SAFETY ANALYSIS REPORT

FOR THE

LOW POWER REACTOR ASSEMBLY

DEPARTMENT OF NUCLEAR ENGINEERING

UNIVERSITY OF ILLINOIS

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TABLE OF CONTENTS

LIST OF FIGURES

SECTION I. INTRODUCTION

The Low Power Reactor Assembly (LOPRA) is an assembly of aluminum and stainless steel clad TRIGA fuel elements, in a rectangular array, located in the bulk shielding tank of the Illinois Advanced TRIGA Reactor. This assembly is coupled neutronically to the Illinois Advanced TRIGA by a thermal column consisting of a lead sheet and graphite. In the steady state mode, the power level of the LOPRA is limited to 10 kW. However, the normal operating power level is less than 100 watts.

Control of the power level of the LOPRA is accomplished by a poison rod worth approximately $1.20. This rod is driven by a motor, operated from the control panel. There are two safety control rods (held by electromagnets) worth approximately $3.00 and $5.00 respectively, which are used for scramming the LOPRA. In normal operation the two safety control rods are completely removed from the LOPRA and the poison rod used to control the power.

The LOPRA is used to study the steady state and transient coupling between it and the Illinois Advanced TRIGA. This involves steady state measurements of the power level of one reactor as a function of the power level of the other. Measurements of the spatial variation of the flux in the LOPRA are also made. For transient measurements, the Illinois Advanced TRIGA is pulsed both from a subcritical and a low power critical state with the LOPRA critical and at power levels not exceeding 100 watts. Measurements of the time and spatial variations of the flux in the LOPRA are made during the pulse.

The LOPRA is also used for approach to critical experiment where fuel is removed from the LOPRA core and then loaded back into the core and 1/M calculations are made to predict when criticality will be achieved.

The LOPRA is also used for the purpose of determining control rod worth by subcritical multiplication. Both of the experiments have been performed many times of the years by Nuclear Engineering students.

The primary safety factor of the LOPRA is the prompt negative temperature feedback of the TRIGA fuel, which limits the power level. The excess reactivity in the LOPRA is limited to 60 cents maximum which limits the steady state maximum power level of the LOPRA to 58 kW.

Much experience has been gained at the University of Illinois in the coupling of two assemblies and the use of TRIGA fuel. A subcritical assembly having the same fuel and lattice as the LOPRA has been operated in the same position in the bulk shielding tank during pulsing of the Illinois Mark II TRIGA(1). A light-water natural uranium subcritical assembly has been pulsed in the bulk shielding tank (2). A heavy water natural uranium subcritical assembly has been pulsed using the main Graphite Thermal Column of the reactor(3). The University used aluminum clad fuel for seven years in the Illinois Mark II TRIGA reactor at powers up to 250 kW and pulses up to $3.00 or 1000 MW peak power using natural convection cooling. General Atomics experiments with TRIGA fuel show it to be safe for much more severe operating conditions than will be encountered in the LOPRA.

The LOPRA is intended primarily for educational applications. Consequently a utilization license will be requested for a period of 10 years.

The information to be presented in this report combines General Atomic Reports on Various TRIGA reactors with experience on the Illinois Mark II TRIGA and analysis of the Illinois Advanced TRIGA.

SECTION II. SITE

The LOPRA will be located in the same building as the Illinois Advanced TRIGA. Information on the site is contained in Section II of the "Safety Analysis Report for the Illinois Advanced TRIGA."(4).

SECTION III. REACTOR ASSEMBLY

III.A DESIGN BASIS

III.A.1 TRIGA Objectives

The basic design criteria for a TRIGA reactor are given on pages III-1 to III-6 of the "Safety Analysis Report for the Illinois Advanced TRIGA."(4)

III.A.2 LOPRA Objectives

The important consideration in the design of the LOPRA is to utilize the coupling through the bulk shielding thermal column of the Illinois Advanced TRIGA to drive a low power reactor. To obtain the measurements which are desired, it is necessary to have a critical assembly with an unperturbed, uniform lattice structure.

III.A.3 Limits Imposed by Design

To obtain an unperturbed reactor system, the design of the control system is such that the unit cell structure of the fuel elements is retained when the control rods are removed. Thus the control rods are situated in spaces between the fuel elements.

The limited amount of external shielding which is available for the critical assembly in the bulk shielding facility places a restriction on the steady-state power level of the system. This is due to the expected radiation levels in the area. This limit and the desire for an unperturbed flux combine to necessitate a small upper limit on the amount of excess reactivity in the assembly. As stated in the introduction, the excess reactivity will be limited to thirty cents.

III.B DESCRIPTION OF THE LOW POWER REACTOR ASSEMBLY

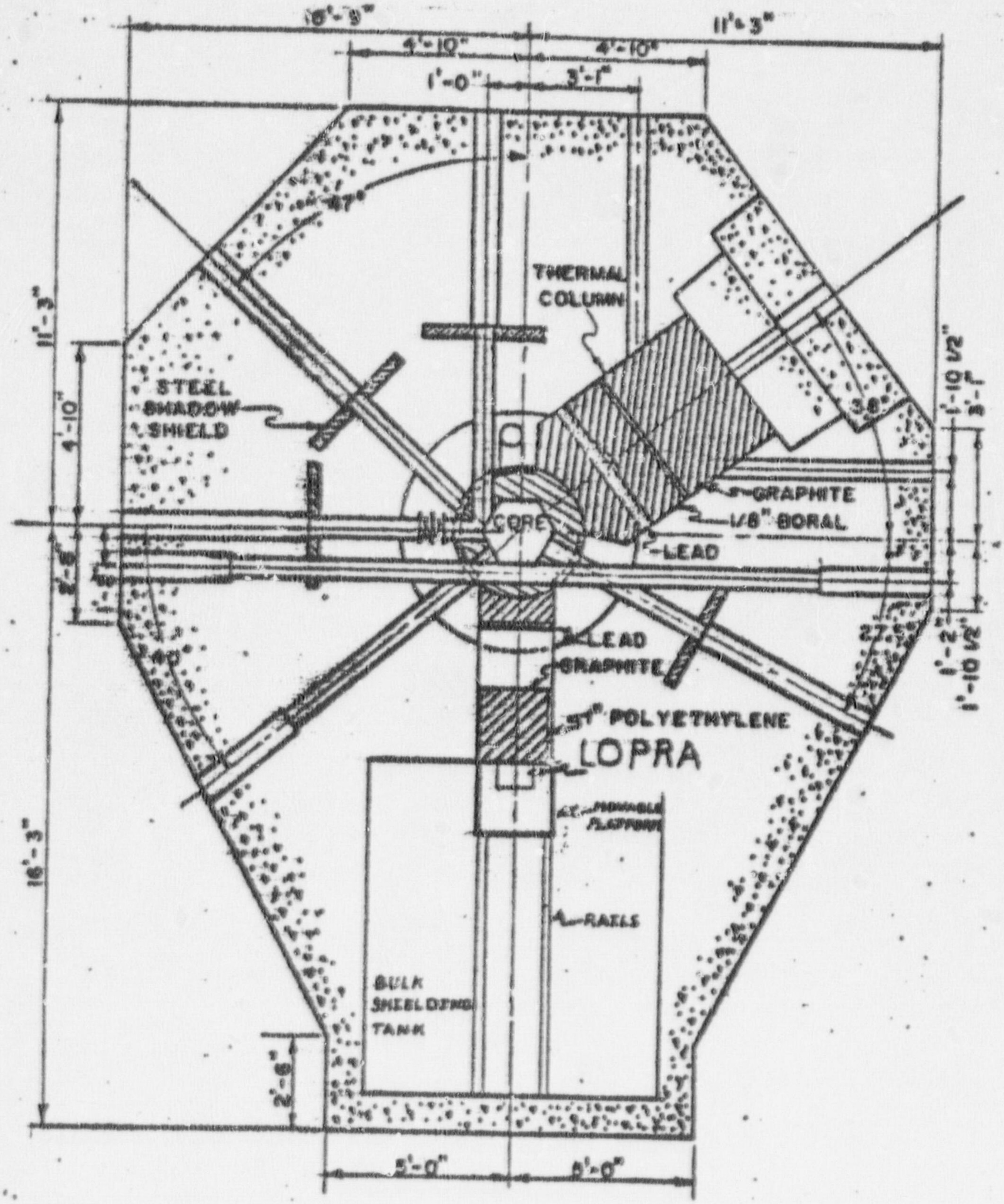
III.B.1 General Description

The Low Power Reactor Assembly consists of a rectangular array of aluminum alloy fuel elements located against the thermal column in the bulk shielding tank of the Illinois Advanced TRIGA. The LOPRA also has a graphite reflector which is located on either side of the core and perpendicular to the thermal column. The location of the LOPRA relative to the Illinois Advanced TRIGA

is shown in figure 1.

Figure 2 is a diagram of the horizontal cross-section through the thermal column. The thermal column is about 4 1/2 feet long with a 2 by 2 feet square cross-section. It is encased in an aluminum container lined with boral. The thermal column is adjacent to the section of the Illinois Advanced TRIGA reflector that has the through beam port in it. In sequence from the Illinois Advanced TRIGA reflector edge, the thermal column is composed of 8 inches of graphite, a 2-inch slab of lead, 19 inches of void followed by 2 feet of graphite up to the face of the bulk shielding tank. The portion of the column containing 2 feet of graphite is lined with polyethylene to provide a greater albedo and to increase the thermal neutron flux available at the end of the column.

The support and grid plates used in the previous subcritical assembly experiments[1] will be used for the LOPRA. The fuel elements are supported by two rectangular grid plates made of 0.75 inch tempered aluminum. They are held 6 inches apart by aluminum rods.



Section of beam port level.

Fig. 1 Cross Section Plan View showing location of the LOPRA and the Illinois Advanced TRIGA

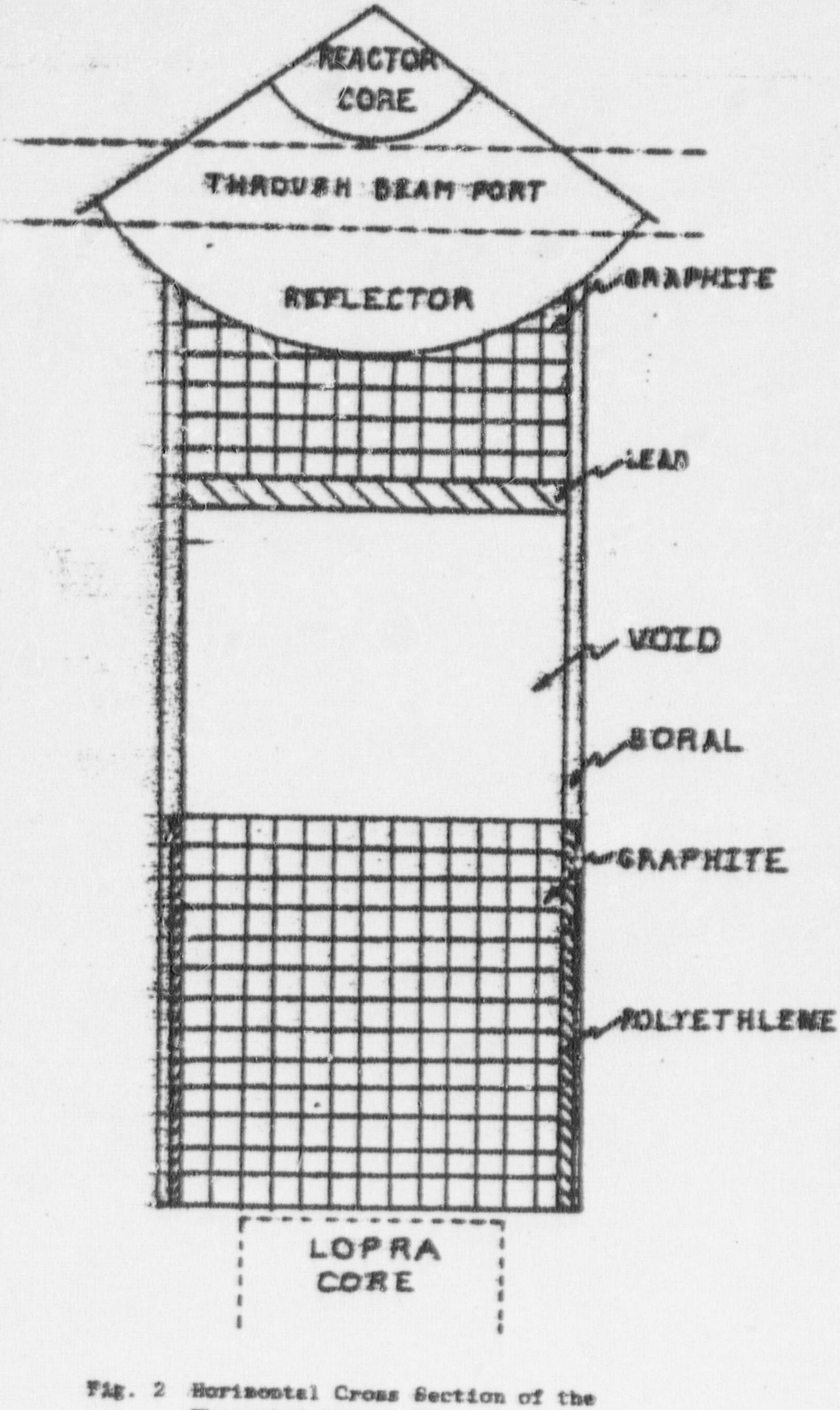


Fig. 2 Horizontal Cross Section of the Thermal Column

The grid plates are 20 5/8 by 16 1/4 inches. The top grid plate has 1.5 inch diameter holes with a 1.625 inch center-to-center spacing. The bottom grid plate has 0.28 inch diameter holes with the same spacing and are machined to receive the lower-end-fixtures of the fuel elements. The fuel portion of the element is completely above the grid plates. The graphite reflectors are two solid pieces of graphite clad in aluminum, which occupy the first two and last two columns of the core.

The LOPRA is located on a raised movable platform so that its center is in line with the center of the graphite thermal column. The platform allows for the movement of the assembly to and from the thermal column. The platform is moved by use of a winch, which can be locked with a padlock, located at the end of the bulk shielding tank.

