaust duct overhead. A handhole in the tank permits periodic sampling of the internals for U. A drain on the bottom permits the removal of condensation.

A glove box mounted on the front end of the furnace tube assures containment of the fine particles during handling and furnace loading/unloading operations. The glove box is connected through a prefilter to the overhead exhaust duct. Four stainless steel fines burning trays about 5-1/4" - 5-1/2" wide by 18-1/2" - 18-3/4" wide by 1-1/2" high can be loaded from the glove box into the furnace tube on a rack specially designed to hold them. For burning filters, two trays which approximate cylinders 6-1/2" ID by 18"-18-1/4" long, cut vertically in half, can be loaded into the furnace tube.

The station limit, when operated in the fines burning mode, is 350 g U-235. The nuclear safety is justified as standard limit Type A in Section 5.5, Part I.

REFERENCES

3.7-1 Mathews, D. R., et al., "GGC-5, A Computer Program for Calculating Neutron Spectra and Group Constants," Gulf General Atomic Report GA-8871, September 27, 1971.

3.7-2 "Nuclear Design Methods in Use at General Atomic," General Dynamics, General Atomic Division Report GA-8010, June 1967.

3.7-3 Lenihan, S. R., "GASE-2, A One-Dimensional, Multigroup, Neutron Diffusion Theory Code for IBM-7090," General Dynamics, General Atomic Division Report GA-3152, August 3, 1962.

3.7-4 Whitesides, G. E., Cross, N. F., "KENO-A Multigroup Monte Carlo Criticality Program," USAEC Report CTC-5, Computing Technology Center, Union Carbide Corporation, Oak Ridge, Tenn., Sept. 10, 1969.

3.7-5 Paxton, H. C., et al., "Critical Dimensions of Systems Containing U-235, Pu-239, and U-233," USAEC Report TID-7028, Los Alamos Scientific Laboratory and Oak Ridge National Laboratory, June 1964.

3.7-6 J. H. Chalmers, G. Walker and J. Puch, "Handbook of Criticality Data," Volume I, UKAEA, AHSB(S), 1965.

3.7-7 Mills, C. B., "Reactor Minimum Critical Dimensions," USAEC Report LA 3221 MS, Los Alamos Scientific Laboratory, University of California, N. Mex., Oct. 1959.

3.7-8 Archibald, P., K.D. Lathrop and D. Mathews, "1DFX-A Revised Version of the 1DF(DTF-IV) SN Transport Theory Code," Gulf General Atomic Report Gulf-GA-B10820, September 27, 1971.

3.7-9 Walti, P. and P. Koch, "MICROX-A Two Region Flux Spectrum Code for the Efficient Calculation of Group Cross Sections," GA-10827, April 1972.

