NUREG-1069

Safety Evaluation Report related to the renewal of the operating license for the General Electric-Nuclear Test Reactor (GE-NTR)

Docket No. 50-73

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

September 1984

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ABSTRACT

This Safety Evaluation Report for the application filed by the General Electric Company (GE) for a renewal of operating license number R-33 to continue to operate its research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commisson. The facility is owned and operated by GE and is located in Pleasanton, California. The staff concludes that the reactor can continue to be operated by GE without endangering the health and safety of the public.

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1 INTRODUCTION AND HISTORY

By letter dated June 13, 1979, the General Electric Company (GE) submitted an application to the Nuclear Regulatory Commission (NRC/staff) for renewal of their Class 104 Facility Operating License (R-33) for continued operation of their nuclear test reactor (NTR) at a nominal power level not to exceed 100 kWt for 20 years. The GE-NTR is located at the GE Vallecitos Nuclear Center near Pleasanton, California. The renewal application is supported by information provided in the GE Safety Analysis Report and the Technical Specifications, both dated April 1981, and responses to questions during a site visit and in a letter from the licensee dated June 1984.

The renewal application contains information regarding the original design of the facility and includes information about modifications to the facility made since initial licensing. The Physical Security Plan is protected from public disclosure under 10 CFR 2.790(d)(1) and 10 CFR 9.5(a)(4).

The purpose of this Safety Evaluation Report (SER) is to summarize the results of the safety review of the GE-NTR and to delineate the scope of the technical details considered in evaluating the radiological safety aspects of continued operation. This SER will serve as the basis for renewal of the license for operation of the GE-NTR facility for operation at thermal power levels up to and including 100 kWt. The facility was reviewed against the requirements of 10 CFR 20, 30, 50, 51, 55, 70, and 73; applicable regulatory guides (RGs) (Division 2, Research and Test Reactor); and appropriate accepted industry standards (American National Standards Institute/American Nuclear Society (ANSI/ANS) 15 Series). Because there are no accident-related regulations for nonpower reactors, the staff has compared calculated dose values with related guidelines in 10 CFR 20 for protection against radiation for employees and the public.

The staff technical safety review, with respect to issuing an operating license, has been based on the information contained in the renewal application and supporting supplements, generic studies performed by national laboratories, site visits, and responses to requests for additional information.

Major contributors to the technical review include the NRC project manager and J. Hyder, C. Thomas, and C. Linder of the staff from the Los Alamos National Laboratory (LANL). This material is available for review at the NRC Public Document Room at 1717 H Street, N.W., Washington, D.C. This Safety Evaluation Report was prepared by Harold Bernard, Project Manager, Standardization and Special Projects Branch, Division of Licensing, Office of Nuclear Reactor Regulation, Nuclear Regulatory Commission.

1.1 Summary and Conclusions of Principal Safety Considerations

The staff evaluation considered the information submitted by the licensee, past operating history recorded in annual reports submitted to the Commission by the licensee, reports by the Commission's Office of Inspection and

Enforcement, and onsite observations. In addition, as part of the licensing review, the staff obtained independent national laboratory studies and analyses of several severe hypothetical accidents postulated for the GE-NTR reactor. The staff's conclusions, based on evaluation and resolution of the principal safety matters reviewed for the GE-NTR, are as follows:

(1) The design, testing, and performance of the reactor structure and systems and components important to safety during normal operation are inherently safe, and safe operation can reasonably be expected to continue.

(2) The expected consequences of a broad spectrum of postulated credible accidents have been considered, emphasizing those likely to cause a release of fission products. The staff performed conservative analyses of the most serious credible accidents and determined that the calculated potential radiation levels at the property line are within the guideline values indicated in 10 CFR 20 for unrestricted areas.

(3) The licensee's management organization, conduct of training and research activities, and security measures are adequate to ensure safe operation of the facility and protection of special nuclear material.

(4) The systems provided for control of radiological effluents can be operated to ensure that releases of radioactive wastes from the facility are within the limits of 10 CFR 20 and are as low as is reasonably achievable (ALARA).

(5) The licensee's Technical Specifications, which provide limiting conditions for the operation of the facility, are such that there is a high degree of assurance that the facility will be operated safely and reliably.

(6) The GE-NTR facility is funded within the annual budget requests of the General Electric Company. The staff agrees that sufficient funds will always be available for the safe operation of the reactor facility.

(7) The licensee's program for providing for the physical protection of the facility and its special nuclear material comply with the applicable requirements in 10 CFR 73.

(8) The licensee's procedures for training its reactor operators and the plan for operator requalification give reasonable assurance that the reactor facility will be operated competently.

(9) The GE Vallecitos Nuclear Center Emergency Plan, which is in compliance with the existing applicable regulations, has been found acceptable (see Section 13.6).

1.2 Operational History

GE applied for a construction permit in 1957. The construction permit and facility license R-33 were issued in November 1957 for operation of the reactor at 30 kWt. The license was amended in 1969 to increase the power level to 100 kWt. The GE-NTR has been operating at 100 kWt since July 1969 at a utilization factor of about 30% of maximum possible use during one shift, 5 days per week.

1.3 Reactor Facility Description

The GE-NTR facility is located at the GE Vallecitos Nuclear Center near the city of Pleasanton, California. The reactor is used principally for irradiation, neutrography,* and to produce radioisotopes for research and commercial activities. The GE-NTR is currently a unique, one-of-a-kind reactor. It is a heterogeneous, 93% enriched uranium-aluminum alloy, graphite-moderated and -reflected, light water cooled, tank-type reactor. The reactor core is an annular cylinder configuration lying horizontally in a large graphite pack. Fuel consists of highly enriched uranium-aluminum washer-like disks, clad with aluminum. The disks are arranged skewer-like on rods and are positioned inside the core cannister by a support reel that can be rotated for fuel replacement. Core cooling is either by natural convection or forced cooling, depending on the power level. Irradiation facilities include a central sample tube and penetrations through and into the reflector, reflector faces, and the beam irradiation ports.

1.4 Shared Facilities

The GE-NTR is located in Building 105 of the GE Vallecitos Nuclear Center. This building also contains offices, laboratories, and another shielded cell that was formally used as a critical experiment facility. The NTR shares utilities, air conditioning, and ventilation supply with the remainder of the Center.

1.5 Design and Facility Modifications

The significant modifications since the 1969 power increase are as follows:

(1) enlargement of the penetration for the neutron beam through the reactor cell north wall (1969)

(2) installation of a rod block circuitry (1969)

(3) addition of a penetration to the south cell east wall (1971)

(4) modification of the ventilation system to include new facility areas and an increase in the capacity from 1,000 cfm to 3,000 cfm (1972)

(5) redesign of the manual poison sheets (1975)

(6) installation of a new facility for performing neutron radiography of irradiated materials and an enclosure (north room) added north of the reactor cell (1976)

(7) the horizontal cavity through the graphite was bored out from 3 in. to 5 in. and then refitted with a 3-in. inside diameter sleeve, 40 in. long, and centered in the graphite pack (1976)

(8) installation of permanent fixed-air sample stations at the facility (1977)

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*Trademark of the General Electric Co.

(9) installation of positive latches on the manual poison sheets (1977)

(10) addition of seismic restraints to the control rod support assembly, fuel loading tank, and reactor shield wall (1977)

1.6 Comparison With Similar Facilities

Although the GE-NTR is a one-of-a-kind design, the highly enriched uranium-aluminum alloy type fuel is used in many research reactors.

1.7 Nuclear Waste Policy Act of 1982

Section 302(b)(1)(B) of the Nuclear Waste Policy Act of 1982 provides that the NRC may require, as a precondition to the issuance or renewal of an operating license for a research or test reactor, that the licensee shall have entered into an agreement with the Department of Energy (DOE) for the disposal of high-level radioactive waste and spent nuclear fuel. GE has an agreement with DOE to ship spent fuel to DOE facilities or designated receivers of the fuel and, therefore, is in conformance with the Nuclear Waste Policy Act.

2 SITE CHARACTERISTICS

2.1 Description

The GE-NTR site is located at the 1,594-acre Vallecitos Nuclear Center (VNC). The site is owned by the General Electric Company and is situated near the center of the Pleasanton Quadrangle of Alameda County. The nearest towns within a mile of the site are Pleasanton and Sunol; Livermore, Dublin, and a part of Fremont are within a 10-mi radius of the site. The VNC is east of San Francisco Bay, approximately 35 air miles east-southeast of San Francisco, and 20 air miles north of San Jose (see Figure 2.1).

The VNC is located in the southwest corner of the Livermore Valley. The Vallecitos Valley, surrounded by barren mountains and rolling hills, is approximately 2 mi long and 1 mi wide. Its major axis is east-northeast and west-southwest, and the valley is at an elevation of 400 to 500 ft above sea level.

The VNC site consists of a quadrilateral, bounded on the west, north, and east by hilly terrain; in some places, the hills are about 700 ft above the general site elevation. Vallecitos Road (State Highway 84) forms the southern boundary of the site, from which an expanse of gently rolling grassland extends for about 3 mi. Beyond 3 mi, mountain ranges form a southern barrier that completes the encirclement of the site.

Approximately one-third of the site is gently sloping or rolling terrain. The remainder consists primarily of the southwestern slope of a ridge serrated by several small draws. The southern part of the site, adjacent to Vallecitos Road, is relatively flat and accommodates the GE-NTR, laboratories, and administrative facilities.

2.2 Reactor and Laboratory Facilities

The facilities located at the VNC are shown in Figure 2.2. The main laboratory buildings are located approximately 1,700 ft north of Vallecitos Road.

Building 105 contains offices and laboratories and houses the GE-NTR and another shielded cell that was formerly used as a critical experiment facility. Building 102 contains the Radioactive Materials Laboratory where postirradiation studies and research and development activities are performed. Building 103 houses chemistry, metallurgy, and ceramics research and development activities, as well as extensive analytical chemistry laboratories. Extensions of some of these facilities are located in special facilities in Building 300. Building 400 has been assigned to Chemical Engineering and Materials Development. Building 401 contains offices and nonradioactive laboratories. Building 106 contains machine, sheet metal, and development shops, and Building 104 contains maintenance and site warehouse facilities.

Facilities are available on the site for handling, sorting, and processing liquid and solid radioactive wastes generated at all VNC nuclear facilities.

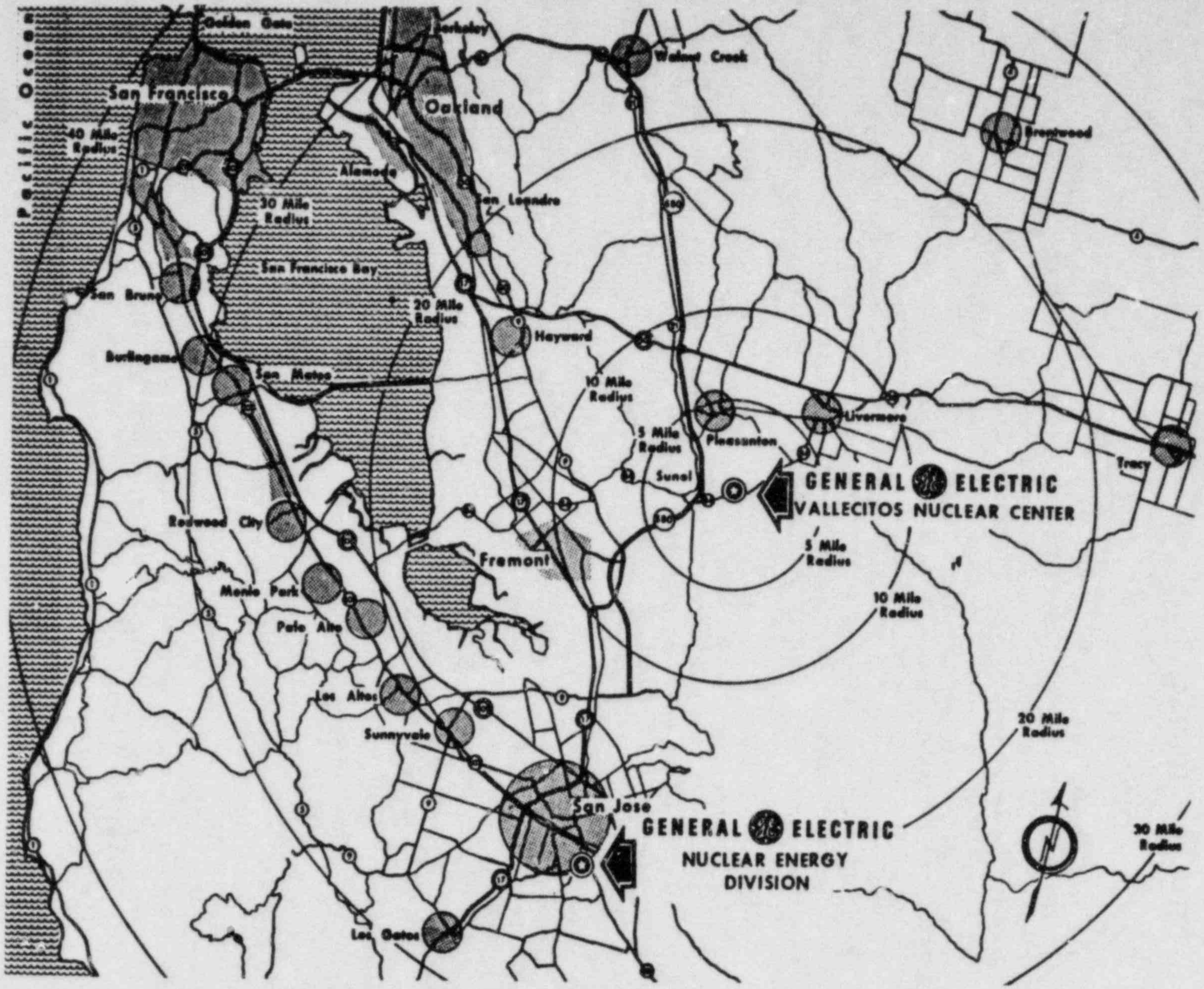

Figure 2.1 Area map of the Vallecitos Nuclear Center

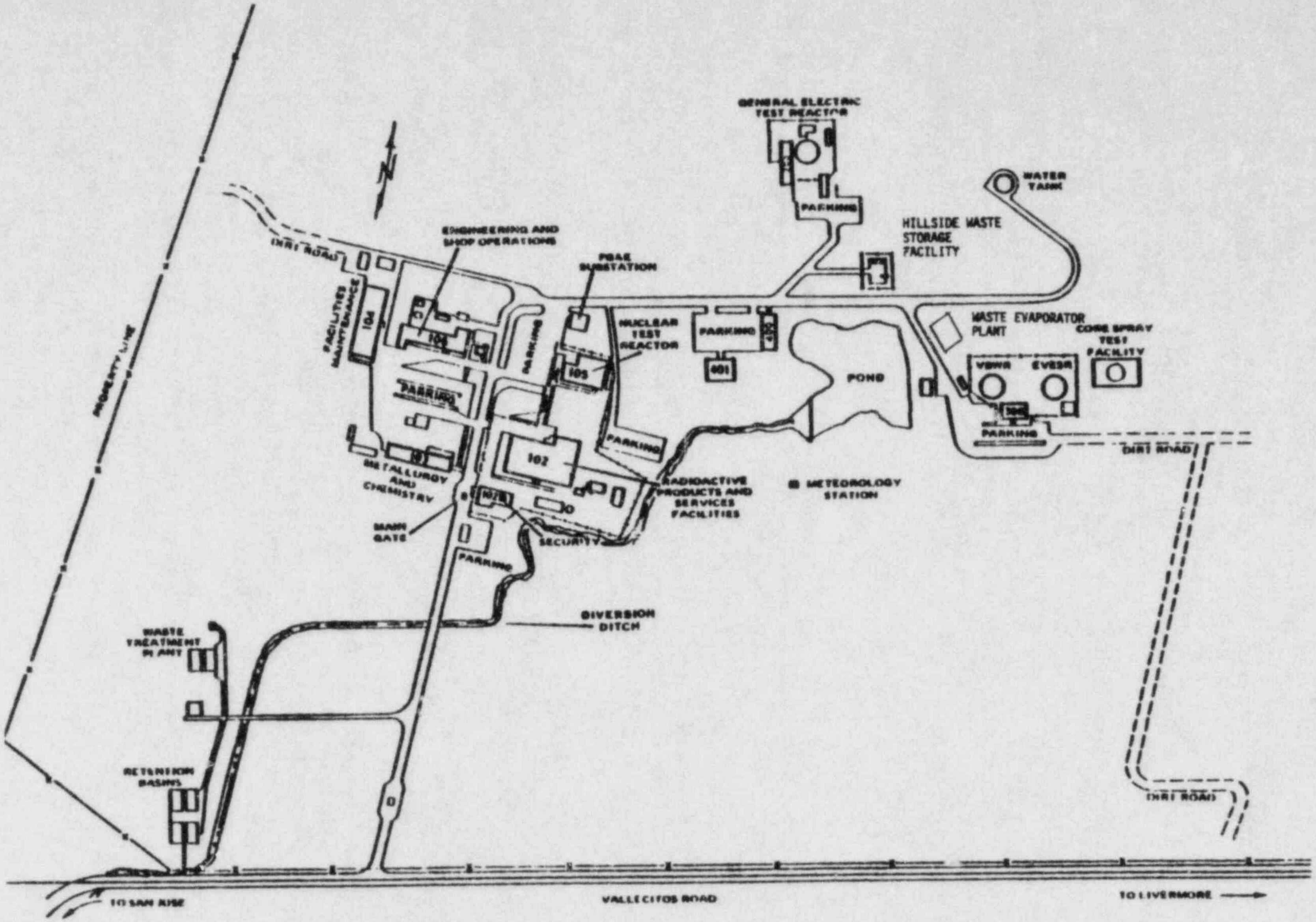

Figure 2.2 Southern portion of the Vallecitos site

Temporary storage of solid radioactive waste is accommodated at the hillside storage facility. A nonradioactive liquid waste chemical treatment plant and sewage treatment plant are located in the southwest corner of the site. A radioactive liquid waste evaporator facility is located near the hillside storage facility. The Vallecitos boiling water reactor (VBWR) and experimental superheat reactor (VESR) are developmental reactors located on the site that are now in a deactivated status. The GE Test Reactor (GETR) is currently in a standby basis; fuel has been removed from the core and the site.

2.3 Topography

Topography of the Pleasanton Quadrangle and the VNC site is shown in Figure 2.3. Vallecitos Valley, about 2 mi long and 1 mi wide, is at an elevation of 400 to 500 ft above sea level and is surrounded by barren mountains and rolling hills ranging from 100 to 700 ft above the site. The flat section of the site is in the the southern part, adjacent to Vallecitos Road, and accommodates all the present facilities.

2.4 Demography

The immediate vicinity of the VNC has a very low residential population density. The farm land within a 3-mi radius is estimated to average less than 50 people per square mile. There are only four houses on the south side of Vallecitos Road and approximately 10 houses immediately west of the site. Minor land development associated with the expansion of the town of Pleasanton and the unincorporated areas of Happy Valley and Sunol has occurred 2-1/2 to 3 mi west and northwest of the site. Population within a 10-mi radius of the site is estimated to be 221,000, while that within a 20-mi radius is estimated to be 1,147,000.

Livermore (located 7 mi northeast of the VNC) has a population of ~51,200 and is the largest population center within a 10-mi radius of the VNC; it is largely a suburban community with some light industry and agricultural activities. A United States Veterans Administration Hospital, with a population of ~1,000, located south of Livermore, is ~5 air miles east of the site. Lawrence Livermore National Laboratory of the University of California is ~8 mi northeast of the site.

Pleasanton, the second largest town within a 10-mi radius of the site, is predominately a suburban community with a population of ~35,000. Pleasanton lies beyond the hills, 5 mi northwest of the site. The towns of Livermore and Pleasanton contain a small amount of light industry, but in no way can be considered industrial centers.

Fremont, located ~12 mi southwest of the site has a population of ~131,000. Fremont borders the eastern shore of San Francisco Bay and is separated from the site by a mountain range that rises 1,000 ft above Vallecitos Valley. Beyond Fremont and generally to the southwest, beginning at a distance of 20 mi from the site, is San Jose, which has a population of over 500,000. The City of Hayward to the northwest and beginning 15 mi from the site, has a population of 100,000. Oakland and San Francisco lie to the northwest of the site ~30 and 35 mi, respectively.

