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HAZARDS SUMMARY REPORT FOR
THE METAL ASSEMBLY

Contract DA-49-146-XZ-171
Defense Atomic Support Agency

August 15, 1963

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**HAZARDS SUMMARY REPORT FOR
THE METAL ASSEMBLY**

by

J. R. Brown and J. L. Russell

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Project 307

Research sponsored by the DEFENSE ATOMIC

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August 15, 1963

I. INTRODUCTION

1.1 PURPOSE

General Atomic has been studying the feasibility of an accelerator pulsed fast assembly for the Defense Atomic Support Agency. The processes on which operation of an APFA are based are as follows. A short pulse of electrons from an accelerator bombards a target inside a multiplying assembly. The electrons produce bremsstrahlung on stopping in the target and the bremsstrahlung produce neutrons by γ -n reactions with the target nuclei. These neutrons are then multiplied by the assembly. The purpose of the device is to produce short, intense bursts of neutrons. The burst widths can be very short because the fission rate in the assembly can be controlled by the accelerator. Burst widths of less than a microsecond are feasible. The ultimate application of APFA systems will be as the radiation source for studies of transient radiation effects on electronics materials, components, and circuits.

Methods have been developed for predicting system behavior. Neutron yields have been measured for small samples of fissionable materials. The next step of the program is to test a complete APFA system.

Arrangements have been made with Oak Ridge National Laboratory to move an oralloy reactor complete with an assembly machine, and a technician to help set up the equipment, to General Atomic where it can be pulsed with the General Atomic linear accelerator. A two month experimental program is planned with the object of verifying the methods and theory to be used to design an APFA facility.

The reactor will be located in the HTGR critical cell approximately 100 ft from the linear accelerator. The assembly will be operated with the

existing console and neutronics instrumentation with a steady state neutron source or with the pulsed neutron source provided by the General Atomic linear accelerator.

The purpose of this document is to provide the information required to obtain authorization to receive and use the fast assembly. The analysis herein offers evidence showing that operation of the assembly will create no undue risk to the health and safety of the public or the personnel of the Laboratory.

1.2 EXPERIMENTAL PROGRAM

Experiments with the accelerator pulsed fast assembly will consist primarily of measurements of neutron yield and pulse shape produced by the electron pulses from the Linac impinging on the spherical metal reactor. Measurements will be made with the reactor at several reactivities from subcritical to positive reactivities corresponding to periods of less than 10 seconds. The program will include measurements of:

1. Reactivity by pulsed neutron methods and/or period method,
2. Pulse shape inside and outside the assembly,
3. Absolute neutron yield per incident electron,
4. Bremsstrahlung component of γ -flux around core,
5. The small but observable mechanical shock produced in the reactor,
6. Response of burst sensors, e.g., phosphors and Compton diodes, to short pulses.

II. DESCRIPTION OF METAL ASSEMBLY

2.1 GENERAL ATOMIC LINEAR ACCELERATOR CRITICAL FACILITY

2.1.1 Layout and Building Descriptions

This section describes features of the linear accelerator and associated critical facility which are pertinent to the discussion of the metal assembly. The critical facility is the same as was used for the HTGR critical experiments¹ and for the Linac pulsed critical experiments.² More general information on the facility and its site is contained in Appendix A.

The General Atomic linear accelerator critical facility is located immediately north of the main laboratory complex (Fig. 1). The facility is divided into three principal areas: the accelerator building, the control and data building and the critical facility assembly area (Fig. 2). These three areas are separate, as far as personnel protection is concerned, in that they are divided by concrete, lead, and earth shielding and are provided with separate air conditioning systems.

Access to the accelerator building is from the control and data building through a long passage with a 6 ft thick concrete door. This door is interlocked with the operation of the accelerator and must be closed before operation of the accelerator can begin. Access to the critical facility assembly room is from the control and data building through an offset labyrinth in an 8 ft thick concrete wall with air tight doors at each end. These doors are interlocked with the operation of both the accelerator and the critical facility.

The control room for the accelerator is located in the control and data building adjacent to the passage leading to the accelerator building.