TRIGA FUEL FABRICATION BUIL

SNM PROCESSING STATIONS AS OF C

GA-A12001, FIG I 3.9-2

DATA ELEVATIONS ARE 0.00 TO 20.00 FEET

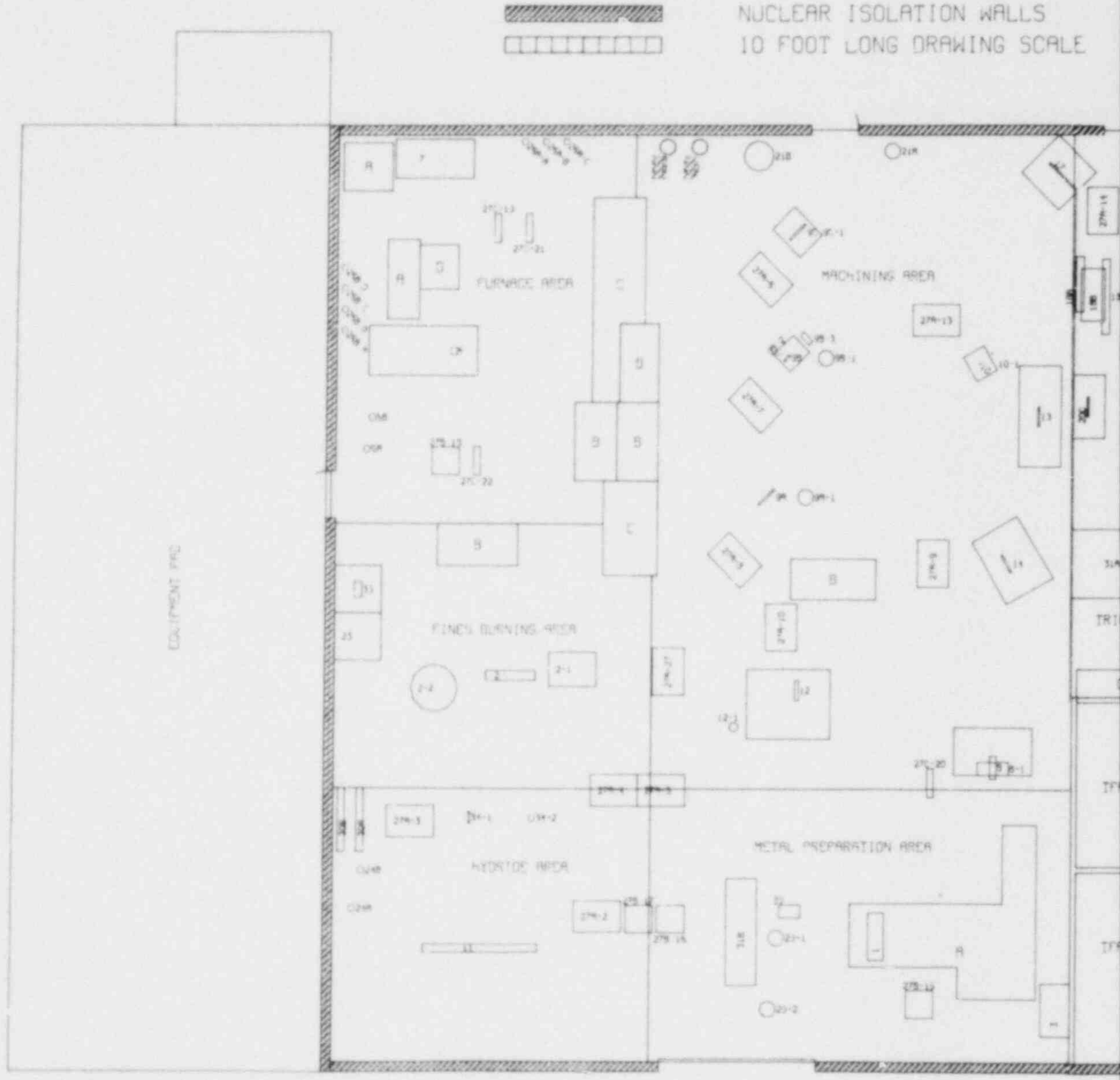
PLATFORM EDGE OR AREA OUTLINE

THIN OR SINGLE SURFACE WALLS

STANDARD WALL CONSTRUCTION