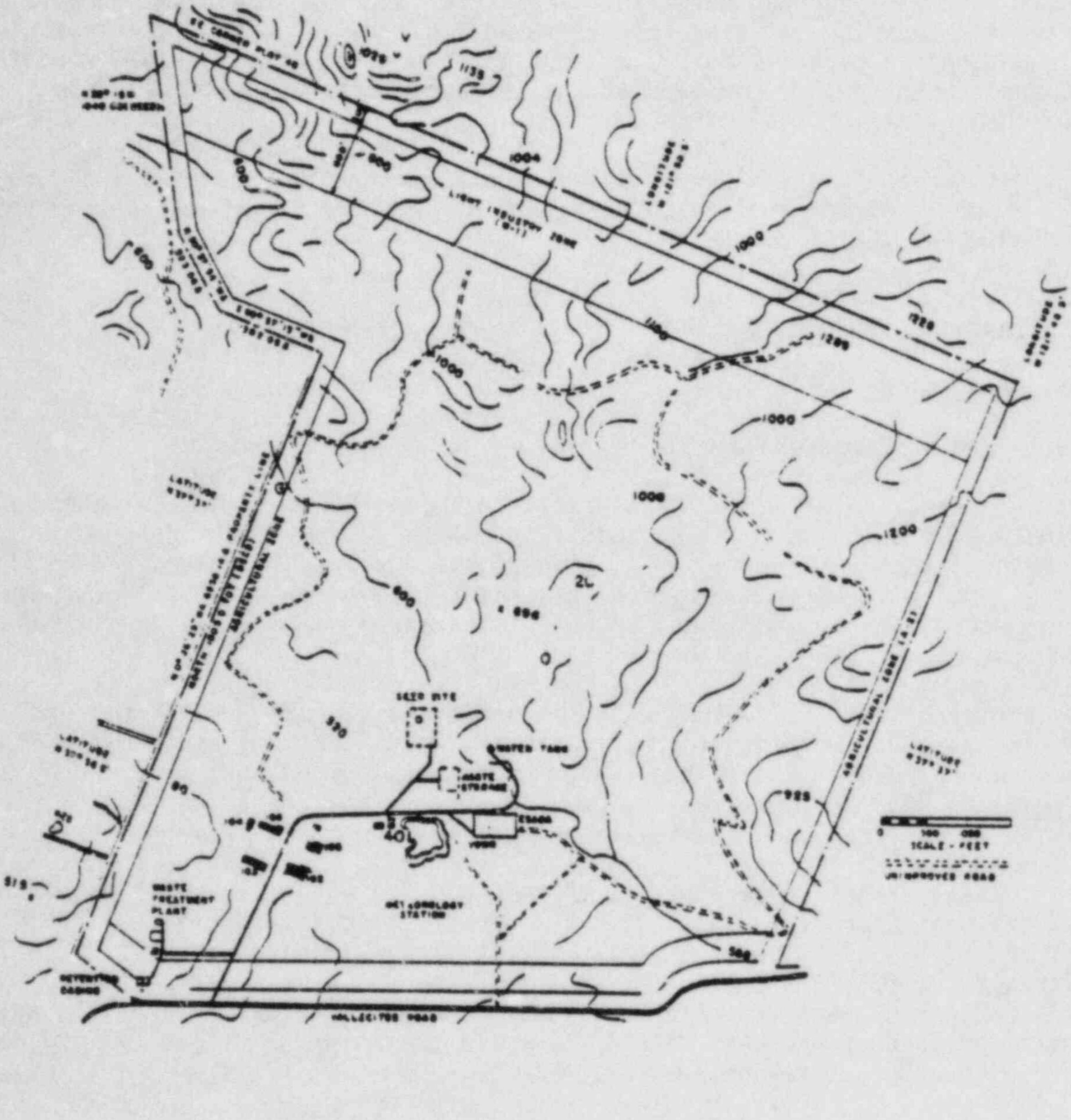

Figure 2.3 Topography contour of Vallecitos Nuclear Center

The rate of population growth in the 30-mi^2 area surrounding the VNC is expected to be slow in the coming decades. The growth rate within this 3-mi radius has been negligible over the last century. Excluding the property owned by General Electric, a considerable portion of the land within the 3-mi radius is owned by the City of San Francisco; it is believed the city would not be inclined to sell the land. The major part of the remaining land is rugged terrain that does not attract industrial or residential development; substantial parcels of the privately owned land have been placed into the Alameda County Land Preserve Program under the California Land Conservation Act of 1965.

2.5 Nearby Industrial, Transportation, and Military Facilities

Livermore and Pleasanton have light industries and the remaining communities in the area provide services related to agricultural economy. Lawrence Livermore National Laboratory does store nuclear fuels; however, the distance from VNC and the safeguards employed at the Lawrence Livermore National Laboratory preclude any effects on the VNC.

Vallecitos Road (State Highway 84), at the VNC property line is a two-lane road that supports normal traffic. Interstate Highway 680 is a heavily used route located about 2 mi from the VNC.

The closest commercial airfields are those in San Jose, Oakland, and San Francisco, 20, 30, and 30 mi from the VNC, respectively.

2.6 Meteorology

2.6.1 Regional Meteorology

The San Francisco Bay Area is generally characterized by a Mediterranean-type climate with warm, dry summers and mild winters with moderate rainfall. The climate of the eastern, inland portion of the Bay Area is controlled by the degree of isolation from maritime influences; the more isolated locations experience a larger annual and diurnal temperature range, less winter rainfall, and less summer low cloudiness.

The summer climate is dominated by the Pacific-subtropical high-pressure system, which shunts incoming storms to the north and imposes an elevated temperature inversion over the area. Local summer winds are governed by area topography and distance from the bay. Daytime winds are a combination of upslope, upvalley, and sea breezes; nighttime flow is the reverse.

The average annual temperature is 15.1 °C (60 °F) with an average diurnal temperature range of 15.7 °C (28 °F). January temperatures average 7.8 °C (46 °F) with a 11.4 °C (21 °F) range; July temperatures average 22.1 °C (72 °F) with a 20 °C (35 °F) range. The highest recorded temperature was 46 °C (114 °F); the lowest recorded temperature was -7.2 °C (19 °F). On the average, there are 58 days per year with the temperatures over 32 °C (90 °F) and 46 per year with temperatures below freezing.

Severe weather is rare in the area. Precipitation statistics for VNC are shown in Table 2.1. In this valley the greatest recorded daily rainfall is about 88 mm (3.47 in.). Thunderstorms occur less than 5 days per year and are not intense;

hail occurs even less frequently (NEDO-12623, 1976). Strong winds with gusts greater than 27 m/sec (60 mph) occur a few times during the fall and winter, usually with southerly winds accompanying a frontal passage.

Table 2.1 Precipitation at the VNC from July to June

Date	Inches
1979 - 1980	19.67
1980 - 1981	9.80
1981 - 1982	22.40
1982 - 1983	28.84
1983 - 1984	11.25

2.6.2 Local Meteorology

VNC has its own meteorological instrumentation which includes wind direction and velocity and precipitation, all plotted with time. Table 2.2, which presents the general distribution of wind direction at Vallecitos, shows that frequencies of less than 5% of the time occur for each direction except SSW, SW, WSW, and W; winds from these directions occur 54% of the time. Topography (local heating and cooling effects) and large scale weather patterns account for the predominance of these directions.

Table 2.2 Frequency of occurrence (%) of wind direction at the Vallecitos Nuclear Center

Direction Wind From	November 1, 1963 to October 31, 1966	January 1, 1974 to December 31, 1974
N	2.7	2.7
NNE	2.6	3.7
NE	3.5	2.9
ENE	3.1	3.0
E	4.3	4.5
ESE	3.4	1.5
SE	3.0	1.2
SSE	2.9	1.8
S	8.7	4.9
SSW	16.5	7.8
SW	18.6	22.4
WSW	7.6	15.5
W	6.7	8.4
WNW	4.5	3.7
NW	3.3	3.1
NNW	1.5	2.1
CALM	7.1	10.1

Stability classes were defined on the basis of the standard deviation of the wind direction and were estimated from the hourly wind direction range. Site topography could be expected to reduce these fluctuations. Table 2.3 shows that neutral conditions existed about 21% of the time with stable and calm conditions accounting for 74% of the total observations. For comparison, stability categories observed at the Lawrence Livermore National Laboratory (NEDO-12623, 1976) are also compared with the VNC. Moderately stable (Pasquill Class F) conditions are found more frequently at VNC, and unstable (Classes A-C) conditions are found significantly less frequently at VNC than at the Lawrence Livermore National Laboratory. These differences may be due to a combination of the channeling effect of Vallecitos Valley and the difference in heights of the wind instruments at the two sites. Stability categories were determined on the basis of wind direction fluctuations.

Table 2.3 Frequency of occurrence of Pasquill stability classes Vallecitos Nuclear Center (VNC) and Lawrence Livermore National Laboratories (LLNL)

	Stablity Class						
Location	A	B	C	D	E	F	Calm
VNC*	0.8	1.0	3.9	20.6	39.6	23.9	10.1
LLNL	10.2	6.3	12.6	29.4	35.9	6.3	

*Percent of the frequency of occurrence.

2.7 Geology

The geology of the area surrounding the VNC is the result of a complex history of deposition, and tectonic activity accompanied by folding, faulting and erosion. The VNC is located in the Vallecitos Valley; the valley is a small topographic depression located in the southwest corner of the Livermore Valley. The area is covered by recent alluvium consisting of Livermore gravels that overlap Tertiary and older rocks. The Livermore Valley is bounded at its west end by the northwesterly-trending Calaveras Fault and at its east end by similar trending faults at the base of the hills separating the Livermore Valley from the San Joaquin Valley. The significance of these faults to the safety of the facility is discussed in Sections 2.9 and 14.7. The hills at the east and west ends consist for the most part of folded and faulted rocks of Cretaceous and lower Tertiary age. The north and south margins of the Livermore Valley are bounded by subdued hills made up of younger sediments of upper Tertiary age.

The GE-NTR is located on the lower edge of the gently sloping colluvial hills in the Vallecitos Valley. A shallow side-hill cut and fill provide a level surface for the GE-NTR facility. The soils beneath the buildings generally consist of dense sand fill or gravelly sand and clayey silt fill underlain to a depth of 50 ft with very dense sand and gravel. Occasional pockets of sandy, silty clay are found in the lower material. The reactor building foundation is located approximately 20 ft below grade and is supported on native material.

2.8 Hydrology

2.8.1 Surface Water Hydrology

VNC discharges its nonradioactive liquid effluents into an arm of Vallecitos Creek, which drains Vallecitos Valley. Vallecitos Creek, an intermittent stream that flows primarily in the winter, rises in the eastern portion of the Vallecitos ground water sub-basin and flows in a generally northeast-southwest direction to enter Arroyo de la Laguna just above its confluence with Alameda Creek. The Arroyo de la Laguna, the only surface stream flowing from the Livermore Basin, flows into the Sunol Basin and empties into Alameda Creek. The discharge from VNC to Vallecitos Creek is located about 2 mi above the confluence with Arroyo de la Laguna.

The U.S. Geological Survey (NEDO-12623, 1976), in cooperation with the Department of Housing and Urban Development, has estimated flood flows in Vallecitos Creek (Table 2.4). Indications are that the VNC site would not be affected by even the estimated 100-year flood flow in Vallecitos Creek which has a capacity in excess of 500 ft^3/s.

Table 2.4 Flood flows in Vallecitos Creek

Flood Frequency	Flow (Cubic Feet per Second)
2 year	30
5 year	90
10 year	145
25 year	220
50 year	400
100 year	480

2.8.2 Ground Water Hydrology

Few water wells are found in the Vallecitos Valley. Two wells had been drilled on the VNC property, but none are in use at present except for water quality monitoring and for watering shrubbery.

Depth of water underlying the VNC site varies, depending on the area and probably according to the season of the year. Depth to water in the vicinity of the GE-NTR has been observed at depths of from 18 to 27 ft, over a 2-year (1973-1974) monitoring period. At the site of the sewage treatment plant, where modifications were done in 1975, seepage was observed in an excavation at a depth of about 10 to 15 ft below the surface.

2.9 Seismology

The region in and around the VNC site is considered to be seismically active. Figure 2.4 shows the faults that are located in the vicinity of the VNC site. Some of these faults are minor structures and are not considered to be possible sources of large earthquakes; others are major structures which have been active in recent years.

The largest fault near the VNC is the Calaveras Fault, which is located a little more than 2 mi from the GE-NTR. The two other major faults in the area are the Hayward Fault, 8.5 mi to the southwest, and the San Andreas Fault, 27 mi to the west. Plate tectonics theory indicates that the San Andreas Fault is the boundary between the Pacific plate, which is the land mass and ocean floor to the west, and the North American plate, which is the land mass to the east. As the Pacific plate moves past the North American plate, strain energy is stored in the rock and released in the form of earthquakes. In a general sense, the Hayward and Calaveras Faults are also part of the same tectonic process.

A hypothetical accident postulates that a collapsing of the core along its three axes occurs as a result of external forces (see Section 14.7). The subsequent analysis indicated that fuel temperatures would increase slightly and fuel would not melt. Accordingly, fission products would not be released as a result of a postulated seismic event that would produce the assumed dynamic environment.

2.10 Conclusion

From the information provided above, the staff concludes that the reactor can be operated without risk to the public regardless of seismic activities in the area and that the GE-NTR facility can withstand all the other credible natural environments without endangering the health and safety of the public.

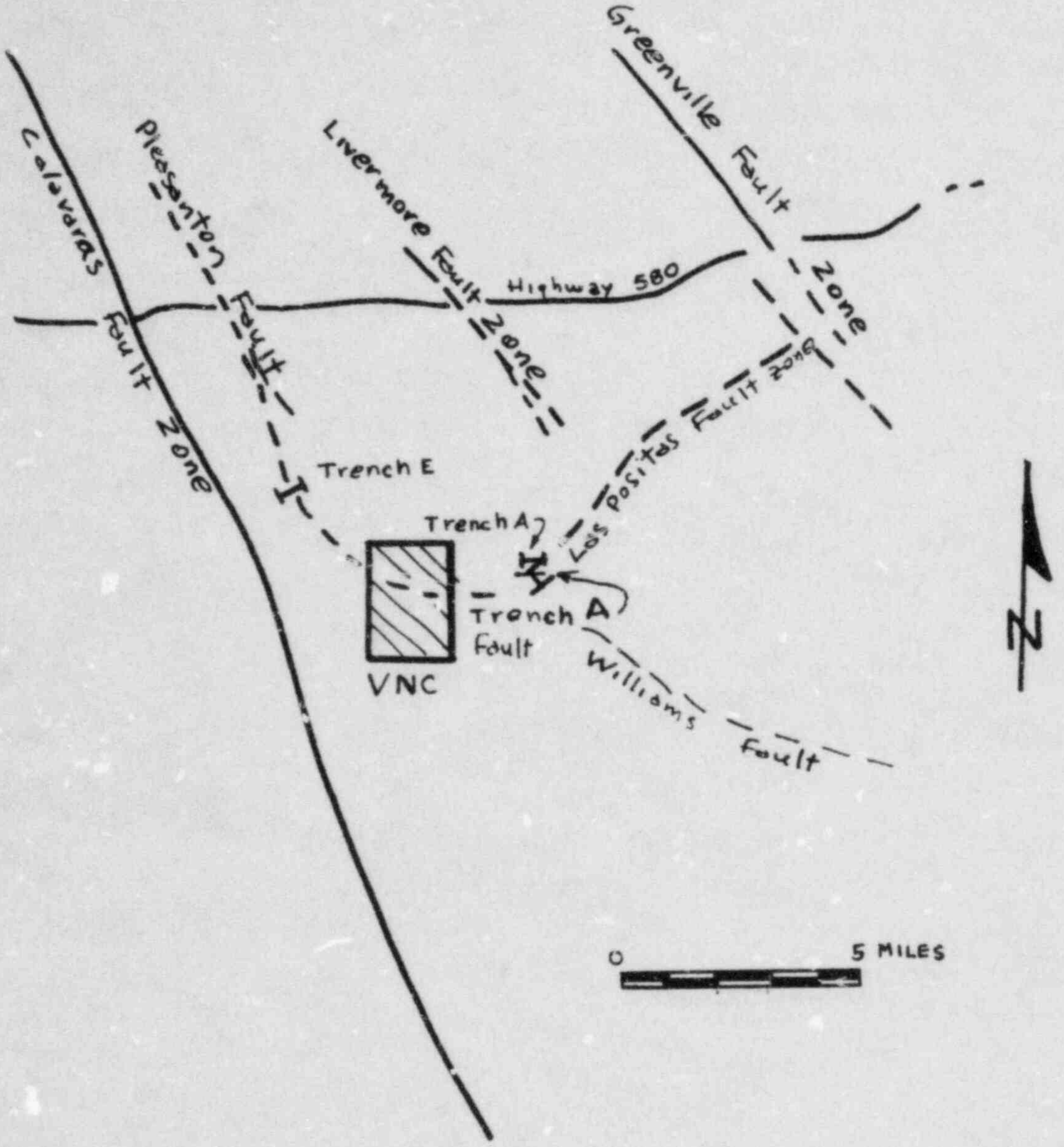

Figure 2.4 Composite of faults mapped near the VNC site

3 DESIGN OF STRUCTURES, SYSTEMS, AND COMPONENTS

3.1 Reactor Building

The GE-NTR facility consists of the reactor cell, control room, north room, shop, dark room, offices, setup room, and south cell and is housed in the east end of Building 105 on the VNC site (as shown in Figures 3.1 and 3.2). The reactor is in a thick-walled, rectangular-shaped concrete cell with approximate internal dimensions of 22-ft wide by 23-ft long by 24-ft high. The principal equipment located within the cell includes the reactor, the coolant systems, a fuel loading tank, holdup tank, 5-ton bridge crane, air-conditioning unit, and fuel storage shelves. Gross volume of the cell is ~11,300 ft^3 and the net air volume is ~10,500 ft^3.

Normal access to the cell is from the control room through a large doorway in the south wall. During reactor operation, the doorway is normally closed by a 1-ft-thick, motor-driven, sliding concrete door lined with 1.25 in of steel. A manually operated, 1-ft-thick paraffin door covered with aluminum and located just inside the reactor cell also is normally closed. Use of the large removable equipment hatch, provided in the cell roof, is limited to special occasions when it is impossible or impractical to use the cell door.

The control room contains the control console and provides space for experiment equipment, experiment preparation, and an operator work area. The south cell is a concrete-shielded room that provides access to the thermal column and the horizontal facility. The north room provides space for performing experiments using the horizontal facility neutron beam and the control and instrument test facility. The setup room is used for storage and setup of experiments.

The existing experiment service penetrations are the south thermal column into the south cell, the horizontal facility tube into the south cell, a 24-in.-diameter hole through the north wall (at approximately core centerline height), a stepped hole through the east wall (approximately 10 ft above the cell floor), a hole for a future thermal column through the east wall (currently filled with unmortared concrete bricks), and two holes (3 and 4 in. in diameter) in the north wall penetrating into the north room.

3.2 Wind and Seismic-Induced Damage

The maximum hypothetical accident (MHA), described in Section 14.1, postulates that the building collapses onto the reactor core, collapsing, in turn, the reactor cell onto the core. The consequences of such an event have been determined to be acceptable. Any wind or seismic damage (discussed in Section 2.6 and 2.9, respectively) to the structure would result in less severe consequences than the postulated MHA.

