LOCKHEED-GEORGIA COMPANY
A Division of Lockheed Aircraft Corporation

LGD/168786

26 September 1963

RECEIVED SEP 27 1963

SUBJECT: TECHNICAL SPECIFICATIONS FOR RADIATION EFFECTS REACTOR, DOCKET NO. 50-172

TO: United States Atomic Energy Commission
Division of Licensing and Regulation
Licensing Branch
Washington 25, D. C.

Attention: Mr. Edson G. Case
Assistant Director for Facility Licensing

1. Attached hereto are the Technical Specifications for the Radiation Effects Reactor. The number of copies being submitted is in accordance with the requirements of 10 CFR 50.30. Attached also are 50 additional copies per request of the Division of Licensing and Regulation.

Very truly yours

C. F. Wagner
Vice President
Lockheed-Georgia Company

C. F. WAGNER, under oath, states that the above and attached statements are true to the best of his knowledge and belief.

Subscribed and sworn to before me this 26th day of September 1963 at Marietta, Georgia.

Gertrude B. [illegible]

Notary Public
My Commission Expires [illegible]

CFW:bc

9202260228
3880
A-8

9202260228 910725
PDR FOIA
SWEENEY91-233 PDR

8545

LAC ltr to AEC, dated 16 September 1963, Subj: Technical Specifications for Radiation Effects Reactor, Docket No. 50-172, LCD/16766

Attachments:

Technical Specifications for Radiation Effects Reactor, dated 17 September 1963.

cc: Col. Jack F. Harris
District Engineer
Corps of Engineers
Savannah, Georgia

DISTRIBUTION:

J. I. Bell
C. T. Childs
W. H. Cone
V. W. Cowden
M. M. Egan
J. C. Flack
J. M. Hare
F. A. Stevens
W. P. Walker
B. D. Dodd
C. I. West
Central Files
Reactor Safety Committee

Pat Burke/Washington

APPENDIX A

TO LICENSE NO. R-86

TECHNICAL SPECIFICATIONS

FOR THE

RADIATION EFFECTS REACTOR

17 September 1963

A-8a

A. SITE

1. PHYSICAL LOCATION

The reactor facility is located in Dawson County, Georgia, on a site which is nominally described by the parallels 34° 20.6 minutes north latitude and 34° 24 minutes north latitude, and the meridans 84° 08 minutes west longitude and 84° 12 minutes west longitude.

2. DESCRIPTION OF CONTROLLED AREA

The reactor is located within the Georgia Nuclear Laboratories, a controlled area of roughly 10,000 acres. The nearest uncontrolled areas are the South Perimeter Fence (8240 feet south), the East Perimeter Fence (9820 feet east) and the West Perimeter Fence (10020 feet west). The minimum distance to the North Perimeter Fence is 14285 feet. All land within that area is controlled by the Lockheed Plant Protection, and the nearest routinely occupied above-ground work area is about 8845 feet from the reactor. A chain link exclusion fence surrounds the reactor generally at a radius of 3600 feet. A segment of the fence North East of the reactor is slightly closer than 3600 feet.

3. EXCLUSION AREA ACCESS CONTROL

Access to the Georgia Nuclear Laboratories and to the gates in the 3600 foot chain link exclusion fence is controlled by Lockheed Plant Protection. Lockheed Plant Protection patrols the 3600 foot fence weekly. All personnel who enter or leave the area within the 3600 foot fence must be identified. The reactor must either be shutdown or immersed with at least 4 feet of pool water above the core center line while personnel are in transit between the operations building and the exclusion fence. Operation of the RER precludes all normal activities above-ground within the 3600 foot fence. Personnel may enter the area within the 3600 foot fence when the RER is operating if necessary in connection with special programs only when closely monitored and controlled by Reactor Operations and Nuclear Safety.

B. BUILDINGS

1. REACTOR BUILDING

The reactor building is of conventional construction with steel I-beam columns and built-up truss work. Siding and roofing are corrugated aluminum. The building is not heated; however, during periods when the ambient temperature is below freezing, the reactor will not be raised from the pool unless heat is provided to prevent auxiliary piping (e.g. shield tank plumbing system) from freezing. Roof mounted fans are provided to ventilate the building as necessary.

2. OPERATIONS BUILDING

The operations building is an underground concrete structure with approximately 2 feet of concrete and 5 feet of earth on the roof to provide shielding. Reactor and experimental system controls are located in this building, and during reactor operations, all personnel remain within the operations building except during shift change (see Section A-3) and when it is imperative to perform certain duties within the pedestrian tunnel when the reactor is operating. Doors to the operations building are electrically locked and controlled from the reactor console during reactor operations. A ventilation system is provided which maintains the operations building at positive pressure differential of at least 1 inch of water with respect to the atmosphere during reactor operations.

C. RADIATION MONITORING

1. GASEOUS AND PARTICULATE MONITOR

Two systems are located inside reactor operations building. One monitors airborne radioactive gaseous and particulate activity in the reactor operations building basement or main floor exhaust. The other is capable of sampling air at several locations outside the operations building at discretion of operator. Normally, exhaust air from reactor building is sampled:

Range:	10 to 10^6 counts/min (both instruments)
Gaseous Sensitivity:	The system as installed is capable of detecting a gaseous activity concentration of 2.9×10^{-6} uc/cc.
Particulate Sensitivity:	The system as installed is capable of detecting a particulate activity concentration of 7.0×10^{-9} uc/cc.
Alarms:	Procedurally set at twice background for operation at a given power level. Alarm-point is adjustable from 10 c/m to 10^6 c/m.
Automatic Devices:	Alarm sounds and reads out on reactor annunciator panel. Decision is then made by reactor shift supervisor and Health Physicist on duty as to required action as dictated by prevailing safety considerations.
Permissives:	If the gaseous and particulate systems in the operations building are not operating during reactor operations, the shift Health Physicist will make periodic surveys for presence of gaseous and airborne particulate matter.

