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OPERATING MANUAL FOR

THE AE - 6 REACTOR

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BY

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O. INTRODUCTION

O.1 PURPOSE

The purpose of this manual is to provide a single reference source for material pertinent to the maintenance and operation of the AE-6 Water Boiler Reactor. Insofar as practical, descriptions of various components are included as well as the common operational and maintenance procedures and check lists. In addition pertinent information will be included regarding the subcritical assemblies that may be studied.

O.2 PHILOSOPHY

In general, the AE-6 Reactor was designed to be a special source of neutrons. The reflector has various access channels in which samples of various sizes may be irradiated. The upper portion of the reflector is specially designed to be a thermal column. This serves as a plane source of predominately thermal neutrons. Various assemblies of moderator and subcritical lattices can be assembled on the thermal column. The peculiar features of the AE-6 reactor and the many different subcritical lattices coupled with improvements in experimental techniques require flexibility in equipment design and in experimental procedures. No design of safety equipment or formulation of operating procedures, however well worked out in advance, can adequately cover every eventual situation. Ultimately, the safety of this facility depends on the competence and judgment of the operating personnel.

Since the AE-6 Reactor is normally operated intermittently and at a low power, the build-up of fission products is small. The consequence of a criticality runaway is therefore not as severe as

a similar power reactor incident. However, in view of the flexibility of the subcritical lattices, the frequent startups and shutdowns of the AE-6 Reactor and the introduction of experimental equipment, the probability of an incident is greater than in a power reactor. Again, the need for a high degree of personnel competence and responsibility is indicated.

0.3 RESPONSIBILITY

Responsibility for the safety of operations lies with the line organization. Authority to approve proposed operations is vested in an Approval Authority designated by the Technical Director. Immediate responsibility for the safety of the experiment at the operating level is assigned to the Physicist-in-Charge.

0.4 AUTHORITY

Authority to approve all operations in the Subcritical Experiments Unit is vested in the Approval Authority designated by the Technical Director. On the operating level, the Physicist-in-Charge will be responsible for the safe and effective conduct of the experimental program.

0.5 APPROVAL

The experimental program will be reviewed by the Research Reactor and Fuels Safeguards Committee, and approved by the Approval Authority, before starting operations. Any significant change in the program will require similar review and approval.

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0.6 EQUIPMENT MODIFICATION

Any significant modification which affects safety of the operation, in company-owned or AEC-owned equipment, will require in advance a safety review and approval by the Research Reactor and Fuels Safeguards Committee.

1. PERSONNEL

1.1 GENERAL

The permanent operating staff of the AE-6 Reactor will be constituted as described in the following paragraphs. Under certain circumstances, depending on the work load and individual ability, functions under more than one job description may be performed by the same person.

Actual manipulation of controls will be performed exclusively by a Qualified Operator or Operator-Trainee as defined in sections 1.2.1 or 1.2.2. Operation of the AE-6 Reactor by any member of supervision will require the same qualifications as a Qualified Operator or Operator-Trainee and specific approval by the Supervisor of the Subcritical Experiments Unit, by the Experimental Physics Group Leader and by the Approval Authority.

1.2 OPERATIONAL JOB FUNCTIONS

1.2.1 Qualified Operator

The Qualified Operators as designated by the Supervisor of the Subcritical Experiments Unit, with the approval of the Experimental Physics Group Leader and Approval Authority, will operate the AE-6 Reactor including manipulation of controls. A list of Qualified Operators will be posted in the control room. Qualified Operators will work under the supervision of the Physicist-in-Charge and will participate in a number of functions including:

1.2.1.1 AE-6 Reactor operation.

1.2.1.2 Planning experiments, and scheduling of operations.

1.2.1.3 Construction and loading of the subcritical assemblies.

1.2.1.4 Recording of pertinent data.

1.2.1.5 Performing instrument checkouts.

1.2.1.6 Planning and performing special irradiations of samples in the reflector stringers and/or the "glory hole".

1.2.2 Operator-Trainee

A person designated as Operator-Trainee by the Supervisor of the Subcritical Experiments Unit and approved by the Experimental Physics Group Leader and the Approval Authority may operate controls under the close supervision of the assigned Physicist-in-Charge. The presence of an Operator-Trainee will not remove the normal requirement that the Physicist-in-Charge and one Qualified Operator be present in the control room during the AE-6 reactor start-up procedures and assembly operations.

1.2.3 Physicist-in-Charge

The Physicist-in-Charge will be appointed by the Supervisor of the Subcritical Experiments Unit with the approval of the Reactor Physics Group Leader and the Approval Authority, to assume responsibility for all phases of operation of the AE-6 Reactor. Specifically, he will:

1.2.3.1 Be responsible for the safety of the experiment at the operating level.

1.2.3.2 Participate in planning new subcritical assemblies and the experimental program.

1.2.3.3 Participate in the preparation of Hazards Summaries.

1.2.3.4 Keep staff members, supervision, and the Health Physicist informed of the current status of the program.

1.2.3.5 Supervise assembly of the subcritical lattices.

1.2.3.6 Schedule operations involving the AE-6 reactor.

1.2.3.7 Supervise all operations including instrument and equipment pre-startup checks.

1.2.3.8 Operate or supervise operation of control throughout the course of the experimental program.

1.2.3.9 Make certain that all pertinent data are recorded.

1.2.3.10 Report results pertinent to the operation of the AE-6 Reactor.

1.2.3.11 Maintain custody of the keys to the control console and the control-rod-lock, and access to the Controlled Area.

1.2.4 Alternate Physicist-in-Charge

The alternate(s) Physicist-in-Charge, are appointed by the Supervisor of the Subcritical Experiments Unit, with approval of the Experimental Physics Group Leader and Approval Authority. The Alternate Physicist-in-Charge will be prepared to assume the duties of the Physicist-in-Charge in his absence, at the request of the Supervisor of the Subcritical Experiments Unit.

1.2.5 Supervisor of the Subcritical Experiments Unit

The Supervisor of the Subcritical Experiments Unit will be responsible for the effective operation and overall safety of the facility. In particular, he will be responsible for:

1.2.5.1 General safety of the personnel, equipment, and special materials in the facility.

1.2.5.2 Evaluation of plans for new subcritical assemblies and associated experimental programs.

1.2.5.3 Assisting in the preparation, evaluation, and presentation of Hazards Summaries.

1.2.5.4 Overall supervision of operations.

1.2.5.5 Keeping management informed on the general status of the unit.

1.2.5.6 Maintaining a high level of technical competence accomplished in part by: keeping the staff informed on current advances in the field; improving techniques where possible; and training new staff members.

1.2.6 Physicist

The designation of Physicist will apply to a member of technical personnel who are a part of the Subcritical Experiments Unit and who will participate directly in the experimental program. However, a Physicist will not actually operate the AE-6 Reactor unless he is duly authorized as a Qualified Operator. Physicists will participate in the experimental program and perform a variety of functions including:

1.2.6.1 Planning of experiments.

1.2.6.2 Planning, designing, building and installing special experimental equipment.

1.2.6.3 Assisting in construction and loading of the subcritical assemblies.

1.2.6.4 Taking data and analyzing results.

1.2.6.5 Preparation of reports.

1.2.7 Health Physicist

Although the Health Physicist will not be a part of the Subcritical Experiments Unit line organization, his importance to the overall operation is such that a description of his function is appropriately included here. The Health Physicist will not participate directly in the construction of the subcritical assemblies of the AE-6 Reactor.

The operation of the AE-6 Reactor is based on the premise that ultimate responsibility and authority for control of radiation and contamination rests with the Subcritical Experiments Unit line supervision. The major function of the Health Physicist is to advise and assist the line supervision in discharging this responsibility such that operations may be carried out safely and effectively. The function of the Health Physicist is advisory. He will detect and report on any conditions which might constitute a radiological hazard. In the event of an emergency, he will ascertain the extent of the incident, determine conditions under which evacuation is recommended, and recommend conditions under which re-entry is permissible.

More specifically, the Health Physicist will:

1.2.7.1 Evaluate and make appropriate recommendations to minimize radiation exposure to personnel.

1.2.7.2 Make periodic radiological safety inspection and make recommendations to eliminate any hazardous condition.

1.2.7.3 Provide personnel radiation monitoring equipment.

1.2.7.4 Keep records of personnel exposures.

1.2.7.5 Monitor the facility for radioactive contamination either in the form of direct or airborne activity. Keep the operating staff and supervision informed on any unusual or hazardous condition. Recommend decontamination if necessary.

1.2.7.6 Recommend criteria for safe entry to the reactor room following shutdown of a particular run.

1.2.7.7 Provide maintenance and calibration checks on radiological detection equipment and emergency equipment.

1.2.7.8 Provide special safety equipment when needed; e.g., shoe covers, gloves, lab coats, respirators, etc.

1.2.8 Electronics Technician

The electronics technician will:

1.2.8.1 Maintain all electronics equipment, and control and safety circuitry.

1.2.8.2 Assist in the design and construction of special electronics equipment, and installation or revision of existing electronics equipment as required.

1.2.9 Subcritical Experiments Laboratory Technician

The Subcritical Experiments Laboratory Technician will perform a number of the following functions depending on his special aptitudes, work load, and possible division of effort.

1.2.9.1 Assist in construction and loading of subcritical assemblies, and preparing foils for activation experiments.

1.2.9.2 Design and construct special experimental devices as required.

1.2.9.3 Assist in taking data and reducing data, making calculations and plotting curves.

1.2.9.4 Perform routine inspections and maintenance of mechanical equipment. Make repairs where necessary.

1.2.9.5 Operate counting room equipment.

1.2.10 Secretary

The Secretary will perform the normal functions of a secretary such as maintaining files, typing correspondence, reports, etc.

1.2.11 Others

Depending on the particular program and specific needs for accomplishing the purpose of the experimental program, a number of persons may contribute in various capacities such as technical consulting, design, drafting, maintenance, etc. No person in this

category, regardless of technical competence, will actually operate the AE-6 Reactor controls unless he has been duly designated a Qualified Operator. The conduct of any person in this category while at the AE-6 Facility will be the responsibility of the Supervisor of the Subcritical Experiments Unit.

A representative from another company may contribute to any of the operational job functions except Physicist-in-Charge. Final responsibility will always rest with the Physicist-in-Charge, an employee of Atomics International subject of course to his line supervision.

1.3 JOB QUALIFICATIONS

The operation of a AE-6 Reactor facility is a cooperative effort, and it is essential that every staff member has, in addition to his technical ability, a good emotional stability and the ability to work well with people.

Minimum technical requirements are tabulated below:

1.3.1 Qualified Operator

Qualified Operators are designated by the Supervisor of the Subcritical Experiments Unit with the approval of the Experimental Physics Group Leader and Approval Authority. A Qualified Operator will have:

1.3.1.1 Read and studied the Summary Hazards Report, Operating Manual, and Emergency Procedures, and thus have a familiarity with pertinent operational and emergency and safety procedures.

1.3.1.2 Demonstrated a basic understanding of reactor physics.

1.3.1.3 Demonstrated a familiarity with the AE-6 Reactor including the structure and control, interlock, safety, and monitoring systems.

1.3.1.4 Shown competence in the area of operational procedure, including experimental and administrative procedures.

1.3.1.5 Shown a familiarity with radiological hazards and exposure tolerances.

1.3.1.6 Demonstrated competence in the actual operation of controls.

1.3.2 Operator-Trainee

An operator-trainee will potentially have the same qualifications as a Qualified Operator. Before actually manipulating controls he will have fulfilled requirements 1.3.1.1 through 1.3.1.5.

1.3.3 Physicist-in-Charge

The Physicist-in-Charge will be a Qualified Operator and, in addition, he will have:

1.3.3.1 A broad experience in reactor physics with a demonstrated capability in carrying out research work.

1.3.3.2 The ability to assume general supervisory responsibility for the program using the AE-6 Reactor.

1.3.3.3 A thorough familiarity with the content and implications of the Hazards Summary.

1.3.4 Alternate Physicist-in-Charge

The qualifications for the Alternate Physicist-in-Charge are the same as for the Physicist-in-Charge. The essential difference in the jobs is the defined responsibility.

1.3.5 Supervisor - Subcritical Experiments Unit

The Supervisor of the Subcritical Experiments Unit will have essentially the same qualifications as the Physicist-in-Charge. In addition, he should have a general familiarity with the Critical Experiment field including experience in the operation of a variety of types of critical assemblies and subcritical assemblies.

1.3.6 Physicist

The qualifications of physicists will vary over a wide range depending on individual fields of interest and specific current needs of program. However, as members of the Subcritical Experiments Unit, each Physicist, regardless of his specific field of interest, will have:

1.3.6.1 A general familiarity with the subcritical assemblies.

1.3.6.2 A familiarity with potential hazards.

1.3.6.3 A familiarity with the operating procedures.

1.3.7 Health Physicist

The assigned Health Physicist should have:

1.3.7.1 General familiarity with radiological hazards and methods of control of such hazards.

1.3.7.2 Familiarity with general AE-6 Facility operations in order to effectively evaluate any situation or incident involving radioactive hazards.

1.3.8 Electronics Technician

The electronics technician should have:

1.3.8.1 A good working knowledge of basic electronic components and the ability to apply it to design of special equipment.

1.3.8.2 A familiarity with nuclear instrumentation including pulse and counting circuits, high gain and linear amplifiers, and control circuitry.

1.3.8.3 A familiarity with reactor operation inasmuch as it influences the requirement for monitoring and control equipment.

1.3.9 Laboratory Technicians

Laboratory Technicians should have:

1.3.9.1 A general working experience with machine tools, and the ability to do precision work.

1.3.9.2 A general familiarity with the laboratory equipment.

1.3.9.3 The ability to design and build special experimental devices.

1.3.10 Secretary

There are no special requirements for the position of secretary in the Subcritical Experiments Unit.

1.3.11 Other

Qualifications of various other personnel will be determined on the basis of their individual function and job assignment. However, persons in this category will not be directly involved in AE-6 Reactor operations, and their specific job definitions or requirements need not be included here.

2. GENERAL RULES

This section contains administrative rules concerning the safety and security of the AE-6 Reactor with the subcritical assemblies as contrasted to Section 5.1 which contains operating rules.

2.1 AREA DESIGNATIONS

2.1.1 Restricted Area

The restricted area includes the AE-6 Facility and that part of the surrounding grounds which are enclosed by a roped off area during the reactor operations. Personnel are restricted from this area outside the control room of the AE-6 Reactor during AE-6 Reactor operations.

2.1.2 Controlled Area

The controlled area includes the Fuel Handling Building, AE-6 Reactor Room, and the region about the door heading from the control room to the reactor room.

2.1.3 Exclusion Area

The exclusion area includes the controlled area, enclosed within the roped off area.

2.2 PERSONNEL DESIGNATIONS

All personnel entering the facility will be classified according to the following definitions:

2.2.1 Operating Staff Members

This category includes the Experimental Physics Group leader, the Supervisor of the Subcritical Experiments Unit, and the designated Physicist-in-Charge and the Alternate Physicist-in-Charge. Other staff members who may be on a senior technical level, but not currently assigned as a Physicist-in-Charge or Alternate Physicist-in-

Charge will be included in group b, Staff Members.

2.2.2 Staff Members

This designation includes all persons inside or outside of Atomics International regularly assigned to and working in the Subcritical Experiments Unit or attached thereto temporarily, or having responsibility by virtue of line or project organization associated with the AE-6 Facility. The Health Physicist is specifically included in this classification.

2.2.3 Emergency Personnel

This classification includes specially-trained firemen, health physics and security personnel, who enter to assist in the event of an emergency or on routine inspection and watch duty.

2.2.4 Visitors

These include all other persons whether or not employees of Atomics International whose major effort and working time is spent in some other area.

2.3 ACCESS TO THE AE-6 REACTOR BUILDING

Access to the AE-6 Reactor Building will be regulated according to the following procedures in order to avoid possible injury to personnel or damage to equipment, and to minimize loss in efficiency and operating time.