The control and data building also contains the data center for the experiments in the accelerator building as well as offices and shops. The accelerator building, the control and data building and the critical facility assembly room are situated below the level of the surrounding laboratory terrain. The control and data building is exposed but the accelerator building is buried under 12 ft of fill earth and its sides are shielded with a minimum of 25 ft. of fill earth.

To the north of these buildings and just beyond the earth shielding is a large level area, below the level of the surrounding terrain, which contains the drift tubes for the neutron time-of-flight experiments and the equipment associated with these experiments. The shielding is sufficient such that a large part of this area is available to personnel during operation of the accelerator or the critical assembly. Those areas not available to personnel are suitably fenced off.

2.1.2 Critical Facility Assembly Room

The critical facility assembly room has earth fill on three sides and an 8 ft thick concrete wall between it and the control and data building on the fourth side. The roof of the critical facility assembly room is 2 ft thick and has no earth cover. The walls are of 18 in. thick poured concrete. The critical facility assembly room is separated from the accelerator room by 16 ft of earth and concrete shielding. This shielding is penetrated by the accelerator electron beam tube. A set of "beam stoppers" is used to control entry of the electron beam into the critical facility assembly room. These beam stoppers are interlocked with the doors and the operation of the accelerator to prevent personnel exposure. The critical facility assembly room has an exit to the rear through an earth covered tunnel. The doors

of this tunnel are also interlocked with operation of the accelerator and the critical assembly.

The control room for the critical facility assembly room is located in the control and data building adjacent to the 8 ft concrete wall of the assembly room. The critical facility assembly room has a filtered ventilation system equipped with absolute filters on the exhaust. The ventilation system is arranged to close the intake and exhaust on any assembly scram.

2.2 METAL ASSEMBLY

2.2.1 Uranium Sphere

A fully enriched uranium sphere will be the fuel for the assembly. It will be machined from uranium metal by the Oak Ridge National Laboratory and will consist of three pieces: a central section and a top and bottom cap. Figure 3 shows these pieces. The diameter of the assembly sphere is approximately 17.6 cm. The sphere will have a horizontal hole of diameter 1 in. and depth of 3 in. to permit the electron beam to impinge near the center of the assembly.

2.2.2 Assembly Machine

The assembly machine to be used is the Oak Ridge National Laboratory Critical Testing Unit (CTU). It will be shipped to General Atomic for use in these experiments. It is described in ORNL-TM-349.* Figure 3 shows a schematic diagram of the parts.

The assembly machine consists primarily of three parts: a fixed central support which is manually adjustable in elevation, a lower vertically movable support device powered, through a magnetic coupling, by a pneumatic-hydraulic system, and an upper vertically movable attachment powered by a pneumatic cylinder.

*"A Safety Review of the Oak Ridge Critical Experiments Facility," Dec. 1962.

The fixed central support is an aluminum frame supported by vertical legs at the corners of a 4 ft square. The central support elevation may be varied (manually) from 6 to 8 ft above the floor.

The lower vertically movable support device is shown schematically in Fig. 3. It contains a magnet housing attached to the vertically driven piston. The release of the magnet causes a drop of the support of 6 in. under gravity. During normal operation the magnet is energized and the support follows the motion of the hydraulic cylinder piston. Full travel is 24 in. at a maximum lift rate of 20 in. per min without load. At a preset position as the piston approaches the upper limit, the rate is decreased by throttling the hydraulic flow. At a preset position in its travel the moving member actuates a switch which diverts the flow through a system of two orifices in parallel, either of which can be manually closed off. Flow through one orifice allows a rate of 0.15 in./min, through the other 0.25 in./min and through both 0.40 in./min. In these experiments at General Atomic the closure rate of 0.15 in./min will be used in the last 1-1/2 in. of travel before closure.

The minimum lowering rate for normal shut down is 40 in./min. When a scram condition occurs, the support device drops 6 in. under gravity and further separation of the parts of the assembly is brought about by reversed hydraulic force on the piston provided by oil under high pressure which moves the piston through its total downward displacement in less than 2 sec.

