

PHASE 2

Final Safety Analysis Report for the Ground Test Accelerator (GTA)

October 1994

**Prepared by Los Alamos National Laboratory
Accelerator Technology (AT) Division
Los Alamos, NM 87545**

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for the
Ground Test Accelerator (GTA)**

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6.0 FAILURE MODES AND EFFECTS ANALYSIS

This chapter covers the single-point failure modes and effects analysis (FMEA) for each subsystem and safety and protection system of the Ground Test Accelerator (GTA). These FMEAs have been used for postulating accidents analyzed in Chapter 7. Only out-of-the-ordinary failure modes are in the FMEA tables. Typical common industrial failures have been considered but are not included. In the course of performing the FMEA, several multiple (common-mode) failure and sequential failures resulting from a single point were identified and measures were taken to mitigate the consequences of such failure.

The following sections describe the failure analysis undertaken for the various operating components of Phase 2. Tables VI-1 and VI-2 explain the descriptors used in the FMEA "effects" category, which is in the last column of the FMEA tables.

Table VI-1 First Descriptor for the Effects Category of the FMEAs

Designator	Hazard Category	Consequences to the Public, Workers, or Environment
I	Catastrophic	May cause deaths, loss of the facility operation, or severe impact on the environment
II	Critical (Major)	May cause severe injury, ^a severe occupational illness, major damage to a facility/operation, or major impact on the environment
III	Marginal (Minor)	May cause minor injury, minor occupational illness, or minor impact on the environment ^b
IV	Negligible (Trivial)	Will not result in a significant injury, occupational illness, or significant impact on the environment

^aOr death to a worker.

^bOr moderate damage/impact to a facility/operation.

Table VI-2 Second Descriptor for the Effects Category of the FMEAs

Designator	Type
a	Hazardous materials release to the environment
b	Hazardous materials release within the building
c	Personnel exposure to hazardous materials
d	Personnel exposure to other than hazardous materials
e	Loss of operational capability
f	Loss of systems capability

6.1 Experimental Equipment

6.1.1 Ground Test Accelerator

6.1.1.1 Injector - The GTA injector provides the H⁻ beams for the accelerator. The injector is patterned after injectors that have been operated for many years at Los Alamos. H⁻ ions are generated in an arc chamber. These are obtained from the discharge volume

by a 35-kV high-voltage extractor. Operational fault modes listed here are based on previous experience with injector operations. Table VI-3 shows the FMEAs for the injector. (Figure 4-17 also shows the short injector and dome.).

6.1.1.2 RFQ, DTL, and IMS - These three units are housed in the connected accelerator vacuum envelope. Failure modes for these accelerator components are associated with the systems that are connected to the RFQ/IMS and DTL's through the vacuum envelope: RF power, cryogenic GHe transport and vacuum. Failure modes that could result in hazardous situations associated with RF power are RF power leakage in connector flanges. GHe leakage from ruptured lines or joints in the vacuum envelope could result in over-pressure of the vacuum envelope. Vacuum pump failure does not present a personnel hazard but could impact the program. Tables VI-4 and VI-5 show the FMEAs, and Figs. 4-21 through 4-24 provide identification of components.

6.1.2 Optics

The FMEAs for optics, which are listed in Table VI-6 are based on experience with the Los Alamos Proton Storage Ring, a device which contains virtually all the elements in the output optics. The storage ring also operates at higher energy and duty factor, with much higher potential for activation and electrical hazards. The optics staff have also had experience with a prototype version of the optics system, which was commissioned at Argonne National Laboratory at twice the GTA energy. Figure 6-1 provides identification of the areas of description in Table VI-6.

6.1.3 Primary Beam Stops

The intermediate and final beam stops are air-cooled designs, which use a graphite or aluminum plate to absorb the proton-beam energy. Both materials have been used in a number of accelerators as beam stops and have operated reliably. The beam stop is encased in a vacuum vessel, which uses a combination of cryogenic and rotary-vane mechanical pumps to provide the required vacuum pressure in the vessel. This vacuum-system equipment is used in industry and has a history of safe, reliable operation.

The intermediate beam-stop plate is cooled by thermally radiating the absorbed energy to the vessel wall. Forced air cooling of the wall is provided by a commercial blower, which has been very reliable. A flow meter in the cooling duct is used to measure and monitor the air-flow rate. Cooling the final beam stop is similar to that of the intermediate beam stop except the vacuum wall is cooled by natural convection to air in the tunnel.

Table VI-3 FMEAs for the Injector

Item #	Identification from Drawing No. 84Y-222923	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	1a 1b 1c	Injector personnel safety system Beam plug Beam interrupt Faraday cup	System failure Plug fails to go into beam Beam fails to turn off Faraday cup fails to go into beam	Mechanical/ Electrical Electrical Mechanical/ Electrical	Detected during periodic testing	Three independent systems are in parallel, reducing likelihood of system failure; health safety personnel monitor for radiation	Personnel possibly exposed to beam-induced radiation	IIIc
2	2	Injector run-permit system	- System failure - One input channel fails - False run permit mode is allowed	Electrical Electrical	Detected during periodic testing	- Other related channels provide redundancy - Accelerator start-up prevented by other interlocks	Possible machine damage and/or degradation of beam quality	IIIc
3	3	Injector radiation monitoring	X-ray monitor fails	Electrical	Detected during periodic testing	Warning lights indicate potential radiation condition	No effect if this is the only failure	IVc
4	4	Injector ion-source system	- Inadvertent hydrogen release - Inadvertent cesium exposure	Mechanical Mechanical	None Sparks	- Only small amounts of hazardous substance - Correct procedure	Personnel injury Personnel injury	IIIc IVc

Table VI-3 FMEAs for the Injector (concluded)

Item #	Identification from Drawing No. 84Y-222923	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
5	5	Injector arc-pulsing system	• ac power interrupt fails in dome	Electrical/Mechanical	Periodic testing indicator lights, voltmeters on ac power lines and capacitor banks	• Repair and redundancy	Personnel injury	Ild
			• Bleeder resistors fail	Electrical				
			• Voltage shorting unit fails	Electrical/Mechanical				
6	6	Injector high-voltage system	• ac power interrupt fails in dome	Electrical/Mechanical	Periodic testing indicator lights, voltmeters on ac power lines and capacitor banks	• Repair and redundancy	Personnel injury	Ild
			• Bleeder resistors fail	Electrical				
			• Voltage shorting unit fails	Electrical/Mechanical				
			• Earthquake overturns dome	Mechanical	Visual	None	Personnel injury	Ild

Table VI-4 FMEAs for RFQ/IMS

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	RFQ drawing	RF coaxial line/waveguide flange	Flange develops RF leak	Mechanical	• RF radiation sensor • Pressure sensor in coaxial cable • Electrical mismatch sensor	• Shutdown and repair • Shutdown and repair • Shutdown and repair	• Possible RF radiation exposure • Possible RF radiation exposure • Possible RF radiation exposure	III d
2	RFQ drawing	GHe line--vane joint	Joint develops He leak	Mechanical	Tank vacuum gauge	Shutdown and repair; vacuum lines violated by gate valves triggered by pressure sensors	Internal He pressure trips relief valve; exposed to cryogenic He; considerable down time	IV e
3	RFQ drawing	Vacuum pump	Pump failure	Mechanical/Electrical	Vacuum gauge	Shutdown/repair; gate valve shuts off pump from system	Down time; no personnel hazard	IV e
4		Vacuum flanges	Flange develops leak	Mechanical	Vacuum gauge	Shutdown/repair	Down time; no personnel hazard	IV e

Table VI-5 FMEAs for DTL

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	DTL drawing	RF coaxial line/waveguide flange	Flange develops RF leak	Mechanical	- RF radiation sensor - Pressure sensor in coax cable - Electrical mismatch sensor	- Shut down/repair - Shut down/repair - Shutdown/repair	- Possible exposure to RF radiation - Possible exposure to RF radiation - Possible exposure to RF radiation	III d
2	GHe line	GHe line -- DT joint	Joint develops leak	Mechanical	Tank vacuum gauge	Shut down/repair vacuum lines isolated by gate valves activated by pressure sensor	Internal He pressure trips relief valve, possible exposure to cryogenic, He, considerable down time	IV c
3	DTL drawing	Vacuum pump	Pump failure	Mechanical/Electrical	Vacuum gauge	Shut down/repair; gate valve shuts off pump from system	Down time; no personnel hazard	IV e
4	DTL drawing	Vacuum flange	Flange develops leak	Mechanical	Vacuum gauge	Shutdown/repair	Down time; no personnel hazard	IV e

Table VI-6 FMEAs for Output Optics

Item #	Identification from Fig. 6-2	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	1	Tuneup beam stop	• Fails to insert • Fails to retract	Electrical/ Mechanical	Microswitch limit trips run permit	Redundant switches; fast protect; radiation monitoring	• High radiation; possible vacuum loss • Activate stop area, damage to stop	IVf
2	2	RF cavities	• Improper RF joints • Inadequate or displaced x-ray shielding	Electrical/ Mechanical	• RF intensity meter • X-ray monitor	RPSS interlock in operations mode; continuous monitoring with power supply interlock; redundant detection	• Personnel injury from RF exposure • Personnel injury from x-ray exposure	IIc
3		RPSS	System failure	Electrical/ Mechanical	Periodic testing	Doubly independent systems	Possible personnel exposure to radiation	IIc
4		Fast-protect system	System failure	Electrical	Periodic testing	Redundant detection	Possible machine damage or activation	IVc IVf
5		Run permit	System failure	Electrical/ Mechanical	Periodic testing	Redundant system	Machine damage	IIIe
6	6	Portable water chiller	Activated coolant leak	Mechanical	Visual inspection; radiation monitoring	Evaluate and repair	Personnel exposure to radiation; radiation release to environment	IIIb IIIb
7	7	Electromagnet terminals	Accidental terminal shorting	Electrical/ Mechanical	Periodic testing of interlock system	Redundant shield switches; lockout tagout procedure	Electrical burns to personnel	IIId

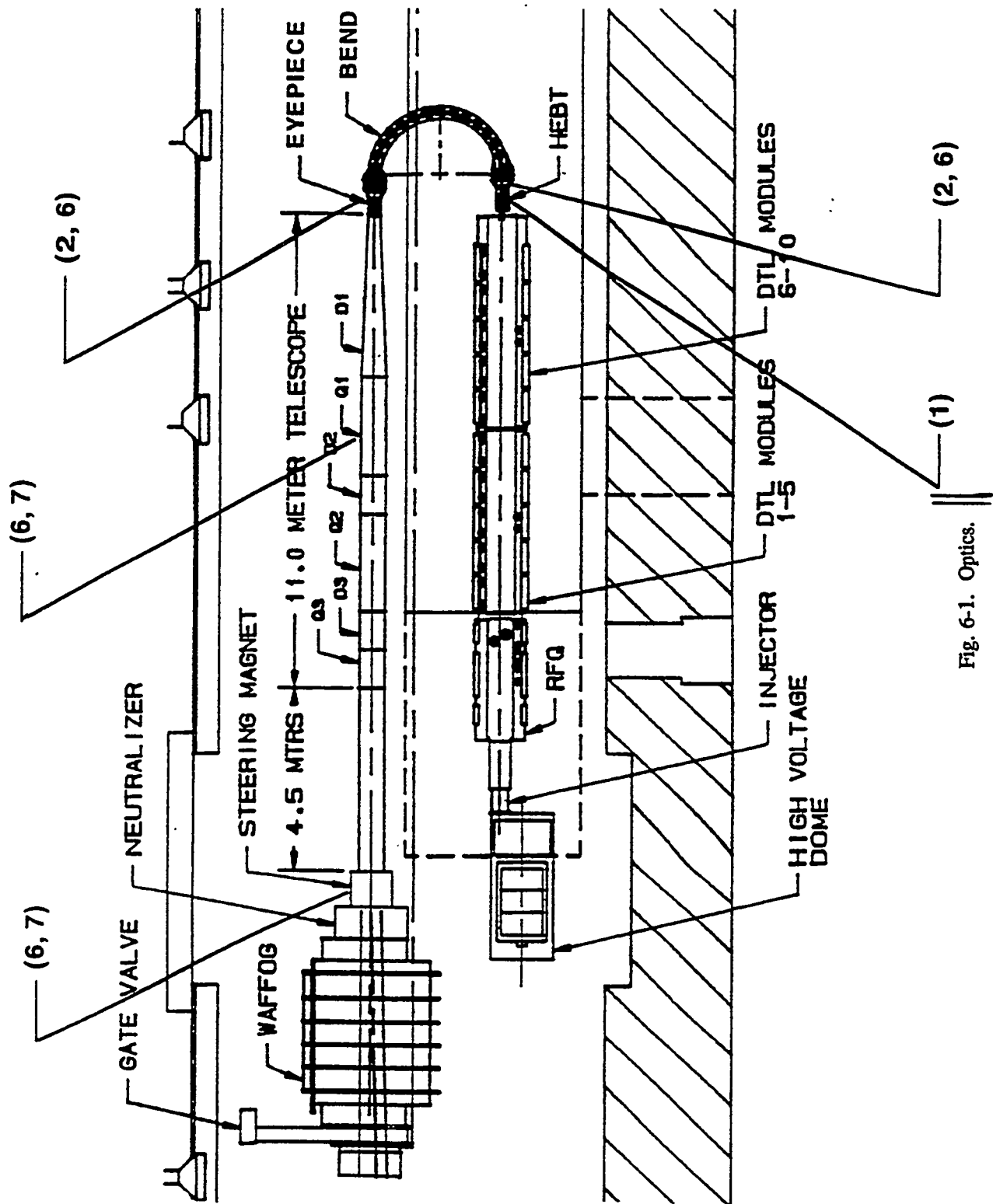


Fig. 6-1. Optics.

Both beam stops use thermocouples in the beam-stop plate and vessel wall to measure and monitor the operating temperatures of these components. (Figure 6-2 is a schematic that shows the type and general location of the instrumentation used to monitor and operate the intermediate beam stop.) Table VI-7 shows the FMEAs for intermediate beam stop. Table VI-8 shows the FMEAs for the final beam stop. Figure 6-3 is a schematic of the final beam stop.

6.1.4 Neutral Beam

The failures possible in the Neutral Beam system, which can effect experiments, include a rupture in the water-cooling lines for the characterization beam stop, a rupture in the LN₂ dewars or supply lines at the detector station, and a breakdown of the support hardware associated with the system's diagnostic hardware (e.g., mechanisms used for translation and positioning of the plate or camera assemblies). Table VI-9 presents the FMEAs for the neutral beam.

6.1.5 Diagnostics

Diagnostics that have a finite probability of failure include the LINDA laser system, the cooling water for cooling electromagnets, the vacuum system, and the intermediate beam stop. Failure modes for the LINDA laser system are presented in Table VI-11. Failure modes for the electromagnets are presented in Table VI-10. The failure modes for other systems in Experiment 2D and beyond are the Vacuum (6.2.2), Beam Stop (6.1.3), and Cooling Water (6.2.3) sections.

6.2 Accelerator Support Systems

6.2.1 RF Power Systems

The GTA and HPCTB RF systems use tetrodes for generating power at 425 MHz and 850 MHz and klystrons for generating power at 850 MHz. A general arrangement of the GTA RF equipment is located on the mezzanine of building MPF-365. (See Fig. 4-39.) Both tetrodes and klystrons are standard high-power devices, which have been used extensively in radar, television, and radio stations. Both devices require high-voltage power supplies as the main power input. Primary dangers come from the high-voltage subsystems and the high-power RF output. Interlocks for these high-power RF systems are used for personnel and equipment safety.

Another hazard associated with the operation of the RF power system is the incidental production of ionizing radiation (soft x rays with energies less than 120 keV) and the intentional production of nonionizing microwave radiation. X rays are produced when the electron beam in the klystron strikes the unit's collector. Lead shielding placed around the collector and the nearby klystron

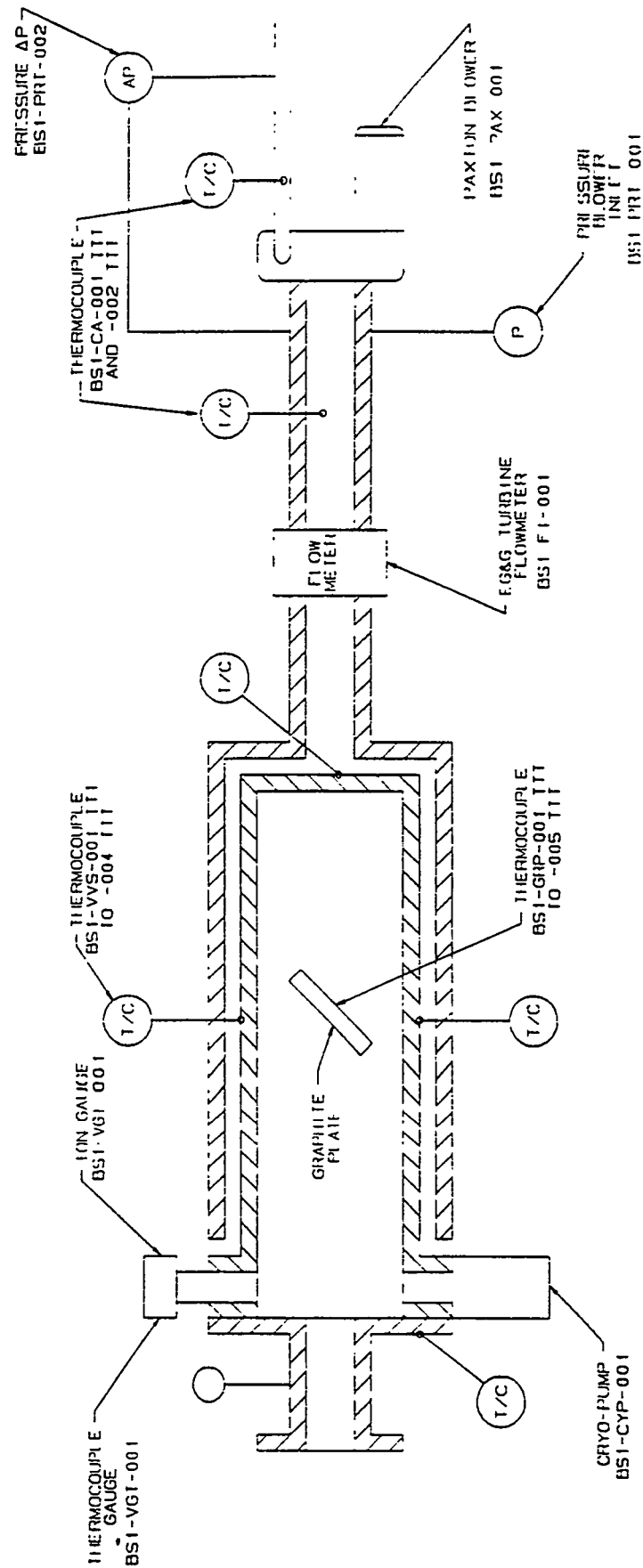


Fig. 6-2. 24-MeV intermediate beam-stop instrumentation drawing.

Table VI-7 FMEAs for Intermediate Beam Stop

Item #	Identification from Fig. 6-2	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	BS1-FI-001	Flow meter	Readings do not appear to be in the right range	Mechanical/ Electrical	- Erratic readings - Low readings - No reading	- Observe pressure transducer readings - Observe thermocouple readings to see if temperatures are in the right range - Evaluate/repair	Possible high temperature in vacuum vessel if cooling flow is low	IVf
2	BS1-VVS-001 TTT to -004 TTT and BS1-GRP-001 TTT to -005 TTT	Thermocouples	- Readings do not appear to be in the right range - No readings	Mechanical/ Electrical	- No readings on thermocouple - Readings out of range	Observe other thermocouple readings in region for comparison	Loss of thermocouple data at location	IVf
3	BS1-PRT-001-002	Pressure sensor	- Readings do not appear to be in the right range - No readings	Mechanical/ Electrical	Reading out of range or no reading	- Observe flow meter readings - Observe other pressure sensor readings	Loss of data at pressure sensor locations	IVf
4	BS1-VG1-001	Ionization vacuum gauge	Reading not in right range	Electrical	No reading or reading out of range	Observe vacuum gauges in beam tube connected to beam stop vacuum vessel	Loss of vacuum will trigger an interlock shutdown of the beam	IVe

Table VI-7 FMEAs for Intermediate Beam Stop (concluded) II

Item #	Identification from Fig. 6-2	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
5	BSI-PAX-001	Blower	- Blower motor not on - Blower not generating airflow	Mechanical/ Electrical	- Pressure drop readings are zero or out of range - Vacuum vessel shell temperatures are increasing	- Monitor pressure and temperature sensors - Evaluate/repair	Accelerator beam will have to be shut down until blower is repaired	IVe
6	BSI-CYP-001	Cryopump	Vacuum readings are not in the right range	Mechanical/ Electrical	Vacuum pressure sensors reading out of range	- Monitor vacuum pressure sensor at turbopump located in beam line - Evaluate/replace	Loss of vacuum will trigger a beam shut-down interlock	IVe

Changed per DOE/AL Comments
October 5, 1994

Table VI-8 FMEAs for Final Beam Stops II

Item #	Identification from Fig. 6-3	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Thermocouples	Thermocouples	- Readings do not appear to be in the right range - No readings	Mechanical/ Electrical	- No readings on thermocouple - Readings out of range	Observe other thermocouple readings in region for comparison	Loss of thermocouple data at location	IVf
2	Final beam stop	Final beam stop	Beam burns a hole in the beam stop and possibly penetrates the vacuum vessel	Mechanical	Possible loss of vacuum	Repair	Accelerator beam will have to be shut down for repairs	IVe

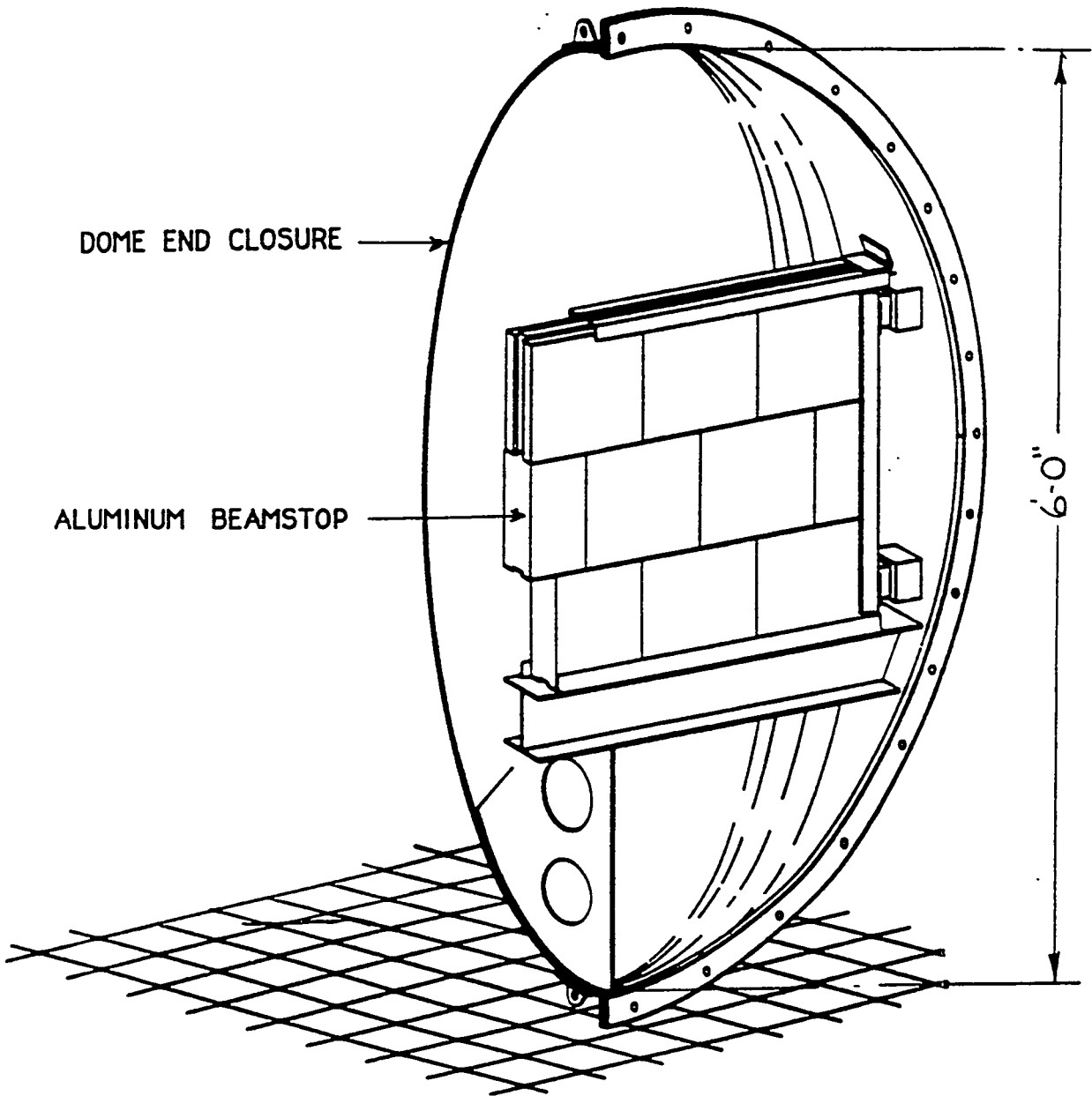


Fig. 6-3. Schematic of final beam stop.

Table VI-9 FMEA for Neutral Beam

Item #	Identification from Drawing No.	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	112Y-281820 and 112Y-281819	Cooling water lines	Rupture (small or large)	Mechanical	Local vacuum gauges and pressure sensors	Repair	- Radioactive water within the vacuum enclosure - Contaminate vacuum - Requires access into a confined space	IVb,c,d,e IVb, c, d, e Id
2	112Y-281811	LN ₂ cooling system	Rupture in lines or dewar	Mechanical	Local vacuum gauges and pressure sensors	Repair	- Contaminate vacuum - Operational delay - Requires access into a confined space	IVb,c,d,e IVb, c, d, e Id
3	112Y-281819 and 112Y-281808	All mechanical and electrical support hardware	Physical breakage, gawling, electrical failure	Mechanical/ Electrical	Micro-switches, LVDTs, temperature sensors, electrical fuses, computer monitoring	Repair	- Operational delay - Requires access into a confined space	IVd,e Id

Table VI-10 FMEAs for Electromagnets Requiring Cooling

Item #	Identification from Fig. 5-4	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Electromagnet		Electrical thermal sensor fails on electro-magnet cooling channel	Electrical	Neighbor sensor trips	Replace	Possible damage to magnet coils	IVc
2	Electromagnet		Flow sensor fails	Electrical/ Mechanical	Thermal sensors trip	Replace	Possible damage to magnet coils	IVe
3	Electromagnet	Series inter-lock circuit fails		Electrical	Magnet performance degradation, increased voltage	Repair circuit; replace/repair magnet if damaged	Probable damage to magnet coils; extreme heat generated; possible rupture of cooling water channels on magnet	IIId

Table VI-11 FMEAs for LINDA Laser

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Beam-diagnostic measurements	- Electrical interlock fails on beam tube - Electrical interlock fails on power supply - Ventilation hood floor failure during changing of laser dyes	- Electrical/Mechanical - Electrical/Mechanical - Motor fails	- IR and visual inspections - Voltage probe - Air-flow indicator	- Repair - Repair shunting bar - Repair - Respirator use	- Severe eye damage - Possible severe electrical shock - Possible exposure to hazardous materials	IId IId IIc
2	N/A	D-plate diagnostics and beam stop	Power supply failure of interlocking system interlock	Mechanical/Electrical	Check voltage with probe	Repair	Minor electrical shock with current limited	IId

output port attenuate x rays to within acceptable limits. Health physics personnel from HS-1 check the dose rate from x rays generated by the klystrons to insure adequate shielding is present.

Microwave radiation is present in the waveguides of the klystron system and coaxial transmission lines of the tetrode system. Both transmission lines are regularly measured for leakage and are interlock protected. Any violation in the structural integrity of either transmission line would be sensed and high-power RF operations would be inhibited immediately. The environment surrounding the tetrode amplifiers is measured by HS-5 for the presence of microwave radiation.

Oil spills constitute another hazard associated with RF power operations. This danger is mitigated because the dielectric oil (nontoxic, nonhazardous Envirotemp 200 Fluid) is contained within the rugged structure of the modulator tanks and is present in each tank in quantities of only 200 gal. Minor spills can be handled effectively using spill clean-up kits on the mezzanine of building MPF-365. In the unlikely event that the spill is too large to be contained in the first moments of an accident, the design of the mezzanine floor, which is surrounded by a physical barrier approximately six in. high, will prevent the migration of the spill into other areas of the building.

Tables VI-12 through VI-17 contain FMEAs for the RF power system.

6.2.2 Accelerator Vacuum System

The GTA-vacuum system consists of several different types of vacuum pumps, a network of remotely operated valves, and an instrumentation-and-control system. A combination of cryogenic, turbomolecular roots-blower, and rotary-vane mechanical pumps are used to provide the pressures required in the accelerator-vacuum vessels. Each of these pumps is commonly used in industry, and each has a history of safe, reliable operations. The status of all the major components in the vacuum system is continually available to the operator by displays and status lights. The control system allows the operator to safely start up or shut down all, or part, of the vacuum, and it provides interlocks that prevent damage to equipment during unscheduled events such as power outages or equipment failures. Failure modes in the vacuum system are given in the accelerator FMEA tables.

6.2.3 Water-cooling System

The GTA water-cooling system is based on a standard industrial design; it employs standards and accepted practices for closed- and open-loop cooling systems. The system has been designed and

1 4 6 0 0 3 4 1

Table VI-12 FMEAs for the High-voltage Power Supply

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	High-voltage power system primary-power contactor	Will not open when coil power is removed	Mechanical	High-voltage dc power supply can-not be shut off	Manual fused disconnect switch can be opened. High voltage power supply shutdown circuit independent of primary power contactor; high-voltage relay shorts power supply if dual failure occurs	High-power RF system cannot be made safe without opening circuit breaker that feeds high-voltage dc power system contactor	IIIe
2	N/A	High voltage power supply cable falls off	High voltage remains on	Mechanical	High voltage cable will arc	Shut down high voltage power supply manually or remotely	High voltage cable (100 kV) is exposed to environment and personnel	IIId
3	N/A	Remote A/B control	High voltage power supply cannot be shut off	Electrical	High voltage DC power supply can-not be shut off	Manually shut off high voltage power supply with contactor	Potential personnel exposure to high voltage	IIId

Table VI-14 FMEAs for RF System 850-MHz Tetrode

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Tetrode interlock system--personnel safety system	Contact welded shut	Electrical	Interlocks do not trip off high voltage when cabinet door opens or grounding hook fails	Replace interlock	Injury or death to a worker from high voltage	Id
2	N/A	Tetrode interlock system--Allen Bradley monitoring	Contact welded shut	Electrical	Allen Bradley does not shut off high voltage	Replace interlock	Equipment damage	IIIc
3	N/A	Tetrode interlock system--high power RF output	Coax pressure detect system fails	Electrical	RF power is in coax and can be transmitted when coax is disassembled	Replace air pressure sensor	Personnel can be injured by high power RF	IIIc

Table VI-15 FMEAs for 850-MHz Klystron Modulator

Item #	Identification from Drawing No. 112Y-280222	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1		Modulator interlock system--personnel safety system	Contact welded shut	Electrical	Interlocks do not trip off high voltage when cabinet door opens or grounding hook fails	Replace interlock	Personnel injury from high voltage	Id
2		Modulator interlock system--Allen Bradley monitoring	Contact welded shut	Electrical	Allen Bradley does not shut off high voltage	Replace interlock	Equipment damage	IIIc
3		Modulator interlock system--high power RF output	Coax pressure detect system fails	Electrical	RF power is in coax and can be transmitted when coax is disassembled	Replace air pressure sensor	Personnel can be injured by high power RF	IIIc
4		Modulator oil tank	Tank ruptures, or leaks, or drain plug is removed	Mechanical	Oil on mezzanine floor	Clean up spill	Oil leaks into lower level or personnel slip on floor	IIIc

Table VI-16 FMEAs for RF System 425-MHz Tetrode

Item #	Identification from Drawing No. 112Y-280250	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1		Tetrode interlock system-- personnel safety system	Contact fused shut	Electrical	Allen-Bradley controller does not shut off high voltage	Replace interlock	Personnel injury from high voltage	IIId
2		Tetrode interlock system--Allen-Bradley monitoring	Contact welded shut	Electrical	Allen Bradley controller does not shut off high voltage	Replace interlock	Equipment damage	IIIf
3		Tetrode interlock system--high-power RF output	Coaxial transmission line pressure-de-tect system fails	Electrical	RF power is in coaxial line and can be transmitted when coaxial is disassembled	Replace air pressure sensor	Personnel can be injured by high power RF	IIId

Table VI-17 FMEAs for RF System: Radiation Monitoring

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Monitors RF radiation-detection instrument	RF-detection channel fails	Electrical	Detected during periodic testing	Other RF-detection channels will indicate RF level	None, unless RF level exceeds safe levels, then individual could receive slight RF radiation dose.	IIId

built to current professional standards and codes of the American National Standards Institute (ANSI), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), and other requirements as stated in the Los Alamos National Laboratory (LANL) ES&H Manual.

A standard operating procedure (SOP) has been developed for the operation and maintenance of the system to eliminate risk to personnel. Practice and training sessions will be held for the appropriate personnel in operating the system; the training will be updated as changes in the system are implemented. Failure modes in the cooling system are those associated with normal industrial-type failures of process water cooling systems. All users of the water system are responsible for providing protection to their equipment in the event of a water-system failure. If an unplanned shut-down occurs in the water system, a "no-go" signal is sent to the computer control room and the accelerator is shut down. FMEAs for the water-cooling system are shown in Table VI-18.

Other risks associated with an unplanned shut-down are not expected to affect the facility or personnel.

6.2.4 Cryogenic-cooling System

A FMEA was made for the LH_2 , LN_2 , and GHe subsystems of the cryogenic-cooling system (CCS). In the FMEA, single-point failures for the components on the P&I diagrams, which were presented at the August 1989, CVI, Inc., design review, were considered.

As a result of that FMEA, it was recommended that the CCS should provide backup safety pressure-relief protection at a number of places in the system. These changes, which were discussed with CVI, have been incorporated into the CCS design. The analysis has been updated to include these changes along with a number of changes recommended by the independent Boyer safety review committee.

The FMEA presented in this section does not include the FMEA for the distribution manifold subsystem that connects the CCS to the GTA accelerator, which is presented in Section 6.2.6. Tables VI-19, VI-20, and VI-21 present the FMEAs and the criticality rating for each item of the LH_2 , LN_2 , and He subsystems, respectively. The identifiers listed refer to the components identified on the CVI piping and instrumentation drawings. (See Figs. 4-49 and 4-50.)

Table VI-18 FMEAs for GTA Water-cooling System

Item #	Identification from Drawing No. 112Y-282230	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Sheet M10	Pumps; primary system loops (process room to cooling tower)	Pump fails	Mechanical (motor burned out, pump impeller broken, bearings frozen, etc.)	Pertinent status, and parameters are continuously monitored by a commercial computer logic control system (PLC)	Evaluate/repair	- Subsystem; moderate, steady increase in the water temperature in secondary loop - Accelerator system; no immediate effect on accelerator; potential accelerator shut-down required to fix problem	IVf IVe, f
2	Sheets M10 & M11	Pumps; secondary system loops (process room to accelerator components)	Pump fails	Mechanical (motor burned out, pump impeller broken, bearings frozen, etc.)	Pertinent status, and parameters are continuously monitored by a commercial computer logic control system (PLC)	Evaluate/repair	Subsystem; rapid increase in operating temperature of accelerator components followed by accelerator shutdown	IVe,f
3	Sheets M10 & M11	Flow valves - automated and manual	- Fails open - Fails closed - Fails to move	- Mechanical - Mechanical - Mechanical	Pertinent status, and parameters are continuously monitored by a commercial computer logic control system (PLC)	Evaluate/repair	- If in control loop, potential accelerator shut-down - If located in noncontrol loop, minor effect	IVf IVe
4	Sheets M10 & M11	Temperature control valves	- Fails open - Fails closed - Fails to move	- Mechanical - Mechanical - Mechanical	Pertinent status, and parameters are continuously monitored by a commercial computer logic control system (PLC)	Evaluate/repair	Potential accelerator shutdown	IVf IVe

Table VI-18 FMEAs for GTA Water-cooling System (continued) II

Item #	Identification from Drawing No. 112Y-282230	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
5	Sheets M1 to M9	Piping	Leaks or line burst	Mechanical (poor joint connection, material failure, accidental physical damage, etc.)	- Minor leaks will be visually identified. - Significant leaks will be detected by computer monitoring as low pressure, high temperature conditions	- Automatic shutdown of critical components - Evaluate/repair	- Subsystem; minor to major, depending on severity of leak and location in system - Accelerator system; none to accelerator shutdown depending on location	IVe, f IVe, f
6	Sheet M13	Water de-ionization subsystem	Water conductivity not within set point range	- Mechanical - Electrical (Ion beds not recharged, instrument monitor failure)	Monitoring instrumentation has local alarm if "out-of-range" conditions occur	Evaluate/repair	- Subsystem; minor over short term of operation; if not corrected, possible corrosion and erosion problems - Accelerator system; minor	IVf IVf
7	Sheets M10, M11 & M12	Manual gauges - instrumentation	- Fails open - Fails closed - Fails to move	- Mechanical - Mechanical - Mechanical	Visual inspection	Evaluate/repair	- Subsystem; minor - gauges will be used only for local visual check - Accelerator system; minor - Subsystem; minor - gauges will be used only for local visual check - Accelerator system; minor - Subsystem; minor - gauges will be used only for local visual check - Accelerator system; minor - Subsystem; minor - gauges will be used only for local visual check - Accelerator system; minor	IVf IVf IVf IVf IVf IVf

Table VI-18 FMEAs for GTA Water-cooling System (concluded)

Item #	Identification from Drawing No. 112Y-282230	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
8	Sheets M10, M11 & M12	Electronic sensors - instrumentation	• Fails open	• Electrical	Visual inspection at sensor location or on computer monitor	Evaluate/repair	• Subsystem; effects depend on location and function of sensor: if in a control loop potentially an accelerator shut-down condition; if in a noncontrol loop, then minor	IVe,f
			• Fails closed	• Electrical			• Subsystem; effects depend on location and function of sensor: if in a control loop potentially an accelerator shut-down condition; if in a noncontrol loop, then minor	
			• Fails to move	• Electrical			• Subsystem; effects depend on location and function of sensor: if in a control loop potentially an accelerator shut-down condition; if in a noncontrol loop, then minor	
9		Secondary heat exchanger in potentially contaminated loop	• Leaks to primary side	• Mechanical	• Primary water activation monitor • Secondary makeup water measurement	Evaluate/repair	• Possible contamination of primary loop with delay in operations	IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	HOV 301	Shutoff valve --truck fill	- Leak - Fails to close	Mechanical	- Noise, ice, vapor plume - Stem position	- Evaluate/repair - Close AOV 300	- Release of H₂, possible ignition - Inability to follow standard-fill procedures	IVc IVf
2	HOV 173	Valve--LH ₂ truck-fill purge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Loss of He	IVd
3	CKV 174	Check valve--LH ₂ truck fill	- Fails to open - Fails to close	Mechanical	- Inability to flow through HOV 173 - Routine inspection	- Purge using HOV 171 - Repair	- Inability to follow standard-purge procedures - Possible mixing of H₂ and He	IVf IVf
4	HOV 171	Isolation valve--LH ₂ lab-fill purge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
5	CKV 172	Check valve --LH ₂ lab-fill purge	- Fails to open - Fails to close	Mechanical	- Inability to flow through HOV 171 - Routine inspection	- Purge using HOV 173 - Repair	- Inability to follow standard-fill procedures - Possible mixing of H₂ and He	IVf IVf
6	HOV 327	Valve--LH ₂ lab fill	- Leak - Fails to close	Mechanical	- Noise, ice, vapor plume - Stem position	- Evaluate/repair - Close AOV 300	- Release of H₂, possible ignition - Inability to follow standard-fill procedures	IVc IVf
7	FLT 325	Filter--LH ₂	- Leak - Clogs	Mechanical	- Noise, ice, vapor plume - Low-fill rate	- Evaluate/repair - Repair	- Release of H₂, possible ignition - Delay of fill	IVc IVf

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
8	PSV 326A	Pressure safety relief--LH ₂ truck fill	- Fails to open at set point - Leak	Mechanical	- Line overpressure, activation of alternate PSV 326B - Noise, ice, vapor plume	- Activation of alternate PSV - Repair/replace	- Release of H₂, possible ignition - Release of H₂, possible ignition	IVc
9	PSV 326B	Pressure safety relief--LH ₂ truck fill	- Fails to open at set point - Leak	Mechanical	- Activation of alternate PSV 326B - Noise, ice, vapor plume	- Activation of alternate PSV - Repair/replace	- Release of H₂, possible ignition - Release of H₂, possible ignition	IVc
10	AOV 300	Valve--transfer-line inlet for the LH ₂ storage dewar	- Fails closed - Transfers open - Leak	Mechanical/Electrical	- Limit switch, inability to transfer LH₂ - Routine valve exercise check - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Inability to fill LH₂ storage or to transfer LH₂ - Normally open during fill operations - Release of H₂, possible ignition	IVf IVf IVc
11	HOV 309	Isolation valve--rupture disk for the LH ₂ storage dewar	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
12	AOV 311	Vent valve--LH ₂ storage	• Fails open	Mechanical/ Electrical	• Routine valve exercise check, flow through vent when holding purge, cannot pressurize dewar	• Repair	• Inability to maintain dewar pressure	IVf
			• Transfers closed		• Limit switch, inability to purge or vent, PT 315 dewar pressure above range, activation of PSV 313	• Activation of PSV 313	• Inability to purge or vent through vent stack	IVf
			• Leak		• Noise, ice, vapor plume	• Evaluate/repair	• Release of H ₂ , possible ignition	IVc
13	RUD 312A	Rupture disk--LH ₂ storage	• Ruptures below design point	Mechanical	• Loud noise, increased vent flow, cannot pressurize dewar	• Switch to RUD312B, replace	• Release of H ₂ , possible ignition	IVc
			• Leak		• Noise, ice, vapor plume	• Switch to RUD312B, replace	• Release of H ₂ , possible ignition	IVc
14	RUD 312B	Rupture disk--LH ₂ storage	• Ruptures below design point	Mechanical	• Loud noise, increased vent flow, cannot pressurize dewar	• Switch to RUD312A, replace	• Release of H ₂ , possible ignition	IVc
			• Leak		• Noise, ice, vapor plume	• Switch to RUD312A, replace	• Release of H ₂ , possible ignition	IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
15	PSV 313	Pressure safety relief--LH ₂ storage	• Fails to open • Leak	Mechanical	• H₂ storage overpressure; activation of rupture disk • Noise, ice, vapor plume	• Open AOV 311, activation of rupture disk RUD312A or B • Repair/replace	• LH₂ storage overpressure activates rupture disk • Release of H₂, possible ignition	IVc, f IVc, f
16	CKV 314	Check valve--H ₂ vent	• Fails to open • Fails to close	Mechanical	• No audible or visible vent, buildup in pressure PT 315, activation of PSV 313 • Dewar pressure PT 315 reads below normal vent pressure	• Activation of PSV 313 • Backflow of air prevented by molecular seal	• LH₂ storage overpressure, activates PSV • Reduced vent pressure, loss of redundancy in backflow protection	IVf IVf
17	HOV 177	Purge valve--LH ₂ storage vent	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Loss of He	IVd
18	HOV 315	Isolation valve--Pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
19	PT 315/PI 315	Pressure transducer/indicator--LH ₂ storage	• Reads in error • Leak	Mechanical/Electrical	• Activation of PSV 313 if AOV 311 is closed • Noise, ice, vapor plume	• Activation of PSV 313 • Evaluate/repair	• Delay in operations • Release of H₂, possible ignition	IVc, e IVc
20	HOV 316A	Isolation valve--level gauge	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
21	LI 316	Liquid-level gauge--LH ₂ storage	- Reads in error - Leak	Mechanical	- Reading does not agree with capacitance sensor LT 323 or with amount transferred from fill truck - Noise, ice, vapor plume	- Use capacitance sensor - Evaluate/repair	- Operational delay - Release of H₂, possible ignition	IVf IVc
22	LLE 323/ LT 323	Liquid-level sensor--LH ₂ storage	- Reads in error - Leak	Mechanical/ Electrical	- Reading does not agree with liquid-level gauge LI 316 - Noise, ice, vapor plume	- Use liquid-level gauge - Evaluate/repair	- Delay in operations - Release of H₂, possible ignition	IVf IVc
23	HOV 316B	Isolation valve--level gauge	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
24	HOV 319	Shutoff valve--LH ₂ vaporizer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
25	PCV 320	Pressure regulator	- Fails closed - Leak	Mechanical	- Inability to pressurize LH₂ storage - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Inability to pressurize LH₂ storage - Release of H₂, possible ignition	IVe IVc
26	PSV 317	Pressure safety relief--LH ₂ vaporizer	- Fails to open at set point - Leak	Mechanical	- PCV 320 pressure reading, activation of PSV 317a - Noise, ice, vapor plume	- Activation of alternate PSV - Repair/replace	- Release of H₂, possible ignition - Release of H₂, possible ignition	IVc IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
27	PSV 317A (to be added)	Pressure safety relief--LH ₂ vaporizer	- Fails to open at set point - Leak	Mechanical	- PCV 320 pressure reading, activation of PSV 317a - Noise, ice, vapor plume	- Activation of alternate PSV - Evaluate/repair	- Release of H₂, possible ignition - Release of H₂, possible ignition	IVc IVc
28	VAP 321	Vaporizer--LH ₂ storage pressurization	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
29	HOV 322	Purge valve--LH ₂ vaporizer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
30	HOV 302	Shutoff valve--LH ₂ transfer line	- Leak - Fails to close	Mechanical	- Noise, ice, vapor plume - Stem position	- Evaluate/repair - Close AOV 303	- Release of H₂, possible ignition - Transfer line fills during the dewar fill	IVc IVf
31	HOV 502	Shutoff valve--vacuum connection for the LH ₂ run dewar	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
32	HOV 175	Purge valve--LH ₂ transfer line	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
33	CKV 176	Check valve--LH ₂ transfer-line purge	- Fails to open - Fails to close	Mechanical	- No vent flow when HOV 175 is opened - Routine inspection	- Repair - Repair	- Inability to purge transfer line - Possible mixing of H₂ and He	IVe IVf

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
34	PSV 324A	Pressure safety relief--LH ₂ transfer line	• Fails to open at set point • Leak	Mechanical	• AOV 303 limit switch in closed position, activation of alternate PSV • Noise, ice, vapor plume	• Open AOV 303, activation of alternate PSV • Noise, ice, vapor plume	• Release of H₂, possible ignition • Release of H₂, possible ignition	IVc
35	PSV 324B	Pressure safety relief--LH ₂ transfer line	• Fails to open at set point • Leak	Mechanical	• AOV 303 limit switch in closed position, activation of alternate PSV • Noise, ice, vapor plume	• Open AOV 303, activation of alternate PSV • Evaluate/repair	• Release of H₂, possible ignition • Release of H₂, possible ignition	IVc
36	HOV 308	Isolation valve--rupture disk for LH ₂ run dewar	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
37	AOV 303	Valve--LH ₂ transfer line to the run dewar inlet	• Fails open • Transfers closed • Leak	Mechanical/ Electrical	• Limit switch, LH₂ level above range • Limit switch, LH₂ level below range • Noise, ice, vapor plume	• Close AOV 300, repair • Repair • Evaluate/repair	• Inability to control LH₂ level--LH₂ run dewar • Inability to fill LH₂ run dewar • Release of H₂, possible ignition	IVe IVe IVc
38	LLE 303/ LLC 303	Sensor/ control--LH ₂ run dewar liquid level	• Reads in error • Leak	Mechanical/ Electrical	• He temperature TE 134 outside of expected range; high-level alarm LLA 328 activated • Noise, ice, vapor plume	• For underfill, open AOV 303; for overfill, close AOV 300 • Evaluate/repair	• Inability to control liquid level properly • Release of H₂, possible ignition	IVe IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
39	TE 304	Temperature transducer--LH ₂ run dewar inlet	- Reads in error - Leak	Mechanical/ Electrical	- Reads outside of expected range - Noise, ice, vapor plume	- Evaluate/repair - Evaluate/repair	- Loss of information - Release of H₂, possible ignition	IVf IVc
40	AOV 305	Vent valve--LH ₂ run dewar	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Limit switch, loss of pressure, PT 318 - Limit switch, PT 318 reads above normal range, PSV 307 is activated - Noise, ice, vapor plume	- Repair - Repair, activation of PSV 307 - Evaluate/repair	- Inability to maintain dewar pressure - Inability to vent - Release of H₂, possible ignition	IVe IVf IVc
41	RUD 306A	Rupture disk--LH ₂ run dewar	- Ruptures below design point - Leak	Mechanical	- Loud noise, increased vent flow - Noise, ice, vapor plume	- Switch to RUD306B, replace - Replace	- Delay in operations - Release of H₂, possible ignition	IVc IVc
42	RUD 306B	Rupture disk--LH ₂ run dewar	- Ruptures below design point - Leak	Mechanical	- Loud noise, increased vent flow - Noise, ice, vapor plume	- Switch to RUD306A, replace - Replace	- Delay in operations - Release of H₂, possible ignition	IVc IVc
43	PSV 307	Pressure safety relief--LH ₂ run dewar	- Fails to open at set point - Leak	Mechanical	- PT 318 reads above range, activation of rupture disk - Noise, ice, vapor plume	- Open AOV 303, activation of rupture disk RUD306A or B - Repair/replace	- LH₂ run dewar over-pressure, activates rupture disk - Release of H₂, possible ignition	IVc, f IVc, f

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
44	CKV 310	Check valve--LH ₂ run dewar vent	- Fails to open - Fails to close	Mechanical	- Pressure PT 318 reads above expected range, activation of PSV 324A if AOV 303 is open - PT 318 reads below normal vent pressure	- Activation of PSV, open transfer line valve AOV 300 and 303 to reduce pressure - Backflow of air prevented by flare molecular seal	- Loss of normal vent capability - Reduced vent pressure, loss of redundancy in backflow protection	IVc, e IVf
45	HOV 318	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Release of H ₂ , possible ignition	IVc
46	PT 318/PI 318	Pressure transducer/indicator--LH ₂ run dewar	- Reads in error - Leak	Mechanical/Electrical	- Activation of PSV 307 - Noise, ice, vapor plume	- Activation of PSV 307 - Evaluate/repair	- Possible overpressure of the run dewar during purge - Release of H₂, possible ignition	IVc, f IVc
47	SOV 166	He purge valve--LH ₂ run dewar	- Transfers open - Fails closed - Leak	Mechanical/Electrical	- Limit switch, abnormal vent rate - Limit switch, no vent flow - Noise, gas jet	- Repair - Repair - Evaluate/repair	- Delay in operations - Inability to purge - Delay in operations	IVd, f IVe IVd
48	HOV 169	Isolation valve--vent purge for the LH ₂ run tank	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Delay in operations	IVd
48a	RUD 318	Rupture disk--LH ₂ run dewar	- Ruptures below design point - Leak	Mechanical	- Noise, increased vent flow - Noise, ice, vapor plume	- Replace - Replace	- Delay in operations - Release of H₂, possible ignition	IVc IVc

Table VI-19 FMEAs for the LH₂ Subsystem of the CCS (concluded)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
49	CKV 170	Check valve--vent-purge check for the LH ₂ run tank	• Fails to open • Fails to close	Mechanical	• No vent flow when HOV 169 is opened • Routine inspection	• Purge vent using AOV 305 and SOV 166 • Evaluate/repair	• Inability to purge vent using HOV 169 • Possible mixing of H₂ and He	IVf
50	CKV 186	Check valve--LH ₂ run dewar purge	• Fails to open • Fails to close	Mechanical	• No vent flow when SOV 166 is opened • Routine inspection	• Repair • Evaluate/repair	• Inability to purge LH₂ run dewar • Possible mixing of H₂ and He	IVe
51	Flare	Flare--LH ₂ run dewar vent stack	Flame is extinguished	Mechanical	Visual, TV camera	Repair	Delay in operations	IVf
52	LLE/LLA 328	Sensor/alarm--high-level LH ₂ run dewar	• Internal fault • Leak	Electrical/Mechanical	• Level sensor LLE 303 above normal range, AOV 303 fails to close, abnormal vent flare flow • Noise, ice, vapor plume	• Close AOV 300, repair • Evaluate/repair	• Delay in operations • Release of H₂, possible ignition	IVc, e

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	HOV 422	Isolation valve--high-pressure GN ₂ truck	- Leak - Fails to close	Mechanical	- Noise, gas jet - Stem position	- Evaluate/repair - Close tube manifold valves	- Delay in operations - Negligible	IVd IVf
2	PCV 423	High-pressure N ₂ regulator	- Fails closed - Leak	Mechanical	- No flow in the N₂ purge system - Noise, gas jet	- Replace - Evaluate/repair	- Inability to purge with N₂ - Possible delay in operations	IVe IVd
3	HOV 401	Shutoff valve--truck fill	- Fails to close - Leak	Mechanical	- Stem Position - Noise, ice, vapor plume	- Transfer to run dewar/truck - Evaluate/repair	- Delay of fill - Possible delay in operations	IVe IVd
4	PSV 417	Pressure safety relief--LN ₂ storage	- Fails to open - Leak	Mechanical	- PT 418 reads above expected range, activation of rupture disk - Noise, ice, vapor plume	- Open AOV 415, activation or rupture disk - Repair/replace	- Delay in operations - Delay in operations	IVd, f IVd, f
5	RUD 416	Rupture disk--LN ₂	- Ruptures below design point - Leak	Mechanical	- Loud noise, vent flow from rupture disk - Noise, ice, vapor plume	- Replace - Replace	- Delay in operations - Delay in operations	IVd, f IVd, f

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
6	AOV 415	Valve-LN ₂ storage vent	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Limit switch, transfer line does not cool down (TE 405) - Limit switch, inability to vent - Noise, ice, vapor plume	- Repair - Activation of PSV 417 - Evaluate/repair	- Inability to transfer LN₂ - Loss of normal vent capability - Possible delay in operations	IVf IVf IVd
7	HOV 418	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
8	PT 418/PI 418	Pressure transducer/indicator--LN ₂ storage	- Reads in error - Leak	Mechanical/ Electrical	- Activation of PSV 417 - Noise, ice, vapor plume	- Activation of PSV 417 - Evaluate/repair	- Delay in operations - Possible delay in operations	IVd, f IVd
9	HOV 414A	Isolation valve--LN ₂ level indicator	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
10	LI 414	Liquid-level gauge--LN ₂ storage	- Reads in error - Leak	Mechanical	- Amount of LN₂ in tank does not agree with amount transferred from fill truck, LN₂ flow observed from vent stack - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Possible overflow of LN₂ storage - Possible delay in operations	IVd, f IVd
11	HOV 414B	Isolation valve--level indicator	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
12	HOV 402	Shutoff valve--transfer line	- Fails to close - Leak	Mechanical	- Stem position - Noise, ice, vapor plume	- Close AOV 404, AOV 410, and HOV 409 - Evaluate/repair	- Transfer line fills during dewar fill - Possible delay in operations	IVf IVd, f
13	PSV 403A	Pressure safety relief--LN ₂ transfer line	- Fails to open - Leak	Mechanical	- AOV 404 limit switch, activation of PSV 403B - Noise, ice, vapor plume	- Open AOV 404, activation of alternate PSV 403B - Repair/replace	- Delay in operations - Delay in operations	IVd, e IVd
14	HOV 501	Valve--vacuum line connection for LN ₂ transfer line	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
15	PSV 403B	Pressure safety relief--LN ₂ transfer line	- Fails to open - Leak	Mechanical	- AOV 404 limit switch, activation of alternate PSV 403A - Noise, ice, vapor plume	- Open AOV 404, activation of alternate PSV - Repair/replace	- Delay in operations - Delay in operations	IVd, f IVd, f
16	AOV 404	Valve--LN ₂ transfer line/LN ₂ run dewar inlet	- Transfers open - Fails closed - Leak	Mechanical/ Electrical	- Limit switch, fails to close when ordered to close, LN₂ level above range, LN₂ flowing from vent - Limit switch, fails to open when ordered to open, LN₂ level below range - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Inability to control LN₂ level of LN₂ run dewar - Inability to fill LN₂ run dewar - Possible delay in operations	IVf IVe, f IVd

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
17	HOV 421A	Isolation valve--liquid-level gauge	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
18	LI 421	Liquid-level gauge--LN ₂ run dewar	- Reads in error - Leak	Mechanical	- LN₂ in tank does not agree with LLE 404 amount transferred from storage dewar; LN₂ flow observed from vent stack, LLA 412 alarm - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Possible overflow of LN₂ run dewar - Possible delay in operations	IVd, f IVd
19	HOV 421B	Isolation valve--liquid-level gauge	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
20	TE 405/TT 405	Temperature transducer/indicator--LN ₂ run dewar inlet	- Reads in error - Leak	Mechanical/Electrical	- Reads outside of expected range - Noise, ice, vapor plume	- Use run dewar level indicator - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
21	AOV 406	Valve--LN ₂ run dewar vent	- Fails open - Transfers closed - Leak	Mechanical/Electrical	- Limit switch - Limit switch, PT 419 reads above expected range, PSV 408 is activated - Noise, ice, vapor plume	- Repair - Activation of PSV 408 - Evaluate/repair	- Inability to transfer LN₂ from run dewar back to the storage dewar - Inability to vent, delay in operations - Possible delay in operations	IVe IVd

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
22	CKV 400	Check valve--LN ₂ run dewar vent	• Fails to open • Fails to close	Mechanical	• Pressure transducer PT 419 reads above expected range, PSV 408 is activated • Inability to maintain normal vent pressure	• Activation of PSV 408 • Evaluate/repair	• Loss of normal vent capability, delay in operations • Possible delay in operations	IVf IVf
23	RUD 407	Rupture disk--LN ₂ run dewar	• Ruptures below design point • Leak	Mechanical	• Loud noise, flow from rupture disk • Noise, ice, vapor plume	• Replace • Replace	• Delay in operations • Delay in operations	IVd, f IVd, f
24	PSV 408	Pressure safety relief--LN ₂ run dewar	• Fails to open • Leak	Mechanical	• Overpressure of LN₂ dewar, activation of rupture disk RUD 407 • Noise, ice, vapor plume	• Activation of rupture disk RUD 407, open AOV 406 • Repair/replace	• Delay in operations • Delay in operations	IVd, f IVd, f
25	HOV 419	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
26	PT 419/PI 419	Pressure transducer/indicator--LN ₂ run dewar	• Reads in error • Leak	Mechanical/Electrical	• Activation of PSV 408 • Noise, ice, vapor plume	• Open AOV 406, activation of PSV 408 • Evaluate/repair	• Delay in operations • Possible delay in operations	IVd, e IVd

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
27	SOV 165	He pressurization valve--LN ₂ run dewar	- Transfers open - Fails closed - Leak	Mechanical/ Electrical	- Limit switch, abnormal vent rate - Limit switch, inability to open - Noise, gas jet	- Repair - Repair - Evaluate/repair	- Loss of He, inability to fill LN₂ run dewar - Inability to transfer LN₂ from LN₂ run dewar to storage - Possible delay in operations possible	IVd, e IVf IVd
28	HOV 409	LN ₂ supply valve--vacuum-pump cold trap	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVc, d
29	LLE/LA 412	Sensor/alarm--high level LN ₂ run dewar	- Internal fault - Leak	Electrical/ Mechanical	- Level sensor LLE 404 above normal range, AOV 404 fails to close, LN₂ from vent stack - Noise, ice, vapor plume	- Close HOV 402, repair - Evaluate/repair	- Delay in operations - Possible delay in operations	IVd, e IVd
30	AOV 410	LN ₂ supply valve--He purifier	- Transfers open - Fails closed - Leak	Mechanical/ Electrical	- Limit switch, fails to close when ordered to close, LN₂ level above range, LN₂ flowing from vent - Limit switch, fails to open when ordered to open, LN₂ level below range - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Inability to control purifier LN₂ level - Inability to fill purifier with LN₂ - Possible delay in operations	IVf IVf IVd

Table VI-20 FMEAs for the LN₂ Subsystem of the CCS (concluded)

Item #	Identification from CVI Drawing No. F434-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
31	LLA/LLE 411	Sensor/alarm--high-level purifier LN ₂	- Internal fault - Leak	Electrical/ Mechanical	- Level sensor LLE 410 above normal range, AOV 410 fails to close, LN₂ from vent stack - Noise, ice, vapor plume	- Close HOV 402, repair - Evaluate/repair	- Delay in operations - Possible delay in operations	IVd, e IVd

Table VI-21 FMEAs for the He Subsystem of the CCS

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	HOV 167	Shutoff valve--high-pressure helium	• Leak	Mechanical	• Noise, gas jet • Stem position	• Evaluate/repair • Close tube manifold valves	• Possible delay in operations • Possible delay in operations	IVd IVf
2	PCV 162	High-pressure helium regulator	• Fails closed • Leak	Mechanical	• No increase in storage pressure when charging • Noise, gas jet	• Replace/repair • Evaluate/repair	• Delay of fill • Possible delay in operations	IVf IVd
3	PSV 178	Pressure safety relief--helium fill line	• Fails to open at set point • Leak	Mechanical	• Helium storage pressure PT 163 reads above expected range, activation of PSV 159 • Noise, gas jet	• Close HOV 167, activation of PSV 159 • Repair/replace	• Delay in operations • Delay in operations	IVd, f IVd
4	AOV 161	Fill valve--helium storage and system supply	• Fails open • Transfers closed • Leak	Mechanical/Electrical	• Limit switch, inability to fill He storage • Limit switch, increase in He storage pressure • Noise, gas jet	• Evaluate/repair • Close PCV 162 • Evaluate/repair	• Loss of fill capability • Blocks flow from He storage to He flow system • Possible delay in operations	IVf IVe IVd
5	HOV 160	Shutoff valve--helium storage	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
6	HOV 163	Isolation valve--pressure transducer	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
7	PT 163/ PI 163	Indicator--helium storage pressure	- Reads in error - Leak	Mechanical/ Electrical	- Activation of PSV 159 - Noise, gas jet	- Use PI 164 - Evaluate/repair	- Possible delay in operations - Possible delay in operations	IVd, f IVd
8	HOV 164	Isolation valve--pressure gauge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
9	PI 164	Pressure gauge--helium storage	- Reads in error - Leak	Mechanical	- Activation of PSV 159 - Noise, gas jet	- Use PI 163 - Evaluate/repair	- Delay in operations - Possible delay in operations	IVd, f IVd
10	PSV 159	Safety relief--helium storage	- Fails to open at set point - Leak	Mechanical	- Pressure increase above range, PT63 reads too high - Noise, gas jet	- Adjust PCV 162 setpoint pressure, activation of alternate PSV 178 - Repair/replace	- Delay in operations - Possible delay in operations	IVd, f IVd
11	HOV 500	Shutoff valve--helium storage vacuum	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
12	PCV 168	Pressure regulator--helium purge	- Fails closed - Leak	Mechanical	- No purge flow when SOV 165, SOV 166 opened - Noise, gas jet	- Repair - Evaluate/repair	- Delay of purge - Possible delay in operations	IVe IVd
13	HOV 158	Helium lab--sample valve	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
14	HOV 157	Shutoff valve--helium storage	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
15	HOV 100	Isolation valve--pressure transducer	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
16	PT 100/ PI 100	Pressure transducer/indicator--helium inlet/return line pressure	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, gas jet	- Multiple detectors, such as PI 163 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
17	AOV 101	Valve--helium system inlet	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- None, until recovery of helium to storage is required, limit switch - Limit switch, PI 103 reads low - Noise, gas jet	- Close AOV 161 - Repair - Evaluate/repair	- Inability to complete recovery to helium storage - Limits helium system pressure - Possible delay in operations	IVf IVe IVd
18	PSV 102	Pressure safety relief--recovery compressor/return heater inlet/return line	- Fails to open at set point - Leak	Mechanical	- Gradual increase in pressure of PI 103 - Noise, gas jet	- Open AOV 101 - Repair/replace	- Possible line rupture and release of small amount of He - Delay in operations	III d, e IVd
19	TI 104	Inlet temperature indicator--recovery compressor	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with TE 115 - Noise, gas jet	- Alternate detector TE 115 can be used - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
20	HOV 103	Isolation valve--pressure gauge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
21	PI 103	Recovery compressor inlet-- pressure gauge	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, gas jet	- Multiple detectors, such as PI 100 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
22	AOV 154	Bypass valve-- recovery compressor	- Fails in line - Transfers to bypass - Leak	Mechanical/ Electrical	- Limit switch, discharge pressure PI 106 above expected range - Limit switch, no pressure rise in compressor - Noise, gas jet	- Repair - Repair - Evaluate/repair	- Inability to bypass compressor - Inability to attain operating pressure - Possible delay in operations	IVe IVe IVd
23	PS 155	Limit switch-- recovery compressor, stage 2 bypass	- Open circuit - Closed circuit	Electrical	- AOV 155 limit switch, compressor discharge pressure PI 106 outside of expected range - AOV 155 limit switch, inability to attain operating pressure	- Repair - Repair	- Inability to bypass compressor high-pressure stage - Inability to attain operating pressure	IVe IVe
24	Comp 105A/105B	Recovery compressor	- Fails on - Transfers off - Head gasket or seal rupture/leak - Loss of cooling water	Mechanical/ Electrical	- Activation of PSV 108 - Inability to increase system pressure - Noise, gas jet - Outlet temperature TI 107 above normal range	- Turn off power - Repair - Repair - Repair	- Delay in operations - Inability to increase system pressure - Delay in operations - Delay in operations	IVe IVe IVd IVe

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
25	AOV 155	Bypass valve--recovery compressor, high-pressure stage	Fails in line • Transfers to bypass • Leak	Electrical/ Mechanical	- Limit switch, discharge pressure P 106 above expected range - Limit switch, inability to attain operating pressure - Noise, gas jet	- Repair - Repair - Evaluate/repair	- Inability to bypass high-pressure stage of compressor - Inability to attain operating pressure - Possible delay in operations	IVe IVe IVd
26	HOV 156	Shutoff valve--recovery compressor discharge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
27	HOV 106	Isolation valve--pressure gauge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operation	IVd
28	PI 106	Recovery compressor outlet--pressure gauge	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, gas jet	- Multiple detectors, such as PT 111 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
29	TI 107	Recovery compressor outlet--temperature indicator	- Reads in error - Leak	Mechanical/ Electrical	- Reads outside of normal range - Noise, gas jet	- Repair - Evaluate/repair	- Delay in operations - Possible delay in operations	IVf IVd
30	HOV 110	Sample port valve	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
31	PSV 108	Pressure safety relief--recovery compressor outlet	- Fails to open at set point - Leak	Mechanical	- PI 106 reads above range, position indicators of CV 111A, AOV 109 - Noise, gas jet	- Open AOV 109 - Repair/replace	- Possible time over-pressure - Delay in operations	IVf
32	AOV 109	Return valve--recovery helium storage	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Limit switch, PI 106 reads low - None, until recovery of helium to storage is required, limit switch - Noise, gas jet	- Close HOV 157 - Flow through AOV 119 and HOV 121 - Evaluate/repair	- Inability to increase line pressure - Inability to complete helium recovery to helium storage - Possible delay in operations	IVe IVf IVd
33	CV 111A/ I/P 111A	Discharge control valve--recovery compressor	- Transfers open - Fails closed - Leak	Mechanical/ Electrical	- Position indicator, increase in line pressure above range - Position indicator, inability to increase line pressure - Noise, gas jet	- Activation of PCV 114 - Activation of PSV 108 - Evaluate/repair	- Inability to control line pressure - Inability to attain line pressure - Possible delay in operations	IVe, f IVe IVd
34	PSV112	Pressure safety relief--main return loop	- Fails to open - Leak	Mechanical	- AOV 122/AOV 122 limit switches - Noise, ice, vapor plume	- Open AOV113 or AOV 122 - Repair/replace	- Line overpressure, possible rupture of inner line and activation of outer line pressure relief - Delay in operations	III, d, e IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
35	HOV 111	Isolation valve--pressure transducer of the main return loop	Leak	Mechanical		Evaluate/repair	Possible delay in operations	IVd
36	PT 111/ PIC 111	Pressure transducer/controller--main system loop	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Loss of system pressure control - Possible delay in operations	IVe IVd
37	AOV 113	Storage return valve	- Fails open - Transfers closed - Leak	Mechanical	- None, unless recovery compressor is used in series with circulating compressor during cool down, limit switch - Limit switch, loss of system flow - Noise, ice, vapor plume	- Cool down with circulating compressor only - Automatic shutdown - Evaluate/repair	- Possible increase in cool down time - Interrupts system flow - Possible delay in operations	IVf IVe IVd
38	CV 111B/ I/P 111B	Control valve--storage return	- Transfers open - Fails closed - Leak	Mechanical	- Position indicator, loss of system pressure - Position indicator, loss of system pressure control - Noise, ice, vapor plume	- Shutdown, recover helium to storage - Recovery flow manually through PCV 114 - Evaluate/repair	- Loss of system pressure - Loss of pressure control capability - Possible delay in operations	IVe IVe IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
39	PCV 114	Pressure regulator-- system overpressure	• Fails closed • Leak	Mechanical	• Pressure relief through pressure safety valves • Noise, ice, vapor plume	• Multiple pressure safety relief valves in parallel, use CV111B • Evaluate/repair	• Loss of redundancy in system-pressure control • Possible delay in operations	IVf IVd
40	HTR 115	Recovery heater	Internal fault	Mechanical/ Electrical	Low discharge temperature	Repair	Inability to use recovery compressor for helium return to storage	IVf
41	TES 115/ TS 115	Temperature transducer/safety switch--recovery heater	• Fails to close at set point • Fails closed	Electrical	• Heater temperature above high limits, requires coincident failure of controller TIC 115 • No response to temperature control	• Repair/replace • Repair/replace	• Possible burnout of heater • Inability to use heater	IVf IVf
42	TE 115/ TIC 115	Temperature transducer/con-troller-- recovery heater	• Open circuit • Short circuit • Leak	Electrical/ Mechanical	• No response to temperature control • Activation of safety switch TS 115 • Noise, gas jet	• Repair/replace • Repair/replace • Evaluate/repair	• Loss of automatic temperature control • Loss of heater capability • Possible delay in operations	IVf IVf IVd
43	AOV 122	Bypass valve-- purifier	• Fails open • Transfers closed • Leak	Mechanical/ Electrical	• None, unless during helium purification cycle, limit switch • Limit switch, loss of system flow • Noise, ice, vapor plume	• Repair • Recover helium to storage • Evaluate/repair	• Inability to use purifier • Loss of flow, auto-matic shutdown • Possible delay in operations	IVf IVe IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
44	AOV 116	Valve-- purifier inlet	• Transfers open • Fails closed • Leak	Mechanical/ Electrical	• Limit switch • Limit switch, inability to flow through purifier • Noise, ice, vapor plume	• None required unless during operation, close AOV 113 • Repair before purification is required • Evaluate/repair	• Possible unplanned admission of helium to purifier • Inability to use purifier • Possible delay in operations	IVf IVf IVd
45	HOV 180	Isolation valve-- purifier	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
46	HOV 117	Sample port valve	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
47	TE 118	Temperature transducer-- purifier	• Reads in error • Leak	Mechanical/ Electrical	• Regeneration sample analysis • Noise, ice, vapor plume	• Replace transducer • Evaluate/repair	• Abnormal purifier operation • Possible delay in operations	IVf IVd
48	PUR 181	Purifier bed/heat exchangers	• Leak • Rupture	Mechanical	• Noise, ice, vapor plume • Loss of line pressure, LN₂ flow from purifier vent	• Evaluate/repair • Replace purifier	• Possible delay in operations • Loss of purifier capability	IVd IVd, f
49	HTR 118	Heater purifier bed	Internal fault	Electrical	No response to temperature control	Replace	Inability to regenerate purifier	IVf
50	TIC 118	Temperature controller-- purifier heater	• Open circuit • Short circuit	Electrical	• No response to temperature control • Activation of high-temperature safety switch	• Repair/replace • Repair/replace	• Inability to regenerate purifier • Inability to operate purifier	IVf IVf

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F 434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
51	TES 118/ TS 118	Temperature transducer/safety switch--purifier heater	• Fails to close at set point • Fails closed	Electrical	• Bed temperature TE 118 above normal range; activation of PSV 120 if HOV 180, HOV 117, AOV 119, and HOV 121 are closed and controller TIC 118 fails • No response to temperature control	• Repair/replace • Repair/replace	• Delay in operations • Inability to regenerate purifier	IVd, f
52	HOV 121	Shut-off valve--purifier	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd
53	PSV 120	Safety relief valve--purifier	• Fails to open at set point • Leak	Mechanical	• Bed temperature TE 118 above LN₂ temperature when not regenerating bed • Noise, gas jet	• Open valve AOV 119 or HOV 121 • Repair/replace	• Line overpressure, possible line rupture • Delay in operations	IIIId, e
54	AOV 119	Discharge valve--purifier	• Transfers open • Fails closed • Leak	Mechanical/Electrical	• Limit switch • Limit switch, inability to flow through purifier • Noise, ice, vapor plume	• None required during accelerator operation • Repair before purification is required • Evaluate/repair	• Unplanned admission of helium to purifier • Inability to use purifier on system loop • Possible delay in operations	IVf
55	HOV 503	Shut-off valve--purifier vacuum purge	Leak	Mechanical	Noise, gas jet	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
56	PSV 123	Pressure safety relief--purifier/run dewars	- Fails to open - Leak	Mechanical	- Gradual increase in PI 124, limit switches of AOV 122, AOV 126, AOV 130, and CV 129 position indicator - Noise, ice, vapor plume	- Open AOV 122 or AOV 126 - Repair/replace	- Line overpressure, possible rupture of inner line and activation of outer line pressure relief - Delay in operations	III d, e IV d
57	HOV 124	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IV d
58	PT 124/ PI 124	Pressure transducer/indicator--run dewar inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Multiple detectors, such as PI 111 - Evaluate/repair	- Loss of information - Possible delay in operations	IV f IV d
59	TE 125/ TI 125	Temperature transducer/indicator--run dewar inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Multiple detectors, such as TI 152 - Evaluate/repair	- Loss of information - Delay in operations	IV f IV d
60	AOV 126	Valve--LN ₂ dewar inlet	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Routine valve exercise - Limit switch, inability to cool-down with LN₂ - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Inability to isolate LN₂ dewar heat exchanger - Disables LN₂ heat exchanger - Possible delay in operations	IV f IV f IV d

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
61	PSV 127A	Pressure safety relief--LN ₂ heat exchanger	• Fails to open • Leak	Mechanical	• Position indicators of AOV 126 and CV 128, activation of PSV 127B • Noise, ice, vapor plume	• Open AOV 126, activation of PSV 127B • Evaluate/repair	• Delay in operations • Possible delay in operations	IVd, f IVd
62	PSV 127b	Pressure safety relief--LN ₂ heat exchanger	• Fails to open • Leak	Mechanical	• Position indicators of AOV 126 and CV 126, activation of PSV 127A • Noise, ice, vapor plume	• Open AOV 126, activation of alternate PSV 127A • Repair/replace	• Delay in operations • Possible delay in operations	IVd IVd
63	NRT 425	LN ₂ heat exchanger	Leak/rupture	Mechanical	Rupture disk 407 ruptures, loss of flow, sudden drop in system pressure	Repair	Program delay	IIIId, e
64	CV 129/ I/P 129	Bypass control valve--run dewars	• Fails open • Transfers closed • Leak	Mechanical/ Electrical	• Position indicator, high-accelerator temperature • Position indicator, inability to warm up system • Noise, ice, vapor plume	• Repair • Repair • Evaluate/repair	• Circulation compressor inlet has a high temperature, automatic shut-down • Inability to maintain cool down temperature limits • Possible delay in operations	IVe IVf IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
65	CV 128/ I/P 128	Discharge control valve--LN ₂ heat exchanger	• Fails open • Transfers closed • Leak	Mechanical/ Electrical	• Position indicator, inability to control accelerator inlet temperature TI 148 during cool down • Position indicator, loss of flow • Noise, ice, vapor plume	• Repair • Repair • Evaluate/repair	• Inability to control cool down rate • Inability to use LN₂ run dewar • Possible delay in operations	IVe IVf IVd
66	AOV 130	Valve--LH ₂ heat exchanger inlet	• Fails open • Transfers closed • Leak	Mechanical/ Electrical	• Routine maintenance • Limit switch, loss of flow • Noise, ice, vapor plume	• Repair • Automatic shut-down, repair • Evaluate/repair	• Inability to isolate LH₂ run dewar • Disables LH₂ heat exchanger • Possible delay in operations	IVf IVe IVd
67	OSV 131A	Pressure safety relief--LH ₂ heat exchanger	• Fails to open • Leak	Mechanical	• Position indicators on AOV 130 and CV 132, activation of PSV 131B • Noise, ice, vapor plume	• Open AOV 130, activation of alternate PSV 131B • Repair/replace	• Delay in operations • Delay in operations	IVd, f IVd
68	PSV 131B	Pressure safety relief--LH ₂ heat exchanger	• Fails to open • Leak	Mechanical	• Position indicators of AOV 130 and CV 132, activation of PSV 131A • Noise, ice, vapor plume	• Open AOV 130, activation of alternate PSV 131A • Repair/replace	• Delay in operations • Delay in operations	IVd, f IVd
69	HRT 330	Heat exchangers	Rupture (see accident analysis)	Mechanical	Noise, rupture disk RUD 306A or B ruptures, loss of flow	Repair	Program delay	III d, e

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
70	CV 132/ IP 132	Discharge control valve--LH ₂ heat exchanger	• Fails open	Mechanical/ Electrical	• Position indicator, inability to warm up	• Normally open during accelerator operation, close AOV 130 to warm up	• Inability to maintain cool down temperatures within limits	IVf
			• Transfers closed		• Position indicator, high circulation compressor inlet temperature	• Automatic shut-down if during accelerator operations, repair	• Disables LH ₂ heat exchanger	IVe
			• Leak	Mechanical	Noise, ice, vapor plume	• Evaluate/repair	• Possible delay in operations	IVd
71	HOV 133	Isolation valve--pressure transducer	Leak	Mechanical	• Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
72	PT 133/ PI 133	Pressure transducer/indicator--circulation compressor inlet	• Read in error	Mechanical/ Electrical	• Does not agree with other line pressures	• Multiple detectors, such as PT 124	• Loss of information	IVf
			• Leak		• Noise, ice, vapor plume	• Evaluate/repair	• Possible delay in operations	IVd
73	TE 134/ TI 134	Temperature transducer/indicator--circulation compressor inlet	• Read in error	Mechanical/ Electrical	• Does not agree with other line pressures	• Multiple detectors, such as TE 138	• Loss of information	IVf
			• Leak		• Noise, ice, vapor plume	• Evaluate/repair	• Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
74	PSV 135	Pressure safety relief--compressor inlet line	• Fails to open • Leak	Mechanical	• Gradual increase in line pressure PI 133; AOV 139, CV 128, CV 129, and CV 132 all in closed position • Noise, ice, vapor plume	• Open AOV 139 • Repair/replace	• Line overpressure, possible rupture of inner line and activation of outer line pressure relief • Delay in operations	III d, e IV d
75	CCP 136	Circulation compressor	• Controller malfunction or loss of power • Shaft seizes • Pump casing cracks	Mechanical/ Electrical	• Sudden drop in speed and flow rate • Sudden drop in speed and flow rate • Sudden drop in line pressure, automatic shutdown, ice on cold box, activation of cold-box pressure relief	• Repair • Repair • Repair	• Delay in operations • Program delay • Program delay	IV e III e III d, e
76	HOV 137	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Possible delay in operations	IV d
77	PT 137/ PI 137	Pressure transducer/indicator--circulation compressor outlet	• Reads in error • Leak	Mechanical/ Electrical	• Does not agree with other line pressures • Noise, ice, vapor plume	• Multiple detectors, such as PI 147A and PI 144 • Repair	• Loss of information • Delay in operations	IV f IV d

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
78	TE 138/ TI 138	Temperature transducer/indicator-circulation compressor outlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line temperatures - Noise, ice, vapor plume	- Multiple detectors, such as TI 148 and TI 150 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
79	AOV 141	Valve--warm-up heater inlet	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Routine valve exercise - Limit switches, gradual increase in heater line temperature - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Inability to isolate heater - Loss of heater capability - Possible delay in operations	IVe IVf IVd
80	PSV 142	Pressure safety relief--warm-up heater	- Fails to open - Leak	Mechanical	- AOV 141 limit switch; gradual increase in line pressure PI 144 - Noise, ice, vapor plume	- Open AOV 141 or HOV 145 - Repair/replace	- Line overpressure, possible rupture of inner housing of the heater and activation of the vacuum-jacket pressure relief - Delay in operations	IIIId, e IVd, f
81	HTR 143	Warm-up heater	Internal fault	Mechanical/ Electrical	Inability to use heater	Repair	Delay in operations	IVe
82	TES 143/ TS 143	Temperature transducer/safety switch--warm-up heater outlet	- Fails to close at set point - Leak	Electrical	- Does not agree with other line temperatures - Noise, ice, vapor plume	- Multiple detectors, such as TE 148 and TE 150 - Evaluate/repair	- Loss of automatic temperature control - Possible delay in operations	IVf IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
83	TIC 143	Temperature indicator controller--warm-up heater	Internal fault	Electrical	Inability to control temperature, possible activation of high temperature safety switch	Repair	Delay in operations	IVe
84	TE 143	Temperature transducer--heater outlet	- Reads in error - Leak	Electrical/ Mechanical	- Does not agree with TE 148, activation of safety switch TS 143 - Noise, ice, vapor plume	Repair Evaluate/repair	- Delay in operations - Possible delay in operations	IVe IVd
85	AOV 139	Bypass valve--warm-up heater	- Fails open - Transfers closed - Leak	Mechanical/ Electrical	- Routine valve exercise - Limit switch, small decrease in flow - Noise, ice, vapor plume	- Repair - Repair - Evaluate/repair	- Delay in operations - All flow is through heater - Possible delay in operations	IVe IVf IVd
86	PSV 140	Pressure safety relief--main supply line	- Fails to open - Leak	Mechanical	- Gradual increase in line pressure, PT 147A, AOV 139, CV 147, and CV 151 all in closed position - Noise, ice, vapor plume	- Open AOV 139 - Repair/replace	- Line overpressure, possible rupture of inner line and activation of outer line pressure relief - Delay in operations	IIIId, e IVd, f
87	HOV 144	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
88	PT 144/ PI 144	Pressure transducer/indicator--warm-up heater outlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Multiple detectors, such as PT 137 and PT 147A - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
89	FE/FT 146	Flow meter--total flow	- Reads in error - Leak	Mechanical/ Electrical	- Erratic behavior, reading outside of predicted range - Noise, ice, vapor plume	- Multiple detectors, such as FE 149 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
90	TE 148/ TI 148	Temperature transducer/indicator--bypass inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line temperatures - Noise, ice, vapor plume	- Multiple detectors, such as TE 138 and TE 150 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
91	HOV 147A	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
92	PT 147A/ PI 147A	Pressure transducer/indicator--upstream bypass	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Multiple detectors, such as PT 137 and PT 144 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (continued)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
93	CV 147/ I/P 147	Control valve-- load bypass	- Transfers open - Falls closed - Leak	Mechanical/ Electrical	- Position indicator, reduced flow to accelerator, automatic shutdown - Position indicator, increased flow to accelerator - Noise, ice, vapor plume	- Repair - Balance flow with CV 151 - Evaluate/repair	- Delay in operations - Loss of automatic pressure-drop control - Possible delay in operations	IVe IVf IVd
94	FE/FT 149	Flow meter--load flow	- Reads in error - Leak	Mechanical/ Electrical	- Erratic behavior, does not agree with sum of accelerator flows, automatic shutdown - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Loss of information - Possible delay in operations	IVe IVd
95	TE 150	Temperature transducer--load inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with other line temperatures - Noise, ice, vapor plume	- Multiple detectors, such as TE 148 and TE 138 - Evaluate/repair	- Loss of information - Possible delay in operations	IVf IVd
96	CV 151/ I/P 151	Control valve-- load adjustment	- Transfers open - Falls closed - Leak	Mechanical/ Electrical	- Position indicator, reduced flow to accelerator - Position indicator, increased flow to accelerator - Noise, ice, vapor plume	- Automatic shutdown, repair - Balance flow with CV 147 - Evaluate/repair	- Reduced flow to accelerator - Increased flow to accelerator - Possible delay in operations	IVe IVf IVd

Table VI-21 FMEAs for the He Subsystem of the CCS (concluded)

Item #	Identification from CVI Drawing No. F434-0200-0201	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
97	HOV 147B	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Possible delay in operations	IVd
98	PT 147B	Downstream bypass--pressure transducer	- Reads in error - Leak	Mechanical/Electrical	- Does not agree with other line pressures - Noise, ice, vapor plume	- Multiple detectors, such as PI 111 - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
99	PSV 153	Pressure safety relief--main return line	- Fails to open - Leak	Mechanical	- Gradual increase in pressure PT 147B, AOW 113 limit switch, CV 151 position indicator - Noise, ice, vapor plume	- Open AOV 113 - Repair/replace	- Line overpressure, possible rupture of inner line and activation of outer line pressure relief - Possible delay in operations	III d, e IVd

The highest hazard category for each of the subsystems that resulted from this analysis are as follows.

- LH₂ subsystem: Category IV - Negligible
- LN₂ subsystem: Category IV - Negligible
- GHe subsystem: Category III - Marginal

FMEAs for the worst-case accident scenarios are analyzed in Chapter 7.

The FMEA does not include rupture as a possible failure for valves, because the rupture of a valve from overpressure is not considered a credible failure. The pressure rupture of cryogenic-piping assemblies, including valves, would be in the bayonet section of the piping and not in the valves, according to information supplied by CVI. The type of cryogenic valves specified for the CCS have been pressure tested to 7,000 psi, without rupture. This pressure is greater than the highest pressure calculated for the CSS from warming a trapped volume GHe at 20 K to ambient temperature. The consequences of possible ruptures of the cryogenic piping are considered separately in Chapter 7.

Failure for the cryogenic pressure-relief safety valves is failure to open. While such a failure is not likely, an undiscovered leak a cryogenic lines in relief valve could result in the formation of ice; the ice may then freeze the valve, making it inoperable. During periods when the valves are removed, a continuous purge flow of GHe at low pressure will be supplied to ensure that no air enters the system. Pressure-relief safety valves protect a line section or a storage vessel from an operator error, or other mechanical failure, which could isolate the line or vessel from its normal pressure and environment when the CCS is shut down. A heat leak into this isolated element will cause a gradual increase in pressure, which, if not detected, will require a safety relief to prevent the overstress or possible rupture of the element. The pressure-relief valve settings have been chosen to be within the American Society of Mechanical Engineers (ASME) Section VIII requirements and are listed in Chapter 11, Table XI-2. During operation of the CCS, the loss-of-power failure modes for the remote cryogenic valves in the CCS have been chosen to prevent such isolation from occurring. These are also the system shutdown modes. Most of the remote cryogenic valves fail open. Exceptions are the LH₂ transfer line inlet valve, the LN₂ transfer line valves, and the helium-control valves between the main cryogenic flow loop and the helium recovery storage tank, which fail closed.

Rupture disks are installed parallel to pressure-relief safety valves on the cryogenic storage dewars. The pressure settings of the rupture disks are listed in Chapter 11, Table XI-2. These

disks backup the relief valves. Two safety relief valves are installed for redundancy in each LH₂ line section that could trap hydrogen. In less critical areas, a single safety pressure-relief valve is provided in each line section that might be isolated by inadvertent valve closure. In addition, pressure transducers are available with limit warnings to detect the gradual increase in pressure that would occur from a heat leak in a section of isolated line, and a valve can be opened to relieve the pressure buildup before the pressure-relief safety valve is activated.

In the course of the earlier FMEA, a few cases showed the possible consequences of a human error coupled with a pressure-relief safety valve failing to open. Even though this event is highly unlikely, backup relief valves are now provided. These backup valves are primarily on the LH₂ transfer and truck fill lines and on the helium heat exchanger lines to the run dewars. In these cases, additional pressure-relief safety valves are provided on each of these lines. A pressure-relief safety valve is also provided in the helium fill line to backup the safety pressure-relief valve on the helium storage tank. While cryogenic temperatures are not involved in the use of this tank and while the possible failure postulated for a cryogenic pressure-relief safety valve is not applicable, the tank is filled from a 2,000 psi tube trailer and could overpressure by an incorrect procedure in the fill operation. The updated FMEA presented here includes these additional relief valves.

Failures that involve the release of helium or nitrogen within an enclosed space, such as the equipment room or tunnel, fall in the Class IV hazard category. They do not present an asphyxiation hazard, because the release rates and quantities are small and oxygen monitors provide personnel protection.

6.2.5 Cryogenic Cooling Distribution Manifold Subsystem

This section covers the FMEA of the cryogenic cooling distribution manifold subsystem in the accelerator tunnel. This subsystem connects the main He coolant loop of the CCS to the accelerator and provides accelerator cooling.

Table VI-22 presents the FMEA and criticality rating for each item of the manifold subsystem. The identifiers in this table are shown in Fig. 4-60.