2. LIQUID MONITORS

Grab samples of the primary coolant system and reactor pool water are collected routinely and analyzed for gross beta-gamma-alpha activity. A continuous fission products monitor is located on a bypass to the primary coolant loop which monitors for Iodine-135. If the rate of increase exceeds a factor of two (2) in fifteen minutes during level operation, the reactor is shutdown pending detailed investigation as to cause. In any event, the gross activity of the primary coolant loop will not exceed 1 x 10^{-2} uc/cc.

3. BUILDING MONITORS

Three gamma ionization chambers are located in the operations building. These instruments are the direct readout type. Range is 0.01 mr/hr to 100 mr/hr.

Alarms are adjustable over the entire range but are procedurally set at 7.5 mr/hr low level and 100 mr/hr high level. Alarms are sounded in the health physics-reactor operations area, Plant Protection Headquarters and the emergency readout room in addition to other administrative areas. Sounding of alarms is an indication of trouble and is investigated by the Emergency Organization. One of these instruments must be operable for reactor operations.

4. REMOTE AREA MONITOR SYSTEM

Approximate locations of the remote area monitoring system stations, and other information related thereto, are shown in the table describing the Remote Area Monitoring System stations. The stations which constitute reactor operating permissives are shown in the table entitled Minimum Remote Area Monitoring System.

REMOTE AREA MONITORING SYSTEM STATIONS

Station Number	Distance From RER	Direction From RER	Functions	Neutron & Gamma Detection Range	Part of Emergency Alarm System
1	3600'	S	A^{41*} & γ	0.1 to 10^4 mr/hr	Yes
2	3600'	SSW	A^{41*} & γ	0.1 to 10^4 mr/hr	Yes
4	3600'	SW	A^{41*} γ & N	0.1 to 10^4 mr/hr	Yes
6	3600'	W	A^{41*} & γ	0.1 to 10^4 mr/hr	Yes
7	3600'	NNW	γ	0.1 to 10^4 mr/hr	Yes
8	3400'	NNE	A^{41*} γ & N	0.1 to 10^4 mr/hr	Yes
9	3600'	ESE	A^{41*} & γ	0.1 to 10^4 mr/hr	Yes
13	11,000' (est)	W	A^{41*} & γ	0.01 to 10^4 mr/hr	No
16	11,000' (est)	E	A^{41*} & γ	0.01 to 10^4 mr/hr	No
17	In RER Bldg.	---	γ	0.1 to 10^4 mr/hr	Yes
18	725'	WSW	γ	0.1 to 10^4 mr/hr	No

*Assuming the worst background conditions, with the RER operating at 3 MW, the minimum change in the amount of A-41 that is practical to interpret is 3.7×10^{-6} uc/cc of air.

MINIMUM REMOTE AREA MONITORING SYSTEM

	Capability			
Basic Station	Argon	Gamma	Neutrons	Backup Station
1	x			9
2	x	x		6, 13
4			x	8
7		x		Passive Dosimetry
8	x	x		7, 16, Passive Dosimetry
9	x	x		16
18		x		Portable Monitoring Eqpt.
4	x	x		6, 13
1		x		9, 10

5. ENVIRONMENTAL MONITORS

Four water samplers are located in the Etowah River; one each upstream from the reactor at the 3600 foot fence and at the Perimeter Fence; and one each downstream at the 3600 foot fence and at the Perimeter Fence. Samples are collected on a weekly basis and are analyzed for gross beta-gamma-alpha activity.

In addition to the remote area monitoring system, continuous particulate air samplers are located at several strategic points on-site as shown by the following table. Filter samples are collected weekly and analyzed for gross beta-gamma alpha activity.

AIR SAMPLER LOCATIONS

	Direction From RER	Distance From RER
1. RER Demineralizer Building Entrance	SSE	140 feet
2. Pedestrian Tunnel Entrance	WSW	750 feet
3. CEF Meteorology Tower	SE	1.6 miles
4. REL Hot Cell Entrance	SE	1.6 miles
5. Post III (RER Air Intake)	S	3600 feet
6. RER Building (VASS System)	Directly over Reactor	30-40 feet
7. Operations Building VASS		

Soil and vegetation samples are collected on a quarterly basis and analyzed for gross beta-gamma-alpha activity.

D. WASTE DISPOSAL SYSTEM

The REF waste disposal system is designed to handle activation products generated by RER operation. Features incorporated in the design include demineralizer resin beds with decontamination factors of 10^3 to 10^4; two 5000 gallon waste decay tanks for retention of waste water with high radioactivity concentrations; and one 150,000 gallon hold and drain tank which may be used for decay and dilution of activity prior to release to the seepage basin.

The activity levels of radioactive waste released to the seepage basin will not exceed limits specified in 10 CFR 20 for restricted areas. The total annual release will not exceed 1 curie.

Radioactive waste materials will not be permanently disposed of by burial at the site except as provided by 10 CFR 20.304.

E. EMERGENCY SYSTEMS

1. EMERGENCY COOLING SYSTEM

a. A gravity-feed emergency cooling system automatically provides coolant through the core at an initial flow rate of approximately 800 gpm if any of the following conditions exist:

(1) Primary coolant flow below .8 normal.

(2) Loss of instrument air

(3) Loss of primary pump if standby pump fails to re-establish normal flow within 5 seconds.

(4) Loss of electrical power

Any of the above conditions will also cause the reactor to scram.

b. The emergency cooling system consists of the following components:

(1) A 100,000 gallon storage tank - located at a mean elevation of 36 feet above the reactor core (reactor in elevated configuration) and approximately 340 feet from the reactor.