The rate of separation of this lower part of the assembly upon scram conditions is about 12 in./sec over the first in., 60 in./sec over the next 9 in. and 10 in./sec for the remainder of the downward stroke. In the spherical assembly discussed here the time rate of reactivity change near closure is 3¢/sec. In a scram shutdown, the rate of reactivity decreases is 150¢/sec over the first inch of travel.

The upper vertical movable support is driven by a pneumatic cylinder and upon a scram signal retracts vertically in times slightly longer than the lower support section.

The central uranium section of the sphere is fixed in position on the stainless steel diaphragm of the fixed table. The upper and lower sections are each attached by threaded bolts and lock-nuts to the upper and lower support devices.

Interlocks are provided such that the upper section must be assembled before the lower section and cannot be driven in the downward direction if the lower drive mechanism is off its lower limit position. The lower section can only be driven in the upward direction if the magnet unit is "cocked."

Other interlocks are provided to initiate scrams upon loss of hydraulic pressure, air pressure or electric power.

2.2.3 Control Rod

A control rod consisting of a small quantity of neutron reflecting material will be positioned horizontally near the midplane of the assembly and exterior to the assembly to provide fine control of reactivity. This rod will be driven by a rack and pinon assembly with position read-out in the control room. The control rod will not be a scramable element. It will be interlocked such that it must be in its fully removed position to permit assembly of either the top or bottom sections. Its speed of travel will be limited to give less than 2β /sec reactivity change at its most reactive position. Its travel will be limited such that the total reactivity it can add after the sections of the sphere are assembled is less than 1 dollar.

2.2.4 Neutron Source

A steady state neutron source is used in the assembly and start-up of the core. This will be a Po-Be or Pu-Be source with a strength of approximately 10^7 neutrons/sec. It will be remotely positionable and an interlock will be installed which requires the source be present for start-up. This interlock takes the form of a low-level trip on the log-micro-microammeter which will be set at a level corresponding to at least 10^6 neutrons/sec in the assembly. Anytime the neutron level drops below this value a scram occurs. In its closest approach to the assembly, the source will be 2 in. from the assembly. The reactivity effect of the source (as a reflector of core neutrons from the Be) will be measured. The source will be retracted to a shielded position when the assembly is critical or when it is being pulsed by the electron beam of the linear accelerator.

2.3 FUEL STORAGE

The fuel pieces will be stored in a vault in a manner approved by the General Atomic Criticality Safeguards Committee.

III. SAFETY SYSTEM AND OPERATIONAL PROCEDURES

3.1 INSTRUMENTATION AND INTERLOCKS

3.1.1 Nuclear Instrumentation

The control system and nuclear instrumentation associated with the safety of the assembly are located in a console in the control room adjacent to the assembly room. The safety system is diagrammed in Fig. 4. The safety system uses three neutron measuring channels each operating independently. One of these channels provides a signal for a period scram. Each channel, a manual control at the console and a manual control at the assembly are capable of scrambling the assembly by releasing the magnet and also the piston down.

Two compensated ion chambers, individually supplied from separate high voltage and compensating voltage supplies give neutron level information on linear micro-micro ammeters with meter relay scrams. A third compensated ion chamber feeds a signal to logarithmic micro-micro ammeter and a period circuit with a meter relay scram on the period output. The logarithmic micro-micro ammeter has a low level meter relay trip for scrambling the reactor if there are insufficient reactions present. The linear micro-micro ammeters also provide signals to two recorders.

In addition, several counting channels consisting of BF_3 or fission counters will be used to provide visual and aural indication of neutron level.

The minimal instrumentation required for start up will consist of the two linear safety channels, the period safety channel (which contains the low level trip) and one counting channel for audible count-rate signal in the control room and in the assembly room.

Temperature monitoring of the assembly will be accomplished with thermocouples or resistance thermometers.

A voice communication circuit will be maintained between the control console, the assembly room and the Linac control room. It will be arranged such that the control console continuously listens to the assembly room.

3.1.2 Interlocks

The magnet power supply and the piston drive power supplies are controlled through a locking type key switch on the console. This will be called the interlock key. This key also fits the lock on the entry door to the assembly room. In addition, when this interlock key is on, the power to the electric latches on the assembly room entry doors is removed. A second key switch controls power to the electronic equipment permitting maintenance to be performed on the console but not closing of the assembly machine. A third key switch is provided which will only control power to the electric latches on the entry doors to the assembly room in addition to this function on the interlock key.