III.B.2 Fuel

The basic core of the LOPRA is composed of aluminum clad elements. Some stainless clad elements of the type used in the Illinois Advanced TRIGA and/or Sandia Annular Pulse Reactor can be added in the outside rows to obtain the desired reactivity. The stainless clad fuel elements used in the Illinois Advanced TRIGA are described in the Section III of the "Safety Analysis Report for the Illinois Advanced TRIGA."[(4)] These elements have the same percent U-235 loading as the aluminum elements but with a higher hydrogen to zirconium ratio in the zirconium hydride moderator. The stainless clad elements used in the Sandia Annular Pulse Reactor have a higher percent U-235 loading than the other two element types and a hydrogen to zirconium ratio about the same as the Illinois Advanced TRIGA elements. The Sandia Annular Pulse Reactor elements and their characteristics are described in various Sandia and General Atomics Reports [(5,6)]. The stainless elements can withstand more severe conditions than the aluminum ones, and their use on the outside of the core should not significantly affect the neutronic characteristics of the LOPRA. The aluminum clad fuel elements used for the basic core are described below.

Figure 3 shows a typical aluminum clad fuel element. Each element is 1.47 inches in diameter by 28.44 inches long. The fuel portion of the element is 14 inches long with 4 inches of graphite on each end. Each element contains 8% U-235 (about 36 grams per element). Fifty-two of these fuel elements were obtained in 1966 from the Armed Forces Radiobiology Research Institute where they were used in their TRIGA reactor and an additional four were obtained from Cornell University. The fuel burnup was less than 0.7% when received and they have been used in a subcritical assembly here so that the additional burnup is negligible. All of these elements have been tested to assure that the cladding is still intact to insure that no fission products can escape.

In 1985, 11 stainless steel clad fuel elements were obtained from Northrup Corp.

III.B.3 Lattice

Approximately 55 fuel elements are needed to make the LOPRA critical. The basic array will be a rectangular block in the rectangular grid plates described earlier in this section. The final elements needed to obtain the desired reactivity will be located along the edge of the basic rectangular lattice. The elements may be repositioned to adjust the excess reactivity in the LOPRA. Graphite dummy elements may also be located along the edge of the rectangular lattice to adjust reactivity.

III.B.4 Control Devices

The LOPRA has two safety control rods each with a negative reactivity worth $3.00 and $5.50 respectively. These are withdrawn during operation. The LOPRA power will be controlled by a motor driven poison rod with a

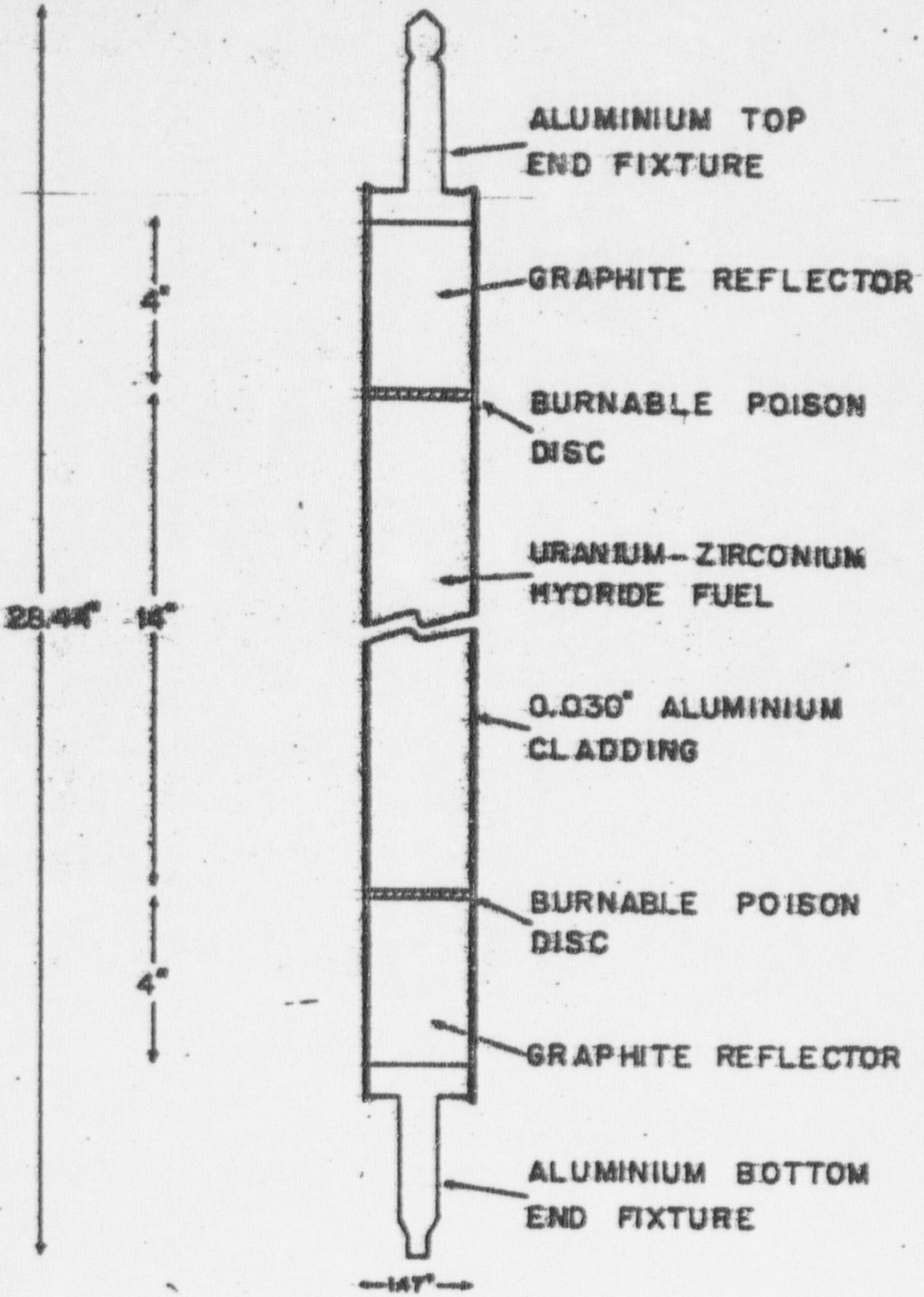


Fig. 3 Standard Aluminum Clad Fuel Element

negative worth of approximately $1.20. The safety system will include two steady-state power level scrams, an nv scram for operation when the Illinois Advanced TRIGA is pulsed, and two manual scrams.

The two safety rods are dropped into the assembly by gravity when a scram occurs. The rods will be held by electromagnets, which will be deenergized for scrams and when the system is shutdown. The rods may also be raised or lowered by hand. The manual scram switches will be located in the control room and next to the bulk shielding area.

III.B.5 Instrumentation

There will be two main systems of instrumentation during experimental runs. One system is for continuous monitoring of the LOPRA and the other for gathering the experimental data. One of the monitoring instruments is connected to a continuous recorder for a permanent record of the operation.

The monitoring instrumentation consists of one BF_3 tube for start-up, one ionization chamber located next to the LOPRA, and one area radiation monitor located above the bulk shielding tank to monitor γ's from the assembly. The γ-counter and the ion chamber are used to monitor the power level and will be connected to the scram system of the LOPRA. The recorders and meters connected to the monitoring instruments are located in a rack in the main control room of the Nuclear Reactor Laboratory.

The power level scrams during steady-state operation of the LOPRA come from signals from the q-counter and the ion chamber. The nv scram during times when the Illinois Advanced TRIGA is pulsed will be obtained from a signal from the ion chamber. The γ-counter is in the water level occurs when the LOPRA is in operation.

III.B.6 Control Panel

The control panel for the LOPPA will be located in the main control room of the Nuclear Reactor Laboratory. This panel contains the controls for moving the poison rod, the meters and recorders for the monitoring instrumentation, and a manual scram.

III.C. REACTOR DESIGN EVALUATION AND ANALYSIS

III.C.1 Fuel Performance and Properties

The inherent safety of TRIGA fuel is gained by the prompt negative temperature coefficient. The temperature coefficient is of sufficient size that the power level and fuel temperature are limited by the amount of excess reactivity in the reactor. The relationships between the equilibrium reactor power level and the fuel temperature is shown in Figure 4. The relationship between the equilibrium power level and the reactivity insertion is given in Figure 5. These curves are for the aluminum clad fuel. Very little difference can be noted if stainless steel clad elements are used as shown by the same relationships on pages III-28 and III-29 of the "Safety Analysis Report for the Illinois Advanced TRIGA."(4)

The steady-state operation of the LOPRA is on the lower end of these curves because of the limitation on the excess reactivity and the steady-state power level. The peak fuel temperature will be less than 80°C which is well below the safety limitations of this parameter.

III.C.2 Coupling of Reactor Systems

The coupling between the LOPRA and the Illinois Advanced TRIGA reactor refers only to the effects of utilizing the neutrons in the thermal column as a source for altering the power level of either reactor. In general, the neutrons in the thermal column generated from operating the Illinois Advanced TRIGA, will be used to drive the LOPRA. These effects are measured for both