(2) A 150,000 gallon drain and hold tank - located 18 feet below the reactor core and approximately 170 feet from the reactor. This tank receives and stores the emergency coolant after it has passed thru the core.

(3) One each manual isolation valve in the supply and drain lines.

(4) One fail-open air-operated flow control valve in the supply line.

(5) Two parallel check valves in the supply line to prevent flow from the primary loop to the storage tank.

(6) Two fail-open air operated electrically controlled dump valves in the drain line.

Emergency flow is initiated when the dump valves are opened from one of the conditions listed in 1.a above.

c. Permissives

(1) Scram reset permissives - the manual isolation valves and the air-operated remote flow control valve must be full open to reset the scram relays.

(2) Procedural permissives

(a) Storage tank must contain at least 80,000 gallons.

(b) Drain and hold tank must contain less than 50,000 gallons.

(c) Dump valves to remain closed at least 5 sec but no longer than 10 sec after the initiating condition exists.

2. EMERGENCY POWER SYSTEM

a. Normal power is supplied to the REF through an 11.9 KV line feeding from the 110 KV station located in the NSL area. In the event of failure of normal power, emergency power is furnished by a 400 KVA diesel-electric generator located in the basement of the operations building.

b. The emergency power supply system supplies power to the following components and systems which utilize no more than 80% of the capacity of the generator.

(1) All reactor control equipment and reactor instrumentation

(2) Emergency lighting

(3) Operations building heating, ventilation, and air conditioning.

(4) Primary and secondary cooling systems.

(5) Plant air compressor

(6) Reactor building doors

(7) Reactor building exhaust fans

(8) Reactor building crane

(9) Air monitoring system

(10) Car ejector pump

(11) Diesel generator support equipment

c. The reactor is not operated unless the generator is operable. The systems utilized in automatic operation of the generator are routinely checked to assure operability, and the diesel generator is started on a weekly basis.

F. FUEL STORAGE

Normally, new fuel elements and partially spent fuel elements are stored in fuel element storage racks in the bottom of the RER storage pool. The fuel element storage rack holds a maximum of twenty fuel elements in a 4 x 5 array. Control rods may fill two of the fuel element positions. The rack is constructed of aluminum, and contains layers of aluminum clad cadmium around the outside of the fuel plate region and between each tier of four fuel elements.

Except for the irradiated fuel element shipping cask, this rack is the only container used for storing fuel at the REF. The calculated U-235 loading required for the fuel elements in one fuel element storage rack to achieve criticality, assuming no leakage, is 211 gms per element. When leakage is assumed from the sides only, a full rack of 211 gm elements would have a calculated multiplication constant of 0.78.

A maximum of four core loadings will be stored. A core loading will consist of a maximum of 33 fuel elements and four control rods.

During transfer of fuel elements to and from the fuel element storage racks, procedural control will restrict movement to one element at a time. Procedural control will also limit placement of fuel elements outside the racks to nuclearly safe locations and configurations in order to preclude the assembly of potentially critical arrays.

The irradiated fuel is removed from the pool in a shielded cask.

G. REACTOR SHIELD TANKS

The reactor vessel is surrounded by segmented shield tanks approximately twenty inches thick except for the removable quadrant. The tank compartments can be remotely filled and drained with demineralized water selectively. Response of the various nuclear detectors within the tanks will be ascertained experimentally, and the effect of filling and draining the shield tanks during routine operation will be determined in advance. Normally the tanks containing the nuclear instrumentation will be filled; any indication that such is not the case will cause an annunciation, and the reactor will be shut down.

E. REACTOR DESIGN

1. LOCATION

The vertical center line of the reactor is located approximately 4'6" from the NE end of the reactor pool. The pool is rectangular and is 11-1/2 ' by 19' by 36-1/2' deep. There is also a storage pool which joins the reactor pool at the SW end. An aluminum gate is provided for separation of the pools. In plan view, the storage section resembles an un-symmetrical letter T. Rough dimensions are stem, 17' by 8'; cross, 24' by 6'. The depth of both of these parts is 21' below the finished reactor building floor. Curbing for both pools is continuous and extends one foot above the finished floor.

2. MECHANICAL DESIGN OF THE RER PRESSURE VESSEL

The RER stainless steel pressure vessel is designed for 150 psig at 200°F. The minimum design and construction requirements of the vessel conform to the ASME Boiler and Pressure Vessel Code, Section VIII, 1956 Edition, and the vessel bears the official code stamp. The pressure vessel is supported by two steel bands welded to four equally spaced vertical members which rest on bearing plates bolted to the platform, which in turn rests on top of the hydraulic lift. The reactor Support System has been designed to support a one-fourth G side load on the reactor and shield tank.

The design loading of the hydraulic lift is 42,000 pounds, and it is designed for a total moment of 16,500 foot-pounds from eccentric loading and other causes. The lift has a stroke of 30 feet and is capable of raising the reactor at a maximum speed of 10 feet per minute. Shoes which slide on T-rails fastened to the pool walls guide the upper end of the ram through its full travel and restrain the top of the reactor to within one inch of its nominal path.

Two parallel bleed lines, controlled by individual solenoids which fail open on loss of power or on improper operation of the safety doors in the operations building, are used to lower the reactor.

The reactor upper closure is a flat, circular, forged plate 3 feet 9 inches in diameter and 5 inches thick. This closure is equipped with holes to accommodate the control rods, the regulating rod, and the fission chamber. It can be removed to provide access to the internals of the pressure vessel.

In addition to the opening closed by the reactor upper closure, the pressure vessel has four penetrations above the core, consisting of 6-inch instrument ports. Below the top of the core, only four penetrations exist. These are four 8-inch pipes which serve as two primary coolant inlets and two primary coolant outlets. No new penetration will be added to the pressure vessel or reactor closure.