As explained in Section 6.2.4, most of the remotely operated valves in the CCS fail open when electrical power is lost. However, the loss-of-power failure mode chosen for the remotely operated valves in the manifold subsystems is for the valves to fail closed. The reason for this choice is to provide isolation between the CCS and the accelerator during normal shutdown

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	CV 188/ 1/P 188	Inlet control valve-- IMS/RFQ	- Transfer open - Fails closed - Leak	Mechanical/ Electrical	- Position indicator, increase in FE 193 above range - Loss of flow in FE 193 - Noise, ice, vapor plume	- Shutdown/repair - Automatic shutdown - Evaluate/repair	- Inability to control IMS/RFQ flow, DTL temp. above range - Inability to cool IMS/RFQ - Delay in operations	IVe, f IVe, f IVd
2	TE 190	Temperature transducer--IMS/RFQ inlet	- Reads in error - Leak	Electrical/ Mechanical	- Does not agree with TE 200, TE 208 - Noise, ice, vapor plume	- Use TE 200 - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
3	PSV 191	Pressure safety relief--IMS/RFQ inlet	- Fails to open at set point - Leak	Mechanical	- Gradual increase in PI190, PI193 - Noise, ice, vapor plume	- Activation of PSV 192 or PSV 197 - Evaluate/repair	- Delay in operation - Delay in operations	IVd IVd
4	HOV 190	Isolation valve--Pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Delay in operations	IVd
5	PI 190	Pressure Indicator IMS/RFQ inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with PI 200, PI 208 - Noise, ice, vapor plume	- Multipole detectors, PI 200, PI 208 - Repair	- Loss of information - Delay in operations	IVf IVd
6	HTR 194	Heater--RFQ Inlet	Internal Fault	Electrical	Inability to control discharge temperature	Repair, if heater is needed	Possible degradation of accelerator performance	IVf

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (continued) II

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
7	TE 194	Temperature, RFQ transducer, RFQ heater discharge	- Reads in error - Leak	Electrical/ Mechanical	- Is not consistent with TE 193 reading - Noise, ice, vapor plume	- Manual control using TE 193/repair - Evaluate/repair	- Loss of automatic heater control - Delay in operations	IVf IVd
8	PSV 197	Pressure safety relief--RFQ inlet	- Fails to open at set point - Leak	Mechanical	- Gradual increase in PI 190 and PI 193 - Noise, ice, vapor, plume	- Activation of PSV 191 or PSV 192 - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd
9	FE/FT 193	Flow meter--IMS/RFQ	- Reads in error - Leak	Mechanical/ Electrical	- Erratic behavior, reading outside of operating range - Noise, ice vapor plume	- Determine flow rate by difference using FE 149, FE 200, and FE 210 - Evaluate/repair	- Loss of information - Delay in operations	IVc IVd
10	TE 193	Temperature transducer--RFQ discharge	- Reads in error - Leak	Electrical/ Mechanical	- Reading is outside of expected range - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
11	PSV 192	Pressure safety relief--RFQ discharge	- Fails to open at set point - Leak	Mechanical	- Gradual increase PI 192 and PI 190 - Noise, ice, vapor plume	- Activation of PSV 191 or PSV 197 - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd
12	HOV 193	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Evaluate/repair	Delay in operations	IVd

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (continued) II

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
13	PT/PI 193	Pressure indicator	- Reads in error - Leak	Electrical/ Mechanical	- Does not agree with PI 202 and PI 204 - Noise, ice, vapor plume	- Multiple detectors, PI 202, PI 204 - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
14	AOV 189	Valve--RFQ discharge	- Fails open - Fails closed - Leak	Mechanical/ Electrical	- Routine maintenance, limit switch position - Loss of flow - Noise, ice, vapor plume	- Repair - Automatic shutdown, repair - Evaluate/repair	- Delay in operations - Delay in operations - Delay in operations - Delay in operations	IVf IVe, f IVd
15	PSV 195	Pressure safety relief--GTA inlet line	- Fails to open at set points - Leak	Mechanical	- Gradual increase in PI 147A - Noise, ice, vapor plume	- Activation of PSV 140 or others - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd
16	PSV 196	Pressure safety relief--GTA return line	- Fails to open at set points - Leak	Mechanical	- Gradual increase in PI 147B - Noise, ice, vapor plume	- Activation of PSV 153 or others - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd
17	CV 198/ IP 198	Control valve--DTL-1 inlet	- Transfers open - Fails closed - Leak	Mechanical/ Electrical	- Position indicator, increase in FE 200 above range - Loss of flow in FE 200 - Noise, ice, vapor plume	- Shutdown/repair - Automatic shutdown - Evaluate/repair	- Delay in operations - Delay in operations - Delay in operations	IVe, f IVe, f IVd

Changed per DOE/AL Comments
October 5, 1994

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (continued) II

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
18	TE 200	Temperature transducer--DTL-1 inlet	- Reads in error - Leak	Electrical/ Mechanical	- Does not agree with TE 190, TE 208 - Noise, ice, vapor plume	- Use TE 208 - Evaluate/repair	- Loss of information - Delay in operations	IVc IVd
19	PSV 201	Pressure safety relief--DTL-1 inlet	- Fails to open at set point - Leak	Mechanical	- Gradual increase in PI 201 and PI 202 - Noise, ice, vapor plume	- Activation of PSV 203 - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd
20	HOV 200	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Delay in operations	IVd
21	PI 200	Pressure indicator--DTL-1 inlet	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with PI 190, PI 208 - Noise, ice, vapor plume	- Multiple detectors--PI 190, PI 208 - Repair	- Loss of information - Delay in operations	IVf IVd
22	FE/FT 200	Flow meter--DTL-1	- Reads in error - Leak	Mechanical/ Electrical	- Erratic behavior, reading outside of operating range - Noise, ice, vapor plume	- Determine flow rate by difference using FE 149, FE 197, and FE 210 - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
23	TE 202	Temperature transducer--DTL-1 discharge	- Reads in error - Leak	Mechanical/ Electrical	- Reading is outside expected range - Noise, ice, vapor plume	- Repair - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd
24	PSV-203	Pressure safety relief--DTL-1 discharge	- Fails to open at set point - Leak	Mechanical	- Gradual increase in PI 202 and PI 200 - Noise, ice, vapor plume	- Activation of PSV 201 - Evaluate/repair	- Delay in operations - Delay in operations	IVd IVd

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (continued) II

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
25	HOV-202	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Delay in operations	IVd
26	PI 202	Pressure indicator DTL-1 discharge	- Reads in error - Leak	Mechanical/Electrical	- Does not agree with PI 193 and PI 204 - Noise, ice, vapor plume	- Multiple detectors, PI 193 and PI 204 - Repair	- Loss of information - Delay in operations	IVf IVd
27	AOV	Valve--DTL-1 discharge	- Fails open - Fails closed - Leak	Mechanical/Electrical	- Routine maintenance, limit switch - Loss of flow - Noise, ice, vapor plume	- Repair - Automatic shutdown repair - Evaluate/repair	- Delay in operations - Delay in operations - Delay in operations	IVf IVe, f
28	CV 207/ IP 207	Control valve--DTL-Z inlet	- Transfers open - Fails closed - Leak	Mechanical/Electrical	- Position indicator increase in FE 210 above range - Loss of flow in FE 210 - Noise, ice, vapor plume	- Shutdown/repair - Automatic shutdown repair - Evaluate/repair	- Delay in operations - Delay in operations - Delay in operations	IVe, f IVe, f
29	TE-208	Temperature transducer--DTL-2 inlet	- Reads in error - Leak	Mechanical/Electrical	- Does not agree with TE 190, TE 200 - Noise, ice, vapor plume	- Use TE 200 - Evaluate/repair	- Loss of information - Delay in operations	IVf IVd

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (continued)

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
30	PSV-209	Pressure safety relief--DTL-2 inlet	• Fails to open at set point • Leak	Mechanical	• Gradual increase in PI 208 • Noise, ice, vapor plume	• Activation of PSV 205 • Evaluate/repair	• Delay in operations • Delay in operations	IVd IVd
31	HOV-208	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Delay in operations	IVd
32	PI-208	Pressure indicator DTL-2 inlet	• Reads in error • Leak	Mechanical/ Electrical	• Does not agree with PI 190, PI 200 • Noise, ice, vapor plume	• Multiple detectors, PI 190 and PI 200 • Repair	• Loss of information • Delay in operations	IVf IVd
33	FE/FT 210	Flow meter--DTL-2	• Reads in error • Leak	Mechanical/ Electrical	• Erratic behavior, reading outside of operating range • Noise, ice, vapor plume	• Determine flow rate by difference, using FE 149, FE 19, and FE 200 • Evaluate/repair	• Loss of information • Delay in operations	IVe, f IVd
34	TE 204	Temperature transducer--DTL-2 discharge	• Reads in error • Leak	Mechanical/ Electrical	• Reading outside of expected range • Noise, ice, vapor plume	• Repair • Evaluate/repair	• Loss of information • Delay in operations	IVf IVd
35	PSV-205	Pressure safety relief--DTL-2 discharge	• Fails to open at set point • Leak	Mechanical	• Gradual increase in PI 204, PI 208 • Noise, ice, vapor plume	• Activation of PSV 209 • Evaluate/repair	• Delay in operations • Delay in operations	IVd IVd
36	HOV-204	Isolation valve--pressure transducer	Leak	Mechanical	Noise, ice, vapor plume	Repair	Delay in operations	IVd, f

Table VI-22 FMEAs for the He Distribution Subsystem Manifold of the CCS (concluded) II

Item #	Identification from Fig. 4-60	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
37	DI-204	Pressure indicator	- Reads in error - Leak	Mechanical/ Electrical	- Does not agree with PI 193, PI 202 - Noise, ice, vapor plume	- Multiple detectors, PI 193 and PI 202 - Repair	- Loss of information - Delay in operations	IVf IVd
38	AOV 206	Valve--DTL-2 discharge	- Fails open - Fails closed - Leak	Mechanical/ Electrical	- Routine maintenance limit switch - Loss of flow - Noise, ice, vapor plume	- Repair - Automatic shutdown - Evaluate/repair	- Delay in operations - Delay in operations - Delay in operations	IVf IVc, f IVd

periods without the requirement for electrical power to the valve operators to permit work on the accelerator without allowing air to enter and mix with the main volume of He in the CCS. Overpressure protection in the manifold subsystem following a loss-of-power shutdown is provided by redundant pressure-relief safety valves. During normal shutdown and warmup operations, warm He from the CCS will be circulated through the accelerator and manifold subsystem, so no increase in pressure will result after shutdown.

The FMEA for the He distribution manifold subsystem revealed no failure modes that would exceed Category IV, a negligible hazard ranking.

6.3 Support Operations/Off-line Test Equipment

6.3.1 HPCTB

The failure modes associated with HPCTB pertain to the equipment being tested and the sub-systems (e.g., cryogenics, vacuum, RF power, etc.) connected to the test chamber rather than the vessel itself.

6.3.2 750-W Refrigerator

The Model 1620 Helium Refrigerator is perhaps the most reliable machine of its type. The concept for its design comes from years of experience in operating similar units and from the various improvements in their designs. Throughout the years their types of failures, their probable causes, and their corrective steps have been accumulated and documented. Information from Koch Process Systems, Inc., which has been designing, building, and operating helium refrigerators for many years, was used in determining failure modes for this refrigerator.

Key factors to trouble-shooting the refrigerator are the operator's experience with the system and the log sheets that are kept while the system is properly operating. By becoming accustomed to the normal sound levels and operating characteristics of the refrigerator, the operator is able to recognize deviations from normal operations. Routine inspections of the equipment and tests of capacity also allow the operator to discover minor degradations of performance before serious difficulties arise. A FMEA for the 750-W refrigerator is not included because failure modes for the refrigerator are normal industrial failures.

6.4 GTA Safety Systems and Other Systems

The GTA safety systems include:

- shielding;
- radiation personnel safety system (RPSS);
- run-permit system;
- fast-protect system;
- fire protection;
- beam-tunnel ventilation system;
- emergency power to component systems;
- telephone;
- cranes and forklifts;
- oxygen monitors;
- hydrogen monitors; and
- accelerator-cooling components.

6.4.1 Shielding

While the facility was designed to shield employees and the public from radiation generated in the tunnel during operations, several potential failure modes exist. These modes would permit radiation to escape from the tunnel or could result in personnel radiation exposure after operations. The former could result from an unintentional reduction in the portable concrete shielding in the truck accesses or steel-door entry or unauthorized plug-door operation. The latter could result from the failure of the RPSS or HS monitoring systems, which would allow personnel to enter the beam tunnel before activation is reduced to permissible levels.

The tunnel shielding was designed to permit operation at 100 MeV, much higher than operation at 24 MeV. Eight-ft-thick concrete walls between the tunnel and the high bay and outside areas plus 18 ft of tamped tuff over the tunnel are intended to protect personnel from radiation generated in the tunnel during operations. Accesses to the tunnel for large equipment were built into the tunnel wall. These consist of two truck-access doors, one personnel-access steel door, three plug doors, and an access hatch in the tunnel roof. (See Fig. 4-4.) The truck-access door, steel door, and the hatch cover will have to be sealed with ~4.5 ft of high density, interlocking concrete blocks to complete the tunnel shielding envelope during 24-MeV operations.

Other potential failure modes in the tunnel shielding envelope are unanticipated opening or closing of the plug doors. In addition to creating a perturbation in the shielding, such a condition could permit activated air to diffuse from the tunnel to other areas.

Once the accelerator has stopped operating, residual activity remains in the beam line for some time. Local shielding is used to reduce air activation and to permit faster access to the tunnel. Unanticipated changes in this shielding could result in higher than anticipated local activity and, therefore, constitute a failure mode.

The FMEAs for these situations is given in Table VI-23. Refer to Fig. 4-4 for identification of the areas of concern.

6.4.2 Radiation Personnel Safety System

The RPSS consists of an access-control system that is intended to prevent unauthorized or accidental entry into areas where the radiation dose rate, due to normal operation of the accelerator, could exceed 5 rem/hr. Elements of this system include physical barriers, signs, warning lights, audible-warning devices, and a body of administrative procedures that define conditions for safe entry and lockup. (See Appendix T).

The FMEA is presented in tables VI-24 through VI-27. Figure 6-4 provides a visual description of the RPSS.

Table VI-23 FMEAs for Tunnel Shielding Envelope

Item #	Identification from Fig. 4-4	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
	Door P	Tunnel shielding plug doors	• Doors fail to close	• Mechanical/Electrical	• Radiation detectors located outside door	• Pre startup inspections; RPSS; shutdown accelerator; repair	• Possible personnel exposure to radiation	IIIc
			• False open signal given during operations	• Electrical	• Radiation detectors located outside door	• Pre startup inspections; RPSS; shutdown accelerator; repair	• Possible personnel exposure to radiation	IIIc
			• Door closes without notice	• Mechanical/Electrical	• Visual	• Pre startup inspections; RPSS; repair	• Possible personnel injury	IVe
	Doors P, R, S	Stacked shielding in doors, wave guide tunnel	• Stacking not to specifications	• Mechanical	Radiation detectors located outside stacked shielding	Shutdown accelerator; add stacking	Possible personnel exposure to radiation	IIIc
		Local component shielding in tunnel	• Stacking not to specifications	• Mechanical	Radiation detectors in tunnel. Entrance to tunnel will be preceded by personnel sweep.	Limit access until appropriate cooling period is completed	Possible personnel exposure to radiation	IIIc

Table VI-24 FMEAs for Radiation Personnel Safety System

Item #	Identification from Drawing No. 94Y-222930	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Door limit switch	Prevent inadvertent entry into exclusion area during beam or RF operation	RPSS fails to trip when the exclusion area door opens	Mechanical	Detected during periodic testing	Kirk key and lock system prevents door opening without active participation of control-room operator	No effect if this is the only failure of the system	IVf
2	Hatch limit switch	Prevent inadvertent entry into exclusion area during beam or RF operation	Hatch limit switch fails to open when hatch opens	Mechanical	Detected during periodic testing	Kirk key and lock system prevents opening without active participation of control-room operator	No effect if this is the only failure of the system	IVf
3	Scram button	Shuts down operations to ensure that no person is in the exclusion area (beam tunnel and underlying basements)	Fails to shut down the accelerator	Mechanical/ Electrical	Detected during periodic testing	Other scram switches are located nearby; doors can always be opened from inside exclusion area; opening any door, gate, or hatch will also shut down the accelerator	No effect if this is the only failure of the system	IVf
4	Sweep reset switch	Acknowledge that area has been swept	Sweep reset switch fails	Mechanical/ Electrical	Detected during periodic testing	None	Sweep procedure cannot be completed	IVf

Table VI-24 FMEAs for Radiation Personnel Safety System (concluded)

Item #	Identification from Drawing No. 94Y-222930	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
5	Horn	Warn that sweep is in progress	Failure of a warning horn	Electrical	Detected during periodic testing	Two other horns in tunnel provide backup	No effect if this is the only failure	IVf
6	Strobe	Warn that sweep is in progress	Failure of a flashing red strobe light	Electrical	Detected during periodic testing	Two other strobe lights and illuminated signs in tunnel provide backup; illuminated signs provide backup outside entry doors	No effect	IVf

Table VI-25 FMEA for RPSS-Injector Interface

Item #	Identification from Drawing No. 94Y-222923	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	LEBT beam plug	Shuts off beam if excessive neutron levels are detected outside, exclusion area	• Beam plug does not insert into LEBT when RPSS trips	• Electrical/ Mechanical	• Detected during periodic testing	• RPSS turns off all RF high voltage and trips run permit, which turns off extractor pulse	• No effect if this is the only failure of the system	IVf

Table VI-26 FMEA for RPSS-RF Power Interface

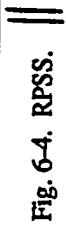
Item #	Identification from Fig. 4-39	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Criticality Ranking
1	RF high-voltage supply	Supplies RF power to accelerator	• An RF high-voltage supply does not trip off when RPSS trips	• Electrical	• Detected during periodic testing	• RPSS turns off other RF high-voltage systems and inserts a beam plug in LEBT	• No effect if this is the only failure of the system IVf

Table VI-27 FMEAs for RPSS Electrical

Item #	Identification from Fig. 6-4	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Power supply	Provide power for system	• Loss of ac or dc power	• Electrical	• LEBT beam plug inserts and RF shuts off	• Normally open relay contacts open on power loss	• Interrupts accelerator operation; no safety effect	IVf
2	Sweep reset switch	Acknowledge that sweep has been completed	• Open circuit or short to ground in RPSS wiring	• Electrical/ Mechanical	• Accelerator is shut down	• Fails safe because relay coils are de-energized and opened contacts cause accelerator shutdown	• No safety effect	IVf

Table VI-28

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6.4.3 Run-permit System

Run permit is a software interlock chain, augmented in hardware, that protects equipment from damage due to improper operation. Run permit uses the facilities of the GTA control system to obtain inputs for the interlocks. The system provides self-protection from failures in software, computer hardware, and local area network. A watchdog timer is the only critical hardware element in the fast protect system. FMEAs for the run-permit system are in Table VI-29.

6.4.4 Fast-Protect System

The fast-protect system truncates the ion beam at the injector within 10 μ s of a failure that could cause beam spill and terminates the RF power. Its purpose is to prevent damage or activation of beam line components. The fast-protect system is distributed throughout the accelerator and has inputs from various detectors and sources, such as beam spill monitors, low-level RF controls, and beam diagnostics. High reliability is achieved from dual redundancy on inputs and from fail-safe circuitry. The system consists of one FP10M master module followed by a number of FP10S slave modules in a daisy-chain configuration. The output from the last FP10S ends in the safety interlock module, where it controls the injector extractor pulse.

The switch settings are read and verified by software programs running on the control system. However, fast protect operates independent of computer equipment and software. FMEAs for the fast-protect system are in Table VI-30.

6.4.5 Computer Control Network

The computer control network is an Ethernet local area network that provides communications between all control system computers. Fiber-optic cables are used throughout the network to reduce EMI effects on the network. A file server machine provides all the files for operating the control system computers, including the input-output controllers (IOCs) and the operator interface (OPI) consoles. The network is described in "AT Division L&Q Secure Network Logical Diagram," (Group AT-8, 16 December 1991). Table VI-31 shows the FMEAs for the Computer Control network.

6.4.6 Input-Output Controllers

Control and data acquisition computers are distributed throughout the GTA facility in IOCs. Functional, instead of geographical, distribution of the IOCs simplifies the design and maintenance of control-system software and allows independent operation of GTA subsystems and components. Each IOC contains a central processor unit (cpu), Ethernet interface, and various input-output

Table VI-29 FMEAs for the Run-permit System

Item #	Identification from Drawing No.	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	112Y-281180	Run permit	• One input channel fails	Electrical	• Detected during periodic testing and by control room operator experience	• Other related channels may indicate condition of failed channel—fast protect system action	• None, unless conditions covered by failed channel are not acceptable; then machine may be damaged or beam quality degraded	IVe
			• False permit signal is generated	Electrical	• Detected during periodic testing and by control room operator experience	• Accelerator start-up prevented by other interlocks	• Interruption of operation until repaired	IVe
2	112Y-281180	Run permit	• Stops operating	• Hardware or software failure	• Hardware "watch-dog" detects most failures	• Critical or high-cost components have independent hard-wired locks; fast protect will prevent beam spill	• Possible damage to accelerator component or equipment	IVe
			• Failure to detect out-of-bounds value or incorrect equipment mode	• Hardware/ Electrical	• Operator observation	• Critical or high-cost components have independent hard-wired locks; fast protect will prevent beam spill	• Possible damage to accelerator component or equipment	IVe

Table VI-29 FMEAs for the Run-permit System (concluded)

Item #	Identification from Drawing No.	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
	112Y-281180		Interlocks incorrectly defined	Human error (incorrectly entered data or mode)	Operator observation	Critical or high-cost components have independent hard-wired locks; fast protect will prevent beam spill; operating mode is set and displayed on an OPI in the control room	Possible damage to accelerator component or equipment	IVe
3	112Y-281180	Operator Interface (OPI) console	- Stops operating (backplane, CPU, memory, or network interface error; can also be caused by software) - Operates out of limits or gives incorrect results	- Electrical or software failure - Software or human (data entry) error	- OPI fails to respond - Incorrect or inconsistent display values noted by operator	- Functions can be moved to an alternate OPI console - Correct software or data error	- Temporary interruption of operations - Temporary interruption of operations	IVf

Table VI-30 FMEAs for Fast Protect System

Item #	Identification from Drawing No.	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	112Y-281187 and 112Y-281188	Fast Protect	• Error in one or more enable switches	• Human error	• Switch settings are monitored by control system	• Run permit disables beam if it detects improper switch settings	• Beam spill, possibly resulting in beam-line damage and/or activation	IVe
			• Fast radiation sensor produces low or no output	• Mechanical/Electrical	• Periodic calibration	• Computer monitors background level; redundant detection circuits at each beam line location; periodic in-situ calibration of sensors	• Beam spill, possibly resulting in beam-line damage and/or activation	IVe
			• Fast protect detection failure	• Electrical	• Observation by operator	• Computer monitors background level; redundant detection circuits at each beam line location; periodic in-situ calibration of sensors	• Beam spill, possibly resulting in beam-line damage and/or activation	IVe

Table VI-31 FMEAs for Computer Control Network

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Computer control network	Loss of network integrity	Electrical or software failure	Operator detects lack of response by IOC's or OPI's	IOC's are programmed to either maintain current level or initiate orderly shut down; run permit will disable accelerator operation	Interrupted operations	IVe

modules. Software and hardware descriptions for each IOC are available from group AT-8. Although all IOCs depend on the control-system network for initialization, most IOCs will continue to operate or will shut-down if the network fails. Table VI-32 shows the FMEAs for the beam-line input-output controllers.

6.4.7 Operator Interface Consoles

Operator interface (OPI) consoles provide the operators a graphic interface with which to control the GTA experiments and display experimental data. OPIs are based on diskless Sun workstations and EPICS software. Loss of an OPI, because of software or hardware failure, does not affect the operation of the control system, and an alternate OPI can quickly take over the functions of a failed OPI. Table VI-33 provides the FMEAs for the OPIs.

6.4.8 Fire Protection Systems

The GTA facility is protected by a fire-alarm system consisting of local alarms in all areas, fire pull box stations, and smoke detectors by the elevator on all floors and in the tunnel. This system is tied to the central alarm system. Sprinkler systems provide coverage in all areas. Fire extinguishers are available throughout the facility. See tables VI-34 and VI-35 for the FMEAs.

6.4.9 Beam-tunnel Ventilation System

The various air-handling units provide the normal air supply for all support areas for the facility. The air system provides a tunnel to support building negative differential pressure and ensures that all potentially radioactive air from accelerator operation is exhausted through the HEPA filters and up the exhaust stack. This prevents exposure of personnel to this air and provides additional decay time before air is exhausted to the environment. Refer to Table VI-36 for the FMEA.

6.4.10 Electrical Power to Component Systems

The electrical power distribution system services several component systems that are divided into eight general component types for analysis within the FMEA format:

- The general power distribution system which provides electrical service to the entire facility and experiment. It is often characterized as the primary distribution system switchgear/bus: "SWG-M." It is, however, any part of the system within the Los Alamos National Laboratory Power Distribution Network, which would affect the entire GTA Facility System. In the FMEA it is called the general power outage.

Table VI-32 FMEAs for Beam Line Input-output Controllers

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Beam-line Input-Output Controllers (IOCs)	- Stops operating (back-plane, CPU, memory, or network interface error; also can be caused by software) - Operates out-of-limits or gives incorrect results	- Electrical or software failure - Software or human (data entry) error	- IOC fails to respond - Incorrect accelerator operation noted by operator	- Critical equipment has independent hardware protection; run permits monitors critical IOCs and I/O channels - Critical equipment has independent hardware protection; run permits monitors critical IOCs and I/O channels	- Interrupted operation of accelerator - Interrupted operation of accelerator	IVf

Table VI-33 FMEAs for Operator Interface Console

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	Operator Interface (OPI) console	- Stops operating (back-plane, CPU, memory, or network interface error; can also be caused by software) - Operates out of limits or gives incorrect results	- Electrical or software failure - Software or human (data entry) error	- OPI fails to respond - Incorrect or inconsistent display values noted by operator	- Functions can be moved to an alternate OPI console - Correct software or data error	- Temporary interruption of operations - Temporary interruption of operations	IVf

Table VI-34 FMEAs for Fire Protection II

Item #	Identification from Drawing No. ENG-C-45209*	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Fire Alarm System	Provides actuation of sprinkler system in beam tunnel & transmits alarms to central alarm station	Failure of a fire alarm initiating device	Mechanical/Electrical	Detected during periodic testing; supervisory alarms	Multiple detection devices, battery backed up fire alarm system and dry pipe sprinkler system activation	Delays sprinkler system activation and fire department response	III
			Failure of a fire alarm circuit	Mechanical/Electrical	Alarm in central alarm station	Fire department responds	None	III
			Failure in the control panel	Mechanical/Electrical	Alarm in central alarm system	Fire department responds	None	IV
			Wiring between site and central alarm station	Mechanical/Electrical	Alarm in central alarm system	Fire department responds	None	IV
2	PVC Piping	Transports water for fire protection system	PVC pipe breaks (pipe is normally dry)	Mechanical	Pressure drop trips an alarm in CAS and piping is filled with water.	Repair	Potential for water leak in beam tunnel and equipment damage	IV

* For electrical information, see sheets 153 through 158 of 196 or E37.2, E38.1, E39.0, E40.0, E41.1, E42.0, and E74.2. For mechanical information, see sheet 90 of 196 or M14.2.

Table VI-34 FMEAs for Fire Protection (concluded) II

Item #	Identification from Drawing No. ENG-C-45209*	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
3	Sprinkler supply valve	Activated when a sprinkler head fuses (Valve is normally kept closed by nitrogen pressure on the system and there is backup emergency power)	Fails closed (stuck in closed position/N ₂ bottle runs empty)	Mechanical	Pressure drop and no water flow observed by CAS	Repair	None unless there is a fire	IVf
4	Wet piping	Holds/transports water for fire protection system	Pipe breaks	Mechanical	Trips a local alarm; visual--personnel see water leak	Use manual pull station to activate sprinklers Repair	Increased fire damage Evacuate area if necessary	IVe or f IVe or f

* For electrical information, see sheets 153 through 158 of 196 or E37.2, E38.1, E39.0, E40.0, E41.1, E42.0, and E74.2. For mechanical information, see sheet 90 of 196 or M14.2.

Table VI-35 FMEAs for Water Deluge Systems for LH₂ Run and Storage Dewars II

Item #	Identification N/A	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Water deluge piping	Transports water for deluge system (normally dry pipe)	Pipe breaks	Mechanical	Upon activation, water is observed coming from other than sprinkler heads	Repair	None	IVd
2	Nitrogen piping	Pressurized at all times to hold deluge supply valve in closed position	Pipe breaks	Mechanical	Deluge system activates when no fire is present	Repair	False alarm and water on the ground	IVd
3	Nitrogen pressure valve	Impact on proper activation of the deluge system	Fails closed Fails open	Mechanical	Leaking valve would deplete of nitrogen, which would falsely activate the deluge system.	Repair or replace	- False activation of system - Potential failure of system to activate in case of fire	IVd IIIc
4	Heat sensor	Fusible metal plug that melts when exposed to a flame	Fails	Mechanical	False activation or failure of system to respond to a fire	Replace sensor	False activation or system fails to respond to a fire	IIIc
5	Shut off valve	Shutoff valve isolates water supply from deluge sprinkler manifold	Fails to close	Mechanical	Routine maintenance	Repair or replace	Inability to reset nitrogen system	IVd

Table VI-36 FMEAs for Beam Tunnel Ventilation System

Item #	Identification from Drawing No. ENG-C-45209*	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	HVAC units	Normal heating, cooling, and humidity control functions	Air circulation stops	Mechanical/ Electrical	Personnel observation	On-spot maintenance	Interruption of operations until repaired	IVe
2	Tunnel exhaust fan	Removal of activated air from tunnel during accelerator operations	Fan fails	Mechanical/ Electrical	Status light	- Stop accelerator operations; delay personnel entry to tunnel - Repair	Activated air accumulates in tunnel; migration of activated air to high bay	IVc
3	Status light	Indicates fan is on or off	Bulb or switch failure	Electrical	Personnel observation	Repair	Lack of warning	IVc
4	Flow indicator	Indicates air flow	Fails on or off	Electrical/ Mechanical	Personnel inspection	Repair	Prevent tunnel entry; prevent accelerator operation	IVc
5	HEPA filters	Remove particulates from exhaust air	Plugged filter/ Breached filter	Mechanical	Pressure drop	Replace filters	Interruption of operations until repaired	IVe

* From M8.2, M19.2, M20.2 and M21.3.

- The major power bus is that part of the system, which services and/or feeds the secondary switchgear: "SWG-A" within the GTA facility.
- The minor power bus is that part of the system, which services and/or feeds the secondary switchgear: "SWG-3" within the GTA facility.
- The isolated power bus is that part of the system, which services and/or feeds the secondary switchgear: "SWG-C" within the GTA facility.
- The 5.0 A HV dc power supply provides the primary power service to the RF system generators for the GTA experiments.
- The interior and exterior/security lighting system for the GTA facility.
- The security system for the GTA facility.
- The emergency lighting system for the GTA facility.

Refer to Table VI-37 for the FMEA.

6.4.11 Telephone/Paging System

This system provides internal and external communications throughout the facility. Local announcement of building status and emergencies can be made from any phone in the building; emergency personnel can be summoned by using any phone (dial 9-911 or 911). Refer to Table VI-38 for the FMEA.

6.4.12 Cranes/Forklifts

Cranes and forklifts are available for local material handling and movement of heavy items. The east and west high-bay cranes also provide personnel access to the ceiling area of the support building. Table VI-39 contains the FMEA for cranes and forklifts.

6.4.13 Oxygen Monitors

Oxygen monitors are used to indicate oxygen depleted atmospheres in the beam tunnel, the laser and waveguide basements, the CCS equipment room, and the cryogenic-compressor room. Figure 6-5 shows an oxygen monitor, and Table VI-40 contains the FMEAs for the monitor.

6.4.14 Hydrogen Monitoring System

The GTA cryogenic site is monitored continuously for the presence of hydrogen gas or vapor by a Bacharach four-channel gas detection and monitoring system. The system uses four combustible gas detectors. Table VI-41 contains the FMEAs for the detectors.

Table VI-37 FMEAs for Electrical Power to Component Systems

Item. #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	General power outage	Power system to facility fails	• Electrical utility failure • Primary main breaker trip for short circuit or ground fault • Lightning strike • Electrical primary system overload • LAMPF distribution substation failure	All electrical systems fail; general facility lighting fails	Battery backed; emergency systems continue to operate	Facility shuts down and accelerator operations stop; all accelerator support utilities fail	IVe

6.0 FAILURE MODES AND EFFECTS ANALYSIS

Table VI-37 FMEAs for Electrical Power to Component Systems (continued)

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
2	N/A	Major power bus--"SWG-A" power interruption	Individual and/or collective power failure of the following systems: facility, exterior, and security lighting; facility HVAC; accelerator tunnel supply and exhaust air; water cooling; cryogenic cooling; HVDC power for test beds; vacuum rough pumps; facility compressed air; radiation plug-door operators; cranes; accelerator beam magnet power supplies; accelerator interim beamstop cooling; accelerator final beamstop cooling; accelerator diagnostic laser; LINDA laser laboratory; and HVAC	Lightning strike Electrical shortcircuit or ground fault Transformer failure	Individual or collective systems failure (most notable will be the facility lighting will fail)	Emergency lighting will operate on batteries for 90 minutes	Facility shutdown and accelerator operations should cease; most accelerator support utilities fail	IVe

Table VI-37 FMEAs for Electrical Power to Component Systems (continued)

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
3	N/A	Minor power bus--"SWG-3" power interruptions	Individual and/or collective power failure to the following systems: facility general receptacles; contaminated-water storage tanks; mixing pumps; fire alarm; vacuum system; radiation shield-door magnetic hold-closed devices; RPSS; accelerator interim beam-stop cooling; accelerator final beamstop cooling; accelerator diagnostic laser; facility HVAC system; accelerator tunnel supply and exhaust controls; RF power; rack ventilation; and guard station power and lighting	• Lightning strike • Electrical short circuit or ground fault • Transformer failure	Individual or collective systems fail	The following emergency/battery-backed systems will operate temporarily; fire alarm; RPSS Kirk-key release; facility HVAC controller (DDC)	Loss of RPSS will shut down accelerator	IVe

Table VI-37 FMEAs for Electrical Power to Component Systems (continued)

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
4	N/A	Isolated power bus--"SWG-C" power interruption	Individual or collective power failure to the following systems: accelerator control rack power; accelerator control; CCS control; cryogenic-cooling plant surveillance; control room console clean power; computer control; telephone; paging; security; open network; and classified "L" network	- Lightning strike - Electrical short circuit or ground fault - Transformer failure	Individual or collective systems fail	The following emergency/battery-backed systems will operate temporarily; telephone (future); paging (future); security	Loss of accelerator control systems' power will shut down accelerator	IVe
5	N/A	Loss of power to 5.0 A HVDC power supply-circuit: "SWG-M:F7"	ac power failure to HVDC system supporting RF generators	- Lightning strike - Primary feeder breaker trip for short circuit, ground fault or circuit overload	Loss of RF power for DTL modules	None	Loss of RF power to DTL modules should shut down accelerator system	IVe

Table VI-37 FMEAs for Electrical Power to Component Systems (continued)

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
6	N/A	Loss of normal facility interior and exterior/ security lighting	Power system failure as described in items #1 and #2, above	• Electrical utility failure • Primary main breaker trip for short circuit or ground fault • Lightning strike • Electrical primary system overload • LAMPF distribution substation failure • Primary feeder breaker trip for short circuit, ground fault or overload • Transformer failure	General interior and exterior lighting failure	Emergency lighting is battery-backed	Shutdown of accelerator operations and facility evacuation	IVe

Table VI-37 FMEAs for Electrical Power to Component Systems (concluded)

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
7	N/A	Security system emergency/battery-backed power failure	Failure of two redundant battery inverters: one feeds to security system panel; the other is located within the security system panel	- Faulty charging unit - Battery cell failure - Insufficient charging time between outages - Power outage extends beyond 90 min	Annunciation to Los Alamos National Laboratory main security system of security system fault	- Redundant battery backing system - Security emergency response to site - Maintenance and testing procedure	Security officers respond for investigation of loss of security system	IVe
8	N/A	Emergency lighting system failure	Individual fixture battery-backup failure	- Fault fixture charging unit - Battery cell failure - Insufficient charging time between outages - Power outage extends beyond 90 min	Individual emergency lighting fixture failures	Testing and maintenance procedure; emergency-lighting fixtures will be placed for overlapping coverage to compensate for individual unit failures	Individually battery-backed emergency lights will fail gradually after 90 min on battery operation; units in need of repair or replacement will leave areas dark within the facility	IVe

Table VI-38 FMEAs for Telephone/Paging System

Item #	Identification from Drawing No. 112Y-282226	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1-	Telephone/paging system	Provides building internal and external communications	Loss of power	Electrical	Personnel observation	Uninterruptible power supply	None	IVf
2	Eagle phone system	Provides building internal and external communications	Loss of Eagle phone system	Electrical	Personnel observation	Repair; use guard station phone for emergencies	Loss of phone service and loss of intercom lines	IVf
3	Paging system amplifiers	Provides building internal communications	Loss of paging system amplifiers	Electrical	Personnel observation	Repair; use manual pull boxes for fire, if evacuation is necessary	Loss of internal building paging; local emergency announcements	IVf
4	Uninterruptible power supply	Provides backup power when normal power is lost	Fails	Electrical	Personnel observation; periodic maintenance	Repair; use manual pull boxes for fire, if evacuation is necessary	None unless normal power is also interrupted; if normal power is also interrupted, internal/external communications are lost.	IVf

Table VI-39 FMEAs for Cranes and Forklifts

Item #	Identification from Drawing No. ENG-C-45209*	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Crane or forklift	Movement of heavy equipment	Failure, overload, or dropping of load	Mechanical	Visual or audio indication	Repair	Depending on the secondary effects, programmatic delay, or serious injury is possible	Id
2	Crane	Movement of heavy equipment	Control failure or loss of electrical power	Electrical	Crane inoperative	Repair; rope off area if a load is suspended	Depending on the secondary effects, programmatic delay, or serious injury is possible	Id

* See numbers S17.0, S35.1, and A15.1 for cranes.

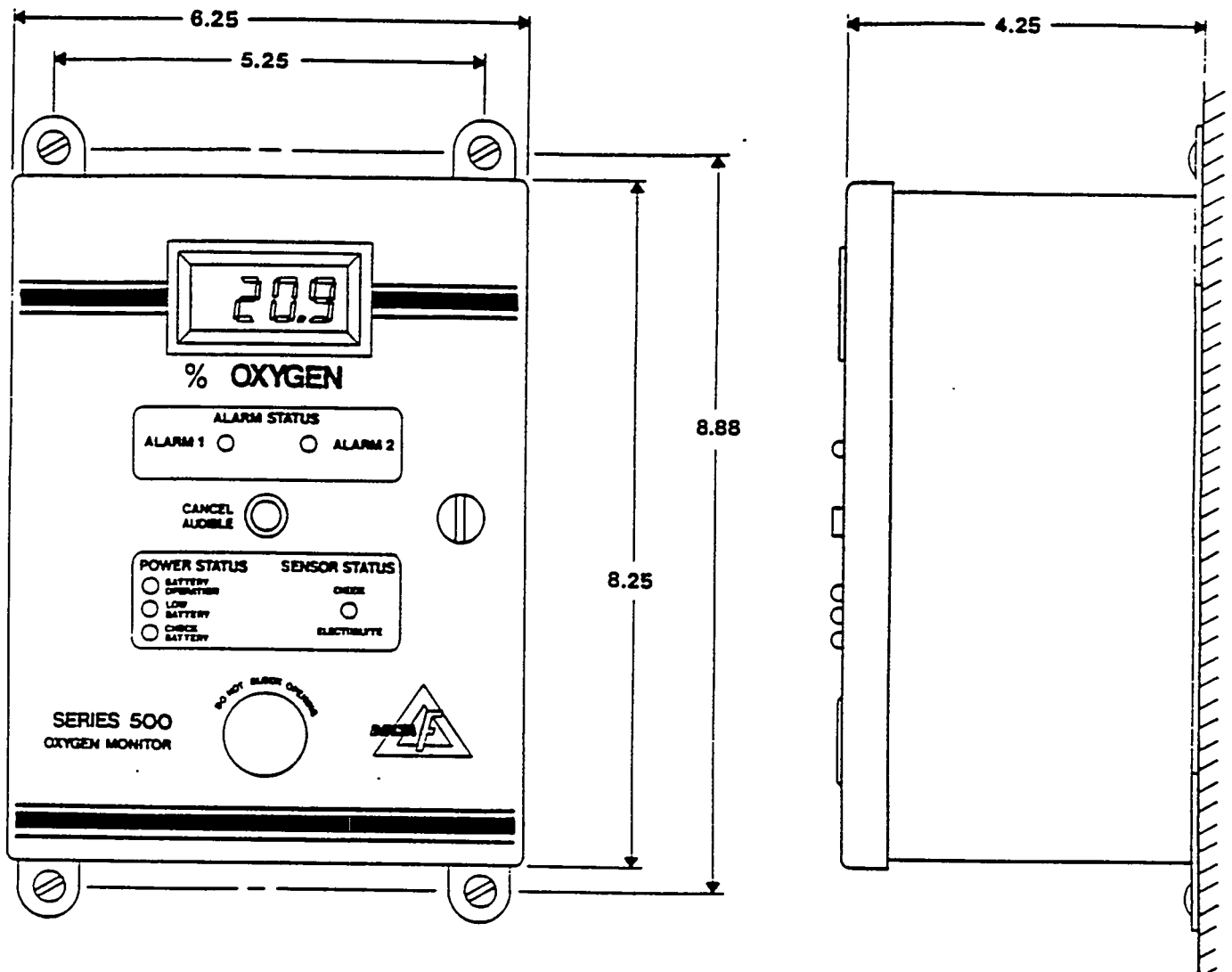


Fig. 6-5. Oxygen monitor.

Table VI-40 FMEAs for Oxygen Monitors

Item #	Identification from Fig. 6-5	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	Oxygen monitors	Detect and warn personnel that atmosphere is oxygen deficient	Electrolyte depleted or contaminated	Chemical	Unit's sentry circuit	Technician replenishes fluid	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
						Use portable monitor	Monitor temporarily out of operation	IVd
						Replace monitor with a spare	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
			Loss of AC power to individual bus	Electrical	LED light warns when monitor switches to battery operation	Monitor automatically switches to battery operation	After 2 hr of power outage, monitor fails to operate	IVd
					Unit's sentry circuit initiates an intermittent audible alarm when batteries are low	Batteries function for a maximum of 3 hr	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
					None when batteries die			
			Loss of AC power to facility	Electrical	LED light warns when monitor switches to battery operation	Monitor automatically switches to battery operation	After 2 hr of power outage, monitor fails to operate	IVd

Table VI-40 FMEAs for Oxygen Monitors (concluded)

Item #	Identification from Fig. 6-5	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
					Unit's sentry circuit initiates an intermittent audible alarm when batteries are low	Batteries function for a maximum of 3 hr	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
			Equipment electrical circuitry fails	Electrical	None when batteries die No front panel lights, sounds, or displays	Use portable monitor	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
					Abnormal lights, sounds, or displays	Replace monitor with a spare Use portable monitor	None, unless the oxygen concentration is below 19.5% at the time that the detector fails and that a person enters the region	IIc, d
						Replace monitor with a spare		

Table VI-41 FMEAs for Hydrogen Detectors

Item #	Identification	Description	Failure Modes	Failure Mechanism	Failure Detection	Failure Compensation	Effects	Criticality Ranking
1	N/A	H ₂ detector (4)	- Reads in error-high - Reads in error-low - Open circuit	Mechanical/ Electrical	- Activates alarm - Periodic calibration - On line functional check	- Investigate/repair - Repair - Repair/replace, use portable detector	- Delay of program - Delay of program; possible undetected hydrogen leak, which could result in a fire - Delay of program, possible undetected leak, which could result in a fire	IVf IIIa IIIa

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7.0 ACCIDENT ANALYSIS

This chapter covers the accident analysis for the Ground Test Accelerator (GTA). The accidents addressed in this chapter were developed from failure effects listed in the failure mode effects analysis (FMEA) tables (see Chapter 6), potential hazards in the accelerator system and facility, and knowledge of hazards existing in similar operations such as at the Accelerator Test Stand (ATS) and the Clinton P. Anderson Meson Physics Facility (LAMPF). Because of the small number of existing systems and facilities similar to those of GTA, sufficient statistical data on the occurrence of the postulated accidents are not available for a quantitative analysis of risk probability. For this reason, qualitative descriptors (Likely, Unlikely, Extremely Unlikely and Incredible) have been chosen following the guidelines of AL 5481.1B. These probabilities are based on the collective judgment and experience of the personnel involved in the GTA safety analysis. An exception is the analysis of an airplane crashing into the LH2 storage dewar or the LH2 run dewar. In these cases, sufficient statistical data were available and a quantitative probabilistic analysis was performed that showed these events to be incredible ($P_e < 10^{-6}/\text{yr}$). Failures designated as catastrophic or critical (Category I or II) in the FMEA were included in the accident analysis. In most cases, serious accidents require multiple and simultaneous failures of the components or systems listed in the FMEA combined with a worker who violates a standard operating procedure (SOP). Conventional industrial accidents have been considered and unusual accidents applicable to GTA have been included.

7.1 Potential Hazards and Their Mitigation

Phase 2 operations of the GTA include experiments 2D, 3A, 3B and 3C in which the GTA is operated at 24 MeV. For this experimental phase, the GTA consists of the injector, the radio-frequency quadrupole (RFQ), the drift-tube linac (DTL) tanks, the intertank matching section (IMS), output optics, neutral beam, and beam diagnostics. The GTA is supported by accelerator controls, radio-frequency (RF) power, vacuum, water-cooling, and cryogenic-cooling systems as well as personnel and equipment safety systems. In addition to 24-MeV operation, the high power cryogenic test bed (HPCTB) is used for off-line testing. The 750-W helium refrigerator provides cryogenic cooling for the HPCTB. Table VII-1 lists the potential hazards and their mitigation.

7.2 Accident Analysis for the Experimental Equipment

Possible accidents involving the experimental equipment have been identified and are presented in the following sections. Tables VII-2 and VII-3 explain the designations used for the accident risk assessments. Potential accidents are summarized in Table VII-4. Table VII-5, the risk-summary table, presents the annual probability of unusual GTA-specific accidents; the impact of these accidents on the public health and safety, the plant, and the program; the dollar loss; and the risk assignment.

7.2.1 Ground Test Accelerator

7.2.1.1 Injector Accidents - The accidents involving the operation of the injector deal with the capacitor bank, bottled hydrogen gas, and cesium.

7.2.1.1.1 Capacitor Bank Accident - Two capacitor banks in the injector are potentially lethal hazards, because they could electrocute a person. To

Table VII-1 Potential Hazards and Their Mitigation

Hazard	Location	Prevention/Mitigation
Injector		
Electrical shock from capacitor banks	High-voltage dome	Mechanical fall-down shorting mechanisms, electrical switches and meters, grounding hooks, training, and controlled access to the hazard
Fire/explosion from hydrogen gas	High-voltage dome	Training, use of small-volume bottles, tunnel ventilation, and controlled access to the hazard
Chemical exposure to cesium metal and chromate	Ion source work area	Training, SOPs, protective eye shields and gloves, using small quantities, and eye-wash facilities
X-ray radiation	Tunnel	Training, SOPs & SWPs, shielding, monitoring system alarms, routine health physics monitoring
RFQ/IMS/DTL		
RF radiation leakage at input to RFQ/DTL	RFQ/IMS/DTL RF-power input flanges	Local, periodic RF sensor survey; pressure sensors in coaxial waveguide lines; electrical mismatch sensors all tied into shutdown procedures
Cryogenic/gaseous He release	RFQ/IMS/DTL internal pressure release valve	Valve located to minimize personnel exposure to cryogenics, pressure gauge reading triggers cryogen shutoff when internal pressure exceeds preset limit, pressure relief valve
X-ray radiation	Tunnel	Training, SOPs & SWPs, shielding, monitoring system alarms, routine health physics monitoring
Optics		
X-ray and RF radiation	Energy dejecter and momentum compactor cavities	Low power, low duty factor, shielding, monitoring, monitors interlocked to the RF run-permit system.
Electrical shock and burns	Telescope corrector magnets and fast steerer	Terminal shields interlocked to power supplies; lock-out tag-out procedures
Secondary radiation exposure to activated components	HEBT, bend telescope, fast steerer	Component monitoring, cool down, dosimeter monitoring, personnel training, low activation; maintenance to activated components require SWP handling, SOP's & SWP's
Activated water leak from portable chillers	Telescope, fast steerer	High quality transfer components, spill containment, small volume
Control System		
Electrical hazards in electronic equipment	Throughout GTA facility	Limited to line voltages (110 or 220 V); protective covers; warning labels on equipment; adherence to codes and standards; training; lockout, tagout procedures; dedicated conduit and cable trays; fiber-optic isolation
RF		
High voltage	Mezzanine capacitor room Modulator tank Tetrode amplifier Racks Klystron	Personnel interlocks, equipment interlocks, manual and computer interlocks, SOP, grounding hooks, controlled access, and training

Table VII-1 Potential Hazards and Their Mitigation (continued)

Hazard	Location	Prevention/Mitigation
X-ray and radio-frequency (RF) radiation	Modulator tank (Klystron) Tetrode RF waveguide DTL	All the above, plus lead shielding for x rays, shielded enclosures and transmission lines, pressurized waveguide, low-duty factor (1% or 2%) average exposure is a concern; HS personnel monitoring radiation and installed instruments
Oil leakage	Modulator tank (Klystron)	Only so much oil to spill (200 gal); containment on floor and level-sensing device on oil tank
Water-cooling Systems Water leaks	Main house water supply High bay Support facilities MPF-365	Visual observation, flow and pressure drop sensors, shut down circulation pumps
Possible activated water leaks	Individual, small water chillers	Visual observations, sensors, shut down pumps, cleanup and monitoring by HS-1
750-W Helium Refrigerator Electrical	Electrical motors, heaters, solenoids, and controls	Safe industry practices
Mechanical	Rotating machinery	SOP and protective covers for machinery
Pneumatic	Relief valve or exit point for helium	Limit the volume of helium that can escape to one type "T" bottle supply over some period of time
Thermal	Penetrations for cold gas	All penetrations are behind the refrigerator, away from the operator, SOP, and routine safety practices
Electrical HV Substation	Outside southwest corner of building	Locking gate to exclusion fence; allowing only authorized personnel to have keys
Mechanical equipment	Fourth floor, north and south sides of building	All switchgear enclosed in metal cabinets; allow only authorized personnel access to cabinets; equipment rooms locked
Ionizing Radiation Exposure From operational accelerator	Tunnel and underlying basements (exclusion area)	Radiation personnel safety system (RPSS) designed to assure no one is in tunnel during operation; scram buttons in tunnel; tunnel-shielding envelope prevents radiation exposure Personnel wear thermoluminescent dosimeter (TLD) badges to track radiation exposure and ensure that exposures are kept within U.S. Department of Energy (DOE) Order 5480.11 occupational standards; SOP's and training

Table VII-1 Potential Hazards and Their Mitigation (continued)

Hazard	Location	Prevention/Mitigation
From non-operating accelerator and beam-line components including beam stops	Tunnel	Local shielding used to reduce component activation; activation cool-down period before access to tunnel permitted; activated air removed from beam tunnel by HVAC system; RPSS active at all times; HS-1 to monitor dose rates at work location
From activated air during operations	Tunnel	Activated air constantly exhausted during operations; negative tunnel pressure prevents leakage to other parts of facility
From beam interactions and activated components during maintenance and repairs	Tunnel	Transport and storage via appropriate shielded casks; off-site transport according to U.S. Department of Transportation (DOT) regulations; monitoring by HS-Division; repairs in appropriate facility; maintenance work under SWP
Of public at site boundary	Boundary 1,000 m north of site	No public hazard - induced radiation generated in experiments 2 and 3; will be confined to tunnel area where shielding is sufficient; activated air levels are low enough to be nondetectable at the 1,000 m boundary
From high-power DTL testing in HPCTB tank	HPCTB tank in high bay	Local shielding on HPCTB tank; HS-1 monitoring; TLD badges required
Industrial		
Falling, slipping, power tools, etc.	Throughout facility	Personnel training, safety-conscious supervision, and facility inspections
Injury from crane or forklift operations	Beam tunnel, high bays	Certified crane and forklift operators; preoperational, monthly, and annual inspection of crane; annual inspection of lifting gear; quarterly forklift inspection
Fire		
Electrically caused	Cable runs and switch gear	All inside areas covered by fire sprinkler system; limited amount of combustibles
Flammable solvents	All inside work areas	Same as for electrical fires; flammable solvents in small containers; hazard communication training; storage in flammable-liquid cabinets
Dielectric oil	RF modulator area, capacitor room	Same as for electrical fires; capacitors have oil with 420°F flashpoint, modulator oil has fire point of 570°F; RF modulator area surrounded by 4-in. high berm; floor penetrations sealed; no PCB-containing oil allowed
High-pressure Gas	Tube trailer stations	Stations constructed according to standard design; operators trained in high-pressure gas safety
	Compressed gas cylinders	Conventional pressure regulation with relief valves; standard storing practices; standard DOT cylinders; and training
Cryogenics; LN₂ and GHe	Beam tunnel, 750-W helium refrigerator	Cryogenic lines double-walled and insulated; only trained technicians connecting and disconnecting cryogenic components; protective equipment and SOPs minimize maintenance hazards; system carefully tested before use

Table VII-1 Potential Hazards and Their Mitigation (concluded)

Hazard	Location	Prevention/Mitigation
Vacuum	All vacuum envelopes	Design according to Section VIII of the American Society of Mechanical Engineers Unfired Pressure Vessel Code; pressure testing; relief valves
CCS Cryogenics	Beam tunnel, CCS site, and cryogenic equipment room	Cryogenic lines double-walled and insulated; only trained technicians connecting and disconnecting cryogenic components; protective equipment, SOPs and training minimize maintenance hazards; system carefully tested before use
Asphyxiation	Beam tunnel, cryogenic compressor, neutral beam vacuum envelope, HPCTB	Oxygen concentration alarms and monitoring of space for oxygen concentration before and during entry; relief valves incorporated into vacuum vessels; testing and calibration of oxygen monitors; ventilation system; buddy system
Chemical Exposure	Laboratories/shops	Employee training; engineered and administrative controls, chemical selection, personal protection equipment, and monitoring
Chemical Spill	Laboratories/shops	Bulk storage outdoors; limited quantities indoors; material handling in accordance with requirements of the LANL Environmental, Safety, and Health Manual
Laser Ocular Hazard	Laser room, laser beam tube, laser alignment to ion beam line	Interlocks, protective eyewear
Natural Phenomena Earthquake	Building	Building designed for Seismic Zone 2; accelerator designed for 0.5-g horizontal acceleration
Flood	Building	Location on top of mesa
Wind	Building CCS	Designed to withstand 80 mph Designed to withstand 93 mph
Lightning	Building	Lightning protection system per National Fire Protection Association 78 and electrical wiring according to National Electrical Code

Table VII-2 Qualitative Accident Hazard Severity

Designator	Hazard Category	Consequences to the Public, Workers, or Environment
I	Catastrophic	May cause deaths, loss of the facility/operation, or severe impact on the environment
II	Critical	May cause severe injury, ^a severe occupational illness, major damage to a facility/operation, or major impact on the environment
III	Marginal	May cause minor injury, minor occupational illness, or minor impact on the environment ^b
IV	Negligible	Will not result in a significant injury, occupational illness, or impact on the program or environment

^a Or death to a worker^b Or Moderate damage/impact to a facility operation

Table VII-3 Qualitative Accident Probabilities

Descriptive Word	Symbol	Nominal Range of Frequency per Year
Likely	A	$Pe > 10^{-2}$
Unlikely	B	$Pe = 10^{-2} \text{ to } 10^{-4}$
Extremely Unlikely	C	$Pe = 10^{-4} \text{ to } 10^{-6}$
Incredible	D	$Pe < 10^{-6}$

prevent electrocution, accessing a capacitor bank requires entering two safety enclosures: one around the two capacitor banks and another around each individual capacitor bank. Entering the safety enclosure around the two capacitor banks requires using a key to open the access door. This entry shuts down all alternating current (ac) power within the enclosure, contacts a fall-down shorting system to the high-voltage dome and activates an automatic fall-down shorting system across both capacitor banks. The two capacitor banks are housed in mechanical structures that require disassembly before the capacitors can be reached. These individual safety enclosures have external meters and grounding hooks for manual shorting.

A worker could be electrocuted if he or she violates the SOP for properly opening the safety enclosures, and when a simultaneous failure of all mechanical and electrical safety systems occurs. Under normal operating conditions, the simultaneous failure of all systems is deemed extremely unlikely. Of more concern is the likelihood that, under test conditions for the ion source, a worker can access the arc leads on the ion source if the safety shield is removed. The leads go directly to the capacitor bank in the high-voltage dome and can be energized if the ac power interlock is bypassed; the interlock may be bypassed during test conditions. This test condition, therefore, warrants the issue of a special work permit (SWP), because operating safety shields have been removed and non-standard operating conditions are used. Only trained personnel under specific procedures can implement this condition; with these precautions, the occurrence of an electrocution is deemed unlikely.

7.2.1.1.2 Hydrogen Fire - As long as proper handling procedures are followed, using a bottle containing compressed hydrogen gas in the injector does not pose a fire hazard. In addition, there is not enough hydrogen gas in the bottle

Table VII-4 Summary of Accidents

Accident	Possible Cause	Probability	Severity	Consequence	Protective/Preventive Measures
Injector Personnel electrocuted in capacitor bank	Personnel error or mechanical and electrical safety system failures	Extremely unlikely	Critical	Severe injury or death to a worker	• Two safety enclosures • Interlocks • Auto shorting • Key access • Training • Use of SWP • Training • Small quantity of hydrogen
Hydrogen fire	Personnel accidentally open valve on hydrogen bottle	Extremely unlikely	Marginal	Personnel burns	
Cesium exposure during maintenance	Elemental cesium reacts with water	Extremely unlikely	Marginal	Eye injury to one worker	• Training • Eye-wash facilities
RFQ, IMS, DTL RF power leakage in transport system	Improper flange coupling	Unlikely	Marginal	Possible personnel exposure to RF radiation	Local, periodic RF sensor survey; pressure sensors in coaxial/ waveguide lines; electrical mismatch sensors; all sensors tied into shutdown procedures
Cryogenic/gaseous He release in vacuum envelope	Joint rupture	Unlikely	Marginal	Excessive gas pressure in RFQ, IMS, DTL vacuum tanks	Pressure relief valve (redundant) releases pressure before it gets too high; pressure valve triggers cryogen shut off when pressure exceeds preset limit; vent stack to reduce personnel exposure to cryogens
Output Optics Exposure to RF leakage from transport system	Failure of RF seal	Unlikely	Low	Exposure to RF radiation exceeding DOE limits	• Seal inspection • RF monitoring with interlock to RF run permit • gas-pressure monitoring of waveguides • SWP for cavity operation with personnel in tunnel

Table VII-4 Summary of Accidents (continued)

Accident	Possible Cause	Probability	Severity	Consequence	Protective/Preventive Measures
Exposure to x-rays	Inadequate shielding, off normal operation	Extremely unlikely	Low	Exposure to x-radiation exceeding DOE limits	- Inspection of shielding - X-ray monitoring - SWP for cavity operation with personnel in tunnel - Interlocked terminal shield - SWP for work on energized magnets - Radiation monitoring - Shielding - Cool-down periods - Personnel training - Maintain low volume - High-quality system - Inspection - Containment vessels - Beam-loss monitor and beam in position - Monitor systems interlock with fast protect system
Shorting of energized-magnet terminals	Dropped tool, carelessness	Unlikely	Low	Burns or shock	
Secondary radiation exposure	Failure to observe procedures	Extremely unlikely	Low	Exposure to radiation exceeding DOE limits	
Leakage of radioactive water	Joint failure in cooling systems	Unlikely	Low	Release of radioactive water into tunnel	
Catastrophic vacuum failure	Errant beam and failure of protect systems	Extremely unlikely	Low	- Interruption of run cycle to restore vacuum - Pressurization of cryogenic lines - Possible component damage from shock wave	
Control System Contact with dangerous voltages	Servicing control-system equipment with power turned on	Extremely unlikely	Critical	Electrical hazard (110/220 V ac) to personnel who are servicing equipment	- Equipment must adhere to codes and standards - Protective covers - Warning labels - Lockout, tagout procedures - Separation of signal cables from high voltages - Fiber-optic isolation from high voltages - Training

Table VII-4 Summary of Accidents (continued)

Accident	Possible Cause	Probability	Severity	Consequence	Protective/Preventive Measures
Water Cooling Systems Main house water supply system leaks Activated water leaks in tunnel Leaks in individual small water chillers	Line rupture, weld failure, joint failure	Unlikely	Marginal	Creates possible electrical and slipping hazards	Flow and pressure drop sensors, visual observation
	Line rupture, weld joint failure	Unlikely	Marginal	Creates possible radiation exposure and electrical, and slipping hazards	Flow and pressure drop sensors, visual observation, monitored by HS-1
	Line rupture, weld joint failure	Unlikely	Marginal	Creates possible electrical and slipping hazards	Flow and pressure drop sensors, visual observation
CCS Hydrogen Fire Break in the transfer line Break in the fill line	Impact by runaway vehicle	Extremely unlikely	Marginal	- Less than first-degree burn at the fence - Replace damaged line section	- Chain-link fence - Barrier along transfer line - Slats in the chain-link fence
	Tanker drives away during the transfer	Extremely unlikely	Critical	- Less than first-degree burn at the fence - Replace the damaged line section	- Chock on the tanker wheels - Tanker brakes locked while the hose is connected - Buddy system for checking operation - Strict adherence to SOP
Penetration of the storage dewar's vacuum jacket Penetration of the run dewar's vacuum jacket Combustion inside the storage dewar	Bullet from rifle	Unlikely	Negligible	Increased boil-off rate	Vent system designed to handle increased vent rate
	Bullet from rifle	Unlikely	Negligible	Repair vacuum jacket	Vent system designed to handle increased vent rate
	Improper purging	Unlikely	Negligible	Increased boil-off rate Repair vacuum jacket Replace rupture disk Recertify dewar	No ignition source in dewar Strict adherence to SOP for purging
Combustion inside the run dewar	Improper purging	Unlikely	Negligible	Replace rupture disk Recertify dewar	Dewar designed to sustain the overpressure
					No ignition source in dewar Strict adherence to SOP for purging Dewar designed to sustain the overpressure

Table VII-4 Summary of Accidents (continued)

Accident	Possible Cause	Probability	Severity	Consequence	Protective/Preventive Measures
CCS Hydrogen Release to the Atmosphere Run dewar overflow	Equipment failure concurrent with operator error	Extremely unlikely	Negligible	- Increased hydrogen quantity burned at flare stack - Repair or replace control equipment	- Liquid-level controller backed up by liquid sensor in vent line - Strict attention to SOP
	GHe line break at the GHe/LH ₂ heat exchanger during operation	Extremely unlikely	Negligible	- Rapid venting of GHe/GH₂ mixture for short time - Repair or replace dewar and GHe/LH₂ heat exchanger	- Redundant pressure-relief devices installed in line and dewar - Lines and heat exchangers have equal or similar thermal expansion - All joints inside the dewar are welded or brazed
CCS Asphyxiation or Frostbite Break in the GHe line in beam tunnel Break in the GHe line in equipment building Break in the LN ₂ supply line in equipment room	No possible cause for this accident was identified	Extremely unlikely	Negligible	- Insufficient helium for asphyxiation - Possible frostbite	Oxygen monitors and alarms
	No possible cause for this accident was identified	Extremely unlikely	Negligible	- Possible asphyxiation during first 8 min if building is occupied - Possible frost bite	Oxygen monitors and alarms
	No possible cause for this accident was identified	Extremely unlikely	Negligible	- Minimum of 8 min before asphyxiation occurs - Possible frostbite	Oxygen monitors and alarms
CCS Stored-energy Release Massive rupture of the GHe recovery vessel	Impact from runaway vehicle	Extremely unlikely	Marginal	- Minor structural damage from overpressure - Possible minor injury from fragments	- Relief devices - Chain-link fence - Barrier to protect from vehicles - Located behind LN₂ dewar

Table VII-4 Summary of Accidents (concluded)

Accident	Possible Cause	Probability	Severity	Consequence	Protective/Preventive Measures
Safety Systems Failure of plug door and radiation escapes	Electrical malfunction	Extremely unlikely	Marginal	• Personnel exposure to activated air • Personnel exposure to neutron streaming	Neutron monitors
Plug door closes without notice HVAC blowers stop operating	Electrical malfunction Electrical failure	Extremely unlikely Unlikely	Negligible Marginal	Possible personnel injury Personnel exposure to radiation	Bell rings when door is in motion Gas sampling system

Table VII-5 Summary of Risk Resulting from Postulated Accidents I

Accident	Annual Probability of Occurrence	Impact on Public and Environment	Impact on Operating Personnel	Impact on Facility	Programmatic Impact	Dollar Loss	Risk Assignment
Injector							
Electrocution from capacitor banks	Extremely unlikely	None	One possible death from electrocution	None	Moderate	Minor	IIC
Hydrogen fire	Extremely unlikely	None	Possible minor injury	None	Minor	Minor	IIIC
Cesium exposure	Extremely unlikely	None	Possible eye injury	None	Minor	Minor	IIIC
RFQ, IMS, DTL							
RF power leakage	Unlikely	None	Possible exposure to RF power	None	None	None	IIIB
Gaseous He leakage	Unlikely	None	Possible exposure to cryogenic He	Minor	Minor	Minor	IIIB
Optics							
RF exposure from cavities	Unlikely	None	Possible radiation exposure exceeding DOE limits	None	None	None	IIIB
X ray exposure from cavities	Extremely unlikely	None	Possible radiation exposure exceeding DOE limits	None	None	None	IIIC
Electrical burns or shock	Unlikely	None	Possible physical injury	None	None	Minor	IIIB
Excessive secondary radiation exposure	Extremely unlikely	None	Possible radiation exposure not exceeding DOE limit	None	None	None	IIIC
Radioactive water release	Unlikely	Slight	Possible radiation exposure	None	Moderate	Minor	IIIB
Catastrophic vacuum failure	Extremely unlikely	None	None	None	Moderate	Minor	IIIC
Control System							
Contact with dangerous voltages	Extremely unlikely	None	Serious burns or electrocution	None	Minor	Minor	IIC

Changed per DOE/AL Comments
October 5, 1994

Table VII-5 Summary of Risk Resulting from Postulated Accidents (continued) 1

Accident	Annual Probability of Occurrence	Impact on Public and Environment	Impact on Operating Personnel	Impact on Facility	Programmatic Impact	Dollar Loss	Risk Assignment
RF Power							
Electrocution from high voltage	Extremely unlikely	None	One possible death from electrocution	None	Moderate	Minor	IIC
X-ray radiation and x-rays from tetrode or klystron	Extremely unlikely	None	Possible radiation exposure exceeding DOE limit	None	None	None	IIIC
Water Cooling Systems							
Main house water supply system leaks	Unlikely	None	Marginal	Negligible	None	\$5 K	IVB
Possible activated water leaks in tunnel	Unlikely	None	Marginal	Negligible	None	\$5 K	IVB
CCS							
Transfer line break	Extremely unlikely	None	Possible minor injury	Moderate	Moderate	\$50 K	IIIC
Fill line break	Extremely unlikely	None	Possible serious injury	Moderate	Moderate	\$50 K	IIC
Penetration of the storage dewar vacuum jacket	Unlikely	None	None	Minor	Minor	\$25 K	IVB
Penetration of the run dewar vacuum jacket	Unlikely	None	None	Minor	Minor	\$25 K	IVB
Combustion inside the storage dewar	Unlikely	None	None	Minor	Minor	\$20 K	IVB
Combustion inside the run dewar	Unlikely	None	None	Minor	Minor	\$20 K	IVB
Overflow of the run dewar	Extremely unlikely	None	None	None	None	\$5 K	IVC
Break in the GHe line (He/H ₂ heat exchanger)	Extremely unlikely	None	None	Moderate	Moderate	\$100 K	IVC
Break in the GHe line (beam tunnel)	Extremely unlikely	None	None	Minor	Minor	\$10 K	IVC
Break in the GHe line (equipment room)	Extremely unlikely	None	Possible asphyxiation if the building is occupied	Minor	Minor	\$10 K	IVC

Table VII-5 Summary of Risk Resulting from Postulated Accidents (continued) I

Accident	Annual Probability of Occurrence	Impact on Public and Environment	Impact on Operating Personnel	Impact on Facility	Programmatic Impact	Dollar Loss	Risk Assignment
Break in the LN ₂ supply line (equipment room)	Extremely unlikely	None	None	Minor	Minor	\$10 K	IVC
Massive rupture of the GHe recovery vessel	Extremely unlikely	Possible minor injury	Possible serious injury	Moderate	Moderate	\$20 K	IIIC
RPSS							
Person left inside exclusion area	Extremely unlikely	None	Possible severe radiation exposure	None	Moderate	Minor	IIIC
Person entering exclusion area while accelerator is operating	Extremely unlikely	None	Possible severe radiation exposure	None	Moderate	Minor	IIIC
Plug Doors							
Open and radiation escapes	Extremely unlikely	None	Possible radiation exposure exceeding DOE limit	None	Moderate	Minor	IIIC
Closes without notice	Extremely unlikely	None	Possible physical injury	None	Moderate	0	IIIC
Stacked Shielding							
Changed; allows radiation to escape	Unlikely	None	Possible radiation exposure exceeding DOE limits	None	Moderate	Minor	IIIB
HV Blowers							
Failure to stop operation and allow radiation to escape	Unlikely	None	Possible radiation exposure not exceeding DOE limits	None	Moderate	Minor	IVB
Local Component Shielding							
Changed; does not meet specifications	Extremely unlikely	None	Possible radiation exposure exceeding DOE limits	None	Moderate	Minor	IVC

Changed per DOE/AL Comments
October 5, 1994

Table VII-5 Summary of Risk Resulting from Postulated Accidents (concluded)

Accident	Annual Probability of Occurrence	Impact on Public and Environment	Impact on Operating Personnel	Impact on Facility	Programmatic Impact	Dollar Loss	Risk Assignment
Accelerator Protection Malfunctions							
Run-permit system	Unlikely	None	None	Minor damage to accelerator component	Minor	Minor	IVB
Industrial Accidents							
Crane-operation accident	Unlikely	None	Serious injuries	None	Minor	10K	IIB
Fork-lift operation accident	Unlikely	Slight	Minor injuries	None	None	Minor	IIIB
Chemical Spill							
Maximum credible loss	Unlikely	None	Negative	Minor	Minor	100K	IIIB
Maximum possible fire loss	Extremely unlikely	None	Negative	Major damage	Long-term interruption	15M	IIC

(size D, 20 scf) to pose any explosive hazard, if it is released in the facility. If a bottle of H₂ gas was released by accident, the building ventilation system would exhaust the gas. If a worker, however, accidentally opens the valve on a hydrogen bottle, the escaping gas can spontaneously ignite and burn with a colorless flame. A fire accident can thus occur from the burning gas plume, resulting in possible burns on the worker. Turbo pumps are used to evacuate the system; these pumps do not accumulate H₂ and, therefore, present no operational hazards.

The probability of this accident is considered to be unlikely, because only trained personnel, who are familiar with the potential fire hazard, are allowed to install or remove hydrogen bottles.

7.2.1.1.3 Cesium Exposure - The GTA injector employs a surface plasma source (SPS) that thermochemically produces small amounts of cesium (less than 0.1 gram) within the arc discharge region. The ion source is periodically removed from the injector, the discharge region is cleaned, and then the injector is reloaded with a titanium and cesium chromate charge. During the cleaning process, very small amounts of elemental cesium could react with water. This reaction could cause eye injury to a worker.

During normal operations, the accidental release of cesium is physically impossible. During the cleaning or loading process, the probability that such an accident will occur is unlikely, because only trained personnel are allowed to clean or load cesium compounds into the ion source, an activity they must perform in specified, safe work areas. Nevertheless, eye-wash facilities are provided in the work area because small amounts of cesium constitute a hazard to the eyes. In addition, personnel must wear safety glasses or eye shields when cleaning the ion source.

7.2.1.2 RFQ/IMS/DTL Accidents - The RFQ/IMS/DTL are passive systems. They consist of an external vacuum tank that houses the RFQ core tank, including vanes, and the DTL modules including the accelerator drift tubes. The accidents involving the RFQ/IMS/DTL include RF and x-ray radiation and cryogenic He.

7.2.1.2.1 RF Power Leakage - RF power is transmitted through coaxial and waveguide lines from the RF power equipment on the mezzanine of building

MPF-365. The lines tie into flanges on the RFQ/IMS/DTL tanks. Each flange is periodically probed with a RF sensor to ensure the integrity of the seal. In addition, the coaxial cable and waveguide interior are slightly overpressured with dry air during normal operations. Gauges monitor the pressure; any decrease in pressure due to a leak would be sensed and the RF power systems would shutdown. Another sensor for a leak is the mismatch sensor, which monitors the electrical interface continuity. Any radiation leak results in a mismatch, which is immediately detected, and the power is shutdown.

7.2.1.2.2 X-ray Radiation - During high RF-power conditions, x rays can be produced by the RFQ, the IMS buncher cavities, and the DTL modules.

7.2.1.2.3 GHe Leakage - GHe is used to cool internal components of the RFQ/IMS/DTL to cryogenic operating temperatures. Internal steel cooling lines connect to the RFQ aluminum vanes and copper drift-tube components through special fittings. Such joints could develop leaks, so cryogenic gas could escape into the vacuum tank. The vacuum tank pressure, conceivably, could build up. To mitigate the pressure effects of such a leak, overpressure safety valves, which exhaust into the tunnel are included in each tank. It is, therefore, conceivable that cold gas could be exhausted into the room and burn personnel. The exhaust valves, however, have been located to minimize the chance that this will happen.

7.2.3 Output Optics Accidents

A passive system, the optics' main constituents are a vacuum system and a large number of permanent magnets, which require no electrical energization. There are, however, three RF cavities that may exhibit RF leakage or emit x radiation. Corrector and steerer magnets are powered at low voltages but can provide high currents if accidentally shorted. Interception of the beam by the vacuum chamber will cause component and cooling-water activation. The beam can be missteered in the bend and cause vacuum failure by vacuum wall penetration.

7.2.3.1 RF Power Leakage and X Radiation - RF power is transmitted to the energy-dejitter cavity and the two momentum-compactor cavities by coaxial waveguides from the RF power system on the mezzanine of building MPF-365. The main momentum-compactor cavity is energized at less than 100-kW peak power; the second-harmonic momentum-compactor and the energy-dejitter cavities are energized at less than 20-kW

peak power each. The normal duty factor is 0.2% and will reach 2% for several hours during a phase of Experiment 3C.

The coaxial waveguides connect with these cavities through flanged bayonet-type seals. Improper sealing of the coax-cavity RF joints could cause RF leakage. Personnel working near an energized cavity could receive unacceptable doses of RF radiation. Because of the relatively low powers applied to the optics cavities, the hazard to personnel is substantially less than in the DTL. To prevent such leakage, each seal is periodically checked for mechanical integrity and examined with a meter that measures the local RF field. The waveguides are pressurized and the pressure monitored. A seal fault leading to RF leakage would decrease the pressure and cause the pressure monitors to shut down the RF power through the RF run permit. RF monitors are located near RF seals so appreciable RF leakage would turn off the RF power through the RF run permit system.

X rays could be produced in the cavities by electrons accelerated to the cavity walls. Most of the rays will be stopped by the cavity walls but a small fraction will penetrate. X-ray production will be measured during commissioning and lead shielding will be appropriately placed around the cavities. The X radiation will also be monitored when work near an energized cavity is required.

Cavities will not normally be energized while personnel are in the tunnel. Energizing of the cavities will be controlled by the RPSS. A SWP will be required when testing the cavities or for any operation of the cavities, while personnel are in the tunnel. The SWP will specify safety precautions and special monitoring.

7.2.3.2 Electrical Accidents - The steerer can be energized to up to 90 V dc and 45 V reactive voltage and, therefore, presents a possible shock hazard. Its power supply is also capable of supplying 400 A which could cause burns if its terminals were inadvertently shorted by a metallic object. The corrector magnets operate at less than 10 V-maximum potential but their supplies can provide up to 100 A.

The terminals of the steerer magnets will have plastic covers. Redundant microswitches, connected to the power-supply interlocks, will shut down the power supplies if the terminals are removed. Work on the magnets will require lockout, tagout procedures. Work on activated magnets will require an SWP.

7.2.3.3 Radiation Accidents - Parts of the output optics system will become activated because of off-normal operation or routine beam-halo scraping. Exposure of personnel to secondary radiation from activated components could occur. The activation will not be substantial and will be monitored. Areas with appreciable activation will be shielded. Cool-down periods will be observed before allowing proximity to activated components. Removal and disposal of activated components will be carefully monitored. Personnel will receive radiation training.

Mild activation of the water used to cool the momentum compactor cavities, corrector, and steering magnets will occur, as will some activation of the water used to regulate the objective temperatures.

Cooling water is confined to small-volume, closed systems and does not mix with unactivated water. Small volumes will be used and the water activation will be monitored. High-quality components will also be used throughout with metal piping and fittings. A spill is possible, however, if water lines rupture or cooling units leak.

7.2.3.4 Vacuum Loss - The output optics system is constructed of high-quality vacuum components, which will not disastrously fail. Experience with similar systems shows a failure mode through gasket leakage, detectable by slowly increasing pressure. Despite the possibility of a failure, no event classifiable as an accident occurs by this failure mode.

It is possible that errant beam in the bend could penetrate the vacuum wall. Such mishaps are guarded against by the beam-loss monitors, which will turn the beam off in less than 10 μ sec, which is adequate to prevent wall failure. The beam-position-monitoring system also continuously monitors off-axis beam motion. Its response, however, is through the computer system and requires seconds. Rapid lateral motion of the beam through component failure and simultaneous failure of the beam-loss monitoring system could lead to rapid vacuum loss. Such loss would cause heating and pressurization of the DTL's helium lines. The cryogenic system safeguards would then be necessary in preventing overpressure conditions in the cryogenic system.

7.2.4 Neutral Beam Accidents

The major sources for accidents in the Neutral Beam system are water-cooling, ionizing radiation, and cryogenics. The water-cooling system has several variables, which could cause an accident, that are discussed in the following text. The radiation accidents involve proper access control, and the cryogenics accident potential is reduced greatly by using the appropriate hardware and configuration.

7.2.4.1 Water-cooling Systems Accidents - The water cooling for the Neutral Beam is provided by a stand-alone system. The system will segregate potentially radioactive water from the main water system. It will be provided by AT-10 for use in the Neutral sector at the pinhole plate station for cooling the characterization beam stop. A SOP has been developed for the operation and maintenance of the system to eliminate risk to personnel. Appropriate personnel will receive practice and training sessions in the use and operation of the system.

7.2.4.1.1 Mechanical Failure of Equipment - The stand-alone water-cooling system consists of a commercial water-to-air chiller unit, which connects to the cooling-water feed-throughs on the pinhole plate station. From there, the cooling-water lines are routed through the vacuum enclosure to the characterization beam stop.

In addition to leaks in fittings, mechanical failure would most likely occur in the internal moving parts and components of the commercial chiller unit. (These internal parts include the water circulating pump, mixer, thermostat, and controls.) Mechanical failure of these components is unlikely, because the commercial units are designed for industrial service.

7.2.4.1.2 Electrical Failure of Equipment - The normal electrical source of power is provided by the local public utility through the LAMPF substation. There are no backup generators in the event of a general power outage. The most likely source of electrical equipment failure would be in the motor for the circulating pump of the commercial water-to-air chiller unit. Electrical failure of the motor is unlikely because the commercial units are designed for industrial use.

7.2.4.1.3 Major Water Spill or Leak - The unlikely event of a major water spill or leak is discussed in Section 7.3.4.3.

7.2.4.2 Ionizing Radiation Accidents - Personnel may be exposed to radiation when entering the neutral beam exclusion areas before the appropriate time lapse has occurred. The exclusion area in the neutral beam system will have a "radiation-cool-down" time because of the radiation induced in, and around, the pinhole plate station (the characterization beam stop) and the final beam stop. Access will be monitored and/or controlled.

7.2.4.3 Cryogenics - Liquid nitrogen from two dewars is used in the neutral beam system at the detector station. The 100 ℓ dewar is outside the vacuum enclosure and will serve as the supply dewar for the small ($\leq 10 \ell$) dewar located within the vacuum enclosure. As with the cryogen lines used elsewhere in the beam line, the lines will be insulated so that contact with them will not be hazardous. Leaks will also be readily visible and the lines will be located so that leaks will not create a hazard. An injury caused by a cryogen is deemed extremely unlikely. This scenario, however, is covered in more detail in Section 7.3.5.

7.2.5 Diagnostics

This section reviews accidents associated with permanent diagnostics for Experiments 2D and beyond, which are not covered elsewhere.

7.2.5.1 Chemical and Laser Hazards - Employee exposure to chemicals above permissible limits is unlikely. Bulk storage and dispensing of commonly used chemicals, primarily acetone, freon, and ethanol, is outdoors. Indoor usage is in small quantities, primarily from $\leq 1\text{-}\ell$ squeeze bottles. Although the chemicals used have low toxicity, they are regulated as hazardous materials. The laser dye solvent (1,2 dichloroethane) is more hazardous, but it is used with local exhaust ventilation and respiratory protection. To prevent chemical exposure, HS-5 monitors chemical usage and prescribes protective clothing and equipment or ventilation hazard communication training is provided for employees. Ocular exposure to the laser-induced neutralization diagnostic apparatus (LINDA) lasers is prevented by interlocks on the door to the laser room and laser pipe and by using protective eyewear. For a listing of safety features associated with commercially available laser systems see Appendix I.

7.2.5.2 Offset Beam Line Electromagnet Interlock Failure - Electromagnet interlocks are designed to protect the magnet and the power supply in the event of coolant

system or electrical system failure. Failure of redundant interlocks for coolant flow and temperature, though extremely unlikely, can result in hazards primarily involving heat. Run-away heating of magnets can result in damage to the magnet coils and functioning interlocks. The most probable scenario is if the interlocks on a faulty coolant channel fail, the heat generated in that channel will eventually cause interlocks on neighboring channels to trip. Severe heating of a given channel prior to tripping other interlocks has been known to result in rupturing of that channel and venting of hot water or steam. Magnet iron may also get sufficiently hot to cause burns and, without cooling, the heat capacity of the magnet will retain the heat for long periods of time.

7.2.5.3 Offset Beam Line Electromagnet Warning Light Failure - Such an event might lead a person to believe the magnet is not energized when indeed it is. This could lead to electrical shock or burns. Mitigation of this type of accident is not as easy as in many other facilities since the magnet power supply is not within sight of the magnets. The appropriate SOP for working on magnets in the GTA tunnel will be followed. Normally this requires that the power supply be tagged and locked out.

7.2.5.4 Electrical Shock - Electrical shock primarily results from improper installation, operation, or servicing of power supplies. Mitigation is simply requiring that the SOP be followed, which normally includes lock out and tag-out. Installation and operation of the power supply must be in accordance with manufacturer's specifications.

7.2.5.5 High Magnetic Fields - The offset beam line bend magnet produces high magnetic fields (~1T). Personnel working in the vicinity with steel tools could be injured by the violent attraction of the tools to the magnet. The magnet warning light alerts workers to this hazard. Workers will be trained to avoid this hazard.

Magnet fields in excess of 10 G present possible hazards to persons wearing a prosthesis (e.g., a heart pace-maker). The maximum allowable field that is not posted with warnings is 10 G, and it is anticipated that at least 1 magnet—the 22.5° bending magnet—will exceed this level more than 1 ft from the magnet. A warning sign will be posted stating this information. No magnet in the diagnostic beam line will present hazardous magnetic fields to a person who is not wearing a prosthesis.

7.3 Accident Analysis for Accelerator Support Systems

Possible accidents involving the accelerator support systems have been identified and are presented in the following sections.

7.3.1 Accelerator Control Accidents

The accelerator control system is made up of a number of instruments and computers. These have no exposed conductors capable of greater than 30 V or 25 A. All instruments and computer equipment purchased, or fabricated at LANL, meets minimum national and LANL codes or standards. Access to electrical hazards (normal line voltages) in these units is prevented by protective panels and warning labels.

Where feasible, all control and instrumentation cables are run in separate conduits, cable trays, and junction boxes, all of which are grounded. No electrical power or high-voltage wiring is run in the same conduit or cable trays with 24-V control signals. Some junction boxes contain both control equipment and 120-V ac wiring. Good electrical practice, lockout, tagout procedures, SOPs, or SWPs are used when servicing any electrical equipment. (The two-man rule is strictly enforced when energized equipment is used.) Fiber-optic cable is used to isolate other sources of high voltage from the control system.

The chance of an accident associated with the control system is extremely unlikely—no worse than in the use of bench-top instruments. Personnel who install and maintain the control system hardware are trained in electrical safety.

7.3.2 RF Accidents

Accidents involving the RF power include high voltage, x-ray and RF radiation, and oil leaks.

7.3.2.1 High-voltage Accident - Potentially lethal high-voltage accidents would be possible in the capacitor rooms for the GTA and HPTCB 850-MHz klystron systems, in the tetrode station, and in the RF stations without proper safety systems. To prevent such accidents in the capacitor rooms, a worker needs to pass through two protection systems to gain access: a mechanically controlled system and a manual system. The mechanical system requires a Kirk key to open the capacitor-room door. The Kirk-key system is comprised of captive keys that are often used on high-voltage systems. These keys are made only by one manufacturer, and no spares are allowed on site. To obtain access to the capacitor room, power supplies are shut-down, which puts a direct short and a bleeder resistor across the capacitors. Once this is done a Kirk key can be inserted into

the capacitor-room door. (Only one key is available and no spare keys exist.) Now the potentially hazardous capacitor room may be entered. When the door is opened, a third set of shorts is placed across the capacitors. The power supplies are locked off, the bleeder resistors are always connected, and three levels of short circuits guarantee that there will be no voltage on or in the capacitors. Finally, the system voltmeter must read zero before personnel are allowed to enter the capacitor room. Grounding hooks are present and are placed in their appropriate marked positions. In addition, the klystron modulators have redundant hard-wire and software interlock chains. The interlock chain is a summation of the modulator deck lid, a Kirk-key switch on the capacitor-room door, a summation of the Allen-Bradley logic controller, grounding hooks in the capacitor room, a manual safety capacitor discharge switch (Ross dump switch), and an emergency on/off switch. This summation closes a contact that goes to the high voltage power system (HVPS) controller, which has an external interlock lead. Opening any of the contacts in the chain removes power from the external interlock and shuts off the high voltage.

Access to the high voltage in the tetrode station, which is housed in steel racks, is also interlock protected. In this case two redundant interlock system—one hard-wire-based, the other software-based—will shut down the high-voltage power supplies if any of the interlocks are tripped. Likewise, the 850-MHz klystron RF station is protected with interlocks that will shut down the high voltage if the modulator deck lid is lifted, a Kirk key is removed, or the Ross dump switch is activated. All interlock systems have emergency on/off switches on control-rack front panels or on walls in strategic locations, which shut off the high voltage to tetrode and klystron sections.

A lethal accident can occur if a worker violates the SOPs for tetrode and klystron operation and, simultaneously, there is a complete and total failure of the multiple safety systems. Under normal operating conditions the simultaneous failure of all safety systems is extremely unlikely. SWPs are issued and used when nonstandard operating conditions exist. These conditions can be implemented only by trained personnel using special, approved procedures. These personnel have also been trained in cardio-pulmonary resuscitation, first aid, and the safety system.

7.3.2.2 X-ray and RF Radiation Accident - The x rays emitted from the tetrodes and klystrons could expose a worker to ionizing radiation. Radiation from the tetrodes is measured by HS-1 personnel while the equipment is operating at more than 200 kW-peak power. No radiation was detected. The tops of the 850-MHz klystron

tubes, the sole source of x-ray production, have been shielded with lead. HS-1 personnel measure for radiation. HS-1 will periodically monitor the area for radiation.

The tetrodes and klystrons also transmit high levels of nonionizing RF radiation, which, in large doses, can result in permanent eye damage before any ill effects are experienced. This would be most likely to happen if a waveguide or a coaxial transmission line were left open during operation. To prevent this from happening, an air-pressure-sensing interlock system has been installed on each type of transmission line. Loss of pressure would immediately terminate high-power RF. Furthermore, waveguides and coaxial runs are periodically checked by trained personnel for RF leakage.

To prevent x-ray and RF radiation exposure, a worker is protected by administrative procedures described in the Conduct of Operations manuals for the tetrode and klystron systems, hard-wired safety interlocks, computer interlocks, controlled access, lead shielding, the operation of the equipment at a duty factor of less than 2%, installed radiation-detection equipment, and training. This type of accident is "extremely unlikely" to happen.

7.3.2.3 Oil Leak Accident - Each modulator tank contains approximately 200 gal. of nontoxic, nonhazardous dielectric oil. An accidental release is extremely unlikely, because the sturdy tank is designed as a no-leak container. The only time a spill is likely to occur is when the oil is pumped in at the beginning of an operation or pumped out to repair the tank. If a spill does occur, the mezzanine floor provides containment to prevent the oil from spreading to other parts of MPF-365. Fire is extremely unlikely, because the oil has a very high flash point (270-306 °C). To prevent any equipment damage associated with an oil leak, a shut-down interlock system with a level-sensing device is in the tank. When the oil goes below a certain level, klystron operation is halted. The operational impact of this type of accident would be negligible to marginal and is extremely unlikely to occur. This is considered a normal industrial accident.

7.3.3 Vacuum

Vacuum vessels for accelerator subsystems and associated piping are designed to Section VIII of the American Society of Mechanical Engineers (ASME) Unfired Pressure Vessel Code. Vacuum vessels are equipped with pressure relief valves, to avoid overpressurization, if there is a cryogen line leak within the vessel. The probability of serious injury or damage from a vacuum-system failure is, therefore, extremely unlikely.

7.3.4 Water Cooling System Accidents

The GTA water-cooling system operates at less than 110 psi and is based on standard industrial designs for most heating, ventilating and air conditioning (HVAC) systems. The system uses standards and practices for closed-loop and open-loop cooling systems used worldwide and has been designed and built to the latest professional standards and codes (American National Standards Institute [ANSI]; American Society of Heating Refrigeration and Air Conditioning Engineers [ASHRAE]; and LANL). A SOP has been developed for the operation and maintenance of the system to eliminate risk to personnel. The appropriate personnel receive practice and training sessions in the use of the SOP and operation of the system.

Hazards to personnel and equipment associated with the water-cooling system, which are predicted to be minimal, would generally be associated with system failures and malfunctions. The hazards are those associated with mixing water and electricity and with minor flooding. The occurrence of these events is highly unlikely. If a line burst, or leaked, the floor drains would not allow the water to rise appreciably. If the drains were plugged, then a limited flooding problem would occur with possible minor damage to equipment located on, or near, the floor.

7.3.4.1 Mechanical Failure of Equipment - The prime movers in the water-cooling system are centrifugal pumps driven by 480-V, three-phase electric motors. The remainder of the system consists of standard industrial piping, valves and associated equipment found in process water cooling systems. The equipment and materials are both efficient and reliable. Problems that would normally occur as a result of human error have been substantially reduced by installation and use of a local computer-control network similar to the direct digital controller (DDC) used in most modern building environmental control systems. The system is constantly observed from monitor stations throughout the building, which provides some redundancy checks in the system. These monitor stations report system status and/or problems to a programmable logic controller dedicated to the water-cooling system. A message is sent from the local programmable logic controller (PLC) directly to the main accelerator computer control center, which signals the "go" or "no go" status of the water-cooling system. System status is fed also to the verbatim auto dialer.

7.3.4.2 Electrical Failure of Equipment - The normal source of power for the facility and water-cooling system is the local public utility company, and it is adequate for normal operation and maintenance. There are no backup generators for electrical power should a failure occur.

7.3.4.3 Major Water Spill or Leak - In the unlikely event of a major water spill, the water-cooling system has been designed so that the PLC will turn off pumps and limit the quantity of water lost from the system. The spilled water would flow into floor drains and then shipped out of the building through the sanitary-sewer system. Only minor damage from water is predicted. Water that may be contaminated at high energies is pumped to a containment tank rather than into the sanitary sewer.

7.3.5 Postulated Accidents for the CCS

Safety has been a primary consideration in the design of the CCS. A detailed and systematic FMEA was conducted during, and following, the design phase of the CCS. As a result of this FMEA, design changes were made to further minimize the adverse consequences of single-point failures. (See Chapter 6.) Based on the final configuration of the CCS, a series of worst-case accidents were postulated and analyzed. In choosing the worst-case accidents to be analyzed, both postulated single-point failures derived from the FMEA and postulated component failures resulting from human errors, or events leading to the defeat of engineered safety systems, were considered.