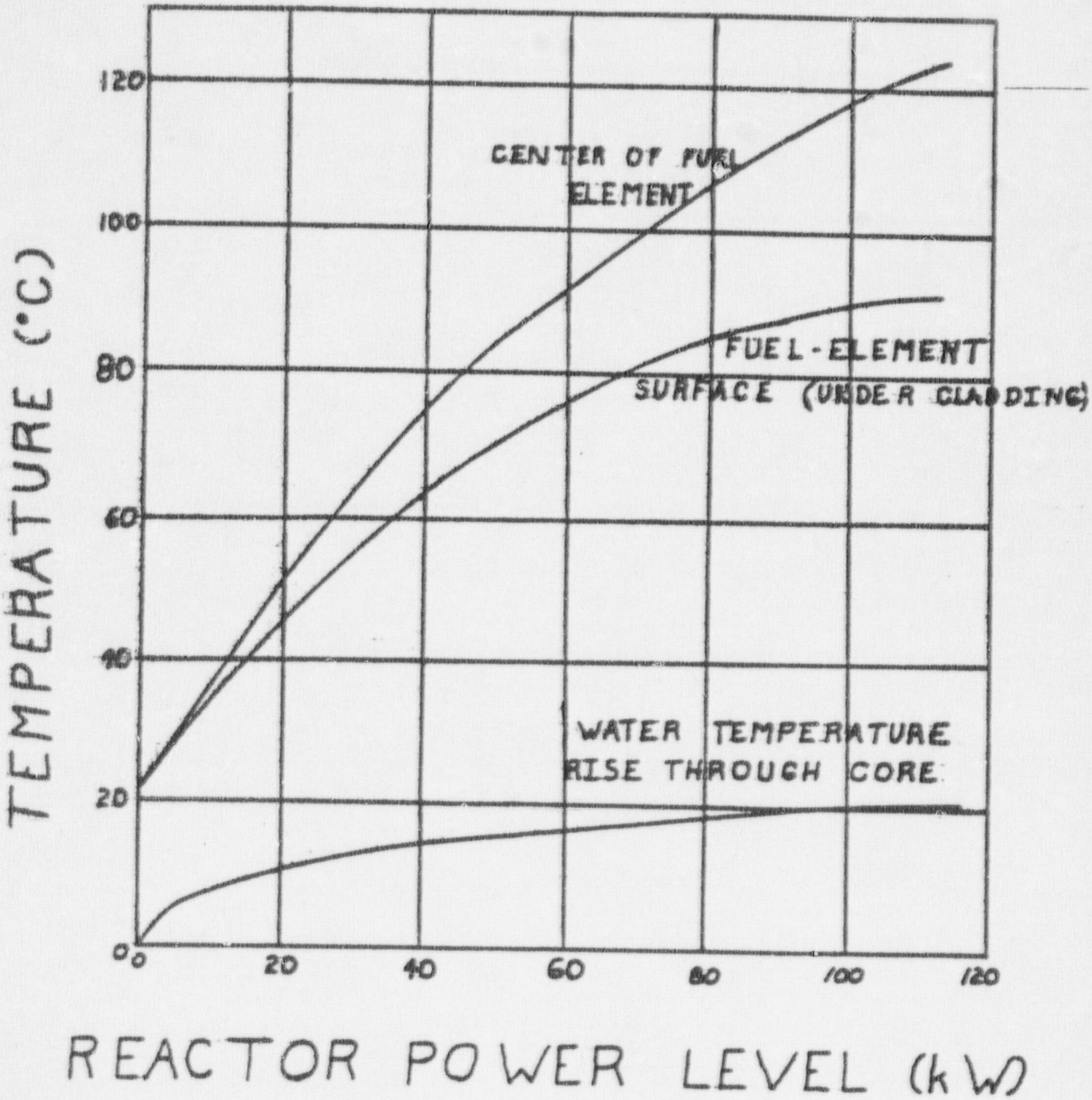


Fig. 4 Reactor Temperatures as a Function of Power Level for TRIGA Fuels

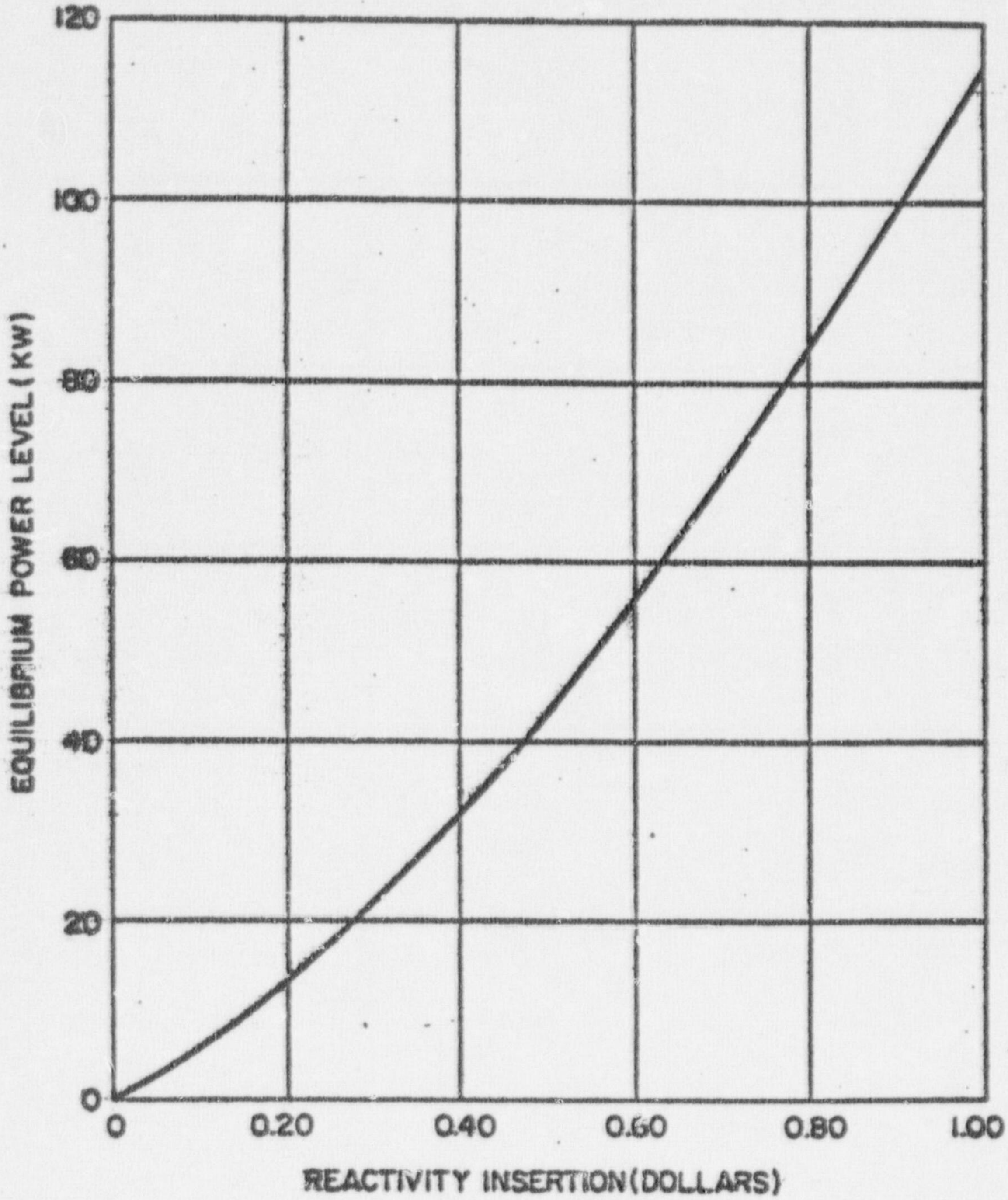


Fig. 5 Equilibrium Reactor Power as a Function of Reactivity Insertion in Excess of Cold Clean Critical

steady-state and pulsed operation of the Illinois Advanced TRIGA. The reactivity effect between the two systems is small. In previous operations with a subcritical assembly of TRIGA fuel elements in the bulk shielding facility ($k_{eff} = 0.95$), no reactivity effects on the Illinois Mark II TRIGA could be detected.

The power level of the LOPRA is affected by the power level of the Illinois Advanced TRIGA. These levels have been calculated for both stead-state and pulsed conditions and are shown by Figures 6 and 7. Figure 6 shows the power level that would be attained in the LOPRA due to operating the Illinois Advanced TRIGA in its higher power ranges. Calculations have been made for various critical conditions of the LOPRA.

Figure 7 shows the peak power levels expected in the LOPRA when the Illinois Advanced TRIGA is pulsed to various peak power levels. As in the case for the steady-state condition, calculations have been made for various critical conditions of LOPRA. The basic measurements are made with LOPRA critical at a low steady-state power (less than 100 watts) when it is hit with the neutron burst resulting from pulsing the Illinois Advanced Triga. The burst will be short enough so that only prompt neutrons will be produced in the time of the pulse. Since the multiplication of neutrons in the LOPRA is only due to prompt neutrons, the multiplication will be the same as the steady state multiplication of an assembly that is $1.00 subcritical. Using this assumption, calculations for Figure 7 were run and gave a peak LOPRA power of 0.8 MW for a peak pulse power of 7000 MW. The nvt of the LOPRA is expected to be less than 10 kW-seconds.

The LOPRA pulse will not produce a reflected pulse large enough to have any effect on the Illinois Advanced TRIGA. This is so because the pulse width in the Illinois Advanced TRIGA is wide enough (15 msec) so that the time the

COUPLED POWER LEVELS

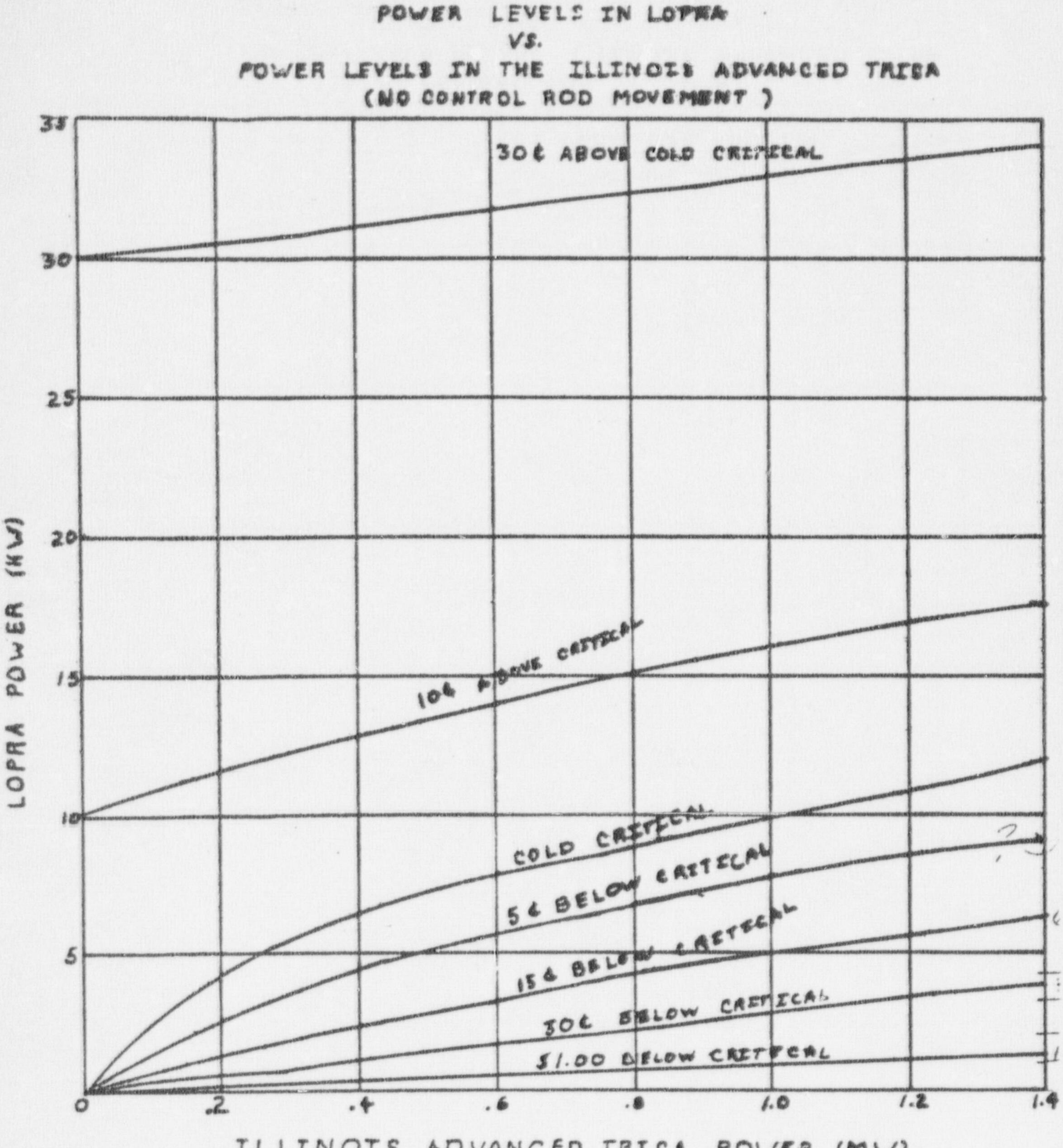


Fig. 6 Power Level in the LOPRA for Various Reactivity Conditions as a Function of the Illinois Advanced TRIGA Power Level

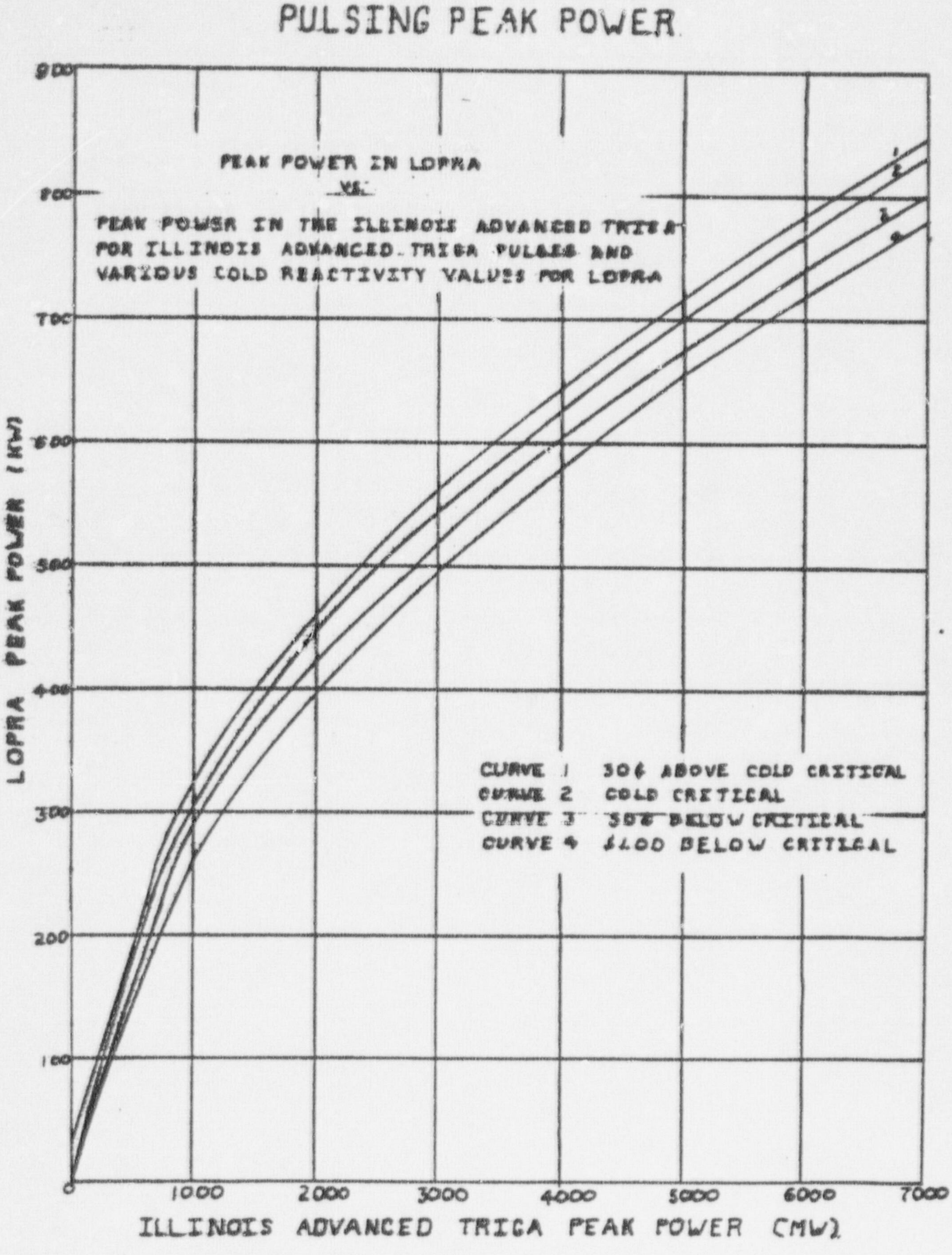


Fig. 7 Peak Pulse Power in the LOPRA for Various Reactivity Conditions as a Function of the Peak Pulse Power of the Illinois Advanced TRIGA

reflected pulse returns (7 msec) to the Illinois Advanced TRIGA it will still be at a high power and subcritical. Thus the introduction of the neutrons from the LOPRA, which are attenuated by a factor of 10^4, will not be large enough to affect the Advanced TRIGA flux.

III.C.3 <u>Reactivity Values</u>

III.C.3.a <u>Fuel Elements</u>

The rectangular lattice for the fuel elements was designed to obtain the same water to fuel ratio (30-35% water) as that found in other TRIGA cores. This water ratio is used to obtain optimum moderation and to assure that the system will be subcritical if voids occur in the core region. As a result, the reactivity worths of the fuel elements will also be similar to other TRIGA cores.

The reactivity worths of individual elements is estimated to vary from $0.20 to $1.50 depending on their distance from the geometrical center of the array. Accurate measurements of the reactivity worth fuel elements can only be obtained for those in the outer periphery because of the limitation on the excess reactivity. The reactivity worths of fuel elements in the outer rectangle may vary by a factor of two due to the difference in the distance to the center of the core.

III.C.3.b <u>Experiments</u>

Experiments with large reactivity worths will not be utilized in the core region because of the desire to maintain a smooth flux profile with minimal perturbation in the core. It is anticipated that gadolinium or cobalt wires will be used to make the desired measurements in the core region during operations. The reactivity worth of these devices is estimated to be less than 10 cents.

III.C.3.c Movement of Assembly

Since the assembly is located adjacent to the bulk shielding thermal column as shown in Figure 1, graphite will serve as a reflector and will have an effect on the reactivity. It is estimated that this worth will be a positive 20 cents. As a result, any movement of the assembly will reduce the reactivity of the system.

III.D SAFETY LIMITS

III.D.1 Fuel

III.D.1.a Operating Levels

The safety limit for aluminum clad TRIGA fuel elements is based on a fuel-moderator temperature where a phase change occurs in the zirconium hydride.[7] This temperature is about 550°C. For a TRIGA system this corresponds to a steady-state operating level of over 1.0 megawatt (natural convective cooling) and a peak power of about 1,000 megawatts for a pulse. The safety limit for stainless steel clad elements is considerably higher than the above values since no phase change occurs with the larger hydrogen content.