3. RER VESSEL INTERNAL STRUCTURE

Internally the vessel consists principally of the inner tank, the hold-down plate, and the core support structure. The inner tank, which is open at the bottom and top, and otherwise has no penetration, serves as a flow guide. The hold-down plate, located above the core, covers the entire core section. Since flow through the core is down, the hydraulic loading of the hold-down plate is not a factor. If the reactor should be inverted, the maximum loading on the hold-down plate would be less than 10,000 psi. The yield stress for the hold-down plate is 32,000 psi at 200°F.

The core support structure consists of a grid plate to position the various core components, a support plate which retains fuel elements, reflector elements and the start-up source within the core and a control rod shock damper which consists of a amin cone, individual shock absorber tubes, and associated structural members. Its function is to transmit the shock load which the control rods impart subsequent to scram to the pressure vessel wall. As a backup to the shock damper, a mechanical stop is welded to the bottom of the pressure vessel.

The entire core structure is supported by a ring welded to the pressure vessel wall. The design criteria on stress for these structures are a maximum stress of 7200 psi on the core support barcket, 2440 psi maximum stress on the support plate, 14,500 psi maximum stress on the grid plate, and 5600 psi on the cone. The yield stress for all of these components is in excess of 25,000 psi.

4. CONTROL SYSTEM AND OPERATING LIMITATIONS

a. Control Rod Design

The control rods are fuel and poison sections enclosed by aluminum tubes approximately 3" square by 85" long. Each has a grapple head at the top and a spring-loaded tip plunger at the bottom. The fuel section contains an aluminum strap extension at the top which extends the length of the poison section. The poison section, a square aluminum tube, slides onto the strap and fits flush against the top of the fuel element assembly. The entire fuel-poison assembly fits into the control rod tube. A mechanical attachment on the fuel-poison section prevents assembly of the control rod if the fuel-poison section is inverted. The control rod is guided and supported within the core by means of four rollers above the core and four rollers below the core. The lower end of the control rod fits within a scram guide tube, which also acts as the hydraulic damper during scram. The poison section is a square cadmium tube, 0.02 inch thick and 32-1/4 inches long. It is clad with a 0.02-inch layer of aluminum on each side so that all edges are sealed. The length provides approximately 4-1/2 inches overlap at each end of the active fuel plates in the reactor core.

The fuel section, which contains about 111 grams of highly enriched U-235, is similar to a standard fuel element; however, it is smaller and contains 14 plates. A mechanical stop at the bottom, and the affixed poison, position the fuel section within the control rod.

The upper end of the control rod tube is fitted with a lifting knob, with which the control drive grapple engages by electro-magnet actuation, for lifting the control rod.

The core regulating rod is located near the periphery of the core. The regulating rod poison is a 30-70 cadmium silver alloy material. The tubular poison section, which has a nominal thickness of 0.09 inch, is enclosed in a tubular aluminum sheath approximately 1-1/4 inches in diameter.

b. Drive Mechanisms

The four control rods are actuated by separate mechanisms, mounted to the top head of the pressure vessel. Each control rod drive mechanism consists of an electric motor, reduction unit, a rack and pinion, limit switches, an electro-magnet and grapple, a spring loaded scram tube which provides an initial 5-g accelerating force to the rods when the grapple is released. The maximum drive speed is 4.5 inches per minute.

Magnets in the control rod and a limit switch in the hold-down plate indicate by an electric signal the position of the rod when fully scrammed as well as engagement of the rod by the mechanism. A selsyn, mounted on the gear reduction casting, gives a continuous position indication of the drive and also an indication of rod position during normal reactor operations.

The regulating rod drive mechanism, mounted to the top head of the vessel, serves to drive the regulating rod. The mechanism and rod are bolted together so that the combination is an integral unit. The regulating rod drive mechanism is very similar to the control rod drive mechanism; but no scram attachment is provided. The drive motor is designed to operate with a servo control system or under manual control.

c. Operating Limitations

(1) The minimum number of control elements in the core shall be four in addition to one regulating rod.

(2) Electronic scram time will be ≤35 milliseconds. This time will be the interval from initiation of signal to magnet release. It includes amplifier rise time and magnet flux decay time.

(3) Scram time will be less than 650 milliseconds. This time will be the interval from initiation of a signal to rod seated.

(4) Collective withdrawal of control rods will be limited by interlock to the regulating rod and one control rod. The maximum reactivity insertion rate shall not exceed 0.0008 $\Delta k/k$ per second.

(5) The minimum shutdown control margin shall be 0.12 $\Delta k/k$. The core loading shall be such that under no circumstances can the reactor go critical on withdrawal of only one rod.

(6) The maximum excess reactivity above cold clean critical shall not exceed 0.050 $\Delta k/k$.

(7) Total rod worth shall be more than 0.160 $\Delta k/k$, and the worth of any individual rod will not deviate from the average of the rod worths by more than 0.005 $\Delta k/k$.

(8) Regulating rod worth shall not be greater than 0.006 $\Delta k/k$.

(9) During core loading operations, the four control rods will be the first core components loaded, and will be the last core components removed on unloading.