3.3 Water Damage

As stated in Section 2.4, a 100-year storm would not produce flooding conditions at the VNC site. As there are no dams in the vicinity that could

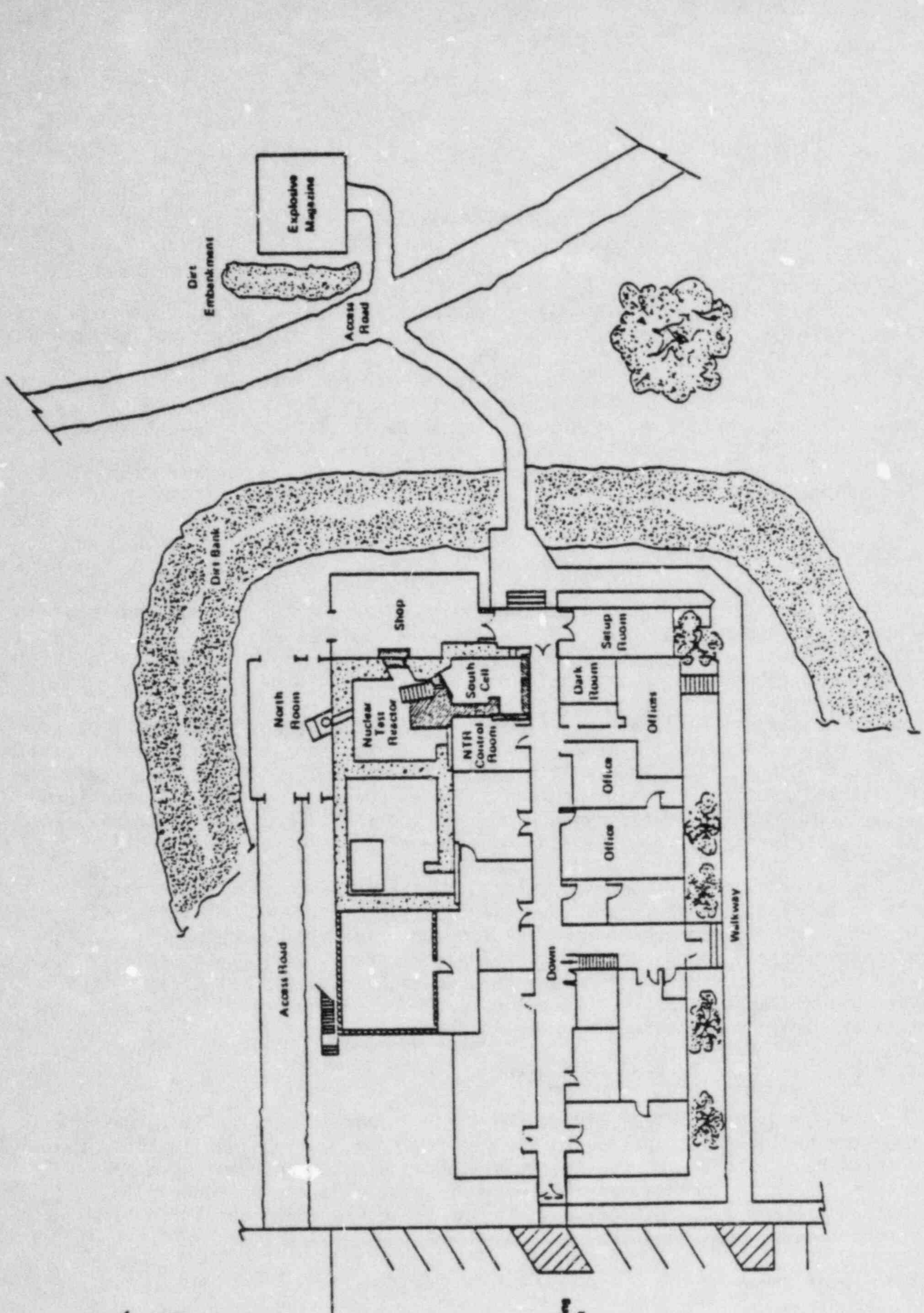

Figure 3.1 Building 105 floor plan

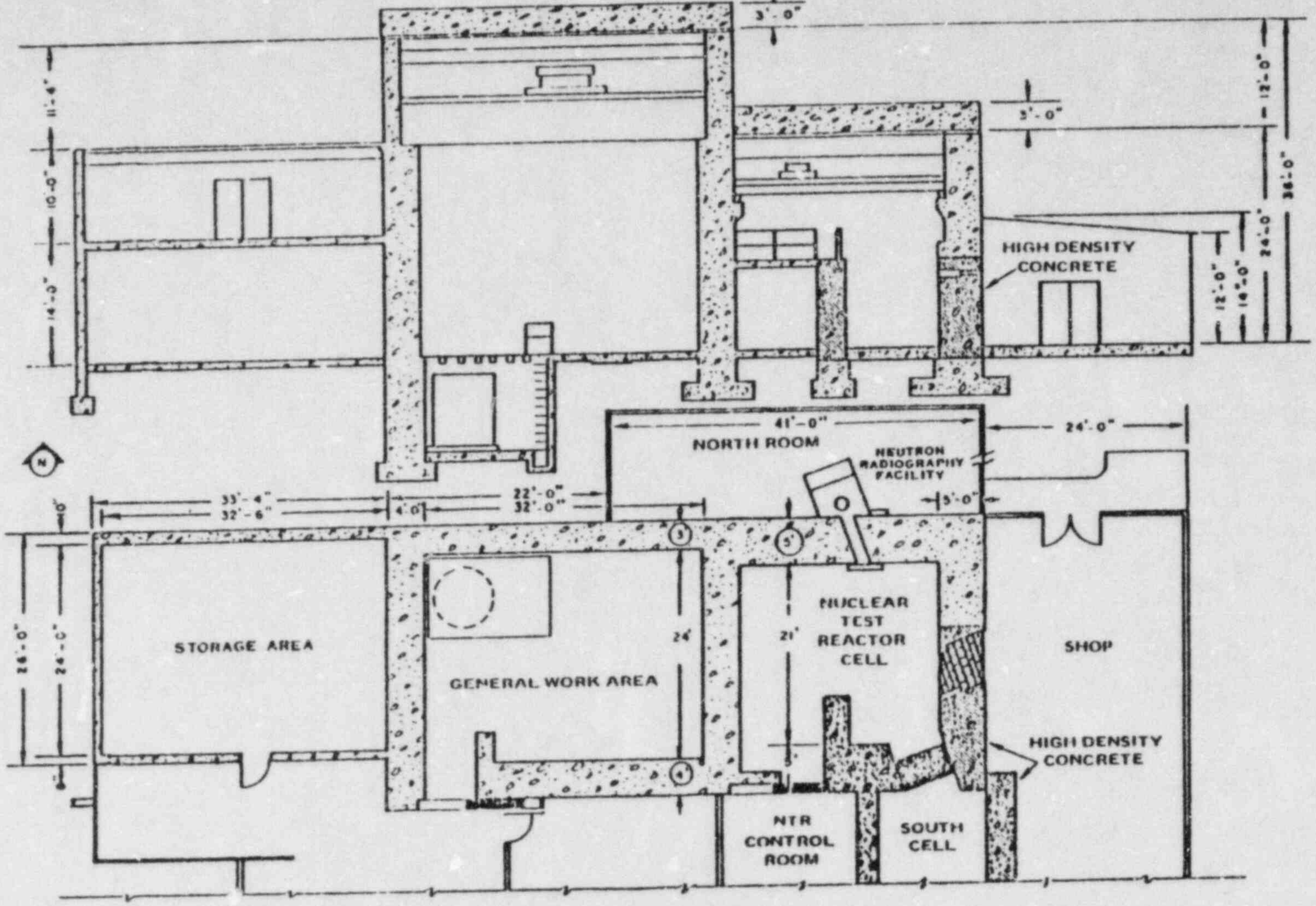

Figure 3.2 GE-NTR facility floor plan and elevation

affect the VNC site, there does not appear to be any water-caused damage that could affect the performance of the reactor.

3.4 Conclusion

From the above analysis, the staff concludes that extreme seismic, wind, and flooding events will not produce consequences to the GE-NTR facility that will result in any significant risk to the public.

4 REACTOR

4.1 Summary Description

The General Electric nuclear test reactor (GE-NTR) is a heterogeneous, highly enriched uranium, graphite-moderated and -reflected, light-water cooled, thermal reactor that is licensed to operate at power levels not in excess of 100 kWt.

The reactor facility, which is used by GE and its customers, has served primarily as an experimental facility It is especially useful for measuring reactivity effects and as a versatile source of neutrons for neutrography. The design and performance characteristics of the GE-NTR are summarized in Table 4.1.

Table 4.1 Current GE-NTR design and performance characteristics

Item	Characteristics
General Features	
Reactor type	Heterogeneous
Licensed rated nominal power level	100 kWt
Fuel and Control Elements	
Fuel disks	93% enriched, uranium-aluminum alloy 5.63 g ^{235}U/disk
Fuel assembly	40 disks, with face-to-face distances between the disks alternating between 0.24 and 0.27 in.
Number of fuel assemblies in the core	16
Initial minimum critical fuel loading (cold)	3.0 kg ^{235}U (512 disks)
Actual initial fuel loading	^{235}U (640 disks, 5.81 g ^{235}U/disk)
Current fuel loading	3.72 kg ^{235}U (640 disks, 5.63 g ^{235}U per disk)
Reactor Control	4 boron-carbide safety rods 2 boron-carbide coarse control rods 1 boron-carbide fine control rod Six locations to manually position cadmium-aluminium poison sheets (MPS); however, only two positions are used currently

Table 4.1 (continued)

Item	Characteristics
Moderator-reflector	Reactor-grade (AGOT) graphite, 5 ft by 5 ft by 5 ft
Reactivity Worths (Typical)*	
2 boron carbide coarse control rods, 1 boron carbide fine control rod	1.54% Δ k/k (2.20$) (total)
4 boron carbide safety rods	2.70% Δ k/k (3.86$) (total)
2 current MPS	1.38% Δ k/k (1.97$) (total)
Maximum worth safety rod	0.77% Δ k/k (1.10$)
Maximum excess reactivity	0.385% Δ k/k (0.76$)
Shutdown margin with maximum worth rod stuck out	1.40% Δ k/k (2.00$)
Reactivity Effects (Typical)*	
4 safety rods and 3 control rods withdrawn	+0.385% Δ k/k (+0.55$)
4 safety rods withdrawn, and 3 control rods inserted	-1.15% Δ k/k (-1.65$)
4 safety rods inserted, and 3 control rods withdrawn	-2.317% Δ k/k (-3.31$)
4 four safety rods inserted, and three control rods inserted	-3.857% Δ k/k (-5.51$)
Coefficients of Reactivity	
Temperature coefficient in water coolant (measured)	-3.99×10^{-5} (T-124)% Δ k/k/°F [-5.7×10^{-3} (T-124) ¢/°F]
Inner graphite (calculated)	($+0.17 \times 10^{-3}$ ¢/°F) $+1.19 \times 10^{-6}$% Δ k/k/°F
Outer graphite (calculated)	($+4.1 \times 10^{-3}$ ¢/°F) $+2.87 \times 10^{-5}$% Δ k/k°F
Average void coefficient	(-5.7 ¢/% void) -3.99×10^{-2}% Δ k/k/%
Doppler coefficient	Negligible
Effective prompt neutron lifetime	2×10^{-4} s
Effective delayed neutron fraction ($\bar{\beta}_{eff}$)	0.70% Δk/k (1$)
Typical Operational Core	16 fuel assemblies, 3/8 MPS in slot #1, 3/8 MPS in slot #5, neutrography source log in horizontal cavity, graphite in vertical and other experimental facilities

*Includes negative reactivity worth of MPS.

4.2 Reactor Core

The fuel is in the form of highly enriched (93% ^{235}U) uranium-aluminum alloy, washer-like disks clad with aluminum. Each fuel assembly consists of 40 fuel disks and spacers placed on a shaft to form a "shish-kebab" assembly. The reactor core consists of a horizontal, double-wall cylinder with 16 fuel assemblies symmetrically arranged in the annulus. The core is centered in a 5-ft cube of AGOT-grade graphite that serves as the moderator, reflector, and core support structure. The horizontal fuel container is an aluminum cylinder 20 in. long and 18 in. in outside diameter with an inner wall diameter of 11.5 in. The 11.5-in.-diameter cylindrical space is filled with graphite and traversed by a horizontal experimental facility. Four safety rods and three control rods are used for reactor control. There are six locations around the outside of the fuel container for manually positioning poison sheets to limit excess reactivity in the core and to modify the flux shape if desired (see Figure 4.1).

4.2.1 Fuel Assemblies

The 16 fuel assemblies currently contain a total of ~ 3.6 kg ^{235}U. Each fuel assembly consists of 40 fuel disks on a 0.5-in. diameter aluminum shaft. Each fuel disk (Figure 4.2) is flat, washer-shaped, and aluminum clad with 23.5 wt % uranium-aluminum alloy meat containing about 5.63 g of highly enriched (93%) uranium. A 0.18-in.-thick aluminum spacer is located between each fuel disk, and an additional 0.031-in.-thick aluminum washer is in every other space. Lateral motion of the disks, spacers, and washers on the shaft is prevented by lock nuts on both ends of the shaft. This arrangement produces an active length of about 15.25 in. with face-to-face distances between the disks alternating between 0.24 and 0.27 in. A 0.75-in. length of each end of the shaft is machined to provide a tip suitable for supporting and positioning the fuel assembly accurately in the core reel of the fuel container. The section of the support tip that extends past the ends of the core reel by 0.375 in. is engaged by a tool during fuel handling.

4.2.2 Safety Rods, Control Rods, and Manual Poison Sheets

Three types of movable neutron poisons are provided to control core reactivity: safety rods, control rods, and manual poison sheets (MPS). The relative positions of these movable neutron poisons are shown in Figure 4.1. All three types of reactor control are located about the outer periphery of the fuel container, and all run in guides that extend from the south end of the fuel container through the reflector and shield to the north face of the reactor. The guides place the center of the control rods on about a 9.5-in. radius about the axis of the core.

The safety rods were designed for rapid insertion to scram the reactor. The poison section of each safety rod is 20 in. long and consists of a core of boron carbide cylinders, 0.5-in.-diameter, contained in a stainless-steel tube. A plug in the north end of the stainless-steel tube connects to the extension rod of the safety rod drive mechanism. All four safety rods must be withdrawn completely before withdrawal of any control rod begins.

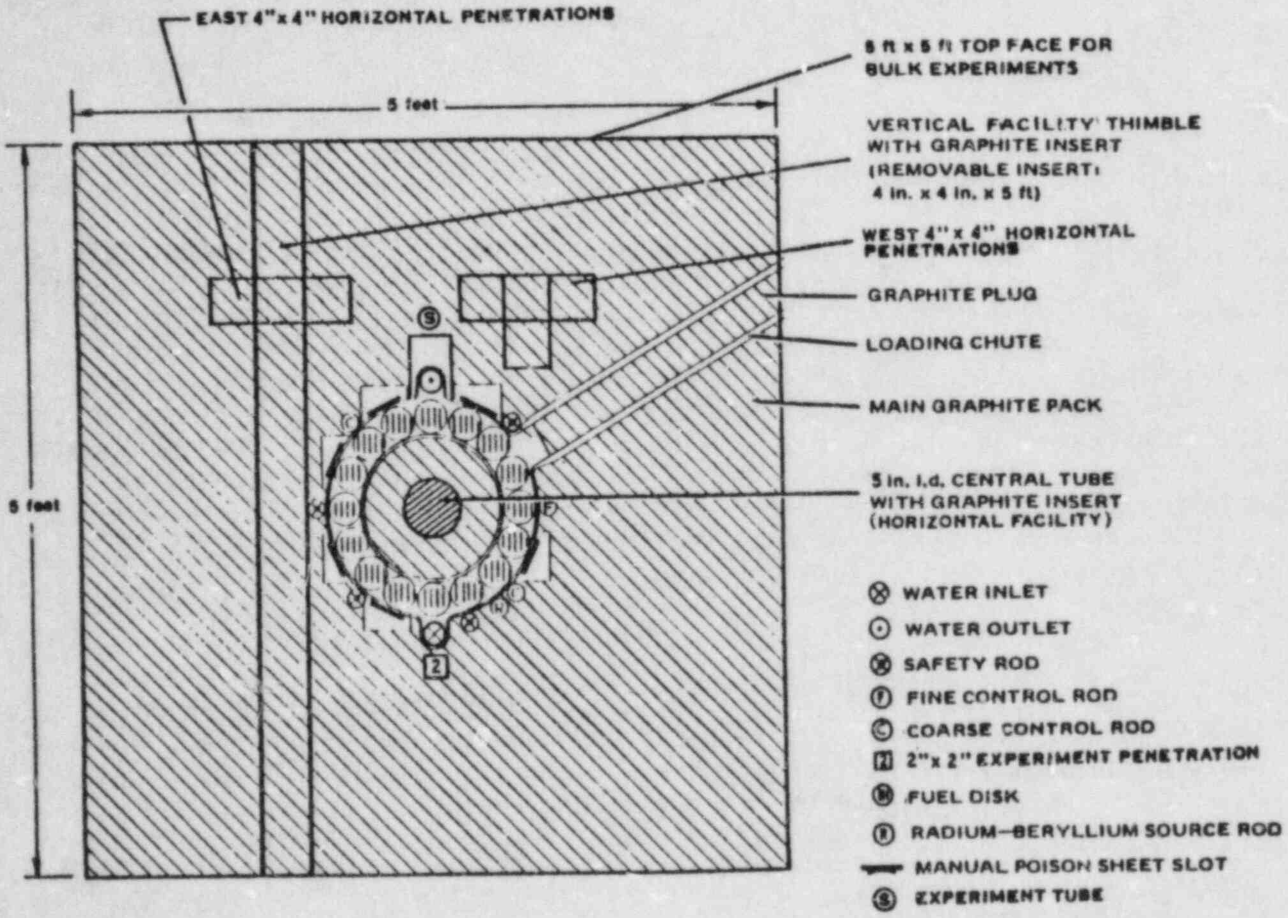

Figure 4.1 Vertical section through the GE-NTR

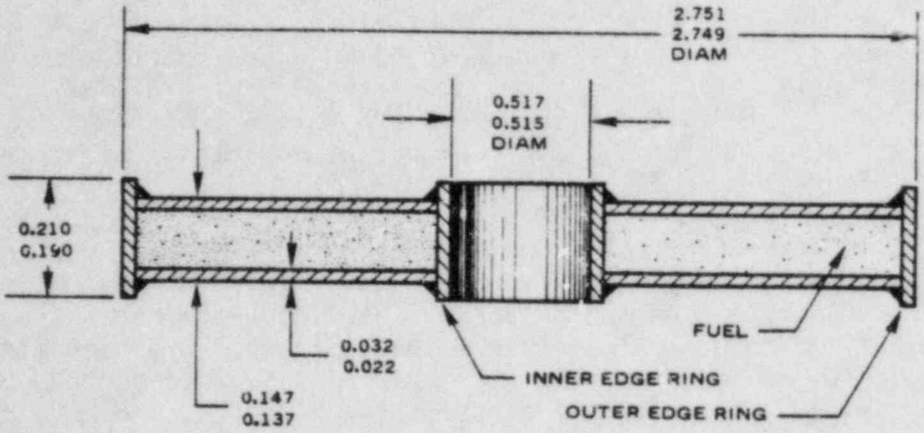

Figure 4.2 Fuel disk

The poison section of each of the two coarse control rods is 16 in. long and consists of a solid core of 0.5-in.-diameter boron carbide cylinders contained in a stainless-steel tube. A plug in the north end of the tube is connected to an extension rod that is attached to a yoke positioned by the drive mechanism. The poison section of the fine control rod is 18 in. long and consists of a solid core of 0.365-in.-diameter boron carbide cylinders contained in a stainless-steel tube. The stainless-steel tube connects to a nut block of the drive mechanism. The control rods can be inserted into the core at a controlled rate but cannot be scrammed.

There are six position slots around the outside of the fuel container to permit manually positioning up to six poison sheets (MPS) to limit the excess reactivity in the core, to increase the shutdown margin, or to modify the flux shape as desired. Each poison sheet is made of 19-in.-long, 0.031-in.-thick cadmium that is laminated between two sheets of 0.08-in.-thick aluminum. The width of the cadmium in each sheet determines its effect on the flux shape, shutdown margin, and reactivity available to the operator. The cadmium poison sheets have the following widths:

Sheet Size	Width
Full	2.75 in.
3/4	2.06 in.
1/2	1.38 in.
3/8	1.06 in.
1/8	0.34 in.

Slots 1, 2, and 5 have been modified with positive restraint latches to ensure that the sheets located in those slots cannot be dislodged accidently. The other slots are not used. For the current core, there is a 3/8 MPS in slot 1 and a 3/8 MPS in slot 5; slot 2 is used when changing an MPS in either slot 1 or 5. The poison sheets do not have a drive mechanism or any automatic function associated with them. A sheet either is inserted fully or removed completely. The poison sheets that are not used are stored in a rack in the reactor cell. An MPS can be changed only while the reactor is shut down.

4.3 Fuel Container, Core Reel, and Core Support Structure

Figure 4.3 is an assembly drawing of the reactor fuel container. The fuel container is a horizontal annular aluminum cylinder with inner and outer cylindrical skins, which are rolled aluminum sheets 0.25 and 0.0625 in. thick, respectively. The end plates are 0.5-in.-thick aluminum. Attached to the inside surface of each end plate is a circular aluminum raceway that supports and guides the core reel assembly.

Openings are provided in the north end plate for 1.5-in. primary coolant inlet and outlet lines. The inlet line is connected to a flow-distributor tube located inside the container below the core. The flow-distributor tube has 25 0.25-in. holes drilled into its lower side; the holes near the core midplane are closer than those at the ends to distribute water flow to correspond to power distribution along the core. The outlet line is connected to a baffle tube with holes on the top side. The tube is located inside the container above the core.

Extending from the outer wall of the fuel container is a rectangular aluminum loading chute (~30 in. long, 20 in. wide, and 4 in. high) that is inclined upward at an angle of about 30° to horizontal. The chute is connected to the fuel loading tank. Slotted adapters inside the chute provide a guide for the aluminum-clad graphite plug that fills the chute when it is not in use. The slots in the adapters line up with radial slots in the two circular raceways to guide the fuel-loading tool to the core reel during refueling.

The core reel assemply is located within the fuel container, and it supports the fuel assemblies at a 7.48-in. radius about the axis of the core. The reel, which is kept in a locked position, can be unlocked and rotated only from within the reactor cell when the reactor is shut down.

The graphite reflector-moderator, a 5-ft cube of reactor-grade graphite, also supports the fuel container. The graphite was machined to fit around the fuel container and loading chute. An aluminum box constructed of 0.375-in. plate and 2-in. aluminum angle contains the 5-ft graphite cube on all faces except the bottom and south faces. (The south face is joined to the 4-ft graphite cube thermal column.) A 0.031-in. cadmium liner is provided for the north and east sides of the box. The box rests on a base consisting of a 0.625-in.-thick aluminum plate fastened to a framework of 5-in. aluminum I-beams that are clamped to steel support plates anchored to the reactor cell floor.

Eight 0.75-in. aluminum tubes supported from brackets attached to the end plates run horizontally along the outside surface of the fuel container to the north face of the reactor. These tubes are guides for the control, safety, and neutron source rods. Six slotted graphite ways (bearing surfaces) attached to the north end plate serve as guides for positioning the poison sheets manually. The only other attachment to the fuel container is a bracket fastened to the south end plate that helps support the 5-in. horizontal facility.