As a result, if the power should reach a level of 10 kilowatts for steady-state operations or a peak power of 10 megawatts when the system is pulsed by the Illinois Advanced TRIGA, there will be no detrimental effect on the integrity of the fuel.

III.D.1.b Loss of Water

If an instantaneous loss of water occurs in a TRIGA core following a long term operation, the fuel temperature will exceed the level during the operation because of the poorer cooling mechanisms. Although the reactor would become subcritical, the gamma heating from fission products will cause the temperature to increase. Previous calculations[8] show that such long term operations would have to exceed 200 kilowatts for the fuel temperature to reach the 550°C of the previous section. Although the possibility of losing the water in the bulk shielding facility is remote, such an occurrence would not endanger the integrity of the fuel.

III.D.2 Radiation Levels

The limiting conditions to be imposed on the operating levels of the LOPRA result from the amount of external shielding rather than any possibility of fuel damage. The selection of maximum operating levels on this basis becomes one of judgment in assuring that a dangerous radiation level is never reached and that adequate controls are available should radiation levels occur where immediate action is required.

The measured dose rates at various places around the bulk shielding facility the LOPRA operating at 100 watts are given by Figure 8. These are:

Region	Dose Rate (mR/hr)
Water surface above assembly	24
Six feet above water surface	12
Three feet above floor at end of bulk shielding tank	4
On reactor deck above the assembly	6

It is estimated that for a pulse where the LOPRA power level reaches a peak of 1 MW, the integrated dose would be equivalent to 10 watt-hrs of steady state operation. The above values were determined from measured values 8 feet above the core of the Illinois Mark II TRIGA Reactor. These values are equivalent for those reported in Amendment No. 6 for the facility license R-69[1].

The operation of the LOPRA is regulated to assure compliance with the provisions of 10 CFR 20 regarding restricted and unrestricted areas and

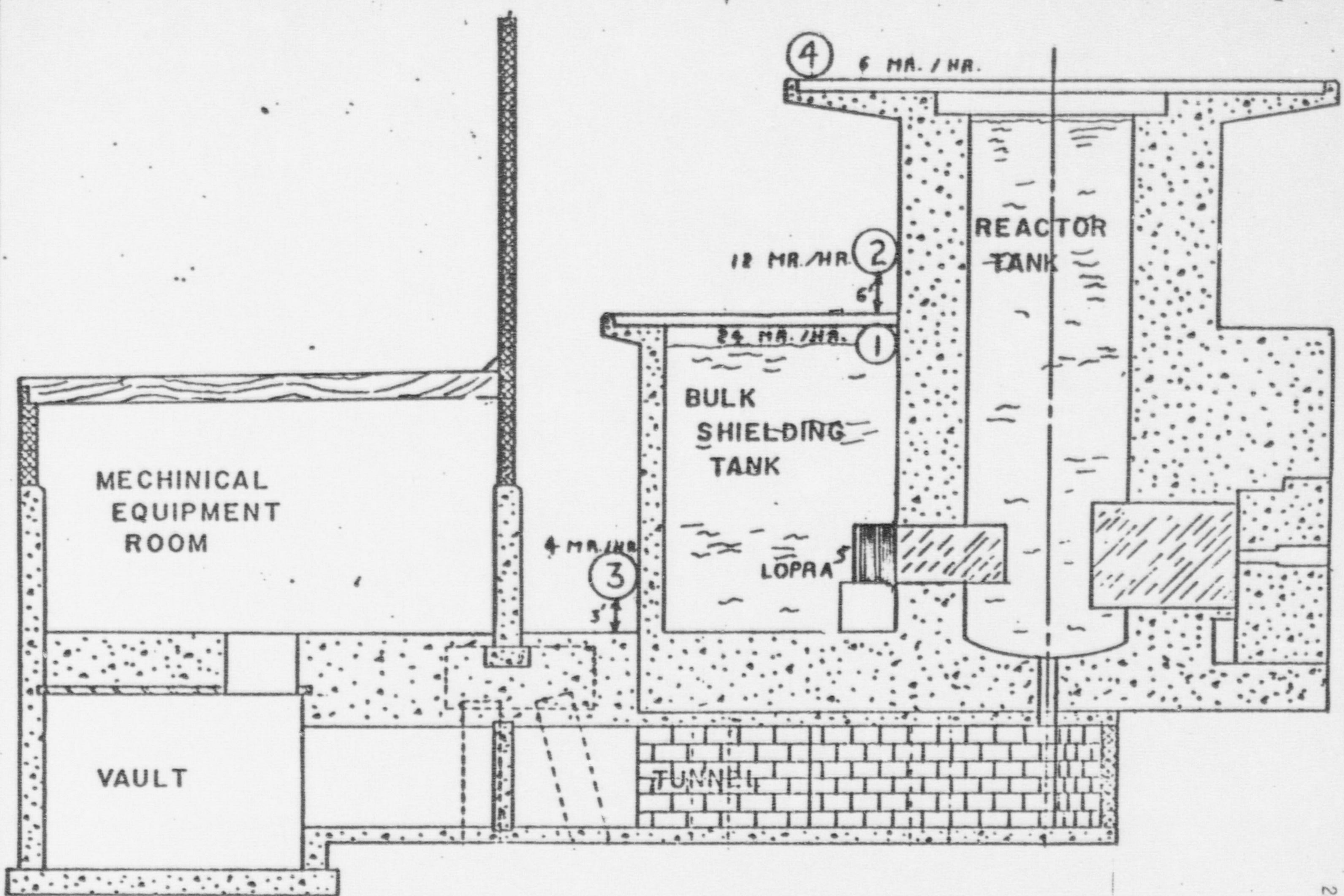


Fig. 8 Dose Rates at Various Locations for a LOPRA Power Level of 100 Watts

personnel exposure. From the above, a maximum safety system setting on the power level during steady-state operation has been selected at 10 kilowatts and the peak power, resulting from pulsed operation of the Illinois Advanced TRIGA, has been set at 10 megawatts. The normal operating power levels of the assembly will be considerably less than these values.

III.E <u>TESTS AND INSPECTIONS</u>

The reactivity worths of the control rods is measured routinely twice a year and recorded. These values have been consistent over the years of operation of the LOPRA. The reactivity worths of measuring devices placed in the core region are measured and recorded in the permanent log record. These reactivity worths are checked when the device is initially used in the core region.

Periodic checks on the safety control rods, poison rod and fuel are made to assure that there is no evidence of corrosion or deformation. The operational procedures and the daily pre-operations checks are given in Section XIII.

SECTION IV. COOLING

Because the LOPRA has a low power output and is located in the bulk shielding facility which contains about 6000 gallons of water, no external cooling is required. Thermal energy balances for the system predict that the bulk water temperature in the tank will increase about 0.05°C for each kW-hr of operation and about 0.0005°C for the integrated power as a result of a pulse by the Illinois Advanced TRIGA. Both are negligibly small for the operating power levels of the LOPRA.

During both steady and pulsed operation the core region of the lopra will be cooled by the free convective flow of water in the bulk shielding facility. The core design presents minimum flow restriction which enhances the free convective flow through it.

SECTION V. CONFINEMENT

The LOPRA is located in the University of Illinois Nuclear Reactor Laboratory. The building and its confinement is described in Section V of the "Safety Analysis Report for the Illinois Advanced TRIGA."(4)

SECTION VI. ENGINEERED SAFEGAURDS

The building exhaust filter system, designed for the Illinois Advanced TRIGA and described in Sections V and VI of the "Safety Analysis Report for the Illinois Advanced TRIGA,"(4) functions as a safegaurd should any release of radioactivity occur from the LOPRA. Additional safegaurds are not required.

SECTION VII. INSTRUMENTATION AND CONTROL

The instrumentation and control system of the LOPRA was designed to provide information on the power level, control of the power level, and adequate safety systems to assure that the system can be shutdown under all conditions. The excess reactivity limitation gives and inherent control over the rate at which power might change and places an upper limit on the other operating parameters. This limitation plus the small degree of coupling between the LOPRA and the Illinois Advanced TRIGA assures that the integrity of the fuel elements will not be endangered.

VII.A DESIGN BASIS

VII.A.1 Power Level

The system provides accurate information on the power level of the LOPRA during start-up and operation of the facility. The system has provisions for initiating a reactor scram should the power level of the LOPRA cause excessive radiation levels in the Reactor Laboratory.

VII.A.2 Power Level Control

Provisions are available for adjusting the power level to a desired value.

VII.A.3 Control Rods

Control rods with scarm capabilities are provided to assure that the reactor can be shutdown under all conditions. Sufficient control is provided to assure a subcritical condition results if one of the control rods failed to drop.

VII.A.4 Radiation Protection

Radiation monitors are located in the vicinity of the assembly to give an early warning of abnormal levels. Additional monitors are in the laboratory to serve as protection to personnel in the building.

VII.A.5 Scrams

In addition to the protection served by the power level scrams manual scrams are provided to assure that appropriate action can be taken by individuals in charge of the operation. The scram logic is such that the system is fail-safe and that a single incident cannot remove all of the scrams from the system.

VII.B SYSTEM DESIGN

VII.B.1 Power Level

The power level instrumentation will consist of a BF_3 tube and associated circuitry for start-up, an ion chamber whose output is connected to a recording device, and a γ-chamber located directly above the reactor assembly. The ion chamber and γ-chamber give readings of the power level during steady-state operations of the LOPRA and any effects that occur from operating the Illinois Advanced TRIGA at high steady-state power levels. When the Illinois Advanced TRIGA is pulsed, the ion chamber will be connected to a circuit to indicate the peak power of the LOPRA.

Reactor scrams can be initiated by either the signal from the ion chamber or the γ-chamber. During pulsing of the Illinois Advanced TRIGA, the signal from the ion chamber will initiate a scram if the peak power is higher than a preset value. The γ-chamber would cause a scram during pulsed operation of the Illinois Advanced TRIGA if the power level of the LOPRA should remain at a high steady-state value.

VII.B.2 Power Level Control

The power of the LOPRA is controlled by a motor driven poison rod worth approximately $1.20. The motor is operated from the panel in the control room. The speed of the rod will be limited so that the maximum rate at which it can be withdrawn from the core is 1/2 in./sec. This will give a reactivity change of about 4 cents/sec. at the mid-position of the rod. Figures 9-11 show various aspects of the poison rod assembly.

The poison rod consists of a watertight hollow aluminum pipe with a sheet of cadmium rolled in it, and enough lead in the bottom to keep it from being buoyant. The rod is 1/2 inch in diameter and 20 inches long. It goes in the space between 4 fuel elements, these elements acting as a guide. The