5. CORE OPERATING LIMITATIONS

a. The core, which has an active height of 24 inches, is designed on a 3-inch modulus in a 6 x 7 array with the four corner positions omitted. The moderator and coolant are light water. The reflector may be light water, or may be solid or canned aluminum or beryllium designed to conform to the unused spaces in the grid and external to the grid but within the inner tank.

b. Fuel material is uranium-aluminum alloy. The enrichment of the fuel is nominally 93% U-235. Cladding is metallurgically bonded 1100 aluminum. The fuel elements are flat plate, modified MTR type, aluminum-uranium assemblies. Each element contains 18 fuel

plates having the approximate dimensions 0.060 inch thick, 2.75 inches wide, and 24.5 inches long. Each fuel plate consists of a nominal 0.020 inch thickness of uranium-aluminum alloy in a picture frame clad with a nominal 0.020 inch thick layer of 1100 aluminum. The plates are positioned in the element by aluminum side plates so that a nominal 0.108 inch wide coolant passage is provided between fuel plates. Each element is loaded with approximately 176 gms U-235. The top end of each element has a handling device. The bottom of each element is equipped with a positioning box about 3 inches square which fits into the grid. The overall length of a fuel element is nominally 38.5 inches.

c. The start-up source is an antimony gamma emitter, placed in the center of a beryllium dummy fuel element, and is positioned in one of the available spare fuel element positions in the grid plate. At minimum strength, the source will provide a neutron flux of at least 15 nv at the fission chamber location.

d. Fuel content verification and other core parameter determinations will normally be conducted at the CER. The following limitations will apply, however:

   (1) The maximum number of fuel elements in the core shall not exceed 33.

   (2) The maximum U-235 content of the core shall not exceed 6.2 kg.

   (3) The core may operate with some central element positions which do not contain fuel elements. Such positions shall contain either dummy elements or the source element.

   (4) As soon as the CER is licensed, it will be utilized to verify that any core utilized in the RER will have a negative temperature and void coefficient of reactivity. The RER will be used to determine temperature coefficient of reactivity for cores loaded prior to licensing of the CER.

   (5) The maximum power level shall not exceed 3 megawatts thermal.

   (6) The maximum permissible heat flux shall not exceed 2.39×10^5 Btu/hr-ft^3.

I. NUCLEAR AND PROCESS INSTRUMENTATION

1. DETECTOR LOCATIONS

Nuclear instrument detectors with the exception of the two fission chambers are mounted in three quadrants of the upper shield tank. The shield tank mounted detectors are located approximately 24" from the vertical center line of the core and approximately 30" above the horizontal center line.

The internal fission counter is mounted on a drive similar to the regulating rod drive. The detector is positioned immediately above the core during reactor start-up. The detector may subsequently be withdrawn.

The external fission counter is mounted in the removable tank section approximately six inches outside the pressure vessel at the core center line.

2. AUTOMATIC CONTROL SYSTEM

a. Description

The servo system consists of two compensated ion chambers, two micromicroammeters, a servo amplifier, and power demand control. A recorder permanently records the output of both micromicroammeters. Only one compensated ion chamber and micromicroammeter is utilized; the second set is duplicate channel, and either channel may be selected. When in use, the servo amplifier drives the regulating rod in the direction necessary to cause the micromicroammeter output signal to nullify the signal set by the power demand control circuit. The channel selector switch, servo power demand control, and automatic-manual selector switch are located on the console.

b. Permissives and alarms

(1) The regulating rod control cannot be put in the automatic mode unless:

(a) The relay scram circuit is reset

(b) The regulating rod is in the most reactive position.

(2) The regulating rod withdrawal speed shall not exceed 45 inches per minute regardless of the magnitude of the servo error signal.

3. NUCLEAR INSTRUMENTATION

Channel Designation	No. of Channels Each	Type	Detector Flux Range	Sensitivity
Start-up	2	Fission Chamber	2.5 to 2.5×10^5 nv	.7 Cps/nv
Log N	1	C I C	5×10^2 to 10^{11} nv	2.2×10^{-14} Amp/nv
Linear Power	2	C I C	5×10^2 to 10^{11} nv	2.2×10^{-14} Amp/nv
Safety	3	I C	5×10^4 to 10^{11} nv	2.2×10^{-14} Amp/nv
Gamma	1	γ I C	1 to 5×10^7 R/hr	2.2×10^{-11} Amps/R/hr

4. MINIMUM INSTRUMENTATION CHANNELS

Channel	Channels Provided For: Normal Operation	Channels Provided For: Reactor Shutdown	Minimum Instrumentation: Startup	Minimum Instrumentation: Routine Operation	Minimum Instrumentation: Loading
Start-up	2	0	1	0	1
Linear Power	2	0	0	0	1
Log N	1	0	1	1	0
Safety	3	0	2	2	0
Gamma	1	0	0	0	1
P.C. Flow	1	1	1	1	0
P.C. Temp.	1	1	1	1	0
P.C. Pressure	1	0	1	1	0
By-pass Dem.	1	1	0	0	0
Pool Dem.	1	1	0	0	1
Conductivity	1	1	0	0	1
F.P. Monitor	1	0	0	0	0
System Temp.	1	0	0	0	0

5. SETTINGS FOR INTERLOCKS, PERMISSIVES, ALARMS, AND SCRAMS

a. Alarms, Scrams, and Permissives

Component Or System	Alarm	Interlock and Permissive	Scram
LCRM		Rod withdrawal interlock; less than 3 cps and greater than 6500 cps	
Log N		Recorder: By-pass LCRM 6500 cps interlock at greater than .01	
Period	"Fast Period" from recorder and sigma amplifier less than 10 sec.	Recorder: Rod withdrawal interlock less than 10 sec.	Recorder: Relay scram less than 5.5 sec. Fast scram ≤ 3 sec.
Linear Power	"Linear Power greater than 60Δ full scale" from recorder		Relay scram recorder greater than 95% full scale.
Trouble Monitor	"Instrument Trouble" for an abnormal light from any sigma amplifier	Clear trouble to reset from relay	Relay scram for abnormal lights from two or more sigma amplifiers or Log N amplifier cal. sw. on ground
Safety Channels	"Neutron Flux High" greater than 1.1 normal		Relay scram at greater than 1.2 normal Fast scram at greater than 1.5 normal

a. Alarms, Scrams, and Permissives (Continued)