Two special sections of the graphite reflector-moderator were designed to be removable: the blocks situated between the fuel container and the north face and the blocks that fill the 11.5-in.-diameter hole formed by the inner skin of

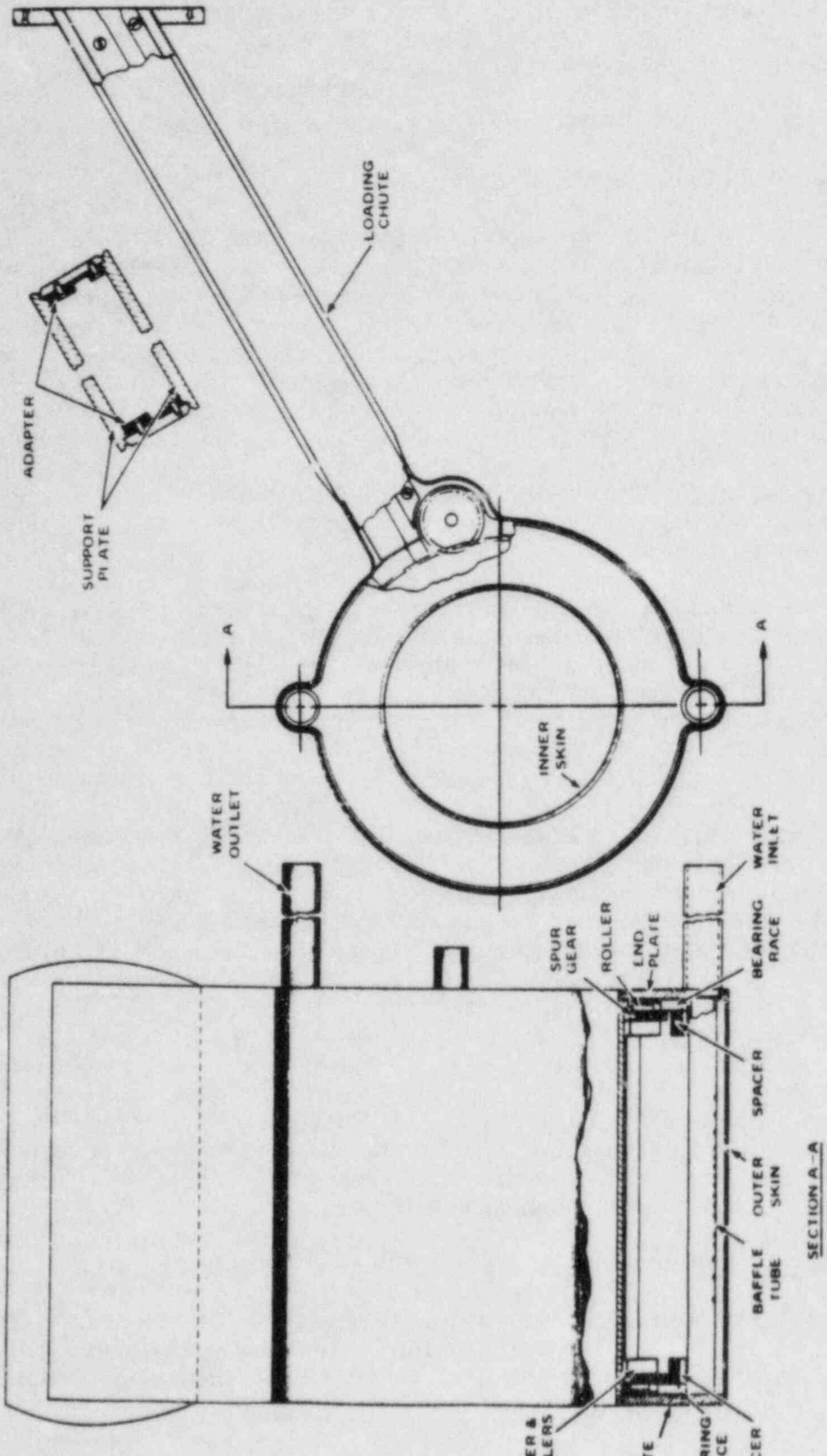

Figure 4.3 Fuel container assembly

the fuel container. These sections make it possible to inspect the fuel container without disturbing the rest of the reflector.

4.4 Shielding

The shielding for the GE-NTR facility is shown in Figure 4.4.

4.4.1 Reactor Cell

The reactor is in a high-density concrete alcove (about 10.67 ft wide by 10 ft high) in the reactor cell. Its east and south sides are shielded adequately by the 5-ft-thick alcove walls. The fuel storage tank provides 4 ft of water shielding on the reactor's west side in addition to the 3-ft-thick west alcove wall. An 8-in.-thick lead shield in front of the reactor (north side) provides shutdown gamma radiation shielding for the control rod drive area. A 1-ft-thick shield of reinforced heavy concrete with a 48-in-diameter hole centered above the reactor core and an 8-in.-diameter hole for limited access to the east face of the reactor covers the top of the core. A 16-in.-thick stepped concrete plug is available for the 48-in. hole. This plug also contains a 6-in.-diameter hole with a plug directly above the vertical facility to permit access without removing the large plug.

The thick walls and roof of the reactor cell are constructed of ordinary reinforced concrete. The outer shield door in the control room leading to the reactor cell is a 1-ft thick, motor-driven, sliding concrete door lined with 1.25 in. of steel. The inner door to the reactor cell is manually operated and made of 1-ft-thick paraffin covered with aluminum.

4.4.2 South Cell

Thick, high-density concrete walls completely surround the south cell experiment area. The wall between the south cell and the control room contains a shield door made of 8-in. high-density concrete, 5.25 in. of paraffin, and two 0.125-in. sheets of boral. A high-density concrete block wall and a 4-in. lead brick wall provide shielding from radiation coming from the thermal column. A thick shutter consisting primarily of lead and borated polyethylene shields against radiation from the horizontal cavity.

4.4.3 North Room

The modular stone monument (MSM) provides shielding in the north room from the north room radiography beam and radioactive objects during the neutron radiographic process. The MSM is made of high-density concrete modular blocks and has a borated lead polyethylene beam catcher.

4.5 Reactor Instrumentation

The reactor instrumentation provides the operator with the information necessary for proper manipulation of the controls. The signals are displayed at the reactor console and are used to initiate automatic scrams if preset limits are

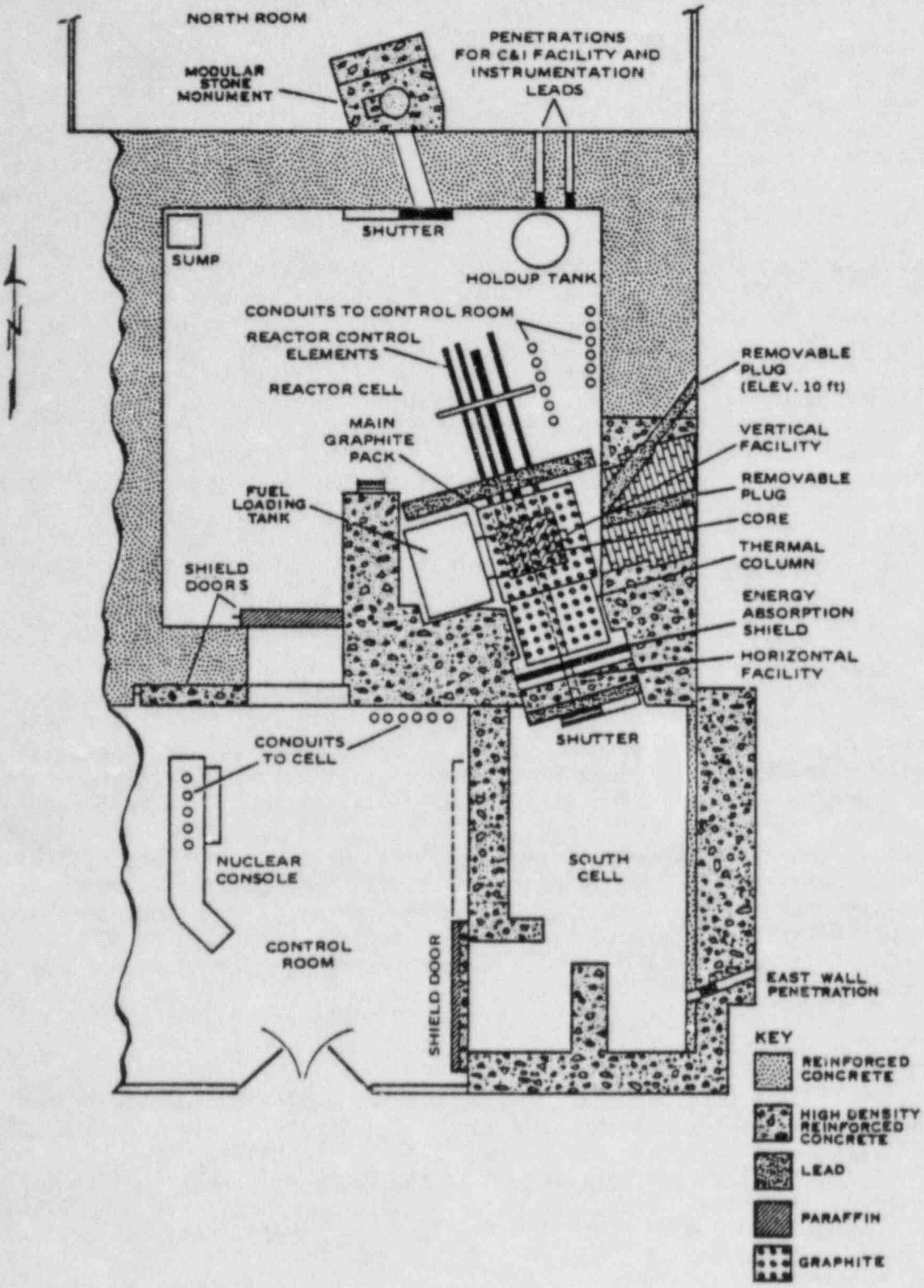

Figure 4.4 Nuclear test reactor facilities (top view)

exceeded. The following nuclear and process instrument channels are provided and are discussed in more detail in Sections 4.7 and 7.

(1) startup channel (optional)
(2) linear power level (three channels)
(3) log-N period channel
(4) primary coolant temperature
(5) primary coolant flow

4.6 Dynamic Design Evaluation

To ensure safe and responsive operation, the reactor is provided with a reactivity control system and nuclear instrumentation. The reactor instrumentation monitors and displays changes in reactor parameters such as power, neutron density, reactor period, coolant flow, and coolant temperature thereby providing information for appropriate operator response. In addition, interlocks prevent inadvertent reactivity addition, and a scram system initiates rapid, automatic shutdown when safety settings are exceeded.

The reactor core system is designed to have a negative coolant temperature coefficient of reactivity for temperatures above 124°F. Thus, in the unlikely event of inadvertent high-power operation leading to high temperatures, the negative temperature reactivity coefficient will tend to limit the reactor power.

4.6.1 Core Thermal and Hydraulic Characteristics

A summary of the core thermal and hydraulic characteristics is given in Table 4.1. Above 0.1 kW, forced circulation of deionized water is used to transfer heat from the core to a heat exchanger. Below 0.1 kW, operation is permitted without forced circulation. The coolant system is designed so that in the event of a loss of flow at any power level because of primary coolant pump failure, the reactor will continue to be cooled by natural circulation (see Section 14.5). Burnout (steam blanketing) of the fuel cladding diminishes the heat transfer from the core and causes the fuel plate temperature to increase. Experimental data for the GE-NTR core indicate that the burnout ratio, or the ratio of burnout heat flux to maximum heat flux at 100 kW, is about 56. This represents a considerable safety margin under normal operating conditions.

4.6.2 Shutdown Margin

For a typical core (refer to Table 4.1), the worth of all four safety rods is 3.86$ (2.70% Δ k/k). The maximum worth of a single safety rod is 1.10$ (0.77% Δ k/k). With the maximum potential excess reactivity of 0.76$ (0.532% Δ k/k) in the core, as limited by the Technical Specifications, and the maximum worth safety rod stuck out, the shutdown margin would be 2.00$ (1.40% Δ k/k) (3.86 - 0.76 - 1.10). The Technical Specifications require a minimum shutdown margin of 1.00$ (0.70% Δ k/k).

4.6.3 Excess Reactivity

The licensee's Technical Specifications limit the potential excess reactivity to 0.76$ (0.532% Δ k/k). This potential excess reactivity includes the excess reactivity that can be added by removing the control rods plus the maximum credible reactivity addition from primary coolant temperature change plus the potential reactivity worth of all installed experiments. For a typical core (refer to Table 4.1), the excess reactivity for the control rods is about 0.55$ (0.385% Δ k/k) and the reactivity addition, because of primary coolant temperature change, is about 0.07$ (0.048% Δ k/k), for a total of 0.62$ (0.433% Δ k/k). Thus, experiments for a typical core must have a potential reactivity worth less than 0.14$ (0.098% Δ k/k).

4.6.4 Experiments

In addition to the above limitations on potential excess reactivity, the Technical Specifications provide the further limitation that no experiment can be moved during reactor operations unless its potential reactivity worth is less than 0.50$ (0.35% Δ k/k). With these limitations, no experimental failure would result in exceeding the maximum step reactivity insertion analyzed by the licensee in a postulated accident that considered a step insertion of 0.76$ (0.53% Δ k/k) (refer to Section 14). On the basis of the tests performed by the licensee on the latching mechanisms that hold the poison sheets in place, it is not considered credible that any of the MPS could be ejected from the reactor core to result in a step reactivity insertion potentially greater than 0.76$ (0.532% Δ k/k).

Experiments may contain explosive materials or materials that can produce a chemical reaction. The licensee's Technical Specifications and safety criteria for explosive and combustible materials have been reviewed by the staff (refer to Section 14) and determined to be satisfactory in minimizing the possibility of any explosions or fires in the GE-NTR facility.

4.7 Functional Design of Reactivity Control System

All control and safety rods have guides that extend from the south end of the fuel container to the north face of the reactor. The control and safety rods have horizontally mounted drive mechanisms that are supported from the north face of the reactor on a 5-ft-high aluminum support plate located about 4.5 ft in front of the north face.

4.7.1 Safety Rod Drives

An extension rod that has a rod-stop armature assembly pinned to the other end is connected to the plug in the north end of the safety rod. Two spiral springs are attached to the extension rod so that withdrawal of the safety rod cocks the springs to store energy. The safety rod is held to the rod drive by an electromagnet that engages the armature attached to the extension rod. When a scram signal is received, the electromagnets are deenergized and the springs insert the safety rods rapidly. Deceleration of each scrammed safety rod is accomplished by an air, dashpot-type shock absorber. Periodic testing of the insertion times verifies the performance of the safety rods.

4.7.2 Control Rod Drives

The plug in the north end of each coarse control rod is connected to an extension rod attached to a yoke that is fastened to a lead screw. This screw runs through a sprocket-and-nut assembly connected through a chain drive to a gear motor identical to those for the safety rods. When a scram signal is received, the coarse control rods are driven to their fully inserted positions automatically, if electrical power is still available.

The stainless-steel tube containing the poison in the fine control rod is connected to a nut block that travels on a lead screw. Following a scram, the fine control rod is driven automatically to the fully inserted position, if electrical power is still available. The control rods do not have to be inserted to ensure shutdown. Any one of the safety rods is adequate to shut down the reactor from the critical condition.

Position indicators are provided for both coarse control rods and the fine control rod. The precison of these indicators is 0.01 in. Their accuracy is verified on a preventive maintenance check and is required to be ±1 in. at a full-out position of 16 in. for the coarse rods and ±0.5 in. at a full-out position of 15 in. for the fine rod.

4.7.3 Manually Positioned Poison Sheets

The manual poison sheet (MPS) is a passive means for limiting available excess reactivity in the core. An MPS can be inserted or withdrawn only by an operator after entering the reactor cell to unlock and remove a shield plug on the shield face. Each sheet is equipped with a spring-loaded latch handle that provides positive restraint of the poison sheet. A special latching tool is required to physically unlatch or latch the MPS before removal or full insertion. Sheets are stored in a rack in the reactor cell and are accounted for before reactor startup.

4.7.4 Scram-Logic Circuitry and Interlocks

The GE-NTR is equipped with scram-logic circuitry and an interlock system that receives signals from nuclear instrumentation and other reactor parameters to initiate a scram by removing electrical power from the safety-rod electromagnets which, when deenergized, cause rapid insertion of the spring-loaded safety rods.

The reactor parameters that can initiate these scrams are as follows. With two-out-of-three or one-out-of-two coincidence there are three parameters:

(1) high reactor power, three channels
(2) loss of compensated ion chamber (CIC) high voltage, three channels
(3) selector switch in other than operate mode

With noncoincidence, there are five parameters. If the limits or operating characteristics of any one of the following instruments are surpassed or not operated as designed, the reactor will scram.

(1) fast reactor period
(2) log-N amplifier mode switch position
(3) log-N CIC loss of positive high voltage
(4) high primary coolant core outlet temperature
(5) low primary coolant flow

In addition, the operator can manually scram the reactor. The safety system is discussed in more detail in Section 7.

4.8 Operational Practices

The GE-NTR has implemented a program that incorporates reviews, inspections, and written procedures for all safety-related activities. The Independent Review Group (IRG) reviews all matters pertaining to the safe operation of the facility. Specific areas of responsibility for IRG include procedures (and their changes) required by Technical Specifications; types of experiments; facility modifications and procedures; proposed changes to the facility operating license, including Technical Specifications and revised bases; facility compliance with Federal regulations and license provisions; abnormal occurrences; performance of facility apparatus and equipment; and any other subjects, as needed. The Vallecitos Technological Safety Council (VTSC) may be called on for assistance by the IRG.

Periodic inspections performed by IRG include evaluating conformance of facility operation to Federal regulations, Technical Specifications, and facility license requirements; the results of all actions to correct deficiencies or increase effectiveness in facility equipment, structure, systems, or methods of operation that affect nuclear safety; and facility emergency procedures, security plan, requalification program, and the licensee's implementing procedures. A comprehensive quality assurance program provides for the modification and maintenance of pertinent plant systems and equipment.

The GE-NTR is operated by trained NRC-licensed personnel in accordance with the procedures described in Section 13.

4.9 Conclusion

The staff has performed a review of the GE-NTR facility design, control and safety instrumentation, operating practices, Technical Specifications, and other pertinent documentation associated with the reactor. Based on the review of this reactor and experience with other man-power reactors with highly enriched fuel, the staff concludes that the GE-NTR is capable of continued safe operation.

5 REACTOR COOLANT SYSTEMS

The GE-NTR coolant systems, as shown in Figure 5.1, consist of a primary coolant system located entirely inside the reactor cell and a secondary coolant system that removes reactor heat from the primary system and transfers it to site retention basins. The instrumentation and controls associated with these systems are described in Section 7.

5.1 Primary Cooling System

Demineralized primary cooling water is pumped to the reactor core at a rate of ~20 gal/min. There it enters the annulus at the bottom of the fuel container, flows around the fuel assemblies, and exits the top of the fuel container. The coolant then flows to the heat exchanger, transfers its heat to the secondary coolant, flows through an air trap, and flows back to the suction side of the primary pump.

One-half gal/min of the primary coolant flow is diverted through two parallel demineralizer cartridges, a filter, and back into the loop upstream of the primary pump. Effluent from the demineralizers normally has a resistivity of about 1 MΩ-cm, and the cartridges are replaced when the resistivity drops below 250,000 Ω-cm. The resistivity of the primary coolant is monitored constantly and displayed on a meter in the reactor cell. A gamma detector is located near the demineralizers that indicates and alarms at the control console.

A 1,500-gal fuel loading tank is the reservoir for primary coolant. Tank water high- or low-level sensors alarm at the control console. The fuel loading tank is joined to the primary loop through the reactor fuel loading chute. When it is necessary to raise the primary coolant level in the fuel loading tank, water from the building potable water supply is transferred into the primary loop through an ion exchange column and three check valves that prevent backflow.

A 500-gal holdup tank is located in the reactor cell and contains coolant from the overflow from the fuel loading tank, the primary coolant vent line, the discharge from the reactor cell sump pump, the air trap vent line, and any portion of the primary coolant inventory.

When necessary, its contents are pumped into a liquid waste transport tank on the site and taken to the waste evaporator for disposal.

5.2 Secondary Cooling System

The building potable water system flows at ~35 gal/min to the tube side of the system heat exchanger and out of the cell to a site retention basin. Basin contents are analyzed for radioactive material before being discharged.