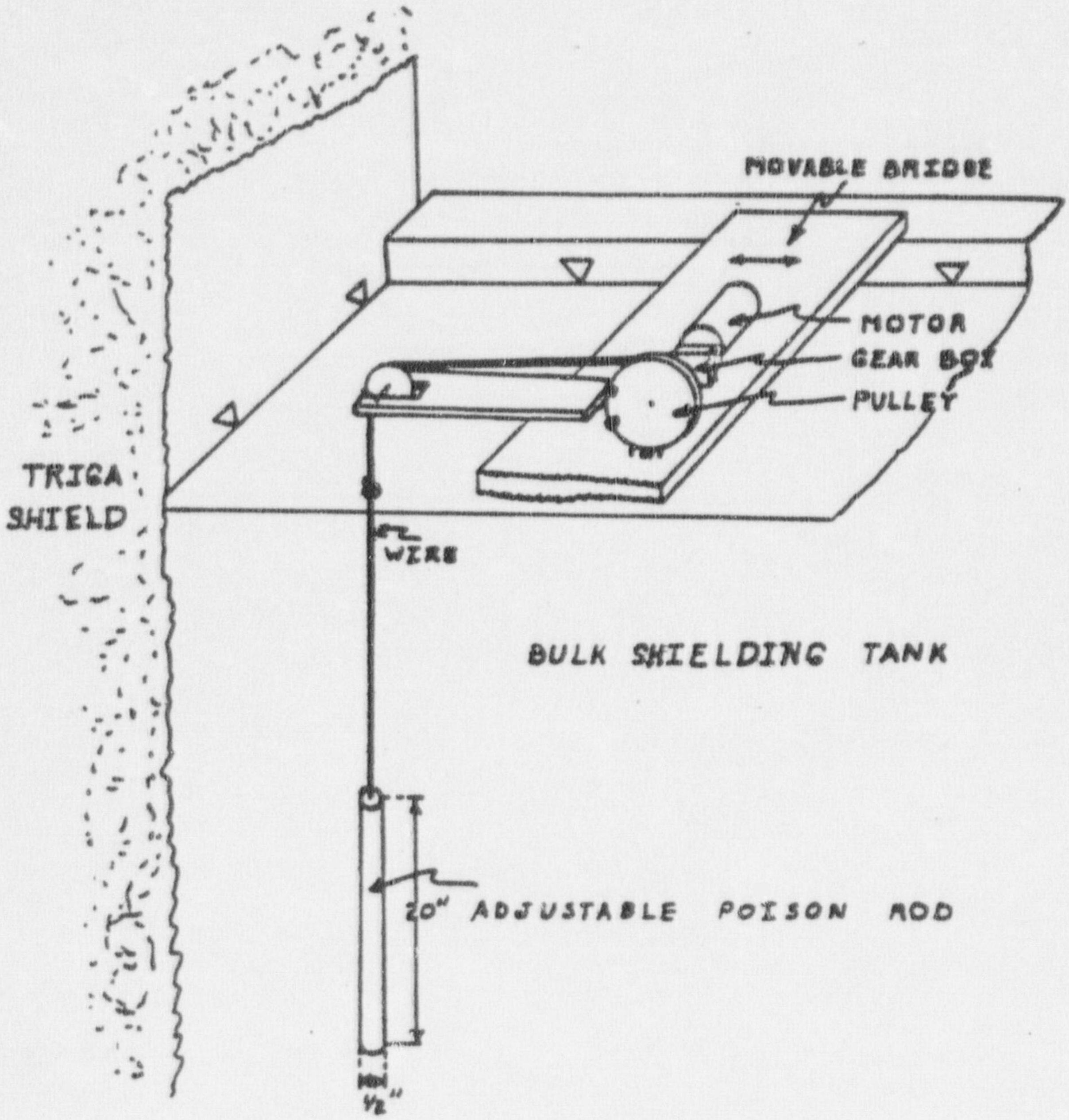


Fig. 9 Isometric Sketch of Poison Rod and Drive Mechanism

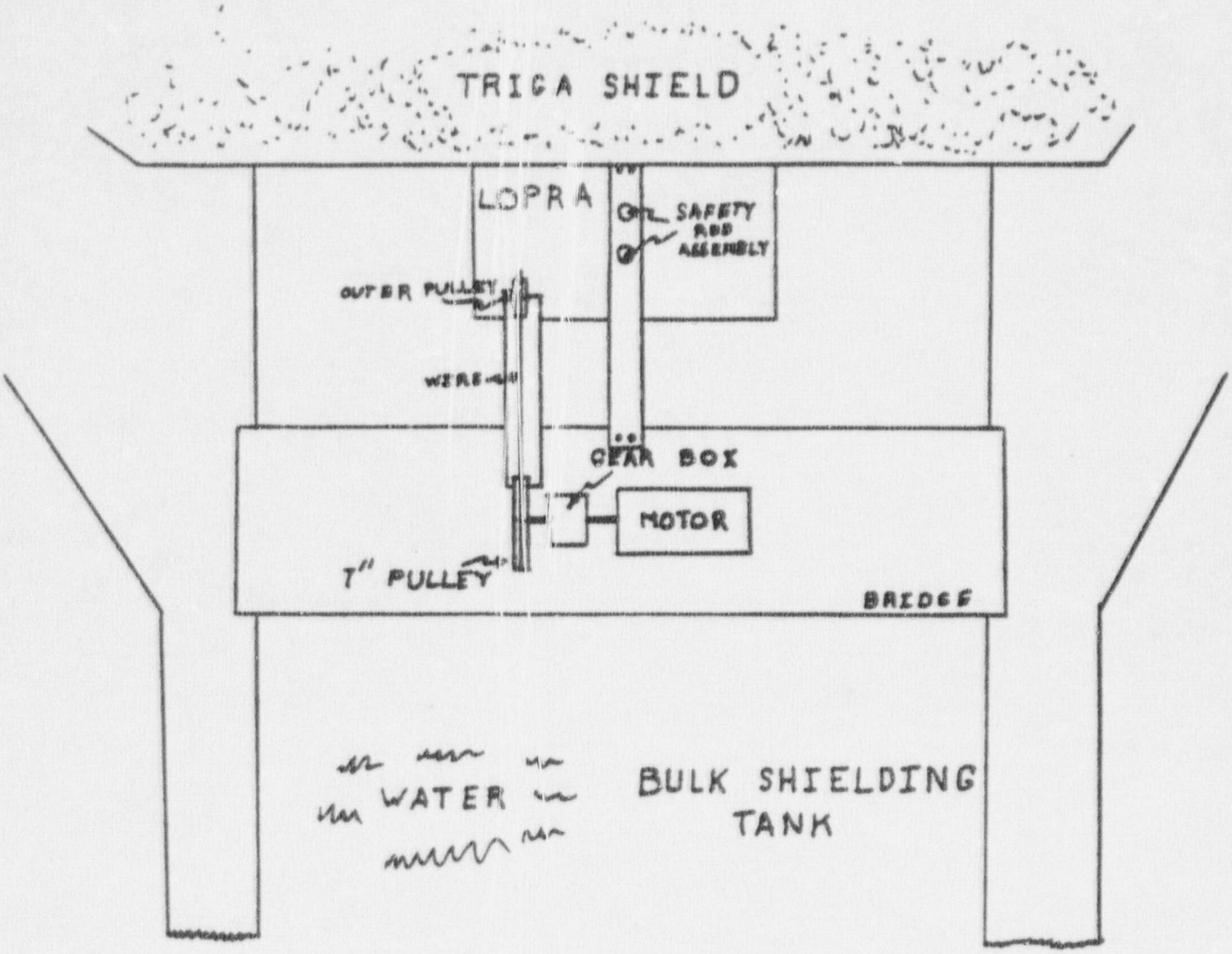


Fig. 10 Sketch of Top View of Poison Rod and Safety Rod Assemblies Showing Location Above the LOPRA

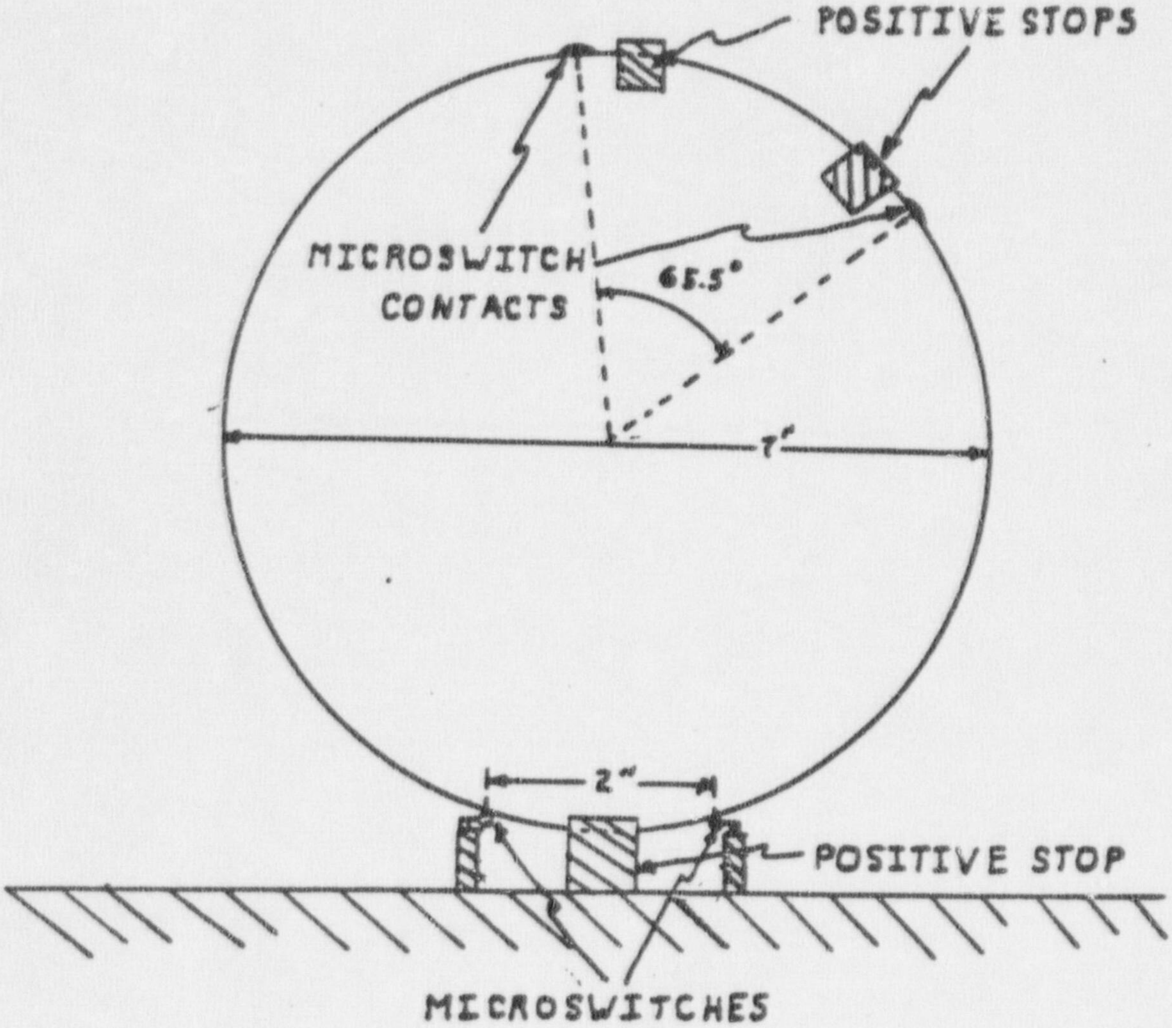


Fig. 11 Sketch of Side View of the Poison Rod Pulley Showing Position of Microswitches and Positive Stops

rod is attached to a cable which goes over a pulley onto a wheel 7 inches in diameter. (Fig. 9-10) This wheel is connected through a gear box to obtain the required speed. The sheel has two microswitches to indicate the up and down position and to stop the motor drive. Mechanical stops are located to keep the rod from being lowered or raised more than is desired. (Figure 11) The travel of the rod is limited to an inserted position of about one inch above the top grid and a withdrawn position of about one inch below the top part of the fuel elements. The motor assembly is placed on one of the movable bridges above the bulk shielding facility. The postion of the rod is indicated on the console rack in the control room.

During the initial loading of the LOPRA, the poison rod was located near the center of the core. After a critical lattice with less than 30 cents excess reactivity has been obtained, reactivity of the rod was determined to be approximately $1.20.

VII.B.3 Control Rods

The system contains two safety control rods with scram capabilities. Figures 12-17 show the design and the location of these rods. Each safety control rod consists of an aluminum bar 21 inches long, with hollow watertight aluminum tubes 1/2 inch in outer diameter, 20 inches long, welded to it. Each tube has one inch of lead at the bottom and then 10 inches of a cadmium sheet rolled inside the tube (Fig. 12). The bar has two guide tubes 30 inches long, attached to each end. These tubes drop down channels designed to guide the safety control rod into the core. The channels (Fig. 13) restrict the movement of the safety rod. When inserted, the rod bottom is about one inch above the top grid plate. At the upper stop, the bottom of the rod overlaps the fuel elements by approximately one inch. This stop prevents the safety control rods from being removed completely from the LOPRA. The safety rods