NUCLEAR ISOLATION WALLS

10 FOOT LONG DRAWING SCALE



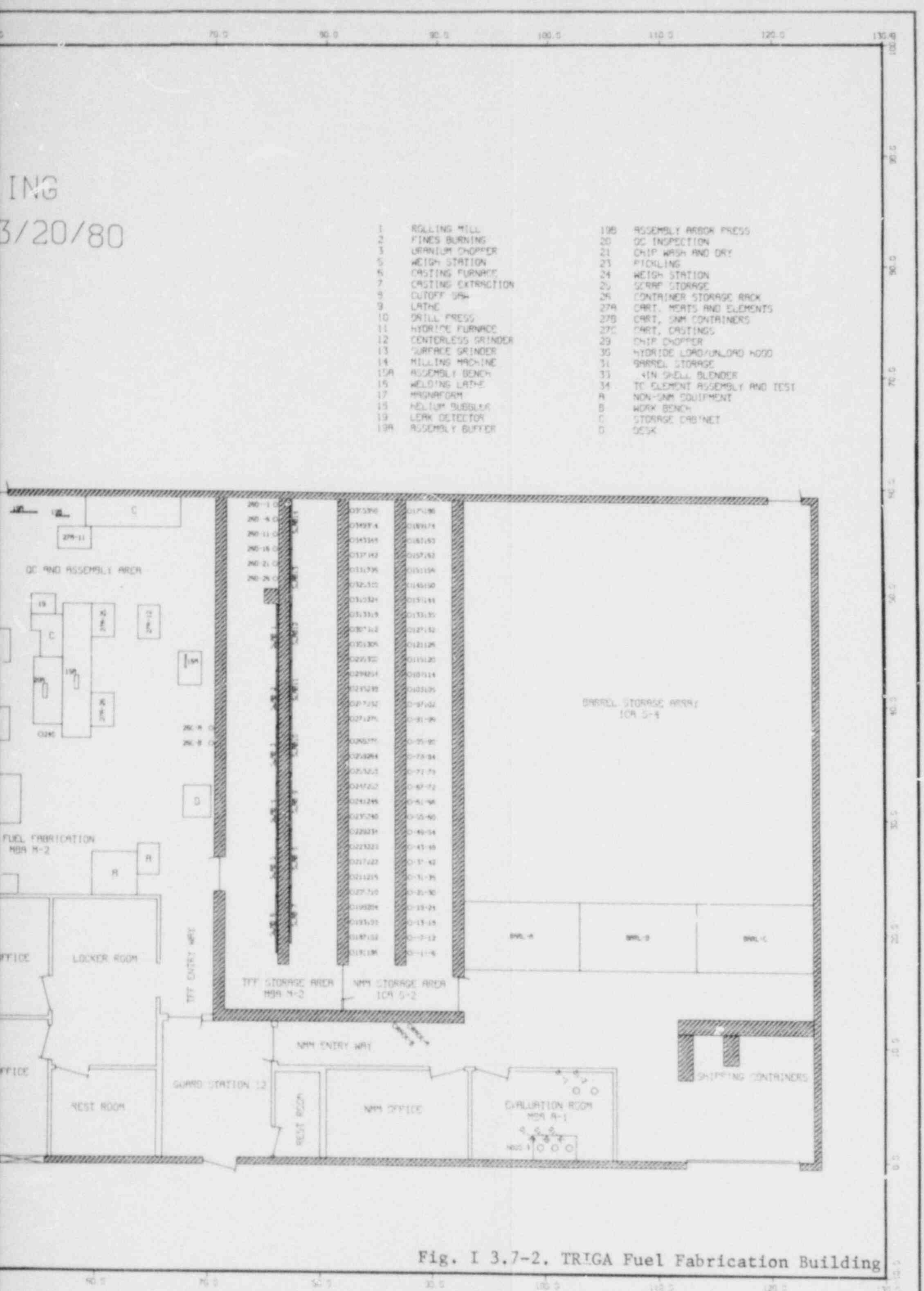


Fig. I 3.7-2. TRIGA Fuel Fabrication Building

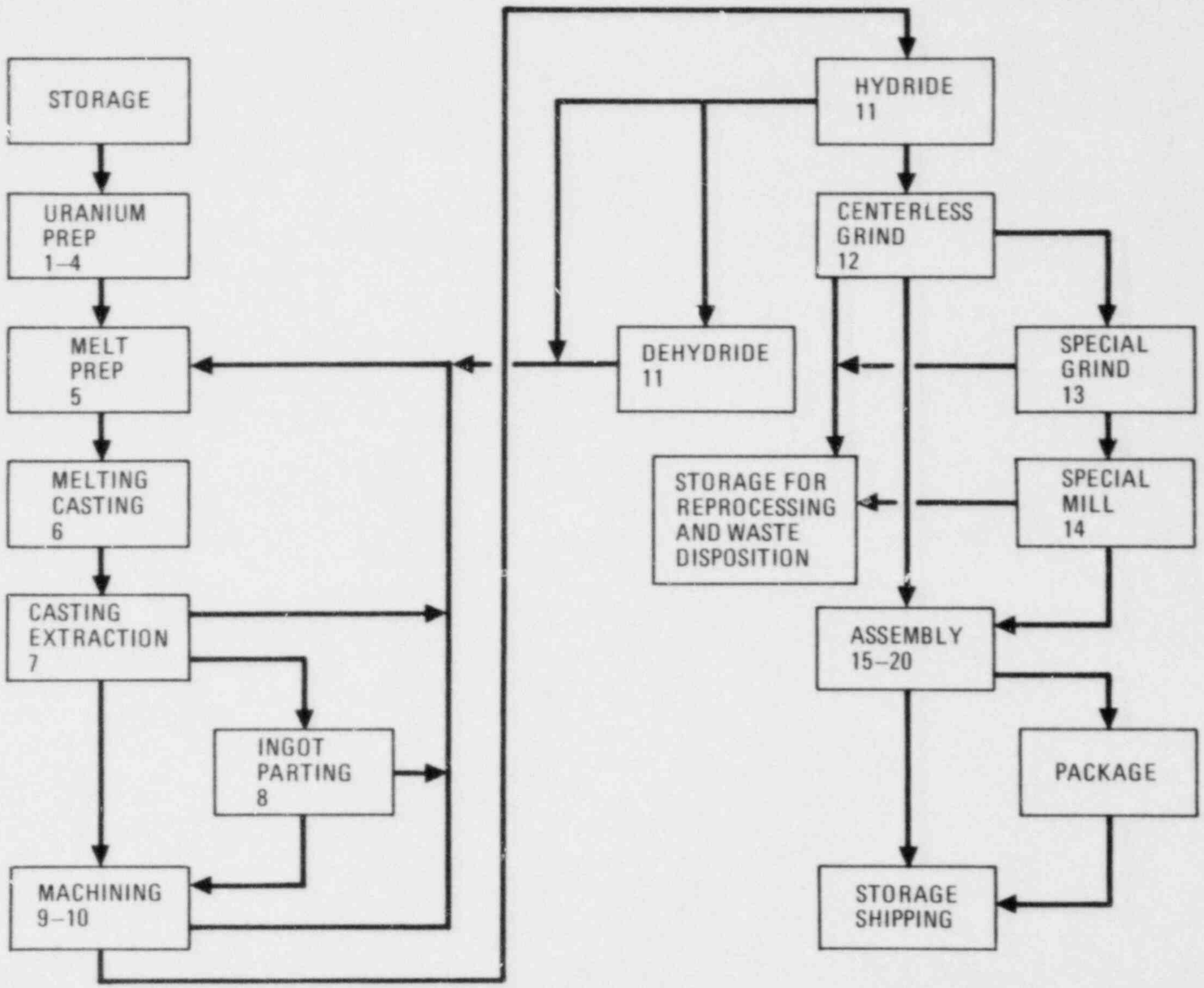


Fig. I 3.7-3. TRIGA fuel fabrication process