To enter the assembly room the interlock key must be removed from the console. Whenever this key is removed from the console switch, a horn sounds in the assembly room until the key is placed in the switch on a small console on the assembly room floor. Upon leaving the assembly room, the key is removed, the horn sounding to warn personnel until the key is again placed in the console switch. The removal of this interlock key from the console will drop the magnet and retract the pistons if this has not already been done manually. Removal of this key from the console also prevents operations of the control rod.

The entry doors to the assembly room and the rear exit doors from the assembly rooms are interlocked with operation of the reactor such that opening of any of these doors causes a scram. These same doors are also interlocked with the operation of the linear accelerator such that if the beam stoppers in the beam tube leading to the assembly room are not closed, the opening of these doors will shut down the accelerator. With the beam stoppers closed, entry into the assembly room can be made without shutting down the accelerator. The beam stoppers are located in the accelerator experimental room near the shielding between the experimental room and the assembly room. Their position is indicated in Fig. 2.

Specific interlocks for the assembly machine, control rod and source are detailed in the sections describing those components.

A low level interlock on the log micro-micro ammeter will scram the magnet and retract the pistons if the neutron level gets below some predetermined level. This level will be determined during start-up and will insure that start-up cannot be accomplished without a minimum number of neutrons present.

A switch permits overriding the period during times when it is desired to use the accelerator pulse. This switch is interlocked with the control rod and assembly machine to prevent any increase in reactivity.

The overhead crane will be interlocked such that it must be at one end of the room to permit start-up. The crane can only be operated from the assembly room.

3.2 ORGANIZATION FOR CONSTRUCTION, OPERATION AND MAINTENANCE

The metal assembly experiments will be conducted by personnel of the General Atomic Linear Accelerator Experimental Group. All operating personnel will report to the Physicist-in-Charge of the Metal Assembly.

Specific duties of the operating group are as follows:

1. Physicist-in-Charge - The Physicist-in-Charge has the responsibility for the safety and operation of the assembly. He is directly responsible for staffing, scheduling and operating procedures and techniques used in the experiments. He will assist in interpretation of experiments and in developing modifications to the specified experimental program.
2. Deputy Physicist-in-Charge - The Deputy Physicist-in-Charge is responsible to the Physicist-in-Charge for carrying out the specified experimental program. He also assists in the planning of experiments, analyzing hazards and interpreting results.
3. Operating Staff - The operating staff may man the control console and assist in all operations of the assembly such as maintenance, loading, experimental set-ups and taking data. They are under the supervision of the Physicist-in-Charge or the Deputy Physicist-in-Charge.

3.3 NORMAL OPERATING PROCEDURES

The metal assembly will be operated in accordance with established administrative procedures. These administrative procedures are discussed in GA-2300 Addendum 3 and are the same as described there except all references to the subcritical multiplying assembly are to be changed to read metal assembly. Some specific differences between detailed procedures for the water assembly and for the present metal assembly are given below.

The formal operating procedures for the metal assembly are summarized as follows:

1. No experiment may be performed without a written approved experimental program.
2. A log book is to be maintained for all loadings, system testing, maintenance and operations. Each section of the log is to be signed by the person responsible for the assembly at that time.
3. The cause of any assembly scram will be determined and entered into the log.
4. Whenever the metal assembly is being operated, at least two persons of the operating staff must be present in the area of the control console one of whom must be the Physicist-in-Charge or the Deputy Physicist-in-Charge.
5. During any operation of the critical assembly and during any core changes, one member of the operating staff will be at the control console.
6. At least two level-scram and one period-scram channel must be functioning properly during any operation except pulsing. During pulsing operation, at least two level-scram channels must be operating properly. The period-scram will never be set for a period shorter than 3 sec.
7. An audible alarm will be functioning in the assembly room and the control room giving indication of any beam current reaching the beam tube in the wall between the accelerator experimental room and the assembly room.
8. An audible signal of neutron multiplication will be functioning at all times in the vicinity of the assembly and at the control console.
9. Operation of the metal assembly will be limited to an excess reactivity of less than 1\$ available to the operator.