The primary hazards considered include fire and uncontrolled hydrogen release (for example, a release at a location other than designed for venting hydrogen) into the atmosphere for LH₂ components; and asphyxiation, frostbite, and stored energy release for LN₂ and GHe components. Accidents were postulated that could result in these hazards occurring.

Postulated accidents that could result in a hydrogen release and fire or internal combustion are:

- a complete off-set break in the LH₂ transfer line during hydrogen transfer;
- a complete off-set break in the LH₂ fill line during hydrogen transfer;
- a massive rupture of the LH₂ storage or run dewars;
- rupture of the LH₂ storage or run dewars by a small projectile; and
- combustion inside the LH₂ storage or run dewars.

Postulated accidents that could result in a release of hydrogen to the atmosphere are:

- an overflow of the hydrogen vent during transfer to the LH₂ run dewar;
- a complete off-set break in the GHe circulation line at the GHe/LH₂ heat exchanger inside the LH₂ run dewar; and
- disconnection of the fill line during a transfer operation between a tanker and the storage dewar.

Postulated accidents that could result in an asphyxiation and frostbite hazard are:

- a break in the GHe circulation line in the beam tunnel; and
- a break in the GHe circulation line or the LN₂ line in the equipment building.

A postulated accident that could result in a stored energy release is a massive rupture of the GHe recovery vessel.

To maximize the safety of the CCS and its planned operations, the analysis of postulated accidents was evaluated in an independent safety review by a group of experts in the field of cryogenic engineering and technology (including LH₂) under the leadership of Dr. Keith Boyer. The Boyer Committee report is in Appendix S. Details of the postulated accident analyses are in Attachment H of that appendix.

Two major premises used in the analysis of the postulated accidents that relate to the possibility of a flammable cloud migrating beyond the GTA-site boundaries were:

- ignition of an unconfined hydrogen/air mixture that may result in a deflagration, but not a detonation; and
- that an event that is sufficiently energetic to produce a massive rupture of a dewar will ignite any hydrogen that is released in the rupture process; further, the probability of no ignition for an event with sufficient energy to completely break apart the LH₂ transfer line is extremely unlikely.

Justification for these premises is given in Appendix S, Attachment H.

Since these accident analyses were presented to the Boyer Committee, additional review of National Aeronautic and Space Administration (NASA) hydrogen accidents and incidents (reference: P.M. Ordin, "Review of Hydrogen Accidents and Incidents in NASA Operations," NASA Technical Memorandum NASA TMX-71565, Lewis Research Center, Cleveland, Ohio, 1974), and discussions with NASA and Air Products experts revealed several cases of component ruptures in which hydrogen was released without igniting; in a large majority of such cases, however, ignition did occur at, or near, the rupture. In none of the accidents reported did a hydrogen cloud ignite at any appreciable distance from where it was released. None of the ruptures reported was caused by an external event, such as in the CCS postulated accidents, and all reported accidents could be explained by improper procedures or improper design.

This additional information indicates that the probability of no ignition at, or near, the rupture for an external event that would completely rupture the LH₂ fill line or transfer line during fill or transfer operations should be considered as unlikely rather than extremely unlikely. This increased probability, when combined with the extremely unlikely probability of the event itself, does not change the evaluation or conclusions of the accident analyses reported earlier.

The more probable accidents that might occur as a result of improper procedures and the failure of safety devices would result in a much smaller release of hydrogen than that of the postulated accidents. For example, a rupture of the LH₂ transfer line because of internal overpressure, as a result from isolation of the line volume by the improper closing of one or more valves, combined with the simultaneous failure of all pressure relief valves, would result in the release of only the amount of hydrogen in the confined volume of the line. This amount of hydrogen would be only a small fraction of that released in the postulated line-rupture accident calculations.

To prevent accidents as a result of improper procedures (such as those reported in the NASA memorandum and by the Boyer Committee), special safety features have been incorporated in the CCS design. (See Chapter 4). All CCS operations will be conducted according to approved SOPs.

There is a distinction between deflagration and detonation, as used in the context of this accident analysis. In a deflagration, the pressure wave caused by ignition of the flammable mixture is subsonic. In a detonation, the pressure wave is a shock wave and travels at supersonic velocity to compress the unburned mixture. The maximum overpressure produced by a deflagration is much less than is possible from a detonation. In describing audible events in which fireballs occur, the term explosion is frequently used to describe either a deflagration or a detonation.

The following sections contain a summary of the accidents considered for the CCS. (Refer to Appendix S, Attachment H, for additional detail and references.)

7.3.5.1 Hydrogen Fire or Internal Combustion - A fire can occur from any hydrogen leak or release—no matter if the leak is large or small. The larger the leak rate, however, the larger the resulting fire, and consequently, the larger the hazard. Thus, the largest conceivable leaks or releases that could be postulated were chosen for evaluation. The postulated accidents, which could result in a fire or internal combustion from the largest conceivable releases of hydrogen, included:

- a complete offset break in the LH₂ transfer line during LH₂ transfer;
- a complete offset break in the LH₂ fill line during LH₂ transfer;
- a massive rupture of the LH₂ storage or run dewar;
- a rupture of the LH₂ storage or run dewar by a small projectile; and
- a combustion inside the LH₂ storage or run dewar.

The primary hazard from these failures is thermal radiation. There will be minimal over-pressure and negligible blast effects, because the combustible mixture will deflagrate and not detonate.

7.3.5.1.1 LH₂ Transfer Line Break - An evaluation was made for a break (in the case of the line's two ends separating completely) occurring during a transfer of LH₂ from the LH₂ storage dewar to the LH₂ run dewar at the following locations in the transfer line:

- at the LH₂ storage dewar;
- at the bend in the transfer line; and
- at the LH₂ run dewar.

The distances from the LH₂ storage dewar to the three postulated breaks are 7.6 m (25 ft), 96 m (315 ft), and 173 m (568 ft). The LH₂ transfer line has an internal diameter of 4.4958 cm (1.77 in.). The LH₂ storage dewar was assumed to be pressurized to about 34 kPa (5 psig) for the transfer operation. Thus, for a break in the transfer line, LH₂ would flow from the LH₂ storage dewar until the transfer line shutoff valve was closed by the operator. If a break did occur, it is most likely that the resulting venting would be directed horizontally, or downward, rather than upward. This conclusion is based on the assumption that the line is broken by an object either falling onto it or running into it. Thus, the fence would provide shielding from a major part of the thermal radiation from the fireball.

Calculations show that regardless of the orientation of the vented hydrogen plume (including vertical or upward flow), the thermal-radiation level that a person at the fence would receive on unprotected skin is below the level required for a first-degree burn. Access to the area along the transfer line will be controlled, and personnel will not normally be in the vicinity of the line during the transfer operation; consequently, exposure to employees from such an accident is

limited. However, operating personnel that were in the vicinity of the accident could be subject to a higher degree of skin burns, depending on their proximity to the break and the ensuing fire.

One possible cause for such an accident is a vehicle crashing into the line. Protection against this has been provided by the installation of concrete barriers (Jersey Bounces) along the length of the line and along La Mesita Road. These barriers will deflect a light truck travelling at 50 mph. The probability of this accident occurring is considered to be extremely unlikely.

7.3.5.1.2 LH₂ Fill Line Break - An evaluation of a postulated break in the LH₂ fill line between a LH₂ tanker and the LH₂ storage dewar during a fill was made. Analyses included the possibility of breaks occurring: at the start, or during, the fill with LH₂ in both the storage dewar and in the tanker; and at the end of the fill with LH₂ only in the storage dewar. The LH₂ tanker was assumed to be pressurized to about 34 kPa (5 psig) for the fill operation, with the storage dewar vented to atmosphere, with about 3.4 kPa (0.5 psig) back pressure. Thus, for a break in the fill line, LH₂ would continue to flow from the LH₂ storage dewar, and/or the tanker, until the fill-line shutoff valve, and/or the trailer fill valve, was closed by the operator. The fill-line shutoff valve is remotely operated and can be closed from several locations, including the control room. The LH₂ flow rate at the break was determined from the relationship for flow through a circular pipe. The fill line from the storage dewar has an internal diameter of 4.4958 cm (1.77 in.), and the distance from the dewar to the break in the fill line was assumed to be 7.62 m (25 ft.). The fill line from the tanker was assumed to have an internal diameter of 5.08 cm (2 in.), and the distance from the tanker to the break in the fill line was assumed to be 3 m (10 ft). Most likely, if a break did occur, the resulting venting would be directed horizontally, or downward, rather than upward because of realistic accidents that could cause the break. Thus, the fence would provide shielding from a major part of the thermal radiation from the fireball.

The thermal-radiation level that a person at the fence would receive on unprotected skin is well below the level required for a first-degree burn. The fill operation will have the truck driver and a Laboratory employee attending to the

fill process. They will be in close proximity to the fill line and, consequently, they could be subject to serious injuries from an accident such as this.

A possible cause for this accident is the truck driver pulling away while the fill is in progress or before the valves on the storage dewar are closed. This possibility will be prevented by requiring that the wheels of the truck be blocked until the fill operation has been completed and the system secured. The SOP for LH₂ unloading requires that a fire truck standby at the CCS site during the fill operation. The probability of this accident occurring is considered to be extremely unlikely.

7.3.5.1.3 Massive Rupture of the LH₂ Storage or Run Dewar -

The worst case failure for a massive rupture of the storage or run dewar is a complete emptying of the tank volume into a pool beneath the tank with subsequent deflagration of the spilled volume. The thermal-radiation level that a person at the fence would receive on unprotected skin from such an event for either dewar is well below the level required for a first-degree burn.

Although the liquid level within the run dewar will be controlled to maintain the minimum level of LH₂ required to cover the heat exchanger at all times (5,600 L), the worst case scenario assumes the run dewar is full of LH₂ (15,330 L [4,050 gal]) when massive rupture occurs.

Such an accident could be caused by a large aircraft crashing into one of the dewars. Protection against such an event is impossible. The probability of such an accident occurring was analyzed and is considered to be incredible. (See Appendix S, Attachment E, p. 45.) The thermal radiation from a hydrocarbon fire (for example, from jet aircraft fuel) would be considerably higher than that from a hydrogen fire.

7.3.5.1.4 Rupture of the LH₂ Storage or Run Dewar by a Small Projectile -

Two cases were considered for this accident: one in which a small projectile penetrates the vacuum vessel but not the liquid vessel; and one in which the projectile penetrates both vessels. These two cases were considered for both the LH₂ storage and run dewars. A possible cause for such an accident is

someone shooting at the dewars with a rifle or the impingement of shrapnel from an explosion elsewhere.

A detonation within the annular space of either dewar is not likely because the perlite, or multilayer, insulation within the annular space limits the free volume and inhibits the diffusion of hydrogen.

7.3.5.1.5 Projectile Penetrates Vacuum Vessel but not Liquid Vessel - This accident has been analyzed for the LH₂ storage and run dewars.

The storage dewar is a double-walled tank with an annular gap of 28 cm that is filled with perlite insulation and is evacuated. In this accident, the penetration of the vacuum vessel from the outside results in the flooding of the perlite insulation with ambient air. The resultant increase in thermal conductance across the annular gap will increase the boil-off rate of LH₂ within the dewar. Previous measurements of heat leak for the storage dewar indicated a boil-off of 0.7% per day resulting in a hydrogen vent rate of 0.61 g/s (0.0013 lbm/s). With loss of vacuum in the insulation, the boil-off rises to 7.0% per day giving a hydrogen vent rate of 6.1 g/s (0.013 lbm/s). This vent rate does not result in a flammable cloud that extends beyond the CCS boundary, and it is well below the acceptable vent rate (according to NASA's Hydrogen Safety Manual) of 113 to 226 g/s (0.25 to 0.50 lbm/s) without flaring. It is unlikely that frozen nitrogen or water will bridge the annular gap and further increase the thermal conductance, because the temperature profile across the insulation from 20 to 300 K is nearly linear. There is substantial insulation volume above the freezing point of either nitrogen or water. The probability of such an event occurring is considered extremely unlikely. No protection from such an event has been provided.

The run dewar has a 7-cm-(2.8-in.-) wide annular gap between the liquid and vacuum vessels. A 2.5-cm-(1-in.-) thick insulation blanket is attached to the outside of the liquid vessel. The blanket is composed of 44 layers of aluminized mylar with spacers between layers. The nominal boil-off rate of 1% per day results in a hydrogen vent rate of 0.123 g/s (0.98 lbm/h). With loss of vacuum in the annulus, the effectiveness of the insulation is reduced because of gaseous conduction. The effective thermal conductivity in air at a pressure of 101.4 kPa (14.7 psia) is 2.6×10^{-4} W/cm K. This results in a vent rate of 12.7 g/s

(101 lbm/h) well below the design flow rate of 84 g/s (667 lbm/h) based on 40 kW heat load from the GHe heat exchanger.

The probability of such an event occurring is considered extremely unlikely. No protection from such an event has been provided.

7.3.5.1.6 Projectile Penetrates the Vacuum and Liquid Vessels -

The analysis for this accident was done for the LH₂ storage dewar and dewars.

Two concerns are apparent when the projectile penetrates both vessels of the storage dewar. First, flooding of the perlite with a mixture of GH₂ and air will further increase the thermal conductance of the insulation system. The worst case is 100% hydrogen saturation of the perlite, so that condition has been analyzed. The increased heat leak results in a boil-off of 19.2% per day. The hydrogen flow rate is 16.7 g/s (132 lbm/h), which is still well within the capability of the vent system. Second, the ensuing jet of LH₂ will ignite when it vaporizes and mixes with the atmosphere. Complete combustion of the expelled cryogen is assumed. No thermal hazard outside the CCS boundary is associated with this event. If the jet fails to ignite, the resulting flammable cloud will not cross or extend beyond the fenced boundary of the CCS. The maximum pressure within the tank, which occurs during transfer to the run dewar, is 34.5 kPa (5.0 psig) otherwise the tank is at slightly above ambient pressure and the liquid jet is gravity fed. Overpressurization of the tank is not expected, however, because the vent system is more than adequate to handle the increased boil-off as a result of the degraded insulation. There is no public hazard associated with this event. The probability of such an event is considered extremely unlikely. No protection from such an event has been provided.

Upon penetration of both walls of the run dewar, a mixture of hydrogen and air will occupy the annular space at a pressure of 101.4 kPa (14.7 psia). Assuming the gap is filled with pure hydrogen, the maximum boil-off will occur. Data on the effective thermal conductivity of multilayer insulations in the presence of hydrogen at 101.4 kPa (14.7 psia) are not available. However, taking the ratio of the thermal conductivities of hydrogen and air (= 7.2 at 300 K) and increasing the effective thermal conductivity of the air-saturated multilayer insulation by this ratio, an estimate of the heat leak for the double-wall penetration can be

obtained. For this case, the hydrogen vent rate is 39.7 g/s (315 lbm/h), which is less than the design vent rate for the 40-kW heat load. The flare system is adequate to handle the worst-case insulation degradation; thus preventing overpressurization of the run dewar. The separation distance of 17 m (56 ft) is adequate to prevent thermal injury from the issuing jet at the fence, and no combustible cloud migration beyond the fence will occur. The probability of such an event is considered extremely unlikely. No protection from such an event has been provided.

7.3.5.1.7 Combustion Inside the LH₂ Storage or Run Dewar -

For combustion to occur inside either the LH₂ storage or run dewar requires the presence of a combustible mixture and an ignition source. The maximum-energy release is obtained with a stoichiometric mixture. Such a condition could occur if hydrogen is introduced into either dewar when air is already present. Further, it is assumed that ignition is delayed until a stoichiometric mixture is obtained. Any ignition source present within the dewar would be a thermal ignition source, and because of the low aspect ratio ($L/D = 2$) of the dewar geometry, would be insufficient to cause a detonation. Therefore, only a deflagration would result. (See Attachment H, Appendix S.)

A deflagration at stoichiometric conditions within either dewar would result in an internal pressure of 0.80 MPa (115 psia), as calculated from Ref. 12, Attachment H, Appendix S. The storage dewar has been hydrostatically tested to a pressure of 1207 kPa (174 psig). The run dewar has a maximum working pressure of 1.03 MPa (150 psig), and has been hydrostatically tested to a pressure of 1.54 MPa (225 psig). Thus, both dewars would be able to contain the combustion of a stoichiometric mixture of hydrogen and air. The working pressure of the run dewar was designated to be sufficient for this purpose. Strict adherence to operating procedures for purging and purification will be used, however, to prevent such an accident.

The probability for such an event is considered extremely unlikely.

7.3.5.2 Hydrogen Release to the Atmosphere - Postulated accidents that could result in a release of hydrogen to the atmosphere include:

- an overflow of LH_2 during transfer to the run dewar (and the flare stack malfunctions);
- a break in the GHe circulation line at the GHe/ LH_2 heat exchanger (and the flare stack malfunctions); and
- disconnection of the fill line between a tanker and the storage dewar during a transfer operation.

As a result of these accidents, released hydrogen could form a combustible cloud whose size and shape would depend on many factors, such as wind speed, atmosphere lapse rate, and topography. The hydrogen mixes with air within a few meters of the release point to form a neutrally buoyant cloud.

7.3.5.2.1 Overflow of LH_2 During Transfer to Run Dewar - An overflow of the run dewar could occur if the transfer of LH_2 from the storage to the run dewar did not end when the proper liquid level was attained within the run dewar. If this should happen, the excess LH_2 would enter the vent line, then the flare stack, and finally be burned. The hydrogen flow rate from the flare stack is estimated to be less than that calculated for the transfer line rupture at the run dewar, mainly because of the additional flow resistance of the vent line itself.

In addition to the liquid-level controller, a liquid sensor is installed in the vent line at the dewar and interlocked with the control valve to prevent this accident from occurring. The probability of this event, therefore, is considered extremely unlikely. As a consequence of the estimate given above for a potential flammable cloud release, which could exist beyond the fence, the CCS run dewar vent will be installed with a flare stack rather than the originally planned vent stack. Thus, the hydrogen vented in the event of this accident will be flared (burned) and no flammable cloud will be released.

7.3.5.2.2 Break in the GHe Circulation Line at the GHe/ LH_2 Heat Exchanger - The postulated accident was for a GHe circulation line in the LH_2 run dewar to rupture during operation so that GHe from both ends of the ruptured line would rapidly vent into the dewar and increase pressure within the dewar. The vent valve on the dewar will be open when this accident occurs; however, no venting was assumed for the pressure buildup analysis. Thus, for a

short time after the failure occurs, a higher than normal vent rate (consisting mostly of GHe) will exist. Four possibilities were analyzed:

- failure during cool down at LN_2 temperature with an ullage volume of 3.1 m^3 (110 ft^3);
- failure during cool down at LN_2 temperature with an ullage volume of 9.3 m^3 (330 ft^3);
- failure at the end of cool down at LH_2 temperature with an ullage volume of 3.1 m^3 (110 ft^3); and
- failure at the end of cool down at LH_2 temperature with an ullage volume of 9.3 m^3 (330 ft^3).

The maximum dewar pressure for the two cases having an ullage volume of 3.1 m^3 (110 ft^3) is approximately 0.69 MPa (100 psia); the maximum pressure for the two cases having an ullage volume of 9.3 m^3 (330 ft^3) is about 0.34 MPa (50 psia). As would be expected, the time to reach equilibrium pressure is much shorter for the warmer (less dense) cases. The maximum allowable working pressure (MAWP) of the dewar is 1.03 MPa (150 psig); thus, the dewar can safely sustain this pressure increase. The GHe will vent rapidly through the flare stack, and the dewar pressure will quickly decrease to, or remain slightly above, atmospheric pressure.

A loss of the vacuum insulation concurrent with the break of a GHe circulation line would have little effect on the pressure in the dewar as previously described.

The GHe circulation lines in the run dewar are copper or stainless steel (with similar expansion coefficients). The tubular helix design of the heat exchangers is such that they are free to expand without constraint and essentially no thermal stresses are introduced during the system cool down or warm up. The probability of this event is considered extremely unlikely.

7.3.5.2.3 Disconnection of Fill Line During LH_2 Fill Process -

A massive break in the fill line was previously discussed and, under such circumstances, any hydrogen released would be ignited when the line was broken. It was postulated, however, that the bayonet connection between the tanker and the storage dewar could be manually disconnected in human error during a transfer. Likewise, if the fill line cap were removed, and both of the valves in the fill

system were opened, then LH_2 could be drained from the storage dewar. (The manually operated fill valve and the fill line cap will be locked to prevent the possibility of this happening.) To disconnect the fill bayonet, the operator would have to use two spanner wrenches to unscrew the connecting flanges; this could be difficult because the flanges would be cold and possibly iced over. Under these conditions, the energy necessary for immediate ignition of the hydrogen might not be available, and the hydrogen released could form a combustible cloud. As soon as the bayonet joint is loosened, a cloud of hydrogen will emerge and serve as a warning to the operator not to proceed with the disconnection. Under such circumstances, the release rate would be very small and the combustible cloud would only exist for a few meters from the release point.

No damage should occur as a result of this accident, but the operator could suffer frostbite or burns if the hydrogen ignited. A fire truck will standby at the CCS site during fill operations. The probability of this accident is considered extremely unlikely. (As a result of an updated FMEA, this probability has been revised from incredible as previously reported.)

7.3.5.3 Asphyxiation and Frostbite - Postulated accidents that could result in asphyxiation or frostbite include a break in the GHe circulation line in the beam tunnel, and a break in the GHe circulation line or the LN_2 supply line in the CCS equipment room.

These postulated failures could result in a cryogen (GHe at temperatures down to about 22 K or LN_2 at 75 K) being released into a closed volume (e.g., the beam tunnel or the equipment room). A potential for asphyxiation, consequently, exists for a limited period after such a failure. In addition, personnel in the vicinity of the break would be exposed to the cryogen's low temperature and, therefore, could suffer frostbite (even to the lungs if low-temperature gases are inhaled). Equipment near such a break could be subject to cold embrittlement. Oxygen monitors installed in the beam tunnel and the equipment room will warn of an oxygen deficiency. Access to the equipment building will also be controlled to minimize the possibility of asphyxiation or frostbite. Thus, personnel injury from these accidents is considered extremely unlikely.

7.3.5.3.1 GHe Circulation Line Break in the Beam Tunnel - In this accident, a GHe circulation line is assumed to suddenly and catastrophically separate completely, so that the GHe in the line is rapidly vented into the tunnel from both ends of the broken line. The primary concerns from such an accident include asphyxiation, frostbite, and the kinetic energy of the GHe.

The GHe circulation system has an estimated volume of 2.2 m^3 (77 ft^3), and contains a helium mass of 109.4 kg (241 lbm) at 2.22 MPa (323 psia) and 21 K (-422° F). The buoyancy of the GHe will depend upon its temperature, but even at its lowest temperature (21 K) it will rapidly become positively buoyant and rise to the top of the tunnel. In addition, the lines are already located near the top of the tunnel.

The beam tunnel is about 6.1 m (20 ft) high, has a maximum width of 10.5 m (34.6 ft), and is 144.2 m (473 ft) long. It has a cross-sectional area of 54.8 m^2 (590 ft^2). If a helium line ruptured, and the helium in the line was vented into the beam tunnel, this mass of helium could occupy a volume of 56 m^3 (1980 ft^3) at 0.1 MPa (14.7 psia) and 25 K (-415 °F). The helium would displace the air in ~1 m (3.3 ft) of the tunnel, if it spread evenly across the cross section of the tunnel for this length.

The tunnel's air-circulation system provides about seven air changes each hour. At this ventilation rate, the helium concentration (if uniformly mixed with the air across the entire tunnel) would decrease from 100% to 0.01% in ~1 hr 25 min. Impaired performance is initiated at a 5% He concentration, and the impairment is complete at 50% concentration at the ambient pressure of Los Alamos. The air-circulation system would reduce the helium concentration in the air below the 50% concentration level in ~8 min and below the 5% level in ~37 min. The helium would rapidly disperse throughout the tunnel, with the highest concentration near the top of the tunnel so that the volume in which the concentration could be greater than 50% would exist only briefly. Asphyxiation and frostbite appear to present a problem in only a small localized area around the end of the ruptured line; personnel should be able to escape from this small area. Oxygen monitors in the tunnel will sound an alarm at an oxygen concentration of 19.5%.

7.3.5.3.2 GHe Circulation Line or LN₂ Supply Line Break in the Equipment Room - The GHe circulation lines and a LN₂ supply line enter the CCS equipment room. This accident scenario involves a break of one of these lines so that He or LN₂ is released into the room. If such an accident occurred while someone was in the room, the noise of the break would alert the occupant and he/she could leave the room. The room, however, is not normally occupied during operation of the CCS. Thus, the major concern is that someone will enter the room without realizing that a failure has occurred, before the air circulation system has had sufficient time to lower the He or N₂ concentration to an acceptable level to prevent asphyxiation.

The CCS equipment room has interior dimensions of ~10.5 m by ~8.2 m by ~4.3 m (~34.5 ft by ~26.8 ft by ~14.0 ft). Thus, the room has an interior open volume of ~293 m³ (~10,350 ft³), which allows for equipment to occupy about 20% of the total interior volume. The air-circulation system in the room will provide about seven air changes each hour. An oxygen monitor in the room will sound an alarm at 19.5% oxygen.

7.3.5.3.3 GHe Circulation Line Break - In this accident, a GHe circulation line is assumed to suddenly and catastrophically separate completely; so that the He in the line rapidly releases into the equipment room from both ends of the broken line. Temperature will determine the He buoyancy but, even at its lowest temperature (21 K), it will rapidly become positively buoyant and rise to the top of the room. Concerns from an accident of this nature include asphyxiation, frostbite, and the kinetic energy of the GHe.

The GHe circulation system has an estimated volume of 2.2 m³ (77 ft³) and contains a helium mass of 109.4 kg (240.7 lbm) at 2.22 MPa (323 psia) and 21 K (-422 °F). If a helium line ruptured, and the He vented into the equipment room, this mass of He would occupy a volume of 56 m³ (1980 ft³) at 0.1 MPa (14.7 psia) and 25 K (-415 °F); about 20% of the open volume of the room.

Impaired performance is initiated at a 5% helium concentration in air, and the impairment is complete at 50% concentration at the ambient pressure of Los Alamos. The air circulation system (seven air changes each hour) would reduce the He concentration below the 50% concentration level in about 8 minutes and

below the 5% level in about 37 minutes. Dispersion of the He throughout the building would proceed at a rapid rate, with the highest concentration near the building's ceiling. As the He warms, it will expand (thus occupying a larger volume), but at the same time the air-circulation system will be removing some of the gas. Thus, the possibility exists that the He will expand to fill the building and could exceed the 50% concentration level for no more than 8 min, or the 5% level for no more than 37 min. An oxygen monitor in the room will sound an alarm at an oxygen concentration of 19.5%.

7.3.5.3.4 LN₂ Supply Line Break - In this accident, the LN₂ supply line, which transfers LN₂ from the storage dewar to the purifier, is assumed to break during a transfer, or the transfer is not terminated and the LN₂ would spill into the equipment room during filling of the cold trap on the vacuum pump cart. The diameter of the line to the cold trap is very small, 0.6 cm (0.25 in.), and transfer of LN₂ to the cold trap is accomplished manually. Thus, the operator should be able to stop the transfer when the cold trap is full and not permit a significant amount of N₂ to be vented into the equipment room. The vent from the purifier is routed outside the equipment room, so if it were overfilled no N₂ would be released inside the building.

The LN₂ supply line is ~55 m (180 ft) long and has an internal diameter of 3 cm (1.2 in.). With a LN₂ storage dewar pressure of 34.5 kPa (5 psig), a flow rate of about 1 kg/s (2.3 lbm/s) would result if the line was broken. This flow could continue until the supply valve was closed, the supply dewar emptied, or until the pressure in the supply dewar dropped sufficiently. The LN₂ would rapidly vaporize, expanding by a factor of about 700 as it warmed to ambient temperature. Thus, the air in the building could be replaced with N₂ to a 50% N₂/air concentration in about eight minutes, neglecting the N₂ that would be removed by the air-circulation system if the LN₂ flow continued at the above rate. Thus, an asphyxiation problem should not exist for about the first eight minutes after the break. This provides sufficient time for personnel to evacuate the room. The oxygen monitor in the room will sound an alarm at an oxygen concentration of 19.5%.

7.3.5.4 Stored-energy Release - A postulated accident that could result in a large stored-energy release is a massive rupture of the GHe recovery vessel, which has a

1 4 6 0 0 9 5 1 0

volume of 45.4 m³ (12,000 gal.), and a maximum operating pressure of 1.72 MPa (250 psig). If the tank were suddenly and massively ruptured, the stored energy of the compressed gas in the tank would be released. The energy released in a sudden, massive rupture of the vessel is found to be 88.5 MJ (65.3 x 10⁶ ft-lb). This is equivalent to 19.1 kg (42 lbm) of TNT. The distance from the vessel to La Mesita Road is approximately 20 m (65 ft). This would result in an overpressure of about 24 kPa (3.5 psig) at the road. The overpressure value is greater than that for breakage of ordinary window glass (3.4 kPa [0.5 psig] to 6.9 kPa [1.0 psig]) and may result in minor personal injury. Consequently, a person on La Mesita Road directly across from the vessel would receive, at most, only minor injury from this accident, except for the possibility of injury from fragments of the tank or broken glass. The latter possibility of injury is partially protected against because the LN₂ supply dewar is between the GHe recovery vessel and the road. This, then, leads to the possibility of the LN₂ supply dewar being damaged by fragments from the rupture of the GHe recovery vessel. Damage to the LN₂ supply dewar could range from no serious damage, to a loss of vacuum, to a puncture of the inner vessel with draining of the LN₂ onto the ground (which is sloped to drain away from this equipment and building MPF-365.) Employees that might be near the vessel at the time of the accident could be seriously injured, but access to the area is controlled and personnel will not normally be in the area.

The GHe recovery vessel is built to appropriate pressure vessel codes, and is an ASME-code-stamped vessel. In addition to its design, it is protected from overpressure by redundant relief devices. The probability of this accident is consequently considered to be extremely unlikely.

7.3.5.5 Conclusions from Analyses of CCS - The following conclusions are made as a result of the analyses of the postulated accidents:

- extra measures have been taken in the design of the CCS and the GTA facility to reduce the probability and the hazard of any one of these accidents occurring;
- the probable occurrence of these accidents ranges from unlikely to incredible;
- the hazard severity in these accidents ranges from negligible to critical; however, those postulated accidents for which the hazard is considered critical are thought to be incredible or extremely unlikely to occur;
- burns from a hydrogen fire would be less than first degree for the public and
- operating personnel outside the fenced boundary of the site;

- no flammable cloud from a hydrogen release would exist beyond the fence;
- for a short period of time, for certain postulated accidents, the possibility of asphyxiation and frostbite hazards exist but, again, the probability of such accidents occurring is considered extremely unlikely;
- accidents involving a release of stored energy would not result in direct personal injury to the public or operating personnel at the fence, but fragments could be a possible source of injury or property damage (however, the probability of such accidents is considered extremely unlikely); and
- none of these postulated accidents will result in exposure of the public or employees to radioactive or toxic materials.

7.4 Accident Analysis for Accelerator Support Operations

Possible accidents involving accelerator support operations have been identified and are presented in the following sections.

7.4.1 Personnel Exposed to Radiation from High Power DTL Testing in HPCTB Tank

Although the walls of the HPCTB tank provide considerable shielding, some external radiation is possible during high-power cryogenic testing of DTL modules. A lead sheet or high-density concrete will be applied to the vessel to provide local shielding, if required, and HS-1 will monitor for radiation during testing. Further shielding or a personnel exclusion area may be added if deemed necessary by HS-1. Thus, the probability of injury to personnel is extremely unlikely. The SOP for the HPCTB controls personnel access to the technicians and engineers who have received safety training for the test chamber.

7.4.2 750-W Helium Refrigerator Accidents

The Model 1620S Koch Helium Refrigeration System comes under the Los Alamos National Laboratory (LANL) Health and Safety Manual classification - "on energized electrical equipment and systems that exceed 130 V, 20 amp, or 10 J...." The potential hazards of operating the system fall into four hazard categories: electrical, mechanical, pneumatic, and thermal. All of these are common causes of industrial accidents.

The probability of an accident happening while operating this system is unlikely based upon thousands of hours of safe operation. GTA technicians have operated a Model 1620S Helium Refrigerator in building MPF-19, without incident, since 1986 and, to date, Koch has not received a report of serious injury or damage to equipment while operating a Model 1620S Helium Refrigerator. From the time the first machine was built and put into service, Koch engineers have

incorporated design improvements and safeguards into the equipment to reduce the probability and potential consequences of an accident.

7.4.2.1 Electrical Accident - An electrical accident could occur if an operator failed to remove power or lockout the electrical service before trouble-shooting the machine. This could result in injury to the operator. This accident is unlikely, however, because the operator must use safe industry practices when working on any part of the refrigerator's electrical system and must follow LANL lockout/tagout procedures. Only trained and experienced technicians will maintain the refrigerator with cognizance of an AT-10 staff member. Energy sources will be locked/tagged out during maintenance. When energy sources are locked out, the key will be kept by the electrician while electrical repairs are being performed.

7.4.2.2 Mechanical Accident - The primary mechanical hazard is that of working around rotating machinery. Left unguarded, the expansion engines exposed flywheel, cam assemblies, belts, pulleys, and crossheads present a constant potential hazard. For an accident to happen, an operator would have to ignore the bold print "Caution" note within the SOP and operate the refrigerator with the protective covers removed. The CCS supervisor checks to ensure operators adhere to this and other caution notes found throughout the SOP. Therefore, such accidents are unlikely.

7.4.2.3 Pneumatic Accident - Also unlikely are conditions that would create a hazard because of an unscheduled release of helium from a relief valve or some other exit point. This type of release can happen only through operator error or through failure of a pressure-control device. Relief valves are provided throughout the system to prevent over pressure. The compressor supply pressure, which is the maximum 240 psig within the helium system, and the relief devices are set to open at 300 psig. All medium-pressure couplings and disconnects for the refrigerator's warm-gas piping are on the bottom panel at the right rear of the refrigerator cabinet and the operator stands in front of the machine. An oxygen monitor is located near the refrigerator.

7.4.2.4 Thermal Accident - The possibility of a worker receiving a burn from escaping cold nitrogen or helium gas is extremely unlikely. Fortunately, the operator is located a safe distance from all sources of cold gas. The LN₂ supply line and vacuum-jacketed He coolant line connections are on the back of the refrigerator. The distance between the operator and the cryogen lines coupled and the rarity of a leak rarely developing at one of these connections helps to support the analysis. Even so, an operator will

watch for signs of a cold gas leak. A cold gas leak will often appear as a frosty spot on the surface of a mechanical connection or as a white vapor in the warm air. At any of these signs, the system will be warmed before making the repair and then a bubble leak check of the connection will be performed before continuing the operation. At all times, the operator will follow the SOP and routine industrial safety practices.

7.4.3 High-pressure Gases

Most compressed gases used within the facility are received from MAT-1 or vendors in U.S. Department of Transportation (DOT) approved cylinders. The cylinders of gas, which include nitrogen, helium, argon, sulfur hexafluoride and hydrogen, are securely stored in bottle racks and are moved from the storage rack to the point of distribution on cylinder carts by trained technicians who follow safe handling procedures. Standard regulators with pressure relief and service rated hoses are used to discharge gas from the cylinders. A high-pressure gas accident is extremely unlikely if safe operating procedures are followed and service rated equipment is used.

MPF-365 is piped with a regulated nitrogen system that is supplied by a tube trailer parked northeast of the building near the cooling tower and La Mesita Road. The tube-trailer station is designed to appropriate standards and has been approved by Facilities Engineering Division and HS. MAT-1 maintains, services and delivers the tube-trailers.

7.4.4 Cryogenics in MPF-365

There are two cryogenics associated with the operation of the 750-W helium refrigerator: the liquid nitrogen supply to the helium pre-cool heat exchanger, and the helium coolant that circulates within the manifold. Both cryogenics are contained within double-walled vacuum insulated lines and are not located where a leak would cause serious equipment or facility damage. Also the vacuum insulated lines present no hazard to an operator if one contacts them. There are no electromagnets that are cryogenically cooled, so loss of cryogenic coolant would not result in a magnet fire. Only trained technicians operate and maintain the refrigerator, and the system is pressure- and leak-tested before each operation. Leaks are readily detected visually, and the refrigerator has built-in automatic controls, which shut-down the system if a malfunction occurs. An injury caused by cryogenics is deemed extremely unlikely.

7.4.5 Asphyxiation

Asphyxiation can occur if a compressed gas or cryogen is released in an enclosed space with inadequate ventilation. All spaces where this hazard is credible (e.g., in the tunnel, laser and waveguide basements, and CCS equipment room) are equipped with oxygen monitors that sound

an alarm in the local area and in the control room. Hazard controls previously listed for compressed gases and cryogenics also reduce the probability of occurrence, which is extremely unlikely.

Asphyxiation can also occur when entering a vacuum or pressure vessel following return of the vessel to 1 atm. Frequently a vacuum vessel is let up to 1 atm with an inert gas such as argon or nitrogen. To prevent exposure to a hazardous environment, all vacuum and pressure vessels are first purged with air, then measured for oxygen content with a portable oxygen monitor before opening the vessel to workers. No one is permitted to enter a vacuum or pressure vessel without being under observation from outside the vessel by another person who is currently certified in CPR and first aid. All confined space entries will be done per the requirements of an approved SWP.

7.5 Accidents from Safety System Malfunctioning

Possible accidents involving malfunctioning of safety systems have been identified and are presented in the following sections.

7.5.1 RPSS Accidents

The tunnel housing the accelerator system is designed to shield employees and the public from exposure to ionizing radiation at the 100 MeV level. Personnel, therefore, will be well-shielded from radiation at the 24-MeV level, if the tunnel shielding envelope remains intact during, and after, accelerator operations. Radiation expected at 24 MeV results from prompt and delayed radiation from the proton beam interacting with beam-line components. (See Section 5.3.2). If the tunnel-shielding envelope is compromised, there are several accident scenarios that can result in radiation exposure. These are:

- the plug doors may be left open during start up resulting in radiation leakage from the tunnel envelope;
- the plug doors may open during operations resulting in radiation leakage from the tunnel envelope;
- stacked shielding in various locations may be inadvertently changed and allow radiation leakage from the tunnel envelope;
- the HVAC may fail and tunnel air pressure equals facility pressure; result could be leakage of activated air into the main facility; and
- local component shielding change, which reduces local shielding and allows exposure to activation during maintenance and repair activities.

No accidents will result in exposure of the public or present a danger to the environment.

The accidents concerning ionizing radiation involve the following scenarios:

- a person is left inside the exclusion area; and
- a person enters the exclusion area while the accelerator is on.

7.5.1.1 Person Left Inside Exclusion Area - A person left inside the exclusion area could be exposed to very high radiation levels. The probability that a person would be left inside, however, is extremely unlikely. The radiation personnel safety system (RPSS) is designed to ensure that no person is left inside the beam tunnel or underlying basements during beam or RF operation. Before RF high-voltage can be turned on, or the LEBT beam stop can be withdrawn, a start-up announcement is made over the public-address system, warning horns are sounded, SWEEP IN PROGRESS signs are lit, a personnel clearance sweep is made by a two-person team, flashing red warning lights are turned on, and a final warning horn is sounded. After a further 60-second delay, DANGER - VERY HIGH RADIATION - RPSS SECURE, signs are illuminated, and accelerator turn on may begin. Scram switches are positioned in the exclusion area so that no person can be more than 50 feet from one. Doors can always be opened from inside the tunnel, and opening any door, gate, or hatch will shutdown the accelerator.

7.5.1.2 Person Enters Exclusion Area While Accelerator is Operating - During accelerator operation, a person inside the exclusion area could be exposed to very high radiation levels. The probability of a person entering the exclusion area during operation is extremely unlikely. The probability of such an entry without shutting down the accelerator is even smaller. The accelerator cannot operate unless the RPSS is secure. With the exception of doors 1 and 6, truck-access doors, which are blocked by concrete-shield blocks, opening any door or shield-plug requires a key release from the control-room operator. Operation of the key-release solenoid trips the RPSS, which shuts down the accelerator. Opening any door or shield-plug operates a limit switch that also trips the RPSS. Entries, other than the truck doors, have both a shield door and another door and both are equipped with limit switches. Flashing-red warning lights and illuminated signs at entries warn personnel of the status of the exclusion area.

7.5.2 Accelerator Protection Systems Accidents

Accidents involving the accelerator-protection systems involve the run-permit and the fast-protect systems for the accelerator.

1 4 6 0 0 4 3 2

7.5.2.1 Run-permit System Malfunction - The run-permit system examines the state of many experimental system parameters. If they are within the proper range, operation of the accelerator is permitted. After start up, the examination occurs at least every macropulse (a 2 msec stream of 425 MHz beam bunches generated at a rate of 10 Hz) or 10 times per second. If any parameter goes out of bounds, the injector and RF high voltages are turned off, so that no further accelerator pulses are generated until the fault condition is cleared. The accident supposes that a system failure permits operation to continue when the accelerator should be shut down. There are many possible effects, but none in the critical or catastrophic category has been postulated.

Proper operation of the run-permit system will be tested at least once a month. The probability of malfunction is considered "unlikely." The accident is considered to be of negligible severity. There is no effect on the public, environment, or workers.

7.5.2.2 Fast-protect System Malfunction - The beam hitting the DTLs, beam transport lines, diagnostics, or optical components will cause equipment damage or activation.

The fast-protect system is designed to truncate the ion beam at the injector within 10 μ s of a beam spill. The fast-protect system is distributed throughout the accelerator and has inputs from various detectors and sources, such as beam spill monitors, low-level RF controls, and beam diagnostics. High reliability of the system is achieved through dual redundancy on inputs and from fail-safe circuitry.

Failure of this system could cause critical or catastrophic equipment damage.

Proper operation of the fast-protect system will be tested before each accelerator run. The probability of the malfunction is considered unlikely. The accident is considered to be of critical severity for operations. There is no effect on the public, environment, or workers.

7.6 Electrical Power

Electrical power systems have been designed and installed under safety codes developed over many decades. Accidents, therefore, are almost exclusively caused by extremely unusual circumstances. Accident effects would be contained in the GTA system with no effect on the public or environment because of the protection built into the power-distribution system. These accidents are normal industrial accidents.

If localized power services within the facility are interrupted, segregated areas of the facility will experience a power outage. If any GTA sector is affected by the outage, the GTA control system interlocks (run permit), will drop out and shut down the accelerator operation and RF power generation. Systems affected by a localized power outage are:

- accelerator control and computer system;
- HVdc power for the RF generators;
- facility interior lighting system;
- accelerator CCS;
- accelerator vacuum system;
- cryogenic-cooling site surveillance system;
- facility exterior security, parking, and area lighting system;
- accelerator tunnel air supply and exhaust system (stack exhaust);
- facility HVAC system;
- RPSS;
- facility compressed-air system;
- hinged doors;
- radiation shield-door system;
- accelerator water-cooling system;
- cryogenic-cooling site hydrogen detector alarm system;
- telephone system;
- paging system;
- open-network system;
- secure-network system;
- accelerator portable chillers (potentially contaminated water);
- accelerator tunnel waveguide-basement sump-pump system;
- accelerator tunnel laser-basement sump-pump and transfer-pump system
- accelerator tunnel crane;
- facility high-bay cranes;
- accelerator source and high-voltage dome;
- accelerator beam magnet power supplies;
- accelerator interim beam-stop cooling system;
- accelerator final beam-stop cooling system;
- accelerator diagnostic laser; and
- accelerator diagnostic laser laboratory HVAC system.

7.0 ACCIDENT ANALYSIS

If primary electrical service or general area-wide power is interrupted, the accelerator and associated systems, including the RF system, will immediately lose power and shut off. The preceding list of system and equipment will also experience an immediate power failure, and shut off or fail.

The following systems and equipment have battery-backed electrical power and will remain operational temporarily during a power outage:

- emergency lighting system (some locally installed emergency lights may not operate during a localized power interruption; incorrectly installed, they violate the National Electrical Code Article: 700-12(f); this violation will be corrected);
- RPSS Kirk-key releases;
- hinged door;
- security system;
- oxygen monitors;
- verbatim auto-dialer;
- facility fire-alarm system;
- cryogenic-cooling site fire-alarm system;
- cryogenic-cooling site fire-deluge system; and
- facility HVAC and control system (direct-digital controller).

7.7 Industrial Accidents

Possible industrial accidents have been identified and are presented in the following sections.

7.7.1 Crane or Forklift Operation Accidents

Three cranes, as well as forklifts, are used in the facility for handling shield blocks and heavy components of the experimental system. Mechanical failure or operator error could result in serious injury to a worker. Crane and forklift operators are recertified at least every three years. Cranes, slings, and other lifting components are inspected annually. Forklifts are inspected semi-annually. The probability of a serious crane or forklift accident is extremely unlikely. There is no effect on the public, environment, or plant.

7.7.2 Occupational Injury Accidents

Minor injuries to personnel caused by falls or misuse of power tools are likely to occur; however, serious injuries are less likely. Supervisors and safety officers monitor operations for unsafe practices. To control unsafe conditions, the building manager and supervision monitor and inspect the facility. Safety meetings and periodic training reinforce safety requirements to workers.

7.8 Fire Accidents

The entire building is protected by an automatic wet-pipe sprinkler system that has been designed according to National Fire Protection Association (NFPA) 13 requirements. The system has also been installed and inspected under the provisions of these requirements. The design and installation along with the required periodic system inspections limit the possibility of a sprinkler failure. Fire, however, is always a possibility. Should a fire occur, some water and smoke damage to the building may be expected; loss of human life and substantial structure and system damage are not expected. These accidents are considered normal industrial accidents.

The Model 1620S Helium Refrigerator is protected from fire by building MPF-365's automatic wet-pipe sprinkler system. The building fire-protection system was designed, installed, and validated according to NFPA 13 requirements and it is maintained in a state of readiness through periodic inspections by the Los Alamos Fire Department. The possibility of a fire occurring within the refrigerator is extremely unlikely. If a fire develops near the helium refrigerator, some building and/or equipment water, fire and/or smoke damage may occur, however, loss of human life and substantial structural or equipment damage are not expected. The action to be taken by the operator is to secure the refrigerator, if possible, before leaving the building and report to the fire evacuation assembly point.

7.9 Chemical Spill

Chemicals are used in small quantities inside the building, so a significant chemical spill is highly unlikely. Chemicals stored in bulk are in 55-gal or smaller drums and stored outdoors on spill-containment pallets. A spill would not endanger personnel; however, if not controlled, it could contaminate the environment. Absorbent materials are available to immediately control small spills, and Emergency Management would be contacted for cleanup of large spills. Handling chemical drums occurs infrequently and is done by qualified forklift operators.

7.10 Accidents Associated with Natural Phenomena

The accidents caused by natural phenomena—flood, earthquake, high winds, and lightning—listed in this section deal with the GTA facilities in general. These are conventional accidents.

7.10.1 Flood

There is little chance of flood damaging the building or injuring personnel, because the GTA building is on top of a mesa.

7.10.2 Earthquake

The GTA building was designed to withstand seismic events expected to occur in seismic Zone 2 areas. Structural failures are not expected to occur if a typical Zone 2 seismic event were to take place. The facility was designed in accordance with DOE Order 6430.1 and the 1985 Uniform Building Code (UBC). (See discussion in Section 4.1.1 and Appendix B). Utilities and equipment were installed in accordance with the mechanical, electrical, and plumbing codes in effect at the time of construction and with equipment manufacturers' recommendations. Damage to these systems would not result in any significant hazard to workers, nor any hazard to the public or environment.

The accelerator and its supporting systems were designed to generally withstand seismic effects in a Zone 2 area. The exception is the injector high-voltage dome. The high-voltage dome is on casters (to allow access for mating/demating RFQ section); it could overturn during an earthquake, possibly injuring personnel standing beside it.

The output energy from Phase 2 experiments may require radiation shielding around the RFQ and DTL. Frames will contain this shielding. The frame/shielding combination could overturn during an earthquake, possibly injuring personnel standing beside it.

The CCS is designed to meet or exceed the seismic requirements of the UBC Zone 2B earthquake and to withstand a wind load of 93 mph in accordance with UCRL 15910. The CVI seismic analysis has been reviewed by a LANL specialist and a dynamic analysis has been performed which shows that the CCS meets the seismic requirements of UCRL 15910 for a moderate hazard facility.

7.10.3 High Winds

The building and the external cooling tower have been designed to withstand a basic wind speed of 80 mph. The CCS was designed to withstand a basic wind speed of 93 mph.

7.10.4 Lightning

Los Alamos is in an area well-noted for lightning, and the possibility of a lightning strike at GTA is above the national average. The GTA building is protected with a lightning protection system, and has been wired according to the National Electrical Code (NEC). In the event of a lightning strike, an equipment failure could occur with no loss of human life. An employee outside the GTA facility during a lightning storm is at possible risk of being struck. The probability of this accident occurring however is extremely unlikely.

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8.0 OPERATIONAL SAFETY REQUIREMENTS

This chapter describes the operational safety requirements (OSR) for the Ground Test Accelerator (GTA) operations and facility and conforms to U.S. Department of Energy (DOE) Order 5481.1B Chapter II, with format changes as recommended by the 1990 DOE Assistance Review of Los Alamos National Laboratory (LANL) OSRs.

8.1 Introduction

The GTA at the Laboratory is the major hardware component of the national neutral particle beam (NPB) program, which is supported by the Strategic Defense Initiative Office. The principal goal of the program is to assess the feasibility of using neutral particle (H^0, D^0) beams outside the earth's atmosphere. The GTA facility is designed as a versatile accelerator test facility to evaluate compact, negative ion (H^-) accelerators for space applications and to evaluate ion beam transport and optical elements for beam steering.

Immediate experimental objectives of the facility include the demonstrations of:

- cryogenic cooling of the accelerator and optics to reduce mass requirements necessary for space applications; and
- beam brightness with orders of magnitude greater than those of existing NPB facilities.

Initially, the main thrust of the GTA program is to build an accelerator that demonstrates all requisites of an NPB system; if this objective is met, then the system becomes operational. At this stage and beyond, the facility serves as a test bed for advanced NPB technology.

The GTA device, as it is presently configured, consists of a number of subsystems:

- the injector, which provides the source of H^- ions;
- the cryogenically cooled radio frequency quadrupole (RFQ), which tailors the beam from the injector into discrete bunches of ions that permit acceleration;
- the cryogenically cooled intertank matching section (IMS), which tailors the beam from the RFQ to the acceptance requirements in the drift-tube linac (DTL);
- the cryogenically cooled DTL, which accelerates the beam to the appropriate energies;
- the magnetic optics and beam steering focus and steer the output H^- beam;
- the radio-frequency (RF) power, which provides beam acceleration;
- the control system, which ties all the subsystems together as a functional device;
- beam diagnostics, provides beam characterization measurements;
- water systems, provides water cooling to accelerator components;

8.0 OPERATIONAL SAFETY REQUIREMENTS

- vacuum systems, which reduce the internal pressure of the vacuum vessels from 1 atm to 1×10^{-6} torr;
- neutral beam system;
- the helium refrigeration system, which is used for off-line testing of accelerator components at cryogenic temperatures (20 to 35 K); and
- cryogenic cooling systems (CCS), which provide cryogenic cooling for accelerator components.

8.1.1 Facility

The GTA facility is on Laboratory lands at Technical Area 53 (TA-53). The construction of the facility is divided into three parts:

- the site and building MPF-365, which houses the accelerator and peripheral equipment;
- the experimental system, which pertains to the accelerator and related equipment; and
- the 40-kW CCS.

Building MPF-365 consists of two major parts: a shielded beam tunnel, ~16,400 ft²; and a conventional four-story, steel-framed building, ~55,800 ft². The GTA accelerator is located within the beam tunnel.

8.1.2 Experimental System

The experimental system consists of a series of hardware configurations that lead to successively higher energies until the 100-MeV high-brightness beam is achieved. Table VIII-1 shows the GTA experimental configurations, their sequence, and the planned phasing of the FSAR revisions. Technical personnel in the six sectors (accelerator, RF, optics, controls, installation and commissioning, and neutral beam) are responsible for designing, procuring, and installing the system.

8.1.3 Cryogenic-cooling System

The CCS consists of three major subsystems, the LH₂ cooling system, the LN₂ cooling system, and the cold, circulating helium gas system. The LH₂ subsystem consists of a storage dewar (28,000 gal), an LH₂ transfer line, a run dewar (4,050 gal) containing the hydrogen-to-helium heat exchanger, and the vent/flare subsystem. The LN₂ subsystem consists of a storage dewar (4,000 gal), transfer line, and a run dewar (1,790 gal) containing the nitrogen-to-helium heat exchanger. The helium gas subsystem consists of a gas storage tank (with ambient temperature and pressure of up to 235 psig), a gas transfer line to the circulating helium lines of the CCS,

Table VIII-1 GTA Experimental Configurations and Their Relationship to the FSAR^a

Experiment	Experimental Configuration	Beam Energy Output (MeV)	Beam Current	Schedule	FSAR Phase
1A	Injector and low-energy beam transport	0.035	50 mA	1/90-9/90	0
1B	(+) ^b RFQ	2.5	50 mA	10/90-6/91	0
1C	(+) IMS	2.5	50 mA	10/91-4/92	0
2A	(+) 2 $\beta\lambda$ DTL (first tank)	3.18	50 mA	7/92-9/92	0
	40-kW CCS installation and operation	0	N/A	6/91-5/92	1
2D	(+) Complete 2 $\beta\lambda$ and 1 $\beta\lambda$ DTL tanks (10 tanks)	24.3	50 mA	7/93-11/93	2
3A ^c	(+)H HEBT and 180° bend	24.3	50 mA	2/94-6/94	2
3B	(+) 24-MeV telescope and steerer	24.3	50 mA	10/94-3/95	2
3C	Beam sensing (WAFFOG)	24.3	50 mA	4/95-8/95	2

^aExperiments 2B and 2C have been deleted from the experimental plan. The numbering sequence has not changed because of other substantial documentation employing specific experimental numbering.

^bThe (+) indicates the subsystem that is added to the previous configuration.

^cExperiments 3A through 3C are revised to reflect program changes.

vacuum-jacketed circulating helium gas lines, a cold-gas circulating compressor, the helium-hydrogen and helium-nitrogen heat exchangers, and the GTA components that will be cooled. Evaporating LH₂ in a heat exchanger located outdoors and external to the accelerator building will provide the necessary refrigeration for cooling the helium stream. The hydrogen vapor arising from the evaporating LH₂ will be discharged to the atmosphere through a vent/flare system. For precooling the entire GTA system, as well as the CCS, the helium-coolant stream will be diverted through a similar heat exchanger that will be cooled by LN₂ instead of LH₂; the resulting nitrogen gas will be discharged directly to the atmosphere through a vent system.

8.2 Safety Limits

As defined in AL 5481.1B, Chapter II, safety limits are limits on important process variables that are found to be necessary to reasonably protect the integrity of the principal physical barriers that guard the public and the environment against the uncontrolled release of hazardous materials.

Two areas of potential concern were identified that required investigation relative to the need for safety limits. These are radioactive emissions from the GTA effluent stack and the uncontrolled release of hazardous materials from the CCS.

8.2.1 Radioactive Emissions

The normal duty factor for 24-MeV GTA operation is 0.2%, with a brief design-point demonstration test at 2% duty factor to be performed at the conclusion of the development program. Calculations have been made for the radioactive gaseous effluent emissions for the planned yearly operating times. Based on these calculations, the potential effective dose equivalent (PEDE) at the site boundary would be far below the EPA threshold of 0.001 mrem/yr that would require confirming measurements (see Appendix F). Therefore, no safety limits are required on air emissions.

8.2.2 CCS Hazardous Materials

Analysis of the engineered safety features and exclusion distances of the CCS, which protect the public from the uncontrolled release of hydrogen, helium or nitrogen, shows that no operational limits on process variables are required. Further, none of the materials handled by the CCS are toxic or pose a threat to the environment. Therefore no safety limits, as defined above, are necessary.

8.3 Limiting Conditions for Operation

In addition to the protection provided by the engineered safety systems, administratively established constraints will be followed during GTA operations to maximize personnel safety. These limiting conditions for operation (LCO) specify the minimum performance level required for the safe operation of the facility and are described below.

8.3.1 Radiation Personnel Safety System (RPSS)

The LCO requires that the RPSS (described in Chapter 11 and Appendix T), is operational during all 24-MeV beam operations of GTA to ensure personnel safety. The 24-MeV beam with associated RF power can produce hazardous levels of radiation in the beam tunnel. A positive means to exclude personnel from the tunnel must be in place during these periods of operation.

The RPSS is to be in place and operational when the personnel sweep is made before securing the tunnel, when the 24-MeV beam with associated RF power is on, and after beam operation until the tunnel is opened for a radiation survey conducted by a Health and Safety (HS) Division Health Protection technician.

The 24-MeV beam with associated RF power cannot be operated unless all conditions of the RPSS have been met. During operation, the beam will automatically shutdown if any condition of the RPSS is not met. If the RPSS is not functioning during a test of the system, the shift supervisor

will be notified and corrective action will be taken. There is no specified time for completion of corrective action, because no hazard is present until beam-line operations that require the RPSS to operate are resumed.

The RPSS interlock check will be performed before each experimental run cycle, before beam operation, and immediately after any modification to the system. This procedure checks proper functioning of every input, all system logic, and all shutdown mechanisms. In addition to this rigorous testing, overall operation of the system will be tested biweekly during experimental run cycles. A system switch is in the control room for this purpose.

8.3.2 Tunnel Ventilation System

The LCO requires that the tunnel-ventilation system operate during specified periods of 24-MeV beam operation. Beam stop and beam loss during 24-MeV beam operation may activate the tunnel air; therefore, the tunnel air pressure must be negative with respect to the adjacent high bay and the ambient atmosphere to protect operating personnel, which requires that the tunnel-ventilation system is operating properly.

If the tunnel-ventilation system is not operating before 24-MeV beam operation begins, operation will be delayed until the ventilation system is operating. If the ventilation system fails during beam operation, the beam will be shutdown, the shift supervisor will be notified. There is no specified completion time for repairs, because 24-MeV beam operation will not be resumed until the ventilation system is operational.

A negative pressure differential between the tunnel and the high bay will be verified before beginning 24-MeV beam operation. System inspection and maintenance will be performed quarterly by ENG-5.

8.3.3 High Efficiency Particulate Air (HEPA) Filters

The LCO specifies that HEPA filters must be in place in the tunnel ventilation system and operating properly during 24-MeV beam operation. The beam stop and beam loss from 24-MeV beam operation may activate dust particles in the tunnel air. Tunnel air is exhausted through HEPA filters to the stack. Filtration is required to minimize the release of activated dust particles to the atmosphere.

All HEPA filters must be in place in the tunnel-ventilation system and operating within an acceptable pressure differential range before beginning 24-MeV beam operation.

If all HEPA filters are not in place before 24-MeV beam operation, or if the filter pressure differential is outside the acceptable range, the shift supervisor will be notified, the operation will be delayed, and corrective action will be undertaken. There is no specified completion time, because beam operation will not take place until proper filter operation has been established.

The filter pressure drop will be logged weekly to establish a pressure drop vs. time plot. From this plot, the time when an excessive pressure drop should occur can be predicted. The filters will be replaced during a scheduled shutdown at a time before the pressure drop exceeds specified limits. The system will be inspected and maintained quarterly by ENG-5. Filter system leakage is tested annually by HS-5 and following filter changes.

8.3.4 Moveable Shielding

The LCO requires that moveable shielding must be in the configuration specified by HS-1 before 24-MeV beam operation. Shielding of certain areas of the beam line, such as a beam stop, may be necessary to reduce the radiation flux outside the tunnel to an acceptable level to protect operating personnel.

The need for removable shielding and its configuration will be specified by HS-1. Calculations will be done by LANL personnel before beam operation in new or altered configurations, which could result in increased radiation levels outside the tunnel, to determine the impact of such changes. HS-1 will review and concur with shielding designs. The shielding designs will be under GTA configuration control and will be periodically inspected to assure configuration compliance.

If shielding is altered, the 24-MeV beam will not be turned on until the affects of the alteration are assessed. There is no specified completion time, because there is no potential hazard until the beam is turned on.

HS-1 will monitor radiation levels outside the tunnel to verify the adequacy of the shielding. The shift supervisor will ensure that shielding is intact before each shift or beam startup. The initial shield configuration will be based on calculations. HS-1 measurements will confirm adequacy and dictate shield modifications.

8.3.5 Oxygen Monitors

The LCO specifies that the oxygen monitor in the CCS equipment room, the three monitors in the GTA beam tunnel, and the two monitors in the tunnel basements operate with the alarm level

set at an oxygen concentration of 19.5%. The LCO protects personnel against physical impairment that could lead to asphyxiation if there was a large helium or nitrogen leak. The alarm setting is the minimum oxygen concentration for workers established both by the Laboratory and by OSHA.

The tunnel detectors and the CCS equipment-room monitor will operate whenever the cryogenic helium lines are pressurized. The detector in the CCS equipment room will also operate if LN₂ is admitted to the equipment room. The tunnel basement detectors will operate when the GN₂ service line is pressurized. The status of oxygen monitor readouts will be brought to the control room when monitor use is required.

If functional checks show that any of the critical oxygen detectors required for the particular mode of operation are not operating, the GTA shift supervisor will be notified and corrective action will be taken to restore, or replace, the detector within 8 hr. If the completion time is not met, and the faulty detector is in the tunnel or CCS equipment room, an orderly shutdown of the CCS operation and recovery of helium to the storage tank will be begun and completed within 12 hr. If, however, the faulty detector is in the CCS equipment room, LN₂ fill operations in the equipment room will not be permitted. If the faulty detector is in either of the tunnel basements, a portable oxygen monitor will be used by personnel entering the basements until the detector is restored.

Detectors will be recalibrated biweekly, along with operational checks of the alarms and functioning performance of the detectors. Maintenance will also be conducted as recommended by the manufacturer.

8.3.6 Hydrogen Detectors

The LCO requires all four combustible gas detectors to operate with the alarm level set at 1% concentration of hydrogen. The LCO has been chosen to detect the onset of a potentially hazardous condition resulting from a hydrogen leak or other unplanned release of hydrogen, which could result in a hydrogen fire. The value chosen to activate the alarm for the four detectors is well below the 4% minimum concentration for a combustible mixture of hydrogen in air but is large enough to give a positive indication hydrogen's presence.

These detectors are to operate whenever hydrogen is in the CCS, including times of passive storage in the storage and run dewars. The LCO, however, applies only to CCS operations when the LH₂ transfer line is in use.

8.0 OPERATIONAL SAFETY REQUIREMENTS

If functional checks show that any of the hydrogen detectors are not operational, the CCS operator will notify the GTA shift supervisor and undertake action to restore the detector or alarm to an operational condition, or replace it, within 8 hr. (A portable detector, which is monitored hourly, may be used to temporarily satisfy this requirement for a period not to exceed 24 hr.) If the completion time is not met, an orderly shutdown to the passive storage mode will be initiated and completed within 4 hr.

The detectors will be recalibrated bimonthly, as recommended by the manufacturer. Functional performance checks of the detectors will be conducted biweekly during run cycles.

8.3.7 LH₂ Run Dewar Vent Stack Flare

The LCO requires that the vent stack flare must be operating before initiating a CCS operation in which the vent rate is expected to be greater than 20 g/s. This LCO has been chosen to protect personnel outside the boundary fence from the possibility of burns from a flammable concentration of hydrogen that could cross the CCS boundary fence at La Mesita Road and later be ignited by an unknown ignition source. Calculations have shown that for vent rates above 25 g/s, such a flammable concentration could cross the boundary fence under certain postulated atmospheric conditions. The maximum calculated vent rate for the LH₂ run dewar for any mode of operation is 65 g/s.

If the flare is not operating, the CCS operator will notify the GTA shift supervisor and delay CCS operations that require the use of the flare. Corrective action will be taken to restore it to use. There is no specified time for completion, because no hazard is present until CCS operations, which require use of the flare, are resumed.

The flare operation will be confirmed by visual observation each time it is needed. Maintenance of the flare will be conducted according to the manufacturer's recommendations.

8.4 Design Features

The GTA facility was designed with massive shielding to provide passive protection outside the beam tunnel from radiation created by accelerator operation in the tunnel. The RPSS is designed to ensure that no personnel will be in the tunnel during operation of the 24-MeV beam with associated RF power. The tunnel-ventilation system is designed to provide a negative pressure relative to the surrounding space to protect personnel from possible exposure to radioactive air.

The CCS has relief devices (in duplicate in the most sensitive locations) to relieve the pressure that could otherwise build up during the warming of a section of the CCS transfer lines. The CCS piping system has sufficient flexibility to accommodate the thermal contraction that will accompany the cooling of GTA to operating temperature. The materials of construction are suitable for operation at the low temperatures involved and, where appropriate, for hydrogen service.

8.5 Administrative Controls

8.5.1 Procedures

All hazardous GTA operations will be conducted in accordance with approved standard operating procedures (SOP) and checklists that include LCO surveillance and action requirements. Only trained operators who have attended formal training and who have been supervised in performing the various operating modes of the CCS and emergency exercises will be allowed to operate the CCS.

Laboratory personnel from the HS Division as well as personnel experienced in handling LH₂ will monitor GTA operations and will review SOPs and checklists, which will be approved by the GTA program manager and the AT-Division leader. Any significant change in operating procedures or modification in the GTA equipment will be reviewed by GTA and Laboratory safety personnel for safety implications and conclusions will be reported to the GTA program manager. Approved changes to the GTA will conform to the GTA Quality Assurance Plan.

8.5.2 Training

The AT Division training coordinator and each GTA group maintain training records; and line managers are responsible for identifying training needs and assuring that training has been completed. Scheduling of required training is the responsibility of the division training coordinator.

Personnel receive training in hazards applicable to their assigned tasks; this includes the requirements of appropriate SOPs. In addition to special training for the CCS operators, the following types of training also apply to some, or all, GTA personnel:

- cardiopulmonary resuscitation;
- hazard communication;
- site specific;
- waste management or minimization;
- electrical safety;

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9.0 QUALITY ASSURANCE PROGRAM

This chapter discusses the quality assurance (QA) program for the Ground Test Accelerator (GTA). There are two aspects to the QA program: one is the building's construction, and the other is the accelerator, including the cryogenic cooling system (CCS). The Engineering Division is responsible for the building QA, and the Accelerator Technology Division is responsible for the accelerator QA. Line supervisors are responsible for the quality of work in their organizations. The GTA QA program is based on DOE Order 5700.6B, "Quality Assurance," and AL Order 5700.6B, "ALO Quality Assurance." This chapter covers the organization, plans, records, audits, and administrative procedures for the QA programs.

9.1 Site and Building MPF-365

The QA program for GTA project construction encompasses design, engineering, procurement, construction, maintenance, repair, and modification. This program is implemented according to the requirements and criteria of the Facilities Engineering (ENG) Division "Facilities Engineering Division Quality Assurance Manual." This manual complies with the requirements of DOE Order 5700.6B, "Quality Assurance," and AL Order 5700.6B, "ALO Quality Assurance."

9.1.1 Organization

The QA program for construction was administered under the authority of the ENG Division QA representative. The QA representative has overall responsibility for establishing and implementing the QA requirements and their application to this project.

9.1.2 Summary of QA Program Plan

The QA program for engineering, design, and construction was established and implemented according to the requirements and criteria of the ENG Division Quality Assurance Manual. The field operations group, ENG-5, performed acceptance and pre-operational tests according to the applicable specifications, codes, and standards. In addition, the group handled the construction quality control. Holmes & Narver, Inc., of Albuquerque, NM, managed the QA program for the design phase of the project.

- *Design and procurement document control:* Measures for document control, which comply with chapters 4 and 6 of ENG's Quality Assurance Manual for Engineering and Construction, have been implemented to ensure that authorized personnel review, approve, and properly distribute appropriate documents, including changes. The architect-engineer accomplished document control according to Section 5 of the Holmes & Narver, Inc., Quality Plan Annex (QPA) for the QA project.

- *Instructions, procedures, and drawings:* Instructions, procedures, and drawings originated by the Laboratory were prepared, reviewed, approved, and issued in accordance with procedures and guidelines in compliance with Chapter 5 of the ENG Quality Assurance Manual. Instructions, procedures, and drawings originated by the architect-engineer were prepared in accordance with Section 4 of the Holmes & Narver, Inc., QPA for the QA Project.
- *Control and identification of purchased material, equipment, and services:* Measures have been established and implemented so that appropriate personnel review and approve descriptive submittals ensuring that purchased items and services conform to the procurement documents. The requirements for item identification and control during construction were incorporated into the design documents prepared by the Laboratory and the architect-engineer.
- *Inspection, surveillance, and testing:* ENG-5 established and implemented the construction inspection program. In this program, ENG-5 is responsible for ensuring that construction activities, items, and services conform to the applicable drawings, specifications, procedures, and instructions. The program requires that records of ENG-5 inspections be maintained and entered into the document-control system in the Records Management Group, ENG-7.

Appropriate Laboratory technical personnel performed, observed, and witnessed acceptance tests in accordance with the applicable specifications, codes, and/or standards. When required, the organization responsible for the tests prepares written test procedures, which are then reviewed and approved by appropriate members of the Design Review Board. The test program requires that adequate records of these tests be entered into the document-control system.

ENG-5 established and implemented measures that identify inspection and test status, which ensure that required inspections and tests are performed and nonconforming items are clearly identified.

- *Nonconforming materials, components, and fabrication and construction features:* Measures were established and implemented so that nonconforming materials, components, and fabrication and construction features were controlled in accordance with the

requirements of Chapter 15 of the ENG Division Quality Assurance Manual, using the Laboratory Nonconformance Report form ENG-QA-15.

- *Corrective action:* Where corrective action was deemed necessary, established measures were implemented as an extension of the nonconformance-control system. These corrective measures were implemented to preclude repeating significant adverse conditions where such repetition may have been possible.

9.1.3 QA Records

ENG-7 is responsible for receiving, storing, and maintaining records for this project. When construction activities were finished, GTA transferred the records to ENG-7 to incorporate and retain in its storage facilities.

9.1.4 Engineering QA Audits

The ENG Division QA section leader, or his delegated representative, was responsible for a comprehensive system of planned and documented audits. These audits were performed in accordance with the requirements of Chapter 18 of the ENG Division Quality Assurance Manual.

9.1.5 Administrative Procedures

When major modifications for the facility require design criteria for construction, ENG-Division Office, in conjunction with the construction project manager, appoints a Design Review Board to evaluate, approve, or disapprove modifications.

Building maintenance is planned, scheduled, and accomplished by ENG Division.

9.2 GTA

The GTA program's QA plan is derived from DOE Order 5700.6B, AL Order 5700.6B, and the Los Alamos National Laboratory (LANL) Quality Assurance Program. Appendix K contains a copy of the QA plan for GTA, and the software QA plan, which have been designed to reflect the experimental nature of the GTA program.

9.2.1 Organization

Figure 9-1 shows the organization of the GTA program. The GTA program office is responsible for the QA plan, design, and audits. The individual groups/sectors are responsible for implementing the plan. The QA officer (QAO), monitors the program's implementation and is an extension of the GTA program office.

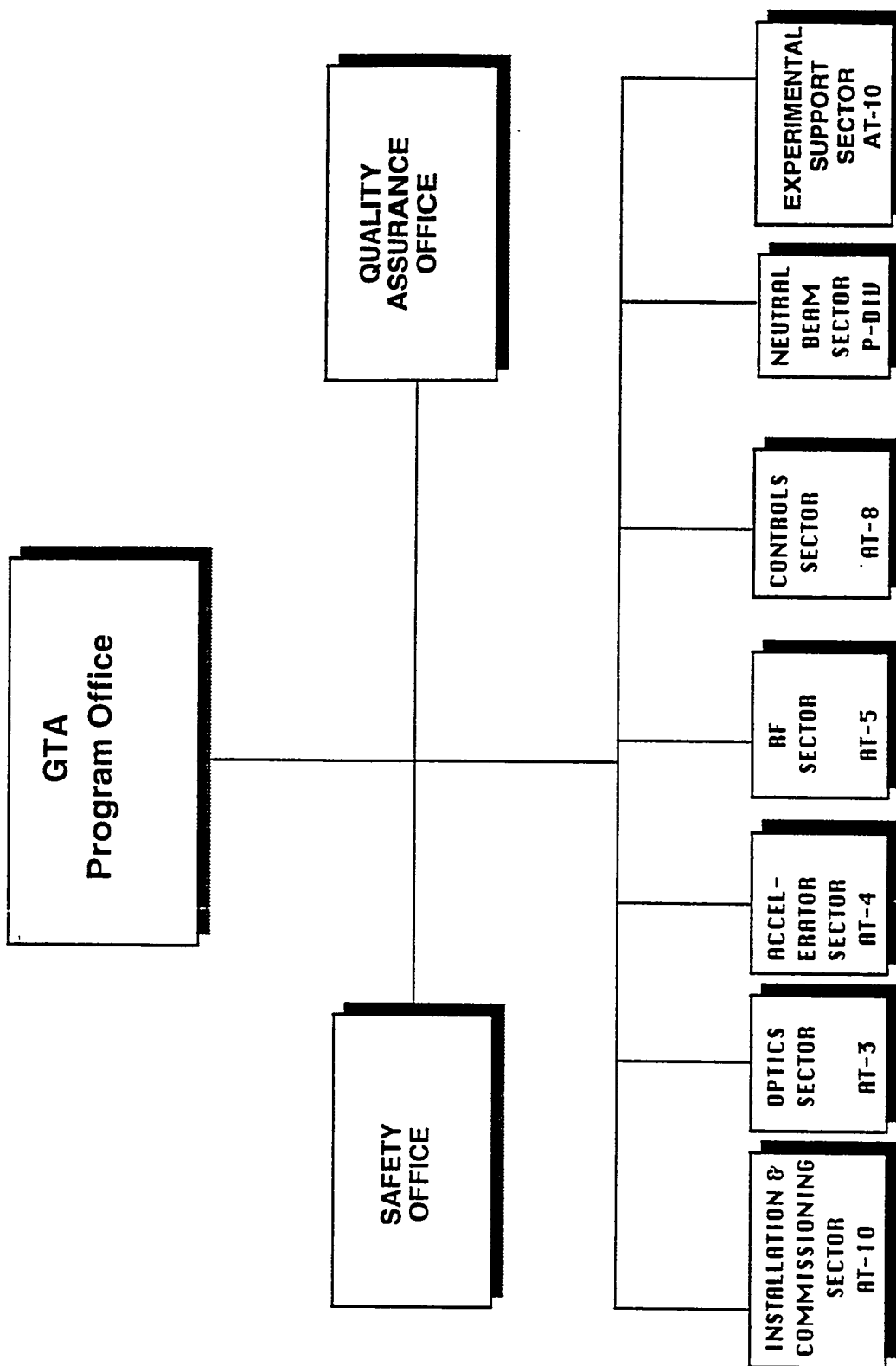


Fig. 9-1. GTA organization showing QA office.

The AT Division QAO also serves as the GTA QAO. As a member of the GTA Project Office, the QAO reports to the GTA program manager. The QAO is responsible for the implementation, monitoring, and enforcement of QA standards throughout the GTA program. The overall responsibility of the QA officer is to generate, verify implementation, and maintain a current QA plan. The QA Program Plan describes the QA responsibilities, functions and activities of the groups/sectors and the program offices applicable to the design, procurement, installation and start-up of the experimental facilities. The GTA QA effort is decentralized as much as possible by group/sector representatives, who are responsible for implementing QA standards under the direction of the QAO. This includes design, hardware acquisition, installation, commissioning, operations, and experiments. The QAO interacts with the various safety and quality offices throughout the Laboratory.

9.2.2 QA Summary

The following points summarize the QA plan for GTA.

- *Design and procurement document control:* The GTA program office sets the standards for design and procurement document control, then individual sections within the GTA implement these standards. The QAO and configuration manager monitor the implementation of the design and document controls, as required by the program office. A Document Change Notice is initiated to cover any changes in drawings and/or documents. For changes that could impact design or procurements, the notice is distributed through interface control for approval and distribution.
- *Instructions, procedures, and drawings:* In accordance with program office guidelines, the sectors are responsible for the drawings and procedures. Drawings are prepared in accordance with American National Standards Institute (ANSI) and/or American Society of Mechanical Engineers (ASME)-14.5 or equivalent. All drawings contain a component identification method that is later used to identify parts. Appropriate signature approvals are required for all instructions, procedures, and drawings.
- *Control and identification of purchased material equipment and services:* All purchased items carry the identification number of the drawing (or procurement) as defined in the purchase requests. All identifiers are permanent and legible. Documentation includes cross references between purchase-order numbers and part identifiers for specific job correlation.

- *Inspection, surveillance, and testing:* The responsible engineers establish inspection, surveillance, and testing plans and requirements. All requirements are included in purchase orders or contracts to vendors, suppliers, and contractors. The engineers are responsible for implementing, planning, and accepting final results and/or items or services. The QAO will conduct on site or documentation reviews and/or audits of these vendors, suppliers, or contractors as appropriate. These requirements will be identified in procurement documentation. An example of a contractor QA program is contained in Section 9.3.
- *Nonconforming materials, components, and fabrication and construction features:* All nonconforming items uncovered by inspection or testing shall be labeled. Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. A nonconformance report (NCR) shall be used to document and track the nonconforming item.
- *Corrective action:* Every effort is made to correct the deficiencies when it is economically feasible. Those items that cannot be corrected are labeled and stored in a separate area to prevent mistaken use. The identification, cause, and corrective action for significant conditions adverse to quality of critical items shall be documented and reported to appropriate sector leaders and the QAO. Corrective actions are required for nonconformance reports and audit finding reports.

9.2.3 QA Records

Original QA records, drawings, specifications, and change orders are kept in the GTA sector offices. Copies of these records are forwarded to the GTA program office central file and to the QAO. The QAO has established a document-control area in the QA office as a permanent location for all GTA quality-related documents. All records bear the names of persons associated with the document.

9.2.4 QA Audits

The QAO performs quarterly QA implementation and maintenance audits. Results of these audits are documented and become part of the central GTA document file.

9.2.5 Preoperational Testing and Retesting

Tests required to verify conformance to specifications or to demonstrate satisfactory service performance are planned, executed, and documented. Test characteristics and methods shall be specified, and the results evaluated, for conformance with requirements. In some cases, retesting occurs until test requirements and acceptance criteria are approved by the sector responsible for the design of the tested item.

9.2.6 Administrative Procedures

All QA functions rely on a cooperative effort between the sectors and the GTA program office. The program office sets the standards for QA performance; the sectors implement QA practices according to these standards. All actions are documented and retained in a central file.

9.2.7 Configuration Management

A GTA Configuration Management Plan (CMP) was developed under the QAO. This CMP outlines policy and procedures for controlling documents, including those which require changes. These changes may occur with large or small systems, whose function affects the health and safety of personnel, or whose hardware requires protection against damage. There are three levels of document control; program office control, local control, and no control.

Configuration control (program level or local level) shall be imposed on all hardware and software that may become part of the 24-MeV characterization experiments. Hardware and software associated only with research and development in support of these experiments do not require configuration control, but shall be listed in the document tree, so they can be traced if necessary.

Computer software configuration identification (CSCI) including, but not limited to, specifications, design documents, and listings will define software requirements and design details for a single CSCI. The software requirements specification will define system requirements allocated to a specific CSCI. The interface requirements specification will describe in detail the requirements for one or more CSCI interfaces. Interface requirements will include the interface between a CSCI and other configuration items.

9.3 CCS

The contractor selected for the design, fabrication, installation, and testing of the 40-kW CCS was CVI, Inc. The company has experience in manufacturing equipment for the US space program and for the nuclear power industry, both are customers with exacting QA requirements.

CVI employs a well documented and controlled QA methodology, which is in the CVI "Quality Assurance Manual." Figure 9-2 shows the manual's table of contents. CVI designed, fabricated, installed, and tested the 40-kW CCS under the QA plan in the manual. The Laboratory had the right to inspect, review, audit, and so on, any phase of design, fabrication, installation, or testing activities at CVI's plant. The Laboratory also had an inspector and/or QA representative at the site during field installation. A formal acceptance test verified the performance of the installed system.

9.3.1 QA Organization

An independent QA manager directed the QA program for CVI and was responsible to the president of the company. The following excerpt from the CVI QA manual, describes the responsibility of the QA manager:

The Quality Assurance Manager shall be responsible and has the authority for implementing, maintaining, and determining the overall effectiveness of the quality assurance system through the Quality Assurance department. He shall have the freedom to identify quality control problems and to initiate, recommend, provide solution, and limit or control further processing.

Figure 9-3, a page from the manual, further details the responsibilities of the QA manager and those of the subcontractors.

9.3.2 Summary of QA Program Plan

The Laboratory accepted the QA plan in CVI's QA manual for the CCS QA program plan. The plan related to all phases of the procurement, including those at CVI and Los Alamos; it also included installation and testing at the Laboratory. The Laboratory had access to all of CVI's QA records.

9.3.3 QA Records

CVI handled QA records according to the methodology described in its QA manual, which was acceptable to the Laboratory. Figure 9-4 shows that portion of the manual which covers QA records.

9.3.4 QA Audits

CVI conducts its audits according to a prescribed method described in its QA manual, which is acceptable to the Laboratory. Figure 9-5 shows the portion of the manual that covers QA audits. Internal audits, as well as those applying to CVI subcontractors are covered. The seven forms referenced in the figure are not included.

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Fig. 9-2. Table of contents for the CVI QA manual.

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2.0 RESPONSIBILITIES WITHIN THE QUALITY ASSURANCE DEPARTMENT**2.1 Quality Assurance Manager**

- 2.1.1 The responsibilities of the Quality Assurance Manager, as previously stated in "The President's Statement", is to implement and maintain the quality assurance system through the Quality Assurance Department, which shall monitor, direct and supplement the quality effort.
 - 2.1.2 The Quality Assurance Manager assigns work to the members of the Quality Assurance Department to Code, Contract and Quality Assurance Manual obligations to meet his responsibilities. Therefore, the assignments stated for the positions that follow are exemplar and may be changed at his discretion.
 - 2.1.3 The Quality Assurance Manager may delegate the authority necessary for the fulfillment of the stated assignments.
 - 2.1.4 The Quality Assurance Manager shall regularly review the status and adequacy of the Quality Assurance Program.
 - 2.1.5 The Quality Assurance Manager and his delegate(s) have the responsibility and the commensurate authority to stop work, or that part of the work, which is in direct violation of contract or codes and/or prevent non-conforming work or components from being incorporated into the final product.
- 2.2 Specific responsibilities affecting quality appear in their related sections of this manual.

3.0 ASSIGNMENTS WITHIN THE QUALITY ASSURANCE DEPARTMENT**3.1 Quality Assurance**

- 3.1.1 QA Systems Formulation
- 3.1.2 QA Policies Consultation
- 3.1.3 QA Manual Maintenance, Distribution Logging, and Change Control
- 3.1.4 QA Program Supplements Preparation and/or Review. Sign-off when released for purchase order and/or for fabrication.
- 3.1.5 QA Studies
- 3.1.6 Special Problems Investigations
- 3.1.7 Selective Invitation-For-Bid (IFB) Reviews
- 3.1.8 Selective Proposal Consultations
- 3.1.9 Selective Major Contracts Review and Approval

Fig. 9-3. Responsibilities of the QA manager.

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- 3.1.10 Selective QA Plans Review and Approval
- 3.1.11 Selective Documentation Lists Review and Sign-Off
- 3.1.12 Inspection and Test Procedures Review or Preparation, Sign-Off, when released for purchase and/or for fabrication.
- 3.1.13 Selective Production Order and Inspection Records Review
- 3.1.14 Purchase Order Review, Sign-Off (when applicable)
- 3.1.15 Maintenance of Approved Vendor List
- 3.1.16 Supplier Surveys, Inspection and Audits
- 3.1.17 Maintenance of Supplier Surveillance Records
- 3.1.18 Testing Consultation
- 3.1.19 Development Testing (when assigned)
- 3.1.20 Inspection Notifications and Assistance to Customer's Inspectors, Auditors, and Authorized Inspectors
- 3.1.21 In-House QA Audits
- 3.1.22 CAR Logging, Distribution and Approval
- 3.1.23 Supplier Certification Approval
- 3.1.24 Review and Maintenance of ASME Code Books and Addendas
- 3.1.25 Maintenance of Welding Procedures
- 3.1 Chief Inspector
 - 3.2.1 Shop Inspector Supervision
 - 3.2.2 Receiving - Inspection
 - 3.2.3 Rejected Material Reports Initiation
 - 3.2.4 Machine Shop Inspection
 - 3.2.5 Pre-Processes Inspection
 - 3.2.6 In-Process Inspection
 - 3.2.7 Post-Processes Inspection
 - 3.2.8 Notification and/or Hold Point Step Readiness Indication (Verbal)

Fig. 9-3. Responsibilities of the QA Manager (continued).

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- 3.2.9 Product Tests
- 3.2.10 Inspector Training
- 3.2.11 Inspector Examinations
- 3.2.12 Inspector Records
- 3.2.13 Final Inspection
- 3.2.14 Inspection Records
- 3.2.15 Gage Calibrations and Control
- 3.2.16 Inspection Equipment Maintenance and Records

4.0 RESPONSIBILITIES OUTSIDE THE QUALITY ASSURANCE DEPARTMENT

- 4.1 Department Managers are responsible to be informed of the general contents of this manual and to discharge their specific assignments as stated in this manual.
- 4.2 As previously stated in the "President's Statement", each supervisor shall be responsible for the quality of work performed under his supervision.
- 4.3 Specific responsibilities affecting quality appear in their related sections of this manual.
- 4.4 Engineering
 - 4.4.1 The Project Engineer is responsible for his assigned project(s). This includes obtaining a technically sound contract, issuance of the necessary directions to obtain drawings, specifications, procedures and give instructions required to complete the project.
 - 4.4.2 Planning is responsible for transferring information from drawings to instructions for obtaining material and for writing Production Orders and Inspection Records.
- 4.5 Spares Sales
 - 4.5.1 The duties and responsibilities of the Spares Sales personnel are:
 - 4.5.1.1 Review all Contract Specifications
 - 4.5.1.2 Prepare new Sales Proposals.
 - 4.5.1.3 Obtain Customer Acceptance to Specification Exceptions.
 - 4.5.1.4 Translate Specification/Contract into a Sales Package.
 - 4.5.1.5 Assist the Contract Administration Department in resolving problems pertaining to existing orders.

Fig. 9-3. Responsibilities of the QA Manager (continued).

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4.5.1.6 Solicit Review of the Bid Specification by the QA, Engineering, Research, Design, and Manufacturing Departments as required.

4.5.1.7 Initiate Processing of Customer Orders.

Fig. 9-3. Responsibilities of the QA Manager (concluded).

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GENERAL OPERATION QUALITY RECORDS

Records	Maintenance Responsibility Note 1	File Loc. Note 1
Quality Assurance Manual Log	QA	QA
Controlled Copy QA Manual Log	QA	QA
CVI Approved Vendor List Master	QA	QA
Supplier Surveillance and Audit	QA	QA
Supplier Material Certifications	QA	QA
Reject Material Report Log	Chief Insp.	Insp. Off.
Corrective Action Request Log	QA	QA
Welding Procedure Qualification Masters	QA	QA
Welder Qualification Masters	WE	WE
CVI NDE Procedure Qualification Masters	SNT Level III	Insp. Off.
CVI NDE Personnel Qualification Masters	SNT Level III	Insp. Off.
Inspection Tools Calibration and Maintenance	Chief Insp.	Insp. Off.
Internal Audit	QA	QA

Note 1 QA is abbreviation for Quality Assurance
 Insp. Off. is abbreviation for Inspection Office
 WE is abbreviation for Welding Engineer

Fig. 9-4. QA records.

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1.0 GENERAL

- 1.1 In order to make data available for analysis, status, records and reporting purposes, a system of inspection forms and records is in operation. The records are compiled and reviewed to aid in the evaluation of vendors, manufacturing, processes, inspection and to facilitate corrective action activities. The forms used are designed to provide evidence of the amount and extent of inspection.

2.0 GENERAL OPERATION QUALITY RECORDS

- 2.1 A list of operation records of direct concern to the Quality Assurance Department appears as Exhibit No. XVII-1. The responsibility for maintaining each of these records and the file location shall be as shown.
- 2.2 Retention of these records shall be for a minimum of seven years except for the Inspection Tools Calibration and Maintenance Records which will be for the duration of each gage listed. Any record summaries or study records are retained per QA Supervisory discretion.

3.0 JOB RECORDS

- 3.1 Basic job records, which are maintained for all contract work, are as follows:

- 3.1.1 The Receiving copies of the Purchase Order which contain the Receiving and Inspection Records. The Stockroom Manager is responsible for the maintenance of these records which are filed in the main stockroom.
- 3.1.2 The completed hardback copies of the Production Order and Inspection Records, Packing Lists and Corrective Action Requests are filed in the job folders in Inspection files. The Chief Inspector is responsible for the maintenance of these files.

- 3.2 Supplementary job records are designated for the job, when required, by the Project Engineer.
- 3.3 When required, Documentation List preparation is the responsibility of the cognizant Project Engineer. He may obtain assistance from QA.
- 3.4 Job records shall be retained, for CVTs benefit only, for seven years.
- 3.5 For information on special control jobs records, see Section XXII, 10.0 of this manual.

4.0 RECORD ENVIRONMENT

- 4.1 Records are kept in office conditions of a modern building.

Fig. 9-4. QA records (continued).

9.0 QUALITY ASSURANCE PROGRAM

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5.0 RECORD PREDISPOSAL ACTIVITY

- 5.1 Each job folder shall be examined for any disposing instructions, the most common being to notify the purchaser of the intent to discard records and to await instructions from the purchaser. These instructions are caused by contract requirements for special control jobs.

Fig. 9-4. QA records (concluded).

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1.0 PURPOSE AND SCOPE

To establish the methods which provide a comprehensive system of planned and periodic audits of all activities within the scope of the Program, to verify compliance with all aspects of the Program and determine Program effectiveness.

2.0 RESPONSIBILITY

The QA Manager or his designee is responsible for planning and conducting audits of activities within the scope of the manual.

Quality Assurance shall be audited by personnel selected by Product Managers.

3.0 QUALITY DEPARTMENT AUDITS

Formal audits of internal activities will be conducted by the QA Manager or his designee annually and in accordance with the Internal Audit Schedule, (Exhibit XIX-2). Audit personnel shall not audit areas in which they have responsibility. Audits shall be performed using the audit check list (Exhibit XIX-1A-1G). Audit Finding Reports for the full internal audit shall be circulated for review by the responsible Department Managers, QA Manager and the President. Follow-up action, including re-audit of deficient areas, will be planned and initiated within 30 days of the initial audit date. Each follow-up audit shall be documented and reviewed similarly to the initial audit.

The Audit Check List shall be prepared, maintained, and revised by QA (as required) to provide for an evaluation of quality assurance practices, procedures, instructions and implementation, and conformance with QA Manual and policy within the scope of the Program. The audits will include evaluation of work areas, activities, processes, and review of documents and records.

4.0 MANAGEMENT AUDITS

Audits of the QA Program and the QA Department shall be conducted annually. The President or his designee is responsible for an annual audit of the QA Department and other audits as he chooses. This audit will be used to determine the effectiveness of this QA Program, its adequacy and status. Individuals assigned will have no responsibility in the area being audited.