2.3.1 Restricted Area Access

Members of the Staff or Operational Staff may enter the facility at any time upon presentation of proper credentials to the security guard at the Atomics International check point. Members of the Operational Staff, and certain members of the Staff authorized by the Supervisor, will possess keys to the buildings; other members of the Staff will be admitted by personnel already in the facility.

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Visitors will be admitted by members of the Staff or Operational Staff, and will sign in and out of the facility. The signing in of all visitors will accomplish a number of purposes:

2.3.1.1 It will afford an opportunity to brief such persons of potential hazards, unsafe area, and emergency procedures.

2.3.1.2 It will prevent visitors from interfering with operations and possibly receiving an unnecessary radiation exposure.

2.3.1.3 It will provide a permanent record of personnel in the facility in the event that a radiation accident occurs during such a visit.

2.3.2 Exclusion Area Access

Access to the control room will be controlled by the Physicist-in-Charge. (See Section 5 for restrictions on access to the control room during operations). He will maintain custody of the keys to the entrance to all parts of the reactor building. During periods when the AE-6 Reactor is in operation, no person will be permitted in the Exclusion Area: for the only exception to this rule, see Section 2.4.6 below.

2.3.3 Controlled Area Access

Personnel are not permitted in the Controlled Area without the knowledge and permission of the Physicist-in-Charge.

2.3.4 Building Access

The normal access to the facility will be by way of the door on the west side and north end of the building. Other accesses will be used for emergency exits, or for delivery of heavy equipment, or for special access required by a particular experiment.

2.3.5 Emergency Personnel Access

Emergency personnel will be supplied with necessary keys and may enter the facility in an emergency or on routine inspection and watch duty.

2.4 RADIATION CONTROL

2.4.1 Health Physicist

Radiation control procedures will be guided by the recommendations of the Health Physicist.

2.4.2 Protective Clothing

Protective clothing, respirators, or personnel radiation monitors will be worn as the situation demands.

2.4.3 Fuel Monitoring

Prior to initial handling all fuel for the subcritical lattices will be monitored for gamma activity and surface contamination. Handling of fuel will be done in such a way as to minimize radiation exposure.

During fuel handling operations, the areas being used will be monitored for airborne contamination as recommended by the facility Health Physicist. Containers for the fuel solution for loading the AE-6 Reactor will be monitored for outside surface contamination.

2.4.4 Area Monitoring

All areas within the AE-6 Facility will be periodically monitored for radioactivity and the contamination level will be kept to a minimum.

2.4.5 Sources

High level radiation sources will be confined to the reactor room or fuel storage area and will normally be stored in containers which reduce the radiation field to tolerance levels:except

2.4.5.1 when being installed in a subcritical assembly, or

2.4.5.2 when being used for instrument checks or calibrations.

In the latter case, the source will be removed for a minimum time necessary to accomplish the immediate purpose. Fissionable material, except for small quantities used for activation experiments, will generally be kept in the controlled area.

2.4.6 Radiation Survey

After the AE-6 Reactor reaches criticality for the first time with a new moderator assembly or subcritical lattice on the thermal column or when going to high power levels, a thorough survey of the neutron and gamma radiation field will be made in and around the facility, in particular in those areas accessible to personnel and in the KEWB Office Building. The maximum power limitations in subsequent operations will be determined on the basis of this survey.

During radiation surveys, the person(s) making the survey may enter the Exclusion Area provided:

2.4.6.1 the reactor power is maintained at a minimum level required for dependable radiation measurements,

2.4.6.2 no increase in power level is made during the time the survey is being conducted,

2.4.6.3 the radiation exposure to the person(s) making the survey is kept to a minimum necessary to make meaningful observations.

2.4.7 Reactor Room Entrance

The first person entering the reactor room following shutdown will ascertain by means of monitoring equipment that such entry is safe.

2.5 EMERGENCY PROCEDURES

A detailed plan of actions * to be taken by personnel in the facility in the event of an emergency either in the AE-6 Reactor Building, Fuel Handling Building, KEWB, or SS Storage Building, ETB and SRE has been formulated (See Appendix J); all personnel are aware of the plan. In addition, short summaries of pertinent actions are posted in the control room and other parts of the building. This plan is presently being incorporated into an overall AI emergency plan which will supersede the present less detailed criticality emergency plan. Emergency supplies including respirators, protective clothing, radiation detectors and other items are stored in readily accessible places.

* Actually this plan is an appendix in the Master Plan formulated by the Industrial Security Department of Atomics International. This appendix includes only those procedures which are peculiar to the AE-6 complex.

3. DESCRIPTION OF FACILITY

3.1 GENERAL DESCRIPTION

The AE-6 Reactor will be used as a low power reactor for use as a plane source of thermal neutrons for the study of the nuclear behavior of heterogeneous subcritical assemblies. The characteristics to be investigated include: the diffusion length of thermal neutrons in various moderators, material buckling, nuclear lattice parameters and the parameters pertinent to the small source theory. The AE-6 is particularly well designed for these uses.

In addition, the AE-6 was designed peculiarly to irradiate small samples in neutron fluxes up to about 10^{11} neutrons/cm²/sec. It is particularly good for calibrating sets of foils and for danger coefficient measurements. Accessory electrical and mechanical equipment are available which enables some of the tasks to be done more easily. A bridge crane makes possible the movement of heavy items such as fuel elements and portable concrete shielding blocks. Also neutron sensitive measuring devices with neutron sensitive probes can be calibrated in quite well known neutrons fluxes.

3.2 REACTOR CORE

The AE-6 core vessel is a 12-inch OD stainless steel (Type 347) sphere having a minimum wall thickness of 0.094-inches. The sphere was fabricated by welding together two hemispheres spun from the stainless steel. This vessel contains approximately 26-feet of 3/8-inch stainless steel tubing for coolant flow. The inlet and outlet of this tubing are located at the bottom of the sphere. Also at the bottom of the vessel is a fill and drain tube which connects with a valve panel.

A 1-1/4-inch OD tube extends through the lower portion of the sphere in order to provide access to the higher flux region of the reactor. This tube is called the "glory hole" of the AE-6 reactor. The details of the core construction are displayed in Figure 1.

3.3 OVERFLOW SYSTEM

A short 2-inch elbow and pipe lead out of the top of the AE-6 core vessel and furnish a duct for both gas and, in the case of power surge, part of the fuel solution. The pipe passes through the graphite reflector rising slightly to the gas recombiner. This pipe is approximately 3-feet long. The end of the pipe extends into the recombiner chamber and is 2-3/4-inches above the bottom of this chamber, providing a holdup of 2.9 liters of solution in the recombiner. A small drain hole (screened to prevent stoppage) allows for a slow runback and a plate welded above the end of the pipe prevents solution from spraying onto and poisoning the gas recombining catalyst. The details of the overflow system are shown in Figure 1.

This overflow system is an important safety feature of the reactor. The overflow pipe provides a region into which portions of the fuel solution can be expelled in the event of a nuclear incident. Removal of a small amount of this fuel solution from the core will quickly terminate the excursion and prevent a possible rupture of the core vessel.

3.4 GAS RECOMBINER

The gas recombiner system for the AE-6 Reactor is a closed, heated catalyst system which is operated at low pressures. This system is displayed in Figure 2.

Figure 1 AF-6 Reactor Core Schematic Diagram and Overflow System

This system was chosen for the following reasons:

1. Economy and Simplicity. This system could be built for only a small fraction of the cost of a recombiner system necessary for higher power reactors. The principal reason for the economy and simplicity of the AE-6 gas handling system lies in the elimination of the need for forced circulation of gases, and the use of a closed system which needs only a small amount of instrumentation.

2. Suitability. The range of gas recombination rates in which this recombiner system has been found to operate satisfactorily fits closely the range of operation of the AE-6 Reactor.

3. Flexibility. This system may be operated at part capacity or may be bypassed or removed if desired.

4. Safety. Operation of the reactor system at low pressures increases the pressure coefficient of reactivity and thus reduces the magnitude of a nuclear excursion. Continued low pressure operation also prevents the accumulation of sufficient hydrogen and oxygen to cause an explosion.

All structural parts of the gas recombiner are of 347 or 321 stainless steel. The overall shape is cylindrical and it is 10-3/4-inches in diameter and 16-inches in height, with the bottom rounded to assure complete drainage. A 6-9/16-inch diameter cylinder is inset at the top of the gas recombiner and is covered with platinumized aluminum pellets which serve as a catalyst for the hydrogen-oxygen recombination. The heating element for the catalyst consists of four (4) 250 watt Chromalox cartridge vertically inserted on the inner wall of the inset cylinder and not extending into the vacuum system. Two sets of cooling coils one located between the inner and outer shells of the recombiner (outer coolant coils) and

the other located within the inset cylinder (inner coolant coils) see Figure 2, are provided to cool the shell of the recombiner vessel and condense the water vapor of recombination which gravity drains back into the core.

Six thermocouples are provided to measure temperatures in the recombiner cooling system. A vertical reentrant tube at the top of the recombiner contains a thermocouple for measuring gas temperatures. Two horizontal reentrant tubes which extend into the top and bottom of the catalyst bed contain thermocouples for recording catalyst temperatures. In addition there is a thermocouple for measuring the total inlet coolant temperature and two thermocouples for measuring the outer coolant temperature of both the inner and outer coolant coils. A pressure transducer and vacuum system are connected to tubing welded into the side of the recombiner assembly.

The gas recombination system is called a "Vapor Pressure Recombiner" because the pressure over the fuel solution and in the recombiner is close to the vapor pressure of the water in the reactor core. Normal pressure in the system at zero reactor power and the core at a temperature of 65° F is 4 cm of mercury absolute including the 1.6 cm due to the vapor pressure of water.

Pressure in the gas handling system is measured by means of a Statham Model P-10-50 G-1200 pressure transducer. This transducer has a stainless steel diaphragm to sense the pressure deflection of the diaphragm is measured by means of a strain gauge system. The transducer is designed to withstand pressure of 600 psi without damage. The output of the pressure indicator is connected to a Sensitrol relay adjusted so that the reactor will be scrambled if the absolute pressure goes above 20 cm of mercury.

Fig. 2 AE-6 Gas Recombiner

Conditions required for hydrogen-oxygen explosions have been investigated for various gas handling systems at Atomic International ⁽¹⁾. It was found that one could not initiate an explosion to a stoichiometric mixture of hydrogen and oxygen when the absolute pressure is less than 40.6 cm of mercury. Both electrical discharge and hot plugs were used in attempts to initiate explosions. A small amount of water vapor in the gas probably has a significant effect in preventing an explosion. Based on these tests, it is not expected that an explosion can occur in the gas phase volume of the reactor. If an explosion should occur because of simultaneous malfunction of two or more safety features, then it is expected that the explosion would not cause much damage.

The present AE-6 recombiner was installed in November 1959. It replaced a similar recombiner which had been in operation since the AE-6 first attained criticality in November 1956. The present method of operating this gas handling system is as follows: The recombiner catalyst is continually heated and held at temperature of 250° F and the coolant water allowed to flow through the outer coolant coils whenever the reactor is not operating when the reactor is operating, the catalyst temperature is maintained at approximately 200° F while the gas temperature is controlled at 65° F. The catalyst is heated both by electrical heaters and by the heat of recombination. The gas temperature may be controlled by means of throttling the coolant water flow to the "outer" cooling coils of the recombiner. It is not necessary to use the "inner" cooling coils to maintain low gas pressures at the present level of the AE-6 operating powers.

40 36

In addition to the recombiner proper, there is a steel panel which is welded to the recombiner vessel. This contains the following components: A gas line outlet, a fuel line outlet, a recombiner gas valve, a fuel line valve, and two inlet coolant valves for regulating water flow through the "inner" and "outer" cooling coils. The outlet lines are capped with swagelok plugs.

3.5 VACUUM SYSTEM

This apparatus is used for removing gas from the AE-6 Reactor during initial start-up with a new fuel loading. This is then retained for subsequent standby duty. Operation of the AE-6 is not permitted unless the pressure in the system is less than 20 cm of mercury. If the pressure should build up above this valve, then the vacuum system can be used to remove the excess gas. Sources of excess gas could be nonstoichiometric production of hydrogen and oxygen in the core, oxidation of surfaces leading to an excess of hydrogen in the system, or an absorption of diffusion of hydrogen which could lead to an excess of oxygen.

The vacuum system can also be used to purge the system of fission product gases which are produced in the reactor. This vacuum system consists of a vacuum forepump, gas storage tanks and associated tubing. Gas is drawn from the system through a stainless steel outlet tube running from the recombiner through the welded panel, and pumped directly into a storage tank. The outlet tube includes a shut off valve and is capped by a swagelok plug.

3.6 GRAPHITE REFLECTOR

The spherical core vessel is located at the center of a right circular cylindrical section of graphite which serves as a reflector. This cylinder is five feet in diameter and six feet high. The top three feet of graphite is called the vertical thermal column since the neutrons that reach the top are predominately well thermalized and can be used as a plane source of thermal neutrons for systems placed on its top. This arrangement is shown schematically in Figure 3.

Fig. 3 Core and Reflector

The "glory hole" and eight removable stringers pass horizontally through the graphite reflector. The glory hole permits small samples to be placed near the highest flux region of the core. The stringers permit access to neutron fluxes which may be used also for irradiations of various types. The most useful, perhaps, are those used for foil calibrations, instrument calibrations, and various and sundry irradiations to determine the biological effects upon irradiated plant seeds and the like.

3.7 COOLING SYSTEM

The AE-6 Reactor core is cooled by a heat transfer coil containing 26-feet of 3/8-inch stainless steel tubing. This tubing is coiled into 12 turns (see Figure 1) and both the inlet and outlet are at the bottom of the core vessel. Water may be pumped through these coils at various rates up to a maximum of 0.62 gpm (1.8 ft/sec.) by a small rotary pump; the heat is removed by a Temprite water to freon heat exchanger. The freon in this exchanger is cooled by a 3.3 kw York compressor unit. The capacity of the cooling system may limit the maximum continuous operating power of the reactor. At present this maximum is about 2 kw.

The flow rate through the core coils may be adjusted by means of a bypass valve shown in the coolant flow diagram Figure 4. The temperature control operates the York compressor whenever the inlet temperature rises above a present valve of 42° F and shuts it off when the temperature goes below 38° F. The following experimental values were obtained for the initial performance of the cooling system.

Figure 4 AE-6 Cooling System Flow Diagram

Reactor Power - - - - - 1 kw
 Coolant Flow Rate - - - - - 0.62 gpm
 Coolant Inlet Temperature - - - - - 42° F
 Coolant Outlet Temperature - - - - - 52° F
 Average Core Solution Temperature - 59.5° F

3.8 CONTROL CONSOLE

The control console of the AE-6 Reactor consists of six (6) instrument bays. This is shown in a block diagram in Figure 5. Numbering from left to right in the block diagram one has the following:

3.8.1 Bay 1

This bay contains the following:

3.8.1.1 An air sampler system capable of sampling air from either the reactor room or the control room for Band X radiation from fission products in case the core or source ruptures.

3.8.1.2 A Jordan Monitor system. This system has four (4) ion chambers so that one is located at the following four areas.

3.8.1.2.1 Control room.

3.8.1.2.2 The reactor room side of the biological shield wall.

3.8.1.2.3 On the reactor shield.

3.8.1.2.4 In the Fuel Handling Building.

The ion chamber in the control room has a "trip" contact so that a siren sound is initiated when a preset radiation level is reached or exceeded.

3.8.2 Bay 2

This bay contains the following:

3.8.2.1 Two Vibrating Reed Electrometers, connected

Fig. 5 AE-6 Reactor Control Console Instrument Bays

to ion chambers, each having range switches and Sensitrol relays for low level neutron monitoring. By means of range switches, each electrometer can cover four decades of power level with full scale reading of 5 Mw to 5 watts.

3.8.2.2 A chart recorder indicating the gas pressure in the core by means of a pressure transducer.

The shutdown power of the reactor with the startup source ($1/4$ Curie RA-BE source) in place adjacent to the reactor sphere is about 0.5 mw with the safety rods in and 1.0 mw with these rods out. There is, therefore, a sufficiently large indication on the power level meters for safe startups of the reactor. During withdrawal of the safety rods, the proper change in power level should be observed by the operator. Routine checks are made on the neutron level indicators before startup (see checklists figures 22 and 23 .