The pressure of the secondary coolant is maintained at about 50 psi at the heat exchanger inlet. This is considerably higher than primary coolant pressure. Thus, any heat exchanger leaks would cause secondary coolant to flow into the

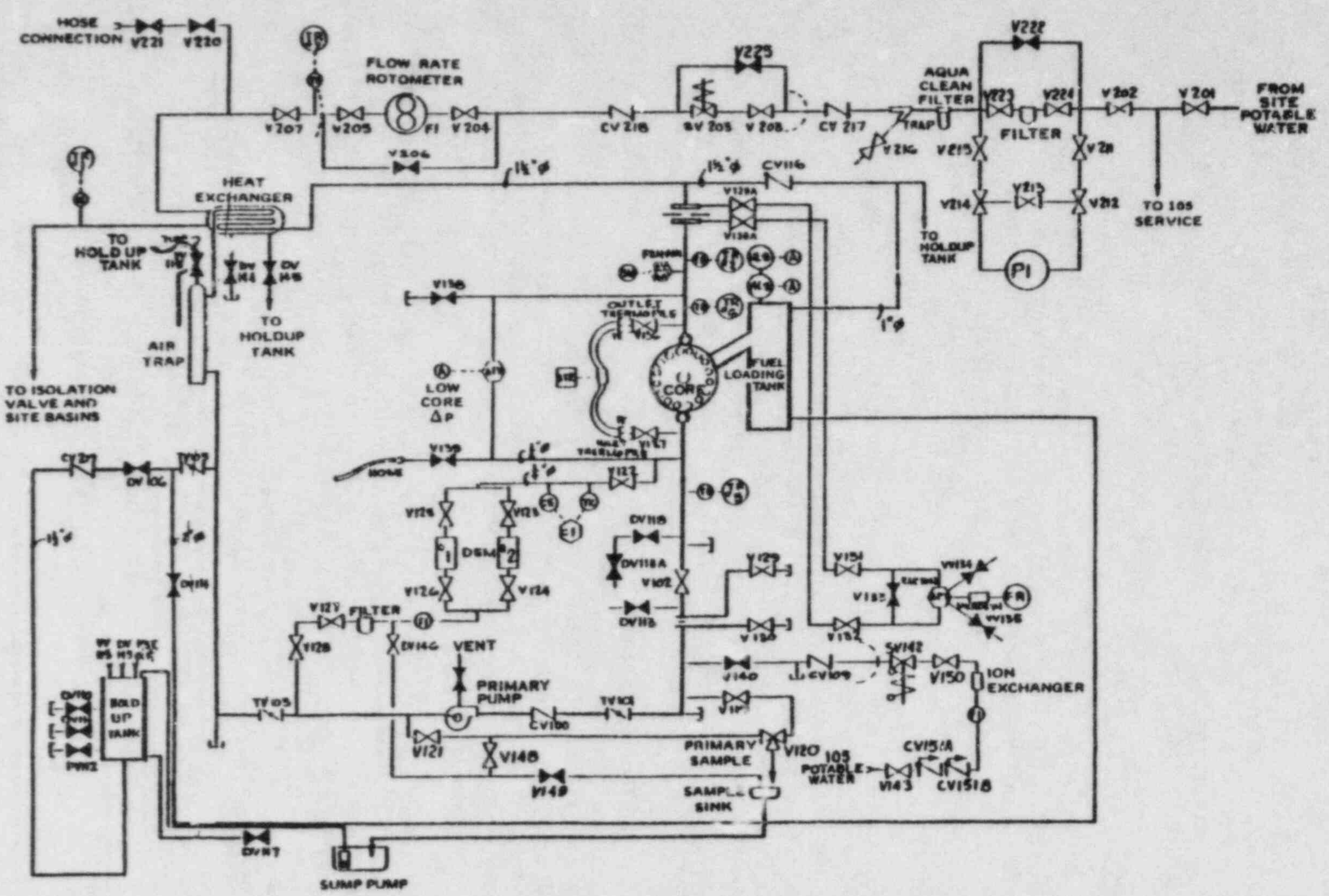

Figure 5.1 Nuclear test reactor coolant systems

primary system, confining any radioactivity in the primary coolant to the reactor cell.

5.3 Conclusion

The staff concludes that the GE-NTR cooling systems are adequate to maintain fuel temperatures within safe limits for all operating conditions. In addition, the purity of the primary coolant is maintained at a sufficiently high level to preclude corrosion-caused failure of primary system components during continued reactor operation.

6 ENGINEERED SAFETY FEATURES

The only engineered safety feature at the GE-NTR complex is the reactor facility ventilation system. The controls and instrumentation for this system are described in Section 7.

6.1 Ventilation System

A 3,000-ft^3/min blower, located on the roof of the reactor cell, vents air from the reactor cell, the south cell, the neutron radiography facility, and the special nuclear material (SNM) cage in the shop; pulls it through a roughing filter and a bank of HEPA filters; and discharges it through the building stack about 45 ft above ground level. No ventilation supply system is installed; outside air enters the vented areas through infiltration.

A separate particulate and radioactive gas system monitors the ventilation system stack discharge. Each system has separate console alarm and recording provisions. These systems are described in detail in Sections 7 and 12.

6.2 Conclusion

The reactor building ventilation system design and procedures are adequate to control and detect the release of airborne radioactive effluents in compliance with the guideline values of 10 CFR 20 and to minimize releases of airborne radioactivity in the event of an accident.

7 CONTROL AND INSTRUMENTATION

The control and instrumentation systems at GE-NTR are similar to those in use at other nonpower reactors in the United States. As stated previously, reactor core control is maintained using four safety rods, two coarse control rods, and one fine control rod. Available excess reactivity is limited by the use of up to six manually positioned poison sheets. The instrumentation system consists of nuclear, process, and radiation instrumentation . The scram and safety-related systems are summarized in Tables 7.1 and 7.2, respectively. The trip points listed in Tables 7.1 and 7.2 are set far enough below the limits of the associated reactor parameters to ensure that inaccuracies in the measurement devices will not result in exceeding these critical values. The staff finds this acceptable.

7.1 Control System

The control system is composed of both nuclear and process control equipment in which safety-related components are designed for redundant operation in case of single failure or malfunction of component essential to safe operation or a shutdown of the reactor.

7.1.1 Nuclear Control System

All the core reactivity control devices are located outside the outer surface of the fuel container.

The safety rods provide for rapid reactor shutdown when a scram signal is received. The reactivity worth of any one of the safety rods is sufficient to ensure reactor shutdown even if control rod insertion is not possible. The safety and control rod drives are controlled by the reactor operator or by the scram instrumentation. The nuclear control system is discussed in more detail in Section 4.7.

7.1.2 Supplementary Control Systems

These control systems are designed to control the various processes involved in reactor operation that are not directly related to safety. Included in this category are circuits and devices that energize and/or monitor the ventilation-heating system, the air conditioning systems, the compressed air system, primary and secondary coolant and bulk graphite temperature, secondary coolant flow rate, reactor cell air radioactivity level, and the differential pressure of the primary coolant across the reactor core. These control systems ensure proper operation of the non-safety-related systems and provide the operator with information on the status of these systems.

7.2 Instrumentation System

The instrumentation system is composed of nuclear, process control, and radiation monitoring circuits. The annunciations and/or indications are supplied at the reactor console or the reactor control room via the electrical system.

Table 7.1 Scram systems

System	Conditions	Set Point*	Function	Scram Type
Linear	High reactor power	≤125 kW	Scram (2 out of 3 or 1 out of 2)	Nuclear
	Loss of positive high voltage to ion chambers (if ion chambers are used)	≥90% of operating voltage	Scram (2 out of 3 or 1 out of 2)	Process
Log-N	Short reactor period	≥ 5 s	Scram	Nuclear
	Amplifier mode switch not in operate position	NA	Scram	Process
	Loss of positive high voltage to ion chambers (if ion chambers are used)	≤90% of operating voltage	Scram	Process
Primary coolant temperature	High core outlet temperature	≤222°F	Scram	Process
Primary coolant flow	Low flow	≥15 gal/min when reactor power is ≥0.1 kW	Scram	Process
Manual	Console button depressed	NA	Scram	Manual
	Reactor cell button depressed	NA	Scram	Manual
Electrical power	Reactor console key in off position	NA	Scram	Process
	Loss of ac power to console	NA	Scram	Process

* Set points are based on the most recent channel calibration.

Table 7.2 Safety-related systems

System	Conditions	Set Point*	Function
Reactor cell pressure	Low differential pressure	$\geq$0.5 in. of water	Visible and audible alarm; audible alarm may be bypassed after recognition.
Fuel loading tank water level	Low water level the fuel loading chute	$\geq$3 ft above	Visible and audible alarm; audible alarm may be bypassed after recognition.
Primary coolant temperature	High core outlet temperature	$\leq$200°F	Visible and audible alarm; audible alarm may be bypassed after recognition.
Primary coolant core temperature differential	Core delta temperature	None	Provide information for the heat balance determination.
Stack radioactivity	Beta-gamma particulate high level	$\leq 1 \times 10^4$ counts/min (0.113 µCi)†	Visible and audible alarm; audible alarm may be reset after recognition.
	Noble gas high level	$\geq 2 \times 10^{-11}$ amps (2×10^{-4} µCi/ml)	
Linear power	Low power indication	$\geq$5% of full scale	Safety or control rods cannot be withdrawn (1 out of 3 or 1 out of 2).
Control rod	Rods not in	NA	Safety rod magnets cannot be reenergized; may be bypassed to allow withdrawal of one control rod or one safety rod or one safety rod drive for purpose of inspection, maintenance, and testing.
Safety rod	Rods not out	NA	Control rods cannot be withdrawn; safety rods must be withdrawn in sequence; may be bypassed to allow withdrawal of one control rod or one safety rod or one safety rod drive for purposes of inspection, maintenance, and testing.

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*Set points are based on the most recent channel calibration.
†Based on ^{36}Cl.

7.2.1 Nuclear Instrumentation

This instrumentation monitors the neutron flux related to reactor power and provides reactor nuclear scram signals in case of excessive power levels or fast power rises. The GE-NTR scram systems are shown in Figure 7.1. This instrumentation is required to be operable during reactor startup and operation and provides the operator with the information necessary for proper manipulation of the reactor controls.

(1) Linear power channels--Three channels are used; each receives data from three independent compensated ion chambers (CICs). The channels have trip circuits that operate in a two-out-of-three (or one-out-of-two if one channel is inoperative) coincidence logic circuit. The scram set point is at ≤125% of full power.

(2) Log-N channel--This channel also receives data from a CIC. The channel uses a log-N and period amplifier that is capable of causing fast period reactor scrams. The alarm set point is at ≤125% of full-power operation.

All CICs are positioned in thimbles in the fuel storage tank or at a face of the reflector. Because the CIC locations can be varied easily with the exact location of a particular chamber (determined by the intended use of the reactor sensitivity of the channel and the desired meter reading), the primary flow rate and core differential temperature are the basic reactor thermal power data for linear and log-N power channel calibration. If the high voltage of the neutron side of the log-N power channel CIC or two out of three (one out of two if one channel is inoperable) of the linear power channel CICs drop to 90% or less of the operating voltage, the reactor will scram. Also, if the log-N channel amplifier mode switch is not in the operating position, a relay contact in the scram system will prevent closure of the scram circuit. Moving the mode switch from the operating position when the reactor is operating will cause a process scram.

Because the linear power channels are sufficiently sensitive to be used as startup channels, a separate startup channel is not required. However, a source range monitor channel is provided for use during fuel changes and for special tests. This channel uses a proportional counter-log count-rate system as shown in Figure 7.2. When the source range monitor channel is not in use, the recorder is switched to the thermopile signal (discussed below) automatically when the reactor power is ≥100 W.

7.2.2 Process Instrumentation

The process instrumentation monitors nonnuclear parameters and provides scram or alarm signals, as appropriate, plus information to assist in operation of the facility.

Primary coolant conditions that initiate a scram are low flow and coolant outlet temperature. The primary coolant flow is measured by means of the differential pressure drop across a calibrated orifice in the primary coolant loop. The coolant outlet temperature scram is activated by a thermal switch in the outlet coolant line.

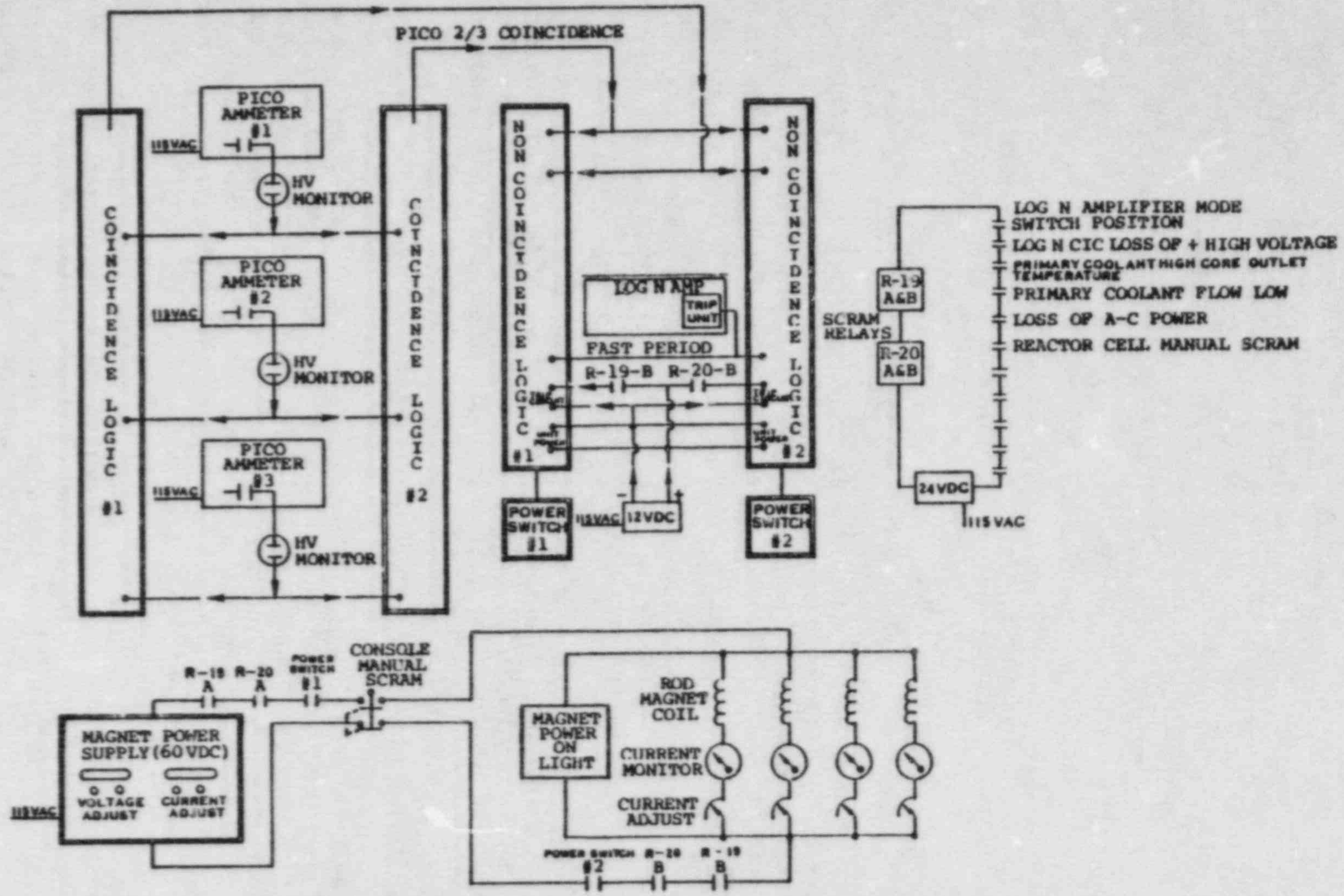

Figure 7.1 GE-NTR scram systems

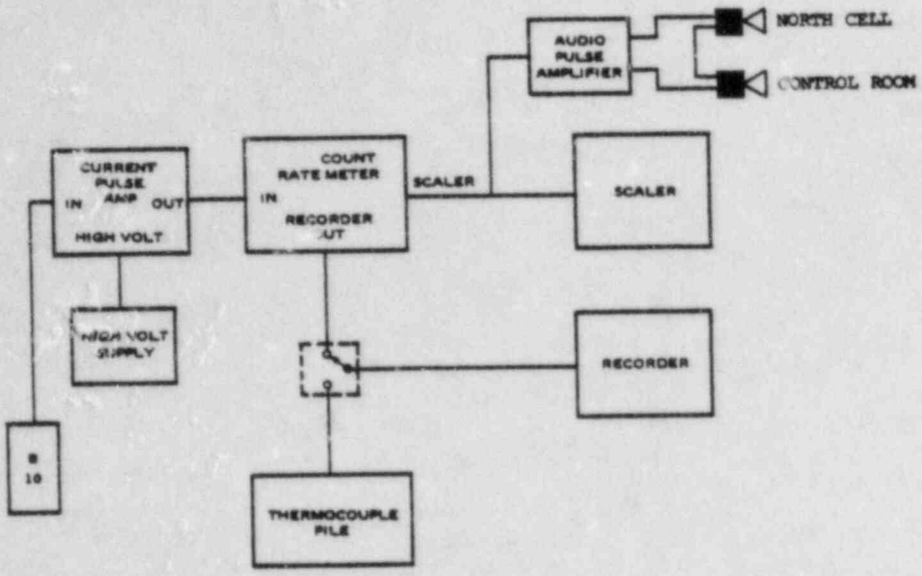

Figure 7.2 GE-NTR source range monitor channel

Loss of ac power to the console will cause the reactor to be scrammed automatically. The reactor console key in the "off" position is essentially identical to the loss of ac power to the console and causes a reactor scram, if turned off when the reactor is running. Both of these scrams are termed "process scrams."

Process parameters that cause alarms are listed in Table 7.2 and include low cell differential pressure, low fuel loading tank water level, and primary coolant outlet temperature.

A thermopile is provided to measure the primary coolant temperature rise across the reactor core. This core temperature differential, in conjunction with the primary coolant flow rate, is used to determine a heat balance that provides the reactor power data used to calibrate the linear and log-N power channels.

7.2.3 Radiation Monitoring Instrumentation

The radiation monitoring instrumentation consists of fixed-position area monitors and a stack air monitoring system. Single area monitors are located in the reactor room, the south cell, and the control room; two area monitors are located in the north cell. The monitors alarm locally and in the control room. The south cell monitor is interlocked to the south cell shutter and door controls to prevent accidental exposure to the south cell neutron radiography beam. Their alarm set points are listed in Table 7.3.

The stack monitor has separate detection systems and alarms for gaseous and particulate materials. A continuous sample is drawn from the discharge of the ventilation stack. The air sample stream passes through the particulate detector, a charcoal filter, and a gas detector and is released through the building stack. The charcoal filter and the particulate filter are changed

Table 7.3 Radiation monitors

System	Conditions	Set Point	Function
Radiation monitors	North room high level	≤100 mr/h Above background	Visible and audible alarm; audible alarm may be bypassed after recognition. May be temporarily out of service if portable instruments are used during personnel entry and occupancy.
	South cell high level	≤100 mr/h Above background	
	Reactor cell high level (reactor shutdown)	≤100 mr/h Above background	
	Reactor cell high level (reactor operating)	≤100 R/h	
	Control room high level	≤5 mr/h Above background	

periodically (generally weekly) and are assayed for ^{131}I and gross α-β activity, respectively.

7.2.4 Inhibits and Annunciations

Inhibits associated with the rod drive system that prevent reactor startup include the following:

(1) Safety and control rods cannot be withdrawn unless two of the linear power channels are above a minimum value.

(2) Safety rod magnets cannot be energized unless the safety and control rods and the neutron source are at their inner limits

(3) Safety rods must be withdrawn in sequence to their outer limit before any control rod can be withdrawn.

An interlock that permits withdrawal of any individual rod is provided for testing and inspecting rods. Only one rod can be withdrawn, and it must be returned to the full-in position before a normal startup sequence can be initiated. In addition to the inhibits listed above, any condition that will cause a reactor scram will prevent reactor startup, unless corrected.

A control console-mounted annuciator panel provides the operator with information on conditions of important variables related to reactor operation. The audible alarm can be bypassed, without correcting the condition causing the alarm, by the operator acknowledging the event. The scram systems and some of the safety-related systems cause annunciations as shown in Tables 7.1 and 7.2, respectively.

Control console lights are provided to indicate rod and rod drive conditions. The conditions indicated include safety rod drives at inner or outer limit, safety rods fully inserted or fully withdrawn, and control rods fully inserted or fully withdrawn.

Coarse and fine control rod position indicators are provided on the console. The control rod position indicators can be read to the nearest 0.01 in. The accuracy of the position indicators must be within ±1 in. at the full-out position (16 in.) for the coarse control rods (6.25% of full travel) and within ±0.5 in. at the full-travel position (15 in.) for the fine control rod (3.33% of full travel). These are verified quarterly.

7.2.5 Reactor Scram System

The control and instrumentation systems are interconnected through the scram system (Figure 7.1) that automatically scrams the reactor when the abnormal conditions given in Table 7.1 occur. All reactor scrams interrupt the current to the safety rod electromagnets, causing a rapid insertion of the spring-loaded safety rods. The scram system uses power switches, scram relays, or a manual scram switch to deenergize the electromagnets. Logic circuits are used to control the power switches. The linear power channel high-power trips function through coincidence logic circuits. The log-N fast-reactor-period trip functions through noncoincidence logic circuits. All other scrams, with the exception of the control console manual scram, operate through scram relays.

7.3 Conclusion

The control and instrumentation systems at the GE-NTR facility are well designed and their performance is verified. Redundancy throughout the operating ranges of power measurements is ensured by requiring at least two linear power channels (that respond from source level to full power) to be operational. The licensee's performance specifications for the individual components used through the system exceed the minimum required, which helps to ensure system reliability and decreases the chances of serious, simultaneous multicomponent failures. The control system is designed so that the reactor is shut down automatically and safely if electrical power is lost. On the basis of its review of the control and instrumentation systems, the staff concludes that these systems are adequate to ensure continued safe operation of the reactor within the limits of the Technical Specifications and the license conditions.