5.0 AUDIT PERSONNEL

Quality Assurance and Management audits are conducted by trained audit personnel qualified in accordance with ANSI N45.2.12 & 23. Training will be in accordance with Section XX of this manual. Auditors will be qualified on the Record of Auditor Qualification Form (Exhibit XIX-3) and this record maintained by the QA Manager.

6.0 CORRECTIVE ACTIONS

6.1 Corrective actions as a result of audits shall be handled in accordance with Section XVIII-3.0 of this manual.

Fig. 9-5. QA audits.

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7.0 VENDOR AUDITS (SUPPLIERS)**7.1 Selection Measures**

Measures used in procurement source evaluations may include one or all of the following:

7.2 Qualification of new vendors and periodic review of the qualifications of established vendors may be based on:

- (a) Full scale Quality System Audit/Survey.
- (b) Reputation of Supplier.
- (c) Survey per mail.
- (d) Listing in C.A.S.E. Register.
- (e) Historical data.
- (f) Any combination of the above.

7.3 These activities may be conducted at the discretion of the Manager of Quality Assurance, depending on dollar volume of business involved and/or the degree of criticality of the item involved.**7.4 Approved Vendor List**

- 7.4.1 Those vendors having met the requirements will be entered on the Approved Vendor List maintained by QA (Section VIII, paragraph 5.2).

Fig. 9-5. QA audits (concluded).

9.3.5 Preoperational Testing

Performance of the CCS was demonstrated using the warm-up heater to simulate the system heat leak and the thermal mass of the accelerator. Defined in Section 3.9, "Final Acceptance Requirements," of the statement of work for CVI, the system checkout demonstrated all aspects of the CCS operation. Incremental and preliminary checkouts of various components or subsystems were performed on a continuous basis to ensure system leak-tightness and proper fit.

9.3.6 Administrative Procedures

To assure the Laboratory that CVI had implemented the appropriate administrative QA measures, visits were made every 6 to 8 wk to CVI. During these visits, Laboratory representatives reviewed CVI's QA documentation and practices. The Laboratory has full access to CVI's QA documents. Trip reports were written and filed reporting the outcome of these audits.

During the installation of the CCS at the GTA site, the Laboratory participated in all aspects of the checkout and acceptance of the system. This included audits of the QA procedures followed during installation, checkout and acceptance.

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10.0 ES&H MANAGEMENT PROGRAM

This chapter explains the environment, safety, and health (ES&H) management program for the Ground Test Accelerator (GTA) facility. The GTA's ES&H program for the GTA is designed to comply with the administrative requirements and safety policies stated in the Los Alamos National Laboratory (LANL) Environmental, Safety, and Health Manual.

10.1 Organizational Structure

ES&H technical support is provided by the Health and Safety (HS) and Environmental Monitoring (EM) divisions: Accelerator Health Physics, HS-1; Safety and Risk Assessment HS-3; Health Physics Measurements HS-4; Industrial Hygiene and Safety, HS-5; Health Physics Policy and Programs HS-12; Waste Management, EM-7; and Environmental Surveillance EM-8. The HS and EM divisions advise GTA personnel on various environmental, health, and safety issues and requirements. In addition, the GTA project and each Accelerator Technology (AT) Division group have an assigned safety officer who is responsible for coordinating ES&H issues. Facility safety is the responsibility of the MPF-365 building manager in conjunction with the GTA safety officer.

10.2 GTA Safety Plan

The GTA program considers safety to be paramount—both in fabrication and operation. Appendix L contains the published and distributed GTA Health and Safety Policy Statement and the GTA Safety Plan.

10.3 As Low as Reasonably Achievable Program

The Laboratory requires that radiation exposures to employees and visitors be kept at levels as low as reasonably achievable (ALARA). The ALARA program at the Laboratory requires organizations involved in radiation work to plan and conduct operations in a manner that maintains personnel and environmental exposures at ALARA levels. Detailed guidance for the Laboratory's ALARA program is given in Technical Bulletin 302, "ALARA Guide." AT Division also has an ALARA program (see Appendix M).

AT Division and GTA use ALARA principles and applicable DOE orders, LANL ARs, and existing standards for exposure criteria and shielding design. The GTA facility was designed prior to DOE 5480.11 and the Rad Con Manual. However, since the duty factor of the accelerator has been reduced by a factor of ten (0.2% vs 2%) since facility design, the shielding will be adequate to meet 5480.11 and Rad Con Manual exposure criteria (0.005 rem/hr in occupied areas, 20% of the standards or 1.0 rem/yr in unoccupied areas). For accident conditions, the commonly accepted criterion of 50 rem/hr is met. Though a written shielding policy specifically for AT Division has not to date been necessary, the need will again be evaluated prior to 24 Me operation.

GTA implements the radiation ALARA program through radiation monitoring, shielding in conjunction with monitoring, radiation personnel safety system (RPSS), a personnel exclusion area, which is secured by the RPSS and use of radiation work permits for maintenance work and other special cases.

10.4 Safety Analysis Program

Safety analysis for the GTA project is accomplished through the development of this final safety analysis report (FSAR). The GTA safety officer is responsible for reviewing changes to ensure that they are within the scope of the FSAR and for identifying its required changes.

10.5 Operational Readiness Reviews

Before each major experimental phase (see Chapter 1), the Laboratory conducts an operational readiness review for GTA. The FSAR, standard operating procedures (SOP), operational procedures, training and other ES&H aspects are checked to ensure readiness for safe operation. The U.S. Department of Energy (DOE) also conducts a preoperational review for each phase of the project.

10.6 Administration and Records

GTA has an assigned program safety officer. Figure 10-1 shows the safety office's position within the GTA organization. This person oversees the administration of safety requirements within the GTA program so that program documentation related to safety, such as training and waste management, is maintained and updated. ES&H documentation is maintained at the program, division, and group levels.

10.7 ES&H Programs

The HS and EM divisions provide ES&H support and expertise for the various divisions within the Laboratory. HS reviews programs, operations, and facilities to help identify health, safety, and environment requirements and any safety problems. Some members of HS Division are assigned to specific Laboratory organizations or sites to become familiar with the operations and the health and safety concerns of that particular area.

The Health Physics Policy and Programs Group, HS-12, provides health physics support to GTA operations, supervises the personnel dosimetry program, and maintains records of radiation received by individuals. Dosimetry records are provided to divisions and groups for review. If an individual receives an unexpectedly large dose, or if the accumulated dose nears the allowable level, the individual is notified and work restrictions are applied, if appropriate. If procedures require an exposure investigation, HS-12 notifies the individual and the individual's line management.

HS-1 maintains health physics surveillance on all activities at TA-53. The group supports GTA operation by:

- providing surveys and health physics technical support;
- specifying and arranging for the maintenance and calibration of fixed radiation monitors;
- specifying the number and type of hand-held radiation monitors;
- providing assistance with dose-rate calculations and shielding requirements; and
- monitoring contamination and establishing exclusion areas and clean-up restrictions.

Support from areas of the Laboratory includes the following groups HS-1, HS-3, HS-4, HS-5, HS-12, EM-7, EM-8, and ENG-8. HS-3 coordinates SOP reviews and assists with FSARs and operational readiness reviews. HS-12

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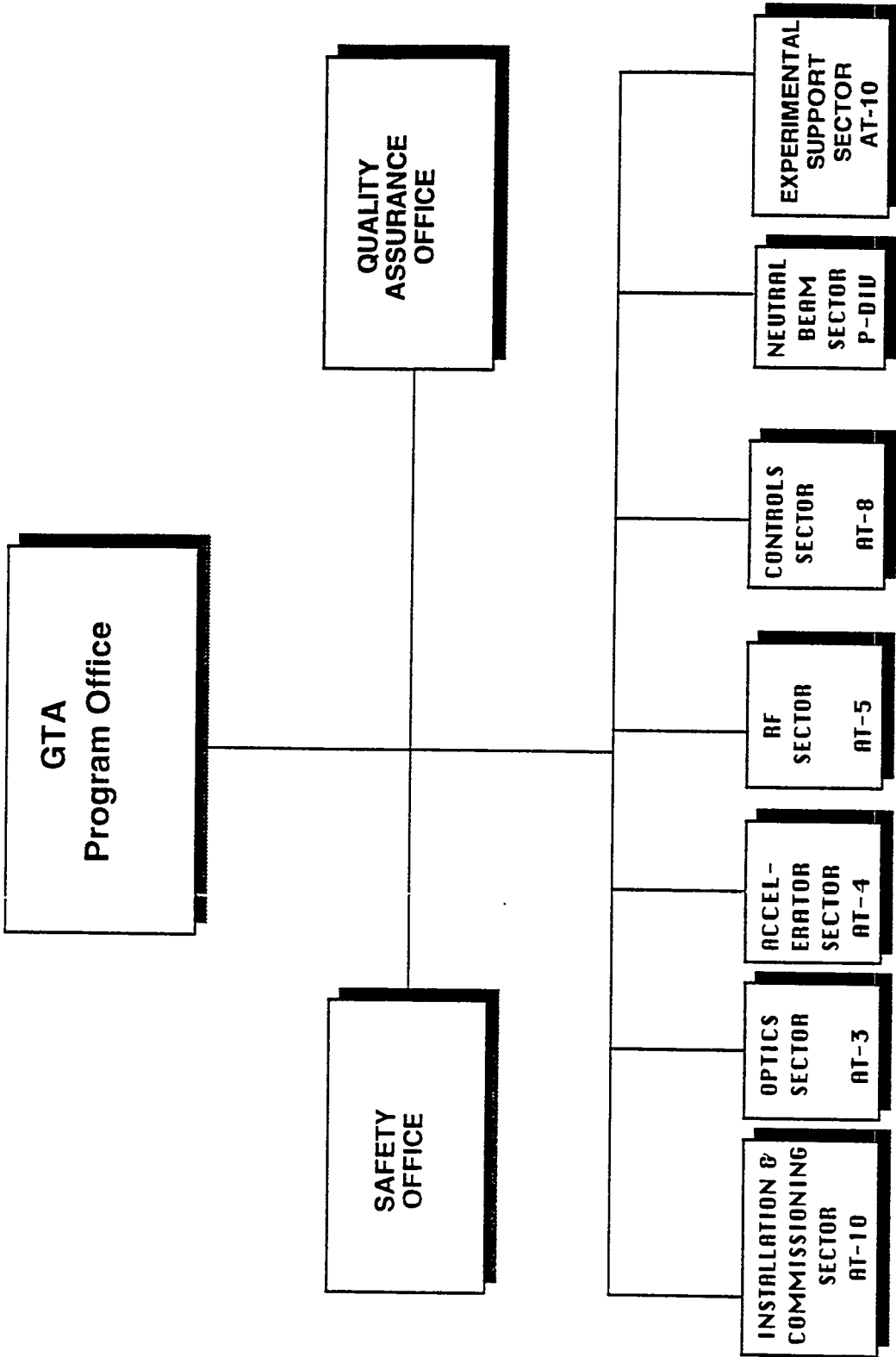


Fig. 10-1. GTA organization showing safety office.

provides dosimetry information. HS-5 conducts safety inspections, reviews SOP, and provides general operational safety assistance. HS-5 also tests, inspects, and certifies high-efficiency particulate air (HEPA) filtration systems; provides respiratory-protection fitting and training; and provides chemical and noise monitoring. EM-7 assists in waste disposal and sampling. EM-8 is involved in routine environmental monitoring, documentation, and evaluation. ENG-8, the Fire Protection and Utilities Group, provides fire detection and alarm systems, pre-testing of the suppression systems, and evaluation of fire protection concerns. In addition the Los Alamos County Fire Department provides fire planning and emergency-response support. The Emergency Management Office assists with emergency planning.

10.8 GTA Responsibilities

ES&H responsibilities for the GTA program are in accordance with Laboratory policies and administrative requirements. A partial list of responsibilities is included here to indicate the general delegation of responsibilities throughout the administrative organization.

10.8.1 Division Leader

The division leader is responsible for ensuring that ES&H responsibilities are discharged by those under his control. The division leader must ensure that programs and procedures for occupational safety, radiation protection, waste management, emergency preparedness, and all other aspects of ES&H are implemented in all areas and operations under his jurisdiction.

10.8.2 Program Manager

The program manager has the overall responsibility and authority for GTA safety and will be responsible for setting the GTA safety policy and, in conjunction with the cognizant ES&H organizations, maintaining safety oversight. He is the GTA safety approval authority for safety-critical portions of program documentation.

10.8.3 Division Safety Officer

The division safety officer oversees the administration of safety requirements within the GTA program so that program documentation related to safety, such as training and waste management, is maintained and updated.

10.8.4 Supervisors

Supervisors are responsible for ensuring that individual responsibilities, as described in Section 10.8.5, are carried out by the personnel under their control. Supervisors are also responsible for:

- instructing employees, for whom they are responsible, in using safe techniques and applying approved safety practices;
- ensuring that the SOPs are written for hazardous operations;
- reviewing and approving SOPs that are developed by their personnel;
- assigning responsibilities for implementing ES&H requirements and ensuring that safe practices are followed;
- ensuring that employees receive ES&H training as determined by job responsibilities; and
- ensuring that major changes in operational procedures, new techniques, alterations in physical plant, or new operations are reviewed for their impact on personnel safety, the environment, or regulatory concerns.

10.8.5 Employees

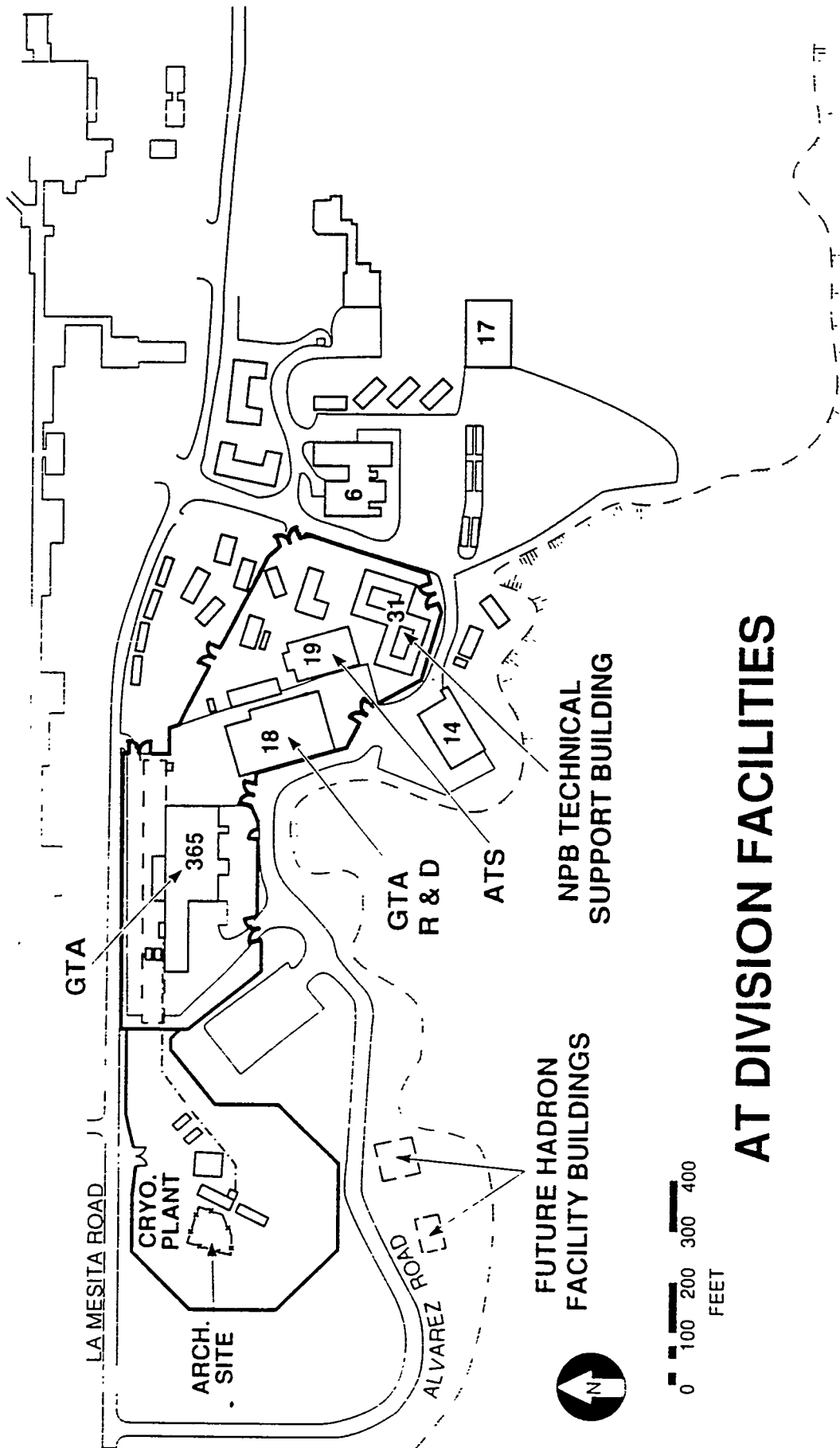
Individual employees in the GTA program are responsible for:

- keeping their own exposures to radiation, and those of others, as low as reasonably achievable;
- reporting injuries promptly to supervisors;
- carrying out recommendations of HS or EM divisions in controlling hazards for which they are responsible;
- contacting a supervisor or HS Division when the hazards of a substance or operation are not fully understood, in which case, no action shall be taken until the required precautions have been identified and taken;
- proper handling, storing, and labeling of chemicals for which they are responsible;
- making themselves familiar with the material safety data sheet for materials used in their work; and
- disposing of wastes in accordance with Laboratory requirements.

10.9 Plant Security

The GTA program is a classified U. S. Department of Defense program. GTA contains substantial elements classified as SECRET, NSI, or CONFIDENTIAL, NSI, and nonclassified sensitive information.

The major part of the GTA program is consequently in a secure area at TA-53. The heavy line on Fig. 10-2 shows the fenced perimeter of the secure GTA area at AT Division. Building MPF-365 houses the accelerator and is within the fence.



AT DIVISION FACILITIES

Fig. 10-2. Fenced perimeter of the secure GTA area at AT Division.

The Laboratory's protective force provides security inspectors to man the access gates. Pedestrians may enter the fenced area through access gates 457 and 458. The security inspectors man Gate 457 24 hr/day, 7 days/wk, and Gate 458 11 hr/day during the work week. Security inspectors have access to all security areas within the fenced perimeter. Badge readers are posted at gates 457 and 458. Persons who can read their badges into the reader data base are allowed access to the facility.

Within the fenced perimeter are additional secure areas, which further limit access to particular zones. Access to these areas is contingent on a "need to know" basis. All security inspectors serving these areas have access to these secure zones.

10.9.1 Hazards and Security

Typical emergency situations, such as fire and injury to personnel, require immediate access to the interior of the fenced perimeter. All security inspectors have keys and access to all secure areas. If a security inspector is not available, the Los Alamos Fire Department is prepared, and has the authority, to cut locks to obtain access. Such access enables emergency response vehicles and personnel to operate within the secure areas with little or no delay.

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11.0 ENVIRONMENTAL, SAFETY, AND HEALTH SYSTEMS CRITICAL TO SAFETY

This chapter explains the environmental, safety, and health (ES&H) systems critical to safety for Ground Test Accelerator (GTA) operations.

The GTA ES&H systems critical to personnel safety in Phase 2 operations are:

- radiation personnel safety system (RPSS);
- shielding;
- interlock systems, including the injector and RF-power system interlock chain;
- fire, detection, and protection systems;
- oxygen monitors;
- air-activation, radiation monitoring;
- hydrogen monitors;
- heating, ventilating, and air conditioning; and
- cryogen cooling system, including the hydrogen and helium systems.

Subsequent facility or equipment modifications will be implemented under the same consequence-of-failure type (CFT)/quality assurance (QA) requirements imposed in the initial design and construction. Other general industrial-type systems, such as waste-disposal and material-handling equipment, are covered in the chapters that particularly address these items.

The acceptance qualifications for ES&H systems include the following:

- comprehensive testing of RPSS interlocks;
- radiation surveys to verify adequacy of shielding;
- local testing and calibration of all safety monitors;;
- testing of the fire protection and suppression systems by ENG-8 and Johnson Controls before the building was occupied;
- testing interlock system for high voltage by observing the operation of the shorting mechanism; and
- testing oxygen monitors according to manufacturer's recommendations.

11.1 Radiation Personnel Safety System

The RPSS is intended to prevent injury from radiation. As originally planned for 100 MeV operation at 2% duty factor the system was to consist of two main components: an access-control system and a radiation-interlock system. Shielding calculations for 24 MeV operation at 0.2% have shown that radiation levels outside the tunnel will not represent a safety hazard to operating personnel. While radiation survey

measurements will be taken at selected locations outside the tunnel the monitors will not be interlocked with the RPSS. The access-control system is intended to prevent unauthorized or accidental entry into areas where the radiation dose rate due to normal operation of the accelerator could exceed 5 mrem/hr. Elements of this system include physical barriers, signs, warning lights, audible-warning devices, and a body of administrative procedures that will define conditions for safe entry and lockup. Administrative procedures will determine instrument-trip levels, define calibration and check procedures, and specify maximum intervals between checks.

The RPSS interlock design includes the following features:

- The RPSS interlock design is simple and consistent with the protection needed. It uses hard-wired relays and is easy to understand and trouble-shoot. It is designed to minimize the number of false trips.
- Loss of ac power to the RPSS, or dc power to logic circuits or to components in the beam area, trip the RPSS and cause beam shutdown.
- Beam shutdown on a RPSS trip is achieved in two ways: a beam plug is inserted in the LEBT line; and RF power to the radio-frequency quadrupole (RFQ), intertank matching system (IMS), and drift-tube linac (DTL) is turned off.
- To reduce the likelihood of accidental damage or tampering, all cables and connections are protected. Cables are run in wire ways, cable trays, conduits, or ducts for protection. Connections between system components are made in locked junction boxes from which all non-RPSS wiring is excluded. Logic equipment is mounted in a stand-alone locked rack. RPSS junction boxes and racks will be labeled as such with appropriate warnings concerning unauthorized disturbance.
- Status panels at doors 3 and 4 and in the control room track the progress of a sweep and lockup and facilitate identification of faults.
- Contacts from the RPSS summation are used in other interlock systems such as run-permit, beam-plug permissive, and RF permissive, but other interlock systems have no input to the RPSS. This is consistent with the intent to keep the logic and operation of the RPSS as simple as possible.

The following access-control features are part of the RPSS system:

- Illuminated signs and flashing-red lights indicate the status of the access-control outside each of the three principal entries to the beam area and at three locations inside the beam tunnel. Warning horns and strobe lights are mounted in the tunnel near each set of illuminated signs.
- Scram switches with large red mushroom-head buttons are clearly visible, labeled, and readily accessible in the beam tunnel and the underlying basements. They are located so that no person can be more than 50 ft from the nearest switch.
- Inner doors cannot be locked from the inside. Shield plugs and doors are equipped with emergency-exit mechanisms.
- Before the accelerator is turned on, members of the operating group perform a personnel clearance sweep and lockup of the beam tunnel and the underlying basements. The sweep is initiated by illuminating SWEEP IN PROGRESS signs, a three-second horn, and a voice announcement on the public-address (PA) system. All doors are locked from the outside to prevent people from entering behind the sweep team. Safety sweep reset switches (SSR) define the search route to assure that all areas come into view of the sweep team. After each of the five zones is swept, the sweep team requests a sweep verification from the control-room operator, after which a ZONE SECURE light is illuminated. When all zones are secure, all shield doors are closed, and all Kirk keys are returned to the keybanks, a three-second horn is sounded and red strobe lights are turned on in the beam tunnel. After a 60-second delay, RPSS SECURE signs are illuminated inside the beam tunnel and at doors outside the tunnel, flashing-red lights are turned on at tunnel doorways, and the RPSS interlocks are satisfied.
- Any violation of the area, such as the opening of a door or gate or pushing a scram switch, trips the RPSS and prevents beam operation. In the unlikely event that someone does not hear the first warning horn and sweep announcement, and is missed by the sweep team, he can push a scram button and exit the tunnel by any of the five doors. Pushing a scram button turns off the accelerator and requires a new sweep. The scram buttons and doors, as well as gates, are separate inputs to the RPSS logic and provide several layers of redundancy to back up the sweep.
- When the RPSS is secure, personnel access to the beam tunnel at each doorway is blocked by a Kirk-key system. The master release key is kept in the control room. The key release is

1 4 6 0 0 5 3 2

powered with a standby power supply to assure emergency access into the beam tunnel if there is a power outage. The two truck access doors are blocked by massive concrete shield blocks.

- During a sweep, if any zone has not been entered since the last authorized sweep of that zone, it does not need to be reswept.

11.2 Shielding

During Phase 2 operations at 24 MeV, passive shielding built into the facility and stacked block shielding protects employees and the public from exposure to radiation. Most of the radiation originates in the tunnel when the proton beam impacts components in the beam line. The built-in shielding and stacked block shielding are critical to safety. The stacked block shielding provides a local radiation shield when required around beamline components. Shielding and its effectiveness is monitored by HS-1. Supplemental shielding arrays are subject to configuration control.

11.3 Interlock Systems

The injector, the lasers, and the RF system each have their own interlock system, which shuts down their electrical systems.

For the injector, a key-enabled high-voltage interlock system protects personnel and equipment. Entering the safety enclosure around the two capacitor banks requires opening the access door with a key. This results in the shutdown of all ac power within the enclosure, the contact of a fall-down shorting system to the high-voltage dome, and the activation of an automatic fall-down shorting system across both capacitor banks.

The laser-interlock system consists of a mechanical disconnect that shuts off the laser power. Interlocks are at the entrance of the laser enclosure. Remote operation of the laser is not allowed unless all interlocks indicate the integrity of the laser beam enclosure (beam tube).

The RF system has several interlocks. One interlock consists of a Kirk-key system for the capacitor room of the 850-MHz klystron. The key is interlocked to the equipment inside the capacitor room. Opening the door activates the interlocks, grounding the capacitors, and causing the room to shut down. Two other interlock systems exist for the 850-MHz klystron station and the 425-MHz tetrode station. All safety-interlock systems have emergency shutoff switches on front panels and walls that shut off the high voltage to tetrode and klystron sections.

11.3.1 Injector and RF Power-system Interlock Chain

The high-voltage components of the RF systems and the injector have hard-wire interlocks for personnel and equipment safety. These systems also have software interlocks to protect equipment, but all personnel safety situations are hard-wire protected.

The injector high-voltage interlock chain consists of an exterior emergency mushroom push button, six door interlock switches, a capacitor bank enclosure key switch, and the high-voltage shield switch. The interlock chain for the injector has a latch, so that, as long as the interlocks are made up, the computer can permit 110 V ac through a switch to the coil, which closes the contacts for the 208 V ac, 3 ϕ . The interlocks are wired so, if the interlock chain is broken, not only does the computer permitted switch open, but it must be reset after the interlock chain is again made up. The capacitor bank for the injector has a fall-down shorting system discharging the capacitors when the interlock chain is interrupted.

There are two RF high-power interlock systems, the tetrode amplifiers (see Fig. 11-1), and the klystron modulator amplifiers (see Fig. 11-2). The tetrode amplifiers rely on two redundant interlock chains for protection of personnel and equipment. The interlocks included in each chain are: hardwire—shorting stick, tetrode door, triode door, nitrogen pressure with relay, and external interlock;—and software (Allen-Bradley) - tetrode door, triode door, external interlock, and shorting stick. The personnel safety chain is hard-wired to high-voltage power supplies. If this chain is interrupted, the 3-kV and 5-kV power supplies are disabled. The second chain is passed through the Allen-Bradley controller. If this chain is interrupted, the 3-kV, 5-kV, and 20-kV power supplies are disabled. In the absence of an interlock failure, both chains will shut down equipment if there is an interlock interruption.

Another method is used to interlock the 20-kV power supply (which is not included in the hard-wire chain because of hardware constraints). The 20-kV supply delivers voltage to a pressurized vessel (tetrode cavity). The penetration of the high-voltage cable into the pressure vessel is essential to the integrity of the pressure vessel; the vessel cannot be pressurized unless the high-voltage cable is in place. Measurement of the pressure in the pressure vessel is used to interlock the 20-kV power supply, ensuring that the 20-kV power supply cannot be enabled unless the high-voltage cable is in place and the integrity of the pressure vessel is maintained.

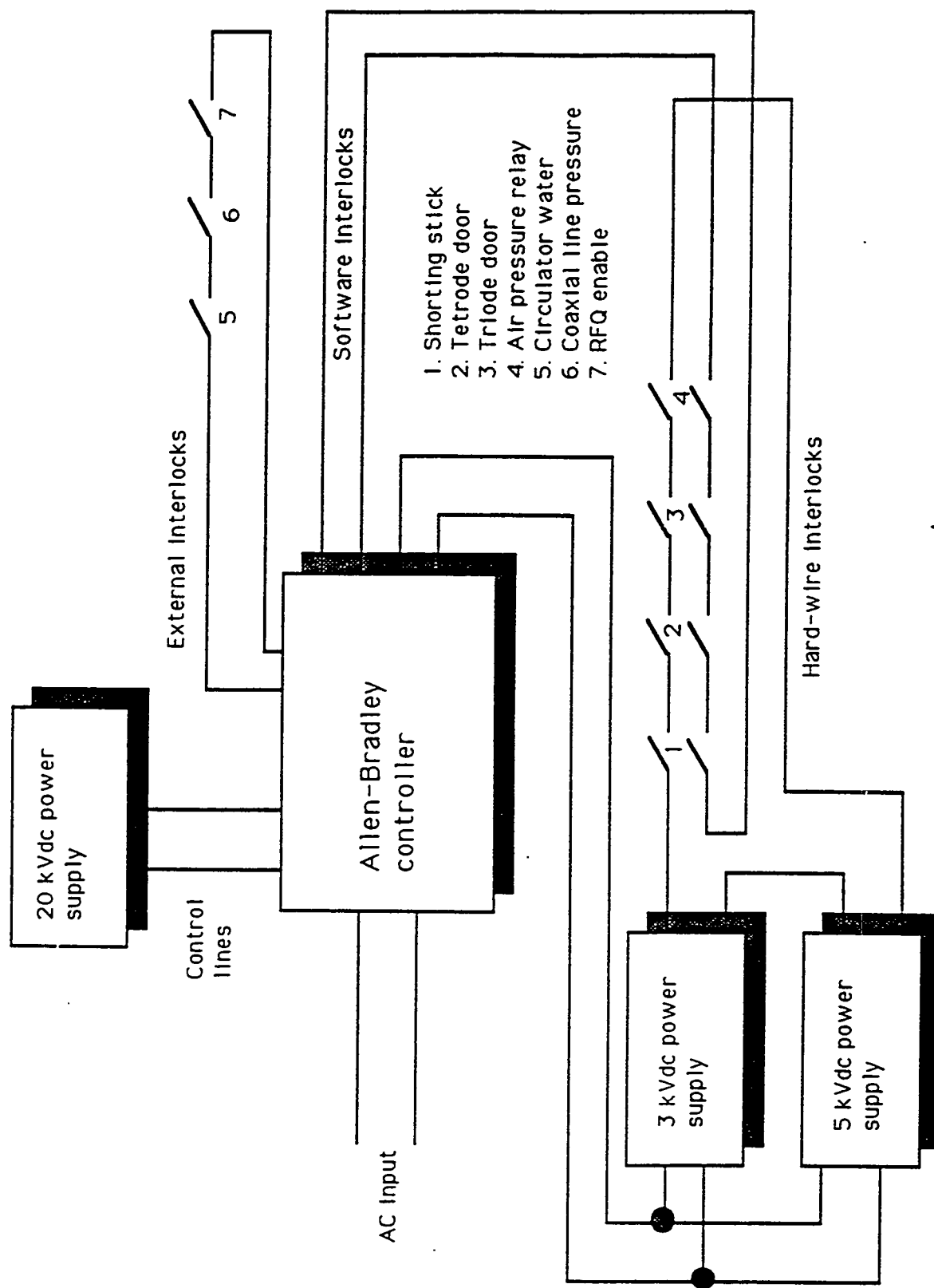


Fig. 11-1. Tetrode.

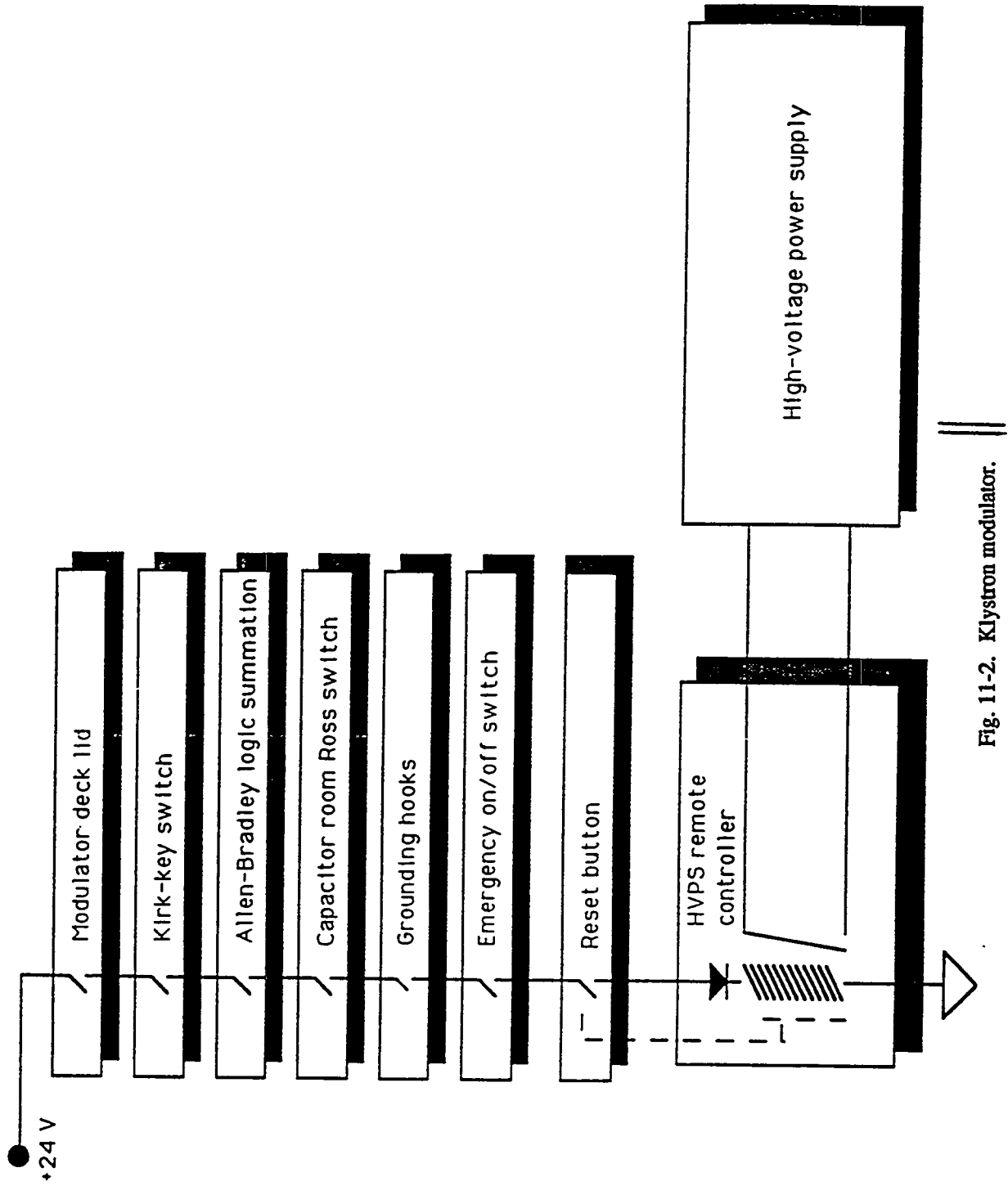


Fig. 11-2. Klystron modulator.

The klystron modulators have redundant hardwire and software interlock chains. The interlock chain is a summation of the modulator deck lid, a Kirk-key switch on the capacitor room door, a summation of A/B logic, ground hooks in the capacitor room, a manual safety capacitor discharge, and a scram button. This summation closes a contact that goes to the high-voltage power supply controller, which has an external interlock pair. Opening these contacts turns the high voltage off.

The RF transport system (waveguide and rigid coax) is interlocked with air pressure switches to ensure that the high-power RF cannot be turned on if the integrity of the transport system is violated.

11.4 Fire Detection and Suppression Systems

Fire detection and suppression systems are described in Section 4.1.5.

11.5 Oxygen Monitors

The RFQ, IMS, and DTL are cryogenically cooled with gaseous helium from the 40-kW CCS. For 24-MeV operation, oxygen monitors are in the beam tunnel, the laser and waveguide basements, the CCS equipment room, and the cryogenic-compressor room east of the GTA building. An oxygen monitor is located near the HPTCB and the 750-W refrigerator. Oxygen monitors are commercially procured and are set to alarm at 19.5% oxygen. They are serviced and calibrated according to a schedule maintained by the installation/operations sector of the GTA program.

11.6 Radiation Monitoring

Radiation monitoring for personnel protection consists of two systems: neutron monitoring; and work-area airborne monitoring. These systems are discussed in the following sections.

11.6.1 Neutron Monitoring

Albatross 2080 neutron monitors will be used at selected locations to the outside of the GTA tunnel to confirm that radiation levels are within safety limits. Potential locations to be surveyed are

- at the top of the laser basement stairway;
- at the LINDA laser shield wall penetration or inside the LINDA laser lab (whichever is more appropriate);
- outside of the east high bay plug door;
- south of the east high bay waveguide tunnel;
- along the wall inside the GTA alignment laboratory;
- in front of the steel-door tunnel entrance;

- in front of the east (outside) plug door;
- outside of the east fork-lift access door;
- above the overhead GTA tunnel access hatch; and
- above the cryogenic gas pipe chase in the CCS equipment room.

Albatross 2080 neutron monitors were developed by Los Alamos National Laboratory (LANL) to monitor pulsed neutron fields at the Clinton P. Anderson Meson Physics Facility (LAMPF). These units incorporate a large (5 in. radius) polyethylene pseudo-sphere, which moderates and thermalizes the neutrons. The thermalized neutrons then interact with a silver foil which is wrapped around a small Geiger-Müller (GM) tube. When the silver (Ag) interacts with a thermal neutron, it is activated from non-radioactive Ag 109 to Ag 110, which has a 24.57-second half life. The Ag 110 then decays by beta emission. After about three minutes, the Ag 110 comes into equilibrium with the neutron activation. (It decays as rapidly as it is activated.) A separate GM tube is wrapped in tin foil (to duplicate the gamma absorption of the silver foil), placed inside the Albatross and shielded from the beta particles produced by decay of the Ag 110. This GM tube measures the background gamma radiation and subtracts it from the signal generated by the Ag 110 decay betas. A portion of the betas emitted from the Ag 110 are counted by the GM tube and electronically converted to neutron dose rate in mrem/hr.

Albatross neutron monitors are calibrated every six months at the LANL, HS-4 instrument calibration facility. The monitors are also source checked with a portable sealed neutron source before each experimental cycle to ensure instrument reliability.

11.6.2 Air Activation Monitoring

Kanne chambers (large flow through ion chambers) monitor the air in the GTA tunnel. Solenoid valves tied to sample ports spaced at intervals along the interior of the GTA tunnel draw air from various sampling locations and through the kanne chamber(s). The solenoid valves can sample the air of each area independently or sample the air from the whole area. Air passing through the kanne chambers is piped back to the GTA ventilation/stack system.

Using scenarios for 24-MeV operation, LANL group T-2 completed a Monte Carlo computer analysis of probable air-activation products and estimated their concentration. According to this estimate, the activation during this phase of GTA will be quite small and may be unmeasurable. Even though this is the case, GTA will still set up the gas-monitoring system in a manner consistent with sound radiological practice.

When the accelerator is in operation, kenne chambers will continuously monitor tunnel air near possible activation sources. After the running period, workers and experimenters will not be allowed back in the accelerator tunnel until activated air concentrations are below DAC values.

11.7 Hydrogen Monitors

The GTA cryogenic site is monitored continuously for the presence of hydrogen gas or vapor by a Bacharach CD850 four-channel gas detection and monitoring system. The system consists of four combustible gas detectors with detector amplifiers and a four-channel control unit. Detectors are in four areas in which combustible gases or vapors may be a hazard. The detectors are located at the hydrogen storage dewar and run tank, inside the 40-kW CCS equipment room, and at the air inlet duct to MPF-365. The control unit, common to all four of the detectors, is on the 40-kW CCS control rack, and the alarm is connected to the GTA autodialer in MPF-365. The CD850 model control unit responds to gas signals with analog percent-of-lower-explosive-limit (% L. E. L.) meter gas concentration readings. Front panel warning and alarm lights signal the presence of dangerous concentrations of gas. If detector or detector circuitry failures render a channel temporarily inoperative, this also is signaled for each channel by a front panel failure indicator light.

The four-channel gas detection and monitoring system may be operated in either of two modes--automatic (AUTO) mode in which the percent L. E. L. meter and recorder respond to the individual channel that has the strongest signal; or a manual channel selection mode in which meter and recorder monitor the area selected by means of a manual control switch.

Each of the four detectors of the system contain a matched pair of resistor filaments; one coated (active) with a catalyst that oxidizes combustible gases and vapors, and the other uncoated (reference), upon which no oxidation of combustible gases or vapors occurs. The two resistor filaments, coated and uncoated are connected in series across a 6-V power supply. So connected, the coated and uncoated resistor filaments divide the applied voltage equally in proportion to the equal resistance values. A third lead connected between the two resistors carries the voltage at this point (3 V if no combustible gas is at the detector) to an amplifier circuit, which is housed in a junction box to which the detector is attached. A second input to the amplifier from a voltage divider on the amplifier printed circuit board provides a standard 3-V reference voltage with which to compare the signal voltage from the detector. In the absence of combustible gas at the detector, the 3-V detector signal voltage equals the 3-V voltage divider reference voltage at the operational amplifier inputs, so that the amplifier produces no output signal.

When combustible gases or vapors appear at the detector, the electrical signals from the detector change in proportion to the concentration of gas or vapor. Combustible gas is oxidized on the catalytic coating of the

detector filament to heat and consequently increase the resistance of this filament. Now the constant 6-V power supply voltage applied across the series-connected active and reference filaments in the detector divides, not equally as in the no-gas condition, but in proportion to the differing resistances. The more gas, the more heat from oxidation on the catalytic filament and the higher the resistance of this filament. With higher resistance comes a larger voltage drop across the resistance, so that the voltage at the signal lead between the coupled resistors becomes less. Consequently, the signal voltage and the standard reference voltage at the two inputs of the operational amplifier differ, resulting in a signal output from the amplifier. The amplifier output signal, an electrical analog of the concentration of combustible gas at the detector, is conducted to the remote system control unit for further processing and display.

11.8 Heating, Ventilation, and Air Conditioning

Heating, ventilating, and air conditioning systems are described in Section 4.1.4.

11.9 Cryogenic-cooling System (CCS)

In order to maximize the overall safety of the CCS and its planned operations, a group of experts in the field of cryogenic engineering and technology performed an independent safety review of the design. The report by this group is given in Appendix S. As a result of the group's recommendations, a number of additional safety features were incorporated into the basic safety design provided by the CCS contractor. The following subsections describe the principal safety features that are in addition to site construction, and fire and lightning protection and detection, which are described in chapters 4 and 5.

11.9.1 Hydrogen System

The hydrogen system is outdoors and consists of the LH₂ dewar, the LH₂ transfer system, the LH₂ run dewar, an atmospheric vent near the storage dewar, and a flare stack for the run dewar vent.

All materials in the hydrogen system are selected for their compatibility with hydrogen service for the designed temperatures and pressures of the CCS. The system is designed to allow inert gas purging of all lines and equipment before introducing hydrogen, as well as post-run purging.

The piping system has sufficient flexibility to ensure that no excess stresses build up during cool down, operation, or warm-up. The piping has the proper fixed support points and the proper expansion/contraction loops and bellows in the vacuum jackets. The piping design incorporates pressure-relief safety devices to ensure that there are no trapped volumes between valves. Both safety-relief valves and rupture disks will be provided for the storage and run dewars, and the transfer and fill lines will have two safety relief valves in each section, which can be isolated by shutoff or control valves. All relief valves will be tested, and pressure settings, as shown in Table XI-2,

will be designated on the device with a metal tag. Vent points will be a minimum of 10 ft above ground and 50 ft from the nearest roadway. The atmospheric vent will be oriented to ensure that the exhausted fluid cannot impinge on personnel, equipment, or combustible materials. Thermal insulation will cover any exposed surfaces that can be cooled below 0°F by the process.

Check valves will be provided in the vent stacks to ensure a positive pressure and to prevent the back-diffusion of air. In addition, a flare will be provided at the run dewar vent stack discharge to ensure that no flammable mixture of hydrogen and air will reach the GTA site boundary along La Mesita Road.

All vacuum-insulated pipe spools are mass spectrometer leak-tested after fabrication. The thermal-insulation system for the vacuum jacket will be tested to show a no-leak indication using a

Table XI-2 CCS Pressure Summary

Component	Normal Operating Range (psig)	Relief Valve (RV) and Rupture Disk (RD) Setting (psig)	Maximum Allowable Working Pressure (psig)	Test Pressure (psig)
LH ₂ storage dewar	-11.5 to 15	25 (RV) 30 (RD)	25 (116*)	37.5
LH ₂ run dewar	-11.5 to 15	25 (RV) 35 (RD)	150	225
LH ₂ transfer line	-11.5 to 15	200 (RV)	244	
LN ₂ storage dewar	0 to 20	35 (RV) 40 (RD)	75	
LN ₂ run dewar	0 to 10	15 (RV) 17 (RD)	20	30
LN ₂ transfer line	0 to 20	400 (RV)	670	
GHe recovery tank	0 to 235	250 (RV)	250	375
GHe circulation lines	-11.5 to 350	400 (RV)	484	
GHe purifier dewar	0	not required	30	
GHe high-pressure storage	250 to 2,200	3,000 (RD)	3,000	4,500
GN ₂ high-pressure storage	250 to 2,200	3,000 (RD)	3,000	4,500

* Maximum allowable working pressure when originally placed in service.

portable Hastings vacuum gauge. After installing the system, all bayonet flange joints in the hydrogen pipe spools will be seal-welded to prevent leakage.

Electrical equipment associated with the LH₂ system meets the requirements of Class 1, Division 2, Group B explosionproof electrical equipment. The electrical codes that cover explosionproof electrical equipment for hydrogen-system use include the National Electrical Manufacturers Association (NEMA) Standards for Electrical Motors and Cabinets; National Environmental Policy Act (NEPA); National Electrical Code (NEC); National Fire Protection Association (NFPA) Standard No. 78, Standard for Liquefied Hydrogen Systems at Consumer Sites; and NFPA 50B, Section 4-9, Items 4-9.1 and 4-9.2.

A four-channel hydrogen monitor is included in the control console in the CCS equipment room. One sensor is in the vicinity of the run dewar; another sensor is at the LH₂ storage dewar fill station; a third sensor is in the CCS equipment room; and the fourth sensor is in the main air intake for the GTA building. This system provides continuous sample monitoring and alarm protection.

Concrete barriers (also known as Jersey Bounces) are installed along La Mesita Road to prevent an errant vehicle from crashing into the hydrogen components and the transfer line. The barrier is designed to deflect a light truck traveling at 50 mph. In addition, a similar barrier is along the transfer line to prevent vehicles and fork lifts from damaging the line. Aluminum slats are built into the chain-link fence along La Mesita Road to provide a thermal-radiation barrier in the event of a possible on-site fire from the accidental release of hydrogen. Television surveillance, by consoles in the main GTA control room, monitors personnel activities within the CCS site and the equipment building.

Although the LH₂ capacity of the run dewar is 4,050 gal, it will be operated under active-level control and will contain no more than 1,500 gal of LH₂ at any time to minimize the potential hazard from the amount of stored hydrogen. Also, for GTA experiments 2D through 5, it will not be necessary to contain more than ~14,000 gal in the 28,000-gal storage dewar, which is determined primarily by the 13,000-gal delivery capacity of an LH₂ transport trailer.

For backup safety protection during fill operations, the LH₂-storage fill line is provided with a remotely operated shutoff valve that can be activated from the fill station, from the entrance gate to the storage area, and from the control console. The LH₂ run dewar has a liquid sensor gauge in the vent stack that is interlocked with the LH₂ storage dewar shutoff valve to prevent LH₂ overflow from the vent stack.

11.9.2 Helium System

The helium system consists of a circulating compressor, heat exchangers in the LH₂ and LN₂ run dewars, purifier, warm-up heater section, and helium-transfer lines outside and within the accelerator tunnel. This closed-loop system will deliver GHe at 318 psia to the accelerator.

The circulating compressor has both over-speed and power-overload protection. During system operation, overpressure protection is provided by a pressure regulating control valve in the circulating loop, which returns helium to the recovery system to maintain safe operating pressure.

All materials in the helium system have been selected for their compatibility with the designed temperatures and pressures of the system. Proper flexibility is incorporated into the design of the system to ensure that design stresses are not exceeded during cool down, operation, or warm-up. External insulation will shield any surfaces that can become sufficiently cold to cause cryogenic burn or injury to personnel.

The system incorporates safety relief valves to ensure that no trapped volumes exist between valves or other nonvented areas in the system. The relief valves will be set at, or below, pressure levels stated in American National Standards Institute 31.3, section 322.6.3. They will be tested, and the pressure settings will be stamped on a metal tag on the device.

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12.0 SUMMARY OF WASTE-MANAGEMENT PROGRAM

The Ground Test Accelerator (GTA) and Accelerator Test (AT) Division activities do not include process-type operations, therefore, only small to moderate quantities of low-level radioactive and hazardous chemical wastes and, possibly, activated cooling water are generated. Due to the similarity of waste streams generated within AT Division, waste-management activities have been addressed in one AT Division safe operating procedure (AT-DO:92-01) for radioactive- and chemical-waste management.

AT Division does not handle any transuranic or fissile materials. Waste streams from the GTA project are, therefore, limited to solid or liquid materials activated by proximity to, or contact with, the particle beam, hazardous chemical wastes (primarily used solvents), nonhazardous wastes and ordinary trash, excess property, nonhazardous vacuum pump oil, and sanitary waste. Mixed, asbestos, and polychlorinated biphenyl (PCB) wastes are not expected to be generated.

The AT Division Environmental, Safety and Health (ES&H) officer is assigned the responsibility for administering and overseeing division waste-management and waste-minimization activities. A designated waste-management coordinator is responsible for maintaining and inspecting storage areas, for coordinating disposal, and for record keeping for the GTA facility.

Waste-management coordinators are trained in accordance with Laboratory requirements, and must be familiar with appropriate LANL administrative requirements (AR) and the AT Division waste management SOP. Waste generators are trained in waste-disposal procedures as per Laboratory requirements. In addition, waste-management coordinators and building managers must ensure that waste generators are familiar with waste-disposal procedures for each waste-storage area.

Transport of wastes is normally done by the Laboratory's waste management group, EM-7. A special work permit or transport forms will be generated for any waste-transport activities done by GTA instead of EM-7.

The generation and description of typical waste streams and methods of storage and disposal are discussed in the following sections.

12.1 Low-level Radioactive Waste

Low-level radioactive wastes are generated by contact with, or proximity to, accelerated particle beams. The waste materials are primarily metallic beam-line components that, after exposure to the beam, have residual gamma and beta activity. Items that have been on a beam line are monitored before their removal

12.0 SUMMARY OF WASTE-MANAGEMENT PROGRAM

from the controlled area where the activation occurred. Items that may have low-level radioactivity are kept in designated controlled areas until they can be monitored. Monitoring is arranged through the HS-1 Accelerator Health Physics Section at TA-53. Suspect items are held in a staging area south of MPF-17 at TA-53. Some GTA personnel are also trained in the use of monitoring instruments and are authorized to monitor beam-line equipment for removal from the beam line.

Some suspect items may be disassembled to facilitate monitoring. After monitoring, items are either released as excess property in accordance with AR 10-6 "Excess Government Personal Property" or disposed of as low-level waste in accordance with AR 10-2 "Low-level Radioactive Solid Waste." If complete monitoring of an item is not possible, and lack of activation cannot be demonstrated by analysis or knowledge of history or process, it is treated as low-level waste.

Most low-level waste is expected to be noncompactible and will be stored in a designated locked dumpster at TA-53 before pickup by EM-7. Items too large for the dumpster will be packaged and marked in accordance with AR 10-2 and stored in a designated controlled area before pickup. The small amounts of compactible waste that are expected will be collected in designated radioactive-waste containers—cardboard boxes lined with a plastic bag—in the work area. This waste will be packaged and marked as compactible waste in accordance with AR 10-2.

Some nonhazardous-waste oils (such as those from vacuum pumps on a beam line) may be categorized as low-level waste. In this case, they are absorbed in an appropriate manner and disposed of in accordance with AR 10-2.

Approval for shipment and pickup of wastes by EM-7 is coordinated by the waste-management coordinator or the AT property administrator. Both are also responsible for proper packaging in accordance with AR 10-2.

Replacement of the high efficiency particulate air (HEPA) filters in the GTA beam-tunnel ventilation system is not expected until GTA has operated above 24 MeV for a number of years. Contamination will only consist of activated dust particles. If the filters are determined to be low-level waste, they will be packaged under the direction of ENG-6 (Facility Maintenance) and disposed of in accordance with AR 10-2.

12.2 Radioactive-liquid Waste

Water used to cool components of the GTA beam line, when operating GTA above 24 MeV, may become contaminated with tritium due to activation of the water. GTA self-contained portable chillers contaminated water, which are physically isolated from the cooling water system for nonbeam line equip-

ment. The water will not have any hazardous chemical components. Water is sampled by HS-1 and analysed by HS-8. When water disposal is necessary, the chiller is drained outside the building, and the water is transported to a disposal location as directed by EM-7.

12.3 Hazardous-chemical Waste

The bulk of hazardous-chemical waste from GTA consists of flammable solvents (e.g., acetone, ethanol, and methanol), halogenated solvents used for cleaning, and rags or wipes used in such cleaning. Other chemicals, such as methylene chloride, cutting fluids, adhesives, and paints may contribute to the waste stream in varying smaller quantities.

Hazardous wastes are disposed of in satellite storage areas (SSA) in building MPF-365. SSA containers are identified with standard Laboratory hazardous-waste labels. Waste liquids are segregated as flammable solvents, halogenated solvents, and, if necessary, into other chemicals categories, according to EM-7 guidance. A "less-than-90-day" storage area is not anticipated for GTA but, if one is required, the responsibility for inspection and compliance with Laboratory requirements will be assigned to the waste-management coordinator. The waste coordinator is responsible for inspecting SSAs and monitoring the quantity of wastes stored. When 80% of the 55-gal capacity of a SSA is reached, the waste coordinator fills out a chemical-waste disposal request and arranges for EM-7 to pickup the waste. U.S. Department of Transportation specified containers for transport are provided by the waste coordinator.

12.4 Nonhazardous Wastes

Nonhazardous wastes consist of non-PCB waste oils, chemicals not classified as hazardous wastes (and with no hazardous constituents), and ordinary trash. Most nonhazardous wastes (with the exception of oils) are disposed of as trash and are transported to the sanitary landfill. Non-suspect vacuum pump oil and dielectric oil is collected in 30-gal drums when dirty and disposal is arranged with EM-7.

Compressed-gas cylinders are returned to the Laboratory's gas processing center or the cylinder supplier for reuse. Excess government property (salvage) is sent to Johnson Controls' Redistribution and Marketing Section for resale.

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13.0 ENVIRONMENTAL MONITORING PROGRAM

This chapter describes the features of the environmental monitoring program for the Ground Test Accelerator (GTA). The Los Alamos National Laboratory has an established routine environmental monitoring program, so the Laboratory-wide program handles the monitoring for GTA. The Environmental Protection Group, EM-8, coordinates most of the activities in the environmental monitoring program. The material for this chapter was extracted from the most recent environmental surveillance report, "Environmental Surveillance at Los Alamos During 1990, LA-12271-MS." Phase 2 operations produce air activation, low-level radioactive waste, and hazardous chemical waste.

13.1 Objectives and Criteria

The Laboratory conducts routine monitoring for radiation, radioactive materials, and hazardous chemical substances at the site as well as in the surrounding region. Monitoring results are used to:

- document compliance with appropriate standards;
- identify trends;
- provide information for the public;
- contribute to general environmental knowledge; and
- assess the Laboratory's impact on the surrounding environment.

The monitoring program also supports the Laboratory's policy to protect the public, employees, and environment from harm that could be caused by Laboratory activities and to reduce environmental impacts to the greatest degree practicable.

The surveillance program complies with U.S. Department of Energy (DOE) Orders 5400.1, "General Environmental Protection Program," and 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements." The results of the program are reported in detail in a series of annual reports that are distributed to the public.

13.2 Guards Against Accumulating Radioactive and Hazardous Materials

The Laboratory is implementing a waste-minimization program to reduce radioactive and hazardous materials. The Waste Management Group, EM-7, prepared a "Waste Minimization and Pollution Prevention Awareness Program Plan," per DOE orders 5400.1, 5820.2A, and 5400.3. The plan is in final draft form. An objective of the waste-minimization program is to educate generators of radioactive and hazardous materials in ways to reduce their wastes by finding alternative materials or by ordering smaller quantities of the materials. Waste minimization for GTA is addressed in SOP AT-DO:92-01. A copy of the SOP is contained in Appendix N.

The GTA program, HS, and EM conduct training in waste handling, and hazard communication. In addition, the GTA program has appointed a waste coordinator for the facility.

13.3 Potential Exposure Pathways

The exposure pathways considered for Los Alamos are atmospheric transport of airborne radioactive emissions, hydrologic transport of treated liquid effluents, food chains, and direct exposure to external penetrating radiation. The principal pathway of exposure at Los Alamos has been via the release of radionuclides into the air, resulting in external radiation doses to the whole body. Other pathways contribute finite, but negligible, doses.

Exposure to radioactive materials or radiation in the environment is determined by direct measurements of airborne and waterborne contaminants, of contaminants in foodstuffs, and of external penetrating radiation. The impact of environmental releases of radioactivity is evaluated by estimating doses received by the public from exposure to these releases. These doses are then compared with applicable standards and with doses from background, medical, and dental radiation. DOE's public dose limit (PDL) restricts the effective dose equivalent to 100 mrem/yr for all exposure pathways. The Environmental Protection Agency (EPA) further limits the air pathway exposure by imposing a limit of 10 mrem/yr (effective dose equivalent).

13.4 Air Monitoring

The Laboratory routinely samples ambient air at several locations on the site, along the Laboratory perimeter, and in distant areas that serve as regional background stations. The air-sampling network for radioactivity consists of 28 continuously operating stations. Thirteen perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary, and 12 on-site stations are within the Laboratory boundary. The regional monitoring stations, located 28 to 44 km (18 to 28 mi) from the Laboratory in Espanola, Pojoaque, and Santa Fe, are reference points for determining regional background levels of atmospheric radioactivity. Figure 13-1 shows the air-sampling stations.

13.4.1 TA-53 Network

An on-site monitoring station, on the site boundary for TA-53, is at the location of maximum off-site impact from GTA and the Clinton P. Anderson Meson Physics Facility (LAMPF) emissions. GTA and LAMPF emissions are monitored mainly with thermoluminescent dosimetry (TLD) stations. Other emissions will be monitored with air samples. (See Section 13.9 for a detailed description of the TLD network.)

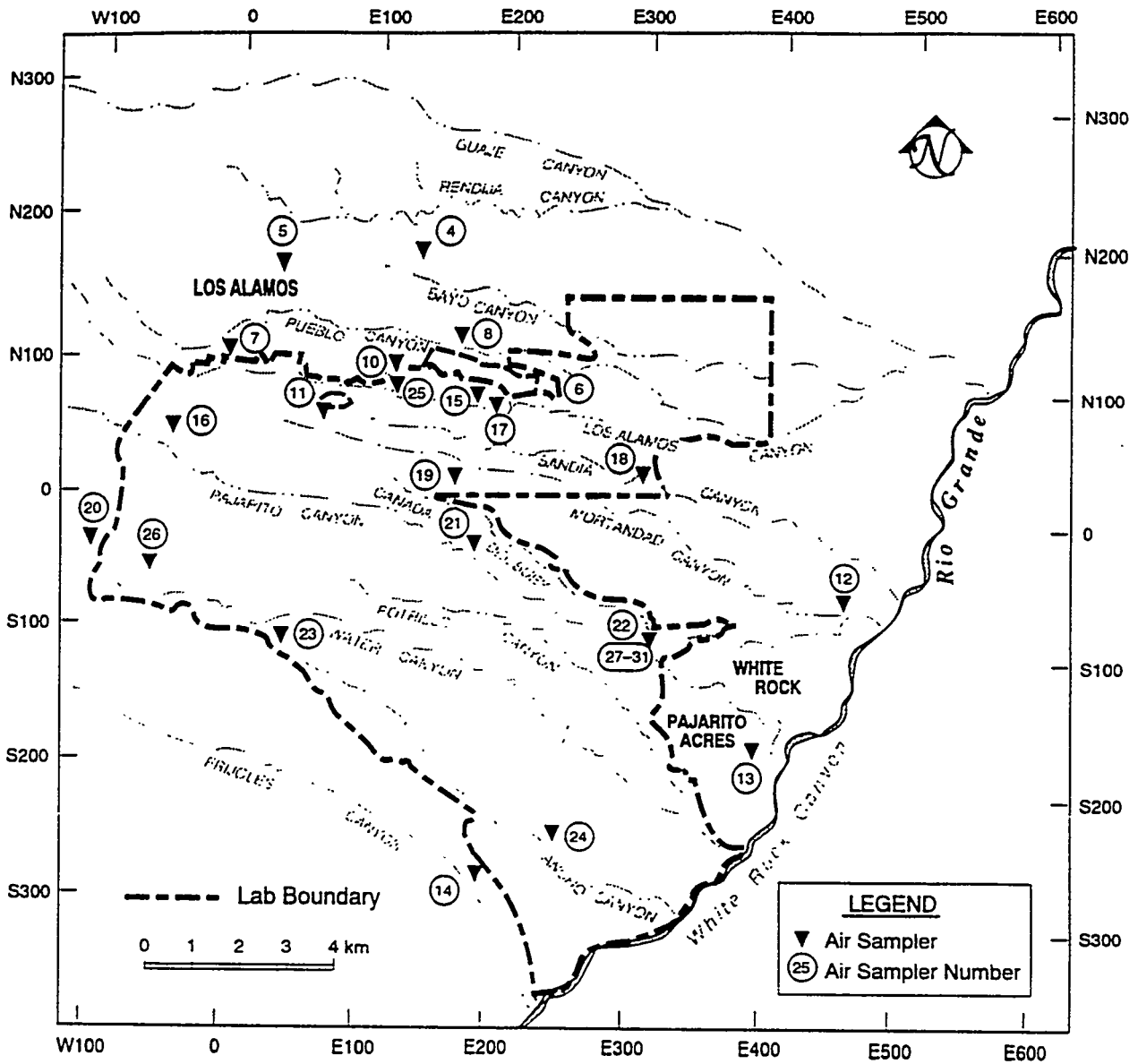


Fig. 13-1. Air-sampling locations on or near the Laboratory site.

13.4.2 Analyses

Samples are collected monthly at the 28 continuously operating stations. Air pumps with flow rates of about 3 ℓ /s are used. Airborne aerosols are collected on 79-mm-diameter polystyrene filters. On a quarterly basis, the monthly filters for each station are collected and cut in half. The filter halves are combined to produce two quarterly composite samples for each station. The first group is analyzed for ^{238}Pu , $^{239,240}\text{Pu}$, and ^{241}Am (on selected filters). The second group of filter halves is saved for uranium analysis. Silica gel cartridges from the 28 air sampling stations are analyzed monthly for tritiated water.

13.4.3 Radioactive Airborne Emissions

During 1990 radioactive-airborne emissions were monitored from 88 discharge locations within the Laboratory. The Laboratory routinely samples air for tritium, uranium, plutonium, americium, and gross beta activity. Quantities of airborne radioactivity released depend on the nature of on-going research activities and vary significantly from year to year as shown in Figs. 13-2 to 13-4. Measurements of radioactivity are compared with concentration guides based upon DOE's PDL. These guides are concentrations of radioactivity in air breathed continuously throughout the year, which result in effective doses equal to DOE's PDL of 100 mrem/yr for off-site areas (known as Derived Concentration Guides for Uncontrolled Areas) and to the occupational radiation protection standards (RPS) for on-site areas (known as Concentration Guides for Controlled Areas).

Only the on-site tritium air concentrations showed any measurable impact resulting from Laboratory operations. Annual average concentration of tritium remained less than 0.1% of DOE's guides at all stations and posed no environmental or health problems in 1990. Annual average concentrations of longer-lived radionuclides in air were also less than 0.1% of the guides during 1990.

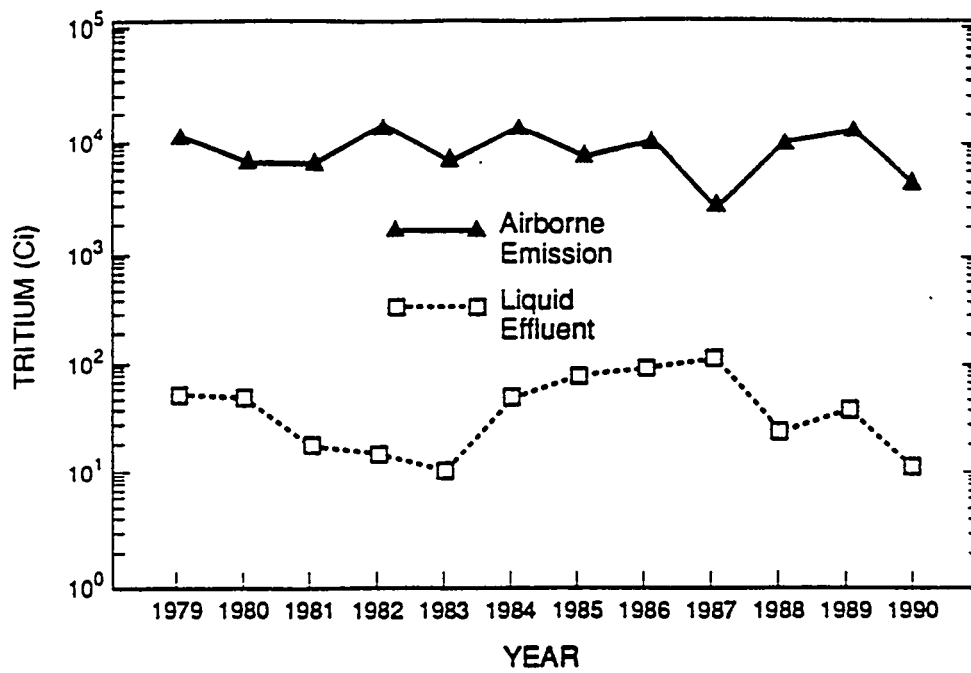


Fig. 13-2. Summary of tritium releases.

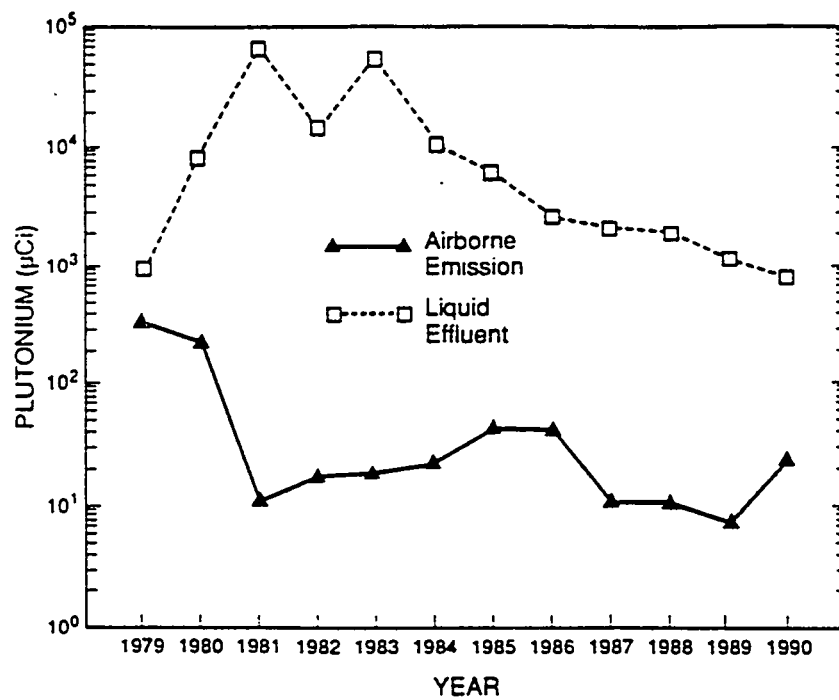


Fig. 13-3. Summary of plutonium releases.

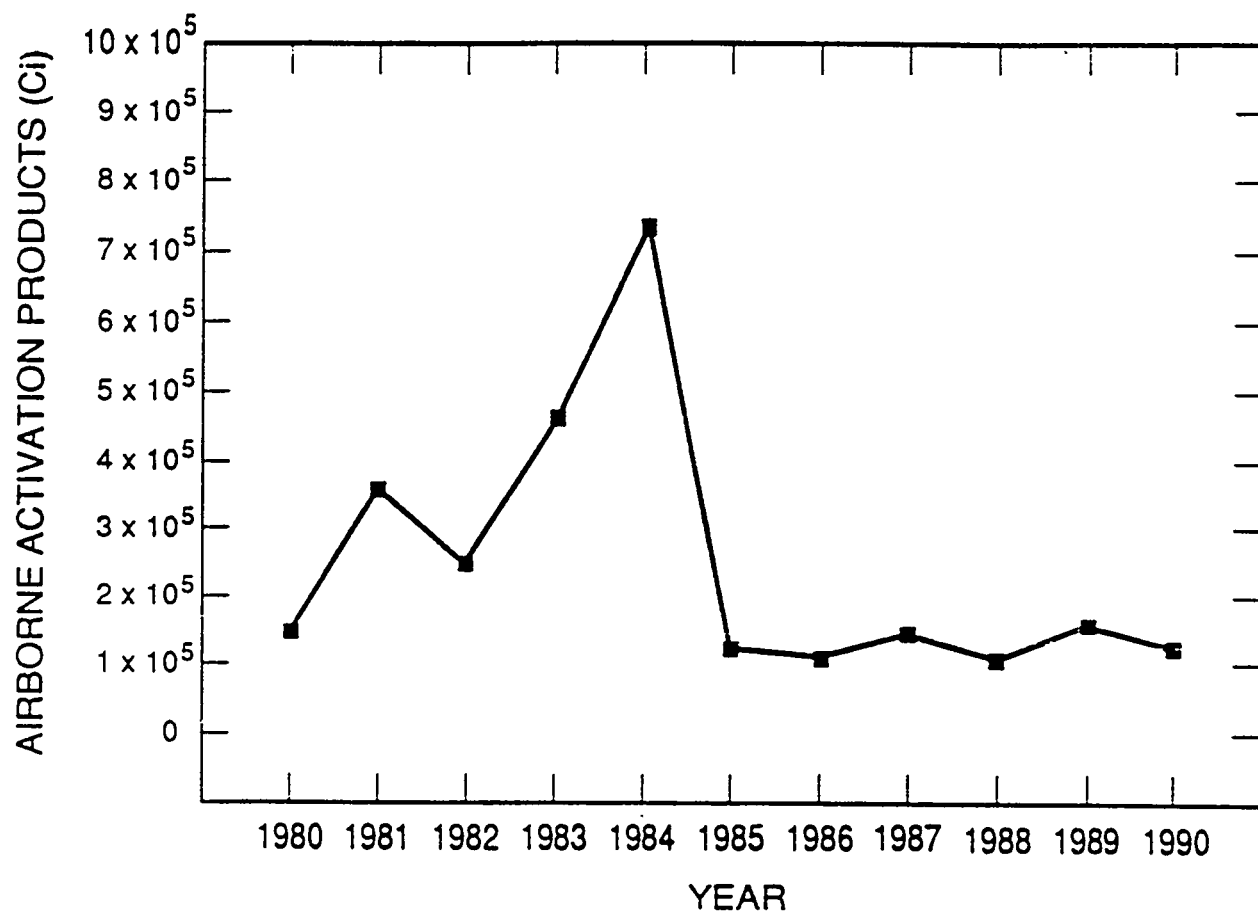


Fig. 13-4. Airborne activation product emissions.

13.4.4 Nonradioactive Airborne Chemicals

Each type of emission is documented in "Environmental Surveillance at Los Alamos During 1990." The GTA project will release no significant nonradioactive airborne chemicals during its operation except motor vehicle emissions.

13.4.4.1 Acid Precipitation - The Laboratory operates a wet deposition monitoring station at Bandelier National Monument. This station is part of the National Atmospheric Deposition Program (NADP) network. The NADP is an independently operated network of monitoring stations located throughout the United States, which are designed to measure regional deposition rates. The samples are collected following standardized procedures and chemically characterized by the NADP Central Analytical Laboratory.

13.4.4.2 Ambient Air Monitoring - Because the Los Alamos area is remote from large metropolitan areas and major sources of air pollution, extensive monitoring for non-radioactive air pollutants has not been conducted. In 1990, the Laboratory operated an ambient air monitoring station south of TA-49 and adjacent to Bandelier National Monument. Data have been collected for ozone, PM₁₀, nitrogen dioxide, sulfur dioxide, and beryllium.

13.4.4.3 Toxic Air Pollutant Sampling Program - During 1990, the Laboratory designed a short-term, intensive toxic air pollutant sampling program. This program was designed to address the complex terrain and meteorology of the area, the low levels of airborne chemical emissions from the Laboratory operations, and potential interferences from Los Alamos community emissions. Three classes of target chemicals were addressed in the plan: inorganic acids, metals, and organic vapors. These chemical classes are representative of the types of emissions from the Laboratory. Five sampling locations have been identified as sites for air samplers. Four were chosen to be downwind of major Laboratory emission sources; one is upwind of all Laboratory areas. This study was conducted early in 1991. It will provide a detailed and comprehensive evaluation of the impact of the Laboratory's chemical emissions on ambient air quality. These data will be used to guide any future air quality studies.

13.5 Meteorological Modeling, Dispersion, and Annual Wind Rose

A detailed report of the climatology and meteorology of the Los Alamos area is in Section 3.5.

13.0 ENVIRONMENTAL MONITORING PROGRAM

13.5.1 TA-53 Network

Two meteorological towers, one on the north side of LAMPF and one across the Los Alamos Canyon, are operated to provide site-specific meteorological data for TA-53. Section 3.4 includes a wind rose for the GTA site, TA-53.

13.6 Water Monitoring

Surface and ground waters from regional, perimeter, and on-site stations are monitored to provide routine surveillance of Laboratory operations. Concentrations of radionuclides in water samples are compared with guides derived from DOE's RPS. Routine analyses of water samples have been carried out for many chemicals since about 1949.

Regional surface-water samples are collected within 75 km (47 mi) of the Laboratory from six stations on the Rio Grande, Rio Chama, and Jemez River. Figure 13-5 shows these stations. The six sampling stations are at U.S. Geological Survey Gauging Stations. These waters provided baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary.

Perimeter stations within 4 km (2.5 mi) of Los Alamos include surface-water stations at Los Alamos Reservoir, Guaje Canyon, Frijoles Canyon, and three springs: La Mesita, Indian, and Sacred. Other perimeter stations are in White Rock Canyon along the Rio Grande just east of the Laboratory.

On-site sampling stations are those not in effluent-release areas and those in areas that are receiving, or that have received, treated industrial or sanitary effluents, such as on-site wells and canyons downstream from technical areas. Figure 13-6 shows the perimeter and on-site sampling stations for the Laboratory.

13.6.1 TA-53

The GTA project has access to a sanitary sewage lagoon system that serves LAMPF. In the past, treated liquid effluents containing low levels of radioactivity have been released from this lagoon system. The lagoon system has since been modified to separate sanitary sewage from radioactive waste water and to eliminate discharge of radioactive waste water to the environment. Evaporation of tritiated water to the environment, however, will still occur. The lagoon system surveillance is part of the on-site sampling of the Laboratory's monitoring program. If a spill occurs in the lagoon system, EM-7 and EM-8 will coordinate special monitoring activities.

13.6.2 Analyses

Water sampling and analysis is conducted in compliance with the Safe Drinking Water Act. Samples are taken monthly at TA-53 for coliform bacteria analysis. Chemical samples are taken

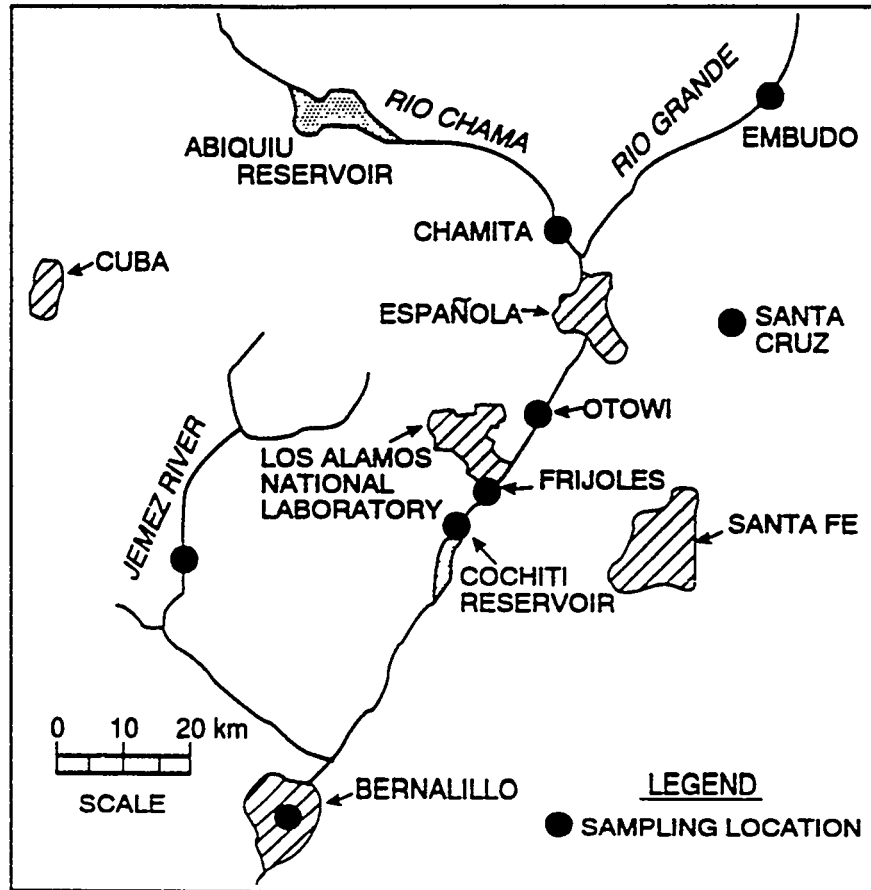


Fig. 13-5. Regional surface-water, sediment, and soil sampling locations.

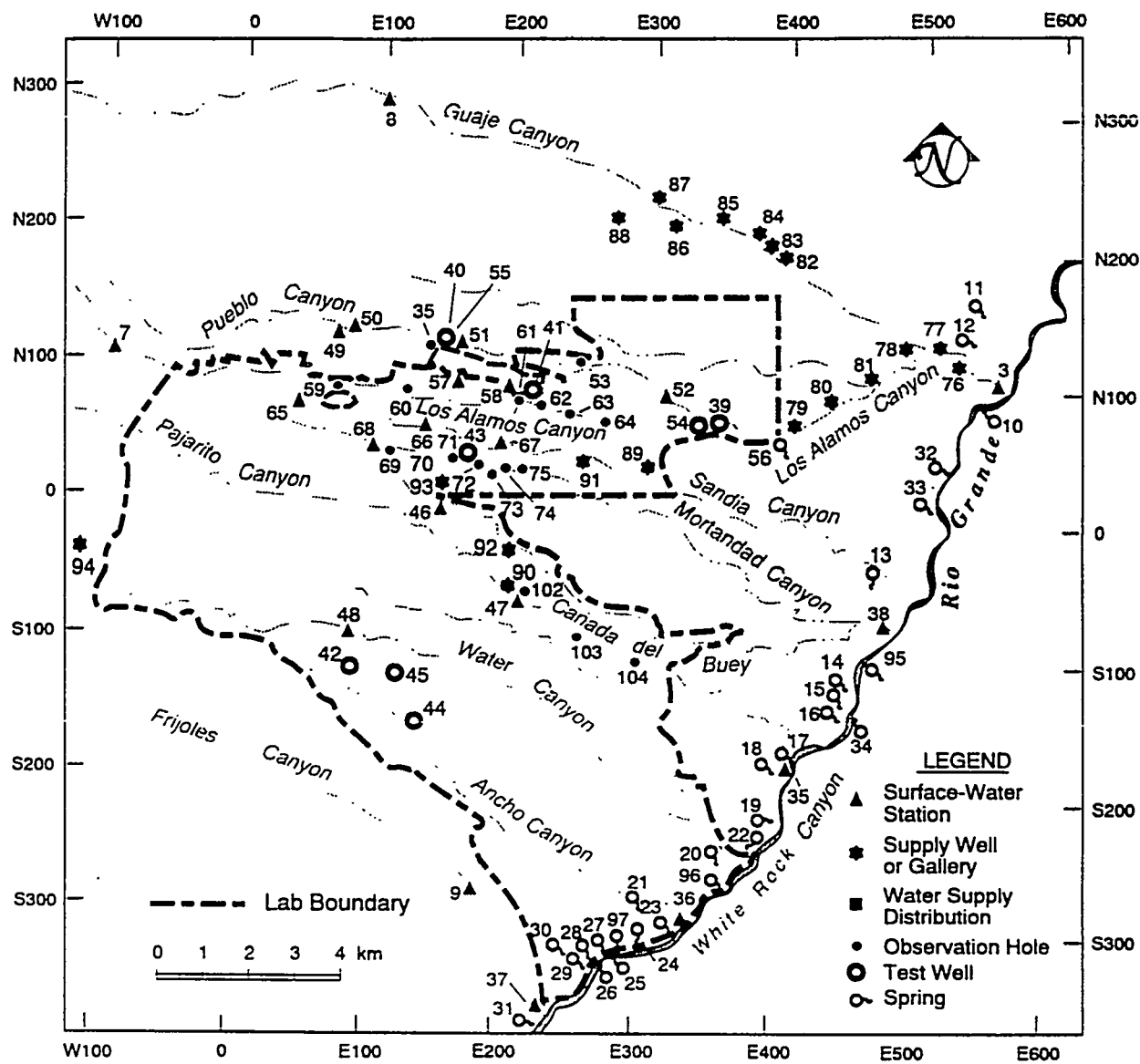


Fig. 13-6. Surface and ground-water sampling locations on, and near, the Laboratory site.

at the well field once a year. The samples are analyzed radiochemically for ^3H , ^{137}Cs , total U, ^{238}Pu , and $^{239,240}\text{Pu}$, and for gross alpha, beta, and gamma activities. The chemical analyses include analyzing SiO_2 , Ca, Mg, K, Na, CO_3 , HCO_3 , P, SO_4 , Cl, F, NO_3^- , N, and total dissolved solids.

In 1990, only the surface waters and shallow groundwaters in on-site liquid-effluent release areas contained radioactivity in concentrations above natural terrestrial and worldwide fallout levels. These waters are not a source of industrial, agricultural, or municipal-water supplies. The quality of water from regional, perimeter, and on-site areas that have received no direct discharge showed no significant effects from Laboratory releases. Samples from test wells and water-supply wells continued to show no radioactive or chemical contamination in the deep aquifer that occurs 180 to 360 m (600 to 1,200 ft) beneath the Pajarito Plateau.

Current waste monitoring at TA-53 includes cooling tower blow down from outfall 03A113. Sanitary wastewaters discharged from the lagoons through outfall 09S are monitored and reported to the EPA in accordance with the Laboratory's NPDES permit No. NM0028355.

Cooling tower blow down is monitored for free available chlorine, total phosphorus, total suspended solids (TSS), and pH. Sanitary effluent is monitored for biochemical oxygen demand, TSS, and pH.

13.7 Soil and Sediment Sampling

Measurements of radioactivity in soil and sediment samples provide data on less direct pathways of exposure. The regional stations for soil and sediment sampling are the same as those for regional water sampling (Fig. 13-5). Six perimeter soil stations are within 4 km (2.5 mi) of the Laboratory (shown in Fig. 13-7), and 10 sediment stations are near the Laboratory boundary and at the confluence of eight major canyons with the Rio Grande in White Rock Canyon (shown in Fig. 13-8). On-site soil samples are collected from 10 stations within the Laboratory boundaries, and on-site sediments are collected from 24 stations within areas that have received treated liquid effluent.

13.7.1 Analyses

The Laboratory uses two procedures for soil sampling: surface composite sampling and surface and subsurface sampling at one sampling station. Soil samples may be analyzed for gross alpha and beta activities, ^{90}Sr , total U, ^{137}Cs , ^{238}Pu , and $^{239,240}\text{Pu}$. Moisture distilled from soil samples may be analyzed for ^3H .

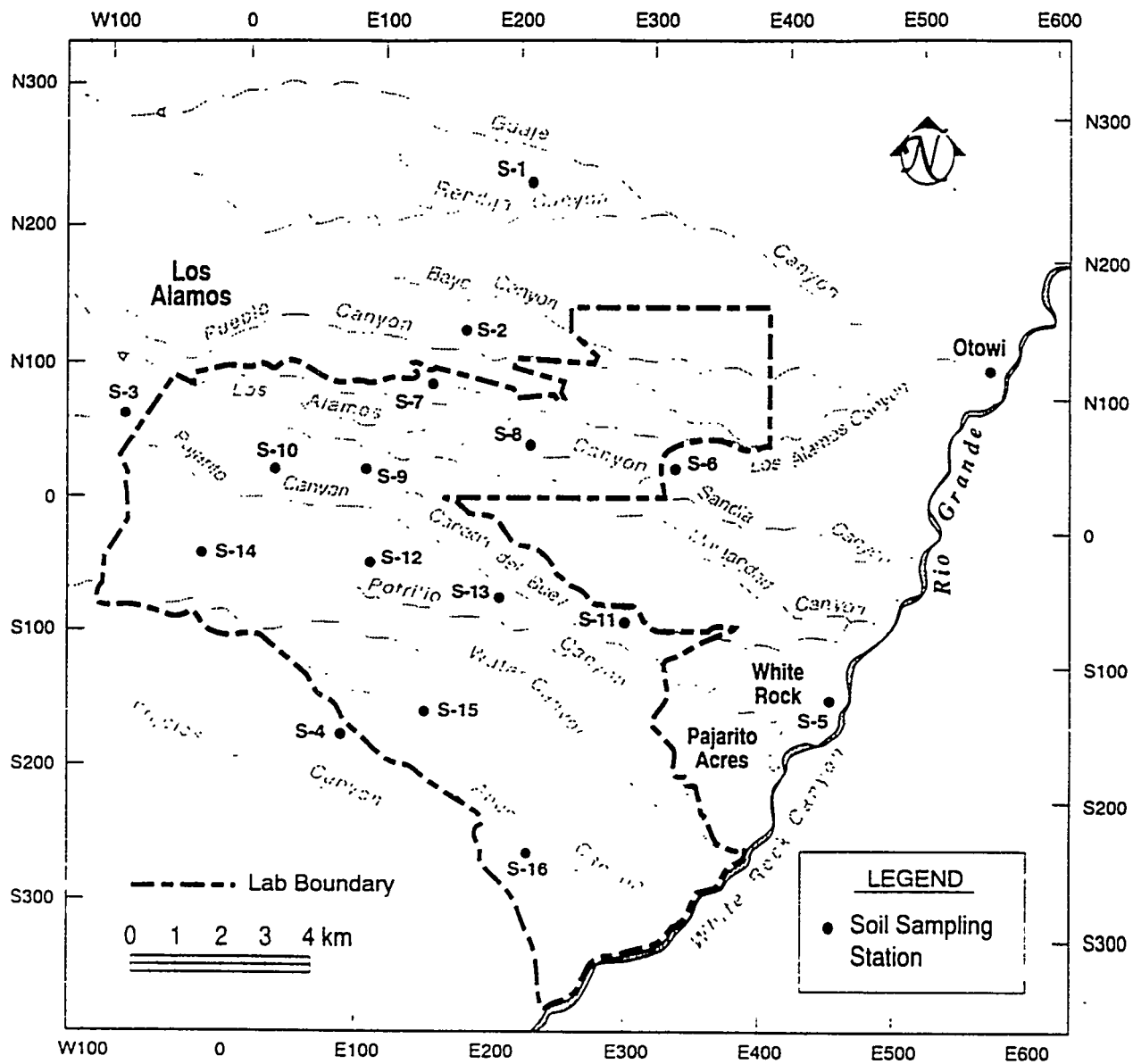


Fig. 13-7. Soil sampling on, and near, the Laboratory site.

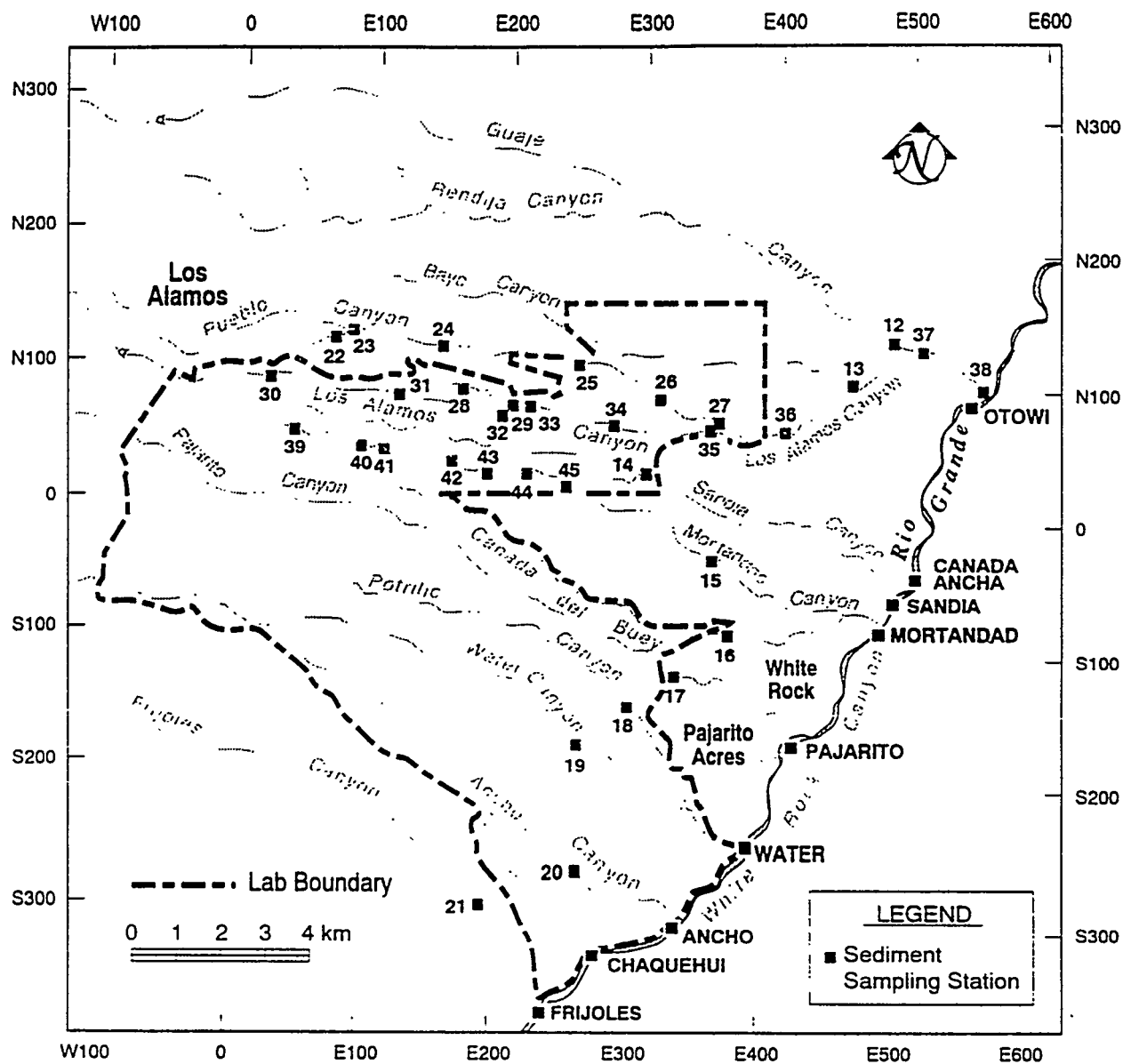


Fig. 13-8. Sediment sampling locations on, and near, the Laboratory site.