10. The assembly will never be taken critical with more than a 50¢ gap.
11. The power level will be kept below 500 watts average.
12. The interlock key is used for the lock on the assembly room entry door and the power supply to the magnet and the pistons. For strict control there will be only two such keys: one kept in a locked key box in the control room and available to the Physicist-in-Charge or Deputy Physicist-in-Charge and one which will be kept in the office of the Director of the Laboratory.
13. Interlocks will not be overridden except on approval of the Criticality Safeguards Committee.
14. The beam stoppers are to be moved only by Linac operators specified by the Physicist-in-Charge of the metal assembly. Each movement of the stoppers is to be logged and signed on a chart located at the beam stoppers. In addition, after each movement of the stoppers, a seal will be attached.
15. An assembly room door interlock plug panel is installed such that each person will remove a plug (to be carried with him while he is in the assembly room). While any plug is out, Linac operation is prevented when the beam stoppers are open.
16. Only one of the three parts of the uranium sphere may be detached from the assembly machine or out of the fuel storage valut at any one time.

3.3.1 Approach to Critical Loading

All fuel loadings will be made with pistons fully retracted, safety instrumentation channels functioning properly and an audible monitor of multiplication operating.

The assembly has a critical mass of 55,000 grams. The initial approach to critical of the completed assembly will be approached in steps, stopping at various positions to obtain neutron multiplication data from the instruments. Subsequent steps will be determined from plots of inverse multiplication vs. separation distance, each step being sized to be less than half the extrapolated distance to critical or \$.50 whichever is larger. This process will be followed each time a change is made in the core loading.

During loading of any fuel, a member of the operating staff will be present at the control console. Either the Physicist-in-Charge or the Deputy Physicist-in-Charge and at least one other person will be present in the assembly room to insure that the fuel has been properly placed.

3.3.2 Check-out-procedure

On days of assembly operation the following check-out procedure must be followed before any assembly of the core can be started:

1. All safety channels and instruments will be checked for proper operation,
2. An interlock check list will be completed. The form of this check list will be made up by the Physicist-in-Charge and approved by the Criticality Safeguards Committee,
3. A visual inspection of the assembly will be made,
4. The assembly room will be cleared of all personnel and the assembly room locked. The person making this check will sign the log to the effect that the room has been cleared,
5. The beam stopper interlock with the linear accelerator will be checked on any day that personnel are to be in the assembly room. Prior to operating with beam stopper closed a radiological survey of the area will be

made if the Linac is operating to insure that the stoppers are closed. If Linac is not operating, the beam stoppers will be visually inspected and logged. The beam alarm in the assembly room will be checked daily on days of operation.

IV. ACCIDENT ANALYSIS

4.1 HAZARDS DURING NORMAL OPERATION

The assembly will always be operated with less than \$1.00 excess. Safety features have been built into the assembly and its instrumentation to provide protection to personnel and to the assembly. In addition, a set of operating procedures has been established* and approved for carrying out experiments in a safe manner.

Particular emphasis has been placed on procedures and interlocks covering the use of the pulsed neutron source in the HTGR assembly room. This pulsed source does not affect the reactivity of the assembly but the associated gamma radiation represents possible lethal doses to any personnel in the assembly room during pulsing. This same situation exists for the linear accelerator experiment room, so the procedures are very similar to those used there which have been successful.

Assembly radiation levels after any operation will be monitored every time personnel enter the assembly room to insure that radiation doses received by personnel are within accepted levels. Pulsed source operation for die-away measurements during the approach to critical and at critical will be at relatively low average levels so that radiation levels of the assembly are expected to be tolerable.

The Physicist-in-Charge, working in cooperation with health physics personnel will insure that all radiation doses received by personnel are within the limits of Title 10, Chapter 1, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation (10CFR20).