Component Or System	Alarm	Interlock And Permissive	Scram
P. C. Temperature	"P. C. Temperature High" recorder sw: Inlet: greater than 120°. Outlet: greater than 126°.		Relay scram recorder sw: Inlet: greater than 130° Outlets: greater than 136°
P. C. Pressure	"P. C. Pressure-Low" recorder. sw: Inlet: less than 126 psi Outlet: less than 90 psi	Isolates pressurizer at $\leq$ 0.8N	Relay scram recorder sw: Outlet: less than 80 psi Inlet: less than 112 psi
P. C. Flow	"P. C. Flow-Low" recorder. sw: At less than .9 normal	Opens dump valves at $\leq$ 0.8N	Relay scram recorder sw or backup sw at less than .8 normal
Emergency Coolant Flow Valves R116, R191, R192	"Graphic Panel Trouble" when closed	Valves open to reset scram	
Equipment Tank	"Leak, Equipment Tank" Float at 3"		Relay scram float at greater than 6"
Preamp Enclosure	"Leak, Preamp Tank" Float at 1.4"		Relay scram at 1.4"
Set-up and Oper. Sw.		Sw in "operate" position to reset scram	
Motor-Generator			Relay scram at less than .9 normal voltage

a. Alarms, Scrams, and Permissives (Continued)

Component Or System	Alarm	Interlock and Permissive	Scram
Safety Doors	"Safety Door Lock Open" any door not closed and locked		Relay scram for any door opened improperly
Servo	"Reg Rod in Limit" Reg Rod at 0" and 18" when in automatic	Permissive to switch Reg Rod to auto at 18"	
Relay Scram Circuit	"Relay Scram" Circuit De-energized	Reset Pushbutton to energize relay scram circuit	Push "Scram" switch to de-energize relay scram circuit
Dump Valves	"Dump" when valves begin to open	De-energizes P. C. pumps during emergency dump	
Lift Reservoir Level	"Lift Reservoir Level Low"	Opens reactor lift raise circuit	

b. Annunciation Only

Annunciator	Actuator
Fission Products	Recorder Sw greater than 90% full scale
System Temperature	Recorder Sw greater than 130°
Primary Equip. Pit. Sump-High	Float Sw in P. E. Sump Pit
Fission Products Sump-High	Float Sw in F. P. Detector sump remote station
Clean-up and Waste Pit Sump-High	Float Sw in Clean-up & Waste Pit Sump
Operations Building Sump-High	Float Sw in Operations Building Sump Pit

b. Annunciation Only (Continued)

Annunciator	Actuator
Continuous Particulate Activity-High	VASS - greater than 2 x normal background
Continuous Gaseous Activity-High	VASS - greater than 2 x normal background
Intermittent Particulate Activity-High	VASS - greater than 2 x normal background
Intermittent Gaseous Activity-High	VASS - greater than 2 x normal background
Graphic Panel	Trouble light from:
	Shield tank window level - abnormal
	Demi. storage tank-high or low
	Pressurizer - water level high or low
	Hold and drain tank - high or low
	Cooling tower - low or empty
	Main loop pump #1 or #2 - motor overload
	Decay tank, #F3 or #F4 - high
	Secondary coolant pressure low
	Pool demineralizer flow - low
	Disposal pump discharge pressure - low
	Make-up pump motor - overheat
	Pool - circ. pump motor - overheat
	Loss of control air
	Emergency coolant flow valves, R116, R192, R191 - closed
Emergency Power	Diesel Generator Control Sw in "Off" position
Ventilation System - Operations Bldg.	Less than 1" Water differential
Ejector Accumulator	Pressure Low

J. EXPERIMENTAL FACILITIES

1. EXPERIMENT LOCATIONS

   a. Within pressure vessel

      In-core experiments will be limited to experimentation on reactor instrumentation, calibration, foil exposures, and reactor checkout tests.

      In-reflector experiments will be limited to very small subsystems, components, materials, instrumentation, core rearrangements, and reactor checkout tests.

   b. External to pressure vessel

      Experiments conducted external to pressure vessel may include irradiation of major assemblies, systems, subsystems, components, materials, animal, biological systems, instrumentation, and safety experiments.

2. EXPERIMENT LIMITATIONS

   a. Within pressure vessel

      No experiment will be conducted in the core except irradiation of foils and sub-miniature detectors. In-reflector experiments shall be rigidly fixed to ensure positively that no movement of the experiment will occur during reactor operation. Any such experiment shall not contain moving parts or components other than relays or switches. No experiment which contains more than trace quantities of liquids or solids which are in chemically active states shall be inserted into the core or reflector. Movable parts and/or evacuated spaces shall not introduce more than 0.0002 $\Delta k/k$. The total worth of any experiment in the reflector region shall not exceed 0.001 $\Delta k/k$, and the combined worth of all experiments in the reflector shall not exceed 0.005 $\Delta k/k$.

   b. External to pressure vessel

      (1) Experiments may be physically mounted on test cars and reactor building structure in such a configuration as to provide a minimum clearance of at least 2 inches between the reactor structure and the experiment.

      (2) Any experiment which contains moving equipment having significant kinetic energy shall have a blast shield located between the moving equipment and the reactor. Such blast shields shall be capable of absorbing the kinetic energy from the moving equipment or fragment thereof.

(3) Test cars will not be moved in the vicinity of the reactor building by means of a locomotive unless the reactor is lowered into the pool. Test cars and experiments that overhang the reactor structure will be equipped with an interlock to stop elevation of the lift prior to contact.