13.8 Foodstuffs Monitoring

Produce, bee, fish, and honey samples are routinely collected and monitored for potential radioactivity from Laboratory operations. Produce, bees, and honey are collected in the Los Alamos town-site, White Rock, San Ildefonso Pueblo, and Espanola locations. Fish samples are collected at Abiquiu and Cochiti reservoirs. Figure 13-9 shows the locations for produce and fish sampling, and Fig. 13-10 shows the sampling locations for the beehives.

13.8.1 Analyses

Local and regional produce is sampled annually. Produce and soil samples are collected from local gardens each fall. Water distilled from samples are analyzed for ^3H . Produce ash and dry soil are analyzed for ^{90}Sr , total U, ^{137}Cs , ^{238}Pu , and $^{239,240}\text{Pu}$.

Fish, sediment, and water samples are taken annually from reservoirs upstream and downstream from the Laboratory. Sediment and water samples are submitted directly for radiochemical analysis. Fish ash is analyzed for ^{90}Sr , total U, ^{137}Cs , ^{238}Pu , and $^{239,240}\text{Pu}$.

For 1990 most fruit, vegetable, fish, bee, and honey samples from regional and perimeter locations showed no radioactivity distinguishable from that attributed to natural sources or worldwide fallout. Some produce, bee, and honey samples from on-site locations had elevated tritium concentrations at levels less than 1% of DOE's guide for tritium in water (there are no concentration guides for produce).

13.9 Monitoring External Penetrating Radiation

The Laboratory monitors levels of external penetrating radiation, including gamma rays and x rays and charged particle contributions from cosmic, terrestrial, and man-made sources. TLDs measure the levels of penetrating radiation. The TLD network for the Los Alamos area consists of three independent networks:

- the Laboratory and regional areas (the environmental network);
- the Laboratory boundary north of LAMPF; and
- low-level radioactive waste-management areas.

The environmental network consists of 40 stations divided into three groups: regional, off-site, and on-site. The regional group has four locations, which are 28 to 44 km (17 to 27 mi) from the Laboratory boundary in the neighboring communities of Espanola, Pojoaque, and Santa Fe, and at the Fenton Hill site 30 km (19 mi) west of Los Alamos. The off-site perimeter group consists of 12 stations within 4 km (2.5 mi) of

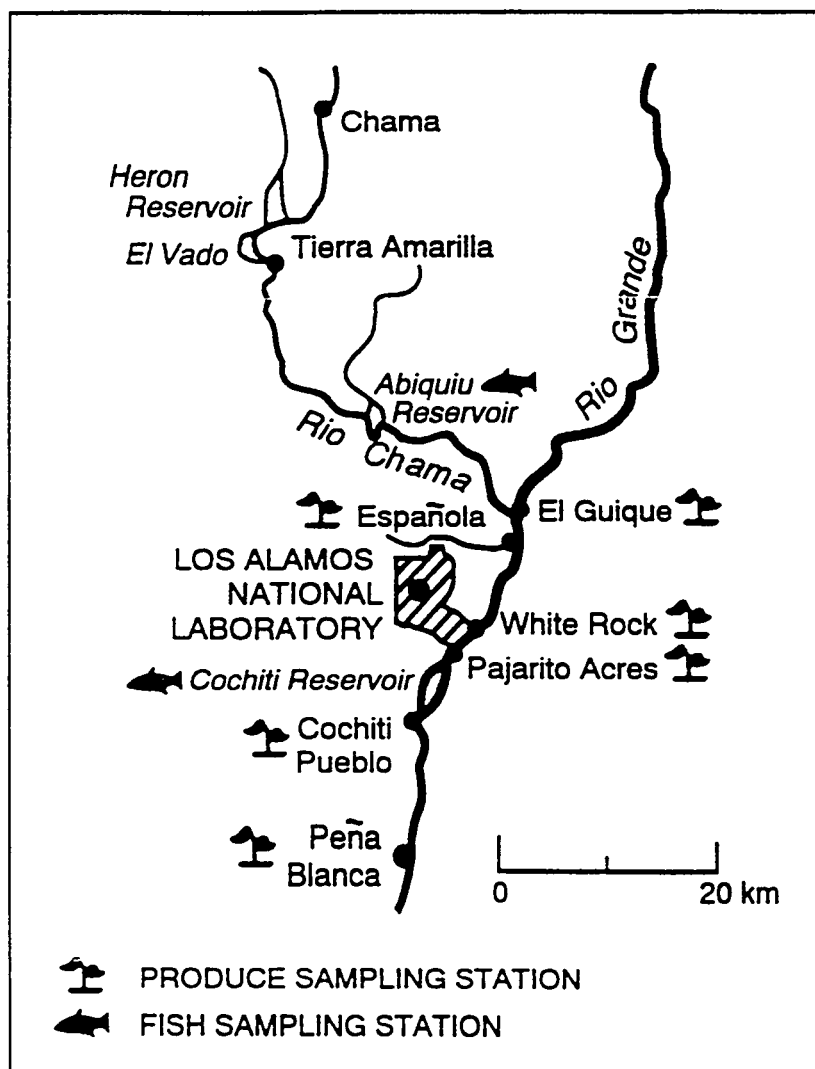


Fig. 13-9. Fish and produce sampling locations.

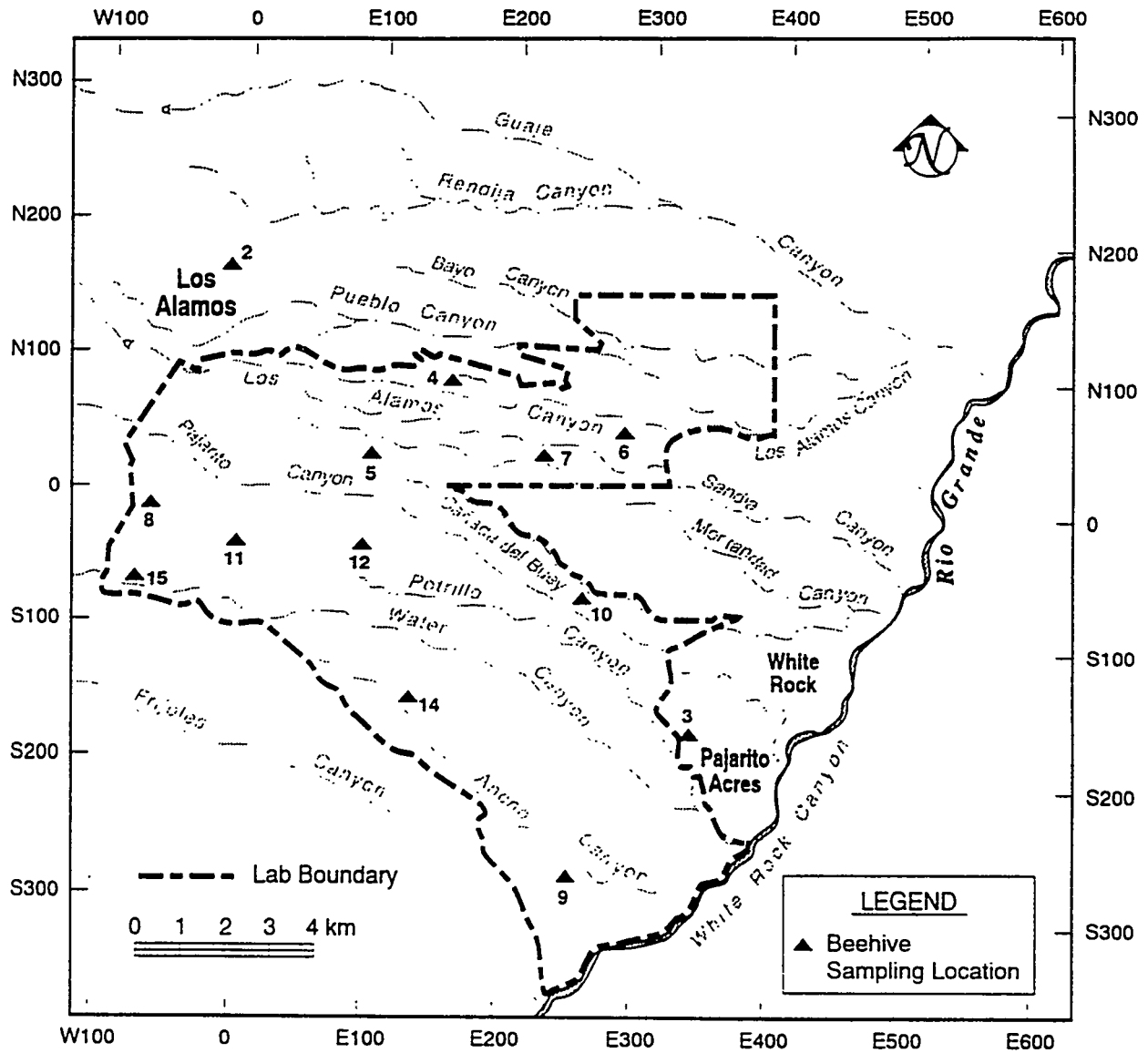


Fig. 13-10. Locations of beehives.

the Laboratory boundary. Within the boundary, 24 locations comprise the on-site group. Figure 13-11 shows the TLD locations on, or near, the Laboratory site.

13.9.1 TA-53 Network

The TLD network monitors external radiation from airborne activation products (gases, particles, and vapors) released by LAMPF and GTA at TA-53. The prevailing winds are from the south and southwest. Twelve TLD sites are downwind of GTA at the Laboratory boundary north of LAMPF along 800 m (0.5 mi) of the canyon rim. Twelve background TLD sites are about 9 km (5.5 mi) from the facility along a canyon rim near the southern boundary of the Laboratory. This background location is not significantly influenced by any Laboratory external radiation sources.

13.9.2 Analyses

The TLDs used at the Laboratory are lithium fluoride (LiF) chips, 6.4 mm square by 0.9 mm thick. After the TLDs have been exposed to radiation, they emit light when heated. The amount of light emitted is proportional to the amount of radiation the TLD received. The TLDs used in the Laboratory's environmental-monitoring program are insensitive to neutrons, so the contribution of cosmic neutrons to natural background is not measured. At the end of each field cycle, whether it is the calendar quarter or the LAMPF operation cycle, the dose at each network location is estimated. At the end of the calendar year, individual field cycle doses are summed for each location.

For 1990, the TLD network monitoring radiation from airborne activation products released by the LAMPF measured about 6 ± 3 mrem/yr (excluding background radiation from cosmic and terrestrial sources).

13.10 Off-site Dose Assessment Methodology

Each year the Laboratory evaluates radiation doses for three principal exposure pathways: inhalation, ingestion, and external exposure (including exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation). Estimates are made of:

- maximum boundary doses for organ and effective dose equivalents to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs (the estimate assumes that the individual is outdoors at the Laboratory boundary continuously 24 hr a day, 365 days/yr);

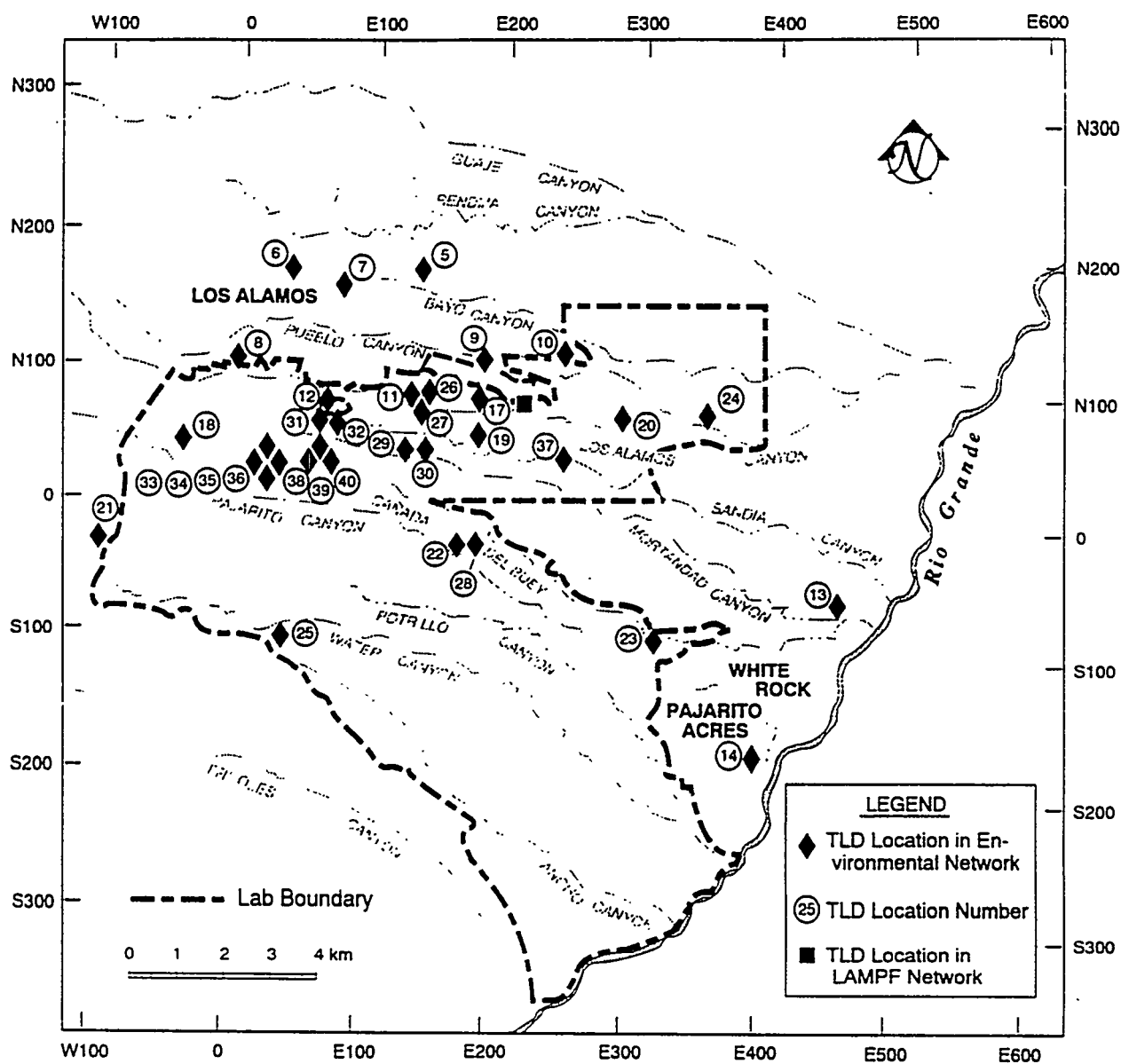


Fig. 13-11. TLD locations on, and near, the Laboratory site.

- maximum doses for individual organ and effective dose equivalents to an individual actually present at or outside the Laboratory boundary where the highest dose rate occurs taking into account occupancy (the fraction of time that a person actually occupies that location), shielding by buildings, and self-shielding;
- average organ or body tissues and effective dose equivalents to nearby residents; and
- collective effective dose equivalent for the population living within an 80-km (50-mi) radius of the Laboratory.

Results of environmental measurements are used as much as possible in assessing doses to individual members of the public. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE, 1981b; NRC).

If these environmental measurements cannot detect the impact of Laboratory operations, individual and population doses attributable to Laboratory activities are estimated by modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table XIII-1. These dose conversion factors are taken from the DOE and are based on factors in Publication 30 of the International Commission on Radiological Protection. The dose conversion factors calculate the 50-yr dose commitment for internal exposure. The 50-yr dose commitment is the total dose received by an organ during the 50-yr period following the intake of a radionuclide that is attributable to that intake.

The dose conversion factors for inhalation assume a 1- μ m activity for the median aerodynamic diameter, as well as the lung solubility category that will maximize the effective dose equivalent (for comparing with DOE's 100 mrem/yr PDL) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the effective dose or organ dose if more than one gastrointestinal tract uptake is given (for comparing with DOE's 100 mrem/yr PDL for all pathways).

External doses are calculated using the dose-rate conversion factors published by the Nuclear Regulatory Commission, a DOE predecessor. These factors, shown in Table XIII-2, give the photon dose rate in mrem/yr per unit radionuclide air concentration in μ Ci/mL. The factors are used in calculating the effective dose equivalent from external radiation for the population in the 80-km (50-mi) area.

Table XIII-1 Dose Conversion Factors (DCF) for Calculating Internal Doses

Radionuclide	Inhalation (rem/ μ Cl Intake)						
	Target Organ						
	Soft Tissue	Lung	Bone Surface	Red Marrow	Liver	Gonads	Effective Dose
^3H	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^{234}U		1.1×10^3					1.3×10^2
^{235}U		1.0×10^3					1.2×10^2
^{238}U		1.0×10^3					1.2×10^2
^{238}Pu			8.1×10^3	6.7×10^2	1.8×10^3	1.0×10^2	4.6×10^2
$^{239,240}\text{Pu}$			9.3×10^3	7.4×10^2	2.0×10^3	1.2×10^2	5.1×10^2
^{241}Am			9.3×10^3	7.4×10^2	2.0×10^3	1.2×10^2	5.2×10^2

Radionuclide	Ingestion (rem/ μ Cl Intake)						
	Target Organ						
	Bone Surface	Red Marrow	Liver	Gonads	Kidney	Lungs	Thyroid
^3H	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^7Be		4.4×10^{-5}		2.1×10^{-4}			
^{90}Sr	1.6	7.0×10^{-1}					
^{137}Cs	4.8×10^{-2}	4.8×10^{-2}		5.2×10^{-2}		4.8×10^{-2}	4.8×10^{-2}
^{234}U	4.1	2.7×10^{-1}			1.7		
^{235}U	3.7	2.5×10^{-1}			1.6		
^{238}U	3.7	2.5×10^{-1}			1.5		
^{238}Pu	67	5.6	15	8.5×10^{-1}			
$^{239,240}\text{Pu}$	78	5.9	16	9.6×10^{-1}			
^{241}Am	81	6.3	17	1.0			

Table XIII-1 Dose Conversion Factors (DCF) for Calculating Internal Doses (concluded)

Ingestion (rem/ μ Cl Intake)						
Radionuclide	Target Organ					Effective Dose
	Soft Tissue	Lower Large Intestine Wall	Small Intestine Wall	Upper Large Intestine Wall	Remainder	
^3H	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}	6.3×10^{-5}
^7Be		4.4×10^{-4}	2.0×10^{-4}	2.7×10^{-4}		1.1×10^{-4}
^{90}Sr						1.3×10^{-1}
^{137}Cs		5.2×10^{-2}	5.2×10^{-2}	5.2×10^{-2}	5.6×10^{-2}	5.0×10^{-2}
^{234}U						2.6×10^{-1}
^{235}U		2.0×10^{-1}				2.5×10^{-1}
^{238}U						2.3×10^{-1}
^{238}Pu						3.8
$^{239,240}\text{Pu}$						4.3
^{241}Am						4.5

Table XIII-2 Dose Conversion Factors (DCF) for Calculating External Doses
([mrem/yr]/[μCi/m²])

Radionuclide ^a	Breast	Lung	Red Marrow	Bone Surface	Testes	Thyroid	Ovaries	Effective Dose
¹⁰ C								
¹¹ C	5,540	4,450	4,560	5,210	5,980	5,530	3,980	5,110
¹³ N	5,540	4,450	4,560	5,210	5,980	5,530	3,980	5,110
¹⁶ N	31,500	25,300	27,400	26,900	33,800	30,600	22,200	29,300
¹⁴ O								
¹⁵ O	5,550	4,460	4,560	5,210	5,980	5,540	3,990	5,120
⁴¹ Ar	6,950	5,890	5,940	6,290	7,740	7,340	5,290	6,630

^a Dose conversion factors for ¹¹C, ¹³N, ¹⁶N, ¹⁵O, and ⁴¹Ar were taken from DOE, 1988. Dose conversion factors for ¹⁰C and ¹⁴O were not given in DOE, 1988.

The Laboratory also calculates doses using computer programs for showing compliance with 40 CFR Part 61 Subpart H, the EPA Clean Air Act regulation governing radioactive emissions from DOE facilities.

Detailed information on methods for calculating the inhalation, ingestion, external radiation, and population doses is included in "Environmental Surveillance at Los Alamos During 1990."

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14.0 FACILITY EXPANSION, DECONTAMINATION, AND DECOMMISSIONING

This chapter describes the facility expansion, decontamination, and decommissioning of the Ground Test Accelerator (GTA). The GTA program will not have an elaborate decontamination and decommissioning program. Laboratory policy from the Los Alamos National Laboratory (LANL) Environment, Safety, and Health Manual AR 10 series, "Waste Management," governs hazardous-waste management for all phases.

14.1 Facility Expansion

The design and construction of building MPF-365 provides sufficient floor space to house any neutral particle beam (NPB) accelerator system that the GTA program presently envisions. Expansion plans for the building, therefore, are not planned in the near future. The present facility is designed to house components that produce an NPB beam with energies ranging from 3 MeV to 100 MeV. Sufficient room has been provided to use the facility as a test bed for advanced-component technology. Radiation shielding has been included for 100-MeV operations at currently anticipated beam currents.

14.2 Decontamination

Accelerator installations have existed for more than 40 yr. Accelerators require frequent maintenance and operational changes, so materials for the construction of accelerators and beam stops are chosen to minimize hazards from induced radiation. (GTA design guidelines are contained in American National Standards Institute [ANSI] N43.1.) Whenever possible GTA has selected materials, according to the ANSI standard, to minimize the induced-radiation hazards during maintenance and operations. Radiation levels will be maintained at as low as reasonably achievable (ALARA) levels. In experiments 2D and 3, the accelerator will produce sufficient amounts of short-lived activation to be of concern. However, sufficient cooling time will be allotted to bring induced radiation to acceptable levels. Activated material will be disposed of according to Laboratory regulations and monitored by HS-1. Special work permits will govern the handling of all activated materials.

14.3 Maintenance and Operations

The GTA project maintains up-to-date as-built drawings. Such drawings help minimize potential exposure to radiation hazards when maintenance is performed. The GTA quality assurance (QA) plan, and the implementation of the plan, cover drawings and their control. Any radioactive waste generated is handled and disposed of according to Laboratory administrative requirements with the support of EM-7.

14.4 Dismantling and Decommissioning

At the present time, no plans exist for dismantling and decommissioning GTA. No chemical contamination of the facility should occur as a result of normal operations. The present design and choice of materials also minimizes the amount of activated materials in the facility.

The only radioactive contamination of the CCS is from the tritium generated by neutrons reacting with helium coolant in the accelerator. The total tritium generation for 1 yr of 24-MeV operation 4-hr/day, 4 day/wk at 2% duty factor was calculated to be 2 μ Ci. Current estimates of operating time and duty factory at 24-MeV would result in less than 5% of this amount. Some tritium will plate out on the inside surfaces of the piping; this amount will be negligible.

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15.0 SUMMARY OF EMERGENCY RESPONSE PLAN

The Ground Test Accelerator (GTA) facility is located within Accelerator Technology (AT) Division facilities at Technical Area (TA) 53 of the Los Alamos National Laboratory (LANL). AT Division facilities are located in both secure and open areas. GTA is a classified program, so building MPF-365, which houses the GTA, is in the secure area.

GTA operates in accordance with the Laboratory's Emergency Response Plan, which describes the emergency-response organization, notification, consequence assessment, recovery, training, and exercises. Building emergency plans describe hazards, evacuation procedures, protection systems, and responsible personnel. Appendix O contains the emergency plans for building MPF-365 and the cryogenic-cooling system (CCS).

15.1 Emergency-response Organization

The Laboratory's emergency management office oversees the implementation of the full range of activities necessary for the preparedness for, response to, mitigation of, and recovery from emergency incidents at the Laboratory. The emergency management office leader is responsible for maintaining the Emergency Operations Center in a ready condition.

Organizational response to emergencies at the Laboratory begins with response by the building personnel, building manager, or alarm activation. The initial phase of an emergency will involve a small number of individuals at the affected area and notification of the on duty emergency manager.

When responding to Laboratory emergencies, the Emergency Management Office provides communications between response units and emergency organizations. The Emergency Management Office provides emergency health and safety support for Laboratory-related off-site emergencies. The Emergency Management Office coordinates with off-site agencies to ensure an integrated response in an emergency.

The emergency manager, who becomes the incident commander, is capable of and has authority and requirement to:

- determine that an emergency exists;
- provide initial classification and assessment;
- promptly notify other groups and individuals in the building and area;
- immediately perform actions necessary to protect Laboratory personnel and the public, including notification of state, tribal, and local authorities should the situation warrant; and
- notify the U.S. Department of Energy (DOE) Los Alamos Area Office (LAAO).

15.0 SUMMARY OF EMERGENCY RESPONSE PLAN

When follow-on phases of an emergency require additional attention, the incident commander can augment the emergency units to meet the requirements of an increased response.

Emergency managers from the Emergency Management Office provide a central point of contact on a 24-hr basis for Laboratory or Laboratory-related emergencies, reportable incidents, and external requests for emergency Laboratory assistance. In the event of an emergency or incident, the emergency manager at the scene becomes the incident commander with full responsibility for all actions at the scene. Other emergency managers respond to the Emergency Operations Center and assume facilitator positions and responsibilities.

Key AT Division personnel, such as building managers and supervisors, are available for consultation and advice to Emergency Management. Liaison with the Laboratory Director's Office and any advisory and support groups is the responsibility of Emergency Management.

15.2 Evacuation

Any employee may initiate an evacuation. Employees evacuate to designated assembly points south and, for the CCS site, east of MPF-365.

Reentry will be determined by the incident commander if an Incident Control Group has been used. The building manager may direct reentry if there is no Incident Control Group. Guidance will be obtained from HS and/or ENG as appropriate.

15.3 Training

All new employees receive instructions on emergency procedures from their groups within 30 days of starting work. Individuals designated to sweep building areas during an evacuation are trained in sweep procedures. Emergency Management personnel and the Los Alamos Fire Department are trained in CCS hazards.

15.4 Exercises

The division holds annual evacuation drills as required by the Laboratory Emergency Response Plan. Full-scale emergency exercises for the CCS site are conducted periodically in coordination with Emergency Management. Their frequency is determined by GTA management based on experimental schedules and training needs.

15.5 CCS Emergency Preparedness Plan

Emergency procedures for the CCS site are included in the MPF-365 facility emergency plan, which is part of the AT Division Emergency Preparedness Plan. The MPF-365 emergency plan is included as Appendix O.

The CCS site is provided with hydrogen sensors in addition to the building fire-alarm system. Both will alarm on the CCS site and in the control room for Phase 2 operations.

The CCS site is usually not occupied. Personnel, however, will be present when a truck is brought into the area to fill the hydrogen storage dewar and, occasionally, during checkout or troubleshooting in the cryo-equipment room. The site is covered by TV camera surveillance, which will be monitored in the control room. Personnel also work periodically in the MPF-365 north mechanical room to the east of the site within the fenced area.

One possible location for an accident is in the area of the hydrogen run dewar and heat exchanger. There are two evacuation routes from this area, one leading down a catwalk into the west end of MPF-365, and the other leading to the eastern extremity of the fenced area, approximately 300 feet from the potential accident site. Warning signs will be posted at the exit to the north mechanical room that will direct personnel to evacuate to the east.

Another possible accident location and time is the hydrogen storage dewar during filling. The gate to La Mesita Road will be kept open during filling operations and thus provide an exit route. An emergency shut-off switch is near the gate, so that a person may shut-off the flow of liquid hydrogen when leaving in an emergency.

Evacuation routes from the CCS site are shown in Fig. 15-1.

→ EVACUATION ROUTES
 X ASSEMBLY AREAS

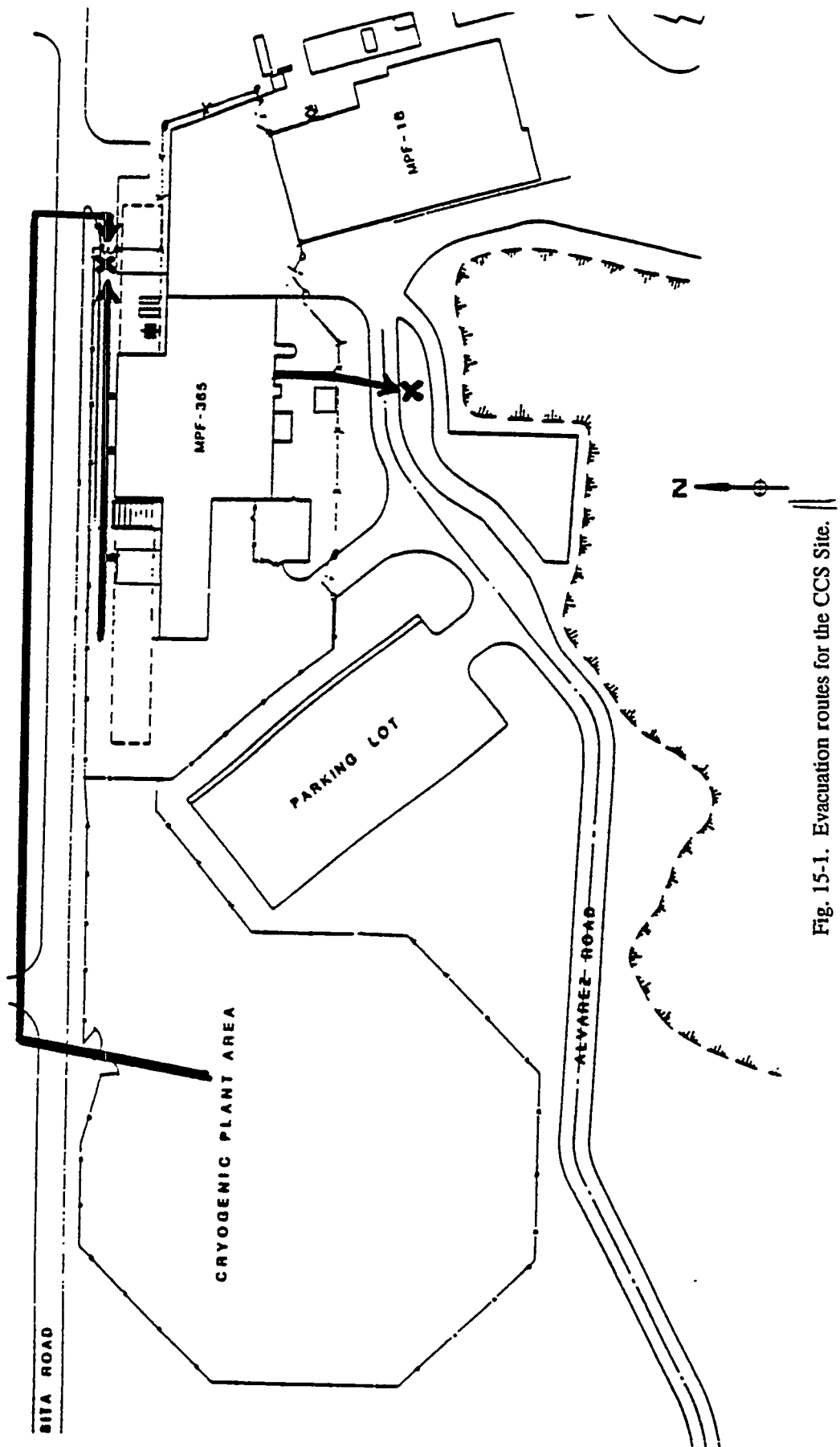


Fig. 15-1. Evacuation routes for the CCS Site.

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16.0 SUMMARY PLAN FOR EMPLOYEE TRAINING

16.1 Training Needs

General, and job-specific training for health and safety is conducted in accordance with Laboratory requirements and employee training needs. The Ground Test Accelerator (GTA) Program Health and Safety Policy Statement (AT/GTA - 89:21, paragraph 2.2.2 and paragraph 7) describes the need for this training in the GTA project. Appendix L contains a copy of this statement. The Los Alamos National Laboratory (LANL) Environment, Safety, and Health (ES&H) Manual states that the training program must include the periodic assessment of training needs, the development and implementation of training activities, and the documentation of training received by each employee.

The GTA line supervisors and the Accelerator Technology (AT) Division training coordinator determine the core training needs of personnel. Supervisors determine the need for job-specific training for employees assigned to potentially hazardous operations.

Core ES&H training is conducted primarily by Health and Safety (HS) and Environmental Management (EM) divisions and includes:

- hazardous-waste generator;
- electrical safety;
- ionizing radiation safety;
- cardiopulmonary resuscitation and first aid;
- forklift and crane operation; and
- hazard communication.

The division-training coordinator or group-safety officer makes arrangements for such training with the sponsoring organization.

Job-specific training is conducted for GTA shift supervisors, cryogenic-cooling system (CCS) operators, and other employees whose work assignments involve hazards not addressed by core ES&H training. Job-specific training is also required as part of hazard communication for employees who work with hazardous chemicals.

16.2 Documentation

Training records are maintained internally and in the Laboratory's Employee Development System database. According to the LANL Environment, Safety, and Health Manual, the documentation of health and safety

training shall include a brief description of the program, the date and duration of each session, the instructor's name, and names of attendees.

16.3 CCS

CVI's contract with the Laboratory provides the initial training of CCS operators. CVI will instruct, both in the classroom and on the CCS, a select group of GTA personnel. The approved standard operating procedures for the CCS is the primary text to be used by the instructors. Additional video/printed material and experienced laboratory personnel will also be used to teach the safe handling of cryogenic liquids. The printed sources included:

- "Recommended Safety Precautions for Handling Cryogenic Liquids," the Cryogenic Society of America, Inc.;
- "Liquid Hydrogen at Consumer Sites," National Fire Protection Association 50B; and
- FM 7-91N, "Hydrogen."

A video tape produced by Air Products, which is the nation's largest producer of LH_2 , will also be used as a training aid. The video tape is based upon Air Products' many years of experience in the safe handling of LH_2 . Although the CCS training provided by CVI will be directed to CCS operating personnel, initial sessions that deal with emergency response teams and personnel safety have included the Los Alamos Fire Department, the Emergency Management Office (OM-1), and other interested personnel, including HS personnel. Follow-up and future training is the responsibility of GTA management. The frequency and content of these training classes will be designed to meet the needs of the individuals being trained. In addition, cryo-operations personnel will receive an annual refresher course that will cover the proper use of safety equipment, hydrogen gas detectors, and oxygen deficiency sensors. An annual emergency response drill will be co-ordinated with, and conducted by, the AT Division Safety Officer. For those personnel who perform specific operational tasks within the CCS, individual instruction will be provided to ensure each operator maintains a high level of proficiency.

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17.0 SUMMARY PLAN FOR OPERATING PROCEDURES

Chapter 17 is a summary plan for the operating procedures needed for Ground Test Accelerator (GTA) operations.

17.1 Preparing the Procedures

AR 1-3, "Standard Operating Procedures and Special Work Permits," of the LANL Environment, Safety, and Health Manual is followed in preparing and applying the standard operating procedures (SOP) for GTA. The manual defines an SOP as a document that describes the procedures and controls for conducting potentially hazardous activities or operations. The SOP identifies potential hazards, precautions, responsible personnel, and organizations involved; provides detailed accounting of support services and equipment needed; and identifies those specific actions to be taken during an emergency.

The sector leaders of the GTA project initially identify the need for SOPs for the:

- accelerator;
- accelerator design;
- facilities;
- injector;
- diagnostics;
- radio-frequency (RF) power; and
- GTA-related research and development activities.

The qualified personnel within the sector prepare the SOPs and provide detailed information on:

- location of work and identification of responsible personnel and organizations;
- equipment, tools, and materials, involved;
- hazardous conditions;
- safe operating procedures;
- emergency or abnormal procedures; and
- functional relationships between the activity and the support functions from HS, ENG, and EM divisions and other sources as required.

17.2 Review and Approval of Procedures

The first level of review starts within the group and division of the GTA sector. The SOPs are reviewed and approved by the:

- group safety officer;
- group leader;

17.0 SUMMARY PLAN FOR OPERATING PROCEDURES

- program manager;
- GTA safety officer; and
- division leader.

The SOPs are then submitted to the Health and Safety (HS) Division for review and comments relating to:

- ionizing radiation/accelerator health protection;
- industrial safety;
- industrial hygiene; and
- waste management.

17.3 Modifying the Procedures

SOPs are reviewed at least yearly; whenever major changes are made to processes, equipment, or facilities, the SOPs are updated as necessary. The originator must maintain records of such reviews and send written notification to the HS SOP office when the SOP is revised. The SOP office in HS-3 periodically sends lists showing SOP status to the GTA safety officer.

17.4 Management Audit of Compliance with Procedures

The GTA safety officer periodically audits GTA activities for compliance with safe operating procedures and the adequacy thereof. The officer documents each audit into a report within a week after the audit. The report contains necessary action items required by the audit findings. Sector leaders are required to respond in writing to the action items within two weeks of receiving them.

Compliance with DOE orders and requirements and federal and state regulations are monitored by the appropriate HS groups.

18.0 GLOSSARY

This chapter defines abbreviations, acronyms, jargon, technical terms, and initialisms found throughout the FSAR.

AABC	American Air Balancing Council
ac	alternating current
ACGIH	American Conference of Governmental Industrial Hygienists
Ag	silver
AIP	artificial intelligence processor
AL	U.S. Department of Energy Albuquerque Field Office
ALARA	as low as reasonably achievable
Am	americium
AMCA	Air Moving and Conditioning Association, Inc.
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
AR	Administrative Requirement (from the Laboratory's Health and Safety Manual)
ARI	American Refrigeration Institute
ASA	American Standards Association
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
AT	Accelerator Technology (Division)
ATS	Accelerator Test Stand
ATSU	Accelerator Test Stand upgrade
Be	beryllium
bldg	building
BLEVE	Boiling Liquid Expanding Vapor Explosion
C	carbon
Ca	calcium
CAD	computer aided design
CAS	central alarm station
CCL	couple cavity linac
CCS	cryogenic cooling system
CCTB	cryogenic component test bed
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CFT	Consequence-of-Failure Type
CGA	Compressed Gas Association
Ci	curie
Cl	chlorine
CLS	Chemical and Laser Sciences (Division)
cm	centimeter
CO3	carbonate
CRT	cathode-ray tube
Cs	cesium
CsOH	cesium hydroxide
D0	deuterium
dB	decibel
dc	direct current
DCF	dose conversion factor
DDC	direct digital controller
deg	degree
d.f.	duty factor
DI	deionized

18.0 GLOSSARY

DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOP	detailed operations plan
DOT	U.S. Department of Transportation
D-plate	diagnostic plate
DTL	drift-tube linac
EM-7	Laboratory Waste Management Group
EM-8	Laboratory Environmental Protection Group
EMI	electromagnetic interference
ENG	Facilities Engineering (Division)
ENG-5	Field Operations group
ENG-7	Records Management group
ENG-8	Fire Protection and Utilities group
EPA	Environmental Protection Agency
ERDA	Energy, Research, and Development Agency
ES&H	Environmental, Safety, and Health
evap.	evaporative
F	fluorine
°F	degrees Fahrenheit
FMDS	factory mutual data sheet
FMEA	failure mode effects analysis
fpm	feet per minute
4PR25OC	high-voltage regulator tube
FSAR	final safety analysis report
ft	feet
g	gram (s)
gal	gallon
GH ₂	gaseous hydrogen
GHe	gaseous helium
GM	Geiger-Müller
GN ₂	gaseous nitrogen
gpm	gallons per minute
GTA	Ground Test Accelerator
GTACS	Ground Test Accelerator Control System
h	hour
H ⁻	negatively charged hydrogen ion
H ⁰	hydrogen atom (neutral)
H ⁺	hydrogen three (tritium)
H ₂	hydrogen
HazCom	Hazard Communication
HCO ₃	bicarbonate
He	helium
HEBT	high-energy beam transport
HEPA	high-efficiency particulate air
HPCTB	high power cryogenic test bed
HSE	Health, Safety, and Environment (Division)
HS-1	Accelerator Health Protection group
HS-3	Facilities and Safety Analysis group
HS-5	Industrial Hygiene group
HS-7	Waste Management group
HS-8	Environmental Surveillance group
HTO	hydrogen tritium oxide (tritiated water)
HV	high voltage
HVAC	heating, ventilating, and air conditioning

HX	heat exchange
Hz	hertz
IAQ	indoor air quality
I&C	instrumentation and control
ICP	integrated control processor
ICRP	International Commission on Radiological Protection
in.	inch
in. wg	inch water gauge
IMS	intertank matching section
I/O	input/output
IOC	input/output controller
IR	infrared
ISA	Instrument Society of America
J	joule
JIC	Joint Industrial Council
K	potassium
K	degrees Kelvin (for example, 35 K)
keV	thousand electron volts
km	kilometer
kV	kilovolt
kW	kilowatt
ℓ	liter
LAAO	U.S. Department of Energy Los Alamos Area Office
ℓ/s	liters per second
LAMPF	Clinton P. Anderson Meson Physics Facility
LANL	Los Alamos National Laboratory
LANSCE	Manuel Lujan, Jr. Neutron Scattering Center
LCO	limiting condition for operation
LEBT	low-energy beam transport
LEL	lower explosive limit
LH ₂	liquid hydrogen
LiF	lithium fluoride
LINDA	laser-induced neutralization diagnostic apparatus
LN ₂	liquid nitrogen
LPCTB	low power cryogenic test bed
LPI	Lightning Protection Institute
LVDT	linear variable differential transformers
m	meter
mA	milliamperes
MAT-1	Metal & Gas Processing Centers
MAWP	maximum allowable working pressure
MeV	million electron volts
Mg	magnesium
MHz	megahertz
mi	mile
Mom. Comp.	momentum compactor
MPF	Meson Physics Facility (building numbers)
mrem	one thousandth roentgen equivalent, man
mph	miles per hour
MSDS	material safety data sheet
MVA	megavolt amperes
MW	megawatt

18.0 GLOSSARY

N ₂	nitrogen
Na	sodium
NASA	National Aeronautic and Space Administration
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NPB	neutral particle beam
O-15	oxygen-15
o.d.	outside diameter
OEL	occupational exposure limit or level
OM-1	Emergency Management Group
OPI	operator personnel interface
OSHA	Occupational Safety and Health Act
OSR	operational safety requirement
P	phosphorous
PA	public address
PC	personal computer
PCB	polychlorinated biphenyls
PEL	permissible exposure limit
P&I	process and instrumentation
PLC	programmable logic controller
PMQ	permanent magnetic quadrupole
p,n	proton-in, neutron-out (of nucleus)
ppm	parts per million
PROM	programmable read-only memory
psi	pounds per square inch
psig	pounds per square inch, gauge
Pu	plutonium
P	differential pressure
QA	quality assurance
QPA	Quality Plan Annex
QAO	Quality Assurance Officer
RAM	random-access memory
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent, man
RF	radio frequency
RFQ	radio-frequency quadrupole (accelerator)
RPS	radiation protection standards
RPSS	radiation personnel safety system
s, sec	second
sccm	standard cubic centimeters per minute
scfm	standard cubic feet per minute
SCR	silicon controlled relay
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Office
SMACNA	Sheet Metal and Air Conditioning Contractor's National Association
SO ₄	sulfate
SOP	standard operating procedure
SOW	statement of work
SPS	surface plasma source
sq	square
Sr	strontium
SSA	satellite storage area

SSR	Safety Sweep Reset switches
SWP	special work permit
TA	technical area
TIG	tungsten inert gas
TLD	thermoluminescent dosimetry
TLV	threshold limit value
U	uranium
UBC	Uniform Building Code
UCRL	University of California Research Laboratory
UL	Underwriter's Laboratory
V	volt
VFQ	variable field strength quadrupoles
W	watt
WAFFOG	wire and fluorescent fiber offset grid
wg	water gauge (pressure)
wk	week
WNR	Weapons Neutron Research
β^-	electron
β^+	positron
ϕ	phase

Appendix A

Environmental Assessment of the GTA Site

1 4 6 0 0 6 0 3

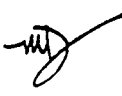
Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

memorandum

TO: DISTRIBUTION

DATE: 3/15/90

FROM: Maria DiStravolo 

MAIL STOP TELEPHONE: H811/5-0808

SYMBOL: AT-DO:90-MD

SUBJECT: REVISED APPENDIX A FOR GTA FSAR

Enclosed is a revised Appendix A for the GTA FSAR. I arranged all memos and documents in this appendix according to their dates, with the most recent ones being first. You will find two versions of the Environmental Assessment report in this appendix--one is a newer and revised version, the older one has missing pages, which are not available. However, all pages are present in the newer version.

Please discard the old appendix. If you have any questions, feel free to call me at 5-0808.

DISTRIBUTION:

L. Andrews, HSE-1, MS K487
C. Oliver, HSE-3, MS H832
H. Lindberg, HSE-3, MS J566
J. Hollander, HSE-5, MS K494
A. Drypolcher, HSE-7, MS E518
W. Scoggins, HSE-8, MS K490
M. Howe, HSE-11, MS H815
B. Foley, ENG-1, MS M721
W. Maybee, ENG-8, MS 718
P. Guthals, ADO-QA, MS A120

1 4 6 0 0 4

PROJECT AUTHORIZATION
FACILITIES AND CONSTRUCTION MANAGEMENT

Authorization No. LSC4
Mod. No. 3
(*Changes this Modification)

AL. Ronald E. Hanson, Director, FCM Division, AL

Date: 9/31/87

PROJECT TITLE: NEUTRAL PARTICLE BEAM PROGRAM/SET. LANL

b. SOURCE OF REQUEST: Memo, Valencia/Hanson, dated June 30, 1987, and meeting at AL on July 10, 1987, with Kidna LAAO, Martinez, FCM and Aragon. OSEA*

c. RESPONSIBLE DOE OFFICIAL: Area Manager, LAAO

d. PROJECT DESCRIPTION: This authorization is for three (3) directive size subprojects for the Neutral Particle Be (NPB) Program at Los Alamos. These projects are the Ground Test Accelerator-1 (GTA-1), Ground Test Accelerator-2 (GTA-2); and the Technical Support Building. GTA-1 will add approximately 13,429 sq. ft. to the Meson Physics Facility (MPF) Building 18 at Tech Area and will modify the existing building. GTA-2 will provide a 67,700 sq. ft. facility consisting of a beam tunnel, an accelerator vault, a high bay assembly area, a beam stop, alignment laboratory, a mezzanine and a four-story laboratory/office area. Extensive sitework is included to provide roads, utilities, parking, storm drainage, landscaping and security fencing. The Technical Support Building will contain three-story, 44,000 sq. ft. facility to provide office space for about 230 people, vault areas, computer room, laboratory space and conference rooms. The facility will be designed to comply with requirements for security classification, Secret-National Security Information.

e. WORK AND COSTS AUTHORIZED:

Titles I, II and III Engineering, Construction, and Procurement for the three subprojects. Authorized funding level is limited to ~~\$14,183,000~~ 26,209,

f. METHOD OF PERFORMANCE:

Engineering I & II	DOE and/or LANL/FP LANL/FP
Engineering III	DOE and/or LANL/FP LANL/FP
Construction	DOE and/or LANL/FP
Procurement	LANL

g. SCHEDULE:	START	COMPLETE
Engineering I & II	11/85	6/87*
Engineering III	6/86	2/90*
Construction	9/86*	8/89*
Procurement	7/86	1/90*

* See page 2
"Remarks"

SEP 22 2 00 PM '87

PROJECT AUTHORIZATION FACILITIES AND CONSTRUCTION MANAGEMENT

Authorization No. 1204
Mod. No. 3
(*Changes this Modification)

LISTING OF SUBPROJECTS:

SUB ITEM #	PROJECT TITLE	2/* TEC (000)	2/* ALLOT (000)	3/* COSTS AUTH (000)	WORK AUTH(1)	SCHEDULE			
						Engineering (1&2)		Construction (Building)	
						Start	Compl	Start	Compl
4A	GTA-1	3,244	3,244*	3,244*	1,2,3,C,P*	11/85	6/86	9/86	10/87*
4B	GTA-2	19,475*	7,266* 18,397	7,266* 18,397	1,2,3,C,P*	4/86	6/87*	10/87*	8/89*
4C	Tech. Support Bldg.	S 5,200*	5,200* 4,572	4,572* 4,572	2,3,C,P*	5/86	10/86*	4/87*	12/87*
									4/88
Total		\$27,918K*	\$14,683* 26,213	\$14,683* 26,213					

(1) Key to Symbols for Work Auth

- 1 - Title I Engineering
- 2 - Title II Engineering
- 3 - Title III Engineering
- P - Procurement
- I - Installation
- C - Construction

Notes*

- 1/ TEC from DOD Form 1391
- 2/ Allotment from MIPR transfer
- 3/ Costs Authorized from available funds at Area Office for Engineering and Construction

REMARKS

This modification updates the Authorized Work, Costs, and Schedules. Titles I, II, and III Engineering, Construction, and Procurement are authorized for all three subprojects. ~~Construction for GTA-2 is limited to site work only.~~ Phase I of ~~Priority~~ ~~only~~. The Environmental Assessment for the NPB has been approved with no significant findings. It is understood that any construction activities will not have any significant environmental impacts on the ~~to~~ archeological resources discussed in the EA. The PSAR for GTA-2 is being completed. EED authorizes start of construction on GTA-2 contingent upon the Environmental Assessment (EA) being updated to reflect any design changes not discussed in the original EA.*

PROJECT AUTHORIZATION FACILITIES AND CONSTRUCTION MANAGEMENT

Authorization No. LRD4
Mod. No. 275
(*Changes this Modification)

CURRENT COST ESTIMATE:

	PRICE (000)	EXPENSE	EQUIPMENT	TOTAL (000)
Engineering	3,410	4254		3,410
Title I	1634	(544)		(634)
Title II	(2,000)	(2,117)		(2,000)
Title III	(717)	(1532)		(717)
Construction	20,829	21009		20,829
(1) Improvements to Land	(1,078)			(1,078)
(2) Buildings (Hods)	(18,751)	(15360)		(13,175)
(3) Other Structures				
(4) Special Facilities	(598)	(644)		(594)
(5) Utilities	(480)	(500)		(430)
(6) Standard Equipment	(532)	(522)		(532)
(7) Project Mgmt.	454	324		454
Procurement	0			0
Installation	0			0
Other (Shielding)	0			0
Contingency	5,225	588		5,225
TOTAL (DEC)	927,918	26213		927,918

Same.

1.	SOURCE OF FUNDS	BUDGET PROJECT NO.	AMOUNT
	MIPR	W31RPD-63-A088	\$6,300,000
		(Total Project funds 25,000,000)	(Construction funds)
	MIPR	W31RPD-7-D4050	\$8,383,000
		(Total Project funds 46,913,000)	(Construction funds)
		Total:	914,683,000

MIPR

W31RPD-8 D4028, 104060
(Total Project Funds
\$4,245,000)

6933K

MIPR

W31RPD-9 D4041
(Total Proj. Funds 50,500,000)

4333K

DISTRIBUTION:

CF&S Branch, LAAO (2)
ENG-3, LANL, MS-M984
Accounting Div., LANL, MS-P239
M&R, LANL, MS-A150 (2)
Pan Am Eng., EMDO, MS-A199 (3)
Pan Am Fiscal, AACD, MS-A199
Technical Programs, LAAO
Reading File, LAAO
Eloy M. Nunez, P&FM Br., LAAO
Project Engineer, P&FM Br., LAAO
P&FM File, LAAO

Total 26,213.

UNITED STATES DEPARTMENT OF ENERGY
Albuquerque Operations
PROJECT AUTHORIZATION
FACILITIES AND CONSTRUCTION MANAGEMENT

FORECAST TO COMPLETION

CURRENT COST ESTIMATE:		GTA-1	GTA-2. Site	GTA-2. FAC	TS Bldg.
<i>Total</i>		<i>933K</i>		<i>2841</i>	
<i>4244</i>	Engineering	<i>894K</i>	115K	<i>1,959K</i>	<i>462K 665</i>
<i>(544)</i>	Title I	<i>206,150K</i>	36K	<i>688K (157)</i>	<i>110K (145)</i>
<i>(2177)</i>	Title II	<i>(317) 603K</i>	50K	<i>1,154K (1264)</i>	<i>222K (263)</i>
<i>(1533)</i>	Title III	<i>(150) 141K</i>	29K	<i>417K (1120)</i>	<i>(130K) (254)</i>
<i>20520</i>	Construction	<i>2,100K</i>	1,297K ✓	13,400K	<i>3,300K 3723</i>
<i>(1078)</i>	(1) Improvements to Land		963K	<i>(100K)</i>	<i>(75K)</i>
<i>(15360)</i>	(2) Buildings (Mods)	2,100K		<i>(12,750K)</i>	<i>3,125K (3548)</i>
	(3) Other Structures				
	(4) Special Facilities				
<i>(544)</i>	(5) Utilities		394K	<i>(100K)</i>	<i>(100K 50K)</i>
<i>(571)</i>	(6) Standard Equipment			<i>(450K)</i>	<i>(50K)</i>
<i>527</i>	Project Mgmt.	<i>96</i>	22K	<i>225</i>	<i>184</i>
		<i>84K</i>		<i>330K</i>	<i>96K</i>
<i>324</i>	Procurement	<i>0</i>	124K	<i>200K</i>	<i>15K 0</i>
		<i>15K</i>		<i>200K</i>	
<i>0</i>	Installation				
<i>0</i>	Other (Shielding)				
<i>584</i>	Contingency	<i>115*</i>	OK	<i>473K</i>	<i>0</i>
		<i>151K</i>		<i>1,947K</i>	<i>1,127K</i>
<i>26213</i>	TOTALS	3,244K	1,558K	<i>17,916K</i>	<i>5,200K 4572</i>
<i>26213</i>		<i>-----</i>	<i>-----</i>	<i>-----</i>	<i>-----</i>
				<i>1.6839</i>	

* Set aside for Beatty Elec. Claim.

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

memorandum

TO: Terry Foxx, HSE-8, MS K490
FROM: Earl Swickard 
SUBJECT: AT/GTA-89:334
SUBJECT: GTA CHANGES SINCE ISSUANCE OF DOE EA-0304

23 August 1989

MAIL STOP TELEPHONE H821/5-2743

DOE EA-0304, Environmental Assessment for Ground Test Accelerators (GTA) 1 and 2, TA-53, Los Alamos National Laboratory, March 1986, covered the construction and operation of two accelerators to be built as part of the nation's neutral particle beam program. Since the issuance of the EA, there have been major changes in the program. Those changes, discussed below, are believed not to be of such a nature as to require a new or amended EA.

GTA 1 was cancelled and GTA 2 became GTA. Beam energy of GTA remained at 100 MeV but the duty factor and beam current of the reference design were changed (beam currents at 100 MeV are classified). The average power of GTA is 0.8 that of GTA 2. Another major change was the accelerator cooling; from chilled water to cryogenic (20K) gaseous helium. The GHe is cooled in a LH₂-GH₂ heat exchanger.

The current experimental sequence begins with a series of six experiments having output beam energies of 35 keV to 24 MeV. These experiments will validate the design of several new concepts, particularly cryogenic cooling and the combining of two ion beams into one by "funneling". At the conclusion of the 24 MeV experiments, accelerating sections will be added to bring the beam energy to the design 100 MeV. The 24 MeV experiments are scheduled to end in mid 1993.

William Wilson has made a preliminary estimate of air activation for 24 MeV operation. I have compared the total curies released per year for 24 MeV operation to the total released in the 100 MeV case described in appendix VII of the EA. The ratio of the 24 MeV to the 100 MeV case ranges from 10⁻³ to 10⁻⁷ depending on the radionuclide. Providing my calculation is correct, we will certainly not expose the public to more radiation than the EA describes.

Air activation has not been calculated for the proposed 100 MeV configuration and so cannot be compared to the appendix VII calculation. I think we should have a formal comparison of 24 MeV calculation to the appendix VII calculation and conclude that, from an airborne radioactivity release standpoint, we need not revise the EA. Let's wait until the 100 MeV operation is a certainty until we consider a revision.

The cryogenic cooling system (CCS) is an environmentally benign system. The CCS consists of a 28,000 gal LH₂ storage dewar, a LH₂ run dewar and a transfer line connecting them. Inside the run dewar a tube bundle is immersed in LH₂ and GHe flowing through the tubes is cooled to about 20K. The GHe is circulated in a closed system to the cryogenically cooled components. Hydrogen gas generated in the storage dewar by heat leak and in the run dewar by cooling GHe is vented (unified) to the atmosphere. The run tank vent rate is about 90 g/s. The maximum heat leak vent rate from the storage dewar is about 5 g/s.

The GHe will contain a very low concentration of ³H from activation by the neutron flux resulting from p,n reactions in the accelerator. For the 100 MeV case the concentration is calculated to be about 2.5×10^{-6} μ Ci/ml. The concentration caused by 24 MeV operations will be very much less.

The GHe is purified by passing through an activated charcoal bed at LN₂ temperature. Activated impurities in the GHe will be trapped in the bed and be released to the atmosphere from a 82.5 ft. stack during bed regeneration. No estimate of the magnitude of the radioactive release or of the regeneration frequency has been made. The GHe is supplied with a few ppm impurity level and that level is reduced in the purifier.

The LH₂ fire and explosion accident analysis was done in a preliminary way in the PSAR and is being considered more fully in the FSAR in preparation. None of the LH₂ accidents considered resulted in toxic or hazardous release to the environment.

The statements made in EA section 6.1 c., effluents, are still correct. The contaminated cooling water loops will use "Culligan bottles" to remove dissolved solids. The remaining radionuclide of any consequence is tritium. At 24 MeV, tritium generation is very low. Activation calculations of beam stop cooling water are planned but have not been completed.

I have enclosed a copy of the PSAR which is presently being reviewed by DOE/AL.

ES/r

cy:

M. Howe, HSE-11, MS H815

M. Charles, HSE-3, MS K483

M. DeStravolo, IS-3, MS H811

File

Notes on 24 MeV Air Dose Calculations

Air is activated in three locations in the 24 MeV experiments - beam loss in DTL No. 2 and beam transport to the beamstop, the accelerator beamstop, and the final beam stop. Bill Wilson, T-2, will calculate the activation of air in these locations. It may be that activation from beam loss is negligible.

Subject to concurrence by Wilson's intuition, or quick estimate, we will not consider activation from experiments 2A, B or C and 3, 8 and 11 MeV respectively.

accelerator

The air volume subject to activation in the 24 MeV beamstop is that volume between the surrounding shield blocks and the vacuum envelope - a small volume. The volume subject to activation near the unshielded final beamstop, when used for 24 MeV operations (experiment 3), is that beam tunnel volume out to the range of the neutrons. Although the activation rate at the final beamstop is much greater than at the accelerator beamstop, only 1 macropulse in 100 (average) is sent to the final beamstop.

The current schedule shows experiment 2D with beam occurring from 24 June 1991 through 12 August 1991 - a period of 51 days or $7 \frac{2}{7}$ weeks. Assume that we operate 4 hr/day and 4 days/week for 16 hr/week. In 51 days we operate $16 \times 7 \frac{2}{7} = 117$ hours. Assume further that each operation lasts for $\frac{1}{4}$ hour and that the beam tunnel is purged after each $\frac{1}{4}$ hour operation. That gives $234 - \frac{1}{4}$ hr periods. For conservatism's sake we will use twice that or $468 - \frac{1}{4}$ hr operating periods.

The schedule shows experiment 3 with beam occurring from 1 September 1991 through 21 January 1992 - a period of 143 days or $20 \frac{3}{7}$ weeks. Using the same arithmetic as for experiment 2D, we find that the dose calculation will use $1308 - \frac{1}{4}$ hr operating periods.

In addition, we will calculate the worst case of activation by continuous beam tunnel purging during operations.

The source terms as generated by Wilson will be given to HSE-8, Tom Buhl, for calculation of the activated air dose to both workers and the public. It is assumed that the beam tunnel air is removed by the ventilation system and exhausted from the 82.5 ft high stack. Tom may or may not include such calculational niceties as beam tunnel transit time and diffusion of air from the accelerator beamstop into the beam tunnel atmosphere.

We need to define a ground release accident, but that definition will require some thought. We will do that later.

memorandum

Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

DATE:

REPLY TO
ATTN OF:

LRDT:DL

SUBJECT: Neutral Particle Beam Program, Ground Test Accelerator 1 and 2 - Design
Summary Reports

TO: James W. Culpepper, Acting Director, OPRM

I am transmitting _____ copies each of Design Summary Reports for Ground Test Accelerator (GTA) 1 and 2 for your review prior to the Headquarters Validation in Los Alamos on May 28, 1986. A detailed cost estimate for both projects will be available for this meeting unless you desire them prior to the meeting. If you have any other questions or require additional information or documents, please let me know. We can address these requests for additional information during the Validation Meeting or transmit specific items prior to the meeting. In either case, we are ready to assist your office in any way necessary to keep these critical SDI projects on schedule.

The design - construct plan for the two projects is as follows:

- a. GTA-1, TEC - \$3,244,000 - Holmes & Narver has been selected to design this project and is currently proceeding with an enhanced conceptual design. Upon receipt of the MIPR from SDIO, the construction plans and specifications can be finalized. Our scheduled design completion is June 1986, thus the competitive-bid contract can be awarded in the July - August 1986 timeframe.

GTA-1 is a 13,600 square foot addition to an existing building (MPF-18) at Technical Area 53, LANL. This facility will be used for the development of a prototype for the Neutral Particle Beam device for Integrated Space Experiment-1, and is the "front end" for the GTA-2.

- b. GTA-2, TEC \$19,474,000 - This project has been approved and funded by SDIO MIPR W31RPD-63-A088, Amendments 01 and 02, dated February 11, 1986, and February 21, 1986 respectively.

The site work for GTA-1 and 2 (TEC \$1.3 Million) has been designed by The Zia Company. The Commerce Business Daily announcement was published on April 7, 1986 and bid opening is scheduled for Thursday, May 29, 1986. The lump sum contract can be awarded in early June 1986 with a construction period of 120 calendar days if Headquarters approves construction start.

The GTA facility (Phase 2) with a TEC of \$14 Million is currently being designed by Holmes and Narver with a scheduled design completion date of July 1986. GTA-2 is a 67,700 square foot

* See page 2
item C

building at Tech Area 53 consisting of a beam tunnel, an accelerator vault, a high bay assembly area, a beam stop, an alignment laboratory and a four story laboratory/office area.

The GTA-2 facility will be used for the development of a 100 MeV prototype for the Neutral Particle Beam device.

- c. Mitigation of Risk - The highest probability of risk is that the design of the process equipment is concurrent with the construction of the facility. The Laboratory CPM will monitor the using groups design effort as it pertains to the facility interfaces and will reconcile those differences either by modifying equipment design to fit the facility, or initiating change orders to the DOE Project Manager to modify the facility, or by modifying the facility utilizing the Laboratory's maintenance contractor after the initial construction is complete.

The Environmental Assessment for GTA-1 and 2 was submitted to Headquarters in early April 1986 and approved on April 30, 1986. Headquarters and AL comments will be incorporated and the final Environmental Assessment issued. The Environmental Notification to EPA Document dated April 18, 1986, for both projects is being transmitted by separate correspondence.

In summary, let me emphasize the timing criticality of the SDI program at LANL. It is imperative that we receive timely review, validation and necessary approval of both projects. To that end, we stand ready to provide whatever additional information, documents, and/or support you require to obtain timely project approval.

T.C. Jones
Director, Office of Strategic
Planning and Analysis

4777A

Attachments:
As stated

1 4 6 U 0 0 1 5

memorandum

Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

DATE. JUN 10 1986

REPLY TO
ATTN OF

LRDT:DL/4982A

SUBJECT.

Ground Test Accelerators 1 and 2 - Environmental Assessment

TO: Thomas C. Jones, OSPA, AL

Headquarters and AL comments on the subject Environmental Assessment (EA) have been incorporated and are reflected in the attached finalized Environmental Assessment. Please review the finalized EA for compliance with HQ and AL comments. If the finalized EA is satisfactory, I will ask the Laboratory to process the final EA.

Please note that concurrence from the Advisory Council on Historic Preservation on our mitigation plan for the archaeological resources located at the construction area has been received (copy attached).

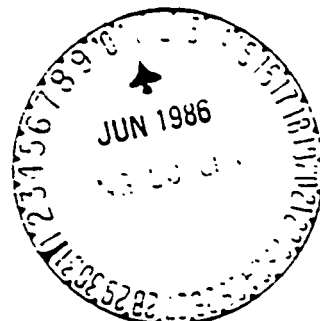

Harold E. Valencia
Area Manager

Attachments:

1. Tiedman-Valencia memo dated 5-23-86 w/atts. (4)
2. ACHP Concurrence

cc:

C. E. Garcia, ESHD, AL, w/atts.
H. F. Mumma, FCMD, AL, w/atts.
W. Myers, DADDCP, MS-F614, LANL, w/o atts.
J. Jansen, DRPDEW, MS-H818, LANL, w/o atts.
J. Allen, ENG-DO, MS-K721, LANL, w/o atts.
A. J. Tiedman, ADS, MS-A120, w/o atts.



0190091

ENVIRONMENTAL ASSESSMENT
FOR
GROUND TEST ACCELERATORS (GTA) 1 AND 2, TA-53
LOS ALAMOS NATIONAL LABORATORY

p. 12
- p. 19

March 1986

I. CONCISE DESCRIPTION OF THE PROPOSED ACTION

The proposed action is construction and operation of two ground-based prototype accelerators at Los Alamos National Laboratory. The GTA facilities will be a key component in the nation's Neutral Particle Beam (NPB) program. The national Neutral Particle Beam (NPB) program is composed of three major elements: (1) the technology base, (2) the space flights of the Integrated Space Experiments (ISE) program, and (3) the ground test accelerators (GTA) supporting ISE. The accelerators, GTA-1 and GTA-2 require two facilities with a total estimated cost (TEC) of \$3.2 million (GTA-1) and \$19.4 million (GTA-2). The GTA was formerly titled Accelerator Test Stand Upgrade (ATSU).

The GTA project will consist of constructing, equipping, and operating in sequential phases two beam tunnels/accelerator-laboratory buildings. A parking lot and access roadway are part of the GTA-2 project. Two other projects, Support (Staging) Building for GTA Facilities and Transportable Office Complex (NPB Technical Support Building) (LJ 7727) will complete the GTA complex at TA-53. The Support (Staging) Building will serve as a transshipment and storage center and the (Technical Support Building) will provide office facilities for 200 people. Laboratory personnel prepared Action Description Memorandums (ADMs) for both buildings in January 1986. The Department of Energy (DOE) determined that no further documentation for these facilities is required. (Ref. Appendix I, memorandum, Valencia to Adams, Environmental Documentation; Strategic Defense Projects at TA-53, 2/05/86.)

GTA-1: The GTA-1 prototype is the front-end of GTA-2 and will also serve as the technology demonstration test bed

for ISE-1. The GTA-1 will be a 50 MeV, 100 mA, 0.1% duty factor, ^{435 M} 3 Hz, ~~H⁺~~ ~~H⁻~~ and ~~H²~~ proton accelerator. Equipment will consist of an injector, a radio frequency quadrupole, a drift tube linear accelerator, an rf power system, beam output optics, a beam sensing and control system, a neutralizer, two beam stops, and an instrumentation and control system. Support systems will include radiation shielding, power, and cooling utilities.

An existing preengineered building, MPF-18, will be modified and a 86 ft x 101 ft addition built to contain GTA-1. The accelerator, high-energy beam transport, buncher, telescope, neutralizer, optics, beam sensing, beam stops, and drift structures will be housed within the building high bay structure in a thick, high-density concrete shield block vault for radiation shielding. (Ref. Figs 1 and 2.)

The GTA-1 will serve as a test bed for GTA-2 equipment and for advancing technology up to 50 MeV. The GTA-1 phase will undertake system and equipment design, development, fabrication, installation and testing. Emphasis during this phase will be placed on transferring technology as fast as possible to the space experiment contractor and his team. The 50 MeV GTA-1 will provide an engineering test bed for the space flight ISE device. The physical configuration will, to the extent possible, be compatible with the space shuttle and will serve as a test bed for space components designed and built by the contractor for ISE-1. Eventually, the GTA-1 accelerator will become the actual (50 MeV) "front end" of the GTA-2 (100 MeV) accelerator. GTA-1 will bridge the technology gap between present small-aperture components and large-aperture components required for GTA 2.

1 4 6 0 0 0 1 0

GTA-2: During the GTA-2 phase, the 50-MeV GTA-1 accelerator will be moved into a new facility (Fig 3), upgraded to 100 MeV and the output beam system integrated.

The GTA-2 building will be approximately 67,000 sq ft in area. The steel building will contain the accelerator and its systems, utility systems, assembly space, offices, and laboratories. (Ref. Figs 4-7.) High-energy beam transport, bunching, telescope, neutralizer, optics and drift structures will be housed in a large corrugated-steel culvert structure using deep-earth burial and thick concrete closures for radiation shielding and equipment installation. (Ref. Fig 8.)

The prime function of the GTA-2 will be to appraise methods for output beam sensing and beam control. In its initial operating phase, GTA-2 will demonstrate the integration of all components into a working high-gradient, low-emittance accelerator. At a later stage, full output beam-optics will be installed, and the ion beam will be tailored into a functional, large-diameter beam of neutral hydrogen atoms. Beam-sensing hardware and complete beam control algorithms will provide a prototype of output neutral beam direction sensing and control. This single feature will be GTA-2's most significant capability. As a versatile test facility, the GTA also will have the inherent ability to demonstrate component integration, beam lethality, automatic accelerator control, and fast accelerator turn-on.

II. NEED FOR THE ACTION

A principal motivation of the national Neutral Particle Beam (NPB) program is the need to assess neutral particle beams as discriminators and directed energy weapons outside

the earth's atmosphere. The White Horse Program at the Los Alamos National Laboratory has been addressing relevant NPB questions for a number of years. Recently, the NPB Program was incorporated into the Strategic Defense Initiative established by President Reagan. The proposed GTA program will be a key component in this country's NPB program.

The GTA will provide important data for development of a near-term space directed energy weapon demonstration. The GTA prototypes will be developed, built, and operated to demonstrate solutions to technological problems in integrated full scale systems. Prototypes are a necessary step toward space experiments. The GTA will demonstrate experimentally critical space parameters. For instance, ability to sense and control the output beam is a critical physics issue that must be addressed to prove feasibility of delivering a neutral particle beam to a distant target.

The GTA facilities will provide space and tools for investigating other NPB program issues. They will provide answers to a number of general physics questions. They will also facilitate Los Alamos efforts to transfer accelerator physics technology to private industry.

III. ALTERNATIVES TO THE ACTION

A. Alternative Site Not at Los Alamos National Laboratory]

If the GTA prototypes are not built at the Los Alamos National Laboratory, the programmatic impact is considered to be a minimum 3-year slip in the NPB program and the possibility of moving the entire Los Alamos effort elsewhere.

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The Department of the Army Ballistic Missile Defense Advanced Technology Command (BMDATC) site survey team has recommended that GTA be built at Los Alamos. The survey team considered four other sites. All four sites were less desirable than Los Alamos in terms of program considerations, technical capability, and physical characteristics. [Ref. Accelerator Test Stand Upgrade Site Survey, BMDATC, 2/85, and letter Office of the Secretary of Defense (Louis C. Marquet to Major General Eugene Fox). Both are on file with Laboratory Group AT-4.]

B. Alternative Siting at Los Alamos National Laboratory

Project and Laboratory siting personnel extensively studied alternative Laboratory sites for the GTA complex. The complex requires approximately 5 acres of open land, available utilities (in particular a large power supply) and closed security.

The siting investigation determined that only one alternative to the TA-53 site met more than one siting criteria. Two Mile Mesa (Fig. 11) is behind security fences and provides ample mesa-top space for the facility. However, the available siting area at Two Mile Mesa lies within an existing 1250 ft safety exclusion radius of Laboratory Dynamic Testing (M)-Division high explosives magazines. Sufficient utilities for the project will not be available within the scheduled time-frame of GTA startup. Supplying a road and utility infrastructure to Two Mile Mesa would delay program operation and add to development cost.

The preferred site at TA-53 has a developed road and utility infrastructure and houses compatible facilities and

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operating personnel. This location avoids splitting Accelerator Technology (AT)-Division research between two or more locations, since the primary supporting research and development efforts are, and will remain, at TA-53. Prior experience in split location research has nearly always resulted in costly errors usually avoided when all (or most) research are co-located. Moreover, travel time for Division employees will be reduced and communications problem will be minimized. Site development will be minimal at TA-53 compared to Two Mile mesa. Adequate utilities and other facilities are nearby (within 100 yards). A common security fence can be used for this facility and new classified facilities.

C. No Action

The GTA facilities are an integral aspect of the nation's NPB weapons' program. This program has been mandated by the President and Congress as necessary for the vital defense of the United States. There is no known reliable defense against intercontinental nuclear missiles in the upper atmosphere. The GTA facilities will provide the basic technology for the NPB program.

IV. ENVIRONMENTAL IMPACT

A. Existing Environment. This project is within Los Alamos National Laboratory boundaries (Fig 11). A detailed description of the local environs is presented in the Laboratory Environmental Impact Statement (EIS) [Department of Energy (DOE)/EIS-0018, Dec., 1979].

Specifically, the GTA complex will be located within TA-53 across La Mesita road from Sectors E and F of the

Los Alamos Meson Physics Facility (LAMPF) beam tunnel. (Ref. Figs 9 - 11.) This location is at the head of a small drainage channel adjacent to an industrialized area showing some soil erosion. Special care will be taken to prevent future soil erosion arising from construction of the new facilities. Site vegetation consists of partially disturbed stands of pinon pine and one-seeded juniper, native grasses, and forbs (weeds). The terrain ranges from steep slopes with road fill to moderate slopes with occasional tuff rock outcrops and very shallow soil covers. (Ref., Soil Survey of Los Alamos County, New Mexico, LA-6779-MS, Los Alamos Scientific Laboratory, June 1978.)

Siting of the GTA facilities are in accordance with the Laboratory Long Range Site Development Plan.

B. Probable Impacts

1. Archaeology. Laboratory archaeologists have surveyed the proposed siting area for the presence of cultural (archaeological and historical) resources. They found no evidence indicating the presence of any resources at the GTA-2 site. (Ref. Appendix II.a, memorandum, Snow to Olinger, dated 4/22/85.) A prehistoric ruin west of the GTA-2 and the Support Building will be fenced by the GTA-2 project prior to any construction in the area to protect it from construction traffic. The access road to the GTA complex was slightly relocated after the initial archaeological survey. Subsequent survey of the road route indicates that it will traverse a prehistoric fragment site (Ref. Appendix II.b, memorandum, McGahee to Olinger, 12/3/85). An adverse impact mitigation plan calls for collecting fragments from this area prior to the beginning of GTA site construction. (Ref, Appendix II.c, memorandum, McGahee to Olinger,

2/23/86.) Field work and data analysis for the fragment scatter, as well as fencing for the prehistoric site, will be funded by the GTA-2 project. The New Mexico State Historical Preservation Officer (SHPO) has been consulted and supplied with a mitigation plan in conformance with Section 106 of the National Historical Preservation Act of 1966 and 36 CFR Part 800. (Ref. Appendix II.d, memorandum, Valencia to Merlan, 3/4/86.) The SHPO has concurred that the proposed data collection, analysis, and reporting will justify a determination of no adverse impact (Appendix II.e, letter, Merlan to Valencia, 4/21/86). The mitigation plan is currently under review by the Advisory Council on Historic Preservation (Appendix II.f, letter, Valencia to Fink, 5/2/86); the Council must respond within 45 days.

2. Floodplain/Wetlands. This project is not located in a floodplain or wetland as described by DOE regulations (10 CFR 1022).

3. Threatened and Endangered Species. Based on current understanding, no threatened and/or endangered species inhabit the proposed siting area. No sightings of animals noted on U.S. Fish and Wildlife listings of local threatened and endangered species have been reported for the project area. No plants contained on the New Mexico Endangered Plant Species List (1985) are known to grow within the project area.

4. Construction. No unusual construction-related environmental impacts are anticipated. Negative impacts on air and water quality due to construction activities will be short-term and minimal. Air quality will be degraded temporarily at intermittent times by dust from construction activities.

The construction area is partially a developed area within the TA-53 LAMPF complex. Site preparation, excavation, and backfill will be required. Soil erosion control will be part of the project.

5. Use of Resources. The operating GTA facilities will use no local natural resources other than routine utilities. Utilities will connect to existing lines at TA-53. The additional load on utilities will not over-extend this system.

Specifically, utilities will include:

1. 15 MW of AC power from an existing switch gear adjacent to the site,
2. 4.23 Mw of cooling water from the Fusion Materials Irradiation Test (FMIT) building cooling tower adjacent to the site,
3. telephones,
4. natural gas,
5. sewage.

6. Impacts from Routine Emissions and Effluents.

1. Normal Operating Conditions.

a) Description. Both GTA-1 and GTA-2 are being designed to provide intense sources of H^+ , H^- and H^0 and particles. The particle beams will be 100 mA of H^- particles accelerated to 50 MeV for GTA 1 and 100 MeV for GTA-2. The duty factor (D.F., time in operation) will be

0.14 with pulse lengths of 0.35 milliseconds every 333 milliseconds, for GTA-1 and $\bar{A}$, with pulse lengths varying from 0.1 milliseconds to 2.0 milliseconds, for GTA-2.

Within each facility the accelerated H^- beam will go through a high-energy beam transport (HEBT) section, expanding and shaping magnets, a neutralizer (producing primarily H^0 particles but also leaving a significant number of H^- and H^+ particles), and finally into a beamstop that will safely dissipate the particle beam and heat. Throughout this system, but especially in high-energy regions and in the beam stop, high-energy neutrons will be generated. These include a high flux of neutrons with energies up to 50 MeV for GTA-1 and 100 MeV for GTA-2. An approximately equal intensity of prompt high-energy gamma rays will also be produced. High energy neutrons will activate materials throughout each beam tunnel, accelerator vault, and beam stop vault. Low level activation of cooling water is also likely to occur. The magnets will be a source of residual radiation. The HEBT and neutralizer sections of the GTA facilities can be made of aluminum, thus reducing activation in the general structures. The beamstops, the greatest sources of residual radiation, will be made primarily of graphite, copper and aluminum. Isolation, shielding, and limited access will be used to minimize radiation exposure from the beamstops. Copper alloys and copper plating will be used to minimize radiofrequency (rf) losses and to maximize heat removal in certain locations.

At the 50-MeV and 100 MeV ends of the drift tube linac (DTL), the highest neutron fluxes are expected from particle losses in the matching section of the HEBT; the fluxes generated will also have the highest energy spectrums. The

high-energy spectrums are important because many of the activation reactions are threshold reactions. For these reasons, the high-energy end of the DTL will be analyzed in a Safety Analysis Report required prior to operation of GTA-2 and a safety assessment required prior to operation of GTA-1.

The accelerator vaults, HEST sections, and beam sensing and beamstop areas will be closed to all personnel during beam-on. Pedestrian traffic during beam-off operations will be through shield-block labyrinths with kirk-key interlocked doors from the accelerator vaults. Sufficient shielding will be placed over and around the accelerator and beam sensing vaults and beamstops to result in radiation dose levels "as low as reasonably achievable" (ALARA) and no higher than the DOE new facility occupational exposure Radiation Protection Standard (RPS) for whole body radiation of 1000 mrem/yr (DOE Order 5480.11 proposed revision).

The Los Alamos National Laboratory Applied Nuclear Science Group (T-2) in collaboration with the Radiation and Shielding Analysis Group of the Hanford Engineering Development Laboratory, are doing a shielding study and will provide engineering data necessary to design shielding to meet exposure criteria. Each accelerator will be covered by high density (H. D.) concrete stepped stack-block shielding that can be quickly moved by an overhead crane for reconfiguration of the accelerator or for maintenance work. Preliminary bulk shielding thickness are analyzed in Appendix III, letters, Morford to Cole, "ATSU, 100 MeV Linac Shielding, 10/20/85" (III.a) and "GTA-1 Bulk Shielding," revised 1/27/86 (III.b). Shielding thickness for GTA-1 beam stop are currently estimated at approximately 8 ft of 243 # HD concrete and for GTA-2 at approximately 9 ft of 243 # HD

concrete. Stacked up block cracks will be sealed to prevent leakage of radioactive air from between the blocks.

The policy of the Los Alamos National Laboratory is that employee and public exposure to radiation and radioactive materials will be kept to the lowest level technically and economically feasible (Health and Safety Manual, Administrative Requirement 3-1). The "as low as reasonably achievable" (ALARA) principle will be adhered to in all activities to minimize operational exposures. During normal beam operation the air in each vault and beam-stop will be stagnant. When the beam is off, air from these areas will be vented through a high-efficiency (99.97%) particulate air (HEPA) filter bank and an exhaust stack. Personnel access will be allowed only when ventilation is operational and safe radiation levels have been achieved.

b) Emissions. No nonradioactive emissions are anticipated which would require regulation under New Mexico Air Quality regulations 702 and 703. No emissions will be produced requiring regulation under Prevention of Significant Deterioration (PSD) rules.

Airborne emissions will consist of activated air discharged to the atmosphere at intermittent times. The only way to dispose of activated air is to hold it for radioactive decay to acceptable levels and then vent it to the atmosphere. Any activated gases from the GTA facilities will be vented so that resulting doses do not exceed the DOE occupational exposure RPS (5480.11 proposed revision) of 0.5 mrem/hr in continuously occupied work areas. No activated air will be circulated or exhausted during beam operations. The quantity and types of airborne radioactive emissions are being assessed in the ongoing GTA radiation study. The

study will be completed prior to final design to permit adherence with DOE radiation safety criteria.

GTA-1: Preliminary air activation data was computed for the ATSU facility (the previous name for the GTA-1 50 MeV accelerator) based on an 8 hour/day irradiation time and various decay times with a beam intensity corresponding to peak intensity expected. (Ref. Appendix IV, letter R. J. Morford, Radiation and Shield Analysis, Westinghouse Hanford Company, to T. R. Cole, AT-4, Los Alamos at the Los Alamos National Laboratory, received April 12, 1985. The code used by Westinghouse-Hanford Co. to calculate the production and quantity of isotopes for GTA-1 is REAC (Reaction Activation). The REAC code is used for activation calculations. It has four basic libraries which makes input very straight-forward. The libraries are: (1) material composition, (2) multigroup flux, (3) multigroup cross sections, and (4) radionuclide decay. This code is probably the best available at this time for high energy neutron activation and is widely used. Many other codes are used as required for specific parameters.

The code was rerun at the Los Alamos National Laboratory using the average beam intensity for a nominal 8-hr running day and various decay times to more accurately reflect the production that can be expected for each isotope. Table I lists primary generated dose-contributing air activation products that were calculated with this rerun. Activation numbers reflect the initial concentration of each isotope after an 8 hr operating period.

The operating day for GTA-1 has since been reduced to 4 hrs and the D. F. from 1 to 0.13 resulting in a factor of 12 reduction. The concentration after daily operation is the

maximum routine release. The normal operating cycle for GTA-1 will consist of running 4 hours/day with 0-16 h of overnight air purge before the beam is turned on the following morning.

TABLE I
GTA-1 AIR ACTIVATION PRODUCTS RELEASES (x approximately 12)

Radionuclide	Half-life	Concentration after 8-hours of operation (Ci/cm ³)	Annual Dose (mrem)
-Ar-41	153.4 min	3.02 10 ⁻⁵	0.28
-N-13	9.96 min	1.55 10 ⁻⁶	7.0 10 ⁻³
-C-11	20.3 min	2.59 10 ⁻⁷	1.5 10 ⁻³
-Cl-40	1.4 min	2.57 10 ⁻⁷	1.2 10 ⁻⁴
-S-37	5.06 min	2.47 10 ⁻⁷	2.0 10 ⁻³
-O-15	2.05 min	1.09 10 ⁻⁷	5.2 10 ⁻⁵
-Cl-39	55.5 min	1.07 10 ⁻⁷	1.0 10 ⁻³
-Cl-38	37.3 min	4.33 10 ⁻⁸	4.5 10 ⁻⁴
-S-38	2.87 hr	5.27 10 ⁻⁹	7.1 10 ⁻⁵
Ar-37	35.1 days	4.69 10 ⁻⁹	6.8 10 ⁻⁸
C-14	5730 yr	1.43 10 ⁻⁹	3.7 10 ⁻⁷
-O-14	1.182 min	1.24 10 ⁻⁹	2.4 10 ⁻⁷
H-3	12.26 yr	6.79 10 ⁻¹⁰	7.0 10 ⁻⁷
-Cl-34	31.99 min	5.27 10 ⁻¹⁰	4.1 10 ⁻⁶
S-35	87.9 days	1.15 10 ⁻¹⁰	4.4 10 ⁻⁹ (vapor)
Ar-39	269 yr	1.10 10 ⁻¹²	2.9 10 ⁻⁸ (particle)
Cl-36	3.08 10 ⁵ yr	8.72 10 ⁻¹⁸	1.7 10 ⁻¹²

Atmospheric dispersion analysis for the ATSU facility indicated that the expected annual whole body dose received at the nearest site boundary for routine release (8 hr day 4 day/wk irradiation time, 1% DF) was 0.3 mrem. (Ref. Appendix V, memorandum, Dewart and Buhl to Olinger, Routine Releases from the Accelerator Test Stand Upgrade, 7/25/85, attached.) The nearest site boundary is the fence bordering State Road 4 (Main Hill Road) 1000 m distant (Fig 11). Emissions from the 50 MeV GTA-1 (0.1% D.F.) are expected to

be approximately 0.025 mrem (a factor of approximately 12 less).

GTA-2: Preliminary air activation data for GTA-2 was computed based on 100 MeV operation, 4 hr/day irradiation time, and to to 16 hr/day decay time. (Ref. Appendix VI, letter, Morford to Cole, "GTA-2 (100 MeV) Air Activation, received at Los Alamos 3/13/86, attached with Table B appendix.) Table II lists primary generated dose-contributing radionuclides likely to result from the GTA-2 process. Activation numbers reflect the initial concentration of each isotope after 4 hours of operation and 0 hrs of decay time. The normal operating cycle for GTA-2 will consist of running 4 h/day with no holdup before purging. The environmental impact calculated in this EA is the maximum expected impact since it addresses the longest run time with venting immediately after the run cycle (no decay time).

GTA-2 AIR ACTIVATION PRODUCTS RELEASES

<u>Radienuclide</u>	<u>Half- Life (s)</u>	<u>Curies after 4 hours Operation</u>	<u>Annual Dose (mrem)</u>
- H-3	3.91E+08	2.01E+00	0.01
Li-5	1.00E-21	4.19E-01	0.00
Be-7	4.58E+06	2.63E-03	.00
B-12	2.02E-02	1.63E+01	0.00
B-13	1.86E-02	4.95E+00	0.00
B-14	1.61E-02	2.34E-03	0.00
- C-11	1.22E+03	3.16E+00	0.19
C-15	2.50E+00	1.56E+00	.00
C-16	7.40E-01	1.43E-04	0.00
N-12	1.10E-02	3.53E-01	0.00
- N-13	5.98E+02	4.43E+00	0.23
N-16	7.20E+00	1.74E+00	.00
N-17	4.15E+00	2.14E-02	.00
N-18	6.30E-01	3.93E-03	.00
- O-14	7.10E+01	3.04E-01	0.01
- O-15	1.24E+02	5.05E-01	0.01
Al-30	7.20E+01	3.76E-03	.00
Si-31	9.40E+03	3.68E-03	.00
Si-33	6.20E+00	2.53E-03	.00
P-30	1.50E+02	1.49E-04	.00
P-32	1.24E+06	1.01E-04	.00
P-33	2.16E+06	1.43E-04	.00
P-34	1.25E+01	1.88E-02	.00
P-35	4.74E+01	7.53E-03	.00
S-35	7.60E+06	2.09E-04	.00
- S-37	3.03E+02	3.08E-01	0.03
- S-38	1.03E+04	5.14E-02	0.01
S-39	1.15E+01	2.09E-02	.00
Cl-33	2.60E+00	1.12E-04	.00
Cl-34	1.56E+00	1.99E-03	.00
- Cl-38	2.23E+03	2.27E-01	0.02
- Cl-39	3.33E+03	3.31E-01	0.03
- Cl-40	8.40E+01	2.80E-01	0.05
Ar-34	8.45E-01	2.73E-04	.00
Ar-35	1.83E+00	6.83E-04	.00
Ar-37	3.02E+06	1.02E-04	.00
- Ar-41	6.59E+03	4.16E-01	0.03

Total = 0.62

Atmospheric dispersion analysis for GTA-2 indicates that the expected annual whole body dose received at the

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nearest site boundary (Main Hill Road) for routine release (4 hr day 4 day/wk irradiation time, 5% DF) was 0.6 mrem. (Ref. Appendix VII, memorandum, Buhl and Bowen to Olinger, Dose Assessments for Routine and Accidental Releases of Radioactive Materials from the Ground Test Accelerator (GTA)-2, 3/27/86, attached.)

The DOE has recently revised radiation protection standards for the public. The pertinent standards are a) 100 mrem/yr effective dose equivalent for a limited number of years of exposure, and b) 25 mrem/yr whole body dose for air pathways. The latter standard corresponds to the Environmental Protection Agency continuous exposure limit issued in 40 CFR 61, 1/85. Recent engineering design improvements to the LAMPF beam stop area have significantly reduced LAMPF's release of activation products to the atmosphere (from 44 mrem in 1984 at the nearest site boundary to approximately 7.3 mrem in 1985). The expected GTA releases will not affect LAMPF compliance with DOE 5480.1A or with CFR 61.

The Laboratory environmental monitoring program monitors radiation from airborne activation products released by LAMPF. The prevailing winds are from south and southwest. A source term for the release of all radionuclides except tritium (H-3) is obtained from ion chamber measurements that continuously sample stack flow. Thermoluminescent dosimeter (TLD) measurements provide a direct dose for the source term values. (Tritium is monitored separately and continuously within the release point stack.) Twelve TLD sites are located downwind at the Laboratory boundary north of LAMPF along 800 m of canyon rim. Twelve background TLD sites are about 9 km from the facility along a canyon rim near the southern boundary of the Laboratory. This background location is not influenced by any Laboratory radiation

sources. The 24 TLDs are changed each calendar quarter or sooner, if LAMPF's operating schedule dictates (start-up or shut-down of the accelerator for extended periods mid-way in a calendar quarter). The radiation measurement (above ground); (11 ± 2 mrem for 1985) is obtained by subtracting the annual measurement at the background sites from the annual measurement at the Laboratory's boundary north of LAMPF.