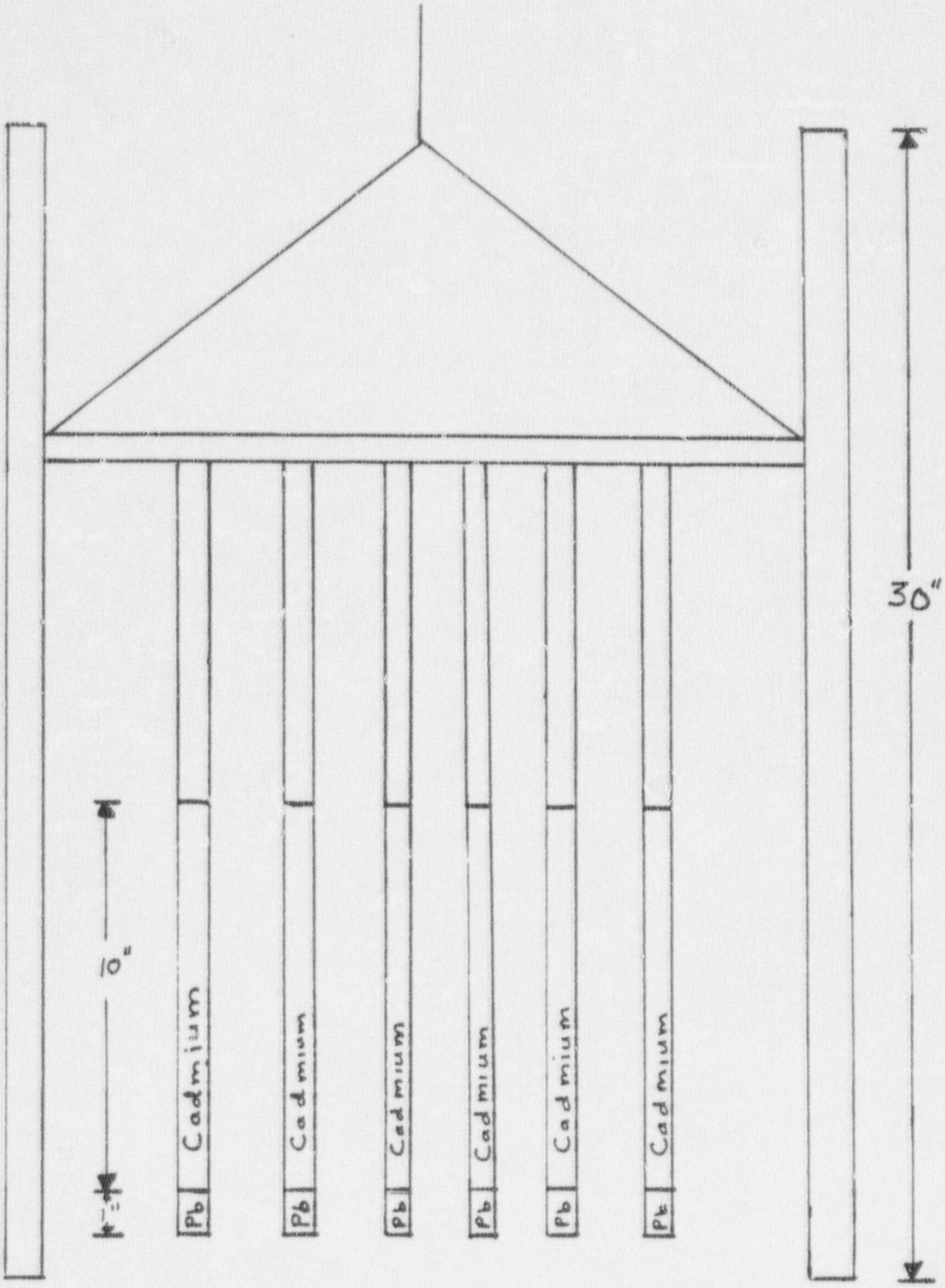


Fig.12 Sketch of one Safety Control Rod Assembly

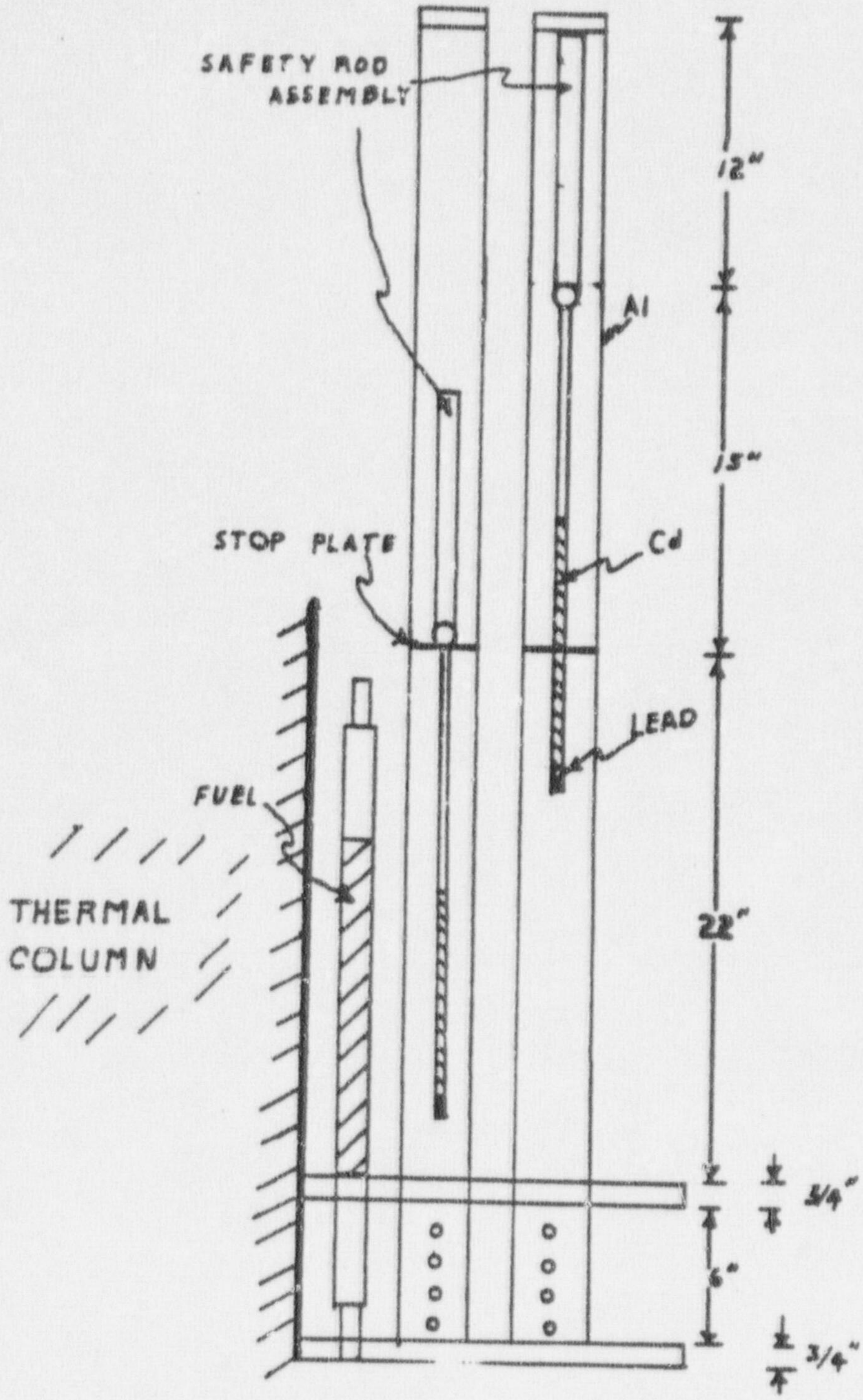


Fig. 13 Sketch of Side View of the Safety Control Rods Showing the Fully Inserted and Fully Withdrawn Positions

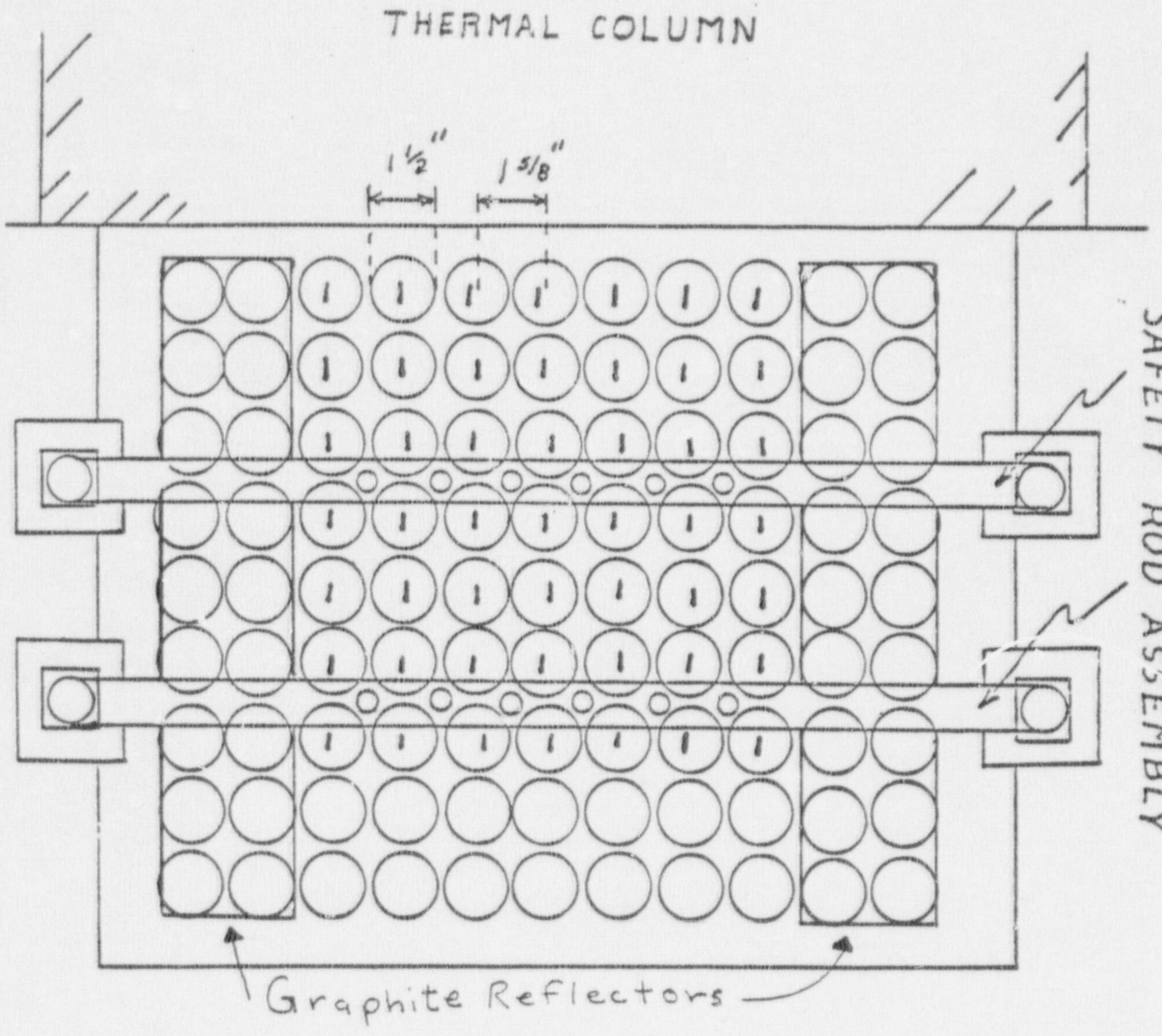


Fig. 14 Sketch of Top View of the LOPRA Core Showing the Location of the Safety Control Rods in the LOPRA Core Lattice

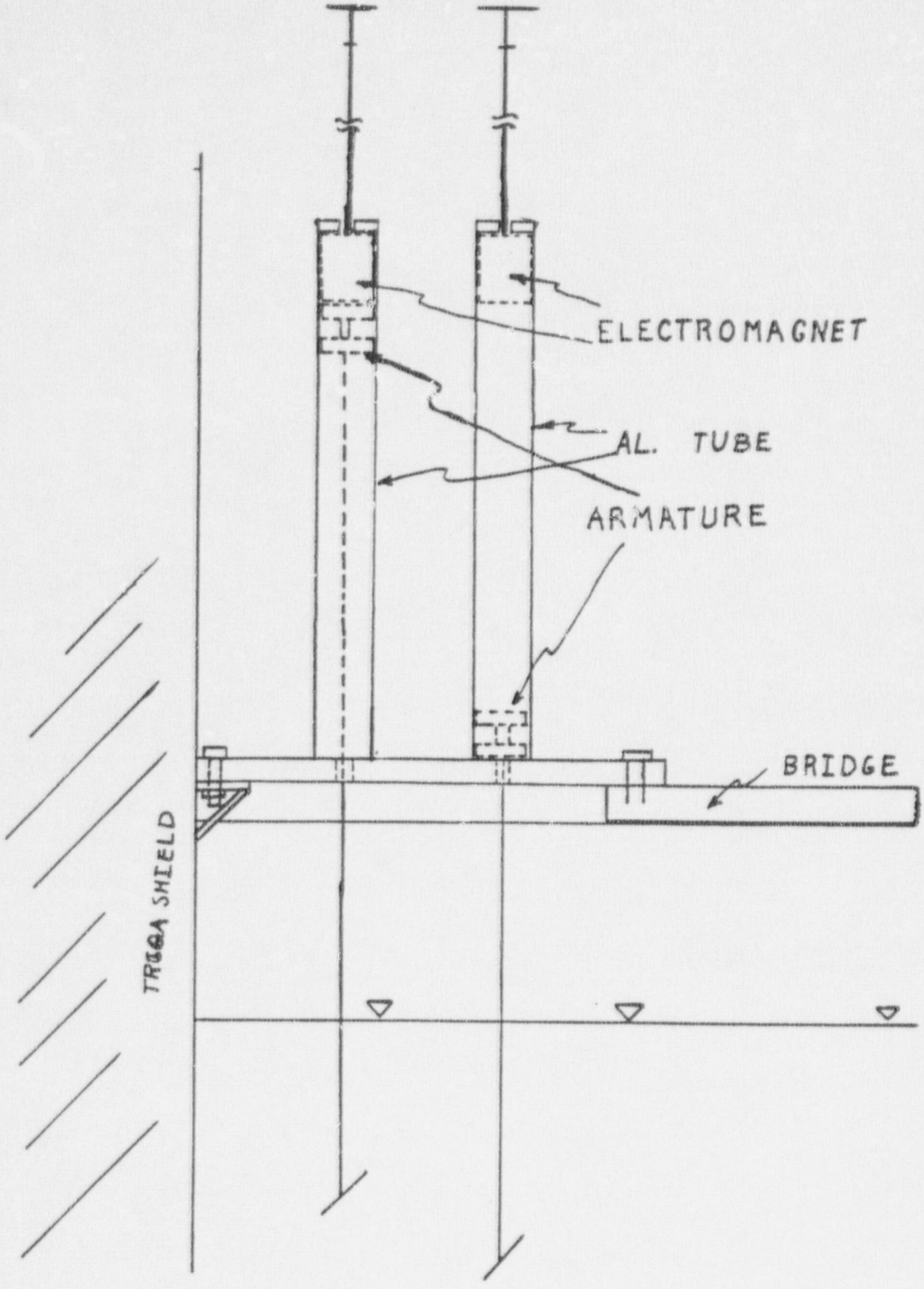


Fig. 15 Sketch Showing Cables and Electromagnet Assemblies for the Safety Control Rods

are located between the third and fourth rows and between the sixth and seventh rods of the LOPRA (Fig. 14). The rods are held by a wire cable which is attached to an armature in an aluminum tube located directly above the rods (Fig. 15). This armature is held by an electromagnet attached to a cable and lifting rod. The magnet assembly, armature, guide tube and lifting rods, as shown in Fig. 15, are designed to prevent any external interference with the free insertion of the safety rod during a scram.

VII.B.4 Radiation Protection

The radiation protection system is described in Section XI of the "Safety Analysis Report for the Illinois Advanced TRIGA."[4] This system will give audible and visible alarms should abnormally high radiation levels occur in the laboratory.

The γ-monitor, located directly above the LOPRA assembly, is utilized for determination of the power level and for radiation protection. During normal operation, the system is set to cause a scram of the LOPRA and to give an audible and visible alarm if the safety system setting is exceeded. This setting is based on the steady-state power level of the LOPRA. However, should an abnormal condition arise, such as a reduction in the water level in the bulk shielding facility, this would be noted by an increase in the reading of this monitor. In this and similar circumstances the protection of scramming the LOPRA as well as audible and visible alarms to alert personnel is present.