3.8.3 Bay 3

This bay contains the following:

3.8.3.1 One Beckman high level neutron indicating linear Micro-Micro-Ammeter readings using a BF_3 ion chamber shielded with lead.

This instrument covers the power ranges from 10 mw to 10 kw in 7 decade ranges with a range switch at the console and is attached to a Sensitrol relay with maximum power trip for each decade and is recorded on a strip chart recorder.

3.8.3.2 Rod controls and positions indication Veeder Root counters, indications lights for maximum travel (in or out).

3.8.3.3 Magnet powers switch and magnet engaged light. A negative power supply for a compensated ion chamber for the Kiethley Micro-Micro-Ammeter in Bay 4 is in Bay 3.

3.8.4 Bay 4

This bay contains the following:

3.8.4.1 Kiethley Micro-Micro Ammeter.

3.8.4.2 A Brown Strip Chart Recorder.

3.8.4.3 Micro-Ammeters with high power level trips and minimum power requirement contacts accessible to any low power level indicating instrument.

3.8.4.4 A scram button. The Kiethley is connected to a compensated BF_3 ion chamber and has power ranges from 1 mw to 30 kw in 11 decades with a range switch at the console and each scale output is connected to a Micro-Ammeter with a high power level trip and a minimum power contact requirement. The output is also recorded on a Brown Strip Chart Recorder.

3.8.5 Bay 5

This bay contains the following:

3.8.5.1 Logarithmic amplifier.

3.8.5.2 Brown Strip Chart Recorder.

3.8.5.3 Water Flow Voltmeter.

3.8.5.4 A two way inter communication system.

The logarithmic amplifier is connected to a BF_3 ion chamber and reads 6.5 decades from 10 mw to 30 kw in one meter range. The power output is connected to a Brown Strip Chart Recorder and a Micro-Ammeter with a high power level trip point.

The logarithmic Amplifier also contains a circuit which differentiates the output of its DC amplifier, thereby providing a second output, which when connected to a meter provides a current, which is proportional to the time rate of change of the logarithm of the signal. The meter is calibrated, in terms of the reactor period, in seconds. The output of the period is connected to a meter

with a period trip contact which actuates a reactor scram for a minimum period. The meter indicates periods from -30 seconds to infinity to + 3 seconds. A reactor period of 3 seconds or less will cause a scram.

The intercommunication system has two speakers in the reactor room, one which is fixed and one which is on an extension cord. The controls provide normal monitoring of the reactor room and a button for the operator to press to talk to personnel in the reactor room.

3.8.6 Bay 6

This bay contains the following:

3.8.6.1 A linear amplifier connected to a proportional counter in the reactor room. This proportional counter will be connected to a extension cord to provide the proper positioning to monitor fuel assemblies erected on top of the reactor for experimental data. The output of the linear amplifier will be fed to a scaler having a range switch output for every event and up to 10^6 nuclear events. This output will supply a signal for an audible "Poppy" in the reactor room and at the console. These assemblies will also be monitored in the reactor room with linear amplifiers and scaling equipment.

3.8.6.2 Process instrumentation.

Thermocouples and a multi-point strip chart recorder are provided to indicate and record temperatures of:

3.8.6.2.1 The cooling water at the inlet and outlet of the reactor core cooling coil.

3.8.6.2.2 The cooling water at the inlet and outlet of the gas handling system.

3.8.6.2.3 The gas temperature in the gas

handling system.

3.8.6.2.4 The outer surface of the reactor core at two different locations.

In addition to temperature measurement, the process instrumentation includes a pressure transducer on the gas recombiner with its associated circuits; and, a flow meter to measure the flow rate of coolant through the core cooling coil. The flow meter is a Waugh, Van type, with a variable frequency alternating current output which is detected by a pulse rate connector.

3.9 PROCEDURE USED FOR THE DRAINING, RINSING AND LOADING OF THE AE-6 REACTOR CORE

The following procedures described are, with some modifications, those that were used when the AE-6 core was drained, rinsed and reloaded during the recombiner installation in November 1959.

3.9.1 Draining of Core System.

At the time the core was drained, the volume of fuel solution was 12.4 liters and total fuel mass 776.6 gm of U_{235} in the uranium which have an enrichment of about 93%. The technique that was used when removing the fuel from the AE-6 reactor was determined by simulated laboratory tests. It was found that a single bottle transfer technique was the most efficient. The fuel bottle was a two-liter container which was filled with 475 cc. The remaining fuel was drained into single pre-calibrated four-liter polyethylene bottles. The radiation level of an unshielded four-liter bottle was 2.5 R/hr at one foot and approximately 15 mr/hr when shielded with four inches of lead.

The mechanics of the fuel removal are given in detail in the following procedures. (See Figure 6 for reference).

Fig. 6 & 8 Diagram for Fuel Draining and Loading the AE-6 Core

3.9.1.1 Place a polyethylene bottle into the lead shield and insert tygon drain line and evacuation line.

3.9.1.2 Connect two 34.5 liter ballast tanks to the vacuum pump and evacuate the tanks by opening valves #6 and #7 to the pump. Close valves #6 and #7.

3.9.1.3 Partilly open recombiner gas valve (#2), and allow the core system pressure to approach atmospheric.

3.9.1.4 Partially evacuate fuel bottle by opening a ballast tank valve (#4 and #5).

3.9.1.5 Transfer the fuel from the core to the fuel bottle by opening the fuel line valve (#1), and regulating the flow of the fuel with valves #2, #3 and #4.

3.9.1.6 Close all valves when each polyethylene bottle has been filled to a pre-calibrated level.

3.9.1.7 Transfer each fuel bottle from the lead shield to the designated storage area.

3.9.1.8 Repeat steps 5 through 8 until the core has been completely drained.

3.9.2 Rinsing of the Core System.

The core and recombiner system was rinsed with three volumes of distilled water. Upon completion of the third rinse, the activity of the water removed from the system was approximately $0.1 \mu\text{c/cc}$. It was decided that additional rinsing would not appreciably reduce the activity further. A sample of the gas remaining in the system was removed to determine its activity. The Xe and Kr activities were found to be $3.5 \times 10^{-4} \mu\text{c/cc}$ and $9.5 \times 10^{-6} \mu\text{c/cc}$, respectively. All gases were contained in a pre-evacuated 34.5 liter ballast tank. Upon removal of the recombiner the overflow pipe was swabbed and prepared for re-welding.

The rinsing procedures are given below(see Figure 7).

3.9.2.1 Disconnect one of the ballast tanks from the fuel-drain bottle assembly and connect it to the recombiner vent line, valve #2.

3.9.2.2 Connect flushing solution bottle to the fuel drain assembly.

3.9.2.3 Open the recombiner vent valve, #2, and evacuate the core by opening ballast tank #4. Close the ballast tank valve.

3.9.2.4 Transfer the rinse solution to the core by opening valve #1 and regulating the flow with valve #3. Continue transfer until the system is filled, indicated by the liquid trap on the vent line.

Note: A minimum of three (3) rinses, using distilled water, will be made.

3.9.2.5 Return the flushing solution to the respected container by evacuating the container with the second ballast tank and regulating the flow with valves #1, #2, #3, #5 and #8.

3.9.2.6 Repeat steps 2 through 5 for each rinse step. Contain all transfer gases in the ballast tanks.

When the core rinse has been completed, the entire system will be left under a negative pressure in preparation for reloading and for safety precautions.

3.9.3 Reloading of the Core System.

Since this was a reloading of the AE-6 core, the method of approach in the loading procedure differed from that undertaken during the initial loading of the AE-6. From the previous loading it was estimated that the reactor would attain criticality at a core loading of 760 gm U ²³⁵, in approximately 12.5 liter fuel

Fig. 7 Diagram used for Rinsing the AE-6 Core

solution at a temperature of 70° F. Earlier analysis of the fuel solution had shown an iron concentration of 64.0 gm.Fe/ml solution. To increase the iron concentration to 200 ppm an additional 2.19 gm. of FE or 10.87 gm. $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$ was added to the fuel bottle which was to be transferred to the core last. This was done to inhibit UO_4 precipitation in the AE-6 core.

Auxiliary start up channels were installed outside the primary reflector prior to the fuel loading. These channels were two BF_3 detectors and scaler systems and an uncompensated ion chamber whose current output was detected by a Keithley Micro-Ammeter. These channels were specifically located in the graphite stringer parts on both the east and west sides of the reactor. The start-up source was situated in the position it occupies during all normal reactor operations. It has a strength of about 3×10^6 n/sec.

The fuel was transferred to the core using the procedures outlined below. All additions were made with the coarse rod fully inserted and the two safety rods fully withdrawn. Inverse multiplication counting was done after each addition with all rods withdrawn with the exception of the fine control rod which was inoperative. The procedures for loading are outlined below (See Figure 8.).

3.9.3.1 All additions will be made with the coarse control rod fully inserted and the safety rods fully withdrawn.

3.9.3.2 Connect evacuated ballast tanks to the recombiner vent line, open valve #2 and #4 and evacuate the core. Close valves #2 and #4.

3.9.3.3 Place the respective fuel bottles in the lead shield and insert these in the fuel line. Transfer the fuel to the core by opening valve #1 and regulating the fuel flow with valve #3.

3.9.3.4 When the fuel transfer has been completed, close valves #1 and #3.

3.9.3.5 Repeat steps #2 as necessary.

3.9.3.6 Repeat steps #2 through #5 for each fuel loading.

The fuel was loaded in steps as given below:

<u>LOADING #</u>	<u>AMT U²³⁵ LOADED (gm)</u>	<u>TOTAL U²³⁵ IN CORE (gm)</u>
1	237	237
2	250	487
3	249	736
4	14	750
5	17	767 *

The last fuel addition of 17 gm U²³⁵ was expected to bring the reactor critical with an initial excess reactivity of 0.11% at 70° F. assuming a mass coefficient of 0.035%/gm U²³⁵ based on previous tests. It was determined from the period measurements that were taken that the excess reactivity was 0.135%. Thus, the critical mass was closed to the predicted value of 764 gm U²³⁵. To bring the excess reactivity to approximately 0.50% at 70° F successive water additions were made as tabulated below:

<u>Amount of water added (ml)</u>	<u>Excess Reactivity (%)</u>
100	0.222
160	0.444
50	0.494

The average water coefficient of reactivity is seen to be approximately .0012% / ml.

* Period measurement was taken after this loading.

Upon completion of the loading the fuel valve was shut allowing the fuel in the core to flow to such a point in the drain line where the liquid pressure of the fuel solution is in equilibrium with the pressure of trapped air in the line. There is no sight gauge on the present reactor fuel system. The ropped-off red tagged area was cleaned up and smears were taken to check for contamination. The smear tests were negative.

3.10 OPERATING CHARACTERISTICS OF THE REACTOR

3.10.1 Gas Coefficient of Reactivity.

Before the reactor was made critical, an attempt was made to observe the effect of low pressure operation on the amount of frothing and the void volume in the reactor core. A transparent mock-up of the AE-6 Reactor core was constructed using a round bottom glass flask. This core was filled with an acidic uranyl sulphate solution of the same concentration as that used in the AE-6 Reactor. Argon gas was bubbled through sintered discs near the bottom of the solution to simulate the generation of hydrogen and oxygen gas. The amount of frothing and the void volume in the solution were observed as functions of gas flow rate. A vacuum pump, in connection with a throttling valve, was used to regulate the pressure in the system to any value desired between atmospheric pressure and the vapor pressure of the solution.

Measurement of the void volume in the fuel solution was done by observing the change in level of the liquid surface. Since under some of the conditions investigated the surface of the solution moved rapidly, it was not possible to determine the void volume with a high degree of accuracy. At a gas flow rate of 3 cu ft. per hur (STP), which corresponds to a reactor power of 5.5 kw, the void volume in the reactor core was determined to be

Fig. 9 Mock-up of AE-6 Reactor Core Showing Extent of Bubble Formation Under Simulated Operating Conditions at 5.5 kw. Absolute Pressure Above the Core Solution is 5.4 in. Hg.

Fig. 10 Mock-Up of AL-6 Reactor Core showing Extent of Bubble Formation if Operated at 5.5 kw Under Atmospheric Pressure

about 160 cm³ at an absolute pressure of 5.4-inch Hg. As the absolute pressure was decreased, the void volume increased and reached 210 cm³ at an absolute pressure of 4-inch Hg. The void volume measurements have an uncertainty of about 40 cm³. Figure 9 is a photograph of the core solution at a pressure of 5.4-inch Hg. and a gas flow rate of 3 cu.ft.per hr. Figure 10 shows the bubble conditions at the same flow rate but at atmospheric pressure.

The power coefficient of reactivity of the Los Alamos SUPO reactor is about 3.3×10^{-2} per cent per kw at 5 kw². Using an estimated gas coefficient of reactivity for a water boiler reactor,⁽³⁾ the corresponding void volume in the SUPO reactor is about 8.3 cm³ per kw. Measurements on a mock-up of the Armour Research Foundation Reactor (L-8 Reactor) at Atomics International⁽⁴⁾ indicated that the void volume at an equivalent reactor power of 50 kw was 450 cm³ or 9 cm³ per kw. It was concluded from these data that the void volume in a water boiler reactor of this type operating at 5.5 kw with the solution under atmospheric pressure would be about 45 cm³. The measurements on the mock-up of the AE-6 Reactor at atmospheric pressure, though barely sensitive enough to detect this amount of void volume, were at least consistent with this value.

Based on the measurements of void volumes, the power or gas coefficient of reactivity of the AE-6 Reactor was estimated to be 4 to 5 times the value that the reactor would have if it were operated at atmospheric pressure. Multiplication of the larger factor by the experimental value of the power coefficient of the SUPO reactor gives a power coefficient for the AE-6 of about -0.165 per cent per kw.

After the reactor had originally been made critical and was put into operation, an experiment was conducted to find the actual power coefficient. All of the rods were gradually pulled out so that the entire 0.71 per cent excess reactivity was available. The power (2.5 kw) and core temperature were noted after equilibrium had been reached. Knowing the temperature coefficient, which is mentioned later, it was possible to determine the amount of reactivity that was taken up because of the rise in core temperature. It was assumed that the remaining excess reactivity was accounted for by bubble formation. In this manner, the power coefficient was found to be -0.075 per cent per kw, although a large uncertainty must be attached to this measurement.

At an operating power of 2.5 kw, the total reactivity contained in the gas bubbles would be 0.188 per cent. If, somehow, this amount of reactivity were to be suddenly added to the reactor by a collapse of the gas bubbles, the reactor power would increase with a period of about 31 seconds. This rate of power increase could be easily controlled manually by the operator, and if not controlled it would be offset by an increase of 13° F in core temperature.

Other experiments have been performed since the reactor has been put into operation. Some of these will be discussed in the following sections.

3.10.2 Control and Safety Rod Worth

The worths of the control and safety rods were determined from both period and inverse multiplication measurements. A graph of the fine and coarse control rod worth for various positions is given in Figure 11. The worth of the safety rods for various

Fig. 11 Control Rod Worth

configurations is given in Table 1.

TABLE I
EXPERIMENTAL WORTH OF THE SAFETY RODS

<u>SAFETY ROD</u>	<u>PER CENT</u>
East	-1.1
West	-1.2
East and West	-2.3

TABLE I CONTROL ROD WORTH

3.10.3 Temperature Coefficient and other Reactivity Measurements

The temperature coefficient was found from period measurements to be -0.015 per cent per $^{\circ}$ F. Period measurements were also made with and without the neutron source in the core and its worth was found to be $-.009$ per cent. Draining the water from the cooling coils in the core produced a change in reactivity of $-.063$ per cent. Placing a 5-foot long $3/4$ -inch lucite rod in the glory hole increased the reactivity by 0.14 per cent. The addition of 20 ml of water to the core solution increased the reactivity by 0.03 per cent, giving a coefficient of reactivity of 0.0015 per cent per ml of water; thus, the critical mass of the system is sensitive to the quantity of water in the core.