Continuing study of potential radiation associated with the GTA will add considerably more detail to existing data. This study will be completed by the time the safety assessment (GTA-1); Preliminary Safety Analysis Report (PSAR), and Final SAR (GTA-2) are prepared and will be used in their analyses.

c) Effluents. Waterborne effluents will consist of routine sanitary waste from restrooms at the facilities and occasional releases of slightly activated waste cooling water used to cool magnets and beam stops. Nuclides expected to be present in the GTA cooling systems consist mainly of water activation products such as H-3, Be-7, C-11, N-13, and O-15. The presence and relative abundance of these nuclides will be different for the two facilities due to the two different accelerating energies (50 MeV and 100 MeV). The coolant systems will also contain some amount of component spallation and corrosion products. These products would be expected to contain radioactive isotopes of Co, Cu, Fe, Mn, V, Cr, and Ni. During normal system operating such products will be removed from the coolant stream and concentrated in the demineralizer beds.

The GTA-1 circulating water system will contain approximately 2200 gal and the GTA-2 system approximately

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2500 gals. The cooling water will be drained at intermittent times into the TA-54 sewage system. Effluent radioactivity is not considered a hazard for the sewage system. Personnel in the Accelerator Health Protection Group (HSE-11) routinely monitor the circulating water system. When it is necessary to drain the system and dispose of the water, proper procedures will be implemented based on the level of activation. The radioactivity in the water will generally be allowed to decay to acceptable levels and then disposed of in the TA-53 lagoons. If such disposition would cause concentrations in the lagoons to exceed DOE regulations, the water will be removed to the Laboratory radioactive liquid waste facility at TA-50 and disposed of there. In past years radioactivity in effluents released from the TA-53 lagoons was reported annually to the DOE and the Environmental Protection Agency. Aerators have been added to the two original lagoon cells and a third cell was added in 1985. Since then no liquid effluent has been discharged from these lagoons and none is expected to be in the future.

The GTA projects are funding a proportionate share of an upgrade of the TA-53 sewage lagoons to ensure compliance with National Pollutant Discharge Elimination System (NPDES) requirements. The upgrade has been completed. Effluent from the GTA complex will not be in sufficient quantity to affect the Laboratory NPDES permit.

d) Soil Activation. Of the four beam stops for the two facilities, none provide an opportunity for soil activation. Consequently, nuclide migration from the GTA site is not likely. The beam stops are located near the centers of the buildings and are thus not subject to direct exposure from rain water. Surface water drainage paths do

not lead under the proposed buildings, and ground water is approximately 900 feet below the site elevation (reference document *). There is no known mechanism for transporting nuclides from the beam stop area to the ground water.

2. Risk of Credible Accidents

2.1. Potential Hazards and Impacts of Possible Accidents. The GTA facilities will be in a controlled access area; however, visitors may occasionally be present. During machine operation, all personnel (including visitors) are normally excluded from hazardous areas within the facility. Hazard to workers will occur in the debugging or checkout stages when normal protection measures must be bypassed. Special work permits will be used for these instances.

1) Radiation. The primary radiation hazard concerns are component activation and prompt radiation along the DTLs, HEBTs, and at the beamstops. Only low-level x-rays will be produced in the GTA injector. A modest thickness of steel or lead will eliminate any personnel hazard from this 100 KeV-radiation source. ~~Relatively high~~ electric fields inside the radio frequency quadrupole (RFQ) will also produce x-rays. Generally, these are well shielded by tank walls, but some leakage [well below the 5000 mrem/yr or 3000 mrem/qtr DOE occupational exposure RPS (5480.1A)] is anticipated from several parts. Neutrons coming back from the high-energy end of the DTL will be the dominant source of neutrons in the RFQ.

*Vadose Zone Characterization of Technical Area 54, Waste Disposal Areas G and L, Los Alamos National Laboratory, New Mexico. Report 3: Preliminary Assessment of the Hydrological System, Bendix Field Engineering Corporation, March 1986.

An accident situation involving release of activated air in excess of that routinely generated after normal daily operating time is not considered credible. The maximum total activated air present at one time, if accidentally released, could result in a whole body dose of 0.0007 mrem at the site boundary for GTA-1 and 0.8 mrem for GTA-2. The largest dose calculated for an unplanned release (GTA-2) was 98 mrem (whole body) occurring onsite near the GTA-2 facility. These doses can be compared to the 25,000 mrem (whole body) accidental release siting guideline proposed for DOE Order 6430.1.

2) Accidental Beam Spill in the Beam Line.

Malfunction of a beam component could allow the beam in GTA-1 or GTA-2 to burn through the aluminum beam pipe and potentially dump the ~~entire-short~~ beam pulse in the beam tunnel before monitors detect the anomaly and turn the injector off. The resulting activity would be contained in the stagnant air volume of the beam tunnel until radiation monitors indicate safe levels for personnel entrance.

3) Failure of RF Waveguide or Coax. Failure

4) High-Voltage Shorts. High-voltage shorts in the capacitors and their conductor system or a complete failure of the capacitor case could allow a small amount of oil to flow onto the capacitor room floor. This accident might result in a fire and noxious gases or smoke. The capacitor room in each facility will be barred to personnel

access during operation and will have a fire suppression system designed to control gasses and smoke.

5) Vacuum Vessel Collapse. While evacuated, a large vacuum vessel could collapse. These vessels will be designed to the intent of applicable provisions of the American Society of Mechanical Engineers (ASME) Boiler Code, but will not be "code stamped."

6) Lifting and Transporting. There will be the usual mechanical hazards associated with lifting, transporting, and placing large (20 ton) shielding blocks by crane.

3. Site Restoration After Decommissioning. At the completion of the GTA project, the GTA facilities will be used for other AT Division accelerator research programs. The complex is expected to have a useful life of many decades in the ongoing high energy physics research program of the US Government. Should the GTA complex have to be abandoned or decommissioned as a useful work area, all radioactive materials will be disposed of using approved techniques of the time.

4. Unavoidable Impacts. Unavoidable environmental impacts from the proposed project are consistent in nature and scope with current activities at the Laboratory

Impacts include short-term and routine dust, noise, and drainage disruption associated with heavy construction. The GTA-1 will modify an existing building. The GTA-2 will be constructed in an undeveloped area. Land ecology inside the undeveloped area will be altered. Existing plants will be eliminated and small animals dislocated. Construction of

the GTA complex will impair an archaeological resource: a small lithic and ceramic scatter. This material will be collected and documented prior to construction according to procedures approved by the New Mexico State Historical Preservation Office. A ^{newly} ruin will be cleared of debris and fenced by the project. 1022.1.2
yes

Radioactive emissions will not significantly affect TA-53 compliance with the DOE Radiation Protection Standard (RPS) for members of the public for exposure from the air pathway (Order 5480.1A). The GTA will add approximately 0.6 mrem/yr to the LAMPF whole body dose. Based on 1985 measurements, the total LAMPF whole body dose including that from the GTA, will be approximately 8 mrem, or about one-third of the 25 mrem RPS. The current maximum individual whole body dose possible at a Los Alamos National Laboratory boundary is approximately 11.4 mrem (1985). GTA effluents will not affect NPDES compliance at TA-53.

Cumulative impacts on the Laboratory from the proposed project include reserving approximately 5 acres of land at TA-53 for GTA use, precluding allocation of the land for future programmatic activities at TA-53. Traffic along East Jemez Road and within TA-53 will be increased by traffic associated with the facility.

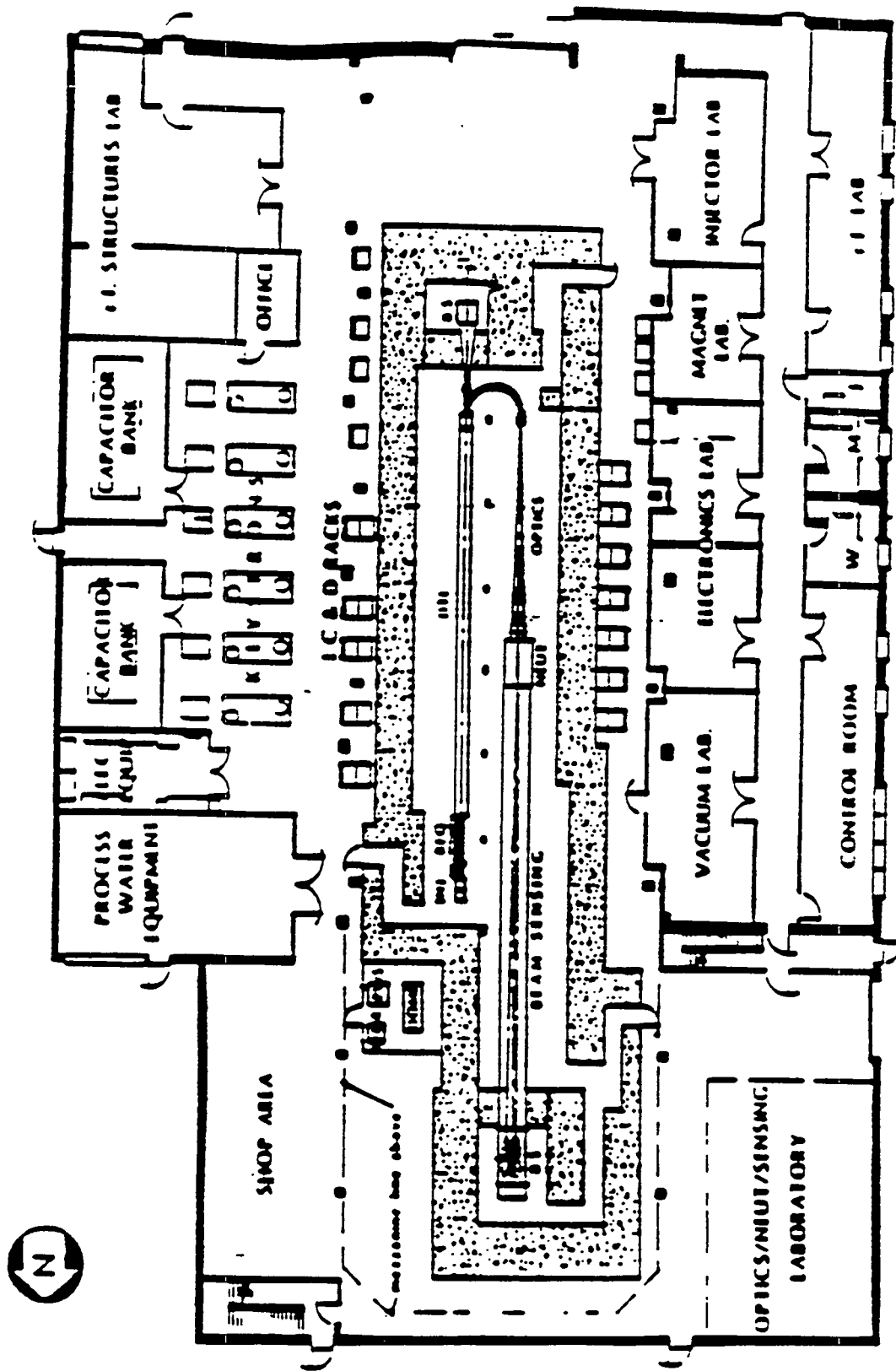
V. AGENCIES AND/OR PERSONS CONSULTED, INCLUDING COORDINATION WITH FEDERAL, STATE, REGIONAL, AND LOCAL AGENCIES

This Environmental Assessment was reviewed by personnel in the Health, Safety, and Environment (HSE) and Facilities Engineering (ENG) Divisions, and by the Accelerator Technology Systems Integration Group (AT-4). It was approved by

the Laboratory Environmental Review Committee. Archaeological adverse impact mitigation is being reviewed by the New Mexico State Historical Preservation Officer. No known conflict exists with any federal, state, regional, or local plan.

VI. ADDITIONAL DOCUMENTATION

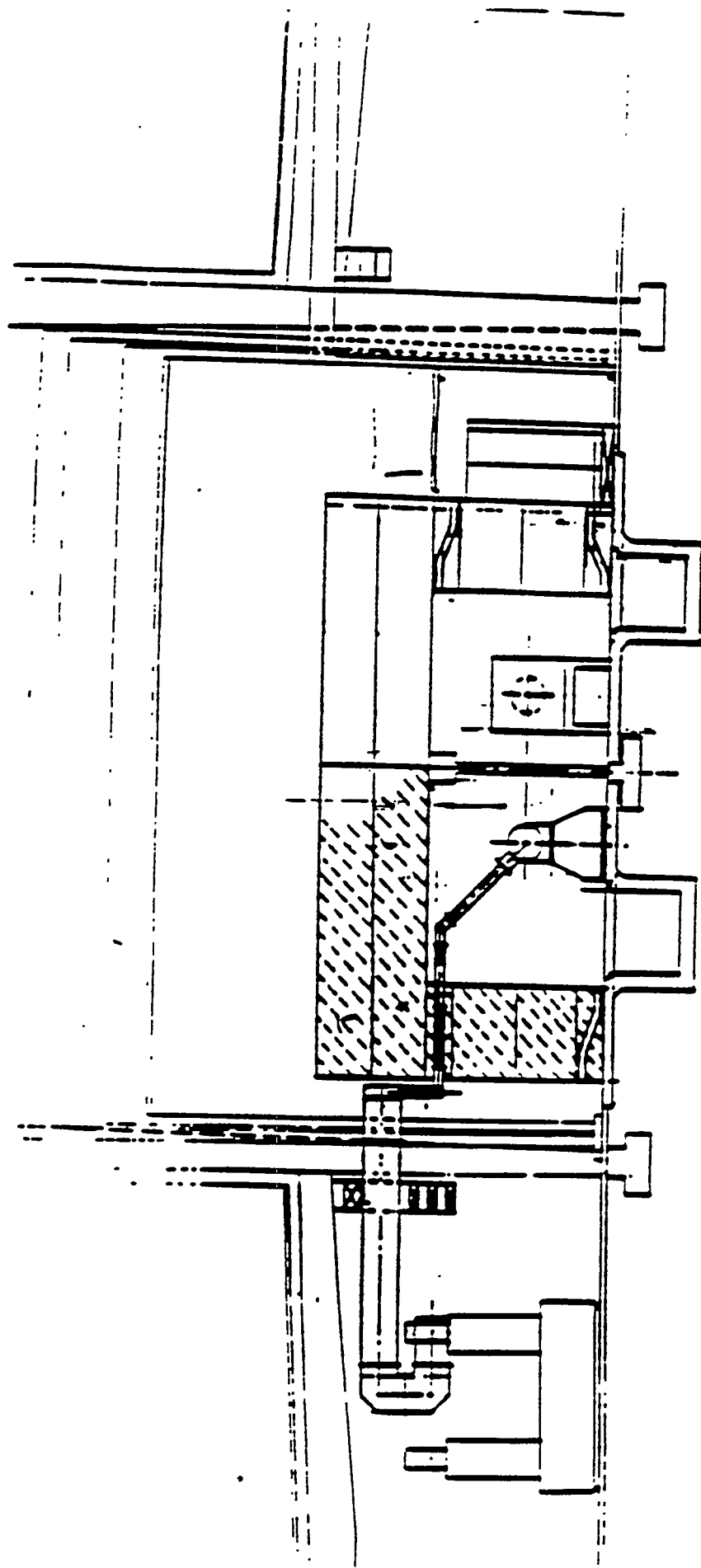
A preoperational site survey of existing environmental conditions at this site is ongoing in accordance with DOE Order 5484.1. A draft safety assessment for GTA-1 will be prepared prior to building construction. A final version will be required prior to operation. A PSAR will be prepared for GTA-2, and an PSAR will be required prior to operation.



GIA-1 CONCEPTUAL ARRANGEMENT

(P R E L I M I N A R Y)

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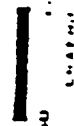


(PRELIMINARY)

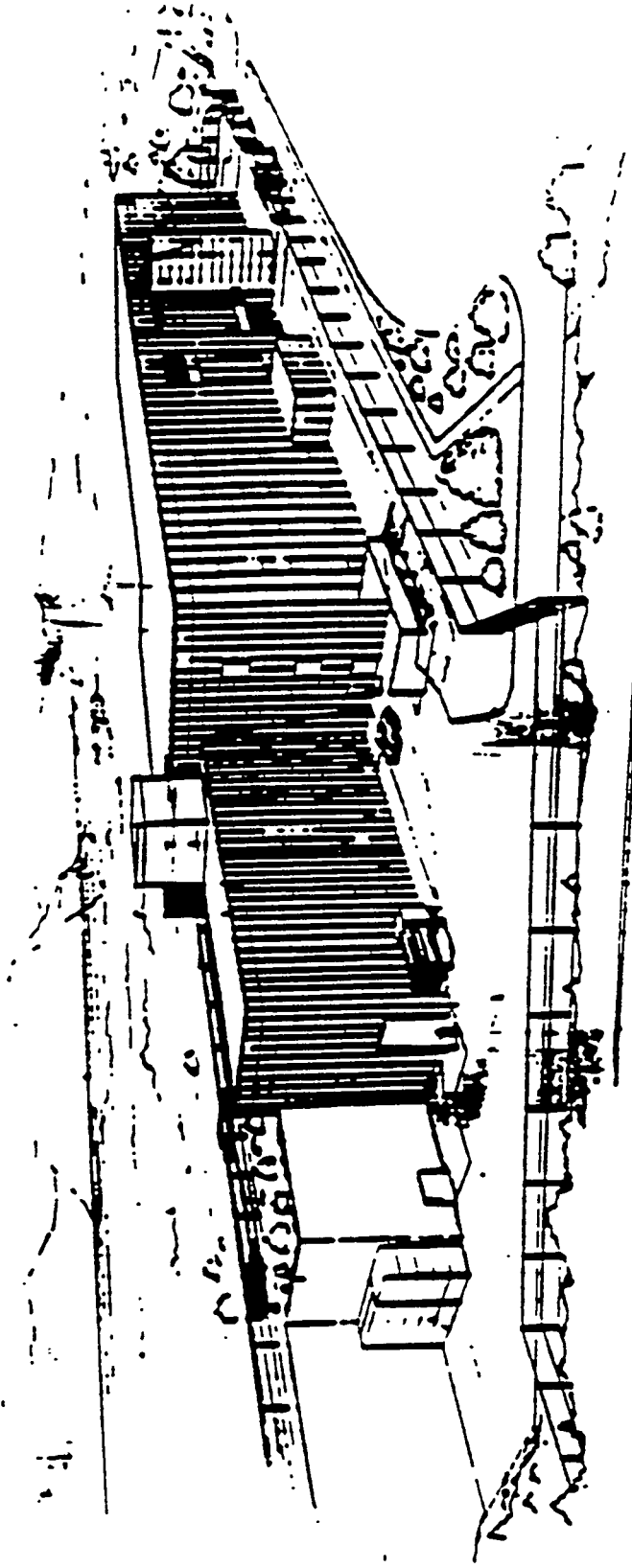
SECTION



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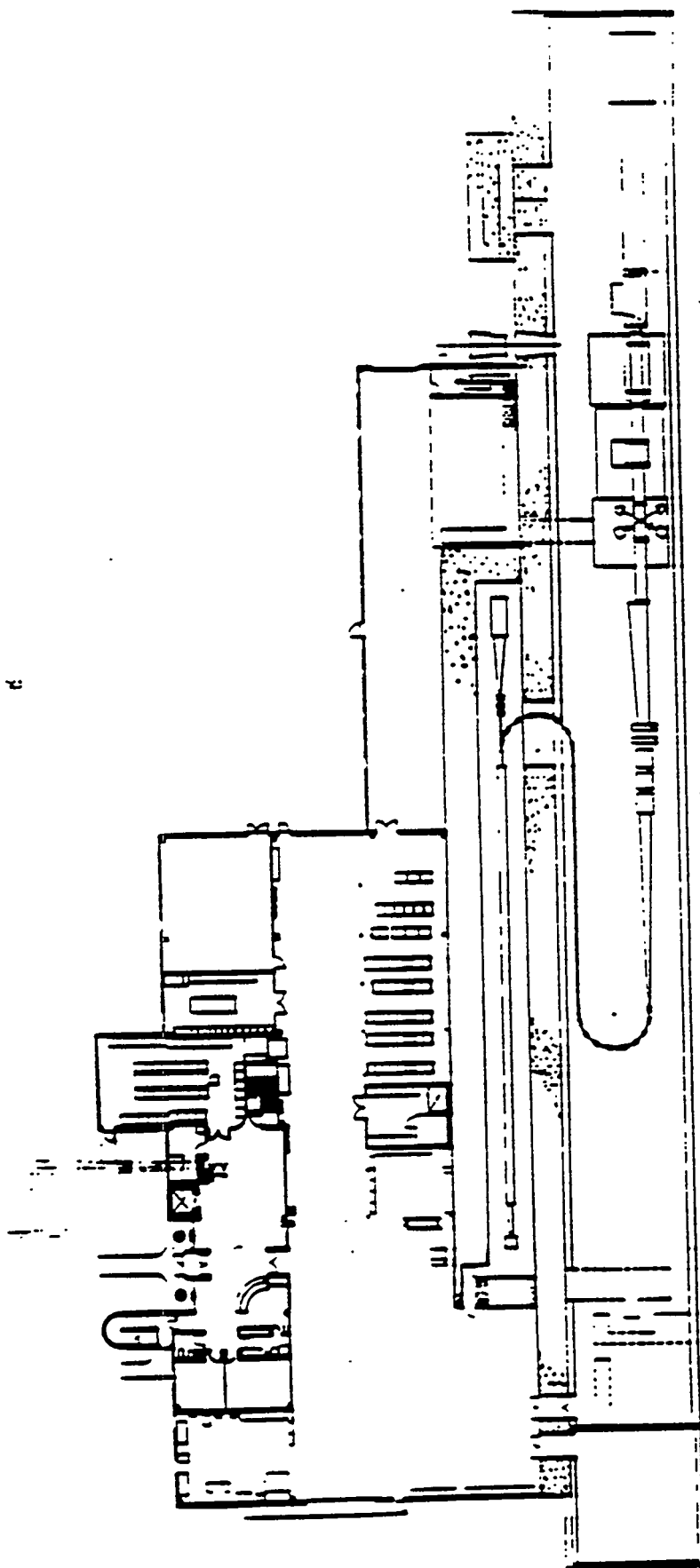
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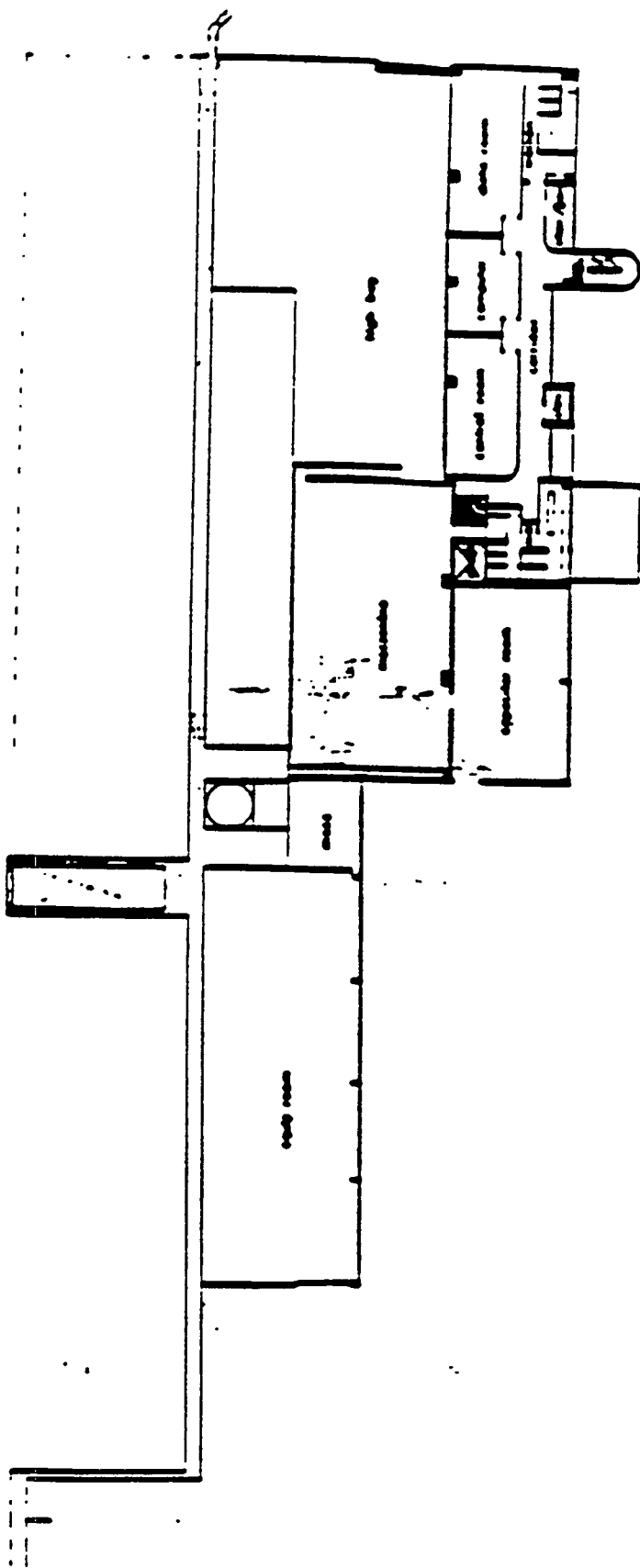


GIA-2 Final Preliminary layout

FIRST FLOOR PLAN

5-1-86

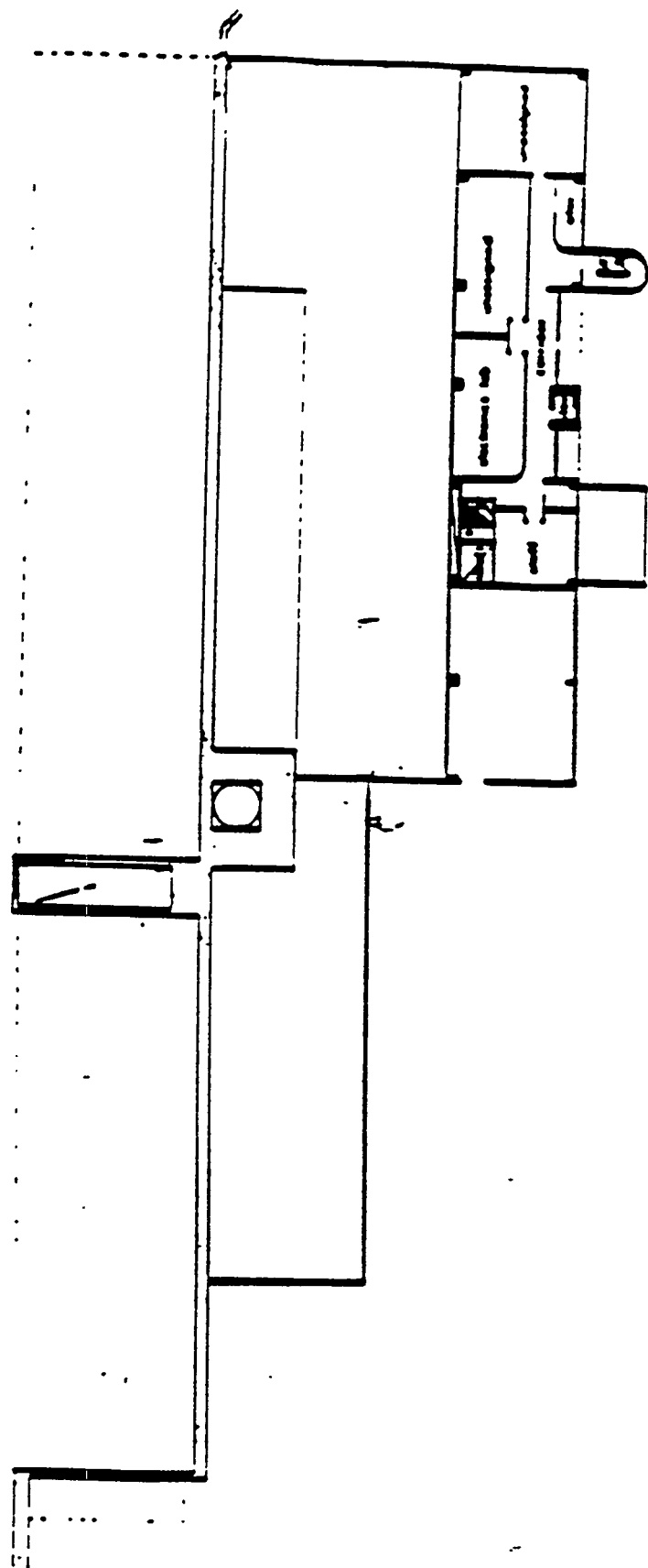
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SECOND LEVEL

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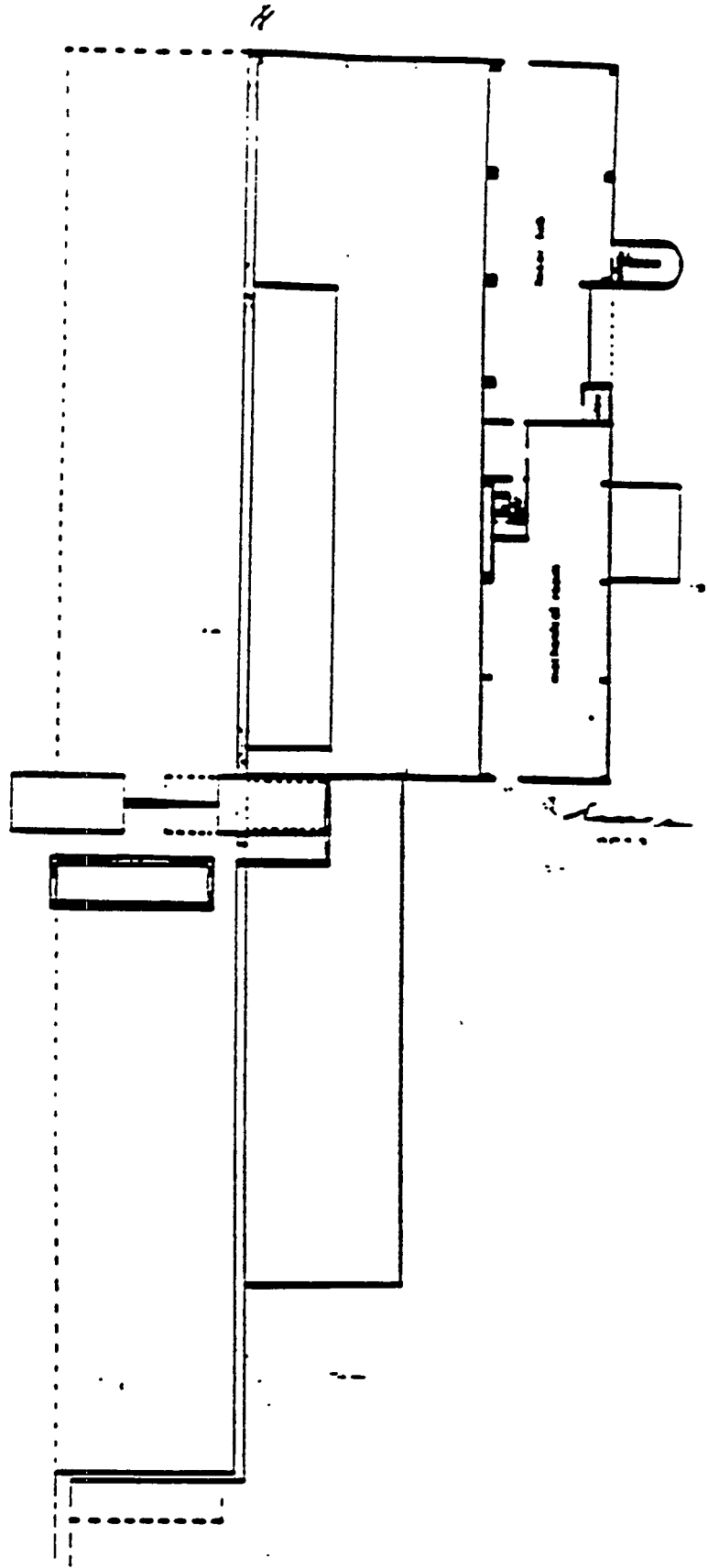
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THIRD LEVEL

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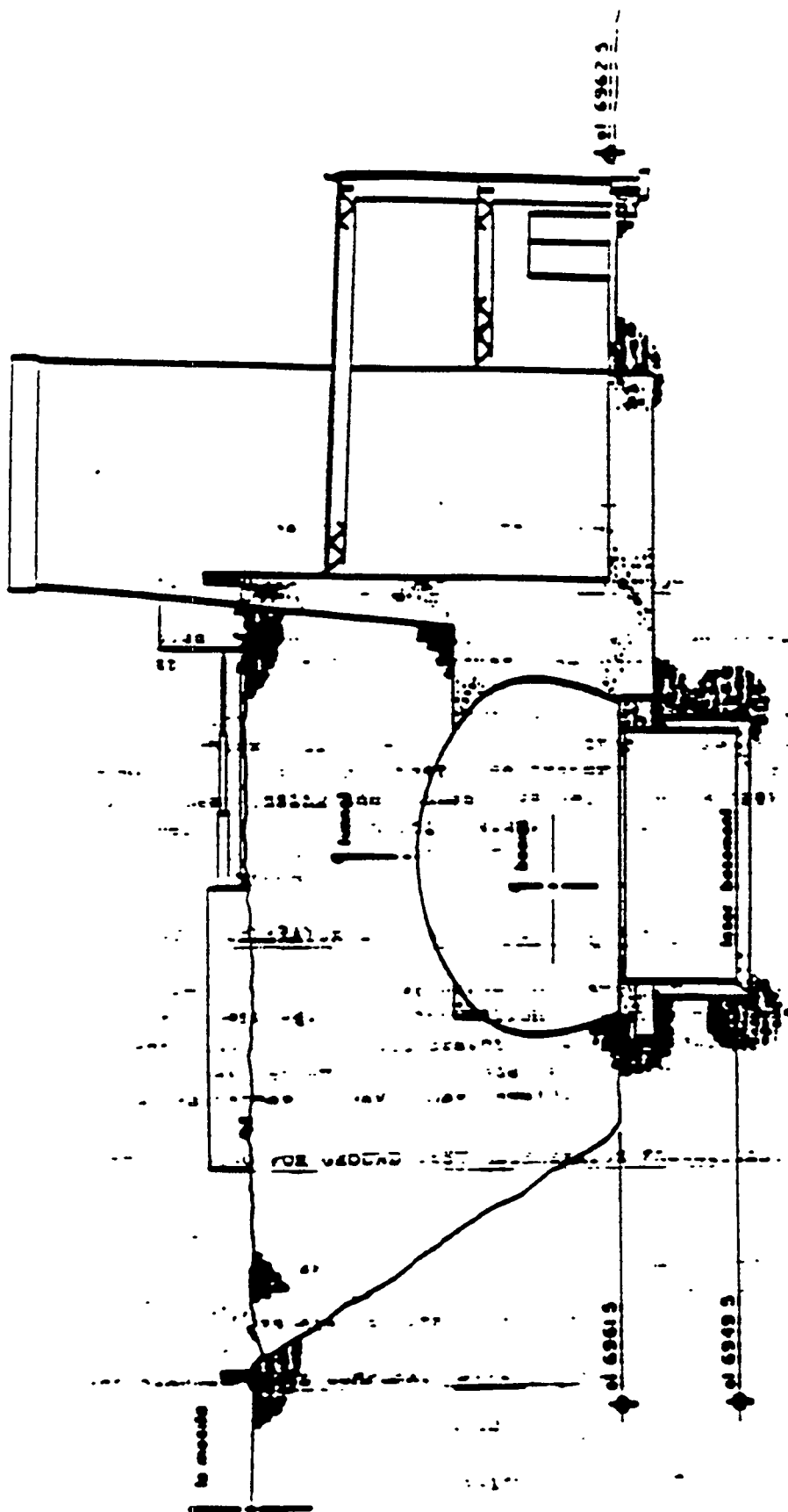
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FOURTH LEVEL

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SECTION A

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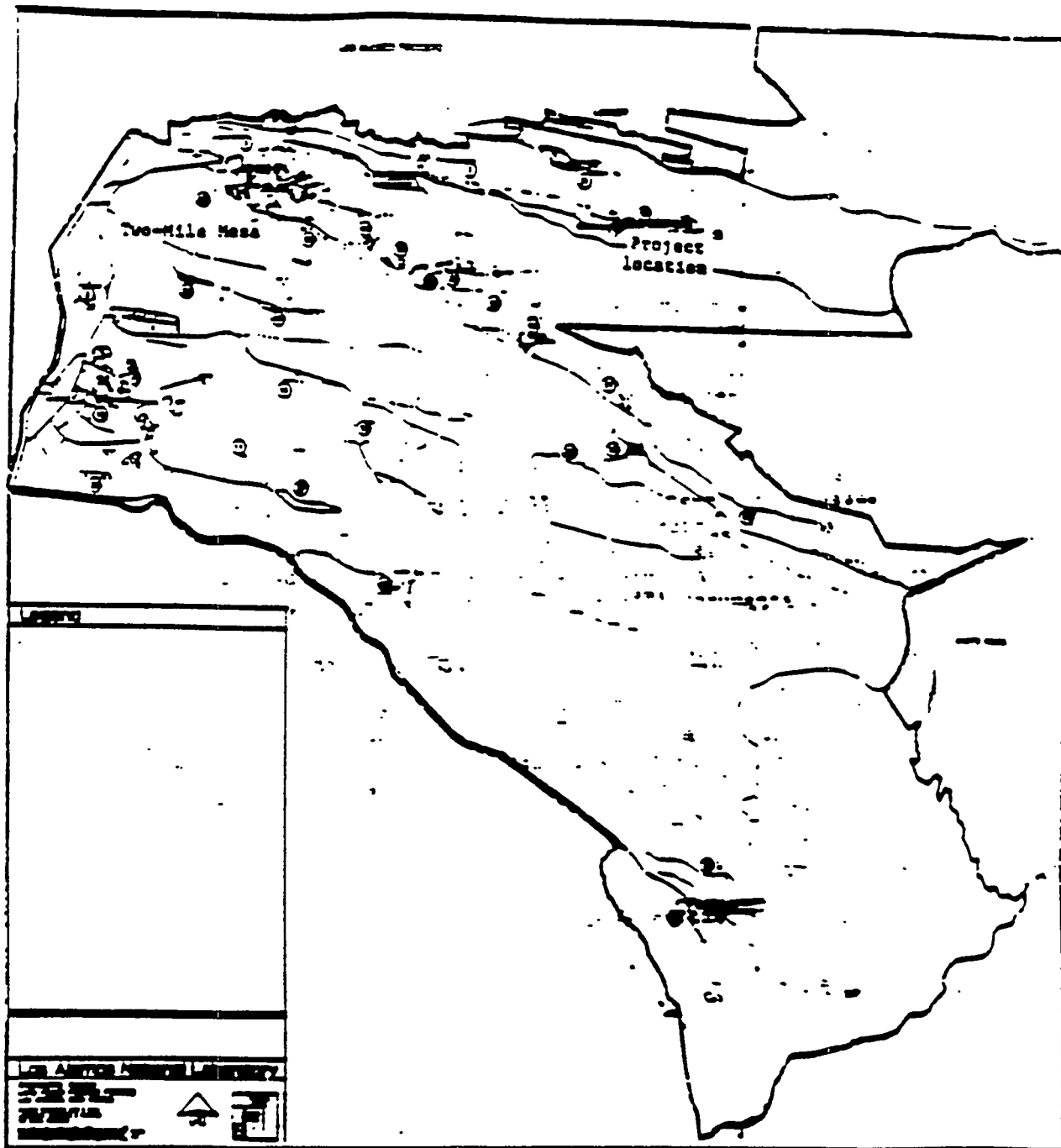
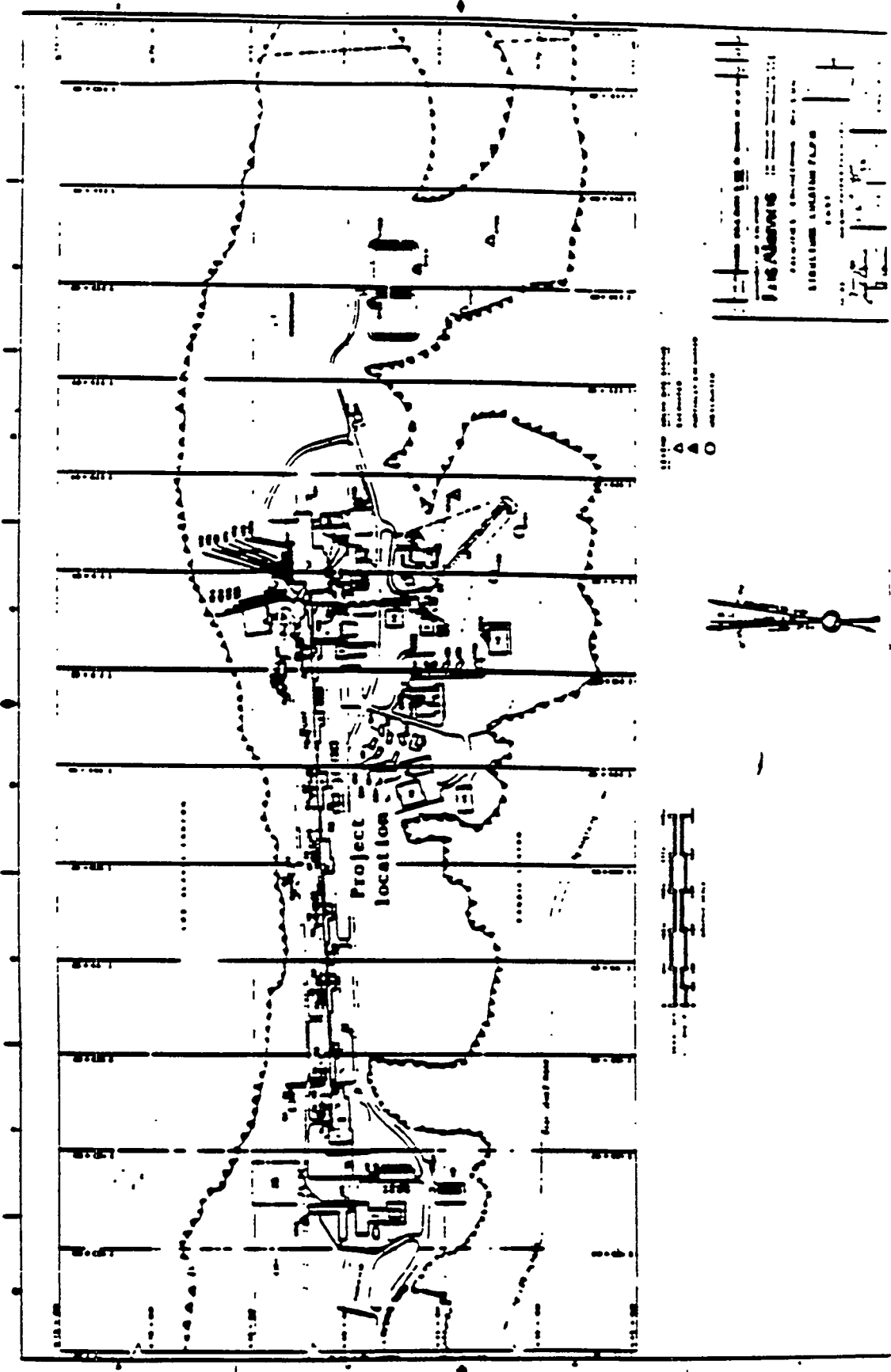
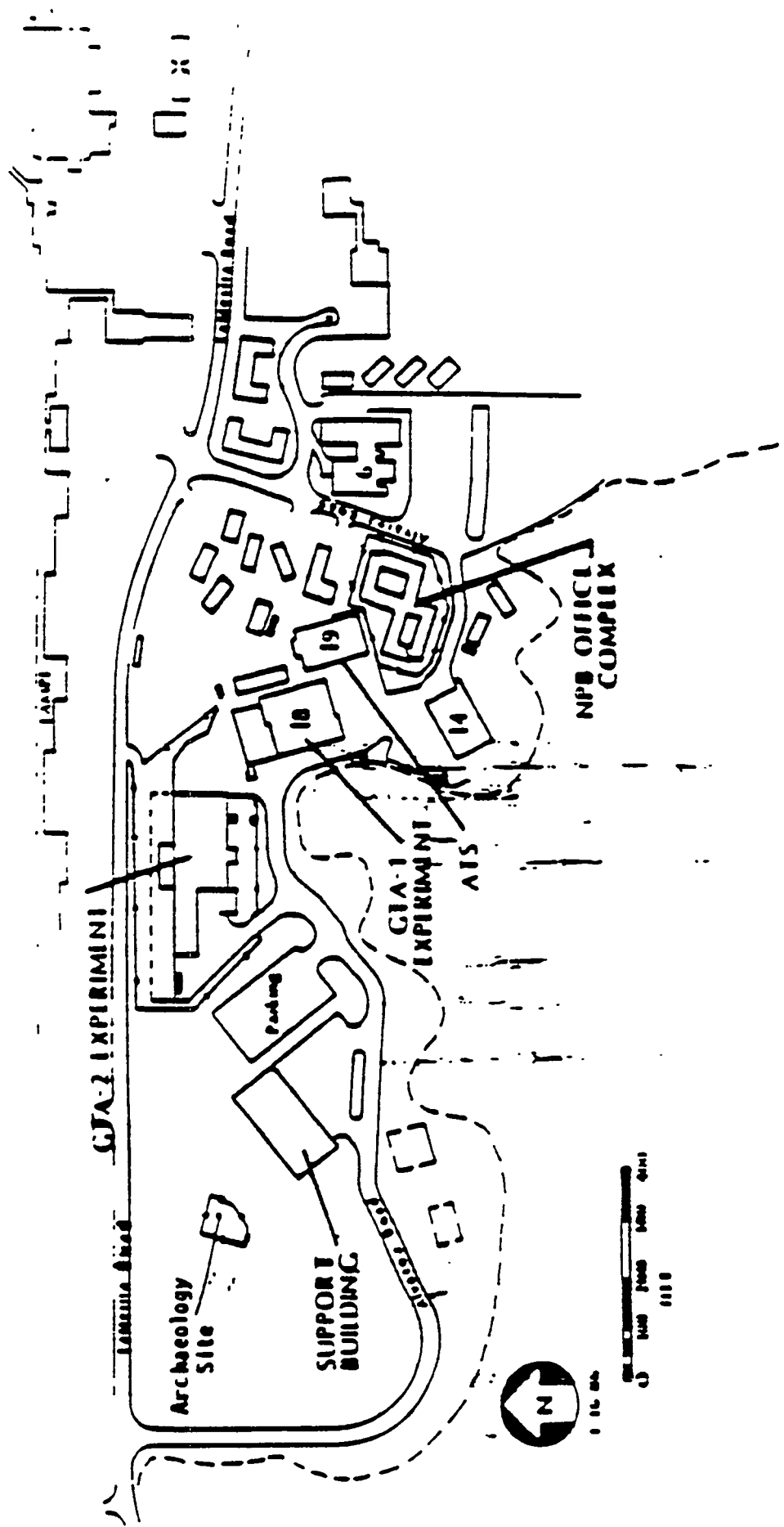


Fig. 9.

1 4 6 0 0 6 4 7





SITE PLAN - AT-DIVISION LABORATORY BUILDINGS

memorandum

Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

DATE MAY 09 1986
REPLY TO
ATTN OF LRDT:DL/4827A
SUBJECT Ground Test Accelerators 1 & 2 - Comments on Environmental Assessment

TO: A.J. Tiedman, ADTS, MS-A120

Please finalize the Environmental Assessment for Ground Test Accelerator (GTA) 1 and 2 incorporating the attached DOE Headquarters' comments (attachment 1) and AL comments (attachment 2). Furnish eight copies of the Assessment to me on or before May 23, 1986. Also attached for your information is Garcia-Dobes Memorandum, dated April 15, 1986, which transmitted to Headquarters, the draft FONSI prepared by the Laboratory.

Please note that action to obtain an agreement from the State Historic Preservation Officer is underway (attachment 4).

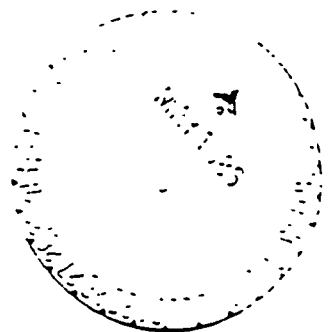
Harold E. Valencia
Area Manager

Attachment

1. Garcia-Valencia Memo, dtd. 5/06/86 w/3 att.
2. Garcia-Valencia Memo, dtd. 4/23/86
3. Garcia-Dobes Memo, dtd. 4/15/86
4. Valencia-Fink Letter, dtd. 5/02/86 w/encl.

cc w/att.:

T.C. Jones, OSPA, AL
C.E. Garcia, ESHD, AL
H.F. Mumma, FCMD, AL
W. Myers, DADDCP, MS-F614, LANL
J. Jansen, DRPDEW, MS-H818, LANL
J. Allen, ENG-DO, MS-K721, LANL



memorandum

Albuquerque Operations Office

DATE MAY 6 1986
REPLY TO
ATTN OF: WOE:RFR

En 25
Dns 5

SUBJECT: Changes to the Environmental Assessment (EA), Ground Test Accelerators (GTA) 1 and 2, TA-53

TO: H. E. Valencia, Area Manager, LAAO

The Office of Environment, Safety and Health, DOE Headquarters has completed their review of the subject EA and has approved the document contingent on changes as noted in the attachments. Please submit a revised EA, which should include the changes as recommended by Headquarters, as well as the AL comments transmitted to you by my memorandum dated April 23, 1986.

The attachments include: 1) the approval memorandum signed by M. L. Walker, April 25, 1986, 2) a Finding-Of-No-Significant-Impact (FONSI) as revised and approved by M. L. Walker on April 25, 1986, for information only, and 3) comments on the EA.

The approval of the EA is contingent on an agreement with the State Historic Preservation Officer that any significant impacts on the two archaeological resources discussed in the EA will be mitigated, as reflected in the first attachment. Address this issue in the EA by referencing the mitigation plan with the State and by providing a copy of the concurrence letter by the State Historic Preservation Officer. Also, indicate the current status of the mitigation procedures. In addition, the approval of the EA is contingent on the incorporation of the comments on the last attachment into the EA. These comments were handwritten by Headquarters and a clarification provided by AL where the copy was illegible. If there are any questions regarding this subject please contact Randy F. Reddick at FTS 846-4340.



Carlos E. Garcia
Director
Environment, Safety and Health Division

3 Attachments

cc:
C. E. Olinger, HSE-8, LANL
MS-K490

ATCH 1

DATE APR 25 1986

Randy Kean
836-4340

U.S. DEPARTMENT OF ENERGY
memorandum

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3

TO
FROM

EH-23

SUBJECT

Environmental Assessment for Proposed Ground Test
Accelerators 1 and 2 at the Los Alamos National Laboratory

TO

S.R. Foley, Jr., DP-1
Assistant Secretary for Defense Programs

This is in response to an April 18, 1986 request from Captain
Dobes to review and approve of the environmental assessment (EA)
for the proposed construction and operation of Ground Test
Accelerators (GTA) 1 and 2 at the Los Alamos National Laboratory
in New Mexico.

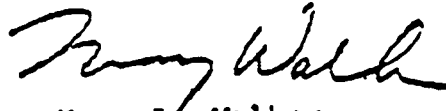
Comments on the EA are provided in the attached marked-up copy.
These comments have been discussed with your staff and with the
staff at the Albuquerque Operations Office and they have agreed
to make the necessary changes. Contingent on the incorporation
of these changes, the EA, in our judgment, presents an adequate
assessment of the environmental effects associated with the
proposed construction and operation of the GTA facilities.
Accordingly, the EA is approved. The Department of Energy number
assigned to the EA is DOE/EA-0304.

Based on the EA, we have determined, after consultation with the
Office of the General Counsel, that the proposed action is not a
major Federal action significantly affecting the quality of the
human environment, within the meaning of the National Environmen-
tal Policy Act (NEPA). Therefore, the preparation of an environ-
mental impact statement is not required. The basis for this
determination is explained in the attached Finding of No
Significant Impact.

This determination is contingent on obtaining agreement with the
State Historic Preservation Officer (SHPO) that there will not be
any significant environmental impacts on the two archaeological
resources discussed in the EA. Until that agreement is reached,
these resources should be protected during construction activi-
ties until a mitigation plan acceptable to the SHPO is agreed on.

Defense Programs is responsible for providing public notice of
the availability of the EA and Finding of No Significant Impact
as required in Section 1506.6(b)(3) of the Council on

Environmental Quality Regulations for Implementing the Procedural
Provisions of the NEPA. Please send three copies of the
finalized EA for our files.



Mary L. Walker
Assistant Secretary
Environment, Safety and Health

Attachments (2)

14600634

U.S. DEPARTMENT OF ENERGY

FINDING OF NO SIGNIFICANT IMPACT

GROUND TEST ACCELERATORS (GTA) 1 AND 2, IN AREA TA-53

AT LOS ALAMOS NATIONAL LABORATORY NEW MEXICO

AGENCY: U.S. Department of Energy

ACTION: Finding of No Significant Impact for the construction and operation of two ground test accelerators, GTA-1 and GTA-2

SUMMARY AND FINDING: The Department of Energy (DOE) has prepared an environmental assessment (EA) on the construction and operation of two ground test accelerator facilities, GTA-1 and GTA-2, at Technical Area (TA)-53, Los Alamos National Laboratory in northern New Mexico (DOL/EA-0304). Based on the findings of the EA, which is available to the public on request, the DOE has determined that the proposed action is not a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969 (NEPA). Therefore, the preparation of an environmental impact statement is not required.

DESCRIPTION OF PROPOSED ACTION AND EFFECTS: The proposed facilities are ground-based prototype accelerators which will be key components in the nation's Neutral Particle Beam (NPB) program. The NPB program is intended to assess the feasibility of

neutral particle beams as directed energy weapons outside the earth's atmosphere. Both GTA-1 and GTA-2 are 100 mA, H^+ , H^- , and H^0 proton accelerators. The 50 MeV GTA-1 will serve as a test bed and front-end for the 100 MeV GTA-2. Construction is projected to begin in 1986, and be completed in 1990.

No significant environmental impacts associated with the construction and operation of the proposed proton accelerators were identified in the EA:

Air Quality -- Radioactive emissions from operation of the accelerators will be "as low as reasonably achievable" and less than the Department of Energy occupational exposure radiation protection standard (RPS) of 0.5 mrem/hr (proposed revision, DOE Order 5480.11) by holding activated air for radioactive decay until the RPS is met. No activated air will be circulated or exhausted during accelerator beam operations. Radiation shielding will be approximately 8 ft of high density (HD) concrete for the GTA-1 beam stop and 9 ft of HD concrete for the GTA-2 beam stop. When the beam is off, air will be vented from each accelerator through a high efficiency particulate air (HEPA) filter bank and an exhaust stack. Annual radioactive emission whole body doses at the nearest Los Alamos National Laboratory boundary are calculated to be approximately 0.025 mrem for GTA-1 and 0.6 mrem for GTA-2. The Department of Energy radiation protection standards for the public are: (1) 100 mrem/yr effective dose equivalent for a limited number of years of exposure; and (2) 25 mrem/yr whole body dose for air pathways. The Environmental

Protection Agency standard for routine radiological releases to the atmosphere (40 CFR 61) is 25 mrem/yr to the maximum individual. The current maximum individual annual dose from radioactive emissions from all Los Alamos National Laboratory activities is approximately 11.4 mrem/yr (1985).

Water Quality -- Slightly activated cooling water will be drained intermittently from the accelerator facilities. Effluent radioactivity is not considered a hazard. The cooling water will be monitored and allowed to decay to acceptable levels before disposal in the TA-53 sewerage lagoons. If such disposition would cause concentrations in the lagoons to exceed DOE regulations, the water will be removed to the Los Alamos National Laboratory radioactive liquid waste facility for disposal. The TA-53 lagoons were recently upgraded to comply with National Pollutant Elimination Discharge System (NPDES) standards; the projected effluent will not affect compliance.

Cultural Resources -- Two archaeological resources are located within or near the project area. Adverse impact mitigation to the archaeological resources is being determined in consultation with the New Mexico State Historic Preservation Officer in compliance with 36 CFR Part 800. The GTA-2 project will, prior to any construction, fence a registered prehistoric ruin located immediately west of the project area. Archaeologists will collect, prior to any construction, available fragments of an unrecorded prehistoric pottery and tool fragment site located inside the project area and will subsequently analyze the

Land Ecology -- Construction activities will increase short-term soil erosion and eliminate existing plants and animals over a partially developed 5-acre site. No threatened and endangered species are known to occupy the site. Runoff control and landscaping measures will be taken to minimize impacts according to requirements of Los Alamos National Laboratory land protection standards.

Socioeconomic Resources -- Construction of the GTA projects will require an average work force of less than 50 people over a 4-year period. The employees will be drawn primarily from the existing pool of construction workers in the northern New Mexico area. Operation and maintenance of the accelerator facilities will offer employment for relatively few workers not already employed at the Los Alamos National Laboratory and will not significantly affect local employment levels.

ALTERNATIVES: Three alternatives to the proposed construction of the GTA facilities were considered. The alternatives were: (1) an alternate site not at the Los Alamos National Laboratory; (2) siting at an alternate location at the Los Alamos National Laboratory; and (3) no action.

FURTHER INFORMATION: For further technical or program information or to obtain a copy of the DA, contact:

Randy F. Reddick
Environment, Safety and Health Division
Albuquerque Operations Office
U.S. Department of Energy
Albuquerque, New Mexico 87115
(505) 846-4340

For further information on the NEPA process regarding this action, contact:

Dr. Robert J. Stern, EH-23
Director
Office of Environmental Guidance
Office of the Assistant Secretary
for Environment, Safety and Health
U.S. Department of Energy
Washington, D.C. 20585
(202) 252-4600

Issued at Washington, D.C. this 25th day of April, 1986.



Mary L. Walker
Assistant Secretary
Environment, Safety and Health

Ignore -
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They re-
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transmission

~~T. A. Cole, AT 47-15-8821 (CO)~~ Delete
March 1966

I. CONCISE DESCRIPTION OF THE PROPOSED ACTION

The proposed action is construction ^{and operation} of ^{plural} a ground-based prototype accelerator^s at Los Alamos National Laboratory. The GTA facility^s will be a key component in the nation's Neutral Particle Beam (NPB) program. The national Neutral Particle Beam (NPB) program is composed of three major elements: (1) the technology base, (2) the space flights of the Integrated Space Experiments (ISE) program, and (3) the ground test accelerators (GTA) supporting ISE. The accelerators, GTA-1 and GTA-2 require two facilities with a total estimated cost (TEC) of \$3.2 million (GTA-1) and \$19.4 million (GTA-2). The GTA was formerly titled Accelerator Test Stand Upgrade (ATSU).

^{and operation} The GTA project will consist of constructing and equipping in sequential phases two beam tunnels/accelerator-laboratory buildings. A parking lot and access roadway are part of the GTA-2 project. Two other projects, Support (Staging) Building for GTA Facilities and Transportable Office Complex (NPB Technical Support Building) (LJ 7727) will complete the GTA complex at TA-53. The Support (Staging) Building will serve as a transshipment and storage center and the (Technical Support Building) will provide office facilities for 200 people. Laboratory personnel prepared Action Description Memorandums (ADMs) for both buildings in January 1986. The Department of Energy (DOE) ^{determined that} ~~is requiring~~ no further documentation for these facilities^{is required}. (Ref. attached memorandum, Valencia to Adams, Environmental Documentation: Strategic Defense Projects at TA-53, 2/05/86.)

GTA-1: The GTA-1 prototype is the front-end of GTA-2 and will also serve as the technology demonstration test bed for ISE-1. The GTA-1 will be a 50 MeV, 100 mA, 0.1% duty

Los Alamos National Laboratory
NPB questions for a number of years. Recently, the NPB Program was incorporated into the Strategic Defense Initiative established by President Reagan. The proposed GTA program will be a key component in this country's NPB program. 11

The GTA will provide important data for development of a near-term space directed energy weapon demonstration. The GTA prototypes will be developed, built, and operated to demonstrate solutions to technological problems in integrated full scale systems. Prototypes are a necessary step toward space experiments. The GTA will demonstrate experimentally critical space parameters. For instance, ability to sense and control the output beam is a critical physics issue that must be addressed to prove feasibility of delivering a neutral particle beam to a distant target.

The GTA facilities will provide space and tools for investigating other NPB program issues. They will provide answers to a number of general physics questions. They will also facilitate Los Alamos efforts to transfer accelerator physics technology to private industry.

III. ALTERNATIVES TO THE ACTION

Alternative Site Not at Los Alamos National Laboratory

A. ~~Rejection~~

Enure the

If the GTA prototypes are not built at the Los Alamos National Laboratory, the programmatic impact is considered to be a minimum 3-year slip in the NPB program and the possibility of moving the entire Los Alamos effort elsewhere.

12

operating personnel. This location avoids operating accelerator Technology (AT)-Division research between two or more locations, since the primary supporting research and development efforts are, and will remain, at TA-53. Prior experience in split location research has nearly always resulted in costly errors usually avoided when all (or most) research are co-located. Moreover, travel time for Division employees will be reduced and communications problem will be minimized. Site development will be minimal at TA-53 compared to Two Mile mesa. Adequate utilities and other facilities are nearby (within 100 yards). A common security fence can be used for this facility and new classified facilities.

C. No Action ← Add a short discussion on no action
IV. ENVIRONMENTAL IMPACT based on unacceptability

A. Alternatives

1. Two Mile Mesa. Construction of GTA facilities on Two Mile Mesa would remove the construction area from future M-Division use. It would relocate or eliminate plant and animal life over a 5-acre area of undeveloped land. Two historical resources, a World War II high explosives testing basin and a pre-World War II homesteading complex (the Gomez-Montoya cabin and associated structures and wagon road), could be unavoidably impaired. Mitigation of adverse impact to these features would require extensive salvage work, add a several months delay to the project and increase project cost.

2. No Action. No action would leave the proposed 5-acre TA-53 siting area (or any alternative site) open for development of other facilities and alternative use for the TA-53 site is not currently foreseen.

~~Change sequence, start with A. here~~

Change sequence, start with A. here

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13

A. Existing Environment. This project is within Los Alamos National Laboratory boundaries (Fig 11). A detailed description of the local environment is presented in the Laboratory Environmental Impact Statement (EIS) [Department of Energy (DOE)/EIS-0018, Dec., 1979].

Specifically, the GTA complex will be located within TA-53 across La Mesita road from Sectors E and F of the Los Alamos Meson Physics Facility (LAMPF) beam tunnel. (Ref. Figs 9 - 11.) This location is at the head of a small drainage channel adjacent to an industrialized area showing some soil erosion. Special care will be taken to prevent future soil erosion arising from construction of the new facilities. Site vegetation consists of partially disturbed stands of pinon pine and one-seeded juniper, native grasses, and forbs (weeds). The terrain ranges from steep slopes with road fill to moderate slopes with occasional tuff rock outcrops and very shallow soil covers. (Ref., Soil Survey of Los Alamos County, New Mexico, LA-6779-MS, Los Alamos Scientific Laboratory, June 1978.)

Siting of the GTA facilities are in accordance with the Laboratory Long Range Site Development Plan.

B. Probable Impacts

1. Archaeology. Laboratory archaeologists have surveyed the proposed siting area for the presence of cultural (archaeological and historical) resources. They found no evidence indicating the presence of any resources at the GTA-2 site. (Ref. memo, Snow to Olinger, dated 4/22/85.) A prehistoric ruin west of the GTA-2 and the Support Building

will be fenced by the GTA-2 project prior to any construction in the area to protect it from construction traffic. The access road to the GTA complex was slightly re-located after the initial archaeological survey. Subsequent survey of the road route indicates that it will traverse a prehistoric fragment site (Ref. memorandum McGhee to Olinger, 12/3/85). Collection of fragments from this area will be completed prior to the beginning of GTA site construction. Field work and data analysis for the fragment scatter, as well as fencing for the prehistoric site, will be funded by the GTA-2 project. The New Mexico State Historical Preservation Officer has been consulted in conformance with 36 CFR Part 800. (Ref. memo, Valencia to Merlan, 3/4/86.)

2. Floodplain/Wetlands. This project is not located in a floodplain or wetland as described by DOE regulations (10 CFR 1022).

3. Threatened and Endangered Species. Based on current understanding, no threatened and/or endangered species inhabit the proposed siting area. No sightings of animals noted on U.S. Fish and Wildlife listings of local threatened and endangered species have been reported for the project area. No plants contained on the New Mexico Endangered Plant Species List (1985) are known to grow within the project area.

4. Construction. No unusual construction-related environmental impacts are anticipated. Negative impacts on air and water quality due to construction activities will be short-term and minimal. Air quality will be degraded temporarily at intermittent times by dust from construction activities.

15

The construction area is partially a developed area within the TA-53 LAMPF complex. Site preparation, excavation, and backfill will be required. Soil erosion control will be part of the project.

5. Use of Resources. The operating GTA facilities will use no local natural resources other than routine utilities. Utilities will connect to existing lines at TA-53. The additional load on utilities will not over-extend this system.

Specifically, utilities will include:

1. 15 MW of AC power from an existing switch gear adjacent to the site,
2. 4.23 MW of cooling water from the Fusion Materials Irradiation Test (FMIT) building cooling tower adjacent to the site,
3. telephones,
4. natural gas,
5. sewage.

6. Impacts from Routine Emissions and Effluents.

a. Normal Operating Conditions.

4) Description. Both GTA-1 and GTA-2 are being designed to provide intense sources of H^+ , H^- and H^0 , and particles. The particle beams will be 100 μA of H^- particles accelerated to 50 MeV for GTA 1 and 100 MeV for GTA-2. The duty factor (D.F., time in operation) will be

47
16

high-energy spectrums are important because many of the activation reactions are threshold reactions. For these reasons, the high-energy end of the DTL will be analyzed in a Safety Analysis Report required prior to operation of GTA-2 and a safety assessment required prior to operation of GTA-1.

The accelerator vaults, HEBT sections, and beam sensing and beamstop areas will be closed to all personnel during beam-on. Pedestrian traffic during beam-off operations will be through shield-block labyrinths with Kirk-key interlocked doors from the accelerator vaults. Sufficient shielding will be placed over and around the accelerator and beam sensing vaults and beamstops to result in radiation dose levels "as low as reasonably achievable" (ALARA) and no higher than the DOE new facility occupational exposure Radiation Protection Standard (RPS) for whole body radiation of 1000 mrem/yr (DOE Order 5480.11 revision).

~~Proposed~~ 5480.11 proposed revision

The Los Alamos National Laboratory Applied Nuclear Science Group (T-2) in collaboration with the Radiation and Shielding Analysis Group of the Hanford Engineering Development Laboratory, are doing a shielding study and will provide engineering data necessary to design shielding to meet exposure criteria. Each accelerator will be covered by high density (H. D.) concrete stepped stack-block shielding that can be quickly moved by an overhead crane for reconfiguration of the accelerator or for maintenance work. Preliminary bulk shielding thickness are analyzed in the attached letters, Morford to Cole, "ATSU, 100 MeV Linac Shielding, 10/20/85" and "GTA-1 Bulk Shielding," revised 1/17/86. Shielding thickness for GTA-1 beam stop are currently estimated at approximately 8 ft of 243 # HD concrete and for

GTA-2 at approximately 9 ft of 243 # HD concrete. Stacked up block cracks will be sealed to prevent leakage of radioactive air from between the blocks. 17

The policy of the Los Alamos National Laboratory is that employee and public exposure to radiation and radioactive materials will be kept to the lowest level technically and economically feasible (Health and Safety Manual, Administrative Requirement 3-1). The "as low as reasonably achievable" (ALARA) principle will be adhered to in all activities to minimize operational exposures. During normal beam operation the air in each vault and beam-stop will be stagnant. When the beam is off, air from these areas will be vented through a high-efficiency (99.97%) particulate air (HEPA) filter bank and an exhaust stack. Personnel access will be allowed only when ventilation is operational and safe radiation levels have been achieved.

b) Emissions. No nonradioactive emissions are anticipated which would require regulation under New Mexico Air Quality regulations 702 and 703. No emissions will be produced requiring regulation under Prevention of Significant Deterioration (PSD) rules.

Airborne emissions will consist of activated air discharged to the atmosphere at intermittent times. The only way to dispose of activated air is to hold it for radioactive decay to acceptable levels and then vent it to the atmosphere. Any activated gases from the GTA facilities will be vented so that resulting doses do not exceed the DOE occupational exposure RPS (5480.4 revision) of 0.5 mrem/hr in continuously occupied work areas. No activated air will be circulated or exhausted during beam operations. The quantity and types of airborne radioactive emissions are be-

5480.11 Propo:
Revision

18

(RPS) for members of the public for exposure from the air pathway (Order 5480.1A). The GTA will add approximately 0.6 mrem/yr to the LAMPF whole body dose. Based on 1985 measurements, the total LAMPF whole body dose including that from the GTA, will be approximately 8 mrem, or about one-third of the 25 mrem RPS. GTA effluents will not affect NPDES compliance at TA-53.

Cumulative impacts on the Laboratory from the proposed project include reserving approximately 5 acres of land at TA-53 for GTA use, precluding allocation of the land for future programmatic activities at TA-53. Traffic along East James Road and within TA-53 will be increased by traffic associated with the facility.

The current maximum individual dose from radioactive emissions from all Los Alamos National Laboratory activities is approximately 11.4 mrem/yr (1985).

V. AGENCIES AND/OR PERSONS CONSULTED, INCLUDING COORDINATION WITH FEDERAL, STATE, REGIONAL, AND LOCAL AGENCIES

This Environmental Assessment was reviewed by personnel in the Health, Safety, and Environment (HSE) and Facilities Engineering (ENG) Divisions, and by the Accelerator Technology Systems Integration Group (AT-4). It was approved by the Laboratory Environmental Review Committee. Archaeological adverse impact mitigation is being reviewed by the New Mexico State Historical Preservation Officer. No known conflict exists with any federal, state, regional, or local plan.

VI. ADDITIONAL DOCUMENTATION

A preoperational site survey of existing environmental conditions at this site is ongoing in accordance with DOE Order 5484.1. A draft safety assessment for GTA-1 will be prepared prior to building construction. A final version

United States Government

Department of Energy

memorandum

Albuquerque Operations Office

APR 23 1986

DATE:

REPLY TO

ATTN OF: WOE:RFR

SUBJECT: Comments on the Ground Test Accelerators (GTA-1) and (GTA-2) Environmental Assessment (EA)

TO: H. E. Valencia, Area Manager, LAAO

The following comments by AL are in regard to the subject EA and should be incorporated into the next submittal. Comments by Headquarters will be transmitted as soon as they are received at AL. Therefore, wait until the comments by Headquarters are received and integrated into the EA before submitting the revised EA to AL.

Overall, the document is well written and addresses the major areas of concern regarding radioactive effluents and shielding with respect to facility operation and expected environmental impacts. The following comments are areas which could be further addressed to clarify the document.

1. The Code used, by the Westinghouse Hanford Company, to calculate the production and quantity of isotopes generated for the operating parameters of GTA-1 should be identified specifically. A brief explanation of the design logic of the Code would also provide additional continuity.
2. The primary generated dose contributing nuclides for GTA-1 and GTA-2 operation should be identified. A discussion of how the environmental monitoring program will be structured to monitor these nuclides should also be stated.
3. The likelihood of soil activation and nuclide migration around the beamstop areas should be discussed in the document.
4. Waterborne effluents will consist of a slightly activated waste cooling water used to cool magnets and beams. Identify the waterborne nuclides that will be generated.
5. The assumption of a normal operating cycle for GTA-2 for the calculation of air activation data was based on a four hour/day irradiation and 16 hour/day decay time. The EA should discuss the environmental impact of shorter run times and the likelihood of having to vent the tunnel immediately after the run-cycle; especially during the commissioning phase of the accelerator when more frequent entry may be required.

ATCH 2

6. The 16 hour/day decay interval for normal operating conditions of GTA-2 seems unrealistically long. Please assure that this is a correct assumption by the operating group, since a major deviation from this condition may invalidate the EA.

7. Page 20, last paragraph, second sentence: please reword this sentence to indicate the subject is a worst case accident and not a daily routine release.

8. It would be of benefit to the reader to organize the attachments into an appendix for ease of reference. The EA itself relies heavily upon the attachments, thus, an organized reference method would be advantageous.

If there are any questions please contact Randy F. Raddick at FTS 846-4340.



Carlos E. Garcia
Director
Environment, Safety and Health Division

cc:
C. E. Olinger, HSE-8
MS-K490, LANL

14600671

memorandum

DATE: APR 15 1986

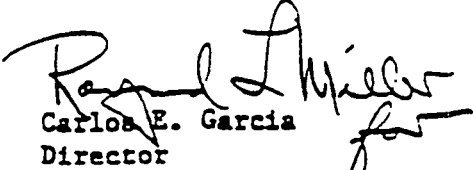
REPLY TO
ATTN OF: WOE:RFR

SUBJECT: Draft Finding of No Significant Impact (FONSI)

TO: J. C. Dobes, Capt., USN, Director, Safety, Environment and Emergency
Actions, DP-226, DOE, HQ

As part of the NEPA process a draft FONSI has been prepared by LANL on the proposed Ground Test Accelerators (GTA) 1 and 2. The subject FONSI is attached for review and approval.

A draft Environmental Assessment (EA) has also been prepared by LANL and is being hand-carried by Ron Hanson, AL, to the responsible authorities for review and approval. Mr. Hanson, currently working under J. W. Culpepper, DP-5, will be used as an AL contact point to forward any comments regarding the EA and/or the FONSI. If there are any questions please call Randy F. Reddick at FTS 846-4340.


Carlos E. Garcia
Director
Environment, Safety and Health Division

Attachment

cc w/o attachment:

J. W. Culpepper, DP-5, DOE, HQ

R. J. Stern, Dir., EH-23, DOE, HQ

w/attachment

R. Y. Lowrey, Dir., ETD, AL

H. E. Valencia, Area Mgr., LAAO

H. F. Mumma, Dir., FCMD, AL

T. C. Jones, Dir., OSPA, AL

w/o attachments

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TONEY ANAYA
GOVERNOR

STATE OF NEW MEXICO
OFFICE OF CULTURAL AFFAIRS
HISTORIC PRESERVATION DIVISION

VILLA RIVERA, ROOM 101
228 EAST PALACE AVENUE
SANTA FE, NEW MEXICO 87503
(505) 827-8320

THOMAS W. MERLAN
DIRECTOR

CLARA APODACA
CULTURAL AFFAIRS OFFICER

April 21, 1986

Harold E. Valencia
Area Manager
Department of Energy
Albuquerque Operations
Los Alamos Area Office
Los Alamos, New Mexico 87544

Dear Mr. Valencia:

Thank you for your letter of April 16, 1986 about mitigation of adverse effect on LA 4714.

I concur that the proposed data collection, analysis and reporting will justify a determination of no adverse effect on this site.

Our concurrence in this determination of no adverse effect is subject to review by the Advisory Council on Historic Preservation. Please forward our correspondence and the proposal to:

Robert Fink, Chief
Advisory Council on Historic Preservation
Western Division of Project Review
730 Simms Street, Room 450
Golden, Colorado 80401

with a request for concurrence. The Council must respond within 45 days.

Please let me know if I can help you to ensure expeditious completion of the Council's procedures.

Thank you for your continuing cooperation.

Sincerely,

Thomas W. Merlan
State Historic Preservation Officer

TWM/bc
Enclosure

Log #5790

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APR 16 1986

Thomas W. Marlan, Director
Office of Cultural Affairs
Historic Preservation Division
Villa Rivera, Room 101
726 East Palace Avenue
Santa Fe, New Mexico 87503

Dear Mr. Marlan:

**ADVERSE IMPACT MITIGATION, LA 4714, LOS ALAMOS NATIONAL
LABORATORY**

Enclosed per your request of March 10, 1986, are:

- I. Proposal for Mitigation.
- II. Initial archeological survey.
- III. Followup archeological survey.

This site is located near impending construction. An additional small ceramic and lithic scatter (unrecorded) is included in the mitigation proposal.

Please advise us concerning the appropriateness of the proposed adverse impact mitigation. Comments should be directed to Avedon Gallagos of my staff.

Sincerely,

Original signed by
Nloy M. Hunez

Harold E. Valencia
Area Manager

Enclosures:
As stated

cc:
Tom Gundersen, (HSEB-86-391.1, 4-4) LANL, MS K490
C. Olinger, HSEB-8, LANL, MS K490
A. Drypolcher, HSEB-8, LANL, MS K490

LTP:AG-0025

CONCURRENC
RTG SYMBOL LTP:d Galle
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memorandum

Albuquerque Operations Office
Los Alamos Area Office
Los Alamos, New Mexico 87544

DATE: MAR 19 1986
REPLY TO: LAM:DL
ATTN OF:
SUBJECT: Ground Test Accelerator-2 - Environmental Assessment
TO: Bill Myers, NSP/DCP, MS-F614

I have been informed by FCMD/AL that DOE Headquarters will not approve the start of any Neutral Particle Beam Program/SDI-related construction work until the Ground Test Accelerator (GTA)-2 Environmental Assessment (EA) is reviewed and approved by Headquarters. To that end, it is imperative that the timely preparation of the EA be emphasized. I have also learned that Headquarters will be looking closely at the "Alternatives" portion of the Environmental Assessment; therefore, it is imperative that all alternatives be thoroughly addressed. AL has notified Headquarters that the EA will be forwarded to them no later than the last week of March 1986.

Original signed by
Harold E. Valencia

Harold E. Valencia
Area Manager

cm:3-18/4546A

cc:
J. Jansen, DRPDEW, MS-H818
Thomas C. Jones, Dir., OSPA, AL
H. F. Mumma, Dir., FCMD, AL
Carlos Garcia, Dir., ESHD, AL

MAR 04 1996

CERTIFIED MAIL- RETURN RECEIPT REQUESTED

Thomas W. Merlan, Director
Office of Cultural Affairs
Historic Preservation Division
Villa Rivers, Room 101
772 East Palace Avenue
Santa Fe, NM 87502

Dear Mr. Merlan:

RE: ADVERSE IMPACT MITIGATION, LA 4714, LOS ALAMOS NATIONAL LABORATORY

The Los Alamos National Laboratory is proposing to construct an accelerator facility (the Ground Test Accelerators, formerly Accelerator Test Stand Upgrade,) at Technical Area (TA)-13. An archaeological survey of the proposed construction site and adjoining area indicates the nearby presence of a prehistoric ruin [Laboratory of Anthropology (LA) No. 4714] and an unrecorded lithic scatter.

In accordance with the National Historical Protection Act of 1966 and the implementing provisions of 36 CFR Part 800, the Department of Energy (DOE) requests your concurrence concerning a proposed Laboratory plan of adverse impact mitigation.

The Laboratory proposes the following mitigation prior to construction of the accelerator facility: (1) clearing aging Laboratory debris from and permanently fencing LA 4714, and (2) systematically collecting and analyzing envelope pottery sherds and lithic material at the construction site.

Please advise us concerning the appropriateness of this action by March 17, 1996. Comments should be directed to Avenida Callejos of my staff at 505-5222.

Sincerely,

Original signed by
Harold E. Valencia

Harold E. Valencia
Area Manager

cm:2-2P/4457A

cc:

T. Gundersen, (HSEB-86-163-1, 2-7), HSE-8, LANL, MS K490
A. Drypolder, HSE-8, LANL, MS-K490
B. Olinger, HSE-8, LANL, MS-K490



memorandum

LOS ALAMOS AREA OFFICE

DATE

FEB 05 1986

REPLY TO
ATTN OF

LTP:TRR

SUBJECT

Environmental Documentations; Strategic Defense Projects at TA-53

TO

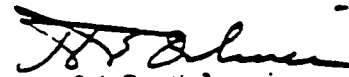
C.S. Adams, ADTS, LANL

I have attached a copy of a memorandum dated January 31, 1986, from Carlos Garcia, Director, Albuquerque ESHD on the subject.

No further Environmental Documentation will be required for the Support Building for Ground Test Accelerator Facilities nor for the Transportable Office Complex.

Further documentation in the form of Environmental Assessments will be required for Ground Test Accelerators 1 and 2. One document may be produced to cover both Accelerators if convenient.

I will appreciate your submitting these Environmental Assessments to me by February 21, 1986.



Harold E. Valencia
Area Manager

ns:01-31/4319A

cc:

Roger Perkins, M.S. A145

146006/5

memorandum

DATE: JAN 31 1986

REPLY TO
ATTN OF:

WOL:RFL

SUBJECT: Environmental Documentation, LAKL

TO: E. L. Valencia, Area Manager, Los Alamos Area Office

We have reviewed the Action Description Memorandums (ADM) forwarded to this office by your January 21, 1986, memorandum.

GROUND TEST ACCELERATOR-1 (GTA-1), LJ8401, TA-53-18

This proposed action is the first of the two ground-based prototypes or Ground Test Accelerators that support the neutral Particle Beam Program. GTA-1 is a 50 MeV, 100 mA, 0.1% duty factor, 3 Hz, H^+ , H^- , and H^0 proton accelerator which will serve as a stepping stone for GTA-2 (100 MeV). The GTA-1 complex will consist of an injector, radio frequency (rf) quadrupole, a drift tube linear accelerator, an rf power system, beam output optics, a beam sensing and control system, a neutralizer, a beam stop, and an instrumentation and control system. The beam stop will be the most active radiation source of the GTA-1. These will primarily be of graphite, copper, and aluminum.

GROUND TEST ACCELERATOR-2 (GTA-2), LJ7770, TA-53

A formal ADM has yet to be prepared on GTA-2, however, an environmental remark was submitted. The information submitted contained the Environmental Assessment (EA) for the Accelerator Test Stand Upgrade (ATSU). The project currently under review is an upgrade of the ATSU project (upgraded to 100 MeV from the former 50 MeV power level).

SUPPORT BUILDING FOR GROUND TEST ACCELERATOR FACILITIES, TA-53

This proposed action is a single story 21,500 square foot building which will primarily as a transshipment and storage center for the GTA facilities. At least three large roll-up truck entrance doors will be provided. Potential hazards are limited to operating personnel and are those normally associated with industrial warehouses.

TRANSPORTABLE OFFICE COMPLEX, LJ7727, TA-53

This proposed project entails a 40,000 square foot office building consisting of 24 transportable office units with a 200 person capacity. The only waste stream from this facility will be the sanitary effluents.

K. E. Valencia

-2-

Numerical generation of radioactive effluents are being assessed in an ongoing GTA radiation study. Preliminary air activation data has been evaluated based on the previous calculations of the ATSU analysis. Because the GTA accelerator complex is located at TA-53 with its close proximity to the Los Alamos Meson Physics Facility (LAMPF), concern over site boundary dose has been an issue in siting additional high-energy facilities. Recent beamstop improvements at LAMPF, however, have greatly reduced the mixed air activation products released from this facility.

Radioactive effluent release data is not yet available in a numerically calculated quantitative form. Expected emissions based on ATSU data and duty factor variations indicate radioactive emissions will probably be minimal.

Due to the extent of analysis required for GTA-1 and GTA-2 and uncertainty of their impacts, it is necessary that an Environmental Assessment (EA) be prepared for these projects. It will be the contractor's decision whether to prepare two separate EA's or combine the projects for one EA. While the data from the ATSU EA will certainly be helpful in preparing the GTA EA's, it cannot be substituted as GTA-1 or GTA-2 NEPA documents.

Based on the information submitted we have determined that the impacts for the other proposed actions, Support Building for GTA Facilities and the Transportable Office Complex, are clearly insignificant and/or have previously been discussed in existing NEPA documentation. These are, therefore, not actions requiring additional NEPA documentation. If there are any questions please contact Randy F. Reddick at FTS 846-4340.


Carlos E. Garcia
Director

Environment, Safety and Health Division

cc:

D. R. Ellis, Dir., ERM, AL
A. R. Griego, Ch., F&IS, ESRD, AL
R. J. Stern, Dir., EH-15, DOE, HQ
J. C. Dobes, CAPT, USN, DP-226, DOE, HQ

CROSS-CULTURAL RESEARCH SYSTEMS

23 January 1986

MEMORANDUM

TO: Colleen Olinger, HSE-8, MS K490
FROM: Ellen McGehee, Cross-Cultural Research Systems, HSE-8, MS K490
SUBJECT: DECEMBER 3, 1985 DATA RECOVERY RECOMMENDATIONS FOR ARCHAEOLOGICAL SITE LA 4714, ATSU PROJECT AREA.

It has been recommended that a systematic collection and analysis of diagnostic artifacts downslope and east of LA 4714 be undertaken by CCRS personnel (see memo of 3 December 1985). This collection strategy is justified by the anticipated future use of the area by the ATSU and proposed LAMPF II projects which will remove diagnostic pottery sherds and lithic materials from the site area.

The existing data from LA 4714 are insufficient for interpretive purposes. Ceramic collections made by Worman and records of the excavation and analyses of artifacts are virtually useless. Lithic materials, present at the site, are not mentioned in any of the records pertaining to LA 4714, and were probably not collected. Unfortunately most of the site can no longer be investigated. We are not recommending mitigation of the remainder of the site at this time, but rather that the site be fenced (see memo of 22 April 1985); our data collection will provide a better data base for future research at such sites.

The proposed collection strategy will require two man-days of effort. We will concentrate on the collection of diagnostic surface artifacts. Pottery will be collected in order to more finely date the occupation of the site, and to further describe the variation in pottery types found at LA 4714. Lithic materials will be collected with the goal of determining the range of lithic use and the types of lithic materials found at the site. Sourcing studies and obsidian hydration dating are other important potential uses for this lithic material.

Eight man-days will be required for artifact analysis and report write-up.

As you have recently indicated that this is a high priority project, we will begin the collection phase as soon as possible.

CROSS-CULTURAL RESEARCH SYSTEMS

MEMO

3 December 1988

TO: Colleen Olinger, HSE-3, MS K490

FROM: Ellen D. McGehee, ^{EMC} Cross-Cultural Research Systems, HSE-3, MS K490

SUBJECT: ARCHAEOLOGICAL CLEARANCE OF REVISED ALVAREZ ROAD LOCATION - WEST
AND SOUTH OF LA 4714.

The mesa top west and south of LA 4714 was surveyed for cultural resources in advance of anticipated road construction activities associated with the Accelerator Test Stand Upgrade (ATSU) project (see previous ATSU clearance memos). No significant cultural resources were noted.

In addition to the mesa top, the canyon area immediately west and south of the proposed Alvarez road corridor was also surveyed for cultural resources since cavates are not uncommon in this region and since any road-filling activities would impact sites on the canyon slopes and bottom. No cavates or other cultural resources were located within the project impact area.

Recommendations:

As no significant cultural resources will be impacted by this project, it is recommended that archaeological clearance be given. However, due to the future use of the entire area for the ATSU and proposed LA 4714 projects, and the unfortunate lack of data from LA 4714, it is further recommended that a systematic collection and analysis of diagnostic artifacts downslope and east of LA 4714 be undertaken by CCRS personnel (see Fig. 1). [LA 4714 was at least partially excavated by Worman in the late 1960's, but records of this work are scanty; see pp. 2, 4, 5, 15 in Excavations at Mesita de Los Alamos by Worman and Steen, 1973, LA-7743-MS.]

xc: Ted Cagle

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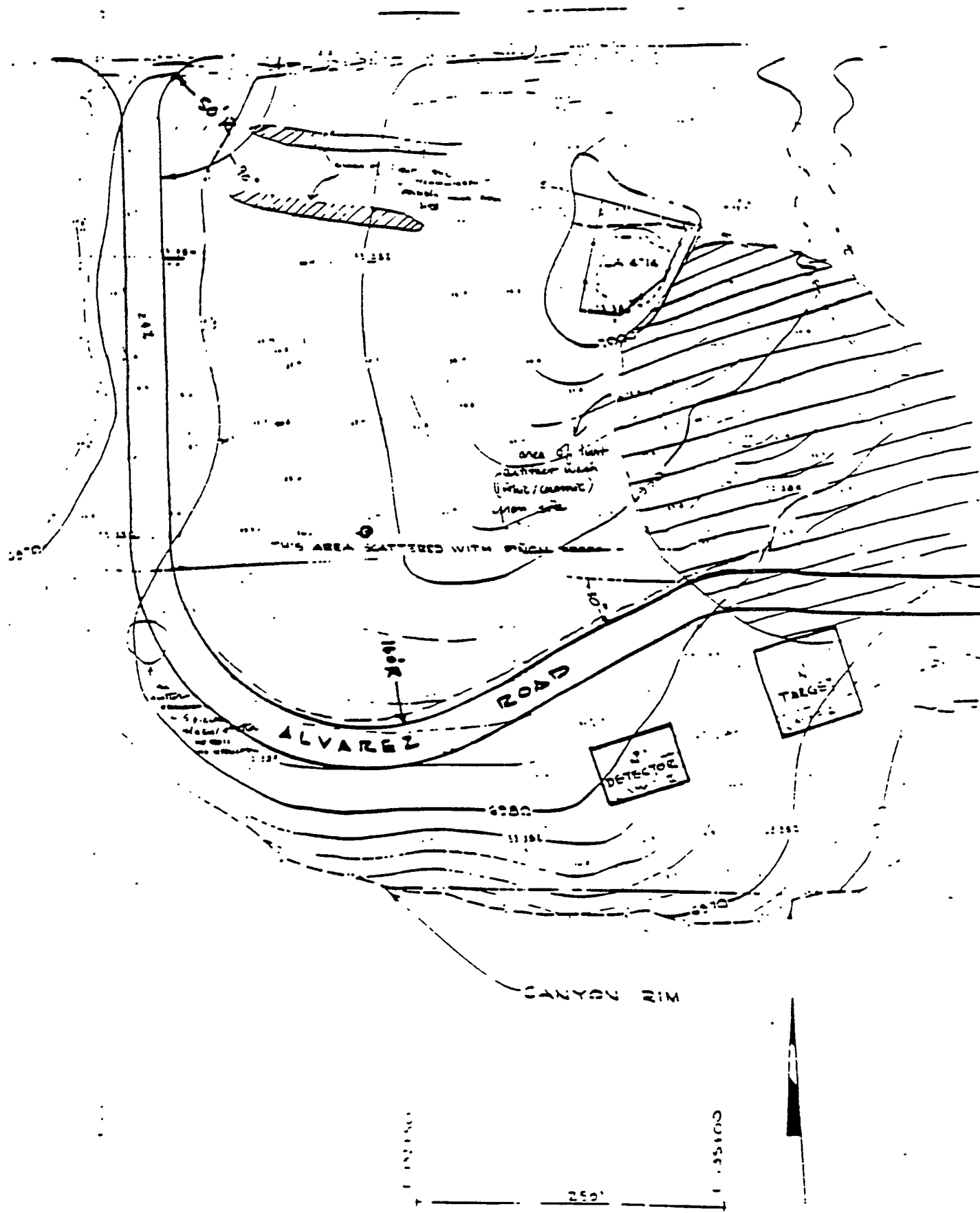


Figure 1. Map showing location of artifact wash from L4774, and other artifact scatters.