(4) No locomotive will intentionally be brought into the exclusion area when the reactor is up and operating. A derail will be located just inside the exclusion area at the railroad gate. The derail will be kept locked in the derail configuration at all times except when the train is passing into or out of the exclusion area. The individual who locks the gate will always be required to lock the derail in the proper configuration before locking the gate and will be required to report that fact to reactor operations by radio at the time he locks the derail. Reactor operations will maintain a log of entry and exit of the locomotive from the exclusion fence and have each exit record the configuration of the derail when reported by the locomotive crew. The start-up procedure for the RER will include checking the entry and exit log to assure that the derail is in the proper configuration. In addition, during reactor operations the railroad switch at the cooling off area will be left in the configuration to route the locomotive from the main line into the cooling off area rather than to the RER.

c. Experiments with explosive potential

Experiments involving energetic fluids or materials may be irradiated without prior permission of AEC, Division of Licensing and Regulation, only if all the following conditions are met:

(1) Energetic fluids or materials are within a containment structure or behind a structure capable of absorbing any pressure wave or shock wave potentially capable of being generated by such materials.

(2) Such material shall be limited to such amounts that if the containment in (1) above were to fail, there would not be sufficient material present to generate shock or pressure waves capable of violating the integrity of the pressure vessel, its supporting structure, or the cooling lines. The configuration of such experiments shall be such that potential shock or pressure waves shall not be directed toward the reactor or such that potential missiles directed toward the reactor shall not contain sufficient kinetic energy to penetrate the pressure vessel.

(3) In no case, however, shall material having a potential of sudden release of chemical energy in excess of 0.1 lb. of

TNT be placed closer than one foot to the reactor pressure vessel. All amounts at other distances may be determined on the basis of R^2 geometric attenuation subject to the further limitation that the total potential lateral loading of the pressure vessel support structure shall not exceed the allowable design loading.

(4) The Lockheed Georgia Company Reactor Safety Committee unanimously concurs with the acceptability of the level of hazard involved. Any other experiment which contains energetic fluids or materials shall not be irradiated until a written description of the experiment and a hazards analysis has been submitted to the AEC, Division of Licensing and Regulation, for evaluation and written authorization has been obtained from the AEC as a change to these technical specifications.

K. REACTOR COOLANT SYSTEM

1. DESCRIPTION OF PRIMARY AND SECONDARY COOLING SYSTEM

The primary cooling system includes 8" and 12" stainless steel piping, pumps, a pressurizer, demineralizers, valves, and the primary heat exchangers. At normally rated conditions the system provides demineralized water coolant to the reactor at the rate of approximately 3200 gpm.

The primary system is housed in a pit adjacent to the reactor building, and two main underground pipe lines connect the primary pit to the reactor. These are rigid pipes with swivel and ball joints, which allow the reactor to move a vertical distance of 30 feet.

Heat removal is provided by two counter flow heat exchangers connected in series. These exchangers transfer heat from the primary to the secondary cooling system, which is connected to cooling towers.

From the heat exchangers, primary coolant flows to the intake side of the circulating pumps, which are connected in parallel, with one running and one on a standby basis. Each pump is powered by a 200-horsepower, splash proof, motor. The primary pump produces only enough head to maintain circulation, so a pressurizer is used to maintain system pressure. The pressurizer, which is connected into the reactor inlet line, maintains the desired pressure at the reactor outlet. If electric power fails, a valve separating the pressurizer from the primary system will close.

Two demineralizers are used to maintain purity in the primary coolant and the pool water. The demineralizers are manifolded so that either one may be used for primary coolant and the other for pool water, or both may be used together for either purpose.

All surface in contact with the primary coolant will be of aluminum and stainless steel with the exception of the pump casings and large valves. These items will be of cast iron or steel. There are two pressure relief valves installed in the primary cooling system to prevent overpressurizing.

2. PRIMARY COOLANT SYSTEM LIMITATIONS

a. Core inlet temperature shall not exceed 130°F

b. Core temperature rise shall not exceed 10°F at 3 MW

c. Coolant system pressure shall not exceed 150 psig

d. Core outlet pressure shall be greater than 90 psig

e. Normal coolant flow rate during reactor operation shall be 3200 gpm.

f. Core pressure drop shall not exceed 50 psig across points of detection (actual core pressure drop is less than 2 psig)

g. Coolant resistivity shall be greater than 500,000 ohms

h. Coolant pH shall be greater than 6.0 and less than 7.5

i. Radioactivity of coolant shall not exceed 1×10^{-2} uc/cc.

j. When the reactor upper closure is removed and the flange is below the surface, the pool water resistivity shall be greater than 500,000 ohms.

3. SECONDARY SYSTEM LIMITATIONS

a. Radioactivity shall not exceed 1×10^{-5} uc/cc

b. The primary system pressure in the heat exchanger shall be at least 30 psig greater than the secondary system pressure.

L. ADMINISTRATIVE AND PROCEDURAL SAFEGUARDS

1. ADMINISTRATIVE ORGANIZATION AND STAFFING

a. Organization

The organization which operates the RER is responsible exclusively for maintenance, calibration, operation and safety of the reactors at GNL including the reactor mechanical systems, reactor controls and instrumentation system, cooling system and associated controls, and other related systems. This organization is also responsible for procuring additional fuel elements as needed, and for safe storage of both unused and spent fuel elements. The organization has no experimental program responsibility, and operates more as a service organization. The reactor operations organization is a group within a larger organization which also includes the health physics and nuclear safety functions. This larger organization also has no experimental program responsibility. The organization reports to the Nuclear Laboratory Division Manager, and is parallel to the experimental programs organizations, which also report to the Nuclear Laboratory Division Manager.