* GA-2300 and addendum

4.2 ACCIDENT CONSIDERATION

The type of accidents discussed in this section are those resulting from events which may cause a change in the reactivity of the assembly sufficiently large or rapid to cause hazardous conditions if corrective action were not taken by the operator or by the automatic safety circuits. All reactivity changes that are made as a part of the normal operation of the assembly will be controlled by the operating procedures and will, in addition, be subject to the protection afforded by interlocks and safety circuits as described in section 3.1. Thus, the accidents discussed here will be the result of simultaneous failure of several parts of this protection. The probability of these accidents is kept small by having many backups and duplications in the protection scheme, so that a succession of highly improbable events is required for the accident situation to develop.

4.2.1 Flooding of Assembly

The possibility of flooding the assembly is extremely small. The assembly sits approximately seven feet off the floor so that approximately 100,000 gallons of water would have to enter the assembly room before the core got wet. This is not considered a credible accident. Outside drainage water cannot get into the assembly room. Water supplies to the room are limited in volume, being recirculating cooling lines. The assembly room has a floor drain that goes to a 500-gallon contaminated storage tank. The slow addition of water to the core, e.g., by condensation, would result in slow addition of reactivity. If this exceeded critical, the reactor power would rise, evaporate the water, and return subcritical. Slow reactivity additions do not produce large excursions.

4.2.2 Power Failure

All controls and equipment are designed so that a power failure will cause the assembly to shut down safely. Upon restoration of power a complete start-up procedure must be followed.

4.2.3 Manual Assembly

The manual assembly of the three core sections with a resultant rapid increase in reactivity above critical is not considered credible for the following reasons:

1. Normal operating procedure requires all three core sections to be mechanically attached to the remote assembly machine. The core is in the separated position whenever there are personnel in the assembly room. To assemble the core manually, a person would have to disconnect the core sections from the assembly machine.

2. Manual assembly of either two of the three core sections would not cause an accident because they would constitute only $2/3$ of a critical mass. The only fuel at the Linac site in a form suitable for use in the assembly machine will be the three core sections which constitute a critical mass.

3. By procedure, only one of the three core sections can be in the critical cell while disconnected from the assembly machine.

4.2.4 Overhead Equipment Falling

The fall of overhead equipment on the assembly with a resultant rapid increase in reactivity is not considered credible for the following reasons:

1. A falling object could add reactivity (by reflection) above prompt critical only if the core were already assembled and at or near critical.

2. The core is under continual observation when assembled, by closed circuit TV.

3. The only overhead equipment in the critical cell is the crane, and it is interlocked so that the reactor cannot be assembled unless the crane is against the wall away from the reactor.

4.3. MAXIMUM CREDIBLE ACCIDENT

The maximum credible accident is assumed to occur if the reactor is assembled at the maximum closure rate (20 in./min) after a reflector has added reactivity so that the reactivity can exceed prompt critical, and if improbable time has been chosen for the assembly operation so that the start of the power rise is delayed by the weak source statistical effect.

The sequence of causal events leading to this accident is difficult to visualize because of the several preventative procedures and interlocks which would have to be violated. However, the size of the accident can be calculated from the given assumptions.

The rate of addition of reactivity at closure can be estimated from data of ref. 1. The reactivity effect of a small gap in a fast metal assembly was measured to be 1.7¢/mil. For a closure rate of 20 in./min, this is 5.6¢/sec. We will assume that this ramp can continue through prompt critical. The work of G. Hansen² shows that in rare instances, a ramp of this type can continue for a surprisingly long time before the neutron chain reaction begins. The methods of ref. 2 calculate that in 99 accidents out of 100, less than 10¢ over prompt critical will be added before a chain reaction starts (our start-up source strength is 10^6 n/sec). The resulting power excursion is equivalent to a 10¢ prompt reactivity step. From ref. 3 this results in a prompt burst of 1.5×10^{16} fissions. The consequences

of this excursion are an average temperature rise of 70°C , which does not damage the core, a burst of fast neutrons, and an inventory of delayed neutron precursors which are a source of approximately 10^{10} n/sec which makes statistical effects unimportant for the remainder of the accident history. The heating can continue until the uranium metal phase transition to β (665°C) and then γ (770°C) phase volume expansion provides the ultimate shut down after approximately 2×10^{17} fissions. The total shut down available from temperature rise and phase expansion is \$5.00. There will be no blast effects because, after the burst, the temperature will follow the reactivity addition and prevent rapid power surges.