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

memorandum

TO Ted Cole, AT-4, MS HB21 .
THRU *Colleen Olinger* Colleen Olinger, HSE-8
Environmental Evaluations Coordinator
FROM Ellen McGehee,
Cross-Cultural Research Systems, HSE-8
SYMBOL HSEB-85-958
SUBJECT AUGUST 7, 1985 RESURVEY OF THE FUTURE ACCELERATOR TEST STAND UPGRADE
(ATSU) BUILDING SITE AND ALVAREZ ROAD

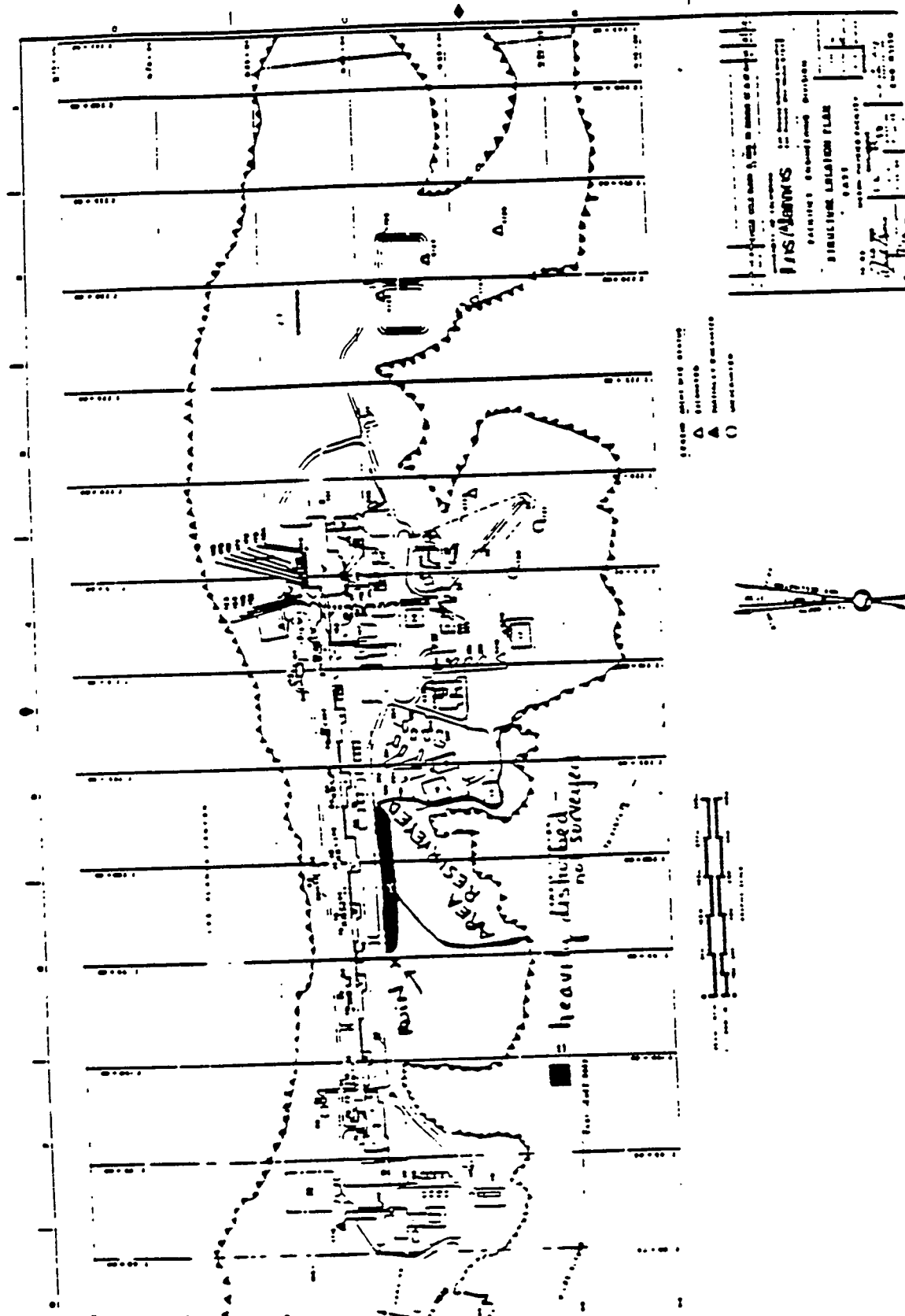
Due to the further refinement of construction plans, the ATSL site was resurveyed. This area, near TA-53, was archaeologically surveyed for evidence of prehistoric or historic cultural remains. As no significant archaeological resources will be impacted, archaeological clearance is given.

Enclosed is a map showing the location of the resurveyed area.

EM:cel

Enc: a/s

Aug. 7th survey



LOS ALAMOS

Los Alamos National Laboratory
Los Alamos New Mexico 87545

memorandum

TO: Colleen Clinger, Laboratory Environmental Evaluations Coordinator, HSE-8
FROM: David M. Snow, Laboratory Contract Archaeologist, HSE-8
SYMBOL: HSEB-85-465
SUBJECT: ARCHAEOLOGICAL CLEARANCE: ACCELERATOR TEST STAND UPGRADE, TA-53
DATE: April 22, 1985
K490/7-5001

David Snow and Ellen McGehee have surveyed the area indicated on the attached TA-53 site map.

One small apparently partially-excavated prehistoric ruin was found at the edge of an old equipment dump site opposite Sector C of the Meson facility (TA-53-3, Accelerator Building). This site is south of the paved road. It should be fenced and protected from construction traffic, although it lies outside the indicated building limits provided the archaeologists.

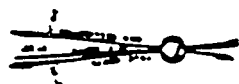
No other sites were found and clearance is recommended for the construction zone indicated.

DHS:mm

Att: a/s

Cj: T. C. Gunderson, HSE-8 Group Leader, MS K490

THE
FEDERAL
BUREAU OF INVESTIGATION



LOS ANGELES

PACIFIC COAST LUMBER CO.

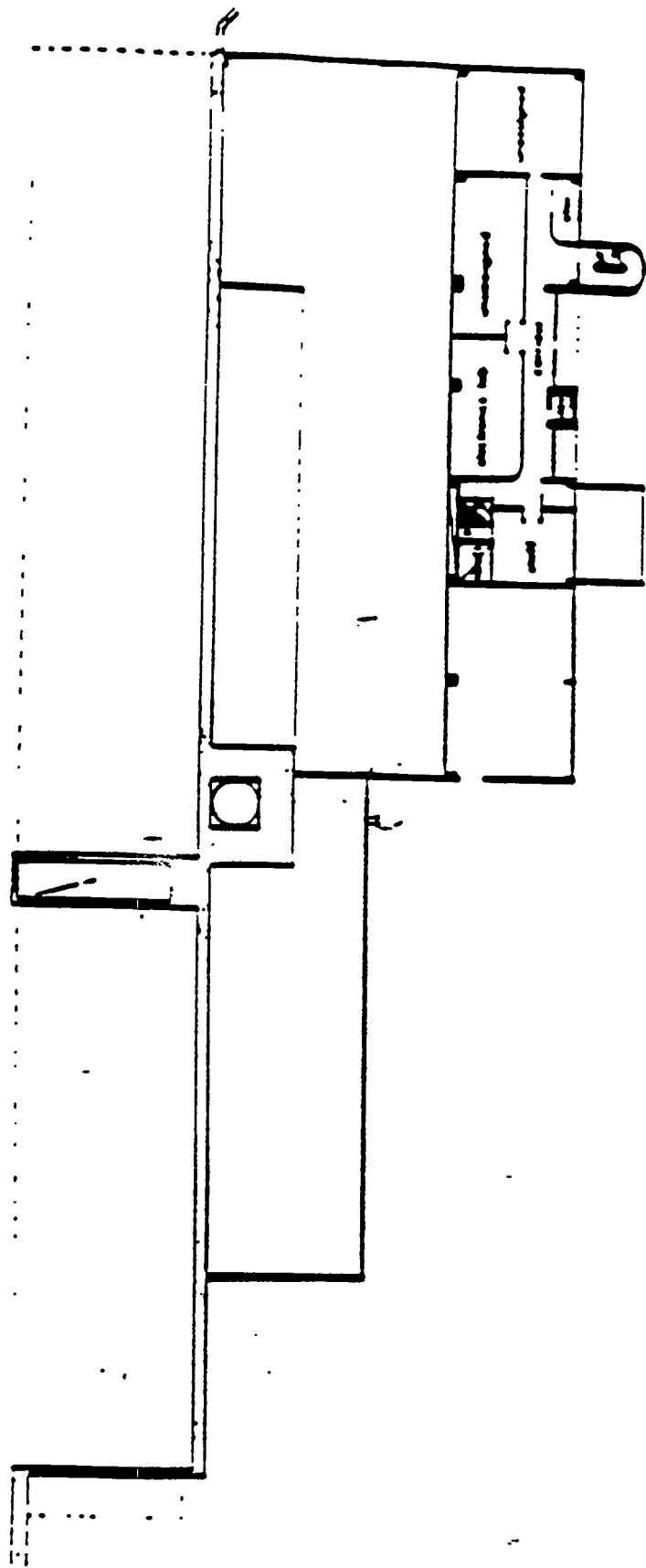
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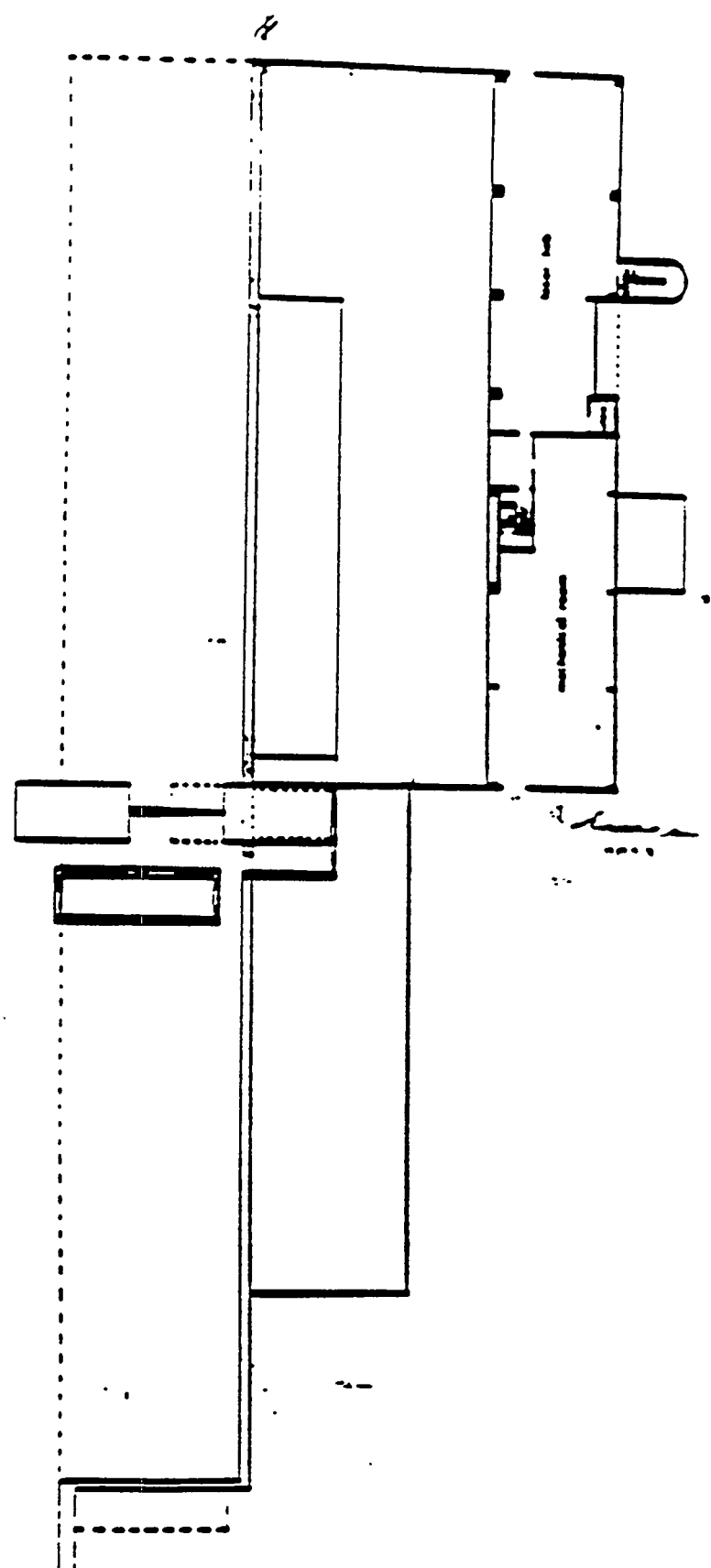
THIRD LEVEL

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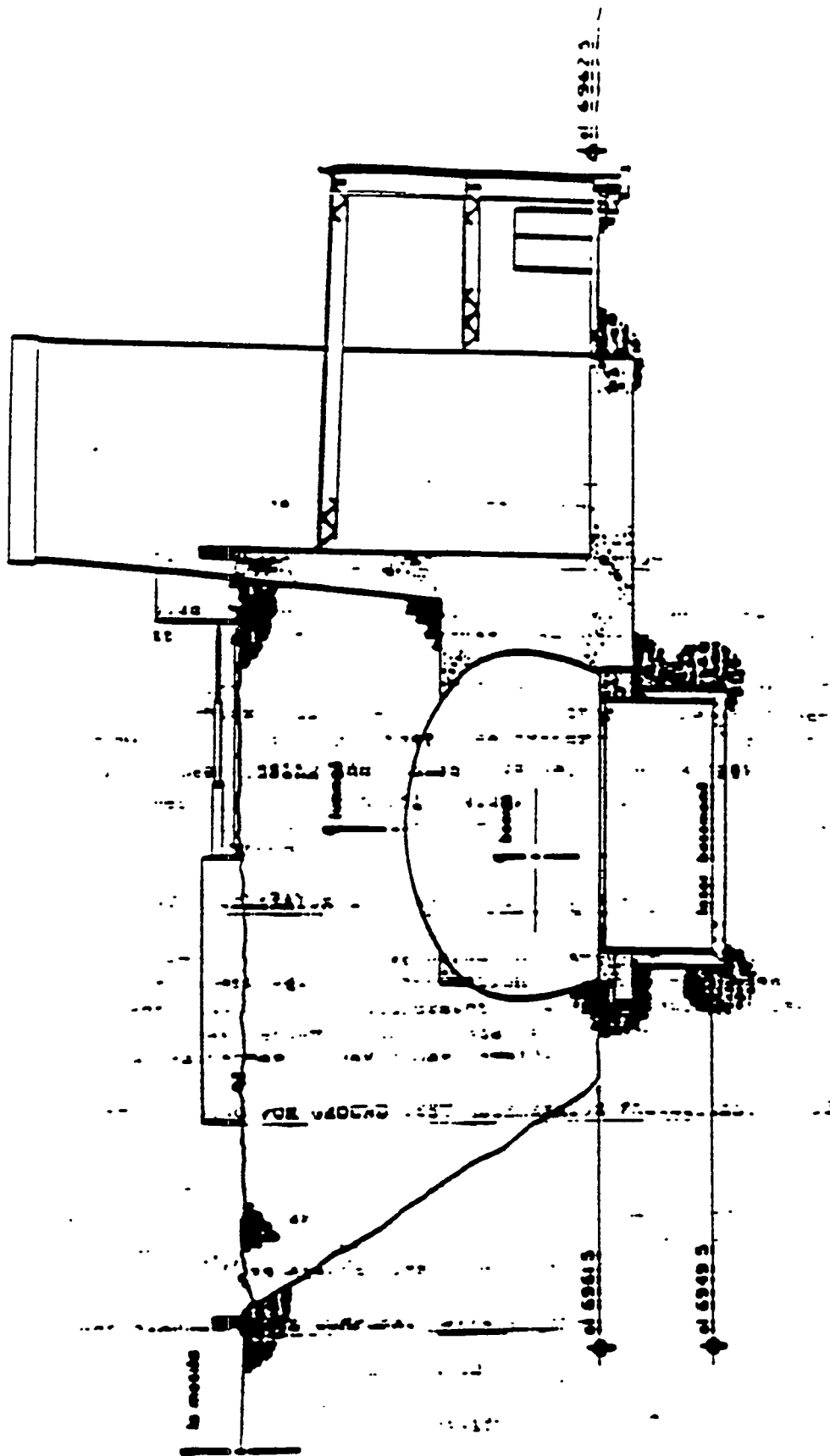
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FOURTH LEVEL

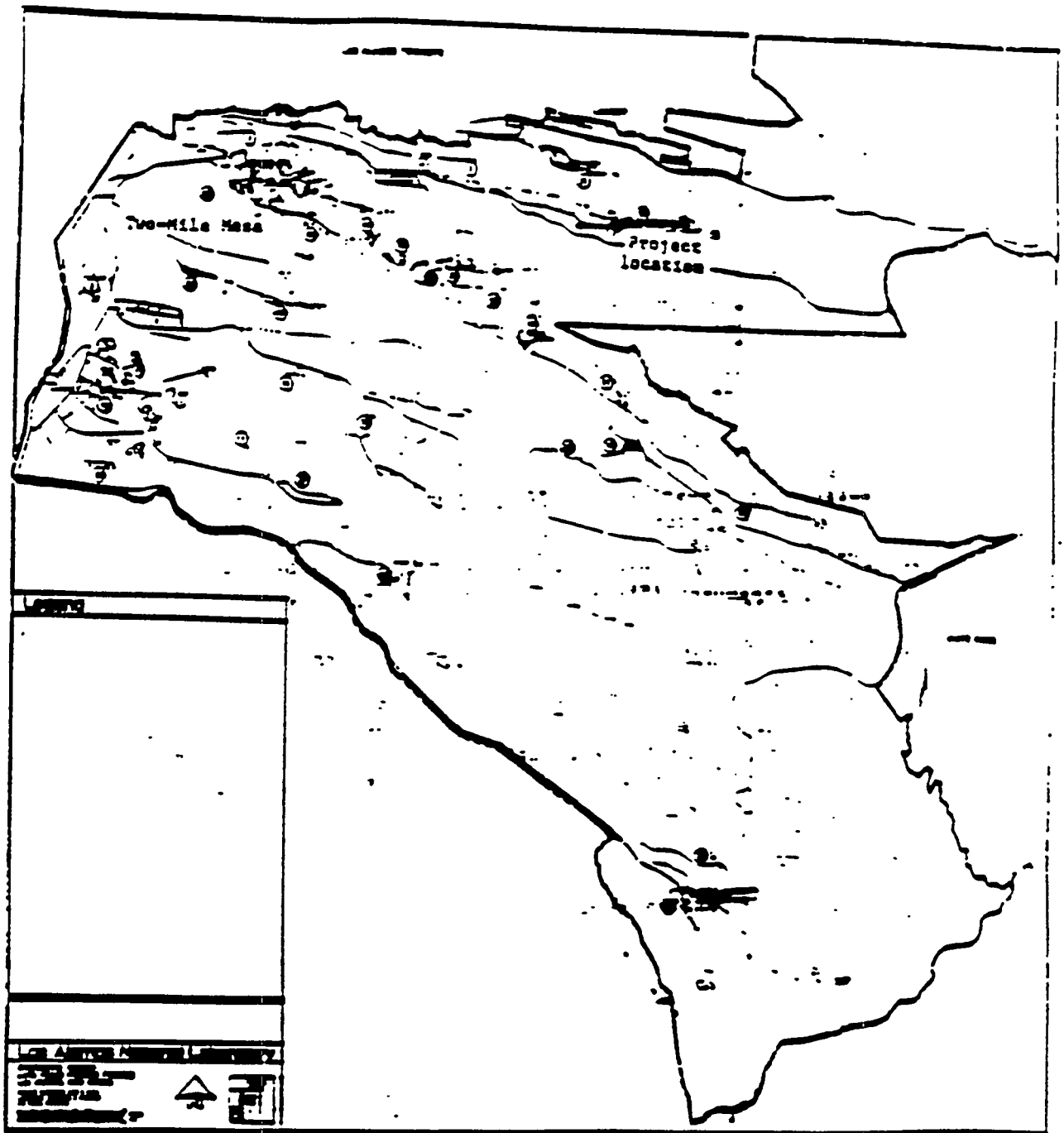


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SECTION A

1-7-65



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Fig. 9.

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Appendix B

Design Criteria Comparison

APPENDIX B

DESIGN CRITERIA COMPARISON

This appendix documents two levels of design criteria comparison performed for the Ground Test Accelerator (GTA) facilities and equipment. Tables B-1 through B-5 provide the tabular design criteria comparison required by U.S. Department of Energy (DOE) Albuquerque Field Office (AL) Order 5481.1B (DOE, 1988). Each table provides a comparison of the GTA facilities to an applicable DOE Order or industry standard. Table B-1 compares the GTA facilities to the applicable portions of DOE Order 6430.1A "General Design Criteria" (DOE, 1989). Division 13 requirements and the -99 portions of other divisions of DOE Order 6430.1A were excluded from the comparison because an accelerator is not classified as a special nuclear facility. Tables B-2 through B-5 compare the GTA to radiation protection design guidelines from DOE, American National Standards Institute (ANSI), and National Council on Radiation Protection (NCRP). Table B-2 presents a comparison to DOE Order 5480.11. Table B-3 presents a comparison to ANSI N43.1. Table B-4 compares the GTA to NCRP 88 and Table B-5 compares the GTA to SLAC 327. The conclusion of the tabular design criteria comparison is that the GTA design favorably compares to the applicable design criteria documents.

Following Tables B-1 through B-5 is the earlier Holmes and Narver study that was performed to compare the MPF-365 design to the requirements of DOE Order 6430.1A. This comparison study was done because the building had been designed and constructed to DOE Order 6430.1 requirements and it was necessary to identify potential modifications to meet the requirements of the new DOE design criteria. (The Cryogenic Cooling System was designed to meet the 6430.1A requirements.) Building MPF-365 design features that did not meet DOE Order 6430.1A requirements and that were considered critical to safety were modified to meet the 6430.1A requirements. A number of findings from the study, which were deemed by the Laboratory's Engineering and Health, Safety, and Environment (HSE) divisions to be nondetrimental to the safety of the facility, were not implemented. These were as follows (numbers referred to in the study are used):

Civil: 1 - Door to the Fan/Boiler Room is on the north side of the building, not recommended for cold climates. 2 - Sanitary sewer line located under new pavement. 3 - Sewer-line manhole is within security fence instead of outside. 5 - No gate valve on a 4-in. water line. 6 - A sanitary sewer line is constructed from PVC pipe instead of ductile iron pipe. 7 - Effect of a 100-yr, 6-hr storm not considered in storm-drain design. 12 - Fence hardware not spot-welded or peened to prevent easy removal.

Structural: 1 - Seismic design was done per 1985 UBC, per DOE Order 6430.1 (see following discussion). A static analysis was done instead of the dynamic analysis required by DOE Order 6430.1A. 2 - Bearing surface of aluminum tubes and grating at laser basement are not isolated.

APPENDIX B DESIGN CRITERIA COMPARISON

Architectural: 1 - Stair-railing height designed to be between 30 in. and 34 in. instead of 34 and 38 in. 3 - No specific single-ply requirements for roofing material design. 4 - Suspended ceiling design per UBC Standard 47-18 instead of UCRL 15714.

Mechanical: 3 - Control valves in HVAC temperature-control system not provided with strainers. 4 - Not all air balancing devices specified by new requirements were incorporated into design.

Electrical: 1 - Exterior lighting not designed as continuous lighting.

With respect to seismic design, the loads used in the structural analysis would be greater under the requirements of DOE Order 6430.1A and UCRL 15910 and the analysis methods would also differ. The former requirements did not include the 0.22 g criterion included in UCRL 15910.

The only consequence to the public or environment of a breach in the structure due to a seismic event would be a release of activated air during, or shortly after, an accelerator-run period. Release of activated air, however, is not foreseen as a problem, because any amount would easily fall within U.S. Environmental Protection Agency limits. The applicable earthquake return period is 1,000 yr, the projected run time is 16 hr/day, 4 days/wk for a maximum of 24 wks/yr. Decay time for the activated air is less than 1 hr, so a release of activated air to the environment is unlikely.

The site buildings are designed to resist the effects of a 100-yr wind of 88 mph, a design criteria from the American National Standards Institute for Exposure C sites. The Cryogenic Cooling System is designed to withstand a 93-mph wind load as specified in UCRL 15910.

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Table B-1 Ground Test Accelerator (GTA) Compliance with DOE Order 6430.1A

Section	Description	Criteria	C	NC	Comments
1	General Requirements				
0110	<u>ARCHITECTURAL AND SPECIFIC DESIGN REQUIREMENTS</u>				
0110-5	HEALTH AND SAFETY				
0110-5.1	Performance Objectives	Specific project design criteria in the areas of emergency preparedness and emergency management shall be developed with the advice and assistance of DOE organizations responsible for DOE emergency management/emergency preparedness programs. Such criteria shall comply with : • DOE 5500.1A • DOE 5500.3	✓		
0110-5.2	<u>Safety Analysis</u>	All DOE facilities shall be evaluated for potential risks to the operators, the public, and the environment. DOE 5481.1B contains criteria.	✓		
0110-5.3	<u>Emergency Preparedness Planning</u>	Each facility that has potential on-site and off-site effects during normal or abnormal operations shall have an Emergency Plan Prepared which shall be incorporated with the Site Emergency Preparedness Plan.	✓		
0110-5.4	<u>Asbestos-Containing Materials</u>	Maintenance, repair, and demolition of DOE facilities shall comply with OSHA-29 CFR and EPA-40 CFR.			N/A
0110-5.5	<u>Polychlorinated Biphenyls (PCBs)</u>	If the use, storage, or disposal of polychlorinated biphenyls (PCBs) or materials containing PCBs is to be encountered in a facility, the facility design shall comply with 40 CFR 761.	✓		
0110-6	<u>FIRE PROTECTION</u>				
0110-6.1	<u>General</u>	Facilities shall comply with the following: • DOE 5480.4 Attachment 2, Section 2.C • DOE 5480.7 • Section 1530, Fire Protection Facilities shall also comply with 29 CFR 1926 and 29 CFR 1910.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0110-6.1	General (concluded)	Except as required by other sections of these criteria, NFPA 101 shall apply where 29 CFR 1926 and 29 CFR 1910 do not apply or where NFPA 101 exceeds the requirements of 29 CFR 1926 and 29 CFR 1910. Definitions, fire resistance ratings, and types of construction shall be as contained in the UBC. Any materials with unusual fire characteristics such as urethane foams, and any materials that develop significant quantities of toxic or other harmful products of combustion, shall not be used as interior finishes or other interior applications without the approval of the cognizant DOE fire protection authority. The use of foamed plastics in construction shall be prohibited unless it fully complies with FM 1-57.	✓		
0110-6.2	Fire Protection Design Analysis	A special fire protection design analysis shall be made of each facility vital to DOE mission accomplishment. The analysis shall use time parameters established in accordance with DOE 5480.7. The analysis shall identify the special fire prevention and protection features and controls to achieve a level of fire protection for vital facilities and programs that meets or exceeds the "improved risk" level. As a part of determining the "improved risk" level, the analysis shall address those conditions in a facility where: • Large or unusual fire potential exists. • There are special life-safety hazards. • Toxic chemicals or biological agents exist. • The consequences of fire include radioactive contamination of the facility, the site, or the public environment. • National security is adversely affected by fire. Special precautions for preventing the spread of fires, such as multiple fire suppression systems, rapid detection of incipient fires, confining fires, increased fire ratings of construction materials, and rapid-response fire departments shall be provided.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0110-6.2	Fire Protection Design Analysis (concluded)	A general fire-protection design analysis shall be made of each facility to ascertain and limit the cost of future damage repair and replacement of facilities and their contents from fire. The analysis shall be made using those parameters established in DOE 5480.7. The analysis shall determine the special fire prevention and protection features and controls deemed by the cognizant DOE fire protection authority to achieve a level of improved risk fire protection that limits damage to an acceptable level. The analysis shall be documented in report form in the facility project files and referenced by the SAR.	✓		
0110-6.3	Fire Resistance Ratings	All facilities shall be divided into areas in which the total potential fire loss to each area and its equipment does not exceed \$75 million as described in DOE 5480.7. These areas shall be separated by fire walls and barriers with not less than 4-hour fire-resistance ratings. Where exceptions are necessary for reasons of operations or equipment, exemption procedures shall comply with DOE 5480.7. Adjacent occupancies of non-compatible groups shall be separated by 2-hour, or better, fire-rated walls, floors, and ceilings as required by the NFPA codes. Wall, floor and ceiling, and roof and ceiling assemblies shall be tested and rated for their fire resistance by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Untested, unrated or unapproved assemblies shall be approved by the cognizant DOE fire protection authority before being considered for use in a DOE facility.	✓	✓	N/A - See Holmes & Narver (H&N) code analysis report. 8-ft-thick concrete door was not fire rated by UL. Radiation shield door of steel and lead, was not fire rated by UL.
0110-6.4	Hazardous Areas	Hazardous areas, such as radioactive spaces or spaces with inert atmospheres, shall have sufficient alarms and interlocks to assure that access by emergency personnel will not endanger such personnel or result in a public hazard. The design of hazardous areas shall facilitate access by emergency personnel from the exterior and, at the same time, shall maintain any required confinement or containment using air locks or other features.	✓	✓	

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0110-6.4	Hazardous Areas (concluded)	The design of the exteriors of facilities shall follow the recommendations of NFPA 80A. Facilities that are not separated as recommended by NFPA 80A shall have fire protection systems such as exterior sprinklers or barrier walls.	✓		
0110-9	Operation, Maintenance, Repair, and Replacement	Planning and design of buildings and other structures, including their operating components and systems, shall take into account all aspects of operation and maintenance including: • Equipment accessibility • Dismantling • Replacement • Repair • Frequency of preventive maintenance • Inspection requirements • Personnel safety • Day-to-day operation	✓ ✓ ✓ ✓ ✓ ✓ ✓		Facilities design Facilities design Facilities design Facilities design Facilities design Facilities design Facilities design
0111	STRUCTURAL DESIGN REQUIREMENTS				
0111-1	GENERAL				
para. 2		Materials, framing systems, and details shall be compatible with the following: • Clear space and span requirements • Serviceability requirements • Applicable fire protection classification • Structural design loads for the specific facility and location	✓ ✓ ✓ ✓		
para. 4		The structural design drawings shall indicate design criteria, the structural materials and their strengths with applicable materials standards, the design loads including loads that can occur during construction, and the allowable foundation loads that were used in the design.	✓ ✓		
0111-2	LOADS				
0111-2.1	General Requirements	Structures and their elements shall be designed for the loads prescribed in these criteria.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0111-2.2	<u>Dead Loads</u>				
0111-2.2.1	General	Dead loads are loads that remain permanently in place. They shall include the weights of all permanent materials and equipment, including the structure's own weight, supported in, or on, a structure. Load calculations shall include an allowance for any loadings anticipated to be added at a later date. Initially assumed loads shall be revised so that the final design reflects the configuration shown on the drawings.	✓		
0111-2.2.3	Service Equipment	Design dead loads shall include the weight of all permanent service equipment.	✓		
0111-2.2.4	Allowance for Partition Loads	The minimum allowance for weights of partitions, where partitions are likely to be rearranged or relocated shall be as follows: • For partition weights of 150 plf or less, an equivalent uniform dead load of 20 psf shall be used. • For partition weights above 150 plf, the actual linear loads shall be used. • Partitions that are likely to be rearranged or relocated should be calculated as live loads for load factor design.			N/A: Live loads used 150 psf to 250 psf for 2, 3, and 4 stories. N/A N/A N/A
0111-2.3	<u>Live Loads</u>				
0111-2.3.1	General	Live loads shall include all loads resulting from the occupancy and use of the structure, whether acting vertically down, vertically up, or laterally. Live loads shall include neither dead loads nor loads from the environment, such as wind, tornado, earthquake, thermal forces, earth pressure, and fluid pressure.	✓		
0111-2.3.2	Buildings and Other Structures	Live loads for buildings and other structures shall be those produced by the intended use or occupancy. In no case shall they be less than the minimum uniform load or concentrated load stipulated in ANSI A58.1. Live loads on roofs shall be as stipulated in ANSI A58.1. They shall include the minimum roof live loads or the snow loads and snow drifts or possible rain loads stipulated therein, whichever produces the more severe effect.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0111-2.4	Wind Loads				
0111-2.4.1	General	The structural frame and exterior components of all buildings, signs, tanks, towers, and other exposed structures shall be designed to resist pressures due to wind assumed to act from any direction.	✓		
0111-2.4.2	Buildings and Other Structures	Wind load design for buildings and other structures shall be determined in accordance with procedures in ANSI A58.1 with the basic wind speed being obtained from UCRL 15910. The basic wind speed shall be derived from DOE site-specific hazard model studies summarized in UCRL 53526, Rev. 1. If site-specific hazard model studies are not available, a hazard model shall be developed that is consistent with the approach used in UCRL 53526, Rev. 1. The basic wind speeds for any specific site shall be determined following the procedures in UCRL 15910, except that Exposure "C" should be used for all construction unless it can be shown that the necessary permanent shielding will be provided by natural terrain (not including shielding from trees or adjacent buildings). To determine the design wind loads, all factors and coefficients stipulated in ANSI A58.1 shall be applied to the site-specific basic wind speeds. Building additions shall be designed as part of a totally new building without regard to shielding from the original building and without regard to lesser wind resistance for which the original building may have been designed.	✓ <		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0111-2.6	Internal Shock and Blast Loads	Building structures (excluding explosive facilities) that house operations that may release energy from rupture of equipment or explosions, either inadvertently or purposely (such as testing), shall be designed to control the resulting internal shock pressure loads per applicable criteria.			N/A
0111-2.7	Earthquake Loads				
0111-2.7.1	Buildings and Other Structures	The basic seismic parameters shall be derived from DOE site-specific hazard model studies summarized in UCRL 53582.		✓	UCRL 15910 draft was received after steel was erected. See pages 8-11 of H&N code analysis report para. C.
		Earthquake load design for buildings and other structures shall be determined in accordance with the procedures contained in UBC and UCRL 15910.		✓	The CCS seismic design complies with UCRL 15910. See page 4-108.
		The provisions and design procedures of TM 5-809-10 for the application of seismic loadings to conventional buildings shall also apply.		✓	
		An independent review of the seismic design shall be made for facilities and buildings where a seismic event can have a potential risk to operator lives, to public safety, or of large economic loss. The review shall be made in two stages, the first at the end of preliminary design and the second before final design is complete. For additional guidance on independent reviews, see LBL-9143 and UCRL 15910.		✓	
0111-2.8	Other Loads for Buildings and Other Structures				
0111-2.8.1	Vibratory Loadings	Equipment supports shall be designed to avoid resonance resulting from the harmony between the natural frequency of the structure and the operating frequency of reciprocating or rotating equipment support on the structure. The operating frequency of supported equipment shall be determined from manufacturer's data prior to completion of structural design.			As required by AT Division Equipment Designers. Beam tunnel floor slab is isolated from surrounding structure. Certain facility equipment is spring mounted to attenuate the forcing functions.

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0111-2.8.1	Vibratory Loadings (concluded)	Resonance shall be prevented by designing equipment supports to reduce the dynamic transmission of the applied load to as low a level as can be economically achieved in the design.			
0111-2.8.2	Earth and Groundwater Pressures	Every foundation wall or other wall serving as a retaining structure shall be designed to resist, in addition to the vertical loads acting on it, the incident lateral earth pressures and surcharges, plus hydrostatic pressures corresponding to the maximum probable groundwater level. Retaining walls shall be designed for earth pressures and potential groundwater levels producing the highest stresses and overturning moments.	✓		
0111-2.8.3	Fluid and Gas Pressures	The design of components of buildings and other structures shall include the effects of fluid and gas pressures, both internal and external.	✓		
0111-2.8.4	Thermal Forces	The design of structures shall include the effects of stresses and movements resulting from variation in temperature.	✓		
0111-2.8.5	Creep and Shrinkage Forces	Concrete and masonry structures shall be investigated for stresses and deformations induced by creep and shrinkage.	✓		No masonry. Radiation shield walls were explicitly designed to preclude cracking at cold joints.
0111-2.10	Combination of Loads and Design Requirements for Buildings and Other Structures	Combination of loads, allowable stresses, and strength requirements for buildings and other structures shall be as stipulated in the UBC, except as otherwise indicated in 0111-99, Special Facilities.	✓		
0111-3	STRUCTURAL SYSTEMS FOR BUILDINGS AND OTHER STRUCTURES				
0111-3.1	Framing	Structural systems shall be designed for ductile modes of failure to the extent feasible.	✓		
0111-3.2	Floors	Excessive loads or equipment subject to vibrations shall be supported by separate pads isolated from the rest of the floor slab with flexible joints.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0111-3.3	Control Joints	Control joints shall be designed and placed in such a manner as to avoid structural distress and uncontrolled cracking from thermal expansion and contraction, concrete shrinkage, and movements due to wind and earthquake forces.	✓		
0111-3.4	Foundations				
0111-3.4.1	General Requirements	The provisions of the UBC shall be the minimum requirements for foundations design.	✓		
0111-3.4.2	Foundation Vibrations	Analysis of foundation vibrations, design to avoid resonance, and vibration and shock isolation, where required, shall be in accordance with Chapter 1 of DM-7.03.		✓	Foundations rest on bed rock; except North Mechanical Building, which is unoccupied.
0140	QUALITY ASSURANCE				
para. 1		Facility design shall be conducted under QA requirements to ensure that the established program and project quality objectives are satisfied. A QA program shall be developed and implemented in compliance with DOE 5700.6B and using the elements of DOE 4700.1 and ANS ANSI/ASME NQA-1.	✓		
para. 2		Control mechanisms shall be established to ensure that: (1) design inputs are correctly translated into design documents in a timely manner; (2) organizational and physical interfaces are identified and controlled; (3) changes to design are controlled in a manner commensurate with the original design; (4) the design is independently verified to be adequate; (5) documentation and records of the design and design verification processes are maintained in accordance with the QA program.	✓ ✓ ✓ ✓ ✓		Design criteria, design review tabulation and change orders are on file in ENG-7 vault.
para. 5		The QA program shall include quality control functions in the following areas: • The design will satisfy program and project requirements. • The prepared drawings and construction specifications adequately incorporate QA, design, and codes and standards requirements and are available in a timely manner.	✓ ✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 5	QUALITY ASSURANCE (concluded)	• Tests, reviews, or inspections confirm the adequacy of design and quality of construction and manufactured components, where appropriate. • Lock and tag systems are provided for turnover acceptance, maintenance, and system outages.	✓		
para. 6		As a part of the QA program, architectural and engineering portions of design should be closely coordinated and functionally analyzed during the conceptual, preliminary (Title D), and detailed (Title II) design phases to avoid conflicts that could result in costly changes during construction. Prior to initiating Title I and Title II design, QA requirements shall be established for the project systems, subsystems, and components. The following shall be determined: • What the facility is to accomplish. • The range of operating conditions. • The required degree of reliability. • The intended useful life. • How it can be maintained, repaired, or replaced.	✓ ✓ ✓ ✓ ✓		
para. 7		Provisions shall be made for review and checking design calculations, drawings, and construction specifications by qualified personnel other than those responsible for the original design.	✓		
para. 8		Deviations from specified standards shall be identified and procedures established to ensure their control.	✓		
para. 9		To the extent practicable, and particularly in the case of innovative design, the design should be independently reviewed by competent consultants in construction or manufacturing techniques to confirm the practicability of construction or manufacture.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0170	CONSTRUCTION CONTRACT CLOSEOUT				
0170-1	MATERIAL TO BE PROVIDED				
para. 1		Prior to final acceptance of a completed contract, the construction contractor shall provide the Contracting Officer various data needed for the successful operation of the facility and material assuring compliance with the construction documents. Contract documents shall ensure that the constructor is responsible for delivering these items. The following noninclusive listings indicate the basic information to be submitted. The design professional shall delete from the listing inapplicable items and add project-specific requirements.	✓		Data are in ENG-7 vault, the ENG-5 maintenance group and AT in some cases.
para. 3		Project documentation: • Record drawings • As-built drawings • Welder IDs, welder qualification records, inspection reports, original radiographic films, weld maps • Action response to inspection reports • Names of contractors, subcontractors and suppliers • Minutes of progress meetings • Accident reports • Photos • Reports of progress and problems • Names of the responsible parties, addresses and telephone numbers	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓		
para. 4		Final survey locations and physical features including: • Building corners • Roads • Parking lots and sidewalks • Quality assurance records • Above- and below-ground utilities, valves, and utility structures	✓ ✓ ✓ ✓ ✓ ✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
2	Site and Civil Engineering				
0200	SITE DEVELOPMENT				
0200-1	FACILITY SITING				
0200-1.1	General				
para. 1		The selection of sites for new facilities shall comply with DOE 4300.1B. Site development and facility utilization planning shall comply with DOE 4300.1B. A site development plan shall be used to locate new facilities on existing or new sites to assure effective site utilization and to preclude future conflicts between existing and new facilities.	✓		
para. 2		During site selection for new facilities the following conditions and requirements shall be considered: • Programmatic and operating efficiency • Natural topographic and geologic conditions • Existing cultural, historic, and archaeological resources • Endemic plant and animal species • Existence of known RCRA and/or CERCLA sites • Special siting requirements for facilities containing, using, or processing hazardous materials • Health, safety and environmental protection requirements • Indoor air quality impacts (e.g., presence of radon in foundation soils, building materials that off-gas irritating chemical vapors and the need to "bake out" new buildings prior to occupancy) • Hazardous operations and consequences of potential accidents in adjacent facilities • Natural hazards including seismic activity, wind, hurricane, tornado, flood, hail, volcanic ash, lightning, and snow • Wave action within any natural or manmade body of water (in accordance with CERC Shore Protection Manual)	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓ <	

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 2	General (concluded)	- Physical protection requirements - Security and safeguard requirements - Adequacy of existing or planned support and service facilities, including utilities, roads, and parking areas - Interrelationships between facilities and aesthetic compatibility - Energy conservation requirements - Impact of site selection	✓ ✓ ✓ ✓ ✓ ✓		
para. 3		Location analysis performed during the preparation of CDRs shall consider but not be limited to these same criteria. The NEPA/DOE 5440.1C require the preparation of an environmental assessment prior to the initiation of a government action that may significantly affect the environment. These requirements shall be considered during facility siting.	✓		
0200-1.2	Radiological Siting Requirements				
para. 2		For those facilities in which radioactive materials are processed, used, or stored, or those facilities that incorporate radiation-producing machines, the acceptability of the site shall be evaluated in terms of potential radiological consequences.			N/A
para. 4		Radiation dose to an off-site individual receiving maximum exposure shall be evaluated. Dose shall be calculated and compared to the dose guidelines established below. Comparisons shall be based on a 50-year committed effective dose-equivalent.	✓		See Appendix A of the FSAR.
para. 5		The off-site individual receiving the maximum dose shall be assumed to be located at the point of highest concentration (or the highest exposure rate) outside the boundary controlled by the site. Meteorological conditions used in dose calculations shall be representative of unfavorable dispersion, determined by comparing the 0.5 percent dispersion factors (χ/Q) for each sector to the 5-percent overall site (χ/Q) and selecting the highest value.	✓		See Appendix A of the FSAR.

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 6	Radiological Siting Requirements (concluded)	Consideration shall be given to on-site individuals. Prudent measures associated with the radiological protection of on-site personnel and in conjunction with the on-site emergency response planning, as required through implementation of DOE 5500.3, shall be incorporated into the design and siting of a new facility.	✓		See Appendix A of the FSAR.
para. 7		Information on the siting evaluation, including the models, parameters, and assumptions used in the dose calculations shall be documented for use in the facility's SAR and emergency response plans.	✓		
0200-1.3	Radiological Siting Guidelines	The following siting guidelines apply to off-site individuals receiving maximum dose from exposure to internally deposited radioactive materials and/or radiation from external sources. The maximum calculated dose shall not exceed 25 rem to the whole body, 300 rem to the thyroid, 300 rem to the bone surface, 75 rem to the lung, or 150 rem to any other organ. If multiple organs receive doses from the same exposure, the effective dose equivalent from all sources shall not exceed 25 rem when calculated by using the ICRP Report No. 26 weighting of factors. When calculating these doses, degraded performance of ESF and administrative controls shall be assumed unless they can be clearly shown to be unaffected by the accident (capable of performing their safety function) by proper design, installation, testing, and maintenance according to prescribed standards.	✓		
0201	SUBSURFACE INVESTIGATIONS				
0201-1	GENERAL	For all permanent structures, subsurface conditions shall be determined by means of borings or other methods that adequately disclose soil and groundwater conditions. Data and other information obtained from prior subsurface investigations shall be used, supplemented by additional investigations at the specific location as deemed necessary by the design professional.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0201-1	GENERAL (concluded)	Subsurface investigations shall be made for critical facilities. Subsurface investigations shall be performed under the direction of a qualified soils engineer. In earthquake-prone areas, appropriate geological investigations shall be made to determine the contribution of the foundation (subsurface) to the earthquake loads imposed on the structure and shall include, but not be limited to, a recommendation of foundation type, determinations of allowable soil bearing design capacity, and the possible effects of seismic activity on the soil mass. A settlement analysis under differential design loads shall be performed where differential settlement may cause structural or architectural damage.	✓ ✓ ✓ ✓		
0201-4	FOUNDATION ENGINEERING EVALUATION AND RECOMMENDATIONS	The soils engineer shall analyze the information developed by investigation or otherwise available, including any aspect of the soil conditions that might affect design and construction of proposed structures, and shall consult with the engineer on the design requirements of the project. The soils engineer shall submit a professional evaluation, recommended construction specifications, and recommendations, including the following where applicable: • Foundation support of the structure and slabs, including soil bearing pressures, bearing elevations, foundation design recommendations, and anticipated settlement. • Soil material and compaction requirements for site fill, construction backfill, and for the support of structures and pavement. • Recommendations and design criteria for shoring and underpinning systems. • Seismic activity. • Analysis of the effect of weather and construction equipment on soil during construction.	✓ ✓ ✓ ✓ ✓ ✓ ✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0201-4	FOUNDATION ENGINEERING EVALUATION AND RECOMMENDATIONS (concluded)	- Analysis of soils to ascertain presence of dispersive potentially expansive, deleterious, chemically active or corrosive materials or conditions, or presence of gas. - Recommendation of the most proper foundation system and other alternative workable systems.	✓	✓	Previous history of LANL construction indicates no problem.
0205-2	DECONTAMINATION AND DECOMMISSIONING	Facilities where radioactive or other hazardous contaminating materials will be used or will result from facility operation shall be designed to limit dispersion and simplify periodic decontamination and ultimate facility decommissioning and disposal or reuse. Requirements are provided in Section 1300-11, Decontamination and Decommissioning.			Special nuclear facility requirements are N/A.
0235	<u>BUILDING FOUNDATIONS</u>				
0235-1	GENERAL	Building foundations shall be designed in accordance with the requirements of the UBC and ACI 318.	✓		
0235-3	CONCRETE	Concrete for building foundations shall be designed in accordance with Section 0330, Cast-In-Place Concrete.	✓		
0235-8	EQUIPMENT FOUNDATIONS	Heavy, vibration-producing equipment, such as high-pressure air compressors, chillers, fire pumps and engine/generator sets, shall have separate, isolated foundations.	✓		
0260	<u>PIPED UTILITY MATERIALS</u>				
0260-2	EXTERIOR UTILITIES	Exterior utilities are defined as those that are more than 5 ft from any building exterior. The design of exterior utilities shall consider possible future extensions of the utility. In general, if expansion is planned, utilities should be extended to the edge of the site or to a point where connection can be made without damage or disruption to existing facilities. Utility corridors shall be established that give each utility a defined location within the corridor. All water mains, supplying fire protection systems, fire hydrants, etc., shall be treated as fire mains and installed in accordance with NFPA 24. Water storage facilities shall comply with NFPA 22.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0260-2	EXTERIOR UTILITIES (concluded)	Gas distribution shall comply with local codes and requirements. Fuel gas shall comply with NFPA 54. Liquefied petroleum gas shall comply with NFPA 58. Separation of utilities from security-related equipment must be considered when planning utility installations. Utilities that penetrate or pass under a security barrier through an opening of more than 96 square inches in smallest dimension shall provide the same degree of penetration delay as is required for the security barrier.	✓ ✓ ✓		
0262	<u>CORROSION CONTROL</u>				
0262-2	CORROSIVE CONTROL TESTS	Water supplies shall be considered as to chemical content. Based on such analysis, protective devices and measures shall be used to prevent corrosion on the interior surfaces of ferrous water lines and other appurtenances. Prior to construction, soil and ground-water conditions shall be considered to determine the necessity for protecting surfaces of buried pipe from external chemical and electrolytic attacks.	✓ ✓		
0262-3	CATHODIC PROTECTION SYSTEMS	The interior of steel water tanks shall be protected by a cathodic protection system when the calcium content of the water is less than 18 ppm or when the calcium content is between 18 ppm and 55 ppm and the sulfate content is greater than 25 ppm. Cathodic protection for underground flammable/combustible liquid storage tanks and piping shall comply with NFPA 30.			N/A N/A
0266	<u>WATER DISTRIBUTION SYSTEMS</u>				
0266-1	General	Cross-connections between domestic and industrial or irrigation distribution systems are prohibited.		✓	Backflow preventers isolate the systems.
0266-4	<u>System Design Considerations</u>				
para. 2		Domestic water distribution systems that also serve fire protection requirements shall be designed to satisfy fire flow requirements plus 50 percent of the average domestic requirements plus any industrial or process demands that cannot be reduced during a fire.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 3		Each fire hydrant within the distribution system must be capable of delivering 1000 gpm at a residual pressure of not less than 10 psi. Where domestic water distribution systems are to serve inter-nal fire protection systems (i.e., sprinklers or foamite systems), adequate residual pressures shall be maintained for proper operation of such fire protection systems.	✓		N/A
para. 4		Fire hydrant branches (from main to hydrant) shall be not less than 6 inches in diameter and no longer than 300 feet. A gate valve shall be installed within each fire hydrant branch to facilitate maintenance.	✓		
para. 5		Water mains shall have a minimum pressure rating of 150 psi. Water distribution systems shall be designed to maintain a normal operating pressure range of 40 psi to 100 psi (at ground level) in distribution mains and building service lines.	✓		
para. 9		Fire hydrants shall be installed at a maximum spacing of 400 feet. Fire hydrants shall not be located more than 300 feet from the buildings to be protected. Each building shall be protected by a minimum of two hydrants.	✓		
0279	<u>EXTERIOR COMMUNICATIONS AND ALARM SYSTEMS</u>	The design professional shall coordinate exterior communications and alarm systems as follows: • Intrusion alarm and fire alarm systems shall comply with the DOE 5632 series, Section 1670, Exterior Communications and Alarm Systems, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, and NFPA 72H.	✓		
0280	<u>SITE IMPROVEMENTS</u>				
0280-1	<u>FENCING</u>	Fencing shall be limited to that required for safety, physical security, and activity control. Fencing shall be grounded around substations, fuel-storage areas, and other hazardous areas.	✓		
			✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0285	SOLID-WASTE SYSTEMS				
0285-1	REGULATORY OVERVIEW				
0285-1.1	General	Management of hazardous solid waste shall comply with 40 CFR 264 and Subtitle C of the RCRA.	✓		
3	Concrete				
	GENERAL REQUIREMENTS				
	BUILDINGS AND OTHER STRUCTURES	Concrete materials, design, and construction for buildings and other structures shall comply with ACI 318 and 40 CFR 249.	✓		
0310	CONCRETE FRAMEWORK	Formwork for concrete construction shall comply with ACI 347 and ACI SP-4.	✓		
0320	CONCRETE REINFORCEMENT				
0320-1	MATERIALS FOR REINFORCEMENT	Reinforcement materials for buildings and other structures shall comply with ACI 318; for special facilities, with ACI 349 (see Section 011-99.0, Non-reactor Nuclear Facilities - General).	✓		
0320-2	DETAILING OF REINFORCEMENT	Reinforcement details shall comply with ACI 352R and ACI SP-66 in addition to ACI 318 for buildings and other structures.	✓		
0330	CAST-IN-PLACE CONCRETE				
0330-2	MATERIALS, TESTING, AND QUALITY CONTROL	Materials, testing, and quality control for cast-in-place concrete shall comply with ACI 318 for buildings and other structures, and with ACI 349 (see Section 011-99, Special Facilities) for special facilities. Tolerances for formed concrete shall be as suggested in ACI 347.	✓		
0330-3	SELECTING PROPORTIONS FOR CONCRETE MIXES				
0330-3.1	Normal, Heavyweight, and Mass Concrete	The selection of proportions for concrete mixes for normal, heavyweight, and mass concrete shall comply with ACI 211.1.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0330-4	MIXING, TRANSPORTING, AND PLACING	The mixing, transporting, and placing of cast-in-place concrete shall comply with ACI 304.	✓		
5	Metals				
0512	STRUCTURAL STEEL				
0512-1	BUILDINGS AND OTHER STRUCTURES	Structural steel for buildings and other structures shall comply with the following: • UBC • AISC • AISC M011	✓ ✓ ✓		
0512-2	LIGHT-GAUGE STEEL	Light-gauge steel shall comply with AISI Specifications for the Design of Cold-Formed Steel Structural Members.	✓		
0512-3	PRE-ENGINEERED METAL BUILDINGS	Pre-engineered buildings shall comply with MBMA Metal Building Systems Manual and Section 0111, Structural Design Requirements.	✓		
0512-5	STEEL WATER TANKS, STANDPIPES AND RESERVOIRS	Steel water tanks, standpipes and reservoirs shall comply with NFPA 22 and AWWA D100.	✓		
0521	STEEL JOISTS	Steel joist floor and roof construction shall comply with the SJI Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders.	✓		
0531	STEEL DECKS	Steel decks for floor and roof construction shall comply with the SDI-Publ. 25 and the SDI-Publ. DDM01.	✓		
0532	METAL FASTENING	Structural connections for buildings and other structures shall comply with the requirements of the UBC and AISC M011. Welding of structures shall comply with the AWS D1.1, AWS D1.2, AWS D1.3, and AWS D5.2.	✓ ✓		
7	Thermal and Moisture Protection				
0727	FIRESTOPPING	Firestopping shall comply with NFPA 101, Chapter 6. Firestopping materials and assemblies shall be tested for their fire resistance and listed by UL or similar nationally accredited testing laboratories, or shall be listed for their fire resistance as approved by FM or similar national insurance organizations. Unrated and unapproved assemblies shall be tested and approved before being considered for use in a DOE facility.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0727	FIRESTOPPING	Where fire-rated assemblies (walls, floor-ceilings, roof-ceilings) are either partially or fully penetrated by pipes, ducts, conduits, or other such building elements, firestopping material shall be placed in and around the penetrations to maintain the fire resistance rating of the assembly.	✓		
0800-2	WINDOWS				
0800-2.1	General	All facilities shall have operable windows for ventilation except those facilities with year-round air-conditioning such as some computer rooms, where windows shall not be operable except for window cleaning purposes.	✓		
0810-1	STEEL DOORS AND FRAMES	Hollow steel doors and frames shall comply with SDI 100 and SDI 108. Insulated steel door systems shall comply with ISDSI 102.	✓		
0870	HARDWARE	Doors that are part of a fire-rated wall assembly and exterior swinging doors that open out shall have door closers.	✓		
9	Finishes				
0900	GENERAL				
0900-3	HAZARDOUS MATERIALS CONTAMINATION	Where radioactive or other hazardous materials are processed or handled, and contamination can occur, washable or strippable finishes shall be used on walls, floors, and ceilings. Where radiological contamination can occur, paint finishes shall comply with ANSI N512.			N/A N/A
0900-4	INDOOR AIR QUALITY	Finish material and its support, backup, and substrate shall be selected, designed, fabricated, assembled, and installed to exclude or prevent the escape of fibers, such as asbestos, and the escape of emissions from volatile organic compounds, such as formaldehyde, and combinations of volatile organic compounds that have been determined to be a health hazard.	✓		
0910-2	CEILING SUSPENSION SYSTEMS	Suspended ceilings shall be earthquake resistant. They shall comply with: • UBC Standard No. 47-18 • ICBO report 4071 • ASTM C635	✓		Deleted from UBC 91

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
0910-2	CEILING SUSPENSION SYSTEMS (concluded)	• ASTM C636 • ASTM E580 Nonstructural suspended systems, including ceilings, electrical components, and equipment, shall be considered in terms of UCRL 15714, Section V.	✓		
0950	ACOUSTICAL TREATMENT				
0950-1	GENERAL	Acoustical analyses shall be made for areas with high sound levels, areas where speech intelligibility is important to occupant performance, and for areas where speech privacy is important to occupant performance or required for security. Acoustical treatments in industrial facilities and other high noise occupancies shall comply with 29 CFR 1926 and 29 CFR 1910. Acoustical treatment and administrative control in areas that require periodic occupancy by operations or maintenance personnel (for example, utility rooms, equipment rooms, storage areas, service areas, support areas, and industrial process areas) and have such high sound levels that personnel would be injured by periodic short-duration exposure shall comply with 29 CFR 1926 and 29 CFR 1920.	✓		
10	Specialties				
1052	FIRE PROTECTION SPECIALTIES	Fire protection specialties shall be tested and listed by UL or similar nationally accredited testing laboratories or approved by FM or similar national insurance organizations.	✓		
11	Equipment				The GTA does not contain enclosure/confinement systems as defined in Division 11.
12	Furnishings				
1201	GENERAL	Furnishings shall be designed and constructed to exclude or prevent the escape of emissions from volatile organic compounds, such as formaldehyde, and combinations of volatile organic compounds that have been determined to be a health hazard.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1230	MANUFACTURED CASE-WORK	The design of manufactured casework for use with radioactive materials shall consider radioactive shielding requirements.			N/A
13	Special Facilities				Accelerator facilities are not addressed as special facilities.
14	Conveying Systems				
1401	GENERAL	Hoisting, conveying, and material handling systems and equipment for hazardous materials shall meet the requirements established by the cognizant DOE authority.	✓		
1460	CRANES	All cranes shall be designed consistent with CMAA-70 requirements.	✓		
15	Mechanical				
1525	MECHANICAL INSULATION				
1525-1	APPLICABILITY	Insulation shall be considered for equipment, ductwork, piping, flue pipe, and breeching to minimize energy loss, to prevent condensation, and to provide safe surface temperatures. All insulation material, media used to apply insulation, and jacketing material shall have a maximum flame spread of not more than 25 fuel-contributed and smoke-developed ratings of not over 50 when tested using UL 723 Test Methods. Exception to the smoke-developed rating of 50 shall be made for exterior underground piping and exterior above-ground piping beyond 15 feet from buildings or individual supports (stanchions). Asbestos or asbestos-containing materials shall not be used.	✓		N/A
1525-4	SAFE SURFACE TEMPERATURES	Insulation shall be provided on hot and cold generation equipment, ductwork, piping, flues or breeching, using a material, thickness, and surface treatment that will maintain the surface temperature between 35°F and 125°F for highly conductive (metal) surfaces or between 32°F and 150°F for nonconductive surfaces.	✓		
1530	FIRE PROTECTION				
1530-1	GENERAL	Fire protection systems shall comply with DOE 5480.7.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1530-3	WATERFLOW AND PRESSURE REQUIREMENTS FOR FIRE PROTECTION				
1530-3.1	General	All sprinkler or other automatic fire suppression system components shall be UL- or FM-approved for the particular application chosen.	✓		
1530-3.2	Occupancy Hazard Classification	NFPA 13 shall be used to determine the Occupancy Hazard Classification for any facility. Light hazard occupancy rules are prohibited.	✓		
1530-3.3	Water Demands for Sprinklered Facilities				
1530-3.3.1	Schedule-Designed Sprinkler Systems	For systems designed using pipe schedule methods, NFPA 13 shall be used for calculating water demand in the absence of specific requirements provided by cognizant DOE fire protection authorities based on unusual occupancies or special hazards.	✓		
1530-3.3.2	Hydraulically Designed Sprinkler Systems	NFPA 13 shall be used to determine water supply requirements for hose streams (gpm) and duration (min). For ordinary hazard occupancies and above, hose stream requirements shall be a minimum of 500 gpm regardless of the hose stream demands listed in the above references unless otherwise specified by the DOE project criteria. Determination of adequacy of water supply shall be made on the basis of actual flow test data gathered using the methods in NFPA 13, Appendix B.	✓ ✓ ✓	✓	Building designed to NFPA 13 at 250 gpm. LH ₂ dewars and new additions.
1530-3.3.3	Fire Hydrant Demand	Where reliance is placed on fire department response, either for protection of unsprinklered buildings or where the fire department will serve as redundant (backup) protection, as a general rule the water supply should be adequate to supply at least 0.03 gpm per cubic foot of fuel (building and contents) in the largest fire area (for high-BTU-content fuels, convert to equivalent ordinary BTU loads). This water supply should be available at 20 psig residual pressure at the hydrants.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1530-4	AUTOMATIC SPRINKLER PROTECTION				
1530-4.1	General	All sprinkler systems shall comply with NFPA 13.	✓		
1530-4.2	Types of Sprinkler Systems				
1530-4.2.1	Wet Pipe	Sprinkler systems shall normally be wet pipe using pipe schedule sizes listed in NFPA 13 for ordinary installations. Hydraulic designs shall be considered for all systems. The system shall be hydraulically designed where residual pressure is marginal, water application rate is high, response time is critical, or special risks are involved.	✓		
1530-4.2.3	Precision	A precision system shall be used where it is particularly important to prevent the accidental discharge of water. Need for a precision system shall be based on review by and recommendation of a professional fire protection engineer. The detection system chosen to activate the precision valve shall have high reliability and a separate alarm/supervisory signal to indicate status. The detection system must be designed to be more sensitive than the close sprinklers in the precision system, but should not be so sensitive as to cause false alarms and unnecessary actuation of the precision valve.	✓		
1530-4.2.4	Deluge	For extra hazard areas and specific hard-to-extinguish fuels, such as explosives and pyrophoric metals, a deluge system with open sprinkler heads may be used to wet down the entire protected area simultaneously. Deluge systems shall comply with NFPA 13. If quick response is required, deluge system piping may be primed with water. The nozzles must be provided with blow-off caps for water-filled deluge systems.	✓		At L _H ₂ dewars.
1530-6	STANDPIPES AND HOSE SYSTEMS	Installation of standpipe systems shall comply with NFPA 14.			N/A
1530-7	PORTABLE FIRE EXTINGUISHERS	Portable fire extinguishers shall comply with NFPA 10.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1530-8	FIRE DETECTION AND ALARM SYSTEMS				
1530-8.1	General	All fire detection and alarm devices shall have UL-listed components or be FM-approved. Devices and systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G and NFPA 72H, as applicable.	✓		
1530-8.2	Alarm Systems				
1530-8.2.1	General	Fire alarm systems shall have the following basic features: • Transmission of signals to the DOE facility fire department alarm center and other constantly attended locations in accordance with the appropriate NFPA Signaling Systems Standard • Local alarms for the building or zone in alarm • Trouble signals as required by the appropriate NFPA Signaling Systems Standard • Emergency battery backup for system operation • Electric supervision of all circuits as required by the appropriate NFPA standard • Supervisory devices for all critical functions (valve position switches, water level, temperature) • Capability of annunciating at least three separate conditions: (1) a fire alarm, (2) a supervisory alarm, and (3) a trouble signal indicating a fault in either of the first two. Annunciating of each condition shall be separate and distinct from the other two. Fire alarm systems for new DOE buildings shall be compatible with those for the DOE complex where the new building is to be located.	✓		
1530-8.2.2	Alarm Actuating Devices	Alarms that respond to flow of water shall be provided wherever a sprinkler system is installed and shall comply with requirements of the NFPA standard for the type of signaling used.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1530-8.2.2	Alarm Actuating Devices (concluded)	- A manual fire notification method such as manual fire alarm boxes shall be provided and located in accordance with the appropriate NFPA standard. - Combined watch reporting and fire alarm systems, if used shall be in accordance with the appropriate NFPA standard.	✓		
1530-8.3	Automatic Fire Detection System				
1530-8.3.1	General	Automatic fire detectors shall comply with NFPA 72E. Detector spacing shall be in accordance with NFPA 72E, Appendices A, B, and C.	✓		
1530-8.3.4	Smoke Detectors	Smoke detectors shall be installed in all areas where required by the appropriate NFPA standard or by the cognizant DOE fire protection authority. Smoke detectors shall be of a type operating on one of the principles described in NFPA 72E. Location and required spacing of smoke detectors shall be determined by the methods of NFPA 72E and its Appendix C. Spacing shall be based upon threshold fire size, fire growth rate, and ceiling height as described in these standards.	✓ ✓	✓	Not in return air ducts.
1530-9	WATER STORAGE AND DISTRIBUTION				
para. 1		Wherever practical, dedicated fire water storage and distribution systems shall be used.	✓		Part of TA-53 system.
para. 3		Underground fire water main or combined fire and domestic water main, including valves, hydrants, and fittings, shall be installed, flushed, sterilized, and tested in accordance with NFPA 24 and Section 0260, Piped Utility Materials. Water storage tanks shall comply with NFPA 22. Fire pumps sufficient to meet the density, pressure, and duration requirements of NFPA 13.	✓		
para. 4		Whenever feasible, all water distribution systems shall be of the looped-grid-type providing two-way flow with sectional valving arranged to provide alternate water flow paths to any point in the system.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 5	WATER STORAGE AND DISTRIBUTION (concluded)	Fire mains (except those supplying a single hydrant or extensions of existing smaller mains) shall be at least 9 inches. Mains shall be sized to supply the largest fire demand plus the largest domestic and process demand with consideration for residual sprinkler system pressure requirement.		✓	Mains are 8 in. diameter.
para. 6		Sprinkler supply lead-ins should be at least 6 inches, except lead-ins of 4 inches may be used for very small sprinkler systems when substantiated by hydraulic calculations. In no case shall the lead-in be smaller than the sprinkler riser.	✓		
para. 9		Outside control valves that can be locked open shall be provided on each supply lead-in, located if possible a minimum distance of 40 feet from the building.	✓		
para. 10		Key-operated buried valves shall not be used for sprinkler control valves. In no case shall there be more than one valve controlling a sprinkler supply lead-in.	✓		
para. 11		All lead-ins shall be connected with the sprinkler system at the base of the riser. Alarm valves shall be located as close as practical to the building entry point.	✓		
1540	PLUMBING/SERVICE PIPING				
1540-1	PLUMBING				
1540-1.1	General	Domestic water shall be supplied by a separate service line and not be a combined fire protection and potable-water service or a combined process water and potable-water system within the building. Plumbing shall comply with the NSPC (or other locally adopted nationally recognized plumbing code), ASHRAE Handbooks, and ASHRAE Standard 90.	✓	✓	Used back flow preventers to isolate systems.
1540-1.2	Fixtures	All fixtures shall comply with FS WW-P-541.	✓		
1540-1.3	Piping				
1540-1.3.1	Supply	No lead solder shall be used for copper pipe in potable-water system.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1540-1.3.1	Supply (concluded)	Where domestic or fire water service lines enter buildings, suitable flexibility shall be provided to protect against differential settlement or seismic activity in accordance with the NSPC or NFPA 13, respectively.	✓		
1540-1.4	Service Water Heating Equipment	The service water heating system shall provide flow within 10 seconds of approximately 110°F at the most remote outlet from generation equipment, except where this is deemed unnecessary by the cognizant DOE authority. Booster heaters shall be provided where sanitizing for dishwashing or where a temperature above the normal water heater outlet temperature is required. Generation equipment and system selection shall be based on LCC analysis and available energy sources.	✓	✓	N/A
1540-1.5	Safety Devices	Tempering valves shall be the fail-safe pressure balance type. As directed by project criteria, emergency eye washes, emergency showers, or combination eye-wash/ showers shall be provided where corrosive or other skin or eye irritant chemicals are stored, handled, used, or dispensed. Equipment shall comply with ANSI Z358.1 and be serviced by the potable water system. Hot-water generation equipment shall be provided with ASME code-stamped tanks, when of sufficient capacity, water temperature, or hot input rate to be within the jurisdiction of the ASME Boiler and Pressure Vessel Code. Approved relief devices, combination temperature-pressure or separate units, depending on the application, shall be provided. Backflow preventers and air gaps shall be used to prevent cross-connection (contamination) of potable-water supplies. Vacuum breakers (to prevent back-siphonage) shall be used only in conjunction with administrative controls.	✓ ✓ ✓ ✓	✓	
1540-1.6	Appurtenances				
1540-1.6.1	Pressure Modification	Pressure-reducing valves shall be provided where service pressure at fixtures or devices exceeds the normal operating range recommended by the manufacturer.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1540-1.6.1	Pressure Modification (concluded)	Wherever a pressure-reducing valve's failure may cause equipment damage or unsafe conditions, a pressure-relief valve shall be provided downstream of the reducing valve.	✓		
1540-1.6.4	Hose Bibbs, Wall Hose Outlets, and Yard Hose Outlets	All units served by potable-water systems shall have integral vacuum breakers, and in addition, administrative controls in the form of signs and scheduled maintenance testing of vacuum breakers.	✓		
1540-1.6.6	Sterilization	New supply systems or rehabilitation to existing supply systems shall require sterilization as per AWWA C652, AWWA C5186, or local governing plumbing code.	✓		
1550	HEATING, VENTILATING AND AIR-CONDITIONING SYSTEMS				
1550-1	GENERAL SIZING AND DESIGN CRITERIA				
1550-1.5	Ventilation-Exhaust Systems Design Requirements				
1550-1.5.1	General				
para. 1		The design professional shall select ventilation-exhaust systems for the effective removal of noxious odors, hazardous gases, vapors, fumes, dusts, mists, and excessive heat and for the provision of fresh air to occupants.	✓		
para. 2		The use of exhaust stack(s) shall be considered to provide dispersion and preclude exhaust-to-intake return of air to this or an adjacent facility. Local weather and site conditions along with guidance found in ASHRAE Fundamentals shall be used to determine requirements.	✓		
1550-1.5.2	Outdoor Air Quality	Outdoor air shall be used to provide makeup air, dilute non-toxic contaminants and provide acceptable indoor air quality in spaces served by ventilation systems. The outdoor air shall meet the quality required by ASHRAE Standard 62. DOE project criteria shall include test data on ambient air quality. If the outdoor air does not meet the ambient air quality standards for particulates, gases, or other contaminants, it shall be	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1550-1.5.2	Outdoor Air Quality (concluded)	treated to remove particles and gases and vapors as required to meet the minimum ambient air quality standards.			
1550-1.5.3	Personnel Ventilation Air Requirements	The outdoor air shall be provided in the quantities indicated for conditioned offices and other occupied spaces in ASHRAE Standard 62. Outdoor air in addition to the quantities required by ASHRAE Standard 62 shall be provided when required to balance a building's or space's exhaust air rate or to maintain the building or space under a positive pressure. Proper ventilation rates shall be demonstrated by calculation if natural ventilation of infiltration is used as the outdoor air introduction method.	✓		
1550-1.5.4	Recirculation	Areas from which air shall not be recirculated include areas that produce or emit dust particles, heat, odors, fumes, spray, gases, smoke, or other contaminants that cannot be sufficiently treated and could be potentially injurious to health and safety of personnel or are potentially damaging to equipment. These areas shall be 100-percent exhausted. Project criteria shall indicate other areas of non-recirculation.	✓		
1550-1.5.5	Industrial Ventilation Requirements	Industrial-type facilities and laboratories shall be provided with ventilation (supply and exhaust) systems as required for heat exposure control, or dilution ventilation. Ventilation air shall be provided in the quantities required to maintain OSHA air quality limits, all the PELs established by 29 CFR 1910 and all ACGIH TLVs. Design air quantities and transport velocities shall be calculated according to the calculation methods prescribed by the ASHRAE Systems handbook, the ASHRAE Applications handbook, the ACHIG Industrial Ventilation Manual, 29 CFR 1910, and NFPA 45. Designers shall consider ASHRAE Applications Chapter 14, "Laboratories," when designing laboratories and laboratory buildings. Makeup air shall be provided in the quantities required to maintain required positive or negative room static pressure requirements and to offset local exhaust air quantities. Makeup air shall be tempered.			

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1550-1.5.6	Local Exhaust Systems	DOE project-specific criteria shall provide information on the source, quantity, and type of contaminants. Local exhaust systems shall be designed to maintain the required capture air velocities for source contaminant control.	✓		
1550-1.5.7	Equipment Room Ventilation	Mechanical and electrical equipment rooms shall be exhausted so that room temperature does not exceed NEMA equipment ratings. DOE project criteria shall provide the space temperature limit criterion. Where mechanical ventilation cannot maintain a satisfactory environment, evaporative cooling systems or other mechanical cooling systems shall be provided.	✓		
1550-2.5.5	Air Cleaning Devices				
	General	Filters shall be constructed of noncombustible materials meeting the requirements for UL 900, Class I.	✓		
	High-Efficiency Particulate Air Filters	HEPA filter assemblies shall comply with ASME N509. HEPA filtration systems shall be used to minimize the release of particulate contaminants such as carcinogens, infectious agents, radioisotopes, or highly toxic materials when determined by safety analysis to be necessary. The design professional shall design for a location that facilitates in-place testing of HEPA filters, with particular attention given to plenum hardware provisions that allow for testing of the HEPA filter bank without requiring the testing personnel to enter the plenum. Utility services shall be extended to the plenum location (e.g., electrical receptacles and compressed air) to facilitate testing work. In-place testing design requirements shall meet all the recommendations of UL 586, ASME N510, and ERDA 76-21. HEPA filtration systems shall be designed with prefilters installed upstream of HEPA filters to extend the HEPA filter's life.	✓ ✓ ✓ ✓ ✓		
	Filters for Air Handling Systems Service Inhabited Space	Filters include air filter devices and air filter media used in building environmental air-handling systems for removing particulate matter from atmospheric air.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
	Filters for Air Handling Systems Service Inhabited Space (concluded)	These filters shall be specified to meet minimum efficiencies required by the ASHRAE Dust Spot method using atmospheric dust for medium-efficiency applications. Filters shall be specified and installed for use as pre-filters, medium-efficiency filters, or high-efficiency filters. These filters shall comply with ARI 850.	✓		
	Fire Protection of HEPA Filter Assemblies	In providing fire protection for the HEPA filters, the design shall separate prefilters or fire screens equipped with water spray sufficiently from the HEPA filters to restrict impingement of moisture on the HEPA filters. Under conditions of limited separation, moisture eliminators or other means of reducing entrained moisture shall be provided. The HEPA filter fire protection system shall be activated in a manner consistent with the fire protection system in the room or building in which the filters are located and as directed by the cognizant DOE fire protection authority.	✓		
1550-2.5.6	Ductwork Systems	Ductwork systems shall be designed to meet the leakage rate requirements of SMACNA HVAC Air Duct Leakage Test Manual. Ductwork, accessories, and support systems shall be designed to comply with the following: • ASHRAE Fundamentals Handbook • SMACNA HVAC Duct Construction Standards Metal and Flexible • SMACNA Fibrous Glass Duct Construction Standards • SMACNA HVAC Duct Design Manual • ACGIH Industrial Ventilation Manual • NFPA 45 • ERDA 76-21 Ductwork shall also be designed to comply with NFPA 90A, including specification and installation of smoke and fire dampers at fire wall penetrations and smoke pressurization/containment dampers as required for smoke pressurization/evacuation systems.	✓ ✓ ✓ ✓ ✓ ✓ ✓		N/A N/A

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1550-2.5.6	Ductwork Systems (concluded)	Fire dampers shall not be used on exhaust system ducting if it is required to maintain confinement of hazardous materials during and after a fire event. Exhaust ductwork shall comply with NFPA 91. Ductwork shall be designed to resist corrosive contaminants if present.	✓ ✓ ✓		
1550-3	TESTING, ADJUSTING, AND BALANCING				
1550-3.1	System Performance Tests	The design professional shall specify system performance tests for mechanical air distribution and HVAC water distribution systems to verify compliance with DOE project criteria.	✓		
1555-2	Steam and High-Temperature Water Generation				
1555-2.1	General	All boilers shall comply with the ASME Boiler and Pressure Vessel Code.	✓		
1565	REFRIGERATION				
1565-1	Chlorofluorocarbon (CFC) Limitation As A Refrigerant				
1565-1.3	Implementation	• New mechanical refrigeration equipment: Use -22 as the refrigerant where feasible.	✓		
1574	CRYOGENIC SYSTEMS				
1574-1	COVERAGE	These criteria shall apply to cryogenics as defined by the NBS.	✓		
1589	AIR POLLUTION CONTROL				
1589-1	GENERAL	These criteria shall be applied to the control, treatment, and subsequent disposal of all airborne and gaseous wastes to assure compliance with the following: • DOE 5400.1 • DOE 5440.1C • DOE 5480.4	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1589-1	GENERAL (concluded)	Federal, state and local standards including restrictions on sulfur content of fuel and other requirements specifically related to the control of air pollutants, as referred to in Executive Order 12088.	✓		
1589-2	IMPROVED RISK CONCEPT	At a minimum, facility confinement systems, including filters and ventilation systems, shall comply with the "improved risk" criteria defined in DOE 5480.7 and shall preclude offsite release of greater than TLV amounts of toxic materials during the maximum credible fire loss conditions.	✓		
1595	CONTROLS				
1595-1	GENERAL	Control systems shall be designed to use the closed-loop feedback method of control. Open-loop systems shall not be used. Proportional-type control shall be used for all control systems; other type control systems shall be used as needed according to the degree of control required. Copper piping shall be used for high pressure air in inaccessible locations (plastic piping may be used if installed in conduit). Air leakage shall not exceed 5 percent of pressure in 24 hr. Transmitters shall be capable of field calibration and thermometers or pressure gauges shall be provided at transmitters. All controllers and thermostats shall be pilot-bleed type.	✓ ✓		
1595-6	CONTROL OF AIR HANDLING SYSTEMS				
1595-6.5	Fire and Smoke Detection and Protection Controls				
para. 01		Engineered smoke pressurization and evacuation systems shall comply with the following: - NFPA 90A - NFPA 72E - ASHRAE Manual, Design of Smoke Control Systems for Buildings - ASHRAE System handbook	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
para. 02	Fire and Smoke Detection and Protection Controls (concluded)	All air handling systems shall be provided with the smoke and fire protection controls required by NFPA 101.	✓		Smoke detection in ducts not provided.
para. 03		All supply, return, relief, and exhaust air ventilation systems shall have interlock controls that interface with fire and smoke detection system controls and either turn off or selectively operate fans and dampers to prevent the spread of smoke and fire throughout the building. These controls shall comply with NFPA 90A.	✓		
para. 04		Special exhaust systems shall be designed to include fire and smoke safety controls as required by NFPA 91.	✓		
1595-8	COOLING TOWER AND WATER-COOLED CONDENSER SYSTEM CONTROLS	Cooling tower fans shall be designed with two-speed and on/off controls to reduce power consumption and maintain condenser water temperature. Bypass valve control shall be provided if required to mix cooling tower water with condenser water to maintain the temperature of entering condenser water at the low limit. Condenser water temperature shall be water at the low limit. Condenser water temperature shall be allowed to float to decrease compressor horsepower as long as the temperature remains above a lower limit required by the chiller. Condenser water temperature or flow shall be controlled from condenser head pressure for reciprocating chillers. The design shall provide basin temperature sensing devices and, if the cooling tower is operated during freezing conditions, hot water or steam control valves and additional control system components to maintain cooling tower sump water temperatures above freezing.	✓ ✓ ✓ ✓		
16	Electrical				
1605	BASIC ELECTRICAL MATERIALS AND METHODS				
1605-1	GENERAL	All systems shall comply with NFPA 70 and ANSI C2. Electrical systems shall be designed so that all components operate within their capacities for initial and projected loads.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1605-1	GENERAL (concluded)	Electrical materials and equipment shall be UL- or FM-tested, with label attached, for the purpose intended, whenever such products are available. Where there are no UL- or FM- listed products of the type, testing and certification by another nationally recognized testing agency may be acceptable. Onsite acceptance testing shall be required for each major electrical system. Tests shall be specified to demonstrate that each function and important parameter is implemented. Specific criteria shall be included to determine pass/fail acceptance. Tests shall be performed in the presence of a government representative. Copies of all test results shall be submitted for approval.	✓		
1605-2	WIRING SYSTEMS				
1605-2.1	Raceways				
1605-2.1.1	General	Raceways that penetrate fire-rated assemblies shall be non-combustible. The complete installation shall be suitably sealed to maintain the established fire ratings as defined in UL Building Materials Directory and UL 1479.	✓	✓	Mechanical room has some recent additions that don't comply.
1605-2.1.2	Electrical Metallic Tubing	EMT shall be used to enclose circuit power conductors, alarm and signal circuits in nonhazardous and noncorrosive locations. It shall not be installed where subjected to physical damages during installation or while in service. EMT shall not be installed underground and shall not be encased in concrete. When EMT is used outdoors or in damp locations, compression-type (rain tight) fittings must be used.	✓ ✓ ✓ ✓		
1605-2.1.3	Flexible Steel Conduit	Flexible steel conduit shall be used for connection to equipment subject to vibration and connection from junction boxed to recessed lighting fixtures.	✓		
1605-2.1.4	Rigid Steel Conduit and Intermediate Metal Conduit	Rigid steel conduit or intermediate metal conduit shall be used in locations classified as hazardous by NFPA 70. Only rigid steel conduit or intermediate metal conduit shall be used to route secure circuits through nonsecured areas. Such circuits shall be capable of detecting tamper with the line.	✓ ✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1605-2.1.5	Aluminium Conduit	Aluminum conduit shall be used for high-frequency circuits where steel will cause magnetic problems or in atmospheres where steel conduit is unsuitable. Aluminum conduit shall not be used to enclose secure conductors carrying classified information (as defined by the cognizant DOE authority). Aluminum conduit shall not be installed underground, encased in concrete, or where the atmosphere is corrosive to aluminum.			N/A
1605-2.1.6	Nonmetallic Conduit	Nonmetallic conduit shall be used only where allowed by NFPA 70. Nonmetallic conduit shall not be used in electro-magnetically sensitive areas or to enclose secure conductors, except when required in red/black design in accordance with NSA NACSIM 5203.	✓		
	Surface-Metal or Nonmetallic Systems	Except for vertical routings to source or termination points, surface-metal or nonmetallic raceways and multi-outlet assemblies shall be used only where allowed by NFPA 70. Surface-metal raceways passing from one floor to another shall have mechanical protection to a height of 4 feet above the floor level.	✓		
1605-2.1.8	Cable Trays	The use of cable trays shall be considered for large multiple-cable applications in both interior and exterior locations.	✓		
		Cable trays that penetrate security barriers shall provide the same degree of penetration resistance as required by the site-specific security plan for the barrier through which they penetrate. This provision applies when the opening at the point the barrier is penetrated is more than 96 square inches in area and over 6 inches in smallest dimension and is located less than: • Eighteen feet above uncontrolled ground, roofs, or ledges • Fourteen feet diagonally or directly opposite windows, fire escapes, roofs, or other openings in uncontrolled buildings • Six feet from uncontrolled openings in the same barrier.	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1605-2.2	Conductors				
1605-2.2.1	General	Conductors for interior electrical systems shall be copper, except that aluminum conductors size No. 4 AWG and larger may be used. Conductors for power and lighting branch circuits shall be not smaller than No. 12 AWG. No. 10 and No. 12 AWG conductors for power and lighting branch circuits shall be solid. No. 8 AWG conductors and larger shall be stranded. Conductors for Class 1 remote-control and signal circuits shall be enclosed in cable and shall comply with NFPA 70. Conductors for Class 2 low-energy remote-control and signal circuits shall be not smaller than No. 18 AWG. Power and lighting conductors shall be 600-volt, Type THW, XHHW, or THWN. Conductors required to be rated 90° C in accordance with NFPA 70 shall be Type RHH, THW, or THNN. Conductors in high-temperature areas shall be NEC Type FEP to TFE as required. Direct-burial conductors shall be Type UF, UJL 493. Bonding and grounding conductors shall be ASTM B1 solid, bare copper for sizes No. 8 AWG and smaller and shall be STM 88 class B stranded copper for wire sizes No. 6 AWG and larger. Each set of contract documents shall indicate the basis for the size of the conductors shown on those plans when the option for aluminum conductors has been chosen.	✓ ✓ ✓	✓	All power conductors are in compliance. Coax & Helix do not comply with NFPA 70 ratings for cable tray routing. Coax is per Mil C 17.
1605-2.2.2	Aluminum Conductor Termination	The termination of aluminum conductors, the connection of aluminum terminating lugs to copper or aluminum pads, and the use of Belleville washers shall comply with IEEE 141. Setscrew termination shall be allowed for connection to approved circuit breakers. Split-bolt terminators shall not be used.			N/A

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1605-2.2.2	Conductor Identification	Voltage levels, grounded conductors, equipment grounding conductors, and ungrounded phase conductors shall be identified. Existing field center wire color-code systems shall be used. If no present field center wire color code exists, the following color-coding system shall be used. • Color coding for 240/120-volt, single-phase systems: - Grounded neutral white - Grounding conductor green or bare - Ungrounded conductor black - Ungrounded conductor red • Color coding for 208Y/120-volt, three-phase systems: - Grounded neutral white - Grounding conductor green or bare - Phase "A" (ungrounded) conductor black - Phase "B" (ungrounded) conductor red - Phase "C" (ungrounded) conductor blue • Color coding for 480Y/277-volt, three-phase systems: - Grounded neutral gray - Grounding conductor green or bare - Phase "A" (ungrounded) conductor brown - Phase "B" (ungrounded) orange - Phase "C" (ungrounded) conductor yellow	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	✓	Laboratory standard used throughout facility. N/A Used white with orange tracer or gray.
1605-2.3	Receptacles	Receptacles shall comply with general grade as defined in FS W-C596. Receptacle circuits shall be provided with ground-fault circuit-interrupters as directed by NFPA 70. Receptacle circuits that serve receptacles installed outdoors (except receptacles that are in secure circuits and are not readily accessible) and within 6 ft of sinks and building entrances shall be provided with ground-fault circuit-interrupters.	✓ ✓ ✓		

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1620	POWER GENERATION	Generally, purchased power from an available off-site utility company shall be used in lieu of enthal on-site generating stations. Cogeneration shall be considered if steam is being produced for on-site processes or if it is possible to achieve greater economy in power cost. Where an on-site central station is justified, design shall be coordinated with utility company. See Section 1555-1.6, Cogeneration.	✓		
1630	SUPPLY EQUIPMENT AND FACILITIES				
1630-1.1	Load Requirements	Demand and diversity factors shall comply with NFPA 70. Demand and diversity for feeder and substation load calculations shall be as stated in Fink and Beaty, Standard Handbook for Electrical Engineers. Electric service quality and reliability shall be considered in conformance with IEEE 493 to ensure that they meet the load requirements. Where loads require a high degree of voltage and frequency stability, the available short-circuit MVA at the service connection and the stability of the supplying utility system shall be considered to ensure adequate power quality.	✓ ✓ ✓		
1630-2.2	Power Supply Lines				
1630-2.2.2	Overhead Lines	Overhead power supply lines shall be used where service is to be installed in remote, unsettled, or industrial areas. Maximum use shall be made of single-pole structures. Joint use of poles for power and communications distribution shall maintain safety standards and shall limit electrical interference to communications services. In the joint use of poles, either for multiple electrical distribution systems or for both electrical distribution and communications lines, underbuilt lines or cables shall be of vertical construction. Use of double-stacked crossarm construction shall be allowed only where proper clearances for hot-line maintenance work can be ensured. Clearances shall comply with ANSI C2.			N/A N/A

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1630-2.2.3	Underground Lines	In congested areas and where required for safety, for service continuity, or for conformance with local practices, primary and secondary power distribution circuits shall be placed underground. Underground distribution circuits may consist of direct-burial cable installations or of cable installed in manholes and ducts. Direct-burial cables shall have physical protection where hazards from rodents or soil will impair their safe operation. Underground cables or duct systems shall be suitably identified under the ground surface and above the cable protective system or duct bank. Direct-burial cable shall be used for secondary (600 volts or below) single-circuit installations through areas not likely to be disturbed by excavation and where service reliability is not of critical importance. Where direct-burial cables are connected to above-grade junction or terminating boxes, they shall be encased in rigid steel conduit from the elevation of the cable to the box. For primary circuits (above 600 volts) and where secondary circuit service reliability is a prime consideration, cable in duct shall be used. Duct bands shall be concrete-encased. Minimum duct size shall be 2 inches. In seismic zones, ducts may be direct-buried when the risk of loss due to earthquakes is greater than the cost of future utility work adjacent to the circuit. Electric manhole covers shall be appropriately labeled. A minimum of 25-percent spare ducts (but not less than two spare ducts) shall be provided in each duct run. Spare ducts shall include nylon or plastic cords of a 200-pound minimum breaking strength to facilitate future cable installation. Spare ducts shall be plugged or capped to prevent contamination. Underground duct runs that penetrate security barriers shall provide the same degree of penetration resistance as required by the site-specific security plan for the barrier through which they penetrate.	✓		
			✓		
			✓		
			✓		
			✓		
			✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1630-2.2.3	Underground Lines (concluded)	This provision applies when the free area within the duct run is more than 96 square inches in area and over six inches in smallest dimension.	✓		
1630-2.3	<u>Substations and Switching Stations</u>				
1630-2.3.1	General	Design of substations and switching stations shall be coordinated with the utility company. When transformation is their main function, the substations shall be located to optimize the lengths of secondary conductors. When switching is their main function, switching stations shall be located as determined by circuit routings.	✓		
1630-5	LIGHTNING PROTECTION	Lightning protection systems shall comply with NFPA 78. Lightning protection systems shall be considered for buildings containing facilities for the use, processing, and storage of radioactive, explosive, and similarly hazardous materials; for buildings over 50 feet in height; and for buildings containing valuable equipment. A risk assessment using the guide in Appendix 1 of NFPA 78 shall be made of these buildings to determine the risk of loss due to lightning. Electric power and communication services to all buildings and facilities and to underground power cables, where connected by overhead power distribution lines, shall have lightning and surge protection.	✓ ✓ ✓	✓	
1639	<u>GROUNDING</u>				
1639-1	GENERAL	Grounding systems shall comply with NFPA 70 and IEEE 142. A separate ground conductor shall be used. Raceway systems shall not be used as ground path.	✓		
1639-2	SUBSTATION AND SWITCHING STATION GROUNDING	Substation and switching station grounding systems shall comply with IEEE. Grounding connections shall comply with IEEE 837.	✓		
1639-3	FENCE GROUNDING	Permanent fence grounding shall comply with ANSI C2.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1639-4	ISOLATED GROUND SYSTEMS	Isolated ground systems may be required to meet special instrumentation or other equipment needs. Such ground systems shall be clearly identified, protected against improper usage, and installed in conformance with NFPA 70.	✓		
1640	INTERIOR ELECTRICAL SYSTEMS				
1640-1.3	Interior Distributing Voltage Levels	Standard voltages shall comply with MIL HDBK 1004/4 or shall continue the 240/120-volt single-phase service provided, as applicable.	✓		
1640-1.4	Power Systems Reliability	Power system reliability consideration shall comply with IEEE 493 to ensure continual power supply to systems and equipment designated as critical by the cognizant DOE authority. The need for multiple transformer-switch-gear service equipment, to ensure power supply continuity within the facility during scheduled or emergency equipment outages, shall also be considered.	✓		
1640-1.5	Power Quality Requirements	Adverse effects of voltage level variation, transients, and frequency variations on equipment operation shall be minimized. Sensitive electrical equipment, such as data processing equipment, shall be isolated as needed for protection. Uninterruptible power systems, motor-generated sets, or power conditioners may be used for isolation.	✓		
1640-1.6	System Protection	System protection shall comply with IEEE 242. For specialized research and development facilities, protection of equipment and systems shall comply with DOE/EV 0051/1.	✓		
1640-1.7	Ground-Fault Protection	Ground-fault protection shall comply with NFPA 70. See also Section 1605-2.3, Receptacles.	✓		
1640-1.8	Neutral Conductors	The neutral conductor for electric discharge lighting and for data processing and other similar equipment shall be sized in accordance with NFPA 70. Calculations shall include harmonic current.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1640-2	SERVICE EQUIPMENT AND FACILITIES				
1640-2.3	Transformers	Interior service transformer installations shall comply with NFPA 70. The minimum number of transformers necessary to satisfy initial and projected facility loads and operational continuity, safety, and security requirements shall be used. Transformer protection and appurtenances shall comply with IEEE C37.91. Transformer installation shall comply with FM 5-4/14-8.	✓		LANL standards require transformers to be rated for operation at 7500 ft. altitude
1640-2.4	Motors	Motors shall comply with NEMA MG-1, except that hermetic refrigerant motor compressors shall comply with UL 984. Motors shall have sufficient rating for the duty they are to perform and shall not exceed their continuous horsepower rating, including service factor, when the driven equipment is operating at the greatest horsepower conditions it is likely to encounter. Starting and running characteristics shall be coordinated with the driven machine and the motor control equipment. Motor enclosures shall be dripproof for indoor dry locations and totally enclosed or totally enclosed fan-cooled for outdoor or other wet locations, except where special conditions require otherwise. Single-phase motors 1/8 hp and smaller shall be shaded-pole or permanent split capacitor; those larger than 1.8 hp shall be capacitor-start. Polyphase motors shall comply with NEMA Design B, unless other characteristics are required by the driven machine or the speed controller. Motors shall be designed for continuous service at 40°C ambient temperature. Motors shall operate at full capacity, with a voltage variation of plus or minus 10 percent of the nameplate voltage. High-efficiency motors shall be considered where loading and nearly constant usage may result in significant energy savings.	✓ ✓ ✓ ✓		LANL standards require motors to be rated for operation at 7500 ft. altitude

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1640-2.4	Motors (concluded)	Except where special conditions require otherwise, motors 1 hp and less shall be specified as single-phase, 115-volt motors, while those greater than 1 hp shall be specified as three-phase, 200- or 460-volt, motors. Motor characteristics shall be selected to avoid excessive acceleration time for motors driving large masses and starting under load. Variable-speed drives shall be considered where motor speed requirements vary widely during normal operation. Solid-state variable-frequency units are recommended for smaller horsepower motors. In all cases, the driven motor shall be selected in accordance with the drive manufacturer's recommendations to ensure a coordinated system and to avoid overheating the motor.	✓		
1640-2.5	Motor Control	Control equipment shall comply with the NEMA ICS standards and UL 508. All motors shall be provided with fully coordinated control equipment to perform the functions required. Overcurrent devices shall be provided in each ungrounded conductor; overcurrent devices located in the motor or controller shall be rated in accordance with the manufacturer's instructions. Manually reset devices are recommended. Single-phase motors may be controlled directly by automatic control devices of adequate rating. Polyphase motors controlled automatically and all polyphase motors rated greater than 1 hp shall have magnetic starters. Control devices shall be of adequate voltage and current rating for the duty to be performed. Pilot control circuits shall operate with one side grounded, at no greater than 120 volts. Where control power transformers are required, they shall be located inside the associated motor starter housing, shall be protected against faults and overload by properly sized overcurrent devices, and shall be of sufficient capacity to serve all devices connected to them without overload. Reduced-voltage starters shall be provided for larger motors where starting the motor may result in unacceptable voltage dip.	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1640-3	POWER SERVICE FOR SECURITY, COMMUNICATIONS, AND ALARM SYSTEMS				
1640-3.1	<u>General</u>	Electric power distribution systems shall be filtered to reduce emanation of detectable electromagnetic signals to acceptable levels as directed by the cognizant DOE telecommunications and security personnel. Installations shall comply with DOE 5300.2B, DOE 5300.3B, and 5300.4B. Additional guidance shall be obtained from the Office of Computer Services and Telecommunications Management, DOE Headquarters, as directed by the cognizant DOE authority.	✓		
1640-3.2	<u>Primary Power Supply</u>	Normal primary power for protective alarm and communications systems shall come directly from the on-site power distribution system or, in the case of isolated facilities, shall come directly from the public utility. Where several primary power sources are available, the most reliable source shall be used.	✓		
1640-3.3	<u>Standby or Emergency Power Supplies</u>	Standby or emergency power supplies for security, communications, and alarm systems shall be provided in accordance with Section 1660, Special Systems.	✓		
1650	<u>EXTERIOR LIGHTING</u>				
1650-1	GENERAL	Exterior lighting systems shall comply with IES Lighting handbook. System control shall use time clock and/or photocell to provide illumination only when needed. Light glare shall be kept to a minimum in these situations where it would impede effective operations of protective force personnel, interfere with rail, highway, or navigable water traffic, or be objectionable to occupants or adjacent properties.	✓ ✓		
1655	<u>INTERIOR LIGHTING</u>				
1655-1	GENERAL	Interior lighting systems shall comply with the IES Lighting handbook. Nonuniform lighting practices shall comply with 41 CFR 101-20.116-2 and with Section 1694, Energy Conservation. Lighting power budget shall be determined in conformance with ASHRAE Standard 90. Exit and emergency			

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1655-1	GENERAL (concluded)	lighting systems shall comply with NFPA 101 and NFPA 110.			
1655-2	LIGHTING SOURCES	Maximum use shall be made of fluorescent and HID lamps. Where HID lamps are used, a standby lighting systems shall be provided to meet emergency lighting requirements during HID lamp restrike periods. When using HID lighting in doors, careful consideration of the required color rendition shall be made from visual and health safety perspectives.	✓		
1655-3	FIXTURES	Fixtures shall have diffusers and lenses constructed of non-combustible materials.	✓		
1660	SPECIAL SYSTEMS				
1660-2	EMERGENCY POWER SYSTEMS	Emergency power systems shall comply with NFPA 37, NFPA 70, NFPA 101, NFPA 110, and IEEE 446. Emergency power systems shall be capable of maintaining full operating of emergency loads for the full time period specified by the cognizant DOE authority (nominally, a minimum of 24 hours). Such power sources shall have the necessary built-in features to facilitate operational testing on a periodic basis to verify their readiness. Where emergency generators are required for loads 25 kVA and smaller, gasoline of LPG engines may be used. For loads greater than 25 kVA, diesel engines shall generally be used. Steam-turbine generators may be used if steam is being produced for on-site processes. Gas turbines may be used if an LCC analysis warrants and if the NEC criteria to emergency power throw-over time is met. Application of diesel engines shall comply with FCC Technical Report No. 69. Batteries, when required, shall be rechargeable and shall be kept fully charged at all times when primary power is available. The charger shall automatically switch from float to fast charge rates at a present drop in DC bus voltage. The charger shall be furnished with a capacity to charge the battery from a fully discharged state to not less than 85 percent of the	✓		N/A
					N/A

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1660-2	EMERGENCY POWER SYSTEMS (concluded)	rated ampere-hour capacity within 24 to 72 hr. See also IEEE 308. Emergency power systems legally required by NFPA 70 shall be installed to meet normal emergency power requirements. More stringent emergency power requirements shall be identified by the cognizant DOE authority on a case-by-case basis.	✓		
1660-3	UNINTERRUPTIBLE POWER SYSTEMS	Uninterruptible power supplies shall be provided for those loads requiring guaranteed continuous power. Application of UPSs shall comply with IEEE 446, as modified by the cognizant DOE authority. UPS installations may be Safety Class 1 (Seismic Category I functional) or standby type dependent on the classification of the loads served.	✓		
1670	EXTERIOR COMMUNICATIONS AND ALARM SYSTEMS				
1670-1	GENERAL	Systems shall be designed to avoid unnecessary duplication of facilities. Emergency power supply facilities, exterior power supply pole lines, and underground power supply dust bank systems shall be used jointly for the installation unless the joint use of facilities will degrade system performance. Joint use shall not expose the security system to damage or to unauthorized access. Power wiring and signal wiring shall not share the same conduit. The following shall be considered in the design of telecommunications and alarm facilities: • Areas and locations to be served • Initial and ultimate requirements for telecommunications and alarm services • Type of construction to be used.	✓ ✓ ✓ ✓		
1670-2	FIRE ALARM AND SUPERVISORY SYSTEMS	Fire alarm and supervisory systems shall comply with NFPA 71, NFPA 72A, NFPA 72B, NFPA 72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, NFPA 72H, NFPA 1221, and ANSI C2 as appropriate for the location. Outside cable plant for fire alarm and supervisory systems shall comply with the standards for telephone cable plant. In the joint use of poles	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1670-2	FIRE ALARM AND SUPERVISORY SYSTEMS (concluded)	for electric power distribution and for supporting fire alarm and telephone cables, separate fire alarm cable shall be placed below the telephone cable. Fire alarm cables installed in underground ducts shall be distinctively marked within manholes and handholes that are shared with other communications cables and shall be kept physically separated from all power conductors. Exterior fire alarm pull boxes and emergency-reporting telephones shall be installed in weatherproof housings manufactured specifically for the mechanism.	✓		
1670-3	SECURITY ALARM AND ASSESSMENT SYSTEMS	Devices and equipment for interior IDSs required for SNM and storage of classified matter shall meet FS W-A-450B or equipment as approved by the cognizant DOE authority. Purchases of new protective alarm equipment or replacement of existing equipment shall be approved by the cognizant DOE authority. Protective alarm systems shall have a primary and emergency power source. Emergency power for protective alarm systems shall be supplied by batteries or engine-driven generators. Switchover to the emergency power shall be automatic on failure of the primary power source, and on failure of both the primary and emergency power sources a signal shall be generated to indicate an alarm condition at the monitor. Rechargeable batteries shall be kept fully charged or subject to automatic recharging whenever the voltage drops to a level specified by the battery manufacturer. Nonrechargeable batteries shall be replaced whenever the voltage drops 20 percent below the rated voltage; a signal shall be activated in the monitor to indicate when this condition exists. Auxiliary power sources shall be capable of maintaining full operation of the alarm system for not less than 8 hours. AS determined by the cognizant DOE authority, such power sources shall contain a switching capability to facilitate operational testing to determine adequate emergency power sources.	✓ ✓ ✓ ✓ ✓ ✓		SNM requirements N/A.