The Nuclear Laboratory Division Manager reports to the Chief Nuclear Engineer, who appoints the Reactor Safety Committee and monitors this committee's activities.

b. Reactor Operations Staffing

At least four men comprise each RER operations shift. One of the four men shall be a senior reactor operator. Each shift will perform all necessary reactor operations and maintenance functions.

During normal level operation of the RER, two persons shall remain in the control room at all times. During operations which could involve changes in core reactivity when the RER is shutdown, the nuclear control instrumentation shall be continuously in operation, attended, and observed.

c. Reactor Safety Committee

A Reactor Safety Committee is established reporting to the Chief Nuclear Engineer. The Committee, which meets at least quarterly, is composed of the following or their Committee approved alternates:

Reactor Systems Division Manager, Chairman
Reactor Operations and Nuclear Safety Dept. Manager, Sec.
Nuclear Laboratory Division Manager
Reactor Operations Group Engineer
Health Physics Group Engineer
At least two scientists/engineers not in the operating line organization.
Consultants as required in the judgement of the Committee.

A quorum will consist of all the personnel listed with the exception of consultants. Actions of the Committee require unanimous concurrence.

The Committee reviews and approves proposed reactor modification; periodically reviews reactor oper on procedures and revisions thereto as well as procedures involving emergency operation; and all new types of reactor experiments proposed for the RER.

A GNL Subcommittee of the Reactor Safety Committee, which meets at least monthly, is composed of the following or their Committee approved alternates:

Reactor Operations and Nuclear Safety Dept. Manager, Chairman and Secretary
Reactor Operations Group Engineer
Health Physics Group Engineer
Consultants as required in the judgement of the Subcommittee.

A quorum will consist of all the personnel listed with the exception of consultants. Actions of the Subcommittee require unanimous concurrence.

This Subcommittee assures that the operating organizations are carrying out mandates of the full Committee; approves repetition of previously approved experiments; and assists the full Committee by providing preliminary review of material being prepared for consideration by the full Committee.

2. QUALIFICATIONS OF SUPERVISORY PERSONNEL

Qualifications for supervisory personnel within the reactor operating organization are established by the next higher level of supervision and approved by the Nuclear Laboratory Division Manager.

3. MODIFICATION OF OPERATING PROCEDURES

Proposed changes in reactor operating procedures are developed by the reactor operating organization, and must be approved by the Subcommittee of the Reactor Safety Committee prior to use. Both the operating organization and the reviewing organizations shall ascertain that all proposed revisions to procedures do not reduce the level of safety of reactor operations.

4. APPROVAL OF EXPERIMENTS

For each new type of experiment utilizing the RER, the Reactor Safety Committee shall review, evaluate and approve the experimental system if acceptable from the standpoint of reactor safety. Experiments which are essentially repetitions of previously approved experiments shall be reviewed by the Subcommittee of the Reactor Safety Committee, and may be approved by the Subcommittee if no increase in the level of potential hazard has occurred since review by the entire Reactor Safety Committee.

5. EMERGENCY PROCEDURES

Detailed emergency plans and procedures, covering all classes of potential GNL incidents, are prepared and published in the GNL Emergency Manual. The Emergency Manual is reviewed and approved by the Reactor Safety Committee, and all revisions to the manual are approved by the Committee at its first regular meeting following preparation of such revisions. Dry runs are held at least quarterly.

6. GENERAL OPERATING PRINCIPLES

a. Access to radiation areas

Detailed procedures for controlling access to potentially dangerous areas have been developed by the Lockheed Plant Protection in conjunction with principles established by the Health Physics and Reactor Operations organization. Enforcement is accomplished by the Lockheed Plant Protection.

b. Investigation of incidents

Unplanned shutdowns will be investigated by reactor operations at the time of the shutdown, and will be reported to the Reactor Safety Committee and Subcommittee for review. All events involving the RER which

could be classed as incidents will be investigated by Reactor Operations, the Reactor Safety Committee, and other Lockheed committees if appropriate.

c. Fuel element manipulation

Detailed procedures have been developed for operations involving fuel handling. All such operations are conducted under the direct personal supervision of a Senior Reactor Operator, and are conducted only when specified nuclear instrumentation and controls are operating and being monitored (Section I-4).

d. Routine maintenance

Routine preventive maintenance is accomplished on reactor systems and on conventional plant equipment on a scheduled basis. Health Physics portable instrumentation is calibrated on a scheduled basis.

e. Personnel dosimetry policy

All personnel at GNL are issued beta-gamma sensitive film badges. Personnel who work at the REF and other key personnel are issued film badges sensitive to both beta-gamma and neutron. Personnel who work in known radiation fields are issued self-reading dosimeters for the duration of the particular work assignment.

f. Health Physics surveillance

Health Physics surveillance is continuously provided during reactor operation.

g. Safety and Emergency System Tests

Safety systems and emergency alarm systems are tested as a part of the pre-operational check which is accomplished each day that the RER is operated.

h. Radiation Safety Principles

The general policy for all operations involving potential radiation exposure shall be avoidance of all unnecessary exposures, and maintaining unavoidable exposures at the lowest level possible consistent with operations to be performed.

i. Operating Procedures

Detailed operating procedures have been prepared covering start-up, approach to power, routine operation at level power, conduct of reactor experiments, maintenance, refueling, shutdown, and emergencies. Compliance with operating procedures is required to assure checkout and proper operation of all safety systems associated with reactor operation. Generally, every step of each procedure associated with the reactor and related systems requires the initials of the person performing the step. Deviation from procedure is permitted only if it is necessary to immediately correct or prevent an unsafe condition.

j. Operations when facility is shut down

Nuclear control instrumentation will be in operation and will be attended and observed at all times during operations which could involve changes in core reactivity when the facility is shut down. All operations which could involve changes in core reactivity when the facility is shut down will be carried out only under the direct and personal supervision of a licensed senior reactor operator.