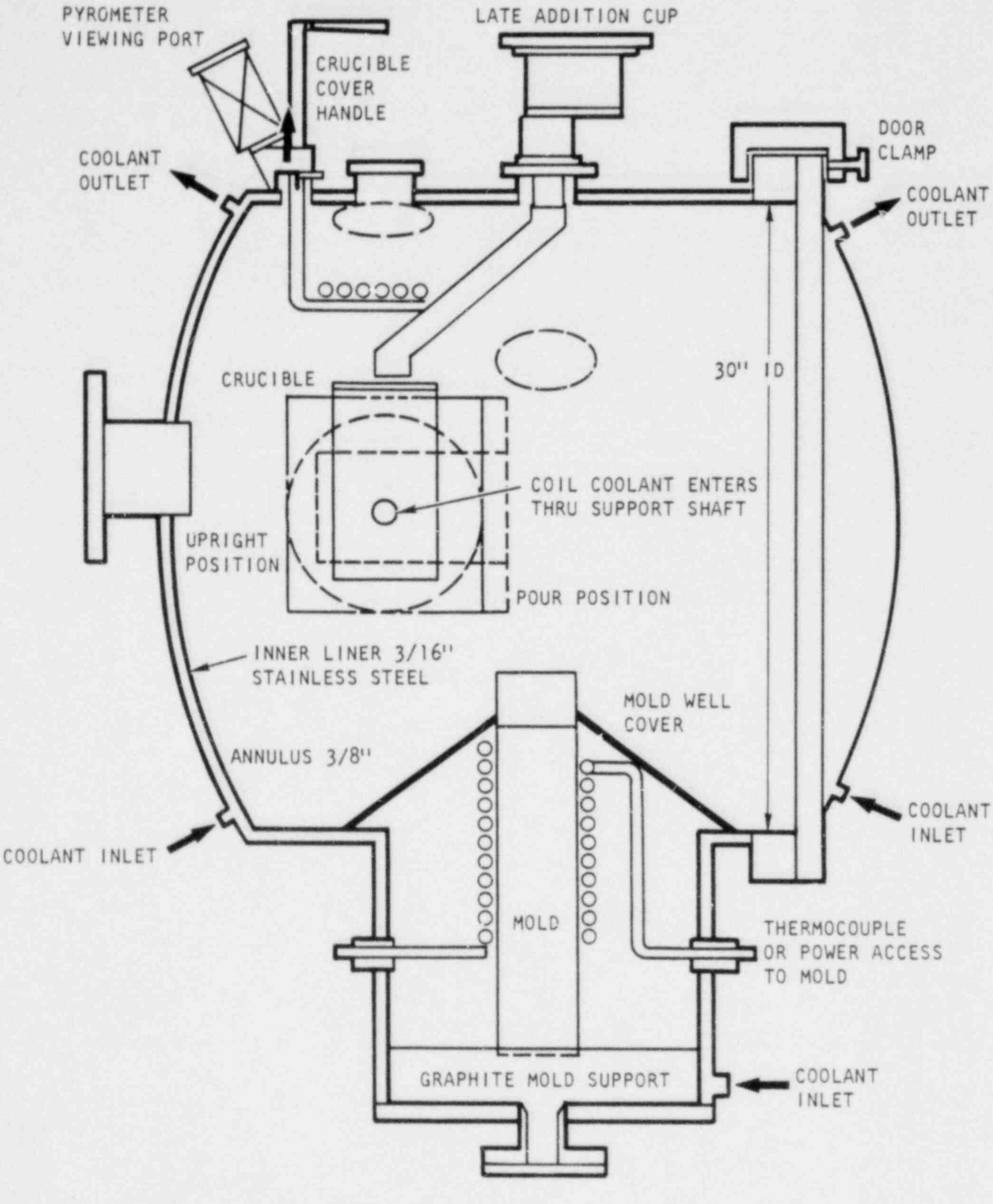


Fig. I 3.7-4. Induction Casting Furnace

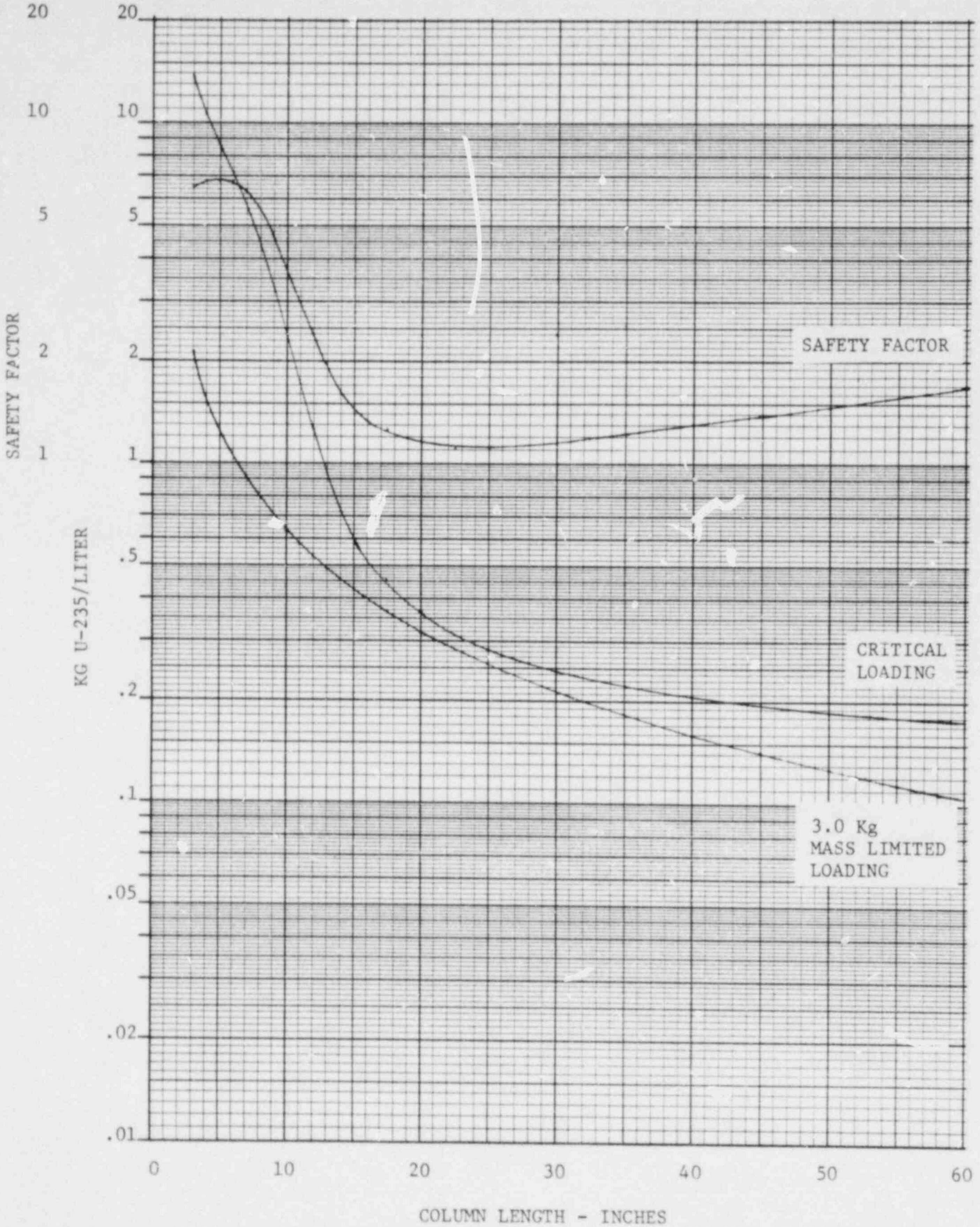
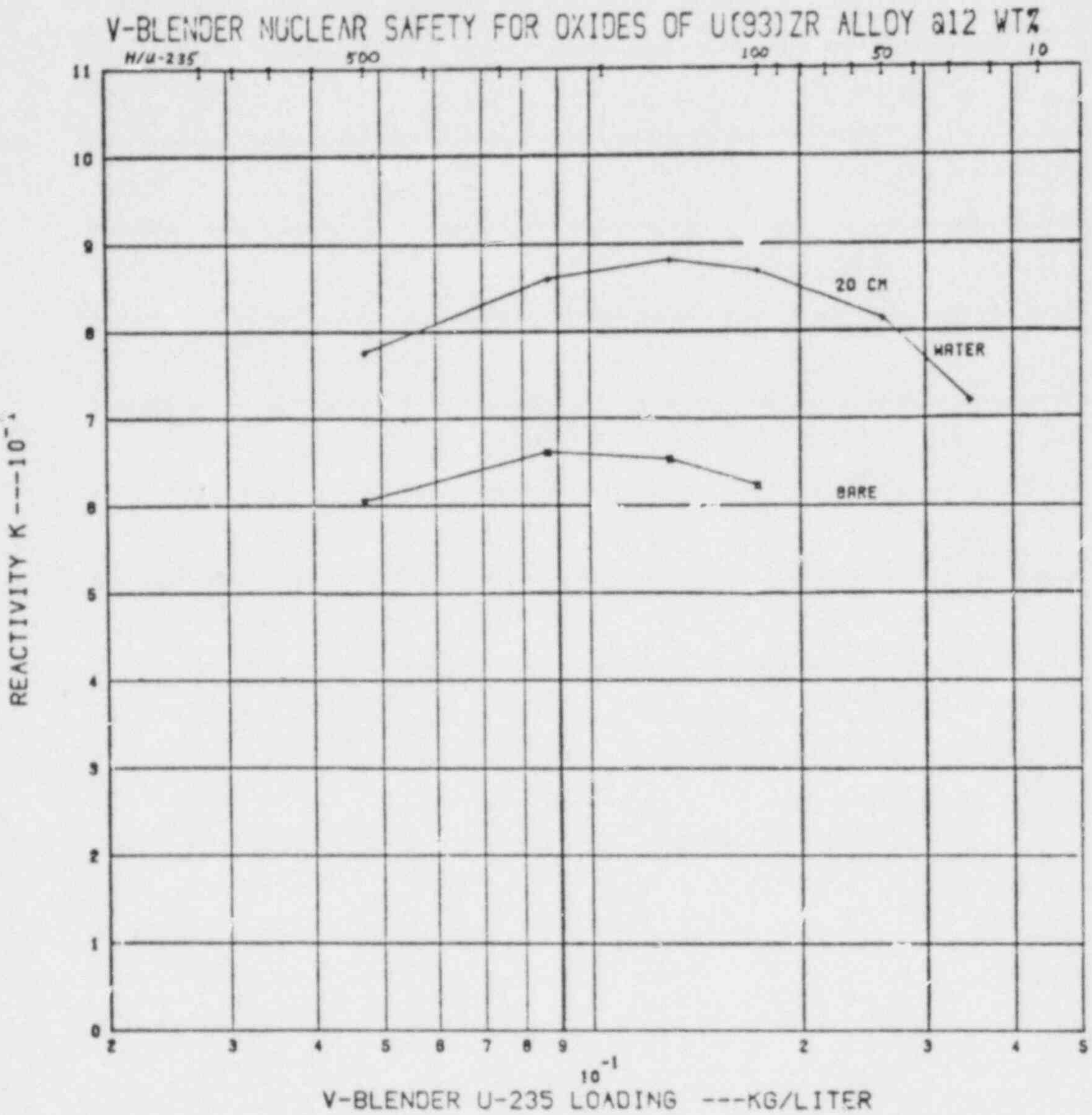


Fig. I 3.7-5 SAFETY OF MASS-LIMITED U-235 - WATER MIXTURES IN WATER-REFLECTED 6.063 INCH CYLINDERS.