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1670-3	SECURITY ALARM AND ASSESSMENT SYSTEMS (continued)	Such power sources shall be maintained by qualified service personnel. The power supply, other than public utility, shall be vented sufficiently to preclude deterioration of any of its components as a result of operation under high temperatures. Supervisory and line-tamper circuits for existing alarm systems that protect Category I or II amounts of SNM shall meet the following requirements: • Direct or alternating current with continuous line supervision adequate to detect a short, open, or substitution shall be the minimum used, provided that all equipment containers, junction boxes, and so forth, are tamper resistant and that alarm wiring is contained in rigid wall metal conduit. Digital line supervision is preferred over direct or alternating current supervision. • The system shall be capable of detecting tamper with the system, any component, or the line in both the secure and access modes. Interface components such as line modems or data-gathering panels shall be located, if practical, either at the central annunciating point or in the protected area. All components located in the field (e.g., line amplifiers) shall be tamper protected and preferably buried or located within a building. • If dedicated telephone cable pairs are used to connect the protected area to the annunciating point, they must not be routed through telephone switching equipment. Where connected through frame rooms, the pairs shall not be identified as alarm system pairs. Supervisory and line-tamper circuits for new alarm systems that protect Category I or II amounts of SNM shall meet the following requirements: • A continuously polled, digital interrogation/ response transmission system shall be used. • Each protected zone shall have a unique digital address code.			N/A SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A.

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
1670-3	SECURITY ALARM AND ASSESSMENT SYSTEMS (concluded)	- The polling shall be in a pseudo-random manner (i.e., all zones are polled during each sequence but the order or start point is varied). Alternately, encryption may be used. - Interface components such as line modems or data-gathering panels shall be located, if practical, either at the central annunciating point or in the protected area. All components located in the field (e.g., line amplifiers) shall be tamper protected and preferably buried or located within a building. - The interface equipment shall be capable of initiating an alarm if any malfunction or tamper occurs while in both the access or secure modes. - The polling sequence shall poll all protected zones at the fastest rate consistent with the type of transmission media used (e.g., coaxial cable, radio, or telephone pairs). - A redundant and separately located transmission line shall be installed. If two cables are used, they shall not be installed in the same trench.			SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A. SNM requirements N/A.
1670-4	SECURE COMMUNICATIONS SYSTEMS	Secure communications systems shall comply with DOE 5300-3B, DOE 5300.4B, and the DOE 5632 series. Data processing, amplifying, telecommunications, and other systems that emit electromagnetic emanations, and communications lines to remote interrogation points used to process classified data processing information, shall be protected against compromise of such data in accordance with DOE 5637.1, DOE 5300.2B, and DOE 5300.4B. For the protection of classified matter, line supervision limits and/or line tamper alarm capability shall meet UL Class AA requirements. Telephones or public address systems in conference rooms or offices in which classified discussions at the Secret or Top Secret level occur shall comply with Section 0110-99.10, Secure Conference Rooms, and Section 0110-99.11, Secure Offices, respectively.	✓ ✓ ✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (continued)

Section	Description	Criteria	C	NC	Comments
	SECURE COMMUNICATIONS SYSTEMS (concluded)	Where transmissions of classified data outside security areas are involved, NSA-approved encryption shall be used or the signal lines shall be installed in accordance with DOE 5300.4B. ADP equipment and cabling shall be installed per NSA NACSIM 5203 or other means approved by the CSOM to preclude compromising emanations from radiating beyond the control zone.	✓		
1670-5	ENERGY MANAGEMENT SYSTEMS AND DEVICES	When directed by the cognizant DOE authority, EMSs and their accessories shall be included in the design of new or upgraded telecommunications and alarm systems.	✓		
1670-6	ANTENNA TOWERS, POLES, AND MASTS	Antennas or reflectors, transmission lines, and other equipment to be mounted on the antenna structures, and the location, number, height, arrangement, and orientation of antenna structures shall comply with DOE 5300.1B and guidance from the Headquarters Office of Computer Services and Telecommunications Management. Reference drawings and specifications obtained from Headquarters Office of Computer Services and Telecommunications Management may be used as guidance for the following: • Typical antenna mast suitable for supporting various types of VHF and UHF and with mounting details. • Underground, hardened, and remotely controlled telescoping pushup antenna structures and facilities for HF applications.			N/A N/A N/A
1671	INTERIOR COMMUNICATIONS AND ALARM SYSTEMS				
1671-1	PLANNING	Specific project communications requirements shall be designated by the cognizant DOE authority.	✓		
1671-1.1	General	Interior communications and alarm systems shall be designed to use standard, commercially available equipment. The initial and projected requirements for telecommunications systems shall comply with DOE 5300.1B. Secure communications systems shall comply with DOE 5300.3B. TEMPEST criteria shall be as set forth in DOE 5300.2B. Protected distribution systems shall comply with DOE 5300.4B. Data	✓		

Table B-1 GTA Compliance with DOE Order 6430.1A (concluded)

Section	Description	Criteria	C	NC	Comments
1671-1.1	General (concluded)	communications facilities, services, and equipment shall comply with DOE 5300.1B. Spectrum-dependent services shall comply with DOE 5300.1B. See also Section 0110-1.2, Systems Integration.			
1671-1.2	Joint Use	Telephone circuits shall be used for other telecommunications and alarm services to the maximum extent practicable. If separate conductors are required, they shall be routed through the main telecommunications and signal raceway systems if raceway systems are present. Separate wireways and cabinets shall be used only when necessary to meet security, technical, or code requirements or to achieve significant economies.	✓		
1671-1.3	Hazardous Locations	Telecommunications and alarm equipment and conductors shall be located outside areas subject to explosion, fire, flood, chemical fumes, excessive dust, radiation or vibration, and excessive electrical or electromagnetic noise levels. Where telecommunications and alarm services must be extended into these areas, equipment and installation shall be suitable for the hazard.	✓		
1671-2	FIRE ALARM AND SUPERVISORY SYSTEMS	Fire alarm and signaling systems shall comply with NFPA 72A, NFPA 72B, NFPA72C, NFPA 72D, NFPA 72E, NFPA 72F, NFPA 72G, and NFPA 72H.	✓		

Table B-2 GTA Compliance with DOE Order 5480.11

Section	Description	Criteria	C	NC	Comments
9	REQUIREMENTS FOR RADIATION PROTECTION OF OCCUPATIONAL WORKERS, UNBORN CHILD, STUDENTS, MINORS, AND ONSITE MEMBERS OF THE PUBLIC				
9.g	Monitoring	Occupational workers shall be monitored, as appropriate, to demonstrate compliance with the radiation protection standards in paragraph 9b and to estimate the dose equivalents received from external and internal sources of radiation. Workplaces shall be routinely monitored, as appropriate, for identification and control of potential exposure sources.	✓		
9.g.3	Workplace	(a) <u>Air Monitoring</u> . Ambient air monitoring shall be performed in occupied areas with the potential to exceed 10 percent of any derived air concentration values given in Attachment 1. Representative ambient air monitoring samples should be taken in strategic locations to detect and evaluate airborne radioactive material at work locations. Data obtained from air monitoring shall be used for assessing the control of airborne radioactive material in the workplace; it should not normally be used to evaluate the dose equivalent to radiation workers. Air monitors shall be routinely calibrated and maintained, and should be capable of measuring one DAC when averaged over 8 hours (8 DAC-hours). (b) <u>Radiation Monitoring</u> . Appropriate stationary (area) and/or portable radiation instruments shall be available and used to measure dose rates for the purpose of controlling exposure to radiation. These instruments shall be routinely calibrated and maintained. The combination of instruments used shall provide capability to measure types of radiation (neutron, gamma, beta, or x-radiation) and dose rates characteristic of that which could be encountered at that facility.	✓		

Table B-2 GTA Compliance with DOE Order 5480.11 (continued)

Section	Description	Criteria	C	NC	Comments
9.j	<u>Design and Control</u>	Radiation exposure rates in controlled workplace areas should be reduced to as low as reasonably achievable levels by proper facility design and control. The primary means for maintaining exposures as low as reasonably achievable are to be through physical controls, e.g., confinement, ventilation, remote handling, and shielding. Administrative controls and procedural requirements are to be considered supplemental means to achieve control.	✓		
9.j.1	<u>Design</u>	During the design of facilities, the following objectives shall be applied: (a) <u>Optimization</u>. Optimization principles, as discussed in ICRP Publication 37, are to be utilized in developing and justifying facility design and physical controls. (b) <u>External Radiation Exposure</u>. The design objectives for personnel exposure from external sources of radiation in continuously occupied controlled areas are ALARA and not exceeding 0.5 mrem (5 microsieverts) per hour on average. The design objectives for exposure rates for potential exposure to a radiation worker where occupancy is generally not continuous are ALARA and not exceeding 20 percent of the applicable standard in paragraphs 9b(1) and (2). (d) <u>Maintenance, Decontamination, and Decommissioning</u>. Ease of maintenance and decontamination and decommissioning is to be considered in facility design and selection of materials.	✓		
9.j.2	<u>Control</u>	During routine operations, the combination of design and control procedures shall provide that, with respect to the radiological workplace, the anticipated magnitude of the prospective committed effective dose equivalent from intakes plus any effective dose equivalent from external exposure will not exceed 5 rem (0.05 sievert) in a year, and the anticipated magnitude of the committed dose equivalent to any organ or tissue from intakes plus any dose equivalent from external exposure will not exceed 50 rems (0.5 sievert) in a year. Compliance with these requirements shall be demonstrated	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-2 GTA Compliance with DOE Order 5480.11 (continued)

Section	Description	Criteria	C	NC	Comments
9.j.2	<u>Control</u> (concluded)	through appropriate workplace monitoring pursuant to the provisions of paragraph 9g(3).			
9.k	<u>Posting and Labeling</u>	Areas in DOE nuclear facilities shall be posted in accordance with the provisions given below. Radioactive material and/or its container shall be individually labeled where normal posting of the area and control of the material would not provide adequate protection. The design of signs, labels, and the radiation symbol shall conform to ANSI N12.1-1971 and ANSI N2.1-1971. The background color is to be yellow; the symbol color may be black or magenta.	✓		
9.k.1	<u>Controlled Area</u>	The access to any controlled area where radioactive materials or elevated radiation fields may be present shall be clearly and conspicuously posted as a controlled area. The type of sign used may be selected by the contractor with the approval of the field organization to avoid conflict with local security requirements.	✓		
9.k.2	<u>Radiological Area</u>	(a) <u>Posting for External Radiation.</u> The access to any area where an individual can at anytime during normal operations receive a dose equivalent greater than 5 mrem (50 microsieverts) in 1 hour at 30 centimeters from the radiation source or any surface through which radiation penetrates shall be posted as below. In addition, the anticipated dose rate or range of dose rates shall be included on or in conjunction with each of the signs, as appropriate. 1 "Radiation Area" for any area within a controlled area where an individual can receive a dose equivalent greater than 5 mrem (50 microsieverts) but less than 100 mrem (1 millisievert) in 1 hr at 30 cm from the radiation source or from any surface through which the radiation penetrates,	✓		

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-2 GTA Compliance with DOE Order 5480.11 (continued)

Section	Description	Criteria	C	NC	Comments
9.k.2	Radiological Area (concluded)	2 "High Radiation Area" for any area within a controlled area where an individual can receive a dose equivalent of 100 mrem or greater (0.001 sievert) but less than 5 rem (0.05 sievert) in 1 hr at 30 cm from the radiation source or from any surface through which the radiation penetrates, and 3 "Very High Radiation Area" for any area within a controlled area where an individual can receive a dose of 5 rem (0.05 sievert) or greater in 1 hour at 30 cm from the radiation source or from any surface through which the radiation penetrates.			
		(c) Posting for Surface Contamination. The access to any area where surface contamination levels greater than 10 times those specified in Attachment 2 are present shall be clearly and conspicuously posted with a sign that identifies the radiological conditions which exist (e.g., "Contamination Area"). The type of sign used shall be consistent with the radiation control policies established at the facility and may be selected by the contractor with the approval of the field organization.	✓		
9.1	Entry Control Program	An appropriate entry control program shall be established for radiological areas. This should include a buffer area prior to entry to a radiological area where appropriate. The level of control should be consistent with the degree of hazard. Signs and barricades, control devices on entrances, conspicuous visual and/or audible alarms, locked entrance ways, and/or administrative procedures should be used as appropriate to ensure that personnel entry into radiological areas is controlled. Step-off pads and protective clothing shall be required for entry to contaminated areas. For very high radiation areas, the entry control program shall include at a minimum one of the following:	✓		

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-2 GTA Compliance with DOE Order 5480.11 (concluded)

Section	Description	Criteria	C	NC	Comments
9.1.1		Control devices on each entrance or access point which function automatically to prevent entry when a very high radiation area exists; permit entry only after the radiation level is reduced below 0.1 rem (0.001 sievert) per hour; and prevent use or operation of the radiation source, thereby preventing the existence of a very high radiation area, while an individual is in the area.	✓		
9.1.2		A control device which energizes a conspicuous visible or audible alarm signal so that the individual entering the very high radiation area through a failed control device is aware of the radiation level and radiation protection personnel are aware of the entry. Administrative procedures shall define the required actions of personnel when alarms are activated.		✓	Visual warnings operate continuously when beam is on. Backup entry alarm is not required, because combination of redundancy and fail safe in the RPSS provides adequate assurance that the beam will be shutdown if the shielding is breached.
9.1.3		Locked entry ways, except during periods when access to the area is required, with positive control over and radiation surveys made for the initial entry and periodically as necessary.	✓		
9.1.4		Control devices that will automatically generate audible and visible alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or the activation of a secondary control device which will prevent use or operation of the source.	✓		

Table B-3 GTA Compliance with ANSI N43.1

Section	Description	Criteria	C	NC	Comments
3	<u>RADIATION PROTECTION DESIGN CRITERIA</u>				
3.1	<u>General Radiation Shielding Considerations</u>				
3.1.5		The shielding design shall be based on the maximum radiation output of the accelerator, considering whichever combination of primary or secondary radiation energy, intensity, and species would require the most shielding. The possibility of operating later at higher energies and/or intensities should be anticipated in the original facility design, within reasonable extrapolations of the expected performance.	✓		
3.1.6		The shielding design shall also be based on continuous operation of the accelerator at maximum radiation output during an 8-hour day for 5 days per week. If it is planned that the accelerator will be in operation in excess of this period, the schedules of the associated radiation workers shall be arranged so that no worker occupies the controlled areas surrounding the accelerator facility for more than 8 hours per day, 5 days per week. Alternatively, the shielding design shall be increased so that personnel occupying the controlled and uncontrolled areas more than 8 hours per day, 5 days per week, will not receive more than the applicable MPDE.	✓		
3.1.7		The shielding design shall conform to all applicable Federal and State regulations pertaining to the specific accelerator installation under consideration, its intended use, and its ancillary apparatus and materials.	✓		
3.2	<u>Radiation Damage</u>				
3.2.1		Special attention should be given to the use of radiation-resistant insulation materials, such as ceramics or mineral-oil insulated wire, where exposure to intense radiation fluxes is to be expected. If plastic materials are necessary, they should be shielded from the intense radiation. Plastic material should not be used in those regions where accumulated doses over 10 megarad can be absorbed by the material in a shorter time than the interval between periodic inspections of the			N/A - Doses are not high enough to cause degradation of insulators.

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-3 GTA Compliance with ANSI N43.1 (continued)

Section	Description	Criteria	C	NC	Comments
3.2.1	(concluded)	accelerator facility. Polytetrafluoroethylene should not be subjected to high radiation doses.			
3.2.2		Components of electrical and electronic devices used for safety that are to function in the presence of intense radiation fluxes shall be chosen for their resistance to radiation damage. Interlock switches, fire detectors, area monitors for radiation or radioactivity, ozone monitors, emergency off-switches, and similar safety devices shall be designed into "fail-safe" circuits, so that radiation-damage effects are positively indicated. Whenever possible, safety devices should be protected from the intense radiation. In any event, they should be periodically tested to insure that they are functioning properly in their radiation environment.	✓		
3.3	Safety Systems				
3.3.1	General Considerations				
3.3.1.4		Materials and workmanship utilized in the design and installation of the safety system should be of the highest grades for dependability and long life. Fully enclosed components should be used wherever practicable, and methods of actuation shall be as failureproof and tamperproof as possible.	✓		
3.3.1.5		The principle of fail-safe shall apply whenever practicable in the design and execution of safety systems. Duplication of methods or redundancy of devices should be considered when it would seem that dependability can be justifiably enhanced.	✓		
3.3.1.6		Maximum reliance should be placed on passive rather than active elements of a safety system. Where possible, wall barriers and locks should be relied upon as compared with warning lights, bells, radiation detection devices or electrical surveillance systems.	✓		

Table B-3 GTA Compliance with ANSI N43.1 (continued)

Section	Description	Criteria	C	NC	Comments
3.4	Accelerator Controls and Interlock Systems				
3.4.1		The primary controls governing the production of radiation shall be attended during the time that the accelerator is in operation. The controls shall be secured (locked) when not attended in order to prevent unauthorized use.	✓		
3.4.2		The operational positioning of controls and the use of colored indicators should comply with the prevailing conventions in the electrical and electronics industries as reflected in applicable American National Standards and the National Electrical Code.		✓	Although some controls and indicators are based on national standards, a local convention was used for OPI screen color codes.
3.4.3		Instrumentation, readouts, and controls on the accelerator control console shall be clearly identified and easily discernible.	✓		
3.4.4		Provisions shall be made in radiation control circuits for the safety interlocks and warning systems. These provisions should not be dependent upon the operation of a single circuit and should be designed so the specific interlock triggering an alarm condition is readily identifiable.	✓		
3.4.5		When an interlock system has been tripped, it shall only be possible to resume operation of the accelerator by manually resetting controls at the position where the interlock has been tripped, and lastly at the main control console.	✓		
3.4.6		All entrances into a target room or exclusion area shall be provided with interlock systems.	✓		
3.4.7		A scram switch, pull-chain, or other emergency power cutoff switch, shall be located within easy reach, and be easily identifiable, in exclusion areas. Such a cutoff switch shall have positive indication as to the operative position of the switch, and shall include, at the same location, a manual reset, so that the accelerator cannot be restarted from the accelerator control console without manually resetting the cutoff switch.	✓		

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APPENDIX B DESIGN CRITERIA COMPARISON

Table B-3 GTA Compliance with ANSI N43.1 (continued)

Section	Description	Criteria	C	NC	Comments
3.5	<u>Warning Devices</u>				
3.5.1		All locations designated as high radiation areas, and entrances to such locations, shall be equipped with easily observable flashing or rotating red warning lights that operate automatically when, and only when, radiation is being produced. Lights of a different color shall be used for other visual indicators when they are required. Redundancy shall be built into the system such that an alarm will sound in the event radiation is produced and the warning light has malfunctioned.		✓	Entrances are posted with illuminated signs. Multiple strobe lights and horns in tunnel warn of beam coming on.
3.5.2		Barriers, temporary or otherwise, and pathways leading to high radiation areas, shall be identified in general accord with ANSI Z53.1, "Safety Color Code for Marking Physical Hazards."	✓		
3.5.3		In a large facility audible warnings shall be given prior to startup of the accelerator. Horns or buzzers should be located in areas with readily accessible scram switches. There shall be no possibility of confusion between the tone and characteristics of these audible systems and the Immediate Evacuation Signal. The audible warning should have a duration such that a person's attention would be attracted above ambient noise, and that he would have time to reach a scram switch or to safely evacuate the space. In a small facility a public address (P.A.) system may satisfy the above requirement.	✓		
3.5.4		Continuous radiation monitoring devices should be operating in or adjacent to high radiation areas, or in other areas where radiation intensity may increase with the operational level of the accelerator. Such monitoring devices shall provide an audible warning to personnel in the vicinity when preset maximum levels are exceeded.	✓		
3.6	<u>Reliability Tests</u>				
3.6.1		All safety and warning devices including interlocks shall be serviced and checked for proper functioning at intervals not to exceed 6 months.	✓		

Table B-3 GTA Compliance with ANSI N43.1 (continued)

Section	Description	Criteria	C	NC	Comments
4	<u>OPERATIONAL HEALTH</u> <u>PHYSICS</u>				
4.5	Area Monitoring Requirements				
4.5.5		Radiation levels in all exclusion areas should be continuously monitored. The monitoring devices shall be capable of providing a remote readout at the control panel and shall be interlocked at all entrances to the areas such that unsafe entry is rendered impossible during operation.	✓		
4.6	Systems				
4.6.1	Ventilation Systems				
4.6.1.3		The air vented from irradiated areas shall be dispersed in the atmosphere in a manner to meet existing State, local, and Federal air pollution laws. In particular, dispersion should be planned to eliminate the possibility of the exhaust air being immediately drawn into neighboring air intakes.	✓		
4.6.4	Interlock and Warning Systems				
4.6.4.1		Particle accelerators shall be secured when not in operation to prevent unauthorized use.	✓		
4.6.4.2		A continuous radiation monitoring system shall be operational and located in proximity to the accelerators with associated read-out and preset alarm devices located within the machine area, and at the control console.	✓		
4.6.4.3		A control switch on the accelerator control console shall be used to turn the accelerator beam on and off. The safety interlock system shall not be used to turn off the accelerator beam except in an emergency. If the interlock system turns off the accelerator, it shall not be possible to resume operation without resetting the accelerator "ON" switch at the control console.	✓		
4.6.4.4		All safety and warning devices, including interlocks, shall be checked for proper operability at intervals not to exceed 6 months.	✓		

Table B-3 GTA Compliance with ANSI N43.1 (concluded)

Section	Description	Criteria	C	NC	Comments
4.6.4.5		If, for any reason, it is necessary to intentionally bypass a safety interlock or interlocks, such action shall be: (1) authorized by the accelerator operator and radiation protection officer on each shift, (2) recorded in a maintenance log or other record and posted at the accelerator control console; and (3) terminated as soon as possible.	✓		GTA does not have radiation protection officer per se; swp with group leader approval is required for bypass.
5	RADIATION MEASUREMENTS				
5.5	Airborne Radioactivity Monitoring and Toxic Gas Detection				
5.5.1		Monitoring methods used for the detection of radioactive gases or particulates shall be sensitive enough to detect the concentrations permissible for occupational and nonoccupational exposure as contained in NCRP Report No. 22 (1959) (Maximum Permissible Body Burdens and Maximum Permissible Concentrations and Radionuclides in Air and Water for Occupational Exposure).	✓		

Table B-4 GTA Compliance with NCRP 88

Section	Description	Criteria	C	NC	Comments
3	<u>ACCESS CONTROL SYSTEMS</u>	Since the purpose of an access control system is to keep personnel from gaining inadvertent access to hazardous areas or to the hazardous condition itself, one of its functions is to provide a warning to facility personnel. The intensity of the warning should be commensurate with the magnitude of the potential hazard. Should the warning go unheeded and the potential hazard be severe, the access control system should prevent access or initiate action to reduce or eliminate the hazard.	✓		
3.1	<u>Types of Access Control Devices</u>				
3.1.1.5	<u>Illumination</u>	All warning signs should be provided with adequate illumination so that they are readable. Where illumination under emergency conditions may be inadequate, emergency lighting should be provided.	✓		
3.1.2	<u>Lights</u>	Access control lights should be of sufficient size and located so that they are readily visible to an individual attempting to enter the controlled access area.	✓		
3.1.3	<u>Audible Signals</u>	Audible signals may be used in addition to visual signals to decrease the likelihood of inadvertent access to hazardous areas. These audible signals should be pulsed to break the monotony of a steady sound. Also, the signal should be loud enough and distinctive enough to be heard over ambient noise levels, but not so loud or irritating that facility personnel are tempted to bypass it.		✓	Klaxon horn is not pulsed but is of brief duration and distinct from other alarms.
3.1.4	<u>Physical Barriers</u>	Barriers that are designed to control access to areas in the high, very high, and extreme potential dose categories (see Section 6.2) should be of sufficient size and strength to exclude accidental or inadvertent access. Also, access to these areas should be secured with a lock. In some cases, the size and weight of a shielded door may preclude accidental or inadvertent access and a lock may not be necessary.	✓		

Table B-4 GTA Compliance with NCRP 88 (continued)

Section	Description	Criteria	C	NC	Comments
3.1.4	Physical Barriers (concluded)	When designing a door or other penetration in a shielding barrier consideration must be given to the need to ensure that the integrity of the shielding barrier against radiation is maintained. For example, unless a maze is used, the door should provide the same equivalent thickness as the rest of the barrier. General design considerations for shielding doors are given in NCRP Report No. 51 (NCRP, 1977).	✓		
3.1.5	Interlocks	Areas containing radiation-producing equipment or sources that could produce potential doses in the high-to-extreme categories (see Section 6.2) should have interlocks as an integral part of their access control system. An interlock is a device that automatically reduces the exposure rate upon entry by personnel into a high-radiation area. Also, interlocks prevent the production of high levels of radiation unless all of the barriers are in place. Interlocks are mounted on doors, gates, shutters, moveable shields, or other barriers, or under pads on the floor.	✓		
		Specific design and operation considerations relating to interlock systems include the following: 1. Interlocks should be "fail safe"; that is, in their most likely failure modes, they will prevent the production of high radiation levels in potentially occupied areas, 2. Each access control barrier to radiation areas that are classified in the very high or extreme potential dose category (see Section 6.2) should be equipped with two independent (redundant) interlocks connected so that either will perform its function in case the other interlock fails, 3. It should not be possible to resume the normal operation of the radiation source simply by closing the interlock once it has been opened. The opening of an interlock should trigger a requirement to reinstate the startup procedure, which would involve searching any controlled access areas that may have been opened when the interlock was broken,	✓ ✓ ✓		

Table B-4 GTA Compliance with NCRP 88 (continued)

Section	Description	Criteria	C	NC	Comments
3.1.5	<u>Interlocks</u> (concluded)	4. If the design allows the interlock to be bypassed under certain controlled conditions, there should be a built-in timer so that the bypass is automatically removed after a designated period of time. The bypass switch should be accessible to authorized personnel only. In some cases, an acceptable alternative to the use of a timer for an occasional interlock bypass is the use of administrative procedures that are carefully followed and documented in the operations log. 5. Interlocks should not be routinely used to turn off radiation-producing equipment. The failure of an interlock under these circumstances can have serious consequences.	✓		
3.1.6	<u>Run/Safe and Emergency Shutdown Switches</u>	Large or complex radiation exclusion areas should be equipped with switches that can (1) preclude starting up radiation production (run/safe switches), or (2) effect an emergency shutdown, or (3) do both in the event that an individual is inadvertently caught within an exclusion area during pre-start-up or actual radiation production operations. The run/safe switches are designed to be set routinely to the safe position by personnel reentering an exclusion area after ceasing radiation production operations. They prevent radiation production operations from starting until they have been manually reset (preferably with a key) to the run position. It is good design practice to require that all run/safe switches in a controlled area have to be reset to the run position before start-up if any one of the switches has been set to the safe position. Manually operated emergency shutdown switches, which immediately terminate the production of radiation or move the radiation source to its shielded enclosure, should be placed conspicuously in areas that contain high-to-extreme potential radiation hazards. These switches should be readily accessible so that an individual inadvertently caught within an exclusion area during prestart-up or actual radiation production operations can shut down the operation, if that is more expeditious than exiting the area. (Interlocked exit doors can be considered to provide the same protection as emergency shutdown	✓		

Table B-4 GTA Compliance with NCRP 88 (concluded)

Section	Description	Criteria	C	NC	Comments
3.1.6	Run/Safe and Emergency Shutdown Switches (concluded)	switches for some facilities.) Unlike run/safe switches, emergency shutdown switches are designed for emergency use only.			
		Run/safe and emergency shutdown switches should be clearly marked as to their intended function.	✓		
3.2	Functional Considerations				
3.2.1	Power Requirements	For areas that might contain high-to-extreme potential radiation dose categories (see Section 6.2), the access control system should be provided with emergency power. Also, if power is lost to the access control system, radiation production should be terminated automatically.		✓	Emergency power not required because power loss trips safety system and accelerator shut-down.
		In the design of a system, it is necessary to consider what would occur in case of a power failure. For example, it should be possible to open an access control door from either side even in the event of the loss of power.	✓		
3.2.2	Environmental	The access control systems should be capable of operation over the range of environmental conditions to which it will be subjected during normal and emergency (i.e., accident) conditions.	✓		
5	RELIABILITY				
5.1	Fail-Safety	Failure of any component, loss of power, or external interferences should not result in an unsafe or potentially unsafe condition, which in the case of an alarm or access control system could result in a hazardous radiation field without suitable warning or means to exclude personnel.	✓		
5.2	Redundancy	Depending on the criteria for reliability, redundancy of the entire alarm or access control system may be needed to ensure that an acceptable probability of proper operation of the safety systems will be achieved.	✓		
5.5	Testing and Internal Diagnostics	It is highly desirable for alarm systems to be equipped with the internal diagnostics or sensors that continuously monitor the ability of the system as a whole, or at least key subsystems and components, to perform its intended functions, and to provide indication when a failure has occurred.	✓		

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities

Section	Description	Criteria	C	NC	Comments
2.4	Shielding Design	In most cases, the applicable dose limits provide a starting point for determining shielding requirements. However, it is inappropriate to design shielding that allows an individual to receive a significant fraction of the exposure limit. DOE now recommends that shielding for new installations keep facility workers from being exposed to doses of leakage radiation greater than one-fifth of the limit or 1 rem/year (10 mSv/year) (DOE Order 5480.1, dated 4/29/81). The facility's boundary dose must not exceed 100 mrem/year (1 mSv/year) (DOE Memorandum from William A. Vaughan dated Aug. 5, 1985).	✓		
2.5	Interlocks and Warning Devices	The interlock must operate with a high degree of reliability. Components and materials should be of high grade for dependability and long life. Materials that resist radiation should be selected for those components located in areas where the radiation levels are high enough to cause radiation damage. Fail-safe circuits and components should be used whenever practicable. Fail-safe design takes into consideration the failure of primary ac power to the area, dc power to logic circuits or beam-line components, or of the pressurized air that feeds air-actuated solenoids in safety devices. In each case, the safety interlock system should react to render the area safe in the event that a key safety component fails or the power source is lost. Duplicate (parallel) circuits or redundant components should always be used in critical applications where the single failure of a circuit or device could lead to a hazard. In design of redundant circuits, parallel chains should be used. The chains should remain independent, and not neck down to a single connection or component. Independence should be carried all the way from duplicate sensors through to the devices or mechanisms that shut off the radiation source. Wherever possible, at least two different methods should be in place to remove the beam or radiation source.	✓		
			✓		Parallel circuits are not used; redundancy is provided by combination of Kirk-key and interlock systems.

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (continued)

Section	Description	Criteria	C	NC	Comments
2.5	Interlocks and Warning Devices (continued)	The access control system is intended to prevent unauthorized or accidental entry into radiation areas. Elements of this system include physical barriers, signs, closed circuit TV, flashing lights, audible warning devices including the associated interlock system, and a body of administrative procedures that define conditions where entry is safe. To reduce the likelihood of accidental damage or deliberate tempering, all cables should be protected. Preferred methods are to use armor-covered cable or to run the cable in conduit. It is acceptable to lay cable in metal trays, particularly where long runs are involved, providing that the cable is run in conduit between the tray and the junction box or cabinet. When using conduit or armored cable, the covering should be continuous, with solid elbows and no inspection plates. For installations in high radiation areas, particular attention should be given to selecting radiation-resistant cable. Logic equipment should be mounted in locked racks, cabinets or boxes. When using racks that are part of a tray of racks used for other systems, solid partitions should be installed between the racks housing the safety equipment and the adjacent racks. Features of an Interlock System • Emergency-off (Scram) buttons should be clearly visible, labeled, and readily accessible. Large, red, mushroom-head buttons are recommended. • Run/safe switches are sometimes used to prevent start-up of an accelerator or radiation source when a radiation area is occupied. They are set to the safe position on entering the area, and must be manually reset to the run position to allow start-up. Run/safe switches serve as a valuable back-up to other interlock devices that break the security chain (door microswitches, keyboard interlocks, and so forth). They also provide a clear and positive indication to personnel in the exclusion area that the interlock chain is broken. • Emergency exit mechanisms must be provided at all doors and man-ways. Emergency entry features are not precluded.	✓		
			✓		
			✓		
			✓		
			✓		
			✓		

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (continued)

Section	Description	Criteria	C	NC	Comments
2.5	Interlocks and Warning Devices (continued)	Warning lights or annunciator signs should be located outside entrances to accelerator enclosures. Inside radiation areas, clear visual warning should be given that the accelerators is about to come on. This may be done with rotating beacons or by dimming or flashing the main lights for the area.	✓		
		Audible warning should be given inside accelerator enclosures before the accelerator is turned on. This may be in the form of sirens with a distinctive sound (2,500 Hz or lower, with 1 Hz pulse modulation, for example) or by a recorded voice warning system that alerts those in the area that the accelerator is about to come on.	✓		
		Search of a radiation area should be initiated by activating a "Search Start" switch. "Search Confirmation" switches, mounted at appropriate locations along the search path, should also be provided. At the conclusion of the area search, a "Search Complete" switch at the exit point should also be set. Run/safe switches can double as "search" switches, if desired. Means should be provided to prevent people from entering behind the search team.	✓		
		The interlock system should prevent beams from being turned on until after the search has been completed and acknowledged and the audible and visual warning light cycle has ended.	✓		
		Any violation of the area, such as a door being opened, or an emergency-off switch being tripped, should cause the interlock system to immediately render the area safe. Restarting the accelerator should not be possible until the area has again been searched, as described above.	✓		
		A "Controlled Entry" mode may be desirable for some larger accelerators. Under this mode, a small number of workers (up to eight, for example) are permitted to enter an already searched area to carry out specific tasks. Each person is issued a key which must be kept in his or her possession during the entry period. Release of the key and			N/A

APPENDIX B DESIGN CRITERIA COMPARISON

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (continued)

Section	Description	Criteria	C	NC	Comments
2.5	Interlocks and Warning Devices (concluded)	records of name, date, and time should be carefully supervised by an operations or health physics group. • The interlock system should permit a key release or a door opening only when an area is safe to enter.			
2.6	Beam Containment	<u>Mechanical Devices</u> Design of a beam line includes a precise calculation of where to locate mechanical containment devices, and lists of their specifications. Design will usually include ray traces, consequences of missteering, shielding calculations for beam loss at various points, and necessary power ratings for slits, collimators, and beam stoppers. One additional type of electronic device for beam containment is a radiation detector or system of detectors set outside the shielding in occupiable areas (Ba68, Aw71). If the dose rate rises above a preselected level, various actions result.	✓		
3.1	Control of Radioactivation and Contamination	Zones of activation or contamination should be clearly marked with appropriate signs or labels indicating the nature and degree of the hazard. If possible, cooling water should be cleaned and reused. No release of contaminated water should be permitted without thorough check of DOE, state, and local regulations. If tritium is the only contaminant, the water can be disposed of through the sanitary sewer, provided the concentration is less than 0.1 microcurie per cubic centimeter (DOE 5480, Chap. XI). Normally, shield enclosures are fitted with drains around their footings to collect water. These drains go to sump pits which can be sampled periodically for radionuclides. Real-time, continuous monitoring of gaseous effluent from some enclosures may be needed to ensure that releases to the environment remain below legal limits.	✓		Periodic sampling is adequate per 40 CFR 61.

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (continued)

Section	Description	Criteria	C	NC	Comments
3.3	Radiation Damage to Components	Radiation damage should be considered during the design phase of the accelerator. When calculations indicate that radiation damage will be a problem in a given area, it may be possible to improve the situation by design changes. • Sometimes magnets can be turned around to take advantage of shielding provided by the magnet's iron. • Sensitive devices can be moved to areas with lower radiation levels. • Radiation-hardened electronic devices are available in some cases. Cables, wiring, and water hoses can be chosen for best radiation resistance. • Alcoves can be provided to partially shield electronics. • Shielding can be installed at critical points. • Scrapers or collimators can sometimes be installed to force losses to occur where they are less of a problem. Metals and ceramics are not usually damaged by radiation. Instead, the worst problems will be with semiconductors and organic materials. Every use of organic and halogenated organic material should be evaluated, including electrical insulation, o-rings and gaskets, lubricants, and optics. The radiation resistance of these materials varies widely. Teflon is probably the least resistant material of interest and should always be avoided in high radiation areas.	✓		
3.6	Experimenter Access to Beams	Beam Barriers. Barriers around the beam serve as important safeguards against accidental exposures. These barriers should be substantial enough to prevent easy removal (a beam pipe rather than simply marking the path with tape) and should enclose the beam specifically, not identify a beam area. Beam-On indicators. Visual and audible indicators which are activated by the beam serve as important reminders to people working in the area that the beam is on.	✓		

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (continued)

Section	Description	Criteria	C	NC	Comments
5.1	Facility Design	During construction, materials should be chosen that will not be significantly activated by the accelerator, to minimize radiation exposure at decommissioning. Prudent initial design could mean the difference, at decommissioning, between having to discard material or incur additional costs, and being able to recover valuable resources without undue exposure of personnel (ANSI78, Go76, LAEA79, Pa73).	✓		
Appendix B	Computers In Personnel Safety Systems	The following constitute the minimum requirements for the use of computers in accelerator personnel safety systems. Hardware 1. Computer-based systems may be used for accelerator personnel safety as long as it can be demonstrated that the use of a computer does not increase the risk of an accident to an unacceptable level. The computer system, including software, must have high reliability. At a minimum, the safety system including the computer and its input/output devices should be designed to have a MTBF of not less than 90,000 hours. Thus, if a monthly service inspection were carried out, the system would be operational 99.2 percent of the time. One method of improving reliability is to use completely redundant hardware-two computers and associated I/O. In some instances, triple redundancy may be justified. Consideration may also be given to the use of the class of "ultra-high availability" fault tolerant computers which have internal built-in redundancy in both hardware and software. This latter approach may only be adopted if it can be demonstrated that the reliability and fault tolerance is at least as high as the independent, redundant hardware approach. For applications in typical accelerators, computers used for safety systems must be dedicated to that function alone. Programs written for computers used in safety systems should reside in Read Only Memory (ROM) or Programmable Read Only Memory (PROM) wherever feasible. If volatile memory must be used, it should have error detection			N/A: RPSS is hard-wired.

Table B-5 GTA Compliance with SLAC 327 Health Physics Manual of Good Practices for Accelerator Facilities (concluded)

Section	Description	Criteria	C	NC	Comments
Appendix B	Computers In Personnel Safety Systems (concluded)	and correction features and it should have sufficient battery backup for long-term retention of the program state. Watchdog timers should be incorporated so that action can be taken if the program fails to reach appropriate checkpoints within a specified time. <u>Software</u> All programming must be undertaken by designated and authorized professionals using accepted methodology to insure software of the highest quality. High modularity and testability must be incorporated in all software. The emphasis must be directed toward writing fault tolerant programs. Software hazard analysis should be performed wherever feasible. Accepted techniques such as redundancy and checkpointing should be used. Program changes to meet new operational needs must be carefully controlled using strict configuration management techniques. All changes must be thoroughly tested, not only for the specific intended function that the program change was meant to accomplish, but also for other unexpected and unwanted effects in other parts of the program. In the approach where parallel independent computers are used to achieve reliability, consideration should be given to installing nonidentical but functionally equivalent software to reduce common mode failure. If computers are chosen for safety interlock applications, there should be, in addition to the computer hardware and its connection to the shutoff equipment, a separate independent operator (crash) override button on the console that permits manual shutdown of the facility.			

Report
For
LOS ALAMOS NATIONAL LABORATORY

ANALYSIS OF DOE ORDER 6430.1
Versus
DOE ORDER 6430.1A
RELATIVE TO DESIGN OF
GROUND TEST ACCELERATOR FACILITY, MPF-365 AT TA-53

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September 1989

I. EXECUTIVE SUMMARY

- A. **Purpose:** This report is a summary of the comparison between DOE Order 6430.1 and 6430.1A regarding the design of the Ground Test Accelerator-2 facility if it were designed under 6430.1A.
- B. **Procedure:** Each discipline reviewed each order to find those items which were changed or added by 6430.1A which were not considered or were more stringent than the criteria for the GTA-2 facility as designed under 6430.1. Following each item is a discussion of what action should be taken to ensure compliance with 6430.1A.
- C. **Summary Conclusions:** The major impacts on the GTA-2 facility to meet DOE Order 6430.1A are:
 1. **Civil:** Site-specific security levels and criteria must be established by user.
 2. **Structural:**
 - a. A dynamic analysis of the High Bay structure is required rather than a static analysis. Results of this analysis would determine the safety factors of the design.
 - b. Base seismic shear is increased by a factor of approximately 1.5. This will significantly reduce safety factors of the design.
 - c. More conservative requirements for component loading and analysis will reduce safety factors.
 3. **Architectural:**
 - a. Seismic design of suspended ceilings needs to be calculated in accordance with UCRL 15714 rather than using the previously acceptable UBC standard detail.
 - b. Raise all stair handrails to 34" - 38" above nosings.
 4. **Mechanical:**
 - a. DOE 6430.1A, Paragraph 0110-12, "Energy Conservation" and DOE 6430.1, Chapter XIII, "Energy Conservation and Use of Renewable Energy Sources" indicate that the differences in these two criteria are numerous. Both criteria require

Life Cycle Cost analysis but the methods of analysis are quite different. It would be impossible to determine the impact of these differences without generating a new analysis and Energy Conservation Report.

- b. All control valves require strainers which were not required by DOE 6430.1.

5. Electrical:

- a. After evaluation by the user, if continuous exterior lighting is required, additional lighting controlled by an uninterruptible power source will have to be added.

II. ANALYSIS

A. Introduction

This report is the result of a multi-discipline analytical review of DOE Orders 6430.1 and 6430.1A relative to the design of the Ground Test Accelerator-2 facility at Los Alamos National Laboratory.

This review will be incorporated into the Safety Analysis Report to be approved by DOE before experimental operations can begin.

The approach of this study entailed each discipline researching the orders for requirements which have changed from DOE Order 6430.1 to 6430.1A. Items were identified which would affect the design of GTA-2 had it been designed according to 6430.1A. Therefore, if there was no substantive effect on the design by a change or added requirement, it was not discussed in this analysis.

The format is to quote the new 6430.1A requirement, state the design as accomplished under 6430.1, and then discuss what is necessary to comply with 6430.1A.

B. Civil

Division 2, "Site and Civil Engineering," was reserved for future use in the DOE 6430.1 document. In the DOE 6430.1A document, there are 70 pages devoted to Division 2.

This report will summarize the differences between the actual design and DOE 6430.1A document.

1. DOE 6430.1A, Paragraph 0200-2 BUILDING LOCATION

"In cold climates, building entrances, stairs and other pedestrian circulation features should not be placed along the north side of buildings or within shaded areas."

Design: The entrance to the Fan/Boiler Room (Mechanical Room, upper level) is located on the north side of the building. Two steps are required to reach stoop level.

Discussion: To comply with DOE 6430.1A the entrance to the Fan/Boiler Room would have to be located on the west side.

2. DOE 6430.1A, Paragraph 0203-1.2 Underground Utilities

"Underground utility lines such as sanitary sewer, water, and gas shall not be placed under existing or proposed pavements, except when crossing such pavements or when adequate space is not available."

Design: A 6-inch diameter sanitary sewer line that runs west to east on the north side of the mechanical room is located under new pavement.

Discussion: To comply with DOE 6430.1A this line would have to be located further to the north to get a portion of it out from under the service drive pavement.

3. DOE 6430.1A, Paragraph 0260-2 EXTERIOR UTILITIES

"In general, if expansion is planned, utilities should be extended to the edge of the site or to a point where connection can be made without damage or disruption to existing facilities."

Design: A 6-inch diameter sanitary sewer line with an end-of-line manhole was designed to extend outside

of the security fenced area to serve as a tie point for a future support building.

As Built: The end-of-line manhole ended up inside the security fenced area due to a conflict with an existing 8-inch diameter waterline.

Discussion: To comply with DOE 6430.1A, the manhole would have to be located outside of the security fenced area or a 6-inch stub would have to be made from this manhole to outside the security fenced area. The waterline would also have to be adjusted.

4. DOE 6430.1A, Paragraph 0260-2 EXTERIOR UTILITIES

"Utilities that penetrate or pass under a security barrier through an opening of more than .96 square inches in smallest dimension shall provide the same degree of penetration delay as is required for the security barrier."

Design: At four locations, 24-inch diameter corrugated metal storm drain pipes go under the security fence.

Discussion: To comply with DOE 6430.1A, the grates on all catch basins within the security fenced area would have to be either tack-welded to the frame or have some means of locking them so that they could not be removed.

5. DOE 6430.1A, Paragraph 0266-4 SYSTEM DESIGN CONSIDERATIONS

"Service lines larger than 2 inches in diameter shall be connected to the distribution main by a rigid connection and shall have a gate valve located below frostline."

Design: There is no gate valve on the 4-inch diameter domestic water service line.

Discussion: To comply with 6430.1A, a gate valve and box would have to be installed in the 4-inch diameter domestic water service line.

6. DOE 6430.1A, Paragraph 0270-1.4 Pipe Materials and Pipe Joints

"Ductile iron pipe shall also be used for inverted siphons and for sewers located in parking lots or other high traffic areas."

Design: A 6-inch diameter sanitary sewer line that is located in the service area is constructed of polyvinyl chloride pipe.

Discussion: To comply with DOE 6430.1A the sanitary sewer line would have to be constructed out of ductile iron pipe.

7. DOE 6430.1A, Paragraph 0270-2.1 General

"The potential effect of larger storms (up to the 100-year, 6-hour storm) shall also be considered."

Design: The potential effect of a 100-year 6-hour storm on the operation of the storm drain system was not considered.

Discussion: To comply with DOE 6430.1A the operation of the storm drain system would have to be checked for the 100-year, 6-hour storm. If the system does not have the capacity for handling a storm of this magnitude, then the chances of flooding the building would have to be determined.

8. DOE 6430.1A, Paragraph 0270-2.5 Street Drainage

"Street drainage in developed areas shall be conveyed within the roadway cross section. Curb inlets shall be used to divert storm flows to surface and subsurface storm water conveyance system."

Design: Street drainage was conveyed to openings in the curb and gutter where it was conveyed in a swale to a drop inlet.

Discussion: To comply with 6430.1A, the street drainage would have to be intercepted by curb inlets.

9. DOE 6430.1A, Paragraph 0273-99.0 Nonreactor Nuclear Facilities - General

"There shall be no interconnections among storm water systems, the sanitary waste system and radioactive or other hazardous material handling system or areas."

Design: The floor drains in the beam tunnel discharge into the sanitary waste system.

Discussion: To comply with DOE 6430.1A, the floor drains in the beam tunnel would have to tie to a separate discharge system since a rupture in the deionized water lines could occur. The deionized

water lines will cool the accelerator and the beam stop and could pick up radioactive particles.

10. DOE 6430.1A, Paragraph 280-1 FENCING

"Barbed wire fencing can be used for boundaries of open, undeveloped areas only."

Design: The cryogenics site is enclosed with a barbed wire fence.

Discussion: To comply with 6430.1A, the cryogenics site would have to be enclosed with chain link fence.

11. DOE 6430.1A, Paragraph 0283-1 General

"The physical protection requirements in this section are not all-inclusive. The applicability of any or all of the physical protection systems to site-specific safeguards and security requirements shall be identified within the threat analysis for each site."

Design: A single chain link security fence was provided with one entry control point at the pedestrian access point along with four uncontrolled vehicle access points.

Discussion: To comply with 6430.1A, a thorough review of Section 0283, PHYSICAL PROTECTION, needs to be performed by the University. There are numerous requirements which may or may not have to be implemented.

12. DOE 6430.1A, Paragraph 0283-3.2.3 Construction

"Once in place, all fence hardware shall be peened or spot welded to prevent easy removal."

Design: The chain link security fence detail sheet or technical specifications do not require the peening or spot welding of fence hardware to prevent easy removal.

Discussion: To comply with 6430.1A, all the fence hardware would have to be peened or spot welded. However, see DOE 6430.1A, Paragraph 0283-1 and Paragraph 11 above.

c. Structural

1. DOE 6430.1A, Paragraph 0111-2.7 - Earthquake Loads

"Earthquake load design for buildings and other structures shall be determined in accordance with the procedures contained in the UBC and UCRL 15910."

1988 Edition of UBC applies.

DOE 6430.1 Design: Seismic design was done in accordance with 1985 UBC, per DOE 6430.1 IV-2g, for Zone 2, I=1.5.

Discussion: To comply with DOE 6430.1A, seismic loads used would be larger than the 1985 UBC loads. Requirements for seismic analysis, design, and detailing would also be different.

DOE 6430.1A provisions for "Important or Low Hazard Facilities" apply to GTA-2. Major differences between UCRL 15910/1988 UBC as required by DOE 6430.1A, and 1985 UBC as required by DOE 6430.1, are summarized below.

a. UCRL 15910 Chapter 4, and 1988 UBC, Section 2312, Seismic Analysis:

UCRL 15910 recommends seismic analysis of structure for "Important or Low Hazard Facilities" by "Static force method for regular facilities or dynamic force method for irregular facilities as described in the 1988 UBC provisions."

1988 UBC provides specific criteria for determining when dynamic analysis is required.

DOE 6430.1 Design: Static analysis was used for the facility per DOE 6430.1.

Discussion: To comply with DOE 6430.1A, a dynamic analysis is required for the High Bay portion of the structure. In the GTA-2 facility, the High Bay and Support Buildings are independent structures. Per 1988 UBC, the High Bay is classified as an irregular structure with the following irregularities:

- (1) Type B, Table 23-M, Mass Irregularity. Mass of Fourth and Second Levels are more than 150 percent of mass at Third Level.

- (2) Type C, Table 23-M, Vertical Geometric Irregularity. Horizontal dimension of frames at Mezzanine level is more than 130 percent of horizontal dimension of frames at levels above.
- (3) Type A, Table 23-N, Torsional Irregularity. For east-west forces, drift at steel frames is more than 1.2 times average drift including concrete shear wall.

Per 1988 UBC 2312(d)8C(ii) and 2312(d)9C, a dynamic analysis is required for the High Bay structure. Results of the analysis would determine the safety factors of the design.

Per 1988 UBC, the Support Building is classified as an irregular structure with the following irregularity:

Type A, Table 23-N, Torsional Irregularity. For east-west forces, drift at steel frame is more than 1.2 times average drift including concrete shear wall.

Per 1988 UBC 2312(d)8B(iii), a static analysis is acceptable for the Support Building structure which is less than 65 feet high.

- b. UCRL 15910 Chapter 4, and 1988 UBC, Section 2312, Seismic Forces:

UCRL 15910 states, "For General Use and Important or Low Hazard DOE facilities, it is recommended that the 1988 UBC provisions be followed, with the exception that Z be evaluated from the hazard curves in Reference 1, and C is the amplification factor from 5% damped median (or mean) response spectra."

Reference 1 is UCRL 53582.

This procedure yields the following design base shear factor:

<u>Factor</u>	<u>Reference</u>
Z = 0.22	UCRL 15910 Table 4-3
I = 1.25	UCRL 15910 P. 4-4
C = 3.5	UCRL 15910 P. 4-1 & Fig. 4-1
	UCRL 53582 P. 29

$$R_w = 6$$

UCRL 15910 Table 4-2
Ordinary Steel Moment
Resisting Frames

$$V = (ZIC/R_w)W = .160(W)$$

DOE 6430.1 Design: Per 1985 UBC, Seismic base shear was computed as follows:

$$\begin{aligned} Z &= 3/8, \text{ Zone 2} \\ I &= 1.5 \\ CS &= .14 \\ K &= 1.33 \\ V &= ZIKCSW = .105(W) \end{aligned}$$

Discussion: To comply with DOE 6430.1A, an increase in base seismic shear by a factor of approximately 1.5 is required for both High Bay and Support Building. Except where design is controlled by other than seismic loading, the structure would be overstressed by significant amounts with these larger forces.

c. UCRL 15910 P. 4-5, 4-15, Peer Review:

"For important or hazardous facilities, all aspects of the seismic design or evaluation must include independent peer review."

DOE 6430.1 Design: Design was reviewed by Holmes & Narver engineers who had not participated in the design and by Los Alamos Laboratory personnel.

Discussion: To comply with DOE 6430.1A, an independent peer review may be required depending on the definition of "independent peer review."

d. 1988 UBC, Chapters 23 and 27, Seismic Design

New detailed requirements for seismic analysis and design are provided.

DOE 6430.1 Design: Design followed requirements in 1985 UBC.

Discussion: To comply with DOE 6430.1A, new provisions must be followed which differ from 1985 UBC in various ways. Some differences are:

- (1) 1988 UBC 2312(e)9 requires that P-delta effects be included in analysis of structural frames. 1985 UBC does not require this.

- (2) 1988 UBC 2312(h)2K requires separation of $3(R_w/8)$ times seismic displacement between adjacent structures. 1985 UBC requires separation to avoid contact under computed seismic deflections. This affects required width of joints between High Bay and Support Building.
- (3) For structures with Irregularity Type A, Table 23-N, 1988 UBC 2312(h)2I(v) permits no $1/3$ stress increase for diaphragm connections and 2312(e)6 requires an increase in accidental torsion. 1985 UBC has no such provisions.
- (4) 1988 UBC 2722(d)2 requires that column splices with partial penetration welds be located a minimum of 3 feet from girder flanges. 1985 UBC has no such provision. Column splices are typically 2 feet from girder flanges.
- (5) 1988 UBC 2722(g)3 requires bracing connections be designed for $(3R_w/8)$ times force in the brace. This is an increase over 1985 UBC forces by a factor of approximately 1.3.

These differences would need to be included in design under DOE 6430.1A. Safety factors would be affected.

2. DOE 6430.1A, Paragraph 0514 - STRUCTURAL ALUMINUM

"Aluminum shall be isolated in applications involving contact with dissimilar metals or with concrete. Isolation shall be achieved by use of coatings, paints, or separating materials."

DOE 6430.1 Design: No requirement for isolation.

Discussion: To comply with DOE 6430.1A, isolation would be required at bearing surface of aluminum tubes and grating at Laser Basement.

D. Architectural

1. DOE 6430.1A GENERAL REQUIREMENTS

"The latest edition of standards and guides shall be used.

"...UBC, (Uniform Building Code)
...NFPA 101, Life Safety Code"

6430.1 Design: From the Uniform Building Code; Stair handrail height above nosings between 30" and 34".

Discussion: To comply with latest edition of UBC and NFPA 101, handrails need to be raised to a minimum height of 34" above stair nosings because both of these codes have changed the range from 30" - 34" to 34" - 38".

2. DOE 6430.1A, Paragraph 0110-13.2, Access Control and Security Areas.

"Controls shall be established to prevent unauthorized access to security areas or removal of security interests."

6430.1 Design: Basically states that site specific criteria will be established by security personnel according to "standards and requirements, as promulgated by the Headquarters Office of Safeguards and Security...."

Discussion: The facility security for areas was not addressed in the design. As the facility is developed, the designer should consult various DOE 6430.1A requirements.

3. DOE 6430.1A, Paragraph 0753 ELASTOMERIC/PLASTOMERIC SHEET ROOFING

"Single-ply roofing shall comply with the following:

- o SPRI Single-Ply Roofing: A Professional's Guide to Specifications, Parts I-IV.
- o SPRI Wind Design Guide for Ballasted Single-Ply Roofing System
- o SPRI Wind Design Guide for Mechanically Attached Single-Ply Roofing Systems."

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- o SPRI Wind Design Guide for Fully Adhered Single-Ply Roofing Systems."

DOE 6430.1 Design: No specific single-ply requirements. General requirements to follow NRCA "Roofing Manual," FM Loss Prevention Sheet 1-28 for Insulated Steel Deck," U.L. Class A, FM Class I and UBC. Because the design was to comply with UBC, an ICBO report was necessary for the system used.

Discussion: The system used should be analyzed by the University relative to the SPRI requirements above to determine compliance.

4. DOE 6430.1A, Paragraph 0912-2 CEILING SUSPENSION SYSTEMS

"Nonstructural suspended systems, including ceilings, electrical components and equipment shall be considered in terms of UCRL 15714, Section V."

DOE 6430.1 Design: Suspend ceiling design to comply with UBC Standard No. 47-18.

Discussion: Suspended ceiling system should be analyzed relative to UCRL 15714, Section V. to determine need for modification. It is expected that additional bracing will be required.

5. DOE 6430.1A, Paragraph 0950-1 GENERAL

"A continuous IAS shall be provided for occupiable spaces above suspended ceilings within protected areas and, as required by site-specific security plan, within limited and exclusion areas.

DOE 6430.1 Design: The computer control room area ceiling has physical barriers at perimeter but not IAS.

Discussion: When developed, a site-specific security plan may necessitate IAS above ceiling.

6. DOE 6430.1A, Paragraph 1027 ACCESS FLOORING

"A continuous IAS shall be provided for occupiable spaces below raised access flooring within protected areas and, as required by the site-specific security plan, within limited and exclusion areas."

DOE 6430.1 Design: The design did not address this.

1 4 6 U U / 8 0

Discussion: As development takes place, and the security plan is formulated, the designer may need to provide IAS as referenced above for limited and exclusion areas with raised access flooring.

E. Mechanical

1. DOE 6430.1A, Paragraph 1530-1, GENERAL

"Fire protection systems shall comply with DOE 5480.7"

DOE 6430.1 Design: Chapter X: Codes, standards and guides including: NFPA, UL, FM, DOE 5480.1A and DOE 5700.6A.

Discussion: An automatic fire suppression system has been provided for the entire structure. Therefore, this revision should have no impact.

2. DOE 6430.1A, Paragraph 1540-1.3.1, Supply

"Accessible drain valves shall be provided to drain the entire system."

DOE 6430.1 Design: No similar requirement.

Discussion: The building domestic water line does not have an "accessible drain valve." To drain the entire system a backflow preventer would have to be removed or a new drain valve installed.

3. DOE 6430.1A, Paragraph 1550-2.3.1, General

"Strainers shall be provided at the suction side of each pump and each control valve."

DOE 6430.1 Design: No similar requirement.

Discussion: Strainers have been installed on each pump. However, none of the control valves have been provided with strainers. They have to be added to comply with DOE 6430.1A.

4. DOE 6430.1A, Paragraph 1550-3.2, Testing and Balancing Devices

"The design professional shall provide as a minimum the balancing devices in Table 1550-3.2a and Table 1550-3.2b."

DOE 6430.1 Design: No similar requirement.

Discussion: Items required in these tables and not included in this project are:

- a. Duct-mounted air stream thermometers on suction and discharge sides of each heating coil and coiling oil.
 - b. Duct mounted airstream thermometer on each mixed-air plenum
 - c. Flow measuring device on each pump
 - d. Flow measuring device on each boiler
5. DOE 6430.1A, Paragraph 1595-6.3 Automatic Control Dampers

"Automatic air control dampers shall be specified to be the low-leakage type with a maximum leakage of 6 cfm/ square foot at maximum system velocity of 1500 fpm and 1-inch pressure differential."

DOE 6430.1 Design: Chapter X, Paragraph 14i: "Automatic air dampers used for thermal isolation and air mixing shall be of the 1 percent leakage type."

Discussion: Although the 6 cfm/square foot requirement is probably more stringent, the system in this building will not be affected. All of the air handling systems have packaged air handling units and, though not specified, have dampers that should meet this requirement.

F. Electrical

1. DOE 6430.1A, Paragraph 0283-7 LIGHTING

"Where HID lamps are used and where continuous lighting is required, a standby lighting system shall be considered to ensure the maintenance of minimum protective lighting during HID lamp start-up and restrike periods. Fixtures adjacent to each other shall, when practical and appropriate, be placed on different circuits so that only a portion of the lighting is extinguished if one circuit becomes inoperative."

DOE 6430.1 Design: The facility was designed using HID lighting fixtures for the fence and exterior building lighting.

Discussion: In order to comply with DOE 6430.1A, the exterior lighting system should be evaluated to determine if continuous lighting is required for this facility. If continuous lighting is required, then additional fixtures, assume quartz, should be installed and controlled by an uninterruptible power source.

Existing fixtures including the wall mounted fixtures should be recircuited to place fixtures adjacent to each other on different circuits.

2. DOE 6430.1A, Paragraph 1639 GROUNDING

1639-1 General

"Grounding systems shall comply with NFPA 70 and IEEE 142. A separate ground conductor shall be used. Raceway systems shall not be used as a ground.

1639-4 Isolated Ground System

"Isolated ground systems may be required to meet special instrumentation or other equipment needs. Such ground systems shall be clearly identified, protected against improper usage, and installed in conformance with NFPA 70.

6430.1 Design: Grounding was provided on this project as directed by the user.

Discussion: The grounding system provided appears to fit within the 6430.1A guidelines.

3. DOE 6430.1A, Paragraph 1640-3.1 General

"Electric power distribution systems shall be filtered to reduce emanation of detectable electromagnetic signals to acceptable levels as directed by the cognizant DOE telecommunications and security personnel. Installations shall comply with DOE 5300.2B, DOE 5300.3B, and DOE 5300.4B. Additional guidance shall be obtained from the Office of Computer Services and Telecommunications Management, DOE Headquarters, as directed by the cognizant DOE authority.

DOE 6430.1 Design: Our design for the Base Building was conduit only. The conduit complies with 6430.1A. User to install the system.

Discussion: User should comply with DOE 5300.2B, .3B and .4B in the design and installation of this system and should provide filtering where required.

4. DOE 6430.1A, Paragraph 1640-3.3, Standby or Emergency Power Supplies

"Standby or emergency power supplies for security, communications, and alarm systems shall be provided in accordance with Section 1660, Special Systems.

6430.1 Design: Battery backup was provided for the Fire Alarm System. No emergency system was provided for the telephone, interphone or public address systems, since these were conduit only.

Discussion: We provided conduit only for telephone, interphone, and public address systems. User should refer to 1660 Special Systems and comply with the design criteria, where required.

5. DOE 6430.1A, Paragraph 1670-4 SECURE COMMUNICATION SYSTEM

"Secure communications systems shall comply with DOE 5300.3B, DOE 5300.4B, and the DOE 5632 series.

"Data processing, amplifying, telecommunications, and other systems that emit electromagnetic classified data processing information, shall be protected against compromise of such data in accordance with DOE 5637.1, DOE 5300.2B, and DOE 5300.4B.

"For the protection of classified matter, line supervision limits and/or line tamper alarm capability shall meet UL Class AA requirements.

"Telephones or public address systems in conference rooms or offices in which classified discussions at the Secret or Top Secret level occur shall comply with Section 0110-99.10, Secure Conference Rooms, and Section 0110-99.11, Secure Offices, respectively.

"Where transmissions of classified data outside security areas are involved, NSA-approved encryption shall be used or the signal lines shall be installed in accordance with DOE 5300.4B.

"ADP equipment and cabling shall be installed per NSA NACSIM 5203 or other means approved by the CSOM to preclude compromising emanations from radiating beyond the control zone."

Design: Secured Communications System was not part of Base Building design. System was to be designed and installed by user.

Discussion: User should comply with codes and standards as described in 6430.1A Section 1670-4.

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GROUND TEST ACCELERATOR-2BUILDING CODE ANALYSISApplicable Codes

Uniform Building Code - Facility Requirements
Life Safety Code - Exiting Requirements

Background

Per previous agreements the Ground Test Accelerator-2 (GTA-2) facility is B-2 occupancy, Type II one-hour construction with automatic sprinklers used as a substitute for the one-hour construction.

Present Situation

Recent modifications to the GTA-2 facility necessitated a review of the Building Code Analysis. The following key issues are discussed and a revised code analysis is attached.

1. The RF Equipment Mezzanine grew in size so that it no longer qualifies as a mezzanine. It is therefore now considered part of the second floor. This area of the second floor requires at least two fire-rated exits to the outside meeting the criteria of the Life Safety Code. This agreement is satisfied by Stair #2 which was already enclosed and enclosing Stair #4 at the west end of the RF Equipment Platform
2. Openings from the Waveguide/Water Basement through the first floor Mechanical Labs and the second floor RF Equipment Platform are acceptable per NFPA 6-2.2.3.4.
3. As defined in Sec. 407 the floor area of a building or portion thereof is that space included within the surrounding exterior walls or if not provided with exterior walls the area shall be the useable area under the horizontal projection of the roof. Since the 8-foot thick concrete shield wall is not useable space it is not included in the floor area calculations.
4. UBC Section 505 (d) says that basement areas need not be included in the total allowable area.
5. The Bean Tunnel is separated from the rest of the GTA-2 facility by the 8-foot thick concrete wall mentioned in the above. This wall is considered an Area Separation Wall and therefore per UBC Sec. 505 (e) shall be considered as a separate building. All doors in this wall have at least a 90 minute fire protection rating. The fact that this wall serves as a nuclear shield inherently makes it an Area Separation Wall.

Required Floor Areas

The UBC analysis is significantly affected by the size of the building. The following is a summary of floor areas which were used to accomplish the code analysis:

FIRST FLOOR AREA

o High Bay Assembly Area	
(1) Basic Floor Area (including Shop)	17,749 SF
o Beam Tunnel (Per UBC Sec. 505 (e) can be considered a separate building.)	
(1) Basic Floor Area	16,150 SF
o First Floor of Multi-Story Area	<u>6,272 SF</u>
Subtotal First Floor	40,171 SF

SECOND FLOOR AREA

14,073 SF

THIRD FLOOR AREA

3,916 SF

FOURTH FLOOR AREA

o Basic Floor Area	5,632 SF
o Mechanical Room (North)	<u>5,366 SF</u>

TOTAL GROSS AREA 69,158 SFAllowable Floor Area

UBC allowable floor areas permit 18,000 SF for a B-2 occupancy and Type II one-hour construction. By providing separation on four sides of the building of 40 feet total UBC allows an area increase of 100% or 36,000 SF total. For multi-storied buildings, the code allows an additional, compounded area increase of 100% for a total of 72,000 SF. Therefore, the building's total gross floor area (69,158 SF) does not exceed the allowable area of 72,000 SF.

Allowable Floor Area for a Single Floor

UBC limits the area of any single floor. For the GTA-2 Facility this allowable area is 36,000 SF (18,000 + 100%). The largest single floor area for GTA-2 is the First Floor which totals 40,171 SF.

The required floor area (40,171 SF) exceeds the allowable (36,000 SF) by 4,171 SF. Therefore, a two-hour area separation wall is required by UBC so that no area exceeds the 36,000 SF limit. This is achieved by using the concrete shield wall of the Beam Tunnel as the area separation wall. One pair of doors leading into the Beam Tunnel from the High Bay Area would be one-and-a-half-hour fire rated. The other door is 8-feet thick concrete. Penetrations in the wall must be well-sealed, but since this is also a shield wall, its compliance as a two-hour area separation should be inherent. This solution reduces the first floor area to 24,021 SF which is below the 36,000 SF maximum.

Atrium

The Laboratory has determined that the High Bay Areas do not constitute an atrium.

Exits

The NFPA Life Safety Code, 101 was used to determine all exit requirements. Holmes & Narver calculated exit capacities based on an Industrial occupancy. Holmes & Narver used the more restrictive condition in determining exit sizes and number. Exits were determined based on 100 SF per person with no allowance for equipment floor area usage. By this method the Code requires exits for an occupancy load of 681 people. In contrast, the Laboratory User Group anticipates an actual occupancy load of less than 60 people. While it may seem inappropriate to design exits for 681 people when only 60 will occupy the Facility, the Code requirement to design with minimum dimensions and number of exits accounts for virtually all of this "extra" capacity.

Therefore, the larger exit capacity is much more a function of meeting minimum code requirements than a function of using more restrictive area-per-person ratios.

BUILDING CODE ANALYSIS

PROJECT NAME: GTA-2

PROJECT NO. 2055.20

Code Check By: MORGAN KRAMM

Date: MAY 28, 1987

Applicable Code Name: UBC, 1982 AND LIFE SAFETY-101, 1985

Fire Zone: N/A

Occupancy Classification (Table 5A):

Principal Occupancy: B-2 (THIS CLASSIFICATION WAS DETERMINED BY THE LABORATORY.)

Fire Resistance of Exterior Wall (Table 5A): Re. 5-A P. 37
ONE HOUR LESS THAN 20 FEET

Non-combustible Wall Allowed (Sec 2203): N/A

Openings in Exterior Walls (Table 5A): Re. 5-A P. 37
NOT PERMITTED LESS THAN 5 FEET PROTECTED LESS THAN 10 FEETOccupancy Separation Required (Table 5B): Re. 503 P. 40
*B-2 to B-2 = 0 hours

* THE LABORATORY HAS STATED THAT THE BUILDING OCCUPANCY IS A B-2 IN ITS ENTIRETY.

Note: 503-C: Requirements for openings AT ONE HOUR WALLS - PROVIDE ONE HOUR RATED OPENINGS.

Maximum Allowable Floor Area (Table 5C): TYPE II

Occupancy: B-2	1-HR
Basic Allowable Area:	18,000 SF
Increase Fire Zone 3:	N/A
Increase for Separation:	18,000 SF
Increase for Fire System:	<u>N/A</u>
Total Allowable Area:	36,000 SF
Maximum for Added Stories: (100% Increase)	72,000 SF
Actual Floor Area (See Def. Chapter 4):	69,158 SF

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APPENDIX B DESIGN CRITERIA COMPARISON

Maximum Allowable Height (Table 5D):

Re.507

P.42

Feet: 65

Stories: FOUR

Special Occupancy Requirements (Chapter 6 thru 15):
NONE

Re.(---)

P.(---)

Windows Required in Rooms (Res.): N/A

Enclosed or Semi-enclosed Courts - Size Required (Res.): N/A

Minimum Ceiling Height in Rooms (Res.): N/A

Minimum Floor Area of Rooms (Res.): N/A

Fire Resistive Requirements (Table 17A):

Exterior Bearing Walls: 1* Hours

Re.(---)

P. 89

Interior Bearing Walls: 1* Hours

Re.(---)

P. 89

Exterior Non-bearing Walls: 1* Hours

Re.(---)

P. 89

Structural Frame: 1* Hours

Re.(---)

P. 89

Permanent Partitions: 1* Hours

Re.(---)

P. 89

Vertical Openings: 1* MECHANICAL SHAFTS:
2 (STAIRS), LIFE SAFETY, 101 STAIRS

Re.(---)

P. 89

Floors: 1* Hours

Re.(---)

P. 89

Roofs: 1* Hours

Re.(---)

P. 89

Exterior Doors: (DETERMINED BY LOCATION
ON PROPERTY) Hours

Re.(---)

P.(--)

Exterior Windows: Hours

Re.(---)

P.(--)

* USE AUTOMATIC SPRINKLERS AS SUBSTITUTE FOR ONE HOUR RATING. (508 p. 33)

See Types of Construction:

Inner Court Walls: N/A Hours

Roof Coverings: FIRE RETARDANT

Re. 3202b

P. 538

Boiler Room Enclosure: ONE HOUR IF GREATER
THAN 400,000 BTU/HP. Hours

Re. 708

P. 50

Parapet Walls (Sec. 1709):

Where Required: NONE

Re. 1709a

P. 81

Height: N/A

Toilet Room Requirements:

Fixture Count Requirements (UPC): 1985 EDITION

<u>Men:</u>	<u>Basis</u>	<u>Actual</u>		
Lavatories	1 PER 10		Re. APP.C	P. 154
Water Closets	3 PER 26-50		Re. APP.C	P. 154
Urinals	1 PER 50		Re. APP.C	P. 154

Women:

Lavatories	1 PER 10		Re. APP.C	P. 154
Water Closets	3 PER 26-50		Re. APP.C	P. 154
Showers Required (UPC):	1 PER 15		Re. APP.C	P. 154

Water Closet Compartments and Showers (UBC Sec. 510):

Walls: SMOOTH, HARD, NONABSORBENT SURFACE		Re. 510	P. 34-35
Floors: SMOOTH, HARD, NONABSORBENT SURFACE		Re. 510	P. 34-35
Compartments Dimension:		Re. 511	P. 35-36
Handicapped: CLEAR SPACE OF 42" X 48" BY STOOL		Re. 511	P. 35-36
Drinking Fountain Requirements : 1 PER 75		Re. APP.C	P. 154

146000193

Guard Rails (Sec. 1711):

Re. 1711

P. 82

Where Required: RF EQUIPMENT PLATFORM

Height Required: 42 INCHES

Fire Alarm (See Occupancy Types):

Required Basis:

Re. NFPA-10-4 thru 10-3.

Type: AUTOMATIC CLASS B MODIFIED TO MEET
LABORATORY REQUIREMENTS.

Stair and Exits: PER NFPA LIFE SAFETY CODE

Occupancy Load:

Re: 28-1.7

P. 101-332

Floor #	SF/FL	Occ. Indust.	SF/Per.	Actual Load	Tributary Floor	Total	Width Inches
ONE	6,272		100	63	SECOND	299	44
TWO	14,073		100	141	THIRD	236	44
THREE	3,916		100	39	FOURTH	95	22
FOUR	5,632		100	56	NONE	56	22
HIGH BAY AREA	17,749		100	177	BEAM TUNNEL	338	88
BEAM TUNNEL	16,150		100	161	NONE	161	44

Number of Exits Required: 2 @ MULTI-STORY,
2 @ HIGH-BAY, 2 @ TUNNEL

Re. 28-2.4.1

P. 101-334

Minimum Width of Exits, basis: 44 INCHES

Re. 28-2.5.1

P. 101-334

Actual: 48 INCHES AT STAIRS, 78 INCHES @ CORRIDORS

Maximum Allowable Travel Distance to Exit: 100 FEET

Re: 28-2.6.1

P. 101-335

With Sprinklers: 150 FEET

Exit Doors:

Re: 5-2.1.1.3

P. 101-19

Minimum Width Allowed: 32 INCHES

Maximum Leaf Width Allowed: 48 INCHES

Width Required for Number of Occupants: 22 INCHES PER 100 PEOPLE

Exit Corridors:

Minimum Allowable Width: 44 INCHES	Re. 28-2.5.1	P. 101-334
Required to Have Exit at Each End of Corridor: NO		
Dead End Corridors Allowed: YES		
Maximum Length: 50 FEET	Re: 28-2.5.3	P. 101-334
Maximum Occupant Load: 100 PER 22 INCHES IN WIDTH	Re. 5-2.1.1.3.1	P. 101-19
Wall Fire Resistance Required: ONE HOUR	Re. 5-1.3.4	P. 101-18
Doors and frames Fire Resistance Required: 20 MINUTES	Re: 5-1.3.4	
DISCHARGE FROM BEAM TUNNEL TO HIGH BAY MUST MEET REQUIREMENTS OF	Re: 5-7.2	P. 101-49

Stairs: CAPACITY = 60 PEOPLE PER UNIT OF WIDTH (22 INCHES)

Minimum Width: 36 INCHES For Occ. Load of 50	Re. 5-2.2.1.2	P. 101-25
44 INCHES FOR Occ. Load of 50 OR MORE	Re. 5-2.2.1.2	P. 101-25
Maximum Riser Allowed: 7 INCH	Re. 5-2.2.1.2	P. 101-25
Minimum Tread Allowed: 11 INCH	Re. 5-2.2.1.2	P. 101-25
Open Risers Allowed: N/A		
Is Winder Allowed: N/A		

Landings:

Minimum Size: WIDTH OF STAIR	Re. 5-2.2.2.5	P. 101-27
Maximum Size Required: 4 FEET	Re. 5-2.2.2.5	P. 101-27
Are Splayed Corners Required: N/A		
Maximum Vertical Distance Between Landings: 12 FEET	Re. 5-2.2.1.2	P. 101-25
Required Height of Rails: 30 TO 34 INCHES	Re. 5-2.2.3.4	P. 101-28

Handrails:

Required at Each Side: YES	Re: 5-2.2.3.1	P. 101-28
Note: Life Safety Requires Both Sides		

APPENDIX B DESIGN CRITERIA COMPARISON

Intermediate Rails Required at Stairs: 88 INCHES WIDE

Maximum Width Between Intermediate Rails: Re: 5-2.2.3.4 (h) P.101-29
88 INCHES WIDE

Exceptions Applicable: N/A

Height Above Nosing: 30 TO 34 INCHES

Balusters Required: N/A

Intermediate Rail Required: (6-INCH Ø SPHERE)

Maximum Post Spacing Allowed: N/A

Handrails Return to Wall at Ends: YES

GUARD RAILS SHALL BE 42 INCHES HIGH WITH 6 INCH Ø SPHERE REQ'S. (EXCEPTION:
SEE 1711-4)

Stair to Roof Required: NO Re. P.

Stair Required to Continue to Basement: N/A

Hatchway Access to Roof Required: YES Re. 3306(m)(o) P.564-565

Ladder Access to Roof High Point Required: NO Re. P.

Stair Enclosure Required: YES, TWO HOURS Re. 5-1.3.1 (b) P. 101-18

Horizontal Exit Requirements (If Applicable): N/A

Protection of Openings Near Exterior Stair Exit Doors: N/A

Smokeproof Enclosure Required: NO Re. 28-2.2 P. 101-333

Ramps:

Maximum Slope to Use as Exit: 1:10 Re. 5-2.6.1.2 P. 101-35

Handrails Required: YES, 50 LBS. LINEAR FOOT Re: 5-2.2.3.1 P. 101-28

Exit Signs Required: YES Re. 28-2.10 P. 101-336

Emergency Lights or Power Required: LIGHTS Re. 28-2.9.1 P. 101-336

Special Hazard Requirements: N/A

Skylights (Chapter 34): N/A

Penthouses (Chapter 36): N/A

Fire Extinguishing Systems:

Sprinklers Required (Chapter 38): NO Re. 508 P. 33
(USED AS SUBSTITUTION FOR ONE HOUR RATED CONSTRUCTION)

Dry Standpipes Required: *N/A Size Re. P.

*DOE STANDARDS PRECLUDE USE OF STANDPIPES.

Location: N/A

Number Required: N/A

Number Outlets Required: N/A

Hose Required: N/A

Siamese Connections Required: N/A

Wet Standpipes Required: N/A

Number Required (Hose Run): N/A

Location: N/A

Fire Extinguishers Required: YES Re. P.

Note: See Life Safety FOR EXITS Chapt. 5

Combination Wet/Dry: N/A

Use of Public Property (Chapter 45):

Doors Prohibited from Swinging into City Property: N/A

Windows Swinging Over Public Property Minimum: N/A

Marquees, Canopies, Etc.:

Support from Building: N/A

Material Restrictions: N/A

Distance Above Walk: N/A

Maximum Distance of Extension Over Walk: N/A

Maximum height: N/A

Drainage: N/A

Other Projections:

Minimum Height Above "Ground": N/A

Maximum Allowable Projection: N/A

Bay Window, Porch, Balconies: N/A

1 4 6 0 0 8 0 2

Cornices, Etc.: N/A

Elevators and Escalators:

Maximum Number in Each Shaft: N/A
 Use as Required Exit: NO

Re. (---)
 Re. (---)

P. (---)
 P. (---)

Ventilate Penthouse: N/A

Machine Room Wall Construction:

Re.

P.

Structural Requirements (See Building Type Chapter 18-22)

Framework: NON-RATED

Re. 508

P. 33

Stairs: NON-COMBUSTIBLE

Re. 5-2.2.2.1

P. 101-27

Floors: NON-RATED

Re. 508

P. 33

Roofs: NON-RATED

Re. 508

P. 33

Partitions: NON-RATED

Re. 508

P. 33

Structural Requirements (Chapter 23):

	<u>Floor Use</u>	<u>Load</u>		
Live Load-Floors:	BEAM TUNNEL	2800 PSF	Re. ANSI*	P. A58.1
	GROUND FLOOR	250 PSF (2-TON FORK LIFT)		
	SECOND FLOOR	150 PSF (170 PSF @ CAPACITOR ROOM & 250 PSF @ RF EQUIPMENT PLATFORM)		
	THIRD AND FOURTH FLOORS	250 PSF		

* OR USER DEFINED

	<u>Pitch</u>	<u>Load</u>		
Live Load-Roof:	1/2 INCH PER FOOT	30 PSF	Re. (---)	P. (---)

SNOW DRIFT PER ANSI A58.1

30 PSF IS BASED ON USER DEFINED REQUIREMENTS

146003

Re: ANSI

P. A58.1
Sec. 6

Minimum Wind Pressure Allowed for Design
(Pounds per Square Foot): 22 PSF KZ = 1.16,
I = 1.07, V = 80

Building Material Requirements (Chapter 24):

(Check all materials used, against code, for conformity of composition,
size, strength.)

Masonry: N/A

Masonry Veneer: N/A

Wood (Chapter 25): N/A

Concrete (Chapter 26): N/A

Special Requirements (List): N/A