3.10.4 Flux Distribution Measurements

The relative flux distribution in the reactor was measured using 1-cm^2 indium foils (100 mg/cm^2) placed horizontally at various known positions in the glory hole. A lucite foil holder was employed. Both bare and cadmium covered (0.020 -inch walled boxes)

foils were used in order to obtain both the thermal and epithermal neutron distributions. Cadmium ratios were calculated according to the equation

$$C.R. = \frac{A_{TOTAL}}{1.05 \times A_{epi}}$$

where A is proportional to the saturated foil activity. Results for a power level of about 85 mw are given in Figures 12 - 14 inclusively.

3.10.5 Heat Transfer Characteristics of the Cooling System

The heat transfer characteristics of the cooling system were studied with special emphasis placed on the heat transfer between the cooling coil and the core solution. It might be expected that this heat transfer coefficient, the so-called tube outside convection coefficient, would be different from that calculated by normal heat transfer methods since these methods do not account for the formation of bubbles in the fuel solution and the nuclear heating of the fluid film surrounding the cooling tubes. The experimentally determined value of the tube outside convection coefficient, using the values given in Section 3.7 was 93.5 Btu/hr/ft²/°F. Since the cooling coils in the AE-6 lie in vertical planes, the theoretical determination of the above coefficient was obtained from the average of the coefficients calculated from the heat transfer equations for vertical and horizontal tubing. By this method, the theoretical value of the tube outside convection coefficient was found to be 92.7 Btu/hr/ft²/°F. The experimental and theoretical values are sufficiently close together so that it

appears as if there is no measured effect from bubble formation or nuclear heating of the fluid film.

Data obtained on the heat transfer characteristics of the SUPO reactor⁵ indicate that for power levels between 3 and 10 kw, the tube outside convection coefficient is lower than that predicted by theory. This is due to radiolytic gas bubbles sticking to the cooling tube walls which thereby reduce the effective cooling area. For power levels above approximately 10 kw, the observed coefficient is higher than that predicted by theory. This is explained by the increased agitation of the fuel solution as more bubbles are formed and swept from the solution at the higher power levels.

Since the results of the AE-6 were obtained at a power level of 1 kw and a core pressure several times lower than that of SUPO, it is difficult to tell whether or not the AE-6 and SUPO data are in disagreement. The lower operation pressure of the AE-6 tends to make the power level appear several times higher than it actually is in so far as bubble formation is concerned. This higher "apparent" power could conceivably put the operation of the AE-6 in the region equivalent to 10 kw where the experimental and theoretical values of the tube outside convection coefficient are the same.

3.11 CALIBRATION OF THE POWER INDICATING INSTRUMENTS

The power indicating instruments have been calibrated for both low power and high power level operation. The low level calibration was made by measuring the thermal flux distribution in the reactor core with gold foils. The foils were placed in a horizontal position on a lucite foil holder and inserted in the glory hole. The reactor was operated for 30 minutes at a power level which was indicated to be 2 watts on vibrating reed electrometer #1. By determining the average thermal flux over the core volume and

using the following equation, the reactor power was found to be 2.24 watts.

$$P = \frac{\phi_{th} \sum f V}{3.1 \times 10^{10}} \text{ watts}$$

where ϕ_{th} = average thermal flux over core volume

$\sum f$ = average macroscopic fission cross section of U^{235}

V = volume of fuel solution in the core.

The power indicating instruments as installed gave the following readings during the above run:

<u>INSTRUMENT</u>	<u>READING (watts)</u>
Vibrating reed electrometer #1	2.00
Vibrating reed electrometer #2	1.70
Beckman	1.73
Log N	1.70

Although the meter readings and the flux distribution measurements disagree by a factor of 1.3, the instrument readings are sufficiently accurate for the purpose intended. Therefore, no readjustments of the instruments calibrations were made. However, this situation is now undergoing a thorough investigation to check the accuracy of these statements. The foil measurements may be somewhat in error because they could not be made in the core fuel itself, but had to be made in the glory hole. Since the lucite foil holder partially filled the glory hole, a quantitative estimate of the flux perturbation in the neighborhood of the foils would be difficult to make.

The thermal neutron flux at the center of the glory hole for a given power level can be determined using the constant 4×10^7 neutrons/cm²/sec/watt. The average thermal flux over the core volume can be approximately determined using the constant 3×10^7 neutrons/cm²/sec/watt.

The indicating meters for higher power operation (Log N and Beckman) were checked by two methods. The first method was to note the rate of temperature increase in the core with no cooling water flowing and the second was to note the difference between inlet and outlet temperatures of the core cooling water while the reactor was operating the reactor at 1 kw, as indicated on the meters, for a period of 17 minutes (Figure 15). The observed temperature rise was 34.5° F. However, due to heat loss to the surroundings, as shown by the slope of the temperature curve after shutdown, it was necessary to add 3.2° F, giving a total temperature rise of 37.7° F. The volume of the solution in the core is 12,481 ml and assuming it to be entirely water, the power output of the reactor was calculated to be 1.07 kw.

The second method was accomplished by operating the reactor with the meter indicating a power of 1 kw, running cooling water at a known rate and measuring the inlet and outlet temperatures of the cooling water. The observed temperature difference for a cooling water flow rate of 0.62 gal/min was 12° F. It was noted, however, that at zero reactor power there was an indicated temperature difference of 2° F due to heat gain from the graphite reflector. Therefore the effective temperature difference was 10° F. From these data the reactor power output was calculated to be 0.917 kw. The results of these two methods again indicate that the instruments are reading close enough to the true power output of the reactor

Fig. 12 Thermal Neutron Activation vs Distance from Center of Core

Fig. 13 Epithermal Neutron Activation vs Distance from Center of Core

Fig. 14 Cadmium Ratio vs Distance from Center of Core

Fig. 15 Core Temperature vs Time at 1 kw With No Cooling

for operational purposes. This situation is being fully investigated again.

3.12 SAFETY OF THE REACTOR

All radioactive fission products which are formed during reactor operation are expected to remain in the reactor core with the exception of the xenon and krypton which will diffuse into the gas handling system. A leak in the reactor core of gas handling system because of corrosion appears very unlikely. Laboratory experiments and previous reactor experience indicate that corrosion of the AE-6 core by the fuel solution should be negligible at the proposed operation temperatures. The material used in the reactor core was rigidly inspected to be sure that it met the specifications of type 347 stainless steel.

Experiments conducted at Oak Ridge⁶ on the corrosion of 347 stainless steel in a solution 0.35 molar in H_2SO_4 and 0.17 molar in UO_2SO_4 indicated a corrosion rate of 0.10 mil per year in a static system and 0.04 mil per year when air was bubbled through the solution. These data were obtained at a temperature of 100°C which is believed to give a higher corrosion rate than the near ambient temperature operation of the AE-6 Reactor. Independent data on the corrosion of stainless steel in water boiler core solutions have been obtained by W. N. McElroy, L. Mondy, and L. Silverman at Atomics International. These data were obtained using solutions under a helium atmosphere since the presence of oxygen retards the corrosion rate. The average corrosion rate for a sample of 347 stainless steel in a solution 0.19 molar in H_2SO_4 and 0.20 molar in UO_2SO_4 was 0.09 mil per year at room temperature. On the basis of either the Oak Ridge or Atomics International data, the rate of corrosion of the AE-6 Reactor core

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should not be significant. For this reason no provision was made to sample the core solution or otherwise check on the extent of corrosion in the core.

The cooling water circuit contains materials other than stainless steel, such as aluminum in the heat exchanger. The cooling water system will be filled initially with distilled water and the purity of this water will be checked periodically by measuring its electrical conductivity. If a significant amount of corrosion takes place, the ionic content and the electrical conductivity will increase and steps can be taken to replace the cooling water or use other means to reduce the corrosion rate.

In the event of a leak in the core it is likely that most of the fuel solution would be held in the graphite reflector since the core is surrounded on all sides with a close fitting reflector of 2-foot minimum thickness. The graphite is contained in a 5-foot diameter steel tank which would catch and contain any of the solution which might filter down through the graphite. Openings are provided in the sides of the steel tank corresponding to removable graphite stringers which extend near the reactor core. It is possible that some solution might leak out of these openings by flowing along the horizontal surfaces between the graphite stringers, but it does not appear likely that this would happen to a significant extent. Any solution which leaks out of the reflector tank will be contained back of the concrete shielding and this should not create a hazard to personnel.

The reactor core and gas handling system were fabricated separately and each was thoroughly tested for leak tightness with a helium leak detector. After fabrication, the reactor core was statically pressure tested at 300 psi, and the original gas recombiner was

put through an operability test using an electrolytic source of a hydrogen-oxygen mixture. Following these tests, the gas recombiner was welded to the reactor core and the entire assembly was again thoroughly checked with a helium leak detector. The second recombiner that was installed on the AE-6 Reactor is essentially like the first except it was not put through the operability test.

Taking the worst possible case, it is conceivable there might be about 1.2 per cent reactivity available for a nuclear excursion. To obtain this excess reactivity it would be necessary to simultaneously cool the core down to 40 ° F and fill the glory hole with lucite. If it is assumed that this reactivity could be inserted in a very short time, which is not possible with the AE-6 control system, and if the period scram mechanism was inoperative, then the maximum power level obtained would be 10 megawatts. This assumption is based on calculations for a water boiler reactor operating at 15 cm of Hg absolute pressure. The AE-6 operates at an absolute pressure of 4 cm of Hg, which is more favorable from a safety standpoint. A peak power of 10 megawatts and reactivity insertion of 1.2 per cent corresponds to an energy release of about 2 megawatts-seconds intergrated over the time of the excursion. Since an energy release of 1 megawatts-second produces about 4 liters of gas (at STP) and since the void volume of the system is 14.8 liters, the pressure increase due to a 1.2 per cent reactivity insertion is 8 psi giving a total of 8.8 psi when added to the pressure already in the system. If it is then assumed that an explosion could occur, which is unlikely at the low operating pressures, the pressure would increase by a factor of about 20 giving a final pressure

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in the system of 176 psi. This far below the pressure at which the core was tested so that a rupture seems highly improbable.

The hazards involved in operating the AE-6 Reactor are now being fully investigated. The results will be published in another document entitled "A Safeguards Summary for the AE-6 Water Boiler Reactor". It may be said that the most recent chemical analysis (October 1959) indicates that no corrosion of the inside of the core vessel is occurring.

4. SUBCRITICAL ASSEMBLIES ON THE AE-6 THERMAL COLUMN

4.1 INTRODUCTION

The purpose of this section is twofold.

4.1.1 It is to call attention to some of the subcritical assemblies which have been or may be placed on the AE-6 thermal column.

4.1.2 To point out some of the general procedures one must go through to assemble these.

4.2 MODERATOR ASSEMBLIES

Some of the moderator assemblies that have been or may be assembled on the AE-6 thermal column include:

4.2.1 D₂O

This moderator has been placed on the thermal column in a cylindrical tank. The tanks range from 2-1/4 feet to 5 feet in diameter and 6 feet tall.

These tanks were placed on a mild steel pedestal which rested on the thermal column. The outside was covered by cadmium sheeting to prevent thermal neutrons entering from the side in case they had either leaked from the edges of the thermal column or from the top of the thermal column if the diameter of the tank didn't match the diameter of the thermal column.

Figure 16 shows a diagram of the system with a typical loading on the thermal column.

4.2.2 Organic

The organic moderators were placed in essentially the same containers as was the D₂O. The organics that have been studied include the following:

Fig. 16 Thermal Column and Test Lattice

4.2.2.1 Diphenyl

This is a solid at room temperatures. To use it as a liquid heat must be added continually to the tank of diphenyl. This is accomplished by either "Strip Heaters" or "Wire Heaters" placed on the outside wall of the tanks. These were then covered with insulation. Care must be taken that the organic and the associated vapor doesn't reach the flash point. To aid in this situation an atmosphere of CO_2 gas is kept over the diphenyl.

4.2.2.2 Terphenyl

This is a liquid at room temperature, hence heating was no problem. However, it was necessary to filter this to remove the material that did not dissolve.

4.2.3 Graphite

Most of the graphite moderators have had square bases of various sizes and a height of approximately 5 feet. Two grades of graphite have been used. These were the AGOT type and the Mold Grade type. These assemblies have been made from rectangular solids pieces of various sizes.

More recently some of the AGOT type graphite has been machined so that a cylinder having a diameter of 5 feet and a height of approximately 5 feet could be assembled on the thermal column.

4.3 FUEL ELEMENTS

In the D_2O and Dyphenyl moderated lattices only simple fuel elements of uranium metal of various enrichments have been used. These elements consisted of single rods clad in aluminum. The diameter of the rods have varied from about 1/4-inch to 1-inch.

Lattices of multiple paralalled fuel plate elements were

assembled in the terphenyl moderator. These plates were 54-inches long, 5-inches wide and 0.1-inch thick. Some elements were made from 10 of these spaced 0.425-inches apart center to center. Other elements were made from 12 of these .358-inches apart center to center.

Using the graphite as a moderator, lattices of single rods have been assembled. In addition some elements have been made by clustering rods into multi-rod fuel elements. These have ranged from 4-rod clusters up to 19-rod clusters. The fuels have ranged from uranium metal of various enrichments up to special alloy fuels e.g., a thorium-uranium alloy and a uranium-molybdenum alloy.

4.4 SUBCRITICAL LATTICES

Some of the subcritical lattices assembled on the AE-6 thermal column include the following:

4.4.1 D₂O - Uranium Lattices

These were all triangular lattices. The elements were held in place with top and bottom grid plates. Metal plates were bored so that holes were located on the circumference of circles of various radii. The elements could be arranged to obtain regular lattices of several fuel volume to moderator volume ratios.

4.4.2 Diphenyl-Uranium Lattices

These lattices are like the D₂O lattices except now the moderator is diphenyl rather than D₂O.

4.4.3 Terphenyl-Uranium Lattices

These lattices were assembled from the multi-parallel plate elements. These lattices were assembled with the elements at the vertices of squares. They were held in place by top and bottom grid plates. The grid plates were so constructed that lattices

with different spacings (distance from center to center of elements) could be obtained.

4.4.4 Graphite-Uranium Lattices

Some of these were composed of these various fuel elements mentioned, with the exception of the 19-rod elements, in the AGOT type graphite. These were located at the vertices of squares when horizontal cross-section of the graphite was a square. Lattice spacings of 7, 9.5 and 12-inches could be obtained.

Other lattices were composed of the 19-rod $3\frac{1}{2}$ w/o enriched U-10 w/o Mo alloy fuel elements placed in the Mold Grade graphite. Again the horizontal cross-section of a lattice was a square. These elements were placed at the vertices of regular hexagons. Different lattices corresponded to hexagons having distances of 13-inches, 16-inches, and 19-inches across their flats respectively.

4.4.5 Buffered Lattices

These are lattices which essentially have two distinct regions. The central region consists of elements of the fuel that one desires to study with the spacing one desires. The outer region consists of fuel, and perhaps elements, of a different type where type here usually means a different enrichment. These are made only when a limited number of the elements of a desired fuel type are available.

4.5 SINGLE ELEMENT-MODERATOR ASSEMBLIES.

These correspond to a single fuel element placed on the central axis of the moderator. Usually the moderator is graphite. The graphite moderator may have a square base. It may, on the other

hand, be a cylinder.

4.6 SHIELDING MATERIAL.

This is simply a portion of some shielding material. It is placed here to study the attenuation of thermal neutrons in the material.

4.7 MODERATOR STORAGE AND IDENTIFICATION.

The liquids are merely stored in suitable containers and properly labeled as to their contents. The solid diphenyl is stored in tanks which are properly labeled.

The graphite logs are stored in boxes which are kept dry and free from contaminants of all types. Each log is identified by a serial number stamped on each end. These identification marks are helpful when one assembles a lattice in that one may properly locate and position them in their proper places.

4.8 FUEL HANDLING.

4.8.1 General

Three general principles will prevail in all fuel handling. These are:

4.8.1.1 Area monitoring and periodic radiological safety inspection will be used to minimize health and criticality hazards.