V-BLENDER NUCLEAR SAFETY FOR OXIDES OF U(93)ZR ALLOY @12 WT%
H/U-235
500
100
50
10
11
10
9
8
7
6
5
4
3
2
1
0
20 CM
WATER
BARE
REACTIVITY K ---10^-1
2
3
4
5
6
7
8
9
2
3
4
5
10^-1
V-BLENDER U-235 LOADING ---KG/LITER

Fig. I 3.7-6

3.11 WASTE DISPOSAL YARD

The Waste Yard is enclosed by an 8-ft-high chain link fence, including a barbed wire extension. The yard is occupied by and under the control of authorized personnel during working hours and is secured by a lock keyed to the security system at off-shift times. A security patrol checks the yard at least every 4 hours during nonworking hours.

3.11.1 Waste Yard Operations

The Waste Yard is an area set aside for collection. processi   and packaging for ultimate disposal of wastes and scrap generated in   ious facilities at the San Diego site. The Waste Yard (Fig. I 3.11-1) consists of service buildings, office, yard storage area, upper storage array and adjacent evaporation ponds. An incinerator for burning combustibles contaminated with SNM is located nearby and is a part of the Waste Yard operations; it is described separately in Section 3.12, Part I. The By-Products Storage Area is located within the Waste Yard but is not involved in waste processing operations. This is discussed in Section 3.3, Part I.

Radioactive waste is not normally buried on site. On-site waste processing consists of the following types of operations:

Solid Dry Waste - Shipped to commercial land burial facility in metal drums or wooden boxes. Some waste materials may be compacted in drums prior to shipment.

Oil - Mixed with absorbent and solidifying materials in metal drums prior to shipment to commercial land burial.

Water - Bed filtered or evaporated in solar evaporation ponds. The bed filters are solidified and packaged for transfer to burial. The pond sludge resulting from evaporation is mixed as appropriate with absorbent and solidifying materials in metal drums, then shipped to commercial land burial.

Acid - Mixed with neutralizing agent, absorbent and solidifying materials in metal drums prior to shipment to commercial land burial.

Radioactive waste, generated at the Hot Cell Facility, is packaged at the Hot Cell for direct removal by a carrier to the commercial waste disposal company.

Except for liquid waste held in solar evaporation ponds, radioactive wastes are not stored at the Waste Yard, other than during periods between receipts and transfers to commercial disposal facilities. At peak periods such shipments are made about every 2 weeks.

In summary, the main functions of the Waste Yard are to reduce the volume of liquids, convert liquid residue to solids, compact nonburnables, incinerate burnables, and either prepare the waste for disposal by licensed radioactive waste disposal companies or hold the concentrated waste for possible reprocessing. These operations naturally divide into the processing of liquid waste and solid wastes. More detailed descriptions follow.

Liquid Wastes

The San Diego site operations which generate liquid wastes containing radioactivity have collection facilities which may range from collection bottles to barrels to plumbing systems and tanks. Those facilities where a possibility exists for significant amounts of U-235 to enter the collection system have critically safe geometry holding tanks. The liquids in the various collection vessels are sampled and analyzed by Quality Control or the Chemistry Department and checked by Health Physics Services before withdrawal for transport to the Waste Yard.

Transport of aqueous waste is accomplished in plastic containers, 55-gallon drums, or up to 500-gallon tank trailers. In any case, a maximum limit of 350 g of U-235 content is observed; experience has shown that the bulk of the aqueous waste is decontamination water and air scrubber water and that the limiting factor on transport is the bulk of water, not the SNM content. These wastes are transported to the Waste Yard for processing.

One holding tank with a capacity of 1000 gallons is available at the evaporation ponds. This unit is used for buffer storage if the ponds are not able to accept an incoming load of aqueous waste. The tank is limited to a maximum of 350 g of U-235, and inventory books are kept on the tank to control the contents.

The evaporation ponds consist of four large concrete ponds each 20 ft by 60 ft and 2 ft deep with a total capacity of about 70,000 gallons. Two of these ponds are subdivided into three 20 ft by 20 ft ponds by means of 2 ft high separators. One of the ponds is subdivided into a 20 ft by 20 ft and a 20 ft by 40 ft by a single 2 ft high separator. The fourth pond is subdivided into three 20 ft by 20 ft by means of 1 ft high separators and, hence, when full, operates as a single large pond, but when the liquid level is low operates as three separate ponds. The basic SNM limit is 350 g of U-235 per pond, large or small. The level of the three small ponds is not allowed to rise to the point where the small ponds merge unless the total inventory in the three is less than 350 g of U-235, and normal practice is to hold the sum of the three below 350 g. The ponds are protected during inclement weather by a removable covering. The surfaces around the ponds are paved and walled to form a catch basin.

The SNM content of incoming aqueous wastes in the drums and/or trailers is established by sampling at the point of origin and by subsequent analysis. This SNM is added to the pond SNM inventory books when the waste is added to a particular pond.

The pH of the water in the ponds is periodically checked and neutralized by the addition of chemicals, if necessary. The solids and sludge settle, and the water evaporates until a damp sludge remains. This residue is shoveled out and mixed with absorbent and solidifying materials in metal drums, then shipped to commercial land burial. Evaporation to dryness is not allowed, since contaminated solids (dusts) might be blown outside of the pond.

The nonaqueous liquid wastes are also sampled and analyzed for SNM content. These materials are neutralized, if necessary, and mixed with absorbing and solidifying materials in metal drums prior to shipment to commercial land burial.

The solidification process is conducted near the area marked Acid Basin on Fig. I 3.11-1. The radioactive materials involved are wet and do not evolve dust so this operation may be safely conducted in the open. The process involves placing the barrel below a large power mixer and gradually adding the neutralizing materials and then the solidifying agent, typically cement. The mixed barrel is then set aside to solidify. After proper solidification takes place, the barrel is closed, secured, and placed with the other barrels awaiting shipment for burial.

Solid Wastes

Each San Diego site operation generating solid radioactive contaminated waste collects this material in designated receptacles. This waste is segregated into collection containers typically identified as burnable or nonburnable waste and as containing SNM or not containing SNM. The collection containers range from plastic bags in the laboratories to barrels and boxes at the fuel fabrication facilities. If known amounts of SNM are to be disposed of in waste, the material is logged into the container; usually, however, the amounts are unknown and require gamma counting to evaluate. Health Physics personnel assigned to the waste generating facilities routinely monitor the waste containers. There is a limit of 100 g of U-235 per barrel and 100 g per box, and any container with over 100 g must be released by responsible management before it is picked up for removal to the Waste Yard.

Outside storage at the Waste Yard is in 30-gallon, or larger, drums or Department of Transportation (DOT) specification wooden boxes. Any cardboard or fiber boxes received are kept in covered storage until they are put into containers suitable for outside storage. A maximum of 2500 drums and boxes is permitted in the Waste Yard at any one time. Each container is marked by paint and stencil with the identity and quantity of the contained material.