The fast neutron dose to the area surrounding the HTGR assembly room was calculated for the case of a 1000 megawatt-second energy release (3.3×10^{19} fissions) in GA-1210* and shown to be less than 2 rem at all points within a 60 ft radius. The results of this calculation are tabulated in Table I. The gamma dose will be less than the fast neutron dose due to the large amount of shielding and reduced skyshine effect from the gammas.

The heating of the air in the room from the approximately 7 megawatt-sec excursion would cause a negligible pressure increase, and the results of the excursion would be limited to the interior of the room.

* GA-1210 "Hazards Summary Report for the HTGR Critical Facility," Feb, 1960

1000 MW-Sec Burst

(Attenuation of 1 ft graphite has been included in the following)

FAST NEUTRON DOSES (CALCULATED)

<u>Location</u>	<u>Distance from Critical Assy. (ft)</u>	<u>Neutron Dose, rem</u>
1. Nearest boundary of laboratory property	700	0.1
2. Science Bldg. B	400	0.2
3. Linear Accelerator Control Room	100	0.6
4. Linear Accelerator Experimental Room	60	1
5. MGCR Critical Facility	60	1
6. HTGR Control Room	24-36	2 (includes direct dose)

APPENDIX A

SITE DESCRIPTION AND EVALUATION

GENERAL LOCATION

The General Atomic metal assembly will be located on Torrey Pines Mesa in the City and County of San Diego, California, where General Dynamics owns a tract of approximately 290 acres of ground. This tract is the site of the John Jay Hopkins Laboratory for Pure and Applied Science of the General Atomic Division.

The center of the tract lies 1-1/2 miles from the Pacific Ocean shore lines. Its southern boundary is about 2600 ft north of Miramar Road in San Diego. Its western boundary is adjacent to U.S. Highway 101, but by agreement with the City of San Diego the buildings are set back at least 400 ft from the highway. The laboratory extends eastward 5000 ft to Soledad Valley (commonly known as Sorrento Valley), where the Santa Fe Railroad line through the valley forms the eastern boundary.

Roughly 130 acres of the ground is level, the remainder being in side slopes and ravines as deep as 250 ft below the mesa tops. The level mesa tops are 300 to 350 ft above sea level.

The building housing the metal assembly and the General Atomic linear accelerator (see Sec. 2.1), is located 1800 ft from the nearest point on U.S. Highway 101, about 450 ft from Science Building B (Fig. 1) and about 1200 ft from a small sewage plant just north of the Laboratory site. This plant is used for the treatment of sewage from the General Atomic site and from a nearby municipal golf course.

The General Atomic linear accelerator is adjacent to the building housing the metal assembly (previously called the HTGR Critical Facility).

Concrete and earth shielding are provided between these buildings. About 90 ft to the northeast is the MGCR Critical Facility and 440 ft to the northeast is the building housing TRIGA, the General Atomic isotope-production reactor, and Mark-F, the General Atomic pulsed reactor. All other buildings on the site are at least 450 ft from the linear accelerator facility.

The accelerator building is surrounded on two sides by earth embankments of a height greater than that of the building. The third side, which faces away from the General Atomic site and toward a steep canyon, is shielded with a 1 ft thick conventional concrete wall and a minimum of 25 ft of earth. On the fourth side, between the accelerator building and control building, there is also a 1 ft thick conventional concrete shield wall and a minimum of 25 ft of earth.

A detailed discussion of the population density, meteorology, geology and hydrology, and seismology of the site may be found in Appendix B and Appendix C of GA-1971.*

*"Safeguards Report for the General Atomic Linear Accelerator Multiplying Assembly," March 1961

Fig. 1--Aerial view of General Atomic.

Fig. 2--Plot plan showing location of the linear accelerator facility. The aerial view of Fig. 1 shows only the control building. The accelerator building is covered by earth.

Figure 3 -- MODIFIED ORNL ASSEMBLY MACHINE

Fig. 4 - Block Diagram of Instrumentation and Safety Circuits