4.8.1.2 All AEC requirements regarding storage and accounting of fuel will be complied with.

4.8.1.3 No fuel handling will take place without the approval of the Physicist-in-Charge or an Alternate-Physicist-in-Charge.

5. REACTOR OPERATIONS

5.1 OPERATING RULES

In addition to the rules specified in Section 2, the following operating rules will be strictly adhered to. The reactor is considered to be "Operating" whenever at least one control rod is being manipulated.

5.1.1 Personnel Rules

5.1.1.1 At least two Qualified Operators will be in the control room at all times during operation. The Physicist-in-Charge must be in the immediate vicinity at all times during operation. The Physicist-in-Charge must be in the control room during startup.

5.1.1.2 During operation a maximum of six persons will be permitted in the control room. If the need arises this number may be increased by the written approval of the Supervisor of the Subcritical Experiments Unit.

5.1.1.3 At least two persons will be involved in any fuel handling or loading operation.

5.1.1.4 No person will be in the reactor room or in the Exclusion Area during startup and operation except for making radiation surveys.

5.1.2 Operating Log

A chronological record of all significant actions will be kept in a bound log book. The operating log will include the names of the operating personnel, description of the experiment in progress, reference to the instrument check list for that particular day, reference to the subcritical loading, and any other pertinent information.

5.1.2.1 The operating log will be present in the control room at all times during startup and operation.

5.1.2.2 Pages will be numbered and no page will be removed.

5.1.2.3 Entries will be made in ink and initialed.

5.1.2.4 Any subsequent changes or additions to the log book will be dated and initialed by the person making the change.

5.1.2.5 Any visitor taking data from the log book will initial the pages from which the data were taken.

5.1.3 Startup Requirements

5.1.3.1 Checkout. The daily checkout procedure must be followed (see Section 5.2) any time the reactor is started up following a shutdown of more than a few hours, provided that if there has been a previous complete checkout the same day, only the scram circuits need to be checked. A checklist will be completed and initialed by the Qualified Operator performing the checkout and by the Physicist-in-Charge; a cross-reference entry will be made in the Operating Log.

5.1.3.2 In no case will the AE-6 Reactor be started under duress or with insufficient time to complete the run carefully.

5.1.3.3 Source. Prior to startup the Qualified Operator performing the checkout must verify that the source is in the proper position. During operation the source must be left in this position. The source is on an interlock such that the reactor cannot be started up unless it is in the proper position.

5.1.3.4 Instrumentation. As a minimum requirement, the following instrumentation must be functioning properly prior to and during reactor startup and operation: one of the two

Vibrating Reed Electrometers, the Log N Power and Log N Period Meters, the Beckman Micro-Micro Ammeter, and the Pressure Recorder.

5.1.4 Power and Period

5.1.4.1 The power will not exceed a level determined by a maximum permissible radiation field of 2 mrem/hr. in all areas accessible to personnel during normal operations.

5.1.4.2 Normal startup and power changes will be made using pile periods of no less than 3 seconds.

5.1.4.3 The period will be limited by the operator to 10 seconds.

5.1.4.4 A period scram will be set at (3) seconds or longer.

5.1.5 Other Operating Rules

5.1.5.1 The assembly must be scrambled upon demand by any person present in the building.

5.1.5.2 Any accident or unusual circumstance encountered in operating a AE-6 Reactor will be reported to the Research Reactor and Fuels Safeguards Committee and the Approval Authority, via the Subcritical Experiments Unit Supervisor.

5.1.5.3 No change in experimental procedure, however trivial, will be made without the agreement of all persons directly concerned. Such changes will be noted in the operating log prior to actually making the change.

5.2 DAILY CHECKOUT OF THE AE-6 REACTOR

Each day, prior to startup, a complete equipment checkout will be performed. This checkout includes an operating test of all control instrumentation plus certain experimental equipment, a check of the source, a check of various startup interlocks and a check

of the scrams provided. (See Appendix F for a detailed description of the Daily Checkout Procedures).

5.2.1 Instrument Check

The instruments listed below, as a minimum are checked for proper operation, using their internal checking circuits. Log N Amplifier for power and period, Beckman, Keithley, Area Monitor, Air Monitor, and the audible("Poppy") Log N Recorders.

5.2.2 Source and Minimum Power Check

In order to determine that the startup source is in place the operator will lock the source in location on the reactor. A minimum power interlock will be checked for operation by attempting to withdraw a safety rod. With the contacts made the low level neutron instrument will be checked for multiplication when the safety rods are withdrawn. Results are recorded on a check sheet.

5.2.3 Interlock Check

Certain of the interlocks will be checked to insure that they are performing their function of preventing rod withdrawal. To do this the prescribed situation will be obtained and rod withdrawal attempted. As a minimum, the following interlocks will be checked: Control rod withdrawal with safety rods in the least reactive position. Startup with the all safety switch on the reactor open. Automatic drive of coarse rod to point of minimum reactivity.

5.2.4 Scram.

Each scram is checked for instrument calibration points⁽¹⁾, e.g. by opening the circuit by cutting power at specified points⁽²⁾, jarring the earth quake mechanism and⁽³⁾ withdrawing the control rod on minimum power scale and turning down scram point on scram meters. The following scrams are checked daily. Manual scram,

run safe, period power scrams, log N-two vibrating reeds Kiethley Earth Quake scram, gas pressure, instrument power failure. The water conductivity and low water level scram with water cooling system will not be checked daily.

5.2.5 Checklist

The detailed checkout procedure and checklist is given as Appendix F. This procedure and list will be used. At the end of the checkout the checklist is initialed by the Physicist-in-Charge and the Qualified Operator as indications that assembly is cleared for startup.

5.3 STARTUP

5.3.1 Preliminary

A routine startup procedure is followed to perform the following three functions: to make sure that the required instrumentation is available and in operating condition; to check for possible hazardous or dangerous situations; and to provide a written record. The daily checklist is inspected, and the Log book prepared. The following instruments at least are checked: Gas pressure recorder vibrating reed electrometers, micro-micro ammeters, core temperature recorder and the recombiner temperature panel meters. The scrams are checked for correct trip points. In addition, the exclusion area and assembly areas are cleared of personnel and locked, the operational power switches are turned on, the recorder charts are dated and noted and turned on, and the personnel at other buildings are notified that startup is to begin.

5.3.2 Checklist

To ensure that all steps are taken, a startup checklist is filled in as each item is completed. When the process of

pulling rods is to begin, both Qualified Operators initial the form. The detailed startup procedure may be found in Appendix G.

5.4 CHANGE IN POWER LEVEL

Power level changes are accomplished by moving a single control rod in or out, or a bank of control rods in. The shortest permissible positive period is 3 seconds. When the new power level is reached, one or more rods are adjusted to maintain that level. An entry in the operating log is made whenever the power is changed.

5.5 SHUTDOWN

Shutdown is accomplished by inserting the control rods in any desired manner. When shutdown was caused by an unintentional scram, an investigation of the cause will be made and corrective action will be taken.

Certain steps are taken following shutdown to secure the assembly and to return to a non-operating condition. These include ascertaining that the rods are completely inserted before entering the reactor room, turning off the operational power and (in the reactor room) locking down the control rods. The first person entering the reactor room following shutdown will ascertain by means of monitoring equipment that it is safe.

In addition, if the shutdown involved completes the day's operations, operating instruments which could be damaged by line surges are grounded or switched to their least sensitive positions.

To ensure that all steps are taken, a shutdown checklist is filled in as each item is completed. The person completing the checklist initials it. A sample detailed shutdown checklist is provided in Figure 24.

ERRATA

6.0 EXPERIMENTAL TECHNIQUES6.0.1 SOURCE MULTIPLICATION

Source multiplication is used for the initial loading of a subcritical lattice since the effects of the final loading cannot be anticipated. The technique is used primarily for safety, but is also used because it provides a systematic method for loading fuel in the subcritical lattices. The technique is described in general terms first, and then specifically for the loading of subcritical lattices on the thermal column of the AE-6 Reactor.

6.0.1.1 Introduction

At or near center of the assembly is placed a neutron source, emitting about 10^7 neutrons per second. This is called the primary source. As a result of fissions in the fuel there is a multiplication of the primary source neutrons. As a system approaches critical by the loading of fuel, the multiplication is nearly $1/(1-k_{\text{eff}})$. At criticality k_{eff} is exactly unity, hence the multiplication would be infinite.

For practical purposes it is convenient to use the reciprocal count rate; this will decrease as the fuel loading increases, and will extrapolate to zero at the critical size. The reciprocal count rate is plotted as a function of some pertinent parameter, such as number of fuel elements loaded, for several detectors; the critical loading can be estimated by extrapolating the curves to zero reciprocal count rate.

6.0.1.2 Technique for Loading Subcritical Lattices on AE-6

Thermal Column

At least two neutron detectors located in or about the assembly must be in operating condition at all times. The counting rates of the detectors are established, with no fuel but with the source in the assembly. Counting rates must be above significantly background, or the detectors will be rearranged until this condition is obtained. Two fuel elements are then loaded. The counting rates of the detectors are again determined and plotted for each channel. A very rough first estimate of the critical loading can now be obtained by extrapolation. One half of the estimated number of additional fuel elements needed for criticality, with a top limit of 4, are added to the assembly. Count rates are again determined and inverse count rate plotted for each channel and a new estimate of criticality made. This process is continued in successive steps with the number of elements loaded in each step being 4, or one half of the remaining number required for criticality, whichever is less. No further loading is permitted whenever extrapolation of inverse counting rate curve to 0 indicates that the lattice would be more than 85% critical due to this.

6. FOIL ACTIVATION MEASUREMENTS

6.1 FOIL CALIBRATION

The foils that are to be used in an experiment are first cut as closely as possible to the dimensions desired. Sets of these are then placed on a wheel displayed in Figure 17, which is driven by an electric motor, and placed in one of the graphite stringers shown in Figure 18. This wheel turns at 100 rpm. The reactor is held at a power of about 50 mw. The wheel is allowed to make a few hundred turns so that the foils are ensured of being exposed to approximately the same neutron flux. The activities of these foils are then determined by means of the scintillation spectrometers in the AE-6 counting room annex. This enables one to know the relative activities of the foils in the set. If it is necessary to use foils of more than one of these sets in a given experiment, then it is necessary to intercalibrate these sets. This is done by choosing the foils from each set and then calibrating these as a set which then gives one the desired information for the intercalibration.

For selecting matched sets of foils one may at first select foils of very nearly the identical sizes and then weighing these. The ones that differ in mass by more than a few tenths of a percent are cast away. The ones that remain are then calibrated in the manner mentioned above.

Fig. 17-A The Wheel Used in Calibration of Foils

17-B The Wheel Used in Calibration of Foils

Fig. 18 Shield Doors Open for Access to Glory Hole and Light Removable Graphite Stringers

6.2 MEASUREMENT OF THERMAL (SUBCADMIUM) NEUTRON DISTRIBUTIONS

Sets of both bare and cadmium covered foils of a given type are exposed in similar positions, along the line which this distribution is desired. The activities of each set are then measured with the scintillation spectrometers. The cadmium covered foil activities are corrected for the attenuation of the epithermal neutrons by the cadmium covers. These corrected cadmium covered foil activities are then subtracted from the corresponding bare foil activities. The resulting activities are those that one needs for the thermal neutron distributions.

6.3 EPITHERMAL (EPICADMIUM) NEUTRON DISTRIBUTION

The information needed for this distribution is contained in the corrected cadmium covered foil activities discussed in section 6-2.

6.4 THERMAL NEUTRON DIFFUSION LENGTH IN A MODERATOR ASSEMBLY

The vertical and horizontal components of this parameter are measured by determining the thermal neutron distributions in these directions. These are then fit to the proper distribution functions. From these fits the parameters that are needed for the thermal neutron diffusion length in the moderator are extracted. These parameters are then substituted into the equation for the diffusion length obtained from solution of the proper diffusion equations.

6.5 THERMAL UTILIZATION

This is a unit cell parameter of a lattice. The thermal neutron distributions are measured for the various components of a unit cell. This enables one to find the thermal neutron absorption reaction rates for each component of the cell. These

are then weighted by the volumes of the respective components of the cell. The thermal utilization is then determined from the ratio of this reaction rate for the fuel to the sum of the reaction rates for all the components of the cell.

6.6 MATERIAL BUCKLING

This is a lattice parameter. The particular lattice of interest is loaded. Then measurements similar to those mentioned in section 6.4 are made. The thermal neutron distributions are fit to the appropriate distribution function. From these fits the information needed for determining the material buckling is obtained.

6.7 RESONANCE ESCAPE PROBABILITY

6.7.1 For lattices containing a uranium fuel of low enrichment. The Np^{239} buildup for the fuel of a unit cell is determined by means of sets of bare and cadmium covered U^{238} foils. This build up as determined for each set of foils is averaged over the fuel of a unit cell. The ratio of the "cadmium covered" build up to the "bare minus cadmium covered" build up is formed. This gives the ratio of the resonance capture of neutrons in the U^{238} to the thermal capture of neutrons by the U^{238} . Substituting the proper relations in this ratio, from the four factor formula, enables one to determine the resonance capture probability. The Np^{239} build up may be determined by detection of the 103 kev internal conversion x-ray from Pu^{239} using the gamma scintillation channels in the AE-6 counting room annex.

6.7.2 Lattices Containing Th^{232} as the Fertile Material. Sets of bare and cadmium covered Th^{232} foils are irradiated in

the fuel. The 89.5 kev x-ray activities of these foils by using the gamma ray scintillation spectrometers. These results are then used in a manner similar to these obtained from the U^{238} foils as mentioned in section 6.7.1.

6.8 FAST EFFECT FOR URANIUM METAL LATTICES

U^{238} and U^{235} foils are used to measure the ratio of the fast to thermal fission rates in the fuel by counting all the gamma ray activity, above about .5 mev, of these foils. This is just the information one needs to determine the fast effect.

6.9 SMALL SOURCE PARAMETERS

A given fuel element is located along the vertical axis of a large section of graphite on the AE-6 thermal column. Thermal and epithermal neutron distributions are then made in the moderator and in the fuel element. From these distributions one may obtain the small source theory parameters.

7. RECORDS AND MAINTENANCE

7.1 RECORDS

Records of activity in the AE-6 Facility will be kept in one of the following log books. In addition, other forms not strictly "records" will also be described below.

7.1.1 Operating Log

The Operating Log will constitute a complete chronological record of all operations performed using the AE-6 Reactor. The Operating Log will be kept at the control console, except by direction of the Physicist-in-Charge, and must be available at startup.

All entries must be in ink. Any corrections, modifications, or additions to the log, not made at the time of the particular run, will be labeled as such and will include the name of the person making the change and the date on which the change was made. Any person other than those regularly assigned to the critical facility (see Section 2.2) taking data from the operating log will sign the pertinent pages in the log.

7.1.1.1 Page Format.

A page format typical of those to be used in the Operating Log are shown in Figures 19 and 20. Variations may be made from time to time as required by the particular conditions of an experiment. The signatures of the Physicist-in-Charge and Qualified Operators are required for every page. A new page is started for each run.

7.1.1.2 Use of Log.

A complete line will be filled in, in general, at criticality, and whenever a change in control rod position is made except for small changes to maintain a steady

AE-6 OPERATING LOG

PIC _____ EXPERIMENTER _____ DATE _____

QO _____ LAB NOTEBOOK # _____

EXPERIMENT _____

FOILS USED _____

START UP _____ LEVEL OFF POWER _____

SHUT DOWN _____ RUN DURATION _____

REMARKS:

SIGNED: PIC _____

QO _____

Date

Lab Notebook #

Experiment

Foils Used

Start Up

Shut Down

Level Off Power

Run Duration

				Time
				Log N Period
				Log N Power
				VRE #1
				VRE #2
				Beckman
				Core Pressure (cm Hg)
				Rec #1 (⁰ F)
				Rec #2 (⁰ F)
				Rec #3 (⁰ F)
				Rec. Cool #1 (⁰ F)
				Rec. Cool #2 (⁰ F)
				Rec. Cool #3 (⁰ F)
				Core (⁰ F)
				Core Cool In (⁰ F)
				Core Cool Out (⁰ F)
				CCR Pos. (cm)
				Rem. Mon. #1
				Rem. Mon. #2
				Rem. Mon. #3
				Rem. Mon. #4
				Rem. Mon. #5
				Core Cool On
				Inner Rec. Cool On
				Outer Rec. Cool On
				Core Cool Off
				Inner Rec. Cool Off
				Outer Rec. Cool Off
				Rec. Heater On
				Rec. Heater Off
				Heater Volt Setting

Cause

Time

By whom

Scram
Flow control valve settings

Signed: PIC

00

Fig. 20 Page Two of the AF-6

Operative Notes

power. Entries may be made for other reasons, as desired. Whenever an entry in the printed form portion of the log is made, a corresponding entry in the journal portion should also be made explaining what has been done.