VII.B.5 Scrams

The LOPRA is scrammed through an interruption of the current to the eletromagnets of the two safety control rods. This may be initiated by an electrical power failure, by a high steady-state power level, by an excessive peak power level when the system is pulsed by the Illinois Advanced TRIGA, by

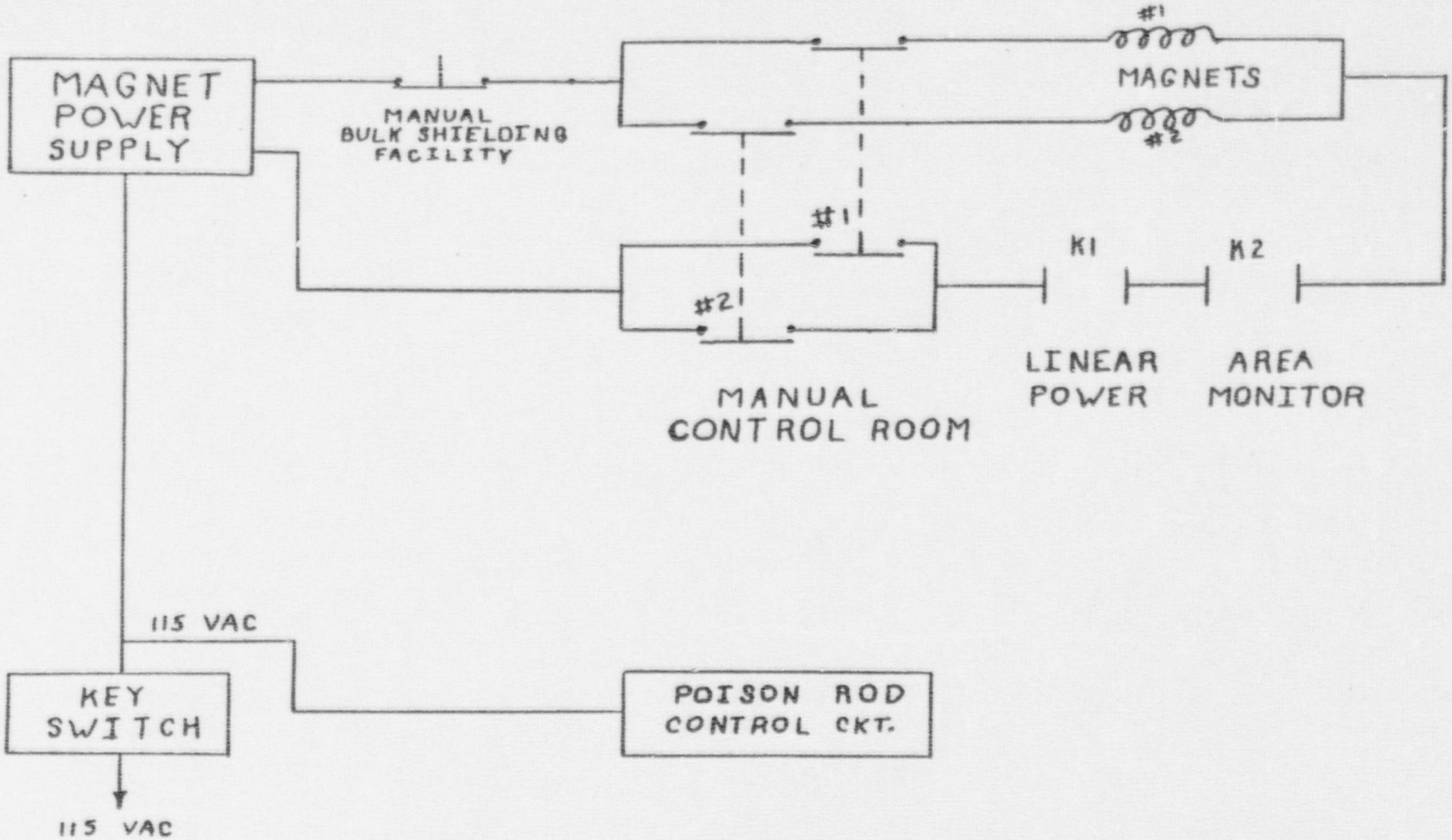


Fig. 16 Electrical Wiring Diagram Schematic Showing Scram Switches and Relays

an excessive radiation level above the assembly, or by manual buttons located in the control room and at the bulk shielding facility.

The functional diagram for these scrams is shown by Figure 16. Primary power is applied to the magnet power supply by a key switch. The output from the magnet power supply is supplied to the magnets through a series scram bus. The scram bus contains the relay contacts for the two power level scrams and the switches from the manual scrams. The manual scram at the console opens two sets of contacts to allow the individual control rods to be dropped and to insure that a single short would not disable the system.

The functional diagram for the two power level channels is shown by Figure 17. This figure also shows the primary supply of power to the linear power channel, the magnet power supply, and the poison rod control circuit.

VII.C <u>EVALUATION</u>

The instrumentation and controls have been provided in view of the low limitation on the excess reactivity and the inherent safety of a TRIGA reactor. The power level instrumentation will give adequate information on this parameter and provides protection against excessive radiation levels in the laboratory. The manual scrams allow for a rapid shutdown from either the control room or at the bulk shielding facility.

Although only two safety control rods will be utilized, either of these rods, if inserted individually, will provide a shutdown margin of at least \$3.00. The administrative controls given in Section XII are set up to place close regulation and surveillance on the loading of the fuel elements into the LOPRA.

VII.D <u>TESTS</u>

Checks on the operability of the power level instrumentation and the safety control rods are made each day the LOPRA is placed into operation.

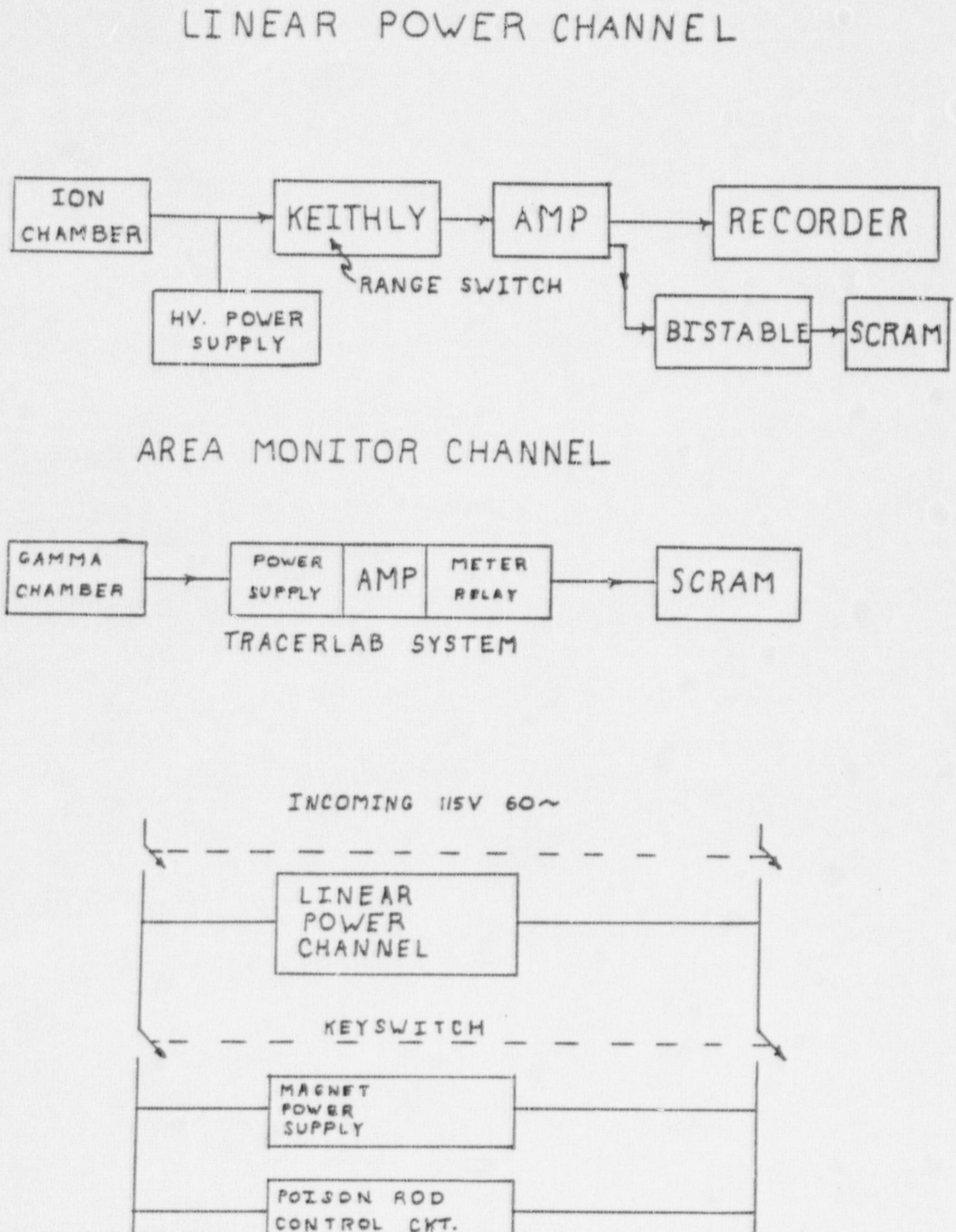


Fig. 17 Schematic Diagram of Electronic Components in the Monitoring and Control Systems

When the system is not in use it is decoupled from the Illinois Advanced TRIGA as indicated later in Section XII. Written procedures will be utilized for returning the system to an operating condition.

SECTION VIII. ELECTRICAL SYSTEM

The electrical power system to be utilized is the same as that described in Section VIII of the "Safety Analysis Report of the Illinois Advanced TRIGA."[4]

SECTION IX. AUXILIARY AND EMERGENCY SYSTEMS

IX.A WATER SYSTEMS

IX.A.1 Building

The water supply for the Nuclear Reactor Laboratory is described in reference 4. This supply has a capacity of about 3000 gpm, at a pressure of 50 psi.

IX.A.2 LOPRA

The bulk shielding experimental tank, when filled, contains about 6000 gallons of water. The water is kept at high purity when fuel elements are either stored or utilized in the facility. The water is circulated by a pump through a filter and demineralizer resin to retain the purity. Water, to replace that lost by evapoartion, is demineralized by the Illinois Advanced TRIGA make-up water system before being added to the bulk shielding tank.

IX.B FUEL STORAGE AND HANDLING

The fuel storage capacities for the University of Illinos Nuclear Reactor Laboratory are given in Section IX of reference 4. Storage space is available for either cold or irradiated fuel elements.

Only those fuel elements utilized in the operation of the LOPRA will be stored in the racks on the walls of the bulk shielding facility when the system is being used for experimental purposes. Any remaining fuel elements are located in the other storage facilities of the laboratory.

With the exception of the fuel elements that were designed as instrumented elements, the fuel is handled with the tool described in Section IX of reference 4. When not in use, this tool is stored in a rack and locked in place to prevent unauthorized movement of fuel elements.

IX.C REACTOR BUILDING SYSTEMS

The remaining auxiliary and emergency systems that are available are described in Section IX of reference 4. This includes the building cooling and heating system, lightning protection for the building, radioactive storage, and the decontamination shower.

SECTION X. EXPERIMENTAL FACILITIES

The bulk shielding facility is considered to be an experimental facility of the Illinois Advnaced TRIGA. In this sense, the LOPRA is an experiment to be utilized in the operation of the Illinois Advanced TRIGA.

The movable bridges described in Section III are utilized for mounting the measuring devices which are placed near or in the core region. As indicated in Section III, these devices are expected to have only a slight reactivity effect on the reactor.

SECTION XI. RADIOACTIVE WASTES AND RADIATION PROTECTION

The solid, liquid, and gaseous waste systems and the area monitoring protective system for the Nuclear Reactor Laboratory are described in Section

XI of reference 4. Each of these systems is available during operations of the LOPRA.

The bulk shielding experimental tank is 12 feet deep, 8 feet wide, and 9 feet long. Figures 1 and 8 show horizontal and vertical views of this facility. The minimum shielding protection occurs directly above the assembly where there is approximately 8 feet of water. The maximum protection is in a lateral direction where the reactor walls contain over 4 feet of concrete. The shielding in the direction of the mechanical equipment room is gained from 8 feet of water and one foot of concrete. Extimates on dose rates, related to the power level of the LOPRA, are given in Section III.D.2. Operations at the higher power levels are limited in time to assure compliance with the 10 CFR 20 limits on restricted and unrestricted areas and personnel exposure.

SECTION XII. CONDUCT OF OPERATIONS

The organization and responsibilities for the administration of the LOPRA will be the same as that outlined in Section XII of reference 4. The Nuclear Reactor Committee will be directly responsible for the safe operation of this low power reactor.

The following special administrative provisions will be in effect during all times when there is sufficient fuel in the bulk shielding facility to make the reactor critical:

(1) Movements of fuel shall not be made except under the direct supervision of a licensed operator of the LOPRA.

(2) The LOPRA shall be locked in its position adjacent to the thermal column to avoid any inadvertent movement of the platform assembly.

(3) During times when the experimental work with the LOPRA is not in progress and the Illinois Advanced TRIGA is to be operated in the

pulse mode or in steady-state mode, the LOPRA shall be shutdown with the following conditions:

(a) The platform containing the grid plates and remaining fuel elements will be moved several inches from the thermal column and locked in this position.

(b) A neutron absorbing curtain will be placed between the thermal column and the LOPRA core.

SECTION XIII. INITIAL TESTS AND OPERATION

Information on the initial test and operation of the TRIGA is contained in the Report on Start-up dated January 18, 1972. This Report is attached as Addendum A to the SAR.

SECTION XIV. ACCIDENT ANALYSIS

XIV.A INTRODUCTION

The LOPRA is a low power reactor assembly of TRIGA fuel elements. The operation will be well below the safety limits which have been shown to be safe from previous operations of TRIGA systems.

The type of accient which might occur from malfunctions of the systems or from errors in judgment or operation, could result in high radiation levels in the vicinity of the bulk shielding facility. However, the levels that might be anticipated under these conditions are low enough whereby corrective measures could be made without excessive exposures to the individuals involved. The accidents to be examined are the removal and failure of the control system and the loss of water.

XIV.B EXCESS REACTIVITY CONSEQUENCE

If the LOPRA is loaded with 60 cents excess reactivity and all controls are removed (the two safety control rods and the poison rod), the reactor power would increase on a 3.5 second period until the prompt negative temperature effects are noted. The power level would eventually reach a level of about 57 kilowatts. Using the measured doses on page 17, Section III.D.2, the radiation level at the water surface would be about 13R/hr. On the reactor deck above the assembly, the rate would be about 3.9R/hr.

Under these conditions, if one assumes that the control system does not operate due to misalignment, an individual could remove fuel elements from the assembly while standing on the reactor deck. The time for the removal of a centrally located element would be less than one minute. This removal would be sufficient to make the system subcritical and the total dose received by the individual would be less than 70 mR.

Even if the error were compounded and the excess reactivity were as high as 80 cents, the power level and resultant radiation levels would still be low enough for the same type of corrective action to be made. The heating of the water in the bulk shielding facility at a power level of 57 kilowatts would be less than 3°C per hour.

XIV.C LOSS OF WATER

The loss of water in the bulk shielding facility is considered very unlikely since there are no openings which extend to the facility from the concrete walls. However, as noted on page 16, Section III.D.1.b, no damage to the fuel would occur, if the water were completely lost, because of the low operating power levels.

A loss of water would result in high radiation levels in the vicinity of the facility. Using the calculation from pages XI-18 to XI-23 of reference 4, the radiation level directly above the assembly would be about 60 R/hr immediately following a continuous operation at 1.0 kilowatts. After one day, this level would be about 8 R/hr, which would allow movement of the fuel elements to a separate storage facility in the reactor laboratory.