8 ELECTRICAL POWER

8.1 Normal Electrical Power System

The entire VNC is supplied with electrical power through a Pacific Gas & Electric substation located near Building 105. A 480-V load center in Building 104 is fed from this substation and, in turn, feeds the power and lighting distribution panels for the GE-NTR facility. Two 120/240-V circuit breakers in the control room feed individual breakers for the primary coolant pump, service outlets, facility lights, and the reactor console. Power supplied to the console is used for the reactor instrumentation and the control and safety rod drive motors. A 24-V dc power supply is provided for operating relay circuits in the reactor safety and control systems.

8.2 Emergency Electrical Power System

Because the reactor will scram in case of a power failure and the decay heat generated in the core after scram will not cause fuel overheating, emergency power for reactor shutdown is deemed to be unnecessary for reactor safety. Accordingly, emergency battery power is supplied only for semiportable emergency lighting units, which are installed at several locations in the facility. Each unit contains a battery that maintains its charge from a 115-V ac system. On loss of ac power, the units are energized automatically to provide light for emergency action, personnel exits, etc.

8.3 Conclusion

The staff concludes that the electrical power system is acceptable for safe reactor operation and that additional emergency power for other than lighting is unnecessary.

9 AUXILIARY SYSTEMS

The auxiliary systems associated with the GE-NTR facility are the fuel handling and storage, the compressed air, the fire protection, and the air conditioning systems.

9.1 Fuel Handling and Storage System

Reactor fuel is not handled routinely at the GE-NTR facility. If it becomes necessary to remove and replace a fuel assembly, the fuel supporting reel mechanism is rotated until desired assembly is at the entrance of the fuel loading chute. The fuel-handling tool (guided by slots in the sides of the chute) slides down the chute, attaches to the fuel assembly shaft, and pulls the assembly up the chute and into the fuel loading tank. A new assembly is installed by reversing the process. The removed irradiated fuel assembly would be placed in a shielded cask in the fuel loading tank for storage or removed to another on-site facility.

9.2 Compressed Air System

Compressed air for the facility is supplied from the building service air compressor located in the second-floor mechanical equipment room. The compressor can deliver 50 ft^3/min of free air at a pressure of 100 psig. A relief valve at the air compressor maintains the system pressure at less than 120 psig. Air is supplied to a breathing air purifying system in the control room. Regulated output from the purifier supplies a manifold inside the reactor cell entranceway. The manifold contains four regulators that supply four individual hose reels, which also are mounted in the reactor cell entrance. In addition, compressed air is supplied to the air piston operator for the south cell door and to an air-operated shutter used for radiation shielding for the south radiation beam. Conveniently located outlets are provided to supply air for experiment equipment or for service air.

9.3 Fire Protection System

The fire protection equipment and procedures for the GE-NTR facility are part of the conventional industrial plant fire protection equipment and procedures established for the site. The equipment and procedures are in accordance with company-wide standards, state and local regulations, and the recommendations of insurance agencies.

Six-inch fire mains, which are legs of a water-supply loop surrounding Buildings 102 and 105, are located on the east and west sides of Building 105. These fire mains supply outdoor fire hydrants located at the northeast, southeast, and southwest corners of Building 105 and an extensive sprinkler system located within the building. Fire hoses and nozzles are located permanently in the hallway and the southeast corner of Building 105. A 500,000-gal raw water storage tank, located on one of the adjacent hills at the site, approximately 130 ft higher than Building 105, is the source of the water for the fire mains; 100,000 gal of this water is reserved for fire protection. In addition to the water system, conventional portable fire extinguishers are located throughout the GE-NTR facility and Building 105.

A building fire team, under the direction of the building emergency coordinator, provides fire protection for Building 105 on the day shift. All members are familiar with work under radiation conditions and requirements of the site instructions for radiation protection. The California Division of Forestry at Sunol will respond to fires at VNC on a 24-hour basis, if called.

9.4 Air Conditioning System

An air conditioning unit is located on the mezzanine of the reactor cell. The air inlet and outlet are located in the cell. The only purpose of the unit is to control air temperature and humidity for human comfort.

9.5 Conclusion

The staff concludes that the GE-NTR facility auxiliary systems are adequate to support continued safe and reliable reactor operation.

10 EXPERIMENTAL PROGRAM

The GE-NTR serves as a source of ionizing and neutron radiation for use in the research, development, analytical, and commercial programs of GE and its clients. Typical experiments include reactivity worth measurements, radiation-effect studies, small sample activations, large sample irradiations, and neutron radiography. Experimental facilities include one large horizontal (central tube) facility, seven 4-in. and one 2-in.-square horizontal penetrations, a 5-in.-square vertical facility, a fuel loading chute facility, a control and instrumentation facility, an external thermal column, reactor face facilities, and the modular stone monument (MSM) dual-neutron radiography facility. These facilities are shown in Figures 4.4, 10.1 and 10.2. The effect of any experiment or sample on excess reactivity, criticality outside the reactor, or on the reactor facility is limited by the Technical Specifications.

10.1 Experimental Facilities

10.1.1 Horizontal Facility

The horizontal or central tube facility penetrates the reactor graphite pack along its horizontal axis (Figure 10.2). The facility is accessed from the south cell through an 8-in.-diameter opening that passes through the south radiation shield into the thermal column. In the thermal column, the facility decreases to a 5-in.-diameter cavity that continues through the reactor core and reflector and is in line with a 24-in.-diameter beam penetration in the north reactor cell wall (Figures 4.4 and 10.1). Within the 5-in. cavity is a tube, 40 in. long and 3 in. in diameter, in a 1-in-thick graphite sleeve that is centered in the main graphite pack. This tube can be removed, thereby enlarging the horizontal facility diameter to 5 in. The facility also is accessible from the reactor cell, and objects may be irradiated in any position within the sample tube or in the external radiation beams. The north reactor cell wall penetration is provided with an electrically operated radiation shielding shutter.

The north cell wall penetration provides the neutron beam for the MSM dual-neutron radiography facility.

10.1.2 Miscellaneous Horizontal Facilities

Two graphite layers in the main graphite pack have been modified to accommodate up to seven 4-in.-square horizontal penetrations (Figure 10.2). In addition, a section of graphite 2 in.^{2} by 36 in. long below the core can be removed and used for small sample irradiations or a rabbit tube facility (Figure 10.2).

Each of the horizontal penetrations is accessible from inside the reactor cell through holes in the north shield wall. These access holes normally are filled with borated lead polyethylene or lead plugs.

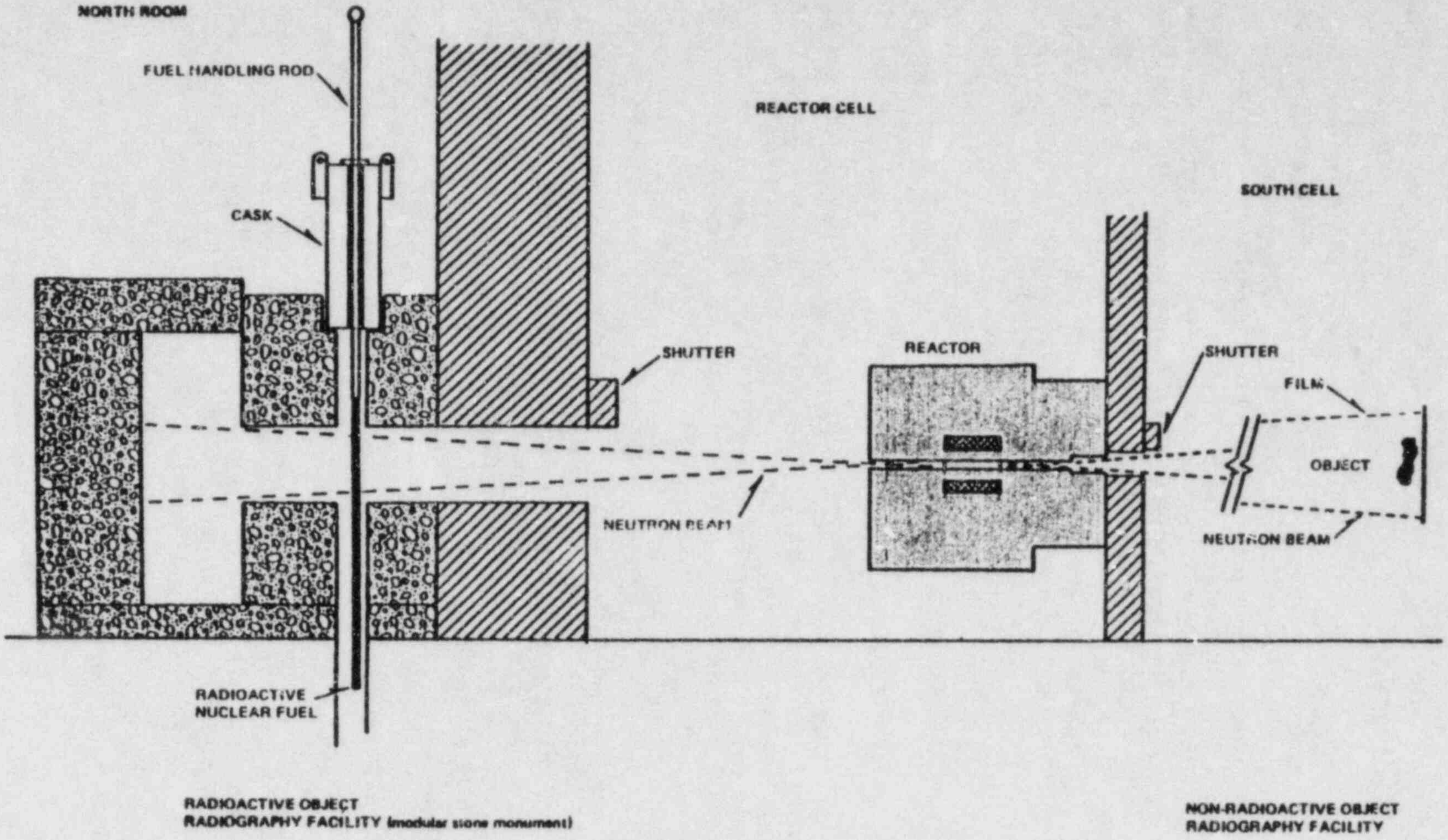

Figure 10.1 GE-NTR neutron radiographic facilities (side view)

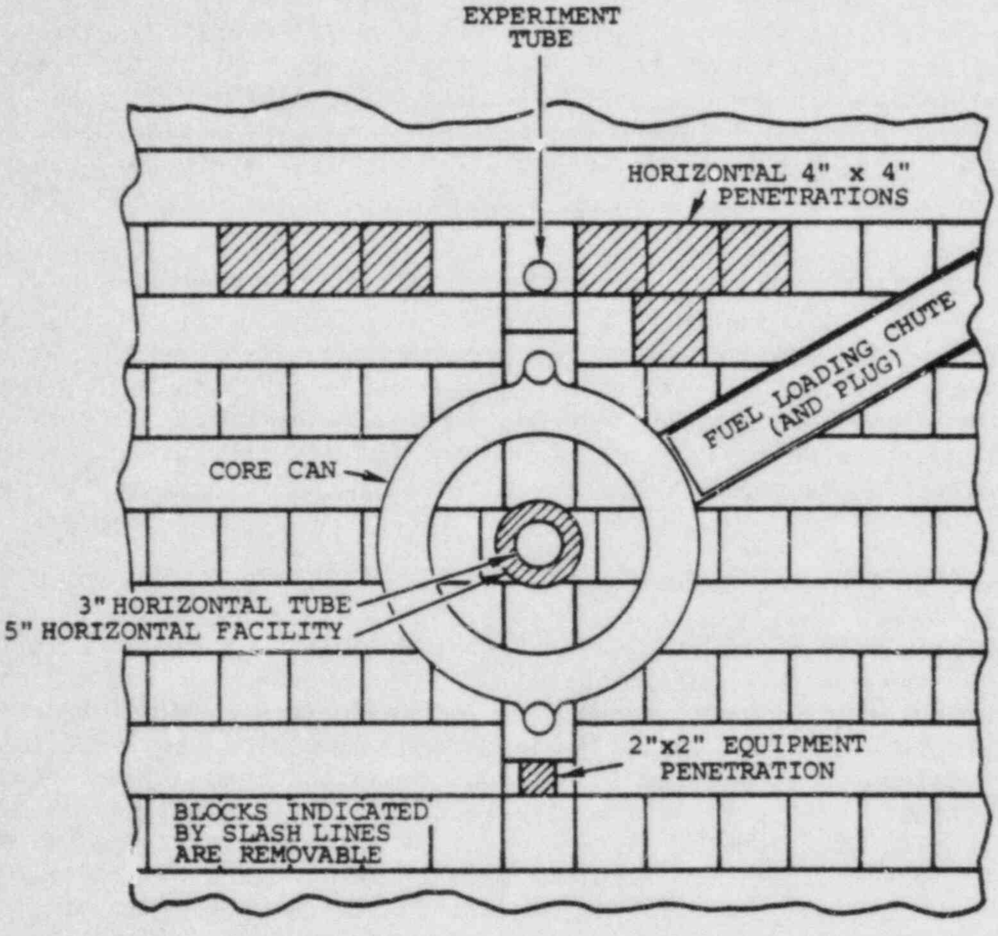

Figure 10.2 Horizontal penetrations

10.1.3 Vertical Facility

The vertical facility is a 5-in.-square aluminum can that penetrates the graphite reflector and is essentially tangential to the east side of the fuel container. When not in use, the facility is filled with a piece of reflector graphite. The facility is accessible only from inside the reactor cell, and irradiations can be performed within the tube or in the external radiation beam emerging from the top of the tube.

10.1.4 Control and Instrumentation Test Facility

The Control and Instrumentation (C&I) test facility is used for testing various types of neutron detectors in a simulated boiling water reactor (BWR) temperature environment at a thermal neutron flux compatible with C&I requirements. The C&I test section is located in the experiment tube (Figure 10.2) that runs horizontally across the top of the reactor can. Access to the facility is through penetrations in the reactor cell north wall. The access tubes are provided with a lead shield in the reactor cell where irradiated detectors may be stored until they have decayed to radiation levels low enough to be handled safely in the north room.

10.1.5 Fuel Loading Chute Facility

Removal of the fuel loading chute aluminum-clad graphite plug provides access to the inside of the fuel container for irradiations. Irradiations inside the core tank are permitted only at reactor power levels of up to 100 W, and the experimental objects must be secured to prevent their getting into the core region during all normal operations. This facility is used for experiments such as those that might be required to determine the nuclear characteristics of the reactor.

10.1.6 External Thermal Column

The external thermal column is a 4-ft cube of graphite located against the south side of the reactor's graphite reflector (Figure 4.4). The horizontal facility traverses the thermal column. A centrally located plug of graphite, 20-in. square by 4-ft long, can be removed to accommodate experiments within the thermal column or to provide an external radiation beam. The thermal column south face is accessible from the south cell. Sections of a biological shield consisting of a boral plate and concrete and lead walls can be removed to provide access to the thermal column face or for the use of radiation beams. A pneumatically operated piston located at the south face of the lead shielding wall provides shielded access to the horizontal facility.

10.1.7 Reactor Face Facilities

Experiments can be conducted using the radiation escaping from faces of the graphite reflector. Removable access plates are provided in the top and east faces of the aluminum box that contains the reflector. The space between the reflector and the top shield slab can be used without removing the 48-in. diameter concrete plug in the shield; however, the plug can be removed to accommodate special experiments. Access to the reactor face facilities is from the reactor cell.

10.1.8 Modular Stone Monument

The modular stone monument (MSM) is a dual-neutron radiography facility that provides the capability of neutron radiographing or unirradiated and irradiated objects (Figures 10.1 and 10.3). The MSM is located in the north room and is made up of six concrete blocks that are the structural and the shielding components of the facility. A 12-in.-inside-diameter pipe runs vertically through the facility and extends 20 ft into the ground beneath the MSM. This pipe is used for making neutron radiographs of long objects such as fuel elements. A recess on top of the MSM provides access to the pipe from large shielding casks for neutron radiography of irradiated objects. A facility on the north end of the MSM is used for neutron radiography or unirradiated objects.

10.2 Experiment Review

All new types of irradiation experiments require a written description and analysis of possible hazards, must be reviewed and approved by the GENTR facility manager or his designated alternate, and must have an independent review and approval by personnel from the Nuclear Safety Group before the irradiation or experiment can be conducted. Approved types of irradiations and experiments are defined in and covered by Experiment Type Approvals (ETAs). Routine experiments* covered by an ETA may be reviewed and approved by a licensed senior operator. Experiments that come under the jurisdiction of an ETA but are not routine must be approved by the Manager, NTR or his designated alternate. The administrative structure and reporting responsibilities of GE-NTR and nuclear safety are discussed in more detail in Section 13.

In addition to ensuring safe reactor use in compliance with the license, this review and approval process allows personnel specifically trained in radiological safety and reactor operations to consider and recommend alternative operational conditions (such as different irradiation positions, power levels, or irradiation times) that might decrease personnel exposure and/or the potential release of radioactive materials to the environment.

10.3 Conclusion

The staff concludes that the design of the experimental facilities, combined with the detailed review and administrative procedures applied to all research activites and the experiment limitations of the licensee's Technical Specifications, are adequate to ensure that experiments (1) are unlikely to fail, (2) are unlikely to release significant radioactivity to the environment, and (3) are unlikely to cause damage to the reactor systems or its fuel. Therefore, the staff considers that reasonable provisions have been made so that the experimental programs and facilities do not pose a significant risk of radiation exposure to the public.

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*Routine experiments are those that are repetitive and involve well-characterized materials and configurations as defined in the ETA.

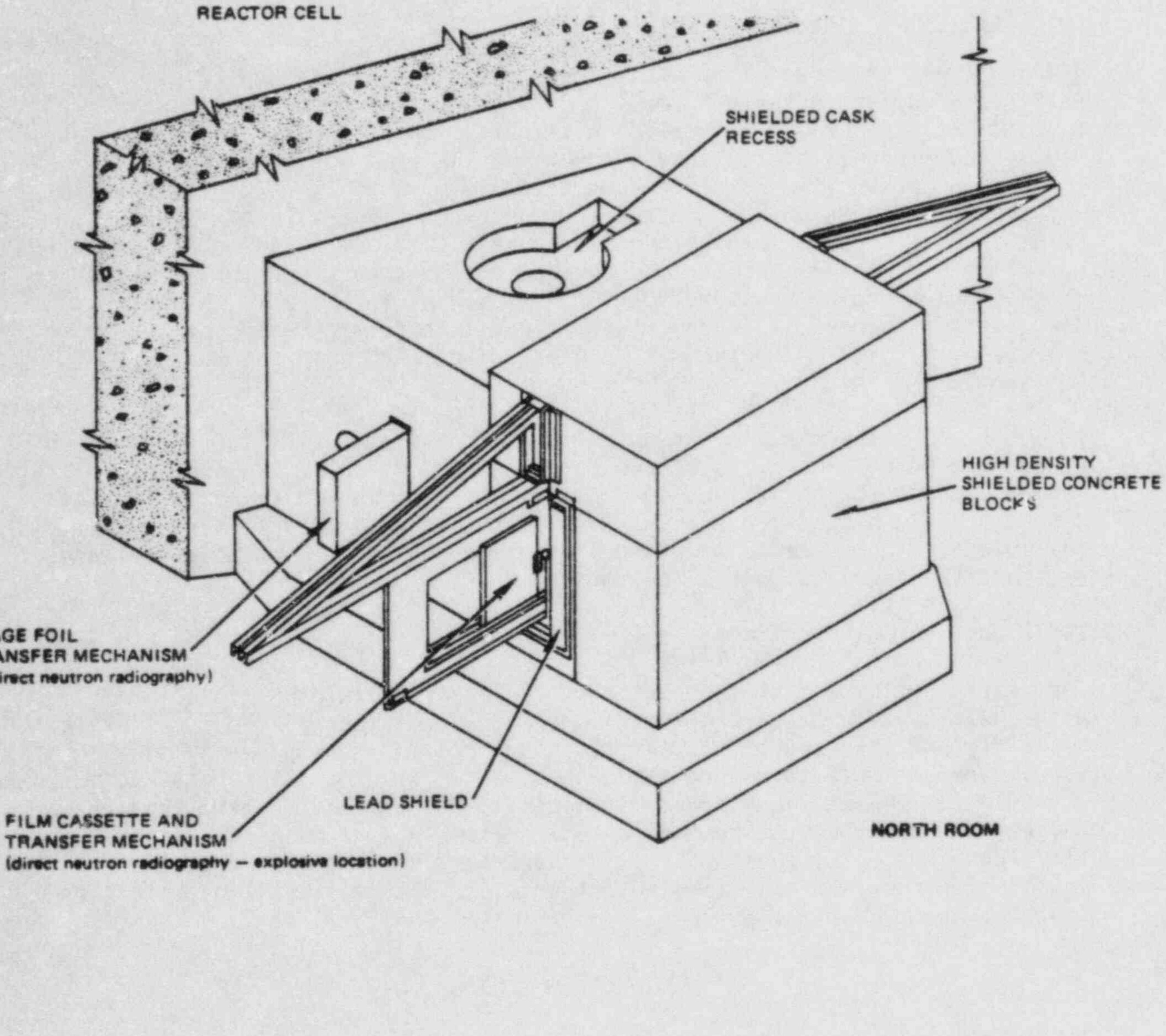

Figure 10.3 Modular stone monument neutron radiography facility

11 RADIOACTIVE WASTE MANGEMENT

The major radioactive waste generated by reactor operations is activated gases, principally ^{41}Ar, and noble gases produced by neutron irradiation of air. A limited volume of radioactive solid waste is generated by reactor operations, and some additional solid waste is produced by the associated research programs. No radioactive liquid wastes are generated directly by normal reactor operations.