On Shutdown the "Scram caused by and time" line should be completed and the log pages signed by the Physicist-in-Charge and Qualified Operator.

7.1.2 Personnel Log

All visitors (as defined in Section 2.2.4) will sign in and out giving their name, affiliation, and the times in and out. This log will be maintained by the Physicist-in-Charge.

7.1.3 SS Material Log

A permanent record will be maintained for all SS or radioactive material received at the AE-6 Facility. This record will be maintained by the person designated by the Physicist-in-Charge.

7.1.4 Fuel Element Card File

A card with all the pertinent information about a fuel element will be made for each fuel element. One of these is placed in the fuel element card file, and will be kept until the elements are disassembled and released for other experiments.

7.1.5 Experiment Notebook

All information pertinent to the various experiments and not directly concerned with the operation of the AE-6 Reactor will be recorded in serially numbered Atomics International Laboratory Notebooks. All pertinent information necessary to duplicate and/or recalculate experimental work done using the subcritical assemblies will be recorded. A notebook will be maintained by each Physicist.

7.1.6 Check Lists

Operating procedures require routine checks and maintenance of all equipment according to a specified schedule. In particular, there is a daily equipment and scram check list (see Appendix F, "Daily Checkout") to be performed each day prior to startup; a startup check list (Appendix G); a shutdown checklist (Appendix H) and calibration and maintenance of equipment (Appendix C).

The Daily Checklist will be filed chronologically and then bound in a permanent book. So will the startup and shutdown checklists, also filed chronologically, will be kept for at least three months. These lists will be normally kept by the Physicist-in-Charge.

7.1.7 Recorder Charts

At the beginning of each run, the date, run number, and time will be noted on each chart.

7.1.8 Instruction Manuals for indicating, control, and recording equipment, as well as complete wiring diagrams, calibration curves, and similar information, will be kept on file. Any changes in wiring, etc., will be noted appropriately by the person making the change in order that all information shall be up-to-date.

7.1.9 Plans and Prints

Construction plans, drawings of parts, and the like will be kept on file and up-to-date. A list is contained in Appendix A.

7.2 MAINTENANCE

7.2.1 Routine

Routine procedures are handled through the daily checks; these checks are both qualitative and quantitative.

7.2.2 Special

Any indication of malfunction or improper adjustment, whether discovered by a routine check or other means, calls for an immediate thorough check and repair of the particular equipment. New equipment will also be given a thorough check and test before being installed.

APPENDIX A

LIST OF DRAWINGS

This appendix contains a list of the drawings that are filed in the AE-6 Control Room which are pertinent to the operation of the AE-6 Reactor. This list is not ordered in any particular sequence and will be added to as more drawings become available.

TITLE OF DRAWING	DRAWING NUMBER
CORE ASSY-AE-6 WATER BOILER	7004-79201
SCHEMATIC DIAGRAM-CONTROL PANEL-CONVERTER REACTOR EXP.	SRD-11569
COVER FOR CONTROL RODS & DRIVES AE-6 REACTOR-BLDG. 093	A3-7143
CORE ASSEMBLY-WBNS	SRD-21705
PLAN-WBNS CONTROL CONSOLE	SRD-25775
WBNS ELECT. SCHEMATIC	SRD-25773
ELECTRICAL POWER & LIGHTING AE-6 WBNS CONVERSION TO 100 WATTS SRE-PROJECT. SANTA SUSANA CALIF.	7004-77267
ASSEMBLY NARR 23 COOLING SYSTEM	SRDL-23043
AE-6 BLDG. FLOOR PLAN	-----
RECOMBINER ASSY. GAS HANDLING SYSTEM	7521-78601
SPRINKLER LINE SUPPORTS FOR NEW CONTROL ROD COVER-BLDG. 093 AE-6 REACTOR ROOM	A3-7193-C
COVER FOR CONTROL RODS & DRIVES AE-6 REACTOR BLDG. 093	
PARKING AREA STRIPING KEWB-AE-6 AREA SANTA SUSANA	PL-303-543-35
ELECTRICAL DETAILS AE-6 WBNS CONVERSION	AE-6 77103
ROD ASSY WBNS CONTROL & SAFETY	SRD-25701

APPENDIX B

FACTS ABOUT THE AE-6 REACTOR

B.1 Core

B.1.1	Core vessel material	stainless steel
B.1.2	Geometry	sphere
B.1.3	Diameter	1 foot
B.1.4	Fuel Solution	uranyl sulphate
B.1.5	Fuel Volume	approx 12,440 ml
B.1.6	Permissible excess reactivity(fuel)	0.5% k/k
B.1.7	Presently loaded excess reactivity (fuel)	0.5% at 70° F
B.1.8	Total excess permissible in addition to fuel	0.5% k/k at 70° F

B.2 Reflector

B.2.1	Material	Graphite
B.2.2	Geometry	Right circular cylinder
B.2.3	Diameter	5 feet
B.2.4	Height	6 feet
B.2.5	Thermal Column Reflector above core -	approximately 3 feet of graphite.

B.3 Shielding

B.3.1 Reactor shielding

B.3.1.1 Materials--concrete wall 3 ft thick with two 1-inch steel plates on inside wall which support 4-inch layer of lead and 4-inch layer of paraffin

B.3.2 Biological Shield

This is a 2-½ ft. thick wall which separates the reactor room from the control room

B.4 Control Rods

B.4.1 Two Safety Rods

- B.4.1.1 Shape: 1-inch on a side square
- B.4.1.2 Material: Cd strip surrounded by boral sheets
- B.4.1.3 Worth (each) Approx $-1.2\% \Delta k/k$

B.4.2 One coarse control rod

- B.4.2.1 Shape: $3/4$ " square on side
- B.4.2.2 Material: Cd strip surrounded by boral sheets
- B.4.2.3 Worth $-1.2\% \Delta k/k$

B.4.3 One Fine Control Rod

- B.4.3.1 Shape: $3/4$ inch diameter
- B.4.3.2 Material: Cadmium
- B.4.3.3 Worth $-.065\% \Delta k/k$

APPENDIX C

The following is a list of instruments located in the six Bays of the AE-6 Reactor control room:

Bay	DESCRIPTION	MANUFACTURER	MODEL #
Bay 1	Area Monitor	Jordan Electronics, Inc.	Rams II
	Air Monitor	Nuclear Measurements	LCRM - 2M
Bay 2	Core gas pressure recorder	Leeds & Northrup	101040
	Vibrating reed Electrometer	Applied Physics Corp.	Model 59
	Vibrating reed Electrometer	Applied Physics Corp.	Model 30
Bay 3	D.C. Power Supply	Atomic Instrument Co.	Model 316
	Strip Chart Recorder Linear	Brown Electroniks	153 x 17 V
	YY Ammeter	Beckman Instruments	
Bay 4	Scram Meters	Semi-Ply-Trol	
	Strip Chart Recorder Linear	Brown Electroniks	y 153 x (18) V-X -(66)N2
	YY Ammeter	Keithley	410
Bay 5	Water Flow Rate Meter	Waugh Engineering Co.	FR-2-11
	Strip Chart Recorder Log	Brown Electroniks	Y153 x 12(VSD)- W7-30 A 1K
	Amplifier Log N	Radiation Counter Lab	32
	Intercomm	RMS	_____
Bay 6	Poppy Amplifier	A.I.	1
	Multi Point Strip Chart Recorder	Brown Electroniks	153 x 60
	Amplifier Linear	Franklin	002
	Scaler	Beckman Berkeley	1452

APPENDIX D
FUEL ELEMENT NOMENCLATURE

The slugs, from which the elements are made, will have serial numbers stamped on them which include the enrichment. As the elements are constructed, the locations of the slugs will be recorded on duplicate filing cards.

On these cards will also be kept a description of the elements e.g. the number of rods, their diameter, their length, etc. The elements will be assigned a number which will be written on the cards. This element number will be written on the top of the element or on its side near the top with a wax pencil.

These cards will be kept at the AE-6 Reactor Building until the fuel has been accounted for, at the end of the experiment, and sent back to the SS Storage Vault.

APPENDIX E

PUMPDOWN OF THE AE-6 GAS HANDLING SYSTEM

The operation of the recently installed AE-6 gas handling system has necessitated several pumpdowns to reduce the pressure. Below are outlined the procedures necessary for a safe and efficiently performed operation. Adequate protective clothing should be worn and continual area monitoring, as advised by Health Physics, should be carried out during all phases of the operation.

E.1 Prior to initiating the actual pumpdown, heat the recombiner catalyst and gases to 250° and cool the core to 55° F. This should ensure that during pumpdown the vapor pressure of the fuel solution will not be drawn off the core. If necessary warm the pump before using. Turn on the air monitor.

E.2 Connect the system as shown in Fig.21. The ballast tank should be pre-evacuated to an absolute pressure of approximately 4 cm.Hg. All valves are to be left closed.

E.3 Open valves (8)(7)(6)(5)(4)(3) in that order. Start the pump, wait approximately 30 seconds and slowly crack (1) and continue opening it until about 3 full turns are completed.

E.4 Follow the pressure decrease on the Leeds Northrup Recorder. Monitor the ballast tanks with a portable survey meter. When a pressure of 4 cm.Hg. is reached in the gas handling system, close (1). Then close (3), (4), (5), (6), (7), (8) in that order.

E.5 Remove the pumpdown apparatus and recap (2) with the swagelok plug. Continue the air-monitoring for an hour.

If at the end of a pumpdown, it is necessary to rezero the pressure recorder, a manometer may be connected in the line as shown, and (1),(3), and(4), cracked slightly to allow the system to come to equilibrium. Upon completion of the readings close (1),(3) and (4), disconnect the vacuum apparatus and replace the swagelok plug on (2).

E.6 Handle and store the gas filled ballast tanks as advised by Health Physics.

Fig. 21 Equipment used for Pumpdown of the AE-6 Reactor Core

APPENDIX F
DAILY CHECKOUT

F.1 Instrument Check

F.1.1 General Instructions

If at any time during the checkout procedure an instrument required for operation is found to be faulty, the instrument will be repaired or replaced before operation may begin. If a non-required instrument is at fault, a tag of some kind should be hung on the instrument stating that it is not working properly. As each check is made enter the required information on the checklist (see Fig.22)

F.1.2 Instrument Power

Instrument power should be on at all times. If any instruments are off without any explanatory tag, turn the instrument on and wait the time indicated in the manufacturer's instructions before checking that instrument.

F.1.3 Air Monitor

Turn the high voltage switch off and hold down the "meter reset" button. Adjust the zero-set control on the meter until the recorder reads 50 counts per minute. Release the "meter reset" button and turn on the "function" switch to 3600 counts per minute. Wait a few moments; adjust the indicator to 3600 counts per minute with the "low" control if necessary. Rotate the high alarm setpoint down-scale until the annunciator panel have both flashed. Then rotate the high alarm set-point up scale to a predetermined redlined

AE-6 Daily Check Out

Date															
Calibrate remote monitors															
Beckman set on lowest power scale															
Log N period															
Log N power scram and calibrate															
VRE #1															
VRE #2															
Beckman scram and zero check															
Sensitrols set back to normal															
Gas pressure															
Instrument power failure															
Earthquake															
Rest annunciators															
% Excess Reactivity															
PIC															
OPR															

Fig. 22 AE-6 Daily Checkout

position on the meter, set the "function" switch to auxilliary and turn the high voltage switch on. The low alarm set point should be set just below 50 counts per minute.

* Before proceeding with any of the following checks, a vessel check should be made to determine if the source is in its proper position.

F.1.4 Jordan Gamma Monitors

Rotate the "function" switch on the large panel meter to check, adjust the indicator to read 1000 on the meter. Reset the "function" switch to operate. On the same meter corresponding to Station I push the "read panel meter" button. The green "panel meter light" should go on. Rotate the alarm set point beyond the 1000 reading of the meter. Push and continue to hold, the "hold to check" button. Wait a few moments. The meter should read 1000 and the red alarm light go on. If necessary adjust the meter to read 1000. Release the "hold to check" button and reset the alarm set point to a predetermined value. Repeat for Stations 2 through 5.

F.1.5 Console Power

Insert the key into the ignition switch and turn the ignition on. In this sequence switch on AC power, rectifier power and battery power. The following lights should be on indicating normal conditions: Battery power (red light), safety rod in (green light), coarse control rod in (green light), safety follower rods in

(green light). The red light indicating that the source is out should not be on; however, the bulb for the light should be also checked daily.

F.1.6 Vibrating Reed Electrometers #1 and #2

Set the meter switches on proper polarity for Meter #1. Rotate the range selector to the 5 milliwatt scale. Adjust the zero set so that the instrument reads 0.5 milliwatts, the "zero" power of the reactor when the source is in place. Repeat for meter #2.

F.1.7 Log N Power and Period Meter and Recorder

Set the "function" switch to ground, the Log N meter and Recorder should read .0001. The Period Meter should momentarily hit 3-4 seconds and the Log N Meter and Recorder should read .0002. If necessary use the "calibrate" screw to bring Log N Meter to .0002. Set the "function" switch to High Calibrate. The Period Meter should go off scale for a few seconds then return; the Log N Meter and Recorder should read 20. Adjust the Log N with the "gain" screw if necessary. If either a "calibrate" or "gain" adjustment was made recalibration may be necessary at the other calibration setting. The entire process should be continued until no change is needed at either position. Return the "function" switch to operate when done.

F.1.8 Beckman Micro-Microammeter and Linear Recorder

Rotate the "range selection dial" to ZERO. Using the "zero" dial, zero adjust the Beckman and the Recorder. Set the instrument on the 10^{10} ampere (10 milliwatt) scale.

F.1.9 Leeds Northrup Gas Pressure Recorder

Press the "standardize" button, hold it momentarily, then release it and allow the indicator to return to its final rest position.

F.1.10 Honeywell Core Temperature Recorder

Same procedure as in F.1.9.

F.2 Scram and Interlock Checks

F.2.1 Preliminary

Unlock the safety rods and take the necessary precautions to insure the safety of all personnel during the low power operations which occur during the scram and interlock checks.

F.2.2 Interlock

F.2.2.1 Withdraw Interlock - attempt to withdraw coarse rod without withdrawing safety rods first.

F.2.2.2 Source Interlock - pull the source out until the red light on the console control panel goes on. Clear the reactor room. Attempt to withdraw the safety rods. Reposition the source in the normal manner.

F.2.2.3 Water Level Interlock - unscrew the float switch head on the coolant water reservoir. Invert the float valve to activate the microswitch. Replace the float switch head in its normal position on the reservoir. Reset the annunciator.

F.2.3 Scrams

F.2.3.1 General - following all scrams during the scram checks shut off the scram alarms by means of the "alarm reset" button and reactivate the safety rod solenoids via the "magnet reset" button located on the console control panel.

F.2.3.2 Vibrating Reed Electrometers #1 and #2 - Double the sensitivity of the Sensitrol associated with Meter #1.* With Meter #1 on the 5 milliwatt scale rotate the "zero adjust" until the scram alarms are set off. Deactivate the Sensitrol and the alarms and magnets and adjust VRE #1 to 0.5 milliwatts. Readjust the Sensitrol to its normal operating condition. Repeat for VRE #2.