The solid waste operations performed at the Waste Yard are those needed to incinerate, compact or bale the waste and make it ready for shipment to authorized disposal sites. The incoming solid wastes are segregated into burnables for incineration and nonburnables for compaction. Incineration is described in Section 3.12. The resulting incinerator residue is either held for possible reclamation of the contained SNM or it is put into the nonburnable waste cycle.

The nonburnable waste is compacted into barrels. The location of these operations are shown in Fig. I 3.11.1. These operations are accomplished using power actuated equipment with any resultant dust drawn off by a hood that exhausts into a high-efficiency air filter system. The drums or boxes are closed and secured prior to removal for storage. All additions of SNM-bearing waste to any accumulation, such as a compacted drum, are done with strict observance of applicable limits on the SNM content.

Procedures prohibit opening containers of dry waste while outside, except when bagged material may be added to containers that hold only bagged material. The bags used are made of substantial plastic with the openings well secured.

All barrels are closed with lids, locking rims, and securing bolts. Shipping boxes are banded and strapped. There has never been a wind in the region of the San Diego site that would be capable of moving or opening these containers. All outside container storage is on asphalt pavement to assure proper drainage and impede corrosion. Corrosion of drums is very low; very little is perceptible when observed over a 3-year span. Drums in storage are checked on a routine basis for signs of leakage and corrosion. At least 10 percent are checked each month and any drum showing signs of deterioration is replaced.

3.11.2 Nuclear Safety

Typical waste containers are 30-gallon or larger volume and occupy at least one square foot of area. No one container may exceed 0.5 g U-235/liter or 100 g U-235 total. For nuclear safety, the assumed areas are those for close packed, minimum area arrays. All containers are stored in a single layer plane array. Each of these storage units, either singly or in mixed array, is less than 160 g U-235/ft^2 and less than 250 g U-235/unit, or sub-crit, hence, the nuclear safety of the storage is justified on the basis of being more conservative than standard limit Type E.

Uranium wastes and scraps, enriched to less than 20% U-235, may be stored outdoors. Such storage may be in 55-gallon or larger metal barrels with a maximum content of 350 gm U-235/barrel. The effective area density of a close packed array of these barrels is 114.94 g U-235/ft^2. The nuclear safety of this storage is based upon standard limit Type F.

Nuclear isolation is not required between the above types of outdoor storage because all are less than the area density limit of 160 g U-235/ft^2 in standard limit Type E and those units that exceed the unit mass limit of 250 g are justified as safe in the array under standard limit Type F and no credit has been taken for the absorption of neutrons in the U-238 in the low enrichment uranium.

SNM in approved shipping containers may be temporarily stored outdoors while awaiting transport or unloading. All limits applicable during transport shall be observed in this storage. Each barrel shall be closed with a bolted locking ring. Each container shall have an identifying serial number printed on it. Written records of the identity and quantity of material, by container serial number, shall be maintained. Additional time and physical protection requirements are imposed on all plutonium, U-233, and uranium enriched in more U-235. These restrictions are set forth in the General Atomic Security Plan and the license amendments related thereto.

The limit of 2500 individual drums and boxes is for administrative control only and is not based on nuclear safety criteria.

Liquid wastes are subject to the same SNM limits imposed on the 55-gallon drums. In each case, the SNM content of liquid is established by sampling and analysis before the liquid is added to an accumulation that is not in an "always safe" geometry. Authorized signature release procedures are utilized to control this phase of the operations and to assure that the basic limits are observed. At any subsequent point where wastes may be held that cannot be flushed after each load, such as underground holding tanks, another SNM determination is made prior to subsequent transfer; this sample is based on a thorough air sparge followed by sampling and analysis. Vessels, such as 55-gallon drums and the tank transport trailers, are flushed after each use and undergo a routine gamma sensitive survey to detect possible SNM accumulation. The evaporation ponds are subject to the 350 g U-235 limit and are individually safe on the basis of standard limit Type A, Section 5.5, Part I.

The SNM in each pond is well distributed over the pond area either in solution or as sediment. An array of adjacent ponds, each containing 350 g of U-235, is safe in that the effective area density of the contained SNM is very low, on the order of 1 g/ft^2. If the materials in two adjacent ponds become agglomerated in optimum configuration on each side of the 6-in. concrete separating wall, it would amount to only 85% of the minimum critical mass, ignoring the effect of the intervening concrete.

3.11.3 Radiological Safety

All operations at the Waste Yard are monitored by gamma sensitive criticality alarms, in conformance with 10 CFR 70.24. These alarms are equipped with local lights and warning horns plus remote alarms which signal into the central security office.

Health Physics makes contamination and radiation surveys in the Waste Yard monthly, or more often if circumstances indicate it would be desirable, to determine if there are significant radiation or contamination levels.

All operations that might expose personnel to airborne particulate radioactivity are monitored by portable air samplers and subsequent counting of the resulting samples.

Suitable protective clothing and equipment are used where there is a splash or dust hazard.

The evaporation ponds are enclosed by wire mesh screening to prevent the entry of small animals and birds. These ponds are never allowed to go to dryness unless the pond has been cleaned; this prevents the residue from becoming powdered and airborne.