11.1 ALARA Commitment

There is a GE management policy and instructions for all personnel to develop procedures to maintain the generation and possible release of radioactive waste materials to a level as low as is reasonably achievable (ALARA).

11.2 Waste Generation and Handling Procedures

11.2.1 Solid Waste

Solid waste generated as a result of reactor operations consists primarily of ion exchange resins and filters, potentially contaminated paper and gloves, and occassional small, activated components. Some of the reactor-based research results in the generation of solid low-level radioactive waste in the form of contaminated paper, gloves, and glassware. This solid waste generation typically has contained several millicuries of radionuclides per year.

During the period between 1970 and 1983, approximately 500 ft^3 of solid waste containing almost 900 mCi of radioactive material was removed from the GE-NTR facility. The bulk of this solid waste was generated during an intensive cleanup campaign conducted during the last quarter of 1982 and the first few months of 1983.

Solid waste is collected and initally packaged by reactor personnel. Interim storage for limited quantities of solid waste is available at the GE-NTR facility. This material later is transferred to the Radioactive Product and Services Department where it is combined with other site-generated waste and packaged for transport. The waste is shipped to an approved disposal site in accordance with applicable regulations.

11.2.2 Liquid Waste

Normal operation of this reactor produces no radioactive liquid waste. However, some of the research activites are capable of generating limited volumes of such wastes.

Potential radioactive liquids generated by GE-NTR-related operations are collected in the reactor cell sump and then are pumped to a 500-gal holdup tank. Portable waste tanks are available if large quantities of potentially radioactive liquids are handled (for example, if the reactor primary system must be drained).

Radioactive liquids are transferred to the Waste Evaporator Plant where they are concentrated and solidified before final disposal as solid waste.

11.2.3 Airborne Waste

No fission products escape from the fuel cladding during normal operations. However, some fisson products (noble gases and possibly iodine) are released from "tramp uranium" and infrequent experiments involving unsealed fueled plates.

The most frequent airborne waste is composed of gaseous ^{41}Ar and neutron-activated dust particulates. This material is produced principally by the neutron activation of air and airborne particulate materials in the thermal column and other experimental facilities. This air is swept constantly from the reactor cell and discharged to the environment through the filtered exhaust stack at a rate of 1,000 ft^3/min. Separate gaseous and particulate monitoring systems measure the concentrations in the effluent.

During the last several years, GE-NTR operations have resulted in an average annual release of about 100 Ci of gaseous radioactive isotopes. The staff evaluations show that this amount of release would lead to exposures in unrestricted areas that are well below the limits specified in 10 CFR 20.

11.3 Conclusion

The staff concludes that the waste management activities of this reactor facility have been conducted and are expected to continue to be conducted in a manner consistent with 10 CFR 20 and with the ALARA principles. Among other guidance, the staff review has followed the methods of ANSI/ANS 15.11 (1977), "Radiological Control at Research Reactor Facilities."

As indicated above, the staff concludes that the doses in unrestricted areas as a result of actual releases of airborne radioactive materials have been only a fraction of the limits specified in 10 CFR 20 when averaged over a year. Accordingly, the staff concludes that potential doses to the public as a result of radioactive effluents will not result in any significant effect on the public.

12 RADIATION PROTECTION PROGRAM

The General Electric Company has a structured radiation safety program at the VNC with a health physics staff equipped with radiation detection instrumentation to determine, control, and document occupational radiation exposures at its reactor facility. In addition, the reactor facility monitors all airborne effluents to document compliance with applicable guidelines.

12.1 ALARA Commitment

GE has formally established the policy that operations are to be conducted in a manner to keep all radiation exposures ALARA. All proposed experiments and procedures at the reactor are reviewed for ways to minimize the potential exposures of personnel. All unanticipated or unusual reactor-related exposures are investigated by both the health physics and operations staffs to develop methods to prevent recurrences.

12.2 Health Physics Program

12.2.1 Health Physics Staffing

The current health physics staff at VNC consists of six professionals and four technicians. This staff provides radiation safety support to the entire research complex including hot cells and several radioisotope laboratories. Many routine health physics-type activities at the reactor are performed by the operations staff. The health physics staff is available for consultation, and the head of the nuclear safety function is a member of the Vallecitos Technological Safety Council. The staff believes that the available radiation safety support is adequate for this reactor facility.

12.2.2 Procedures

Detailed written procedures have been prepared that address the radiation safety support that is expected to be provided to the routine operations of the reactor facility. These procedures identify the interactions between operational and experimental personnel. They also specify numerous administrative limits and action points as well as appropriate responses and corrective action if these limits or action points are reached or exceeded. Copies of these procedures are readily available to the operational and research staffs and the administrative personnel.

12.2.3 Instrumentation

The GE-NTR facility has a variety of portable detecting and measuring instruments available for monitoring potentially hazardous ionizing radiation. The instrument calibration procedures and techniques ensure that any credible type of radiation and any significant intensitities will be detected promptly and measured correctly. Additional instrumentation is available from other VNC facilities.

12.2.4 Training

The VNC safety standards specify the level and type of training in radiation safety required of all employees. This includes a 20-min "Initial Radiological Safety Orientation" course on the first day of employment and a 4-hour "New Employee Radiological Safety Orientation" course within 30 days of employment. In addition, individual instruction from immediate supervisors and a number of formal specialized training programs are available.

12.3 Radiation Sources

12.3.1 Reactor

Sources of radiation directly related to reactor operations include radiation from the reactor core, ion exchange columns, filters in the water cleanup systems, and radioactive gases (primarily ^{41}Ar).

The fission products are contained within the aluminum cladding of the fuel disks. Radiation exposures from the reactor core are reduced to acceptable levels by water, graphite, and concrete shielding. The ion exchange resins and filters are changed routinely before high levels of radioactivity have accumulated, thereby limiting personnel exposure.

Personnel exposure to the radioactive materials in the stack effluent is limited by dilution and prompt removal of this gas from the reactor cell and its discharge to the atmosphere from the elevated stack where it diffuses further before reaching occupied areas.

12.3.2 Extraneous Sources

Sources of radiation that may be considered as incidental to normal reactor operation, but associated with reactor use, include radioactive isotopes produced for research, activated components of experiments, and activated samples or specimens.

Personnel exposure to radiation from intentionally produced radioactive material, as well as from the required manipulation of activated experimental components, is controlled by rigidly developed and reviewed operating procedures that use the normal protective measures of time, distance, and shielding.

12.4 Routine Monitoring

12.4.1 Fixed-Position Monitors

The five ion chamber area monitors and the reactor cell continuous air monitor are described in Section 7.2.3.

12.4.2 Experimental Support

The health physics staff participates in the planning of experiments by reviewing all proposed procedures for methods of minimizing personnel exposures and limiting the generation of radioactive waste. Approved procedures specify the type and degree of radiation safety support required by each activity.

12.5 Occupational Radiation Exposures

12.5.1 Personnel Monitoring Program

The GE-NTR personnel monitoring program is described in the VNC Safety Standards Instructions. Personnel exposures are measured by the use of film badges assigned to each individual who might be exposed to radiation. Instrument dose rate and time measurements are used to administratively keep occupational exposures below the applicable limits in 10 CFR 20.

In addition to monitoring personnel exposure to external radiation, potential internal deposition of radionuclides is monitored by in vivo (whole body) counting. The in vivo counter uses a 5-in. by 5-in. NaI(Tl) scintillation detector located in a shadow shield for background reduction.

12.5.2 Personnel Exposures

The GE-NTR facility personnel annual exposure history for the last 5 years is given in Table 12.1.

Table 12.1 Number of individuals in exposure interval

		Number of individuals in each range				
Whole-body exposure range (rem)		1979	1980	1981	1982	1983
No measurable exposure		0	0	0	1	1
Measurable exposure:	<0.5	3	0	3	2	1
	0.5 to 1	2	1	3	0	0
	1 to 2	2	4	3	2	5
	2 to 3	0	0	0	3	0
	>3	0	0	0	0	0
Number of individuals monitored		7	5	9	8	7

12.6 Effluent Monitoring

12.6.1 Airborne Effluents

As discussed in Section 11, airborne effluents from the reactor facility consist of activated gases and noble gas fission products.

The stack monitoring system measures the radioactive effluent discharged from the reactor cell; the sampling and monitoring are discussed in Section 7.2.3. The gaseous system was initially calibrated using known concentrations of ^{133}Xe. The instrument response was compared immediately with the radiation field of an external ^{60}Co source. The instrument now is checked periodically for its continued response to the ^{60}Co source.

12.6.2 Liquid Effluents

As stated in Section 11.2.2, liquid effluents from the GE-NTR are evaporated and disposed of as solid waste.

12.7 Environmental Monitoring

GE has a program to monitor the potential effect on the environment of the VNC facility. These environmental measurements include routine checks of the radioactivity of surface wastes, ground waters, steam bottoms, vegetation, and air particulates and iodine. All samples are analyzed for gross alpha and beta-gamma activities. All water samples also are analyzed for tritium. Stream bottoms and vegetation samples are assayed for additional specific radionuclides.

The environmental radioactivity data obtained during the last 5 years, when compared with preoperational site data, indicate that the operations at the VNC have not resulted in measurable increases in the environmental radioactivity levels.

12.8 Potential Dose Assessments

Natural background radiation levels in the San Francisco Bay Area result in an exposure of about 50-100 mrem/year to each individual residing there. An additional 8% (~8 mrem/year) will be recieved by those living in a brick or masonry structure. Any medical diagnosis X-ray examinations will add to these natural background radiations, increasing the total cumulative annual exposure.

Conservative calculations by the staff, based on the amount of ^{41}Ar released during normal operations from the reactor facility stack, predict a maximum annual increased dose of less than 1 mrem in the unrestricted areas.

12.9 Conclusions

The staff concludes that radiation protection receives appropriate support from the corporate administration. The staff further concludes that (1) the program is properly staffed and equipped, (2) the health physics staff has adequate authority and lines of communication, and (3) the procedures are integrated correctly into the research plans, and (4) surveys verify that operations and procedures achieve ALARA principles. Furthermore, the staff has found no instances of reactor-related exposures of personnel above applicable regulations and no unidentified significant releases of radioactivity to the environment.

The staff concludes that the effluent monitoring programs conducted by the GE-NTR facility personnel are adequate to promptly identify significant releases of radioactivity to predict maximum exposures to individuals in the unrestricted area. These predicted maximum levels are well below the guideline values of 10 CFR 20.

For the above reasons, the staff concludes that the GE-NTR and VNC radiation protection programs are acceptable, and there is reasonable assurance that the personnel and procedures will continue to protect the health and safety of the public during routine reactor operations.

13 CONDUCT OF OPERATIONS

13.1 Organization

The GE-NTR facility organization, including the interrelationship between operating and support units is indicated in Figure 13.1.

13.2 Staff Responsibilities

13.2.1 Operations

The Manager, Irradiation Processing Operation (IPO), has the overall responsibility for the GE-NTR license operation and safety.

The Manager, Advanced Nuclear Applications (ANA) has the overall responsibility for operation of the reactor and he is responsible for changes to the facility or procedures, and for safety reviews.

The Manager, GE-NTR, is responsible for the operation of the reactor and performance of the staff and all activities related to the actual operation of the reactor.

Other operating staff, such as reactor supervisors and crew, are also responsible for the safe operation of the reactor and for conformance to various written procedures and the Technical Specifications.

13.2.2 Safety Reviews

The function of the Nuclear Safety Group is to provide an independent review of new experiments and audit of the GE-NTR activities for safety and compliance with the GE-NTR license, Technical Specifications, 10 CFR, and other written safety requirements.

The Vallecitos Technological Safety Council is also an "external" organization that performs independent reviews required by the Technical Specifications. This group, when utilized, advises the Manager, IPO, on safety matters affecting any of the operations or activities on the VNC site. This group is comprised of representatives from all site activities.

13.3 Administrative Controls in GE-NTR Technical Specifications

Besides the above descriptions of the GE-NTR organization and its components, the Technical Specifications also provide administrative requirements for radiation safety procedures, radiation safety equipment, radiation safety training, and radiation safety reporting.

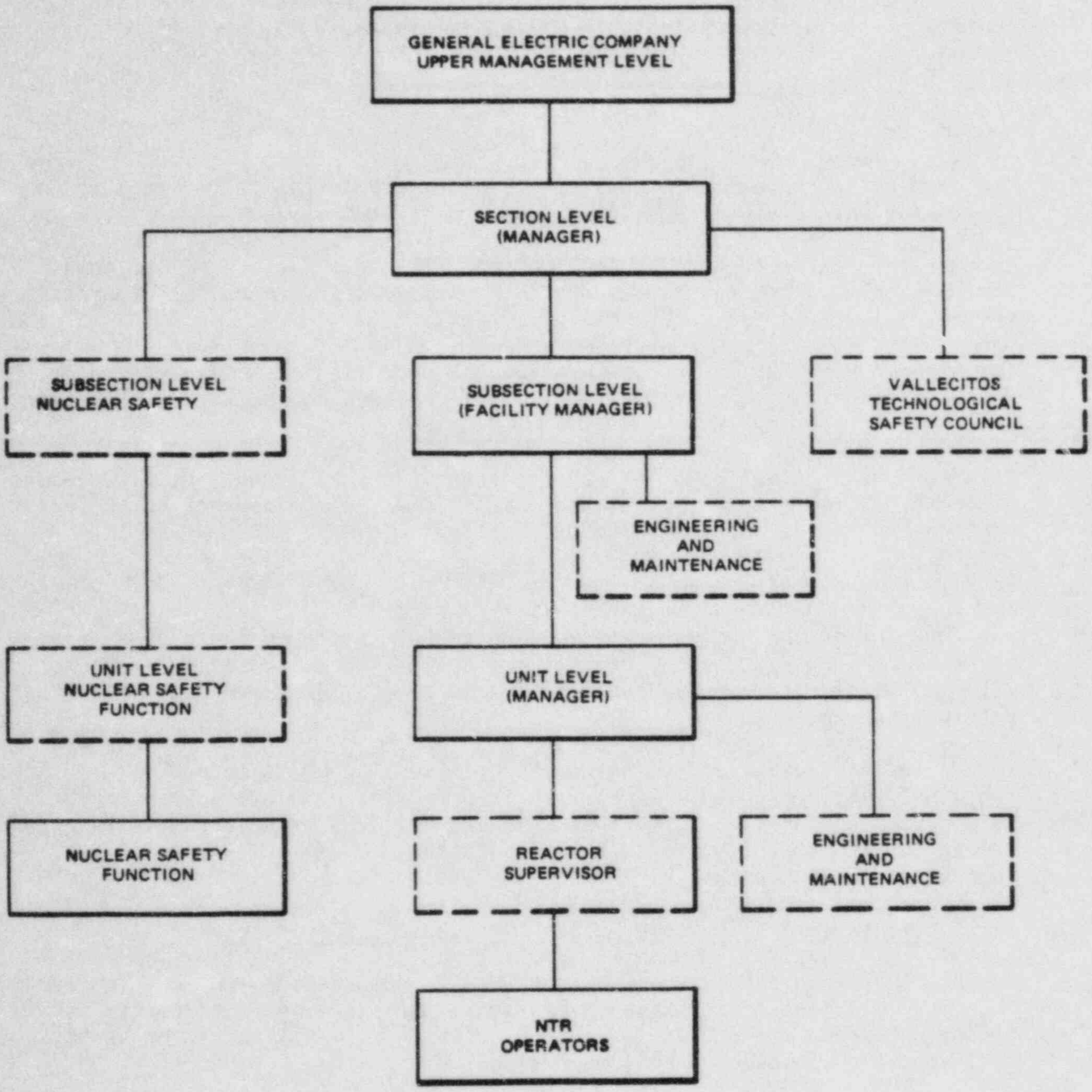

Figure 13.1 VNC facility organization

13.4 Training

The qualifications for key supervisory personnel regarding educational and operating experience, stipulated in Section 6.1.4 of the Technical Specifications, satisfy the requirements of 10 CFR 50.34(b).

13.5 Operational Review and Audits

As stated in Section 13.2.2, reactor safety review and nuclear reactor operation audits are performed by the Internal Review and Audits and the Nuclear Safety Group and the Vallecitos Technological Safety Council.

13.6 Emergency Planning

10 CFR 50.54 and Appendix E to 10 CFR 50 require that nonpower reactor licensees develop and submit emergency plans. By letter dated October 29, 1982, GE submitted an Emergency Response Plan for the VNC site, dated October 1982, in accordance with NRC and the American Nuclear Society (ANS) 15.16 guidelines.

On the basis of its review and evaluation, the staff found that the emergency plan for the VNC facility demonstrates that the licensee has the capabilities to assess and respond to emergency events, provides the assurance that the necessary emergency equipment is available, and describes a plan of action to protect the health and safety of workers and the public. For the above reasons, the staff concluded that the VNC facility's emergency plan meets the requirements of the regulations and, therefore, is acceptable.

13.7 Physical Security Plan

VNC has established and maintains a program designed to protect the reactor and its fuel and to ensure its security. The NRC staff reviewed the plan and visited the site. The staff has concluded that the plan, as amended, meets the requirements of 10 CFR 50.34(c) (license amendment No. 16, dated July 11, 1983). Both the Physical Security Plan and the staff's evaluation are withheld from public disclosure under 10 CFR 2.790(d)(1).

13.8 Conclusion

On the basis of the above discussions, the staff concludes that the licensee has sufficient training, experience, management structure, and procedures to provide reasonable assurance that the reactor will be managed safely and will cause no significant risk to the health and safety of the public.

14 ACCIDENT ANALYSIS

In establishing the safety of the operation of the GE-NTR, the licensee has analyzed anticipated operational occurrences and postulated accidents to ensure that these events would not result in significant hazards to the reactor staff or to the public. Postulated accidents are events not expected to occur during the course of plant operation but that have been hypothesized to evaluate the safety margins of the reactor under ultraconservative accident scenarios. The postulated accidents or events analyzed are

(1) failure of a fueled experiment
(2) pyrotechnic or explosive device accident
(3) criticality accidents in storage areas
(4) loss of primary flow
(5) loss of primary coolant
(6) rapid insertion of reactivity (nuclear excursion)
(7) core crushing accident

Of these anticipated or postulated events, only certain experiment failures can have a potential effect on the environment outside the GE-NTR facility. For the purposes of this classification, the staff designated the failure of a fueled experiment as the maximum hypothetical accident (MHA). An MHA is defined as an accident for which the risk to the public health and safety is greater than from any other event that can be postulated. Thus, the staff assumes that the accident occurs, but does not attempt to describe or evaluate all the mechanical details of the accident or the probability of its occurrence. Only the consequences are considered.

14.1 Failure of a Fueled Experiment

The failure of the encapsulation boundary of an experiment is considered the MHA. The experimental material is ^{239}Pu or ^{235}U, in powder or sintered oxide pellet form with either single or double encapsulation. The most probable path of the released material, when encapsulation failure occurs, is from the experiment location to the reactor cell area. This is considered as a single-mode nonviolent failure; thus, credit is taken for the airborne material to be exhausted by the ventilation system through the high-efficiency particulate air (HEPA) filter bank and out the stack. The HEPA filter efficiency is assumed to be only 99%. The capsule containing 1 g of ^{239}Pu or equivalent amount of ^{235}U was assumed to have been irradiated for 1 day in a thermal neutron flux of 10^{12} n/cm^2-s. To obtain site boundary conditions, type F meteorlogical conditions with a wind speed at 1 m/s were used. The total release was assumed to be distributed uniformly over a period of 2 hours following the failure. The assigned release fractions of plutonium fuel and fission products are given in Table 14.1.

In the unlikely event that the MHA was accompanied by an electrical power failure, the reactor facility would be evacuated and all doors would be closed until power was restored and the ventilation system was again exhausting through the HEPA filter bank.

Table 14.1 Assigned release fractions

Release	Powder (%)	Pellet (%)
From capsule to reactor cell		
^{239}Pu or ^{235}U	100	0
Noble gases	100	100
Iodine	100	25
All remaining fission products	100	0
From reactor cell to stack		
^{239}Pu or ^{235}U	1	1
Noble gases	100	100
Iodine	100	100
All remaining fission products	1	1

Using the data in Table 14.1 for input to the DOSE77 computer code, the licensee calculated organ doses for boundary and restricted area exposures (Table 14.2). The calculated doses are less than 10 CFR 20 guideline values. The licensee also determined limits on experimental materials so that the total accumulated radiation dose from the amounts of ^{239}Pu and ^{235}U that could be irradiated at any one time (Table 14.3) would not result in doses in excess of 0.5 rem whole body or 1.5 rem thyroid to a person in an unrestricted area continuously exposed for 2 hours.