F.2.3.3 Log N Power and Period Meter - set the "function" switch to low calibrate on the Log N Power and Period Meter the resetting 3 seconds period should set off scram alarms. Deactivate the Sensitrol and reset alarms. Do not readjust the Log N Period Sensitrol. Double the sensitivity of the Log N Power Sensitrol by reversing the "toggle" switch directly above the Sensitrol. Rotate the "function" switch from low calibrate to high calibrate. The scram alarms should go off. Deactivate the Log N Power Sensitrol. Rotate the "function" switch to operate on the Meter. Reset the alarms on magnets and readjust both the Log N Power and Period Sensitrol to their normal operating conditions.

F.2.3.4 Manual Scram - withdraw the safety rods. Check the red lights on the console control panel that indicate that the follower rods and safety rods are fully withdrawn. Check the red flashing lights in exclusion area to see if they are functioning properly when the safety rods are out. Push the large red button

* By reversing the "toggle" switch directly below the Sensitrol.

titled SCRAM on the console control panel. Reset alarms. Check if green "Safety Rods" in lights are on. Bring in the follower rods and reset the magnets.

F.2.3.5 Beckman Micro-Micro Ammeters - double the sensitivity of the Sensitrol associated with the Beckman by reversing the "toggle" switch directly above the Sensitrol. With the Beckman set on 10^{-10} ampere (10 milliwatt) scale, rotate the "zero adjust" knob until maximum possible deflection is obtained (a reading of approximately 23). Withdraw the safety rods and then the coarse control rod until such a power level is reached (approximately 3 milliwatts) that a scram occurs. Deactivate the Sensitrol and reset the alarm. Observe that the control rod returns to its position as indicated by the corresponding green light on the console control panel. Bring in the follower rods and reset the magnets. Readjust the Sensitrol to its normal operating condition.

F.2.3.6 Gas Pressure - depress the "standardize" button and hold it until the indicator travels beyond the alarm set point at 20 cm Hg and causes a scram. Release the button. Reset the alarms and magnets.

F.2.3.7 Instrument Power Failure - depress the button on the console control panel which semulates a low level instrument power failure. Reset the alarms and magnets. Repeat the procedure for a high level instrumentation power failure.

F.2.3.8 Earthquake - disengage the plunger and bob in the earthquake detector switch mounted on the north shield wall inside the control room. After a scram is indicated reengage the mechanism. Reset the alarms and magnets.

F.4 Reactivity Check - upon completion of the instrument, interlock, and scram check outs a measurement to determine the excess reactivity of the Reactor will be made. This will consist of withdrawing the coarse control to a specified point of known worth, computing the corresponding period and temperature correcting the reactivity to 70° F.

F.5 Final Items (General) - upon completion of the daily check out if no reactor run is immediately scheduled, the console power should be turned off and the safety rods locked. If a run is immediately scheduled and no normal reactor functions disturbed (e.g. graphite stringer removed for foil calibration) then the reactivity check may be incorporated into the run when going up to power.

APPENDIX GSTARTUP PROCEDURESG.1 GENERAL

The purpose of the startup checklist (Figure 22) is threefold: first, to make sure that the required instrumentation is available and in operating condition; second, to check for possible hazardous or dangerous situations, such as personnel in the exclusion area; and third, to provide a written record of certain conditions.

G.2 PRELIMINARY

Record date, time, and run number. Check the "Daily Checklist" to make sure it has been completed. Make sure the subcritical lattice is properly loaded and experiment is properly set up. Prepare the Log Book by filling in the required information (see Figure 23).

G.3 INSTRUMENTATION

Certain instrumentation is required before operation may begin; other instruments are desirable without being required. The required for-operation instruments are as follows:

Leeds and Northrup core pressure recorder

Log-N amplifier and Brown Log-N power recorder

Vibrating Reed Electrometer - one for low power level indication

Keithley Micro-Micro Ammeters to monitor and indicate minimum power and strip chart recorder.

Area monitor - Jordan

Linear Amplifier - Scaler and "Poppy" system.

Multi-point temperature recorder.

AE-6 Daily Start Up Procedure

[illegible]

Fig. 23 AE-6 Daily Startup Procedure

The Keithley Micro-Micro Ammeter must be working and indicating a minimum power as marked in red on instrument. The minimum power interlock must be set at this red line. Vibrating reed electrometers 1 or 2 must be working and indicate a power increase when safety rods are withdrawn. A fixed and well known minimum power should be observed on the vibrating reed as indicated by the red line on the instrument meter before start up. Core pressure recorder must be working and scram point set on the red line on recorder before startup.

The log N amplifier and recorder and period meter must be working before startup. Area monitor must be working and warning contacts must be set on meter red line warning level.

The linear amplifier, scaler and poppy must be working and the poppy adjusted to a few counts per minute. A count rate increase must be observed when the safety rods are withdrawn.

The multi-point temperature recorder must be working and all scram contacts adjusted to red lines on the scram meters.

All scram relays must be closed with all scram contacts set a red line scram points.

G.4 SAFETY CHECKS

These concern primary personnel safety. Unlock the control rods. Check the reactor room for personnel, close all exclusion areas gates and look for light indicating on panel that all gate switches are closed. Look into exclusion area for personnel, notify KEWB of intention to run and indicate the desired power level and time duration of the run. Close and lock all doors to the reactor room. Look in men's room for personnel, put up all internal chain gates and observe that red warning lights are on when safety rods are withdrawn.

G.5 FINAL PROCEDURES

Check the Annunciator panel and clear; check all interlocks. Reset any tripped scrams. Turn on all recorder charts and make necessary notes. Start up will not proceed without the consent of the PIC and Opr. Any person in the control room may demand that the reactor be scrammed. A minimum number of six persons only will be allowed in the control room except by special permission of the supervisor of Subcritical Experiments Unit.

APPENDIX H

SHUTDOWN PROCEDURE

H.1 INTRODUCTION

The following paragraphs summarize the procedures employed during and immediately following the shutdown of the AE-6 Reactor upon the completion of a normal reactor run. A run is normally terminated by pushing the red SCRAM button on the console control panel.

H.2 SAFETY RODS

Upon scrambling the reactor the safety rods are moved into their least reactive position by means of gravitationally driven counter-weights. The indication that the safety rods are fully inserted is given when the green "safety rods in" light on the console control panel goes on.

H.3 FOLLOWER RODS

With the safety rods fully inserted in their least reactive position, the follower rods holding the solenoids are mechanically driven into contact with the rear of the safety rods by means of the follower rod toggle switches on the console control panel. Limit switches automatically regulate the length of travel of the follower rods and set them in their proper positions.

H.4 COARSE CONTROL ROD

At the occurrence of any scram the course control rod is automatically inserted to its least reactive position. When the rod is fully inserted a corresponding green "coarse rod in" light on the console control panel goes on.

AE-6 Daily Shut Down Procedure

Date																	
Safety rods in																	
Follower rods in																	
CCR in																	
Console power off																	
Recorders off																	
Outer chain gates open																	
Safety rods locked																	
Operating log signed																	
PIC																	
OPR																	

Fig. 24 AE-6 Daily Shutdown Procedure

H.5 CONSOLE POWER

When the coarse rod and safety rods are in their least reactive position, shut off the AC power, rectifies power, and battery power. Turn off the ignition and withdraw the key.

H.6 RECORDERS OFF

Follow the decrease in reactor power on the Log N Power and Beckman Micro-Micro ammeter recorders. When the power levels read 10 mw, the recorders may be turned off.

H.7 CHAIN GATES

When the reactor power reaches the 10 mw level both inner and outer chain gates, as well as the access road gates should be opened.

H.8 SAFETY RODS LOCKED

When the reactor power level has reached 10 mw the reactor room may be re-entered provided that radiation levels (due to irradiated exponential experimental assemblies, etc.) as determined by health physics constitute no immediate hazard to personnel. Upon initial re-entry the safety rods are to be locked.

H.9 OPERATING LOG

The final step in shutdown is to check that all information pertaining to the completed reactor run has been properly recorded in the operating log. The operating log is then to be signed by the physicist-in-charge and the Qualified Operator.

H.10 SUMMARY

The check list which is used following every shut down is shown in Figure 24.

APPENDIX ISUMMARY OF OPERATING RULES

I.1 This appendix is a resume of the rules appearing in various portions of the operating manual with a few exceptions.

I.1.1 No person will be permitted to operate the controls of the AE-6 Reactor unless he is a Qualified Operator or Operator-Trainee. A member of supervision requires the same qualifications as a Qualified Operator, and the permission of the Reactor Physics Group Leader and the Approval Authority, before he may operate the controls.

I.1.2 At least two Qualified Operators must be in the control room at all times during start-up and operation. The Physicist-in-Charge must be in the immediate vicinity at all times during operation. The Physicist-in-Charge must be in the control room during start-up of the AE-6 Reactor.

I.1.3 A maximum of six persons may be present in the control room during operations.

I.1.4 At least two persons must be involved in any fuel handling or loading operation whether it be for loading the AE-6 Reactor core or loading fuel in a subcritical lattice on the thermal column.

I.1.5 No one is permitted in the reactor room or the Exclusion Area when one or more control rods are being manipulated, except for purposes of making radiation surveys. These surveys are made with the reactor held at a power level so that one can make meaningful radiation measurements. One may enter the reactor room or the Exclusion Area if the reactor is held at a steady power of 0.25 watts or less.

I.1.6 Visitors to the facility must sign in and out.

I.1.7 No personnel, including emergency personnel, will be permitted in the controlled area without the specific permission of the Physicist-in-Charge.

I.2 LOG BOOK

I.2.1 The log book must be present at all times during start-up and operation of the AE-6 Reactor.

I.2.2 All entries in the log book must be in ink.

I.2.3 All changes or additions to the log book will be initialed and dated.

I.2.4 Visitors taking data from the log book will initial the page from which data was taken.

I.2.5 The pages will be numbered and no page will be removed.

I.2.6 When a log book is filled it will be stored permanently in the AE-6 Reactor control room.

I.3 STARTUP REQUIREMENTS

I.3.1 A complete instrument check will be made before start-up anytime the reactor has been shut down for more than a few hours. If there has been a complete check earlier the same day, only the scrams need to be checked.

I.3.2 No startup will be made under duress or without sufficient time to complete the run carefully.

I.3.3 Prior to startup the Qualified Operator must verify that the source is in position. This source must remain in place at all times during startup and during the operation of the reactor.

I.3.4 The following instrumentation must be in operation at all

times during startup and operation.

- I.3.4.1 One Vibrating Reed Electrometer
- I.3.4.2 Logarithmic Amplifier (both power and period).
- I.3.4.3 Keithley and Beckman Micro-Micro ammeters
- I.3.4.4 Core pressure Recorder
- I.3.4.5 Temperature Recorder
- I.3.4.6 The Area Monitor in the control room.

RADIOLOGICAL EMERGENCY PLAN
FOR THE AE-6 WATER BOILER REACTOR AND OTHER BUILDINGS
IN THE SUBCRITICAL EXPERIMENTS UNIT

J.1 PURPOSE AND SCOPE

To establish responsibilities and procedures at the AE-6 Reactor Building, Fuel Handling Building and Buildings 030 and 035 in the event of a disaster or other emergency situation which results in a real or potential release of radioactive material or radiation beyond normal enclosures.

J.2 DESIGNATION OF RESPONSIBILITIES

J.2.1 Physicist-in-Charge

The Physicist-in-Charge on duty at the AE-6 Reactor or the most senior alternate available will assume primary responsibility for the general execution of the plan. (A list of alternates by seniority, appointed by the Supervisor of the Subcritical Experiments Unit and approved by the Approval Authority will be posted at the AE-6 and circulated to all interested parties). He will maintain this responsibility unless relieved by his supervision. In particular, the Physicist-in-Charge shall be responsible for:

J.2.1.1 The general safety of personnel in the immediate area.

J.2.1.2 The initiation of the notification system.

J.2.1.3 Any immediate remedial action of a technical nature which involves the reactor and its associated components.

J.2.1.4 The decision to evacuate (consistent with class determination) and the directing of any immediate facility evacuation that may become necessary.

J.2.1.5 Coordination of the efforts of operating personnel during the emergency when established emergency units arrive at the site.

J.2.1.6 The establishment of temporary access controls at his discretion or at the request of the Health Physicist.

J.2.1.7 Preparation of that part of a detailed report on the incident which concerns the cause, equipment damage, costs, extent of remedial measures, and other technical aspects.

J.2.1.8 Notification of Control Center when relieved by supervision. Referral of matters pertaining to the emergency to supervision then in charge.

J.2.2 Responsible Person for Buildings 030(AE-6 Counting Room) and 035 (AE-6 Office Building).

Generally speaking the Supervisor of the Subcritical Experiments Unit of the Reactor Physics Group will assume duties and responsibilities at these two buildings similar to those of the Physicist-in-Charge at the AE-6 Reactor and Fuel Handling Buildings. Specifically he shall be responsible for:

J.2.2.1 The general safety of the personnel in these buildings.

J.2.2.2 The initiation of the notification system.

J.2.2.3 Any immediate remedial action of a technical nature.

J.2.2.4 The decision to evacuate the two buildings consistent with class determination.

J.2.2.5 Coordination of the efforts of operating personnel during the emergency when established emergency units

arrive at the site.

J.2.2.6 The establishment of temporary access controls at his discretion or the request of the assigned Health Physicist.

J.2.2.7 Preparation of that part of a detailed report on the incident which concerns the cause, equipment, damage costs, extent of remedial measures, and other technical aspects.

J.2.2.8 Notification of control center when relieved by supervision. Referral of matters pertaining to the emergency to supervision then in charge.

J.2.3 Health Physicist

The assigned Health Physicist on duty shall assist, as necessary, the Physicist-in-Charge and/or the Supervisor of the Subcritical Experiments Unit in the discharge of the above responsibilities.

J.2.4 Alternates

J.2.4.1 In the absence, or with the inability of the Physicist-in-Charge to discharge his responsibilities, the most senior alternate Physicist-in-Charge at the AE-6 shall assume his position (duties and responsibilities) in the Emergency Plan.

J.2.4.2 If the Subcritical Experiments Unit Supervisor is not available or is unable to discharge responsibilities at Buildings 030 and 035, then the most Senior Person present will assume his duties and responsibilities in the Emergency Plan.

J.2.4.3 In the absence, or with the inability of the assigned Health Physicist to discharge his responsibilities, the senior Health Physicist at the SRE Facility shall be summoned by the Control Center to assume his position in the emergency plan,

until relieved by the site Health Physicist.

J.2.4.4 In the absence of a Physicist-in-Charge or an Alternate Physicist-in-Charge at the AE-6, the person discovering the incident shall be responsible for notifying the KEWB and reporting the emergency to the Control Center at Santa Susana (Ext.44). The assigned Health Physicist or Radiation Engineer, whoever becomes available first, shall discharge all the responsibilities to the best of his abilities. The Physicist-in-Charge will assume responsibilities for operations upon arrival.

J.3 CLASSIFICATION OF EMERGENCIES

J.3.1 Determination

J.3.1.1 AE-6 Reactor Building and Fuel Handling Building. The assigned Health Physicist has the responsibility for the immediate assessment of the radiological hazard. If the Health Physicist is not immediately available, this duty will revert to the Physicist-in-Charge. The class determination may be revised following more extensive surveys by Health Physicis.

The determination is primarily based upon the air contamination readings in the control room, reactor room, and fuel handling building. These activities will be recorded in the control room.

Class II will be declared if the automatic detection apparatus indicates volatile activity in any of the three areas in concentrations exceeding MPC but less than 1000 x MPC.

Class III will be declared if the automatic detection apparatus indicates volatile activity in any of the three areas in concentrations exceeding 1000 x MPC.

Other emergencies will be Class I.

The initial declaration may be increased from the above specifications if the deciding person has reason to believe such a condition exists.

J.3.1.2 Buildings 030 (AE-6 Counting Room Building) and 035 (AE-6 Office Building).

The assigned Health Physicist has the responsibility for the immediate assessment of the radiological hazard. The class determination may be revised following more extensive surveys by Health Physicist in case.