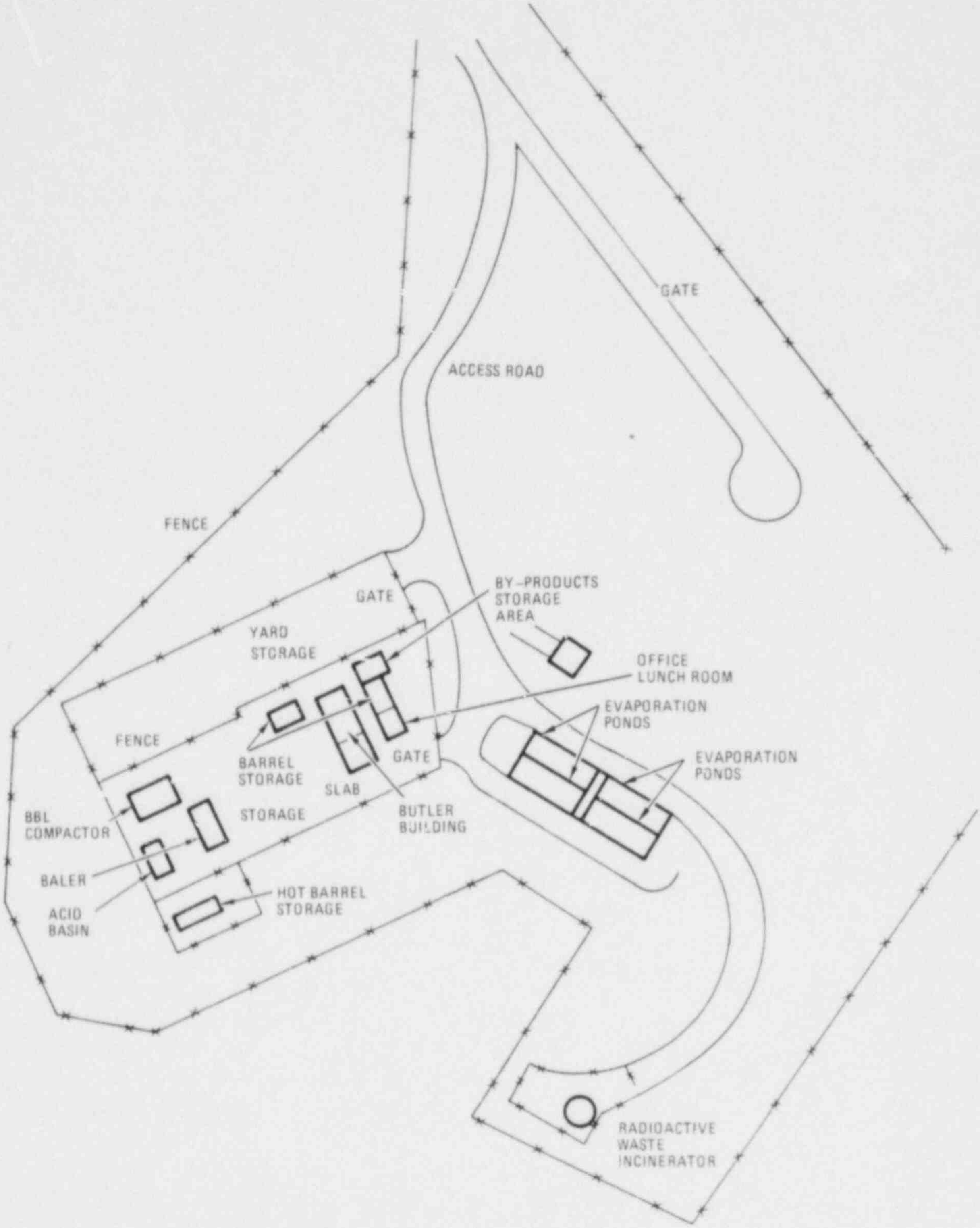


Fig. I 3.11-1 Waste Yard and Adjacent Facilities

3.12 INCINERATOR*

The incinerator, used to burn nonirradiated industrial trash with U-235 contamination, is located in the northeast portion of the Waste Yard (see Section 3.11, Fig. I 3.11-1).

The incinerator area is enclosed by an 8 ft chain link fence, topped by three strands of barbed wire and equipped with a gate and secured by a padlock. During nonworking hours, the area is checked by the security patrol at intervals not exceeding 4 hours.

3.12.1 Incinerator System Description

The incinerator system consists of:

1. Plibrico Sales and Service Company multichamber incinerator, Model 1-100, equipped with a special charging lock.

2. First stage of exhaust system consisting of an American Air Filter Company, Model B-2 Amertherm, Size 19-32-1800 (32 tubes, 19 ft high, 1800 ft^2 net surface area) equipped with siliconized Dacron dust collecting bags.

3. Second stage of exhaust system consisting of a filter system containing American Air Filter Company "Dri-Pak" filters or their equivalent with a rated efficiency of at least 90% for particles of 0.3 micron.

---

*Currently the incinerator is dismantled. It's replacement is being considered. The replacement may be either the equivalent of that described in 3.12.1 or a fluidized bed combustor, having both prefiltered and HEPA filtered exhausts. The operating procedures, nuclear and rod safety criteria are for illustration purposes and represent past safe practices.

4. Third stage of exhaust system consisting of high-efficiency filters with a rated efficiency of at least 99.97% for particles of 0.3 micron.

5. Supporting equipment such as blower, power panel, and natural gas line.

3.12.2 Operating Procedure

A schematic diagram (Fig. I 3.12-1) shows the processing of waste in the incinerator system. The overall operation is as follows.

Combustible waste is loaded directly into the charging lock of the incinerator in bags or cartons. The incinerator is charged by means of a push rod. Upon burning, ash is cleaned from the incinerator by either (1) vacuum removal into the Amertherm unit and collection in the unloading hopper, or (2) moving the ash directly from the incinerator through a vacuum cleaner equipped with a high-efficiency air filter rated at 99.97% efficiency for particles of 0.3 micron. During the ash removal operations, the incinerator is kept at a negative pressure (about 1-in. water gauge). Unloaded ash is held in 55-gallon drums for recovery or disposal.

Approximately 650 ft^3/min of air at a normal operating temperature of 1100°F (1700°F extreme) are exhausted from the incinerator by a duct connected to the incinerator discharge elbow.

Immediately following the barometric damper is a spray nozzle cluster with a solenoid valve control operated upon a signal from the Barber-Colman Capacitrol (or equivalent) indicating excessive heat (approximately 285°F at the Amertherm top plenum). The duct work immediately following the spray nozzle cluster includes a baffle, collection sump, and manual drain valve.

Liquid condensate is present only under emergency conditions. The duct work following the spray chamber includes a cooling air inlet to provide ambient air to the system. The ambient air is also drawn in at the canopy hood over the charging lock, thereby affording some draft control at this point.

Between the cooling air inlet and the transition to the Amertherm, the duct work has an inlet and connection for a flexible hose vacuum system, which the incinerator operator may use for cleaning the incinerator, and a motor-operated pressure-controlled damper for system pressure/volume control. Each of the various inlet dampers includes a slide damper for shutoff or volume control.

The Amertherm constitues the first stage of the exhaust system and collects the majority of airborne particles. This unit can be switched to the automatic bag collapse cycle, which cleans the filter bags allowing collected dust material to fall into the discharge hopper for removal. After any bag cleaning cycle is completed, the unit is shut down and allowed to cool. The Amertherm unit is cleaned by operating the rotary lock on the unloading hopper, then discharging collected dust material into a plastic bag fastened to the lock with the bag contained inside a metal container.

The exhaust from the Amertherm passes through the second and third stages of the exhaust system before release to the atmosphere. These stages filter out remaining airborne particles by using the filters described in Section 3.12.1.

3.12.3 Nuclear Safety

Combustible waste delivered to the incinerator site will be contained in plastic bags within closed 55-gallon metal drums or within closed boxes occupying at least 1 ft. square floor area. All containers will be marked with grams of uranium contained. Closed boxes delivered to the incinerator site shall contain no more than 100 grams of U-235, shall occupy at least one square foot of floor or pavement area per container and shall be stored in planar array with the 55-gallon drums.