Table 14.2 Organ dose summaries for boundary and restricted area exposures for GE-NTR experiment isotopes[a]

	Soluble Isotopes 50-Year Organ Dose (Rem)[b]			
	Pellet-form Capsule		Powder-form Capsule	
Organ	Boundary (MFP[c] Only)	At Stack (MFP Only)	Boundary (MFP+^{239}Pu)[d]	At Stack (MFP+^{239}Pu)[d]
Total Body				
Inhalation	2.92×10^{-4}	1.17×10^{-2}	3.59×10^{-2}	1.45
Submersion	4.54×10^{-3}	2.41×10^{-1}	9.89×10^{-3}	4.72×10^{-1}
Kidneys	1.44×10^{-3}	5.85×10^{-2}	1.53×10^{-1}	6.19
Liver	8.63×10^{-4}	3.50×10^{-2}	4.77×10^{-1}	1.93×10^{-1}
Bone	4.37×10^{-4}	1.76×10^{-2}	7.4×10^{-1}	3.00×10^{-1}
Lung[a]	3.54×10^{-3}	1.40×10^{-1}	2.55×10^{-1}	1.03×10^{-1}
Thyroid	1.61×10^{-1}	6.58	6.47×10^{-1}	2.63×10^{-1}
Stomach	5.84×10^{-4}	2.47×10^{-2}	2.39×10^{-3}	1.012×10^{-1}
Small Intestine[b]	2.62×10^{-4}	1.10×10^{-2}	1.37×10^{-3}	5.72×10^{-2}
Upper Large Intestine[b]	1.02×10^{-4}	4.15×10^{-3}	9.27×10^{-4}	3.77×10^{-2}
Lower Large Intestine[b]	2.16×10^{-4}	8.77×10^{-3}	2.18×10^{-3}	8.81×10^{-2}
Skin, Submersion	7.59×10^{-3}	4.74×10^{-1}	1.54×10^{-2}	8.13×10^{-1}

[a] (1g ^{239}Pu[d], Experiment Fission Power = 60 W, Irradiation Time = 24 h)

[b] Most organ doses are calculated for soluble forms of the isotopes; the lung, small intestine, upper large intestine, and lower large intestine doses are calculated for insoluble forms.

[c] MFP = mixed fission products.

[d] ^{239}Pu or equivalent ^{235}U.

Table 14.3 ^{239}Pu and ^{235}U experiment limits*

	^{239}Pu Limits		^{235}U Limits	
Capsule Form	Quantity	Power**	Quantity	Power**
Single-clad				
Solid Pellet	0.46 g	28 W	0.60 g	28 W
Powder	0.078 g	5 W	0.15 g	7 W
Double-clad				
Solid Pellet	4.6 g	280 W	6.0 g	280 W
Powder	0.78 g	50 W	1.5 g	70 W

*Assumes a 24-hour continuous irradiation at a thermal neutron flux of 1×10^{12} n/cm^2-s.
**Experiment fission thermal power.

The staff has reviewed the methodology and the DOSE77 computer program and concludes that there will be no adverse effects on the health and safety of the public. Moreover, any radiation dose obtained as a result of a worst-case experiment failure of the type described would be within allowed limits.

14.2 Pyrotechnic or Explosive Device Accident

Some experimental programs at the GE-NTR facility involve neutron radiography of fissile or explosive materials. The licensee has analyzed potential accidents involving such materials and has established criteria for activities involving either fissile or explosive materials. The various criteria and their bases are discussed below.

The licensee's Technical Specifications permit experimental activities, primarily neutron radiography, involving pyrotechnic and explosive materials in the form of finished or test sample devices only. An in-depth analysis of the consequences of accidental explosions at the GE-NTR facility is presented in the SAR (NEDO-12727). This analysis was used to establish limits on distance from specific points and/or equivalent TNT (alpha-trinitrotoluene) mass for the south cell, north room, and setup room (Figure 14.1). An explosive storage magazine for storage of up to 10 lb of class A and B explosives with a total maximum of 100 lb, including Class C materials, is provided at a location that is separate from the GE-NTR facility (Building 105) as shown in Figure 3.1. The various weight and distance limits as well as other limitations on explosive materials irradiation are incorporated in Section 3.7 of the Technical Specifications and are summarized in Table 14.4 of this report. The staff has reviewed the computational procedures used by the licensee and concludes that they are appropriate, thus ensuring that the licensee's activities involving pyrotechnic and explosive devices do not represent a hazard to the facility, the staff, or the general public.

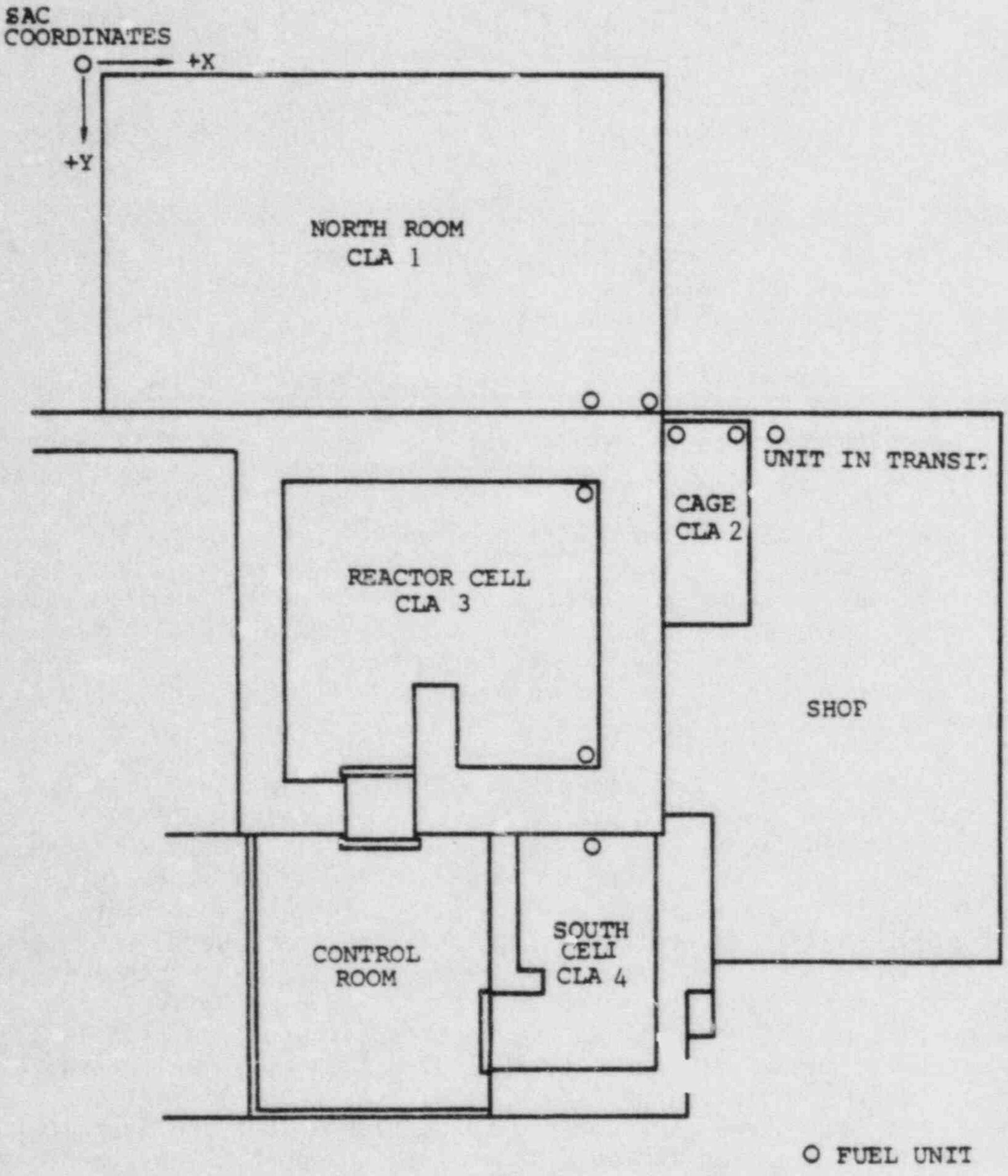

Figure 14.1 Criticality limit areas

Table 14.4 Explosive material limitations

Maximum cumulative radiation exposures		
Neutron	3×10^{12} n/cm^2	
Gamma	1×10^4 R	
Mass and distance limits*		
South cell	$W \leq (D/2)^2$	$W \leq 9$ lb, $D \geq 3$ ft
North Room		
Without MSM	$W \leq D^2$	$W \leq 16$ lb, $D \geq 1$ ft
With MSM	$W \leq 2$ lb	
Setup Room	$W \leq 25$ lb	
where	W = TNT equivalent mass, and D = distance from south cell blast wall or north room wall	
Radioactivity and Fissile Material		
10 Ci maximum and ≤ 50 g of uranium may be in storage in the South Cell or the North Room when explosive materials are present provided the storage location is ≥ 5 ft from explosive material. No radioactive materials are allowed in setup room other than those produced by the neutron radiograph exposure when explosive materials are present.		
High-frequency Generating Equipment		
Must not be operated <50 ft from explosive device.		

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*An assembly or accumulation of fissile material is one wherein the parts are separated from each other by less than 12 in.

14.3 Criticality Accidents in Storage Areas

The licensee's Technical Specifications permit the handling and storage of fissile materials in four criticality limit areas (CLAs) (Figure 14.1) and establish criticality limits for such materials in those areas that have $k_{eff} \leq 0.9$ under conditions of optimum moderation and full reflection by light water. These limits apply to all special nuclear material (SNM) at the GE-NTR facility with the exception of SNM in the reactor core. The licensee's criticality analysis specifies limits for ^{235}U, enriched uranium with enrichments <93.5%; uranium dioxide with ^{235}U enrichment >5%; and plutonium containing >5 wt % ^{240}Pu. Three calculational methods were used in the criticality analysis. Hand calculations were used to estimate the minimum critical mass for fissile accumulations (a single item or group of fissile materials). The KENO-IV Monte Carlo Criticality Code was used to calculate those fissile accumulations. The solid angle method was used to specify safe parameters for an array of accumulations (assemblies)* of fissile materials.

These methods have been used to develop the criticality limits in the Technical Specifications. Compliance with these limits ensures that SNM accumulations, assemblies, and arrays can be stored, used, or handled in the CLAs so that inadvertant criticality will not occur. The Technical Specifications define specific k_{eff} and solid angle criteria that must not be exceeded, computational techniques, and restrictions and specify that the two-contingency criterion is to be used in evaluating the subcriticality of individual accumulations and arrays of fissile materials. The critical analysis and the derived criticality limits are presented in depth in both the SAR and the Technical Specifications. The staff has reviewed the computation methods used by the licensee and concludes that they are appropriate and were properly applied. The staff finds that the criticality limits contained in the Technical Specifications are conservative and provide assurance that the licensee's activities involving SNM external to the reactor core will not lead to an inadvertant nuclear excursion.

14.4 Loss of Primary Coolant Flow

The worst loss-of-flow accident assumes the instantaneous seizure of the rotor in the single recirculation pump in the primary system. It is assumed that the reactor is operating at 100 kW and that the low-flow scram does not function to terminate the transient. After the flow has decreased to the natural circulation rate (within 1 s), the coolant temperature and the natural circulation flow rate will increase until (1) bulk boiling at the hot spot produces enough voids to stop the power rise through reactivity feedbacks or (2) the average coolant temperature rises sufficiently to allow the negative temperature coefficient to halt the power rise. As the coolant temperature increases, the excess reactivity also increases until the turnaround temperature of 124 °F is reached, at which point the temperature coefficient becomes negative. The peak reactor power reached is 101.2 kW, and the maximum fuel temperature reached during the transient is 238 °F, which is well below the melting point of the fuel of 1,058 °F (670 °C). The transient is terminated by bulk boiling at the hot spot. At equilibrium, reactor power is 16 kW, reached at 160 s, following the incident initiation, with a maximum temperature of 226°F.

14.5 Loss of Primary Coolant

For a loss-of-coolant accident, it is postulated that the primary system ruptures at some point below the core entrance so that all water is lost rapidly, which shuts down the reactor. The only mechanism considered for decay heat removal is radiation heat transfer from the core to the graphite. The initial power level of the reactor is assumed to be 100 kW. The licensee, using the transient heat transfer (THT) computer program, calculated the resulting maximum fuel temperature to be 620 °F (assuming a peaking factor of

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*The licensee defines an assembly as an array of accumulations of fissile material where the accumulations are separated from each other by less than 12 in.

1.58). The staff has compared these results with those for an Argonaut core with a graphite moderator-reflector operating at 100 kW. For an intact core with no airflow, the calculated peak temperature in Argonaut fuel is 676 °F. (Cort, June 1981) These should be regarded as conservative upper limits because convective heat losses were ignored. Considering the similar analysis for an Argonaut reactor with the assumption of no airflow, the staff concludes that there is no danger of fuel or cladding melting in a loss-of-coolant accident at the GE-NTR.

14.6 Rapid Insertion of Reactivity (Nuclear Excursion)

In this scenario, an experiment involving the movable poisons or the safety sysem must fail to obtain a rapid insertion of reactivity (nuclear excursion). In either case, the licensee's Technical Specifications limit the potential excess reactivity to 0.532% Δk/k (0.76$). It is postulated that the support structures for the control and safety rod mechanism and experiments might fail or move during a seismic event in such a manner as to withdraw the control rods and experiments from the core region and prevent operation of the safety rods. Because of the testing that has been done on the latching mechanisms for the manual poison sheets (MPS), it is not considered credible that they would fail; thus, they will not move relative to the core during a seismic event. Thus, the above event yields a step insertion of 0.76$ (0.532% Δk/k). Assuming an initial power level of 100 kW, a calculated maximum power of 3.9 MW is reached at 2.3 s with a fuel temperature of 254 °F and an energy release of 7 MW-s. The transient is terminated by void formation before any fuel damage can occur.

If the initial power level is 1 x 10^{-7} kW (source level), for a 0.532% Δk/k (0.76$) insertion (including positive reactivity feedback from the temperature coefficient), maximum power of 4.2 MW is reached at 55 s, the energy release is 10.4 MW-s, and the maximum fuel temperature is 255 °F. The transient is terminated by void formation before any fuel damage occurs. Because these transients are relatively long (>40 s), essentially the same results are obtained if the excess reactivity is introduced in a ramp insertion.

Accidents were also analyzed for ramp insertions of reactivity with the reactor operating at 100 kW and the scram systems initiated at 150 kW. Calculations indicate that the maximum fuel temperature reached was approximately 400°F, well below the fuel melting temperature.

14.7 Core-Crushing Accident

For this accident scenario, it was assumed that in some unidentified way the reactor was crushed and the graphite pack was fractured to obtain a lower thermal conductivity and a loss of coolant. Using a 67% lower value for thermal conductivity for the graphite, the licensee analyzed this loss-of-coolant transient. Using the THT computer program, it was found that the peak fuel temperature would be 645°F (358°C), which is well below the melting points of the fuel cladding and fuel meat (670°C).

Compaction of the fuel would not cause the reactor to go critical because of the water loss, increased self-shielding in the fuel, and the geometry change as a result of flattening the cylindrical core. These are all negative reactivity effects. Therefore, regardless of the mechanical damage to the reactor or the reactor fuel, the staff concludes that there would be no danger of fuel melting.

14.8 Conclusion

The staff has reviewed the postulated accidents for the GE-NTR along with the methodology and computer programs that were used for analyzing the transients. The staff concludes that the methodology used provides conservative estimates of the important reactor parameters of maximum power, maximum fuel temperature, and energy release. On the basis of the above analyses, the staff concludes that no credible accidents or transients can occur that would result in the release of significant quantities of fission products to the unrestricted environment.

15 TECHNICAL SPECIFICATIONS

The licensee's Technical Specifications evaluated in this licensing action define certain features, characteristics, and conditions governing the continued operation of this facility. These Technical Specifications are explicitly included in the license renewal as Appendix A. Formats and contents acceptable to the NRC have been used in the development of these Technical Specifications and the staff has reviewed them using the ANS 15.1 1982 standard, "The Development of Technical Specifications for Research Reactors," as a guide. On the basis of its review, the staff concludes that normal plant operation within the limits of the Technical Specifications will not result in offsite radiation exposures in excess of 10 CFR 20 limits. Furthermore, the limiting conditions for operation and surveillance requirements will limit the likelihood of malfunctions and mitigate the consequences to the public of off-normal or accident events.

16 FINANCIAL QUALIFICATIONS

The GE Vallecitos Nuclear Center is part of the General Electric Company, which is a multi-billion dollar diversified corporation.

The staff reviewed the licensee's financial status and concludes that funds will be made available to support continued operations and, when necessary, to shut down the facility and maintain it in a safe shutdown condition. The licensee's financial status is in accordance with the requirements of 10 CFR 50.33(f)(ii). Therefore, the staff concludes that the licensee's financial qualifications are acceptable.

17 OTHER LICENSE CONSIDERATIONS

17.1 Prior Reactor Utilization

Although the staff has concluded that the reactor was initially designed and constructed with both inherent safety and engineered safety features, the staff reviewed the effects of 25 years of past operations and future operations at 100 kWt on the risk to health and safety of the public. Significant factors that minimize the effects of historical use follow:

(1) Use of the GE-NTR has averaged 2.5 MW-days per year, or about 30% of maximum one-shift operation for 260 days/year.

(2) Because of the low utilization factor, fuel is not expected to be replaced during the term of this license, so future fuel handling will be minimized.

(3) Full elements are inserted into the core via a chute during fuel relocation manipulations. Because of the low fuel utilization and unique design of the core and in-core fuel handling, no significant fuel or core damage has been identified in the past or is expected to occur.

(4) The GE-NTR facility personnel perform regular preventive and corrective maintenance and replace components, as necessary. There have been some random one-of-a-kind incidents and malfunctions of equipment. However, there is no indication of significant degradation of the instrumentation; furthermore, the GE-NTR facility procedures, calibration, testing, and preventive maintenance program would lead to adequate identification and replacement before significant degradation occurred.

(5) The Technical Specifications require periodic testing and/or calibration of components. For the reasons provided above, early identification of degrading parts will occur.

(6) When components fail, and reactor safety-related limit set points are reached, the reactor automatically scrams.

17.2 Corrosion

As stated in Section 5, the GE-NTR maintains its water at a high purity, which ensures minimum corrosion of the fuel cladding or other components in contact with the coolant. In addition, the Technical Specifications and the radiation alarm settings provide for early detection of any deficiencies in component performance or breach of cladding, respectively.

17.3 Conclusions

The staff concludes that there is adequate evidence that any future degradation will lead to early detection and prompt remedial action by the GE-NTR staff, and there is reasonable assurance that there will be no significant increase in the likelihood of occurrence of a reactor accident as a result of component malfunction resulting from previous use.

Following the above considerations, the staff also concludes that there are no other credible events that could produce effects greater than those already analyzed in Section 14.

18 CONCLUSIONS

Based on evaluation of the application as set forth above, the staff has determined that

(1) The application for renewal of Operating License R-33 for the GE-NTR, dated June 13, 1979, as amended, complies with the requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's regulations set forth in 10 CFR Chapter I.

(2) The facility will operate in conformity with the application as amended, the provisions of the Act, and the rules and regulations of the Commission.

(3) There is reasonable assurance (a) that the activities authorized by the operating license can be conducted without endangering the health and safety of the public and (b) that such activities will be conducted in compliance with the regulations of the Commission set forth in 10 CFR Chapter I.

(4) The licensee is technically and financially qualified to engage in the activities authorized by the license in accordance with the regulations of the Commission set forth in 10 CFR Chapter I.

(5) The renewal of this license will not be inimical to the common defense and security nor to the health and safety of the public.

19 REFERENCES

American National Standards Institute/American Nuclear Society (ANSI/ANS), 15 Series.

---, ANSI/ANS 15.11, "Radiological Control at Research Reactor Facilities," 1977.

American Nuclear Society (ANS), 15.1, "Standard for the Development of Technical Specifications for Research Reactors," Draft - May 1982.

---, ANS 15.16, "Standard for Emergency Planning for Research Reactors," Draft - 1978 and Draft 2 - November 29, 1981.

Code of Federal Regulations, Title 10, "Energy," U.S. Government Printing Office, Washington, D.C.

Cort, G. E., "Fuel Temperatures in an Argonaut Reactor Core Following a Hypothetical Design Basis Accident (DBA)," Los Alamos National Laboratory report LA-8917-MS, NUREG/CR-2198, June 1981.

General Electric Company Report, NEDO-12623, "Environmental Information Report for the General Electric Test Reactor," July 1976.

Rice, S,; Stephens, E.; and Real C.; "Geologic Evaluation of the General Electric Test Reactor Site Vallecitos, Alameda County, California," August, 1979.

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13. ABSTRACT *(200 words or less)*

This Safety Evaluation Report for the application filed by the General Electric Corporation for a renewal of operating license R-33 to continue to operate a research reactor has been prepared by the Office of Nuclear Reactor Regulation of the U.S. Nuclear Regulatory Commission. The facility is owned and operated by the General Electric Corporation and is located in Pleasanton, California. The staff concludes that the reactor facility can continue to be operated by GE without endangering the health and safety of the public.

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SER RELATED TO THE RENEWAL OF THE OPERATING LICENSE FOR THE GENERAL ELECTRIC-NUCLEAR TEST REACTOR (GE-NTR)

SEPTEMBER 1984