J.4 NOTIFICATION SYSTEM

J.4.1 In the event of an emergency at the AE-6 Reactor Building, the Fuel Handling Building and/or (Buildings 030 and 035), the Physicist-in-Charge and/or (Subcritical Experiments Unit Supervisor) will immediately:

J.4.1.1 Execute any prompt action to maximize personnel safety.

J.4.1.2 Notify KEWB, E.T.B. and SS Storage Building.

J.4.1.3 Notify the Industrial Security Control Center at Santa Susana via the emergency telephone or other provided methods that a Class (I, II or III) emergency has occurred at the AE-6, Fuel Handling Building and Buildings 030 and 035 whichever is affected.

J.4.1.4 Notify the assigned Health Physicist, if he can be contacted, prior to his notification by the Control Center.

J.5 EMERGENCY PROCEDURES

J.5.1 Hazard Assessment

The real magnitude of the potential or existing

radioactivity hazard will not usually be immediately apparent. A thorough radiation survey of the situation should be initiated as soon as possible under the direction of Operating and Health Physics personnel, thereby enabling a more accurate evaluation of the emergency. Such surveys will be conducted utilizing the necessary protective and dosimetric devices as advised by the responsible Health Physicist. The final class determination will be made by the procedures discussed above.

J.5.2 Plan of Action - Emergency at AE-6 or Fuel Handling Building.

J.5.2.1 Class I

J.5.2.1.1 Execute any prompt action to maximize personnel safety.

J.5.2.1.2 Shutdown procedure.

J.5.2.1.2.1)Reactor Running

J.5.2.1.2.1.1)Scram reactor leave instrumentation on.

J.5.2.1.2.1.2) Clear affected area and maintain clear

J.5.2.1.2.1.3) Allow coarse control rod to return to least reactive position

J.5.2.1.2.1.4) Bring safety rod solenoids into contact with rods

J.5.2.1.2.1.5) Shut off power to control rod panel

J.5.2.1.2.1.6) Reactor Instrumentation should be kept in operating order as long as possible.

J.5.2.1.2.2 Reactor Not Running

J.5.2.1.2.2.1) Clear affected area of personnel

J.5.2.1.2.2.2) Assign one person to keep affected area clear.

J.5.2.1.3 Notification (Section V-A)

J.5.2.1.4 Complete analysis of extent and degree of contamination. Initiate, if necessary and feasible, contamination control measures to minimize the spread of radioactivity.

J.5.2.1.5 The primary objective will be confined the radioactivity as much as possible. A radiation and contamination survey will be made around the affected area. If this area is the reactor room, particular attention must be given to the following locations:

J.5.2.1.5.1) Glory hole and graphite stringers.

J.5.2.1.5.2) Concrete block sections of the biological shield.

The utilization of sealing materials, such as masking tape, will be employed to assist in the confinement as necessary.

J.5.2.1.6 Initiate corrective action.

J.5.2.1.7 Written records will be kept throughout the action provided such records will be kept without, in any way, affecting the safety of the personnel involved or the restoration of normal operations.

J.5.2.2 Class II

J.5.2.2.1 Execute any prompt action to maximize personnel safety.

J.5.2.2.2 Shutdown procedure - Scram reactor, leave instrumentation on.

J.5.2.2.3 Notification (Section V-A)

J.5.2.2.4 All personnel should put on respirations, hoods and dosimeters.

J.5.2.2.5 All personnel except the Physicist-in-Charge and the Health Physicist will evacuate to a location designated by the Physicist-in-Charge with the advise of the Health Physicist. This location will automatically be the Control Center unless this is obviously inadvisable. The route to the evacuation point must be chosen in such a manner as to minimize potential exposure and contamination hazards. The Health Physicist and the Physicist-in-Charge may remain in the area in order to assist in emergency procedures, to set up temporary access controls, and to initiate appropriate remedial measures.

J.5.2.2.6 The Physicist-in-Charge will keep the Control Center fully informed of actions being taken.

J.5.2.3 Class III

J.5.2.3.1 Execute any prompt action to maximize personnel safety.

J.5.2.3.2 Shutdown procedure - Scram Reactor (Leave Instrumentation on).

J.5.2.3.3 Notification (Section V-A)

J.5.2.3.4 All personnel should put on respirators, hoods, and high level dosimeters.

J.5.2.3.5 All personnel will evacuate to a

location designated by the Physicist-in Charge with the advise of the Health Physicist. This location will automatically be the Control Center unless this is obviously inadvisable. The route to the evacuation point must be chosen in such a manner as to minimize potential exposure and contamination hazards.

J.5.2.3.6 Re-entry of the AE-6 facility by Health Physics personnel for the purpose of examining the area will be done under fresh-air breathing apparatus and full protective clothing conditions. Portable survey instrumentation will be utilized during re-entry.

J.5.2.3.7 If, upon re-entry, no unusual activity is detected, the Health Physicist will notify Industrial Security that the area may be re-occupied.

J.5.2.3.8 If, upon re-entry, activity is detected, access to the area will remain restricted. Fresh-air breathing apparatus and full protective clothing will be required for entry. Operating personnel may assist the Health Physicist in actions deemed appropriate to effect a reduction of the hazard and subsequent downgrading of this emergency.

J.5.3 Plan of Action - Emergency at Buildings 030 (AE-6 Counting Room) and 035 (AE-6 Office Building)

J.5.3.1 Class I

J.5.3.1.1 Excute any prompt action to maximize personnel safety.

J.5.3.1.2 Clear affected area and assign one person to keep this affected area clear.

J.5.3.1.3 Notification (Section V-A)

J.5.3.1.4 Complete analysis of extent and degree of contamination. Initiate, if necessary and feasible, contamination control measures to minimize the spread of radioactivity.

J.5.3.1.5 The primary objective will be to confine the radioactivity as much as possible. A radiation and contamination survey will be made around the affected area. The utilization of sealing materials, such as masking tape, will be employed to assist in the confinement if necessary.

J.5.3.1.6 Initiate corrective action.

J.5.3.1.7 Written records will be kept throughout the action provided these records can be kept without, in any way, affecting the safety of the personnel involved or the restoration of normal operations.

J.5.3.2 Class II

J.5.3.2.1 Execute any prompt action to maximize personnel safety.

J.5.3.2.2 Notification (Section V-A).

J.5.3.2.3 All personnel should put on respirators, hoods and dosimeters.

J.5.3.2.4 All personnel except the supervisor of the Subcritical Experiments Unit and the Health Physicist will evacuate to a location designated by the supervisor of the Subcritical Experiments Unit with the advise of the Health Physicist. This location will automatically be determined, in advance and marked on the Master Evacuation Route Map for Santa Susana, unless obviously inadvisable.

The route to the evacuation point must be chosen in such a manner as to minimize potential exposure and contamination hazards. The Health Physicist and the Subcritical Experiments Unit Supervisor may remain in the area in order to assist in emergency procedures, to set up temporary access controls, and to initiate appropriate remedial measures.

J.5.3.2.5 The Supervisor of the Subcritical Experiments Unit will keep the Control Center fully informed.

J.5.3.3 Class III

J.5.3.3.1 Execute any prompt action to maximize personnel safety.

J.5.3.3.2 Notification (Section V-A)

J.5.3.3.3 All personnel should put on respirators, hoods and dosimeters.

J.5.3.3.4 All personnel will evacuate to a location designated by the Supervisor and the Subcritical Experiments Unit with the advise of the Health Physicist. This location will have been automatically chosen in advance and be indicated on the Master Evacuation Route Map for Santa Susana. This will be used unless obviously inadvisable.

The route to the evacuation point must be chosen in such a manner as to minimize potential exposure and contamination hazards.

J.5.3.3.5 Re-entry of these buildings (030 and 035) by Health Physics personnel for the purpose of examining the area will be done under fresh-air breathing apparatus and full protective clothing conditions. Portable survey instrumentation will be utilized during re-entry.

J.5.3.3.6 If, upon re-entry, no unusual activity is detected, the Health Physicist will notify Industrial Security that the area may be re-occupied.

J.5.3.3.7 If, upon re-entry, activity is detected, access to the area will remain restricted. Fresh-air breathing apparatus and full protective clothing will be required for entry. Operating personnel may assist the Health Physicist in actions deemed appropriate to effect a reduction of the hazard and subsequent downgrading of the emergency.

J.5.4 Plan of Action - at AE-6 and Fuel Handling Building for Emergencies at Other Facilities

J.5.4.1 Class I

J.5.4.1.1 Emergencies at KEWB, SS Storage Building and E.T.B. The reactor will be shutdown in a normal manner. Standby for further instructions.

J.5.4.1.2 Other facilities - No special action will be taken.

J.5.4.2 Class II or Class III, or Unclassified Emergencies

J.5.4.2.1 Emergencies at either of the following: KEWB, SS Storage Building and E.T.B.

J.5.4.2.1.1 Shutdown procedure-Scram at AE-6 Reactor

J.5.4.2.1.2 All personnel at AE-6, Fuel Handling Building and Buildings 030 and 035 will put on respirators, hoods and dosimeters and evacuate as described in Sections VI-B-3-e and VI-C-3d.)

J.5.4.2.2 Emergencies at other Facilities

J.5.4.2.2.1 Shutdown procedure-Normal

shutdown as time permits.

J.5.4.2.2.2 Standby for further instructions.

J.5.6 Emergencies at AE-6 and Fuel Handling Buildings
with no Initial Classification.

J.5.6.1 Plan of Action - Person discovering
emergency

J.5.6.1.1 Notify, KEWB, Buildings 030 and
035, E.T.B. and SS Storage Building.

J.5.6.1.2 Notify Control Center at Ext. 44.

J.5.6.1.3 Proceed according to own
emergency plans.

J.5.6.2 Plan of Action - Industrial Security (After
notification) To be followed at all hours.

J.5.6.2.1 AE-6, KEWB, Buildings 030 and
035, E.T.B. and SS Storage Building, area via public address
system, "An emergency of unknown classification now exists at
the AE-6". Repeat.

J.5.6.2.2 Notify Radiation Engineer
during day shift or SRE Health Physicist during off hours.
Advise of situation and request further information as to class
determination.

J.5.6.2.3 Upon receipt of classification,
Industrial Security will proceed as described above.

J.5.7 Action at the AE-6 Office Building, Counting Room
and Workshop for Emergencies at Other Facilities

(It is assumed that the Public Address System is the same as that at the AE-6 site)

J.5.7.1 Class I at AE-6, KEWB, SS Storage Vault and E.T.B.

J.5.7.1.1 Notify Supervisor of Subcritical Experiments Unit (The whereabouts of the supervisor when on duty will be known to the Unit Secretary).

J.5.7.1.2 Standby

J.5.7.2 Class II or Class III, or Unclassified Emergency at AE-6 or KEWB. Evacuate to Control Center if feasible or to an alternate site if necessary.

J.5.7.3 Class II or Class III, or Unclassified Emergency at any facility other than the AE-6, KEWB, SS Storage Vault or E.T.B. put on protective clothing and await further instructions.

J.5.8 Special Actions or Instructions

J.5.8.1 Physicist-in-Charge if not at AE-6 facility at time of emergency.

J.5.8.1.1 Class I at AE-6 or KEWB. Return to AE-6 and assume responsibilities as described above.

J.5.8.1.2 Class II or Class III at AE-6. Report to Control Center unless obviously inadvisable and await further instructions.

J.5.8.2 Evacuation

If any evacuation of the facility is ordered, such evacuations will be made under the direction of the responsible person. No private or company vehicles in the facility area will be utilized for the purpose.

J.5.8.3 Personal Option

No personnel shall be asked to remain in the immediate area against their will.

J.5.8.4 Access Controls

The radiation control gate at the entrance to the KEWB facility shall be closed as soon as practicable during any emergency. Additional controls will be established by operating personnel at the direction of the Health Physicist until this duty is assumed by Industrial Security.

J.5.8.5 Remedial Measures

J.5.8.5.1 During a Class I emergency the Operating personnel may undertake any remedial measures deemed appropriate by the Physicist-in-Charge and/or Supervisor at Buildings 030 and 035, with the approval of the Health Physicist.

J.5.8.5.2 Subsequent to evacuation in either a Class II or Class III emergency, the Health Physics personnel in control will attempt to establish the magnitude and geographical limits of the hazardous areas. The Operating personnel will make themselves available to the Health Physics Group for these purposes.

J.5.8.6 Staging Area

The Industrial Security group will establish a staging area at the earliest possible time. The staging area location will be determined by the Health Physicist. Industrial Security personnel will furnish the Health Physicist with a list of supplies available from emergency reserves at the accessible areas. Those supplies, e.g., coveralls, shoe covers, respirators, fresh-air breathing

apparatus, gloves, boundary markers, survey equipment, plastic suits, earthmoving tools, etc., designated by the Health Physicist in charge will be transported by Industrial Security to the pre-selected staging area. The staging area will also be utilized to collect used and contaminated apparatus and garments.

J.6 EMERGENCY SUPPLIES

J.6.1 Depot

A complete store of emergency supplies will be partly shared with the KEWB and partly kept in the AE-6 counting room area. These supplies will be used until it can be determined if those routinely stored in the reactor room can be safely utilized.

J.6.2 The following supplies will be stored at the AE-6 Building:

- J.6.2.1 Coveralls - 10 pair
- J.6.2.2 Shoe covers - 10 pair
- J.6.2.3 Respirators - 10 (assault masks)
- J.6.2.4 Gloves, cotton - 10 pair
- J.6.2.5 Gloves, rubber - 10 pair
- J.6.2.6 Head covers, cloth - 10 pair
- J.6.2.7 Juno - high range
- J.6.2.8 Hi-range, personnel film - 5
- J.6.2.9 Hi-range, dosimeters - 5
- J.6.2.10 Flashlight - 3
- J.6.2.11 Wire cutters
- J.6.2.12 Sledge hammer
- J.6.2.13 Jack knife

J.6.3 The following supplies will be stored at the KEWB facility:

- J.6.3.1 Hi-volume (staplex) air sampler - filter paper
- J.6.3.2 Self-powered air sampler
- J.6.3.3 Rope - 500 feet
- J.6.3.4 Stakes, wood - 1" x 1" x 3' - 200
- J.6.3.5 Wire (for barrier marking) - 500'
- J.6.3.6 Radiation warning signs - 10
- J.6.3.7 Radiation warning tags - 100
- J.6.3.8 Complete plastic suit - 2
- J.6.3.9 Air supply mask and tank - 2
- J.6.3.10 Plastic boxes (with blank labels) - 25
- J.6.3.11 150' extension cord
- J.6.3.12 Stretcher
- J.6.3.13 Axes - 2
- J.6.3.14 Masking tape - 2" width (4 rolls)
- J.6.3.15 Polyethylene sheeting - 3' width (one 50' roll)

J.6.4 The following supplies will be stored at the breeze-way between buildings 030 and 035.

- J.6.4.1 15 red lined lab coats
- J.6.4.2 15 hoods
- J.6.4.3 15 pair shoe covers
- J.6.4.4 15 pair rubber gloves
- J.6.4.5 15 pair cotton gloves
- J.6.4.6 1 roll of plastic tape
- J.6.4.7 15 respirators assembled and polyethylene bags.
- J.6.4.8 dosimeters (10)

J.7 TEST TRIALS OF EMERGENCY PLAN

Periodic test of the emergency plan are essential in order to establish and maintain the effectiveness of the procedures.

J.7.1 The Director of Industrial Security and the Group Leader of Reactor Physics shall initiate the test by telephoning the Physicist-in-Charge at the AE-6 (Supervisor at Buildings 030 and 035) and informing him of a test. Such tests are covered in detail in the Master Plan.

J.8 MODIFICATIONS OF EMERGENCY PLAN

Changes in the emergency plan may be made upon the agreement of the Director of Industrial Security with the Approval Authorization. Such changes must be reviewed by the Research Reactor Hazards Review Committee.

APPENDIX K
INSTRUMENT SETTINGS

This appendix will contain currently correct instrument settings for normal operations. Those settings which are variable (bias settings, scram set-points, and the like) and will be determined from time to time at the discretion of the Physicist-in-Charge. These are now being investigated. New pages for this appendix will be distributed internally as needed.

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