The nuclear safety of the incinerator is assured by limiting each subcritical (subcrit) unit to 500 grams U-235 each. The incinerator subcrits are:

1. Fire box unit consisting of fire box, charge air lock, ash pit, secondary burner and exhaust plenum.

2. Amertherm unit.

3. Hopper.

Since the system is thoroughly cleaned prior to any gamma survey, the remaining material is fixed and it is not credible for this fixed material to migrate from one incinerator section to another. The limit for each section shall be comprised of the following components:

1. Gamma survey holdup values for individual subcrit.

2. Accumulated MUF for the incinerator.

3. Amount of additional material charged to the incinerator since the removal of the last ash material.

The 500 gram limit is based upon a maximum burden of 740 g reduced to reflect the 50% uncertainty currently associated with the gamma counting of the charged material. Past experience has shown the holdup, after cleanout, is fairly constant. This gives assurance that the material is fixed in place and does not migrate between the major incinerator components. All materials charged for burning have prior SNM measurement. The materials for each burn run are specifically preidentified in documentation controlling that run. Proper combustion also dictates a controlled rate of feed and indiscriminate charging cannot be done. Double batching is not considered as credible under the several restraints.

Additional safety is provided by the limited reflection, the lack of supplied water to provide moderation and the less than optimum physical geometries.

An incinerator log will be maintained by the operator indicating the U-235 contained charged to the system, removed from the system (counted ash) and holdup in the limiting subcrit (largest value) of the system. The holdup at any time is the sum of the gamma survey value for the limiting subcrit and the (MUF) difference of U-235 charged to the system minus the counted ash removals. The incinerator will not be operated when the sum of any charge and the holdup exceeds 500 g of U-235 in any one subcrit. When this limit of 500 g is reached, incinerator operations will be suspended, the system will be thoroughly cleaned, new components will be installed, if necessary, and the system will be resurveyed to establish a new (initial) holdup for each subcrit. At no time will MUF adjustments be made which cause the holdups to be less than the initial gamma survey holdup.

Each drum of ash will be limited to a maximum 350 g U-235, including the uncertainty of the measurement. Drums of ash will be stored in an approved storage building.

3.12.4 Radiological Safety

The incinerator system is within a fenced-in area at the Waste Yard. Only authorized personnel are allowed in this area. Operating personnel are required to:

1. Wear a film badge.
2. Wear a dosimeter.
3. Submit to the bioassay program for orutine urine analysis and lung burden checks.

An air sampler, located at the stack outlet, samples isokinetically while the incinerator system is in operation. If the exhaust effluent at the point of release reaches a level of 1×10^{-12} µCi/ml, an investigation is made and the findings evaluated. If the investigation reveals that 4×10^{-12} µCi/ml may be exceeded as an annual average concentration, the incinerator will be shut down and corrective action taken.

Another air sampler is placed to sample at the inlet to the charging lock, the point where the greatest concentration of airborne activity is expected under adverse circumstances and the point where the operator is working during the loading operations. This sampler is also used to sample during the unloading operations at the fire pit and at the Amertherm.

The area is monitored by a criticality alarm probe, which is part of the Waste Yard system and alarms both locally and at the main site security office.

Periodic surveys are made as identified in Section 3.12.3.

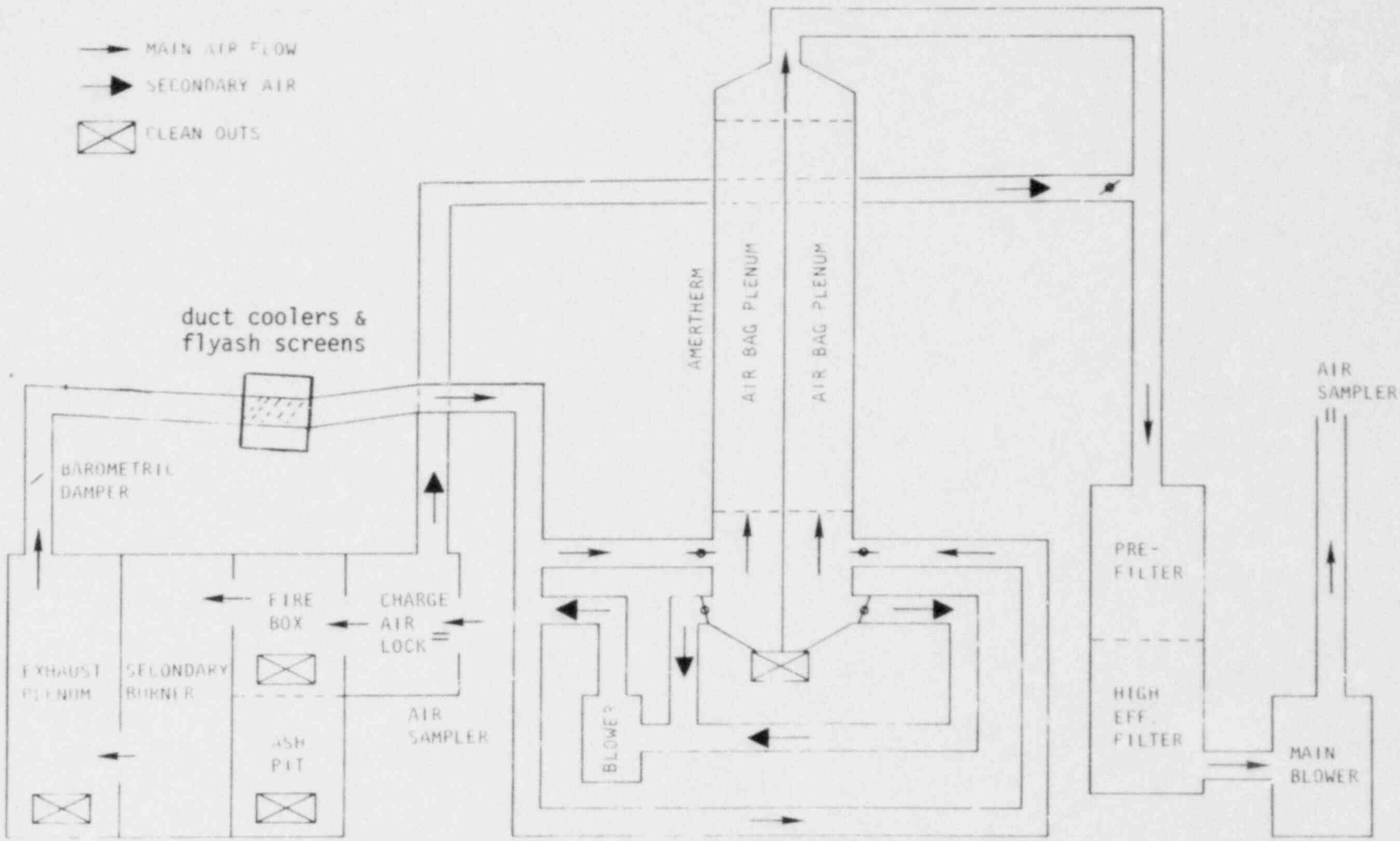


Fig. I 3.12-1 Incinerator flow chart

19430