XIV.D OBJECTS FALLING ONTO THE CORE

The core of the LOPRA has protection from falling objects during operation since a steel bridge across the bulk shiedling tank will be located above the core. In addition, the reactor deck overhangs the core when LOPRA is adjacent to the thermal column. Thus, objects cannot fall into the water directly above the core during operation of the LOPRA.

If objects should fall into the bulk shielding tank water, the bouyancy of the water and its resistance to rapid free fall motion would greatly reduce the force with which the object could strike the core. However, the likelihood of an object, which enters the water not directly above the core, striking it is small.

If an object should fall on the core breaking the fuel elements, the two most serious effects which must be considered are those of reactivity changes and the release of fission products. Since the LOPRA is optimally moderated for the fuel-water ratio of the lattice, any compression or expansion of the core would decrease its reactivity. The fission product inventory in the fuel is not large since the LOPRA will be operated at low powers and for short periods of time. Using an estimate of 6 months of operation at 100 watts, assuming that the whole core or 60 elements are ruptured and using the analysis of Section XIV.D.2 of the "Safety Analysis Report for the Illinois Advanced TRIGA,"[(4)] the fission product release would be; 13 μc of Kripton, 30 μc of Iodine and 25 μc of Xenon. The Iodine would be absorbed in the water and would give a concentration of about 1.2×10^{-6} $\mu c/cm^3$ of Iodine in the

Bulk Shielding Tank water. This is well below the concentration estimated for one ruptured fuel element in the Illinois Adviaced TRIGA. The gaseous fission product release for a whole core rupture would give an air concentration in the reactor laboratory of 1.2×10^{-6} $\mu c/cm^3$ or a dose rate of 6×10^{-3} mR/hr. Again the concentrations are much less than the estimations for one ruptured fuel element in the Illinois Advanced TRIGA. The numbers above are based on Section XIV.C.2.d of the "Safety Analysis Report for the Illinois Advanced TRIGA."[(4)] The consequences of this concentration are also discussed in the above mentioned section and in Section XI.C of the same reference. The water soluble fission prudcts would be removed by the ion exchange resin of the separate deionization system of the bulk shielding facility.

It is concluded that, even if the remote possibility of an object falling onto the core and damaging the lattice or fuel should occur, the possible changes in reactivity and the possible fission product release would not create an unmanageable hazard.

XIV.B <u>PERSON FALLING INTO BULK SHIELDING TANK</u>

The likelihood of a person inadvertantly falling into the bulk shielding tank is remote since both the reactor deck above the bulk shielding facility and the top of the bulk shielding tank itself are fenced. Personnel working directly with the facility would generally not be stationed near the edge of the tank or over the water surface during operation of the LOPRA. However, during shutdown conditions personnel may be working on the bridge and near the tank's edge. It is, therefore, appropriate to examine the possible radiation exposure a person could receive by 1) falling into the tank, above the core, during shutdown and 2) falling into the tank, but not over the core, during operation.

During shutdown, the exposure near the surface of the tank is not significant since the fission product inventory in the core is small due to low power operation and short period of operation (Section XIV.C.2 reference 4). During operation, say at or below the usual power level of 100 watts, the radiation exposure level, due mostly to gamma radiation, at or near the surface of the water in the tank would not exceed 50 mR/hr. If a person would sink to 2 ft. for one minute he would receive a dose of approximately 50mR.

REFERENCES

1. Facility License R-69 Amendment No. 6. Also see: P. K. Doshi, "Neutron Pulse Propagation Through Multiplying Media," Ph.D. Thesis, N.E. Program, U. of Ill. (1968).
2. Facility License R-69 Amendment No. 4 (Jan. 7, 1964).
3. Facility License R-69 Change No. 3 (May 25, 1966). Also see: H. Hassan, "Experimental and Theoretical Studies of Space-Time Nuclear Reactor Kinetics," Ph.D. Thesis, NE Program, U. of Ill. (1969).
4. "Safety Analysis Report for the Illinois Advanced TRIGA," University of Illinois (Aug. 1967).
5. Hosenkamp, A., "Final Safety Analysis: Annular Core Pulse Reactor," Sandia Corporation SC-RR-66-2609 (Nov. 1966).
6. "Fuel Demonstration Test," General Atomics Report GACD-7438, General Atomic Division of General Dynamics Corp. (Sept. 1964).
7. "Technical Specifications for the Illinois Advanced TRIGA Reactor," License No. R-115 (June 25, 1969) Appendix A, Section 2.1, p. 4.
8. "Proposed Amendment, Utilization Facility License Number R-69," (June 3, 1963), pp. 8 and Appendix C (Amendment No. 3 received on August 22, 1963).

REPORT ON START-UP OF LOPRA

January 18,1972

Appendix A

Section I

INITIAL LOADING

The loading of the LOPRA was started at 10:00 a.m. on December 28, 1971. The loading was carried out under the supervision of the LOPRA Supervisor--Orville Whipple; Reactor Health Physicist--Paul Hesselman; and Reactor Supervisor--Gerald Beck. Gary Thayer (Licensed LOPRA Operator), Hernan Carvajal, and Harold Keiser assisted in the loading. The loading was carried out according to the written Initial Loading Procedures, with the exception that loading number 5 in the written procedures was split into two loadings--one of 5 elements and one of 4 elements. In step number 13, where a Sandia element was substituted for an Al element, the two 1/M measurements with the poison rod withdrawn gave an increased reactivity worth of about 5¢. Therefore, Sandia elements were added without first adding an aluminum element in the position. The LOPRA went critical at 4:58 p.m., December 28, 1971 with a loading of 61 elements--56 aluminum elements and 5 Sandia elements at a poison rod position of 1089. Figure 1 gives the locations of the aluminum and Sandia elements in the final loading. Table 1 gives the data taken during loading. Figures 2 and 3 give the 1/M curves generated during loading. Tables 2 and 3 summarize the reactivity worth of the last elements added, and the reactivity worth of the poison control rod at various loadings. It should be noted that the reactivity worth values are dependent on correct source readings.

Figure 1

Critical Loading 12/28/71

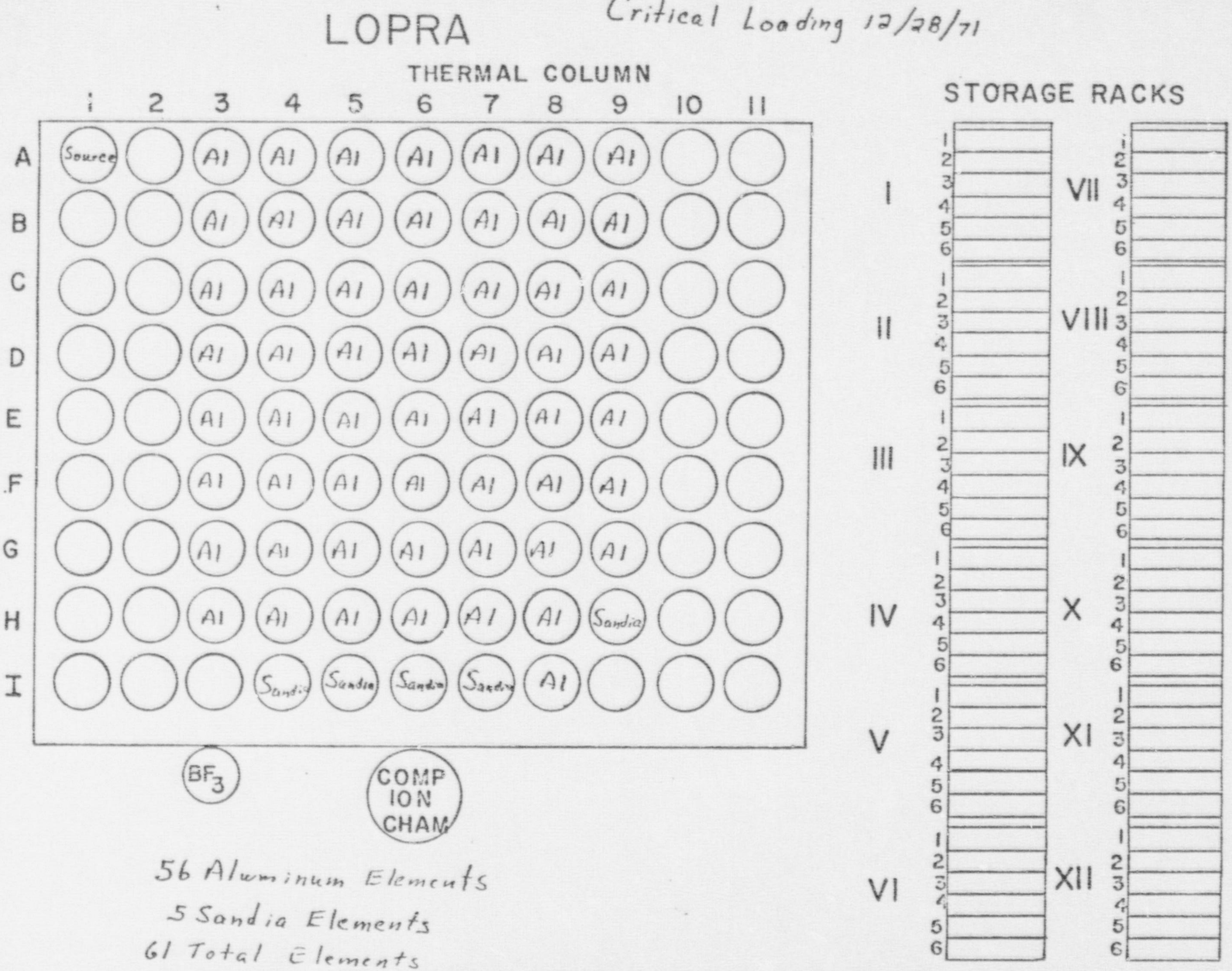


TABLE 1

1/M MEASUREMENTS APPROACH TO CRITICAL - LOPRA

December 28, 1971

Condition	Counts at Console					Counts at BST				
	CPM			AVG.	1/M	CPM			AVG.	1/M
Source In (A-1) No Fuel S. Rods Down Poison R. Up	305 282 299	328 311 292	303			150 149 155	144 162	152		
S. Rods Up Poison R. Down	298 287 279 311 309	309 307 272 290	296			106 84 120 101	98 94 105 103	102	100	1.00
Poison R. Up	293 290 304	292 304 281	294	295	1.00	84 107 87	109 96 90	95	95	1.00
Source Out	10 0	9				1/5 min.				
Source In: Poison R. Down	280 294	299	291			89 91	105 97	95		
Loading Starts										
Source In (A-1) F.E.: 10 Poison R. Down	303 318 300	304 346 325		317	0.93	121 121 119	126 125		122	0.82
Poison R. Up	331 323 308	349 299 354		327	0.90	106 119 122	102 110		112	0.85
F.E.: 20 Poison R. Down	419 462	453 473	429	447	0.66	206 199	193 186	203	197	0.51

TABLE 1

1/M MEASUREMENTS APPROACH TO CRITICAL - LOPRA

December 28, 1971

	Counts at Console					Counts at BST				
	CPM			AVG.	1/M	CPM			AVG.	1/M
F.E.:20										
Poison R. Up	478	478	422			167	176	192		
	440	464		456	0.645	186	207		186	0.51
F.E.: 30										
Poison R. Down	827	783	815			296	282	292		
	776	786		797	0.370	310	275		291	0.344
Poison R. Up	854	812	860			292	263	305		
	882	828		847	0.347	253	277		278	0.342
F.E.:40										
Poison R. Down	1799	1857	1829			638	659	713		
	1864	1809		1831	0.161	723	670	696	680	0.147
Poison R. Up	1932	1991	2010			695	674	694		
	1997	2001		1986	0.148	703	713		696	0.136
F.E.: 45										
Poison R. Down	2476	2433	2422	2444	0.121	934	963	1005	967	0.103
Poison R. Up	2806	2845	2759	2803	0.105	1009	981	980	987	0.096
F.E.: 49										
Poison R. Down	4940	4892	4741	4858	0.0607	1501	1482	1457	1480	0.0676
Poison R. Up	6046	6032	6031	6036	0.0487	1657	1740	1738	1712	0.0555
S. Rods Down										
Poison R. Up	1943	1914	1896	1918	0.153	974	963	925	954	0.100
F.E.: 52										
Poison R. Down	7439	7351	7620	7470	0.0394	1784	1775	1758	1772	0.0564
Poison R. Up	9822	9739	9945	9835	0.0300	2126	2129	2140	2132	0.0446
F.E.: 55										
Poison R. Down	12380	12580	12650	12540	0.0235	2329	2334	2254	2303	0.0434
Poison R. Up	18790	18840	18690	18870	0.0157	3239	3245	3220	3235	0.0294

TABLE 1

1/M MEASUREMENTS APPROACH TO CRITICAL - LOPRA

December 28, 1971

Condition	Counts at Console					Counts at BST				
	CPM			AVG.	1/M	CPM			AVG.	1/M
F.E.: 56										
Poison R. Down	14880	14940	14580	14800	0.0199	2633	2616	2644	2613	0.0383
Poison R. Up	23880	24310		24090	0.0122	3920	4113	4054	4029	0.0236
F.E.: 56										
Poison R. Down	14740	14690		14720	.0200	2815	2750		2782	.0359
Poison R. Up	24230	24340		24280	.0121	4049	4129		4089	.0232
F.E.: 57										
Poison R. Down	18540	18540		18540	.0159	3158	3246		3202	.0312
Poison R. Up	34290	35100	35250			5195	5466	5374	5420	.0175
	35140			35160	.00836					
F.E.: 58										
Poison R. Down	23930	23510		23720	.0124	3831	3832		3832	.0261
Poison R. Up	51720	53000	53520							
	53400			53460	.00550	7625	7607		7616	.0125
F.E.: 59										
Poison R. Down	30510	30550		30530	.00966	4606	4640		4558	.0219
Poison R. Up	101250	101980	101900	101900	.00288	13123	13669	13820	13537	.0070
F.E.: 60										
Poison R. Down	43180	43240	43390			5865	5878	5843		
	43670			43210	.0068	6008			5898	.0170
Poison R. Up	37360	38090	38320	38037	.00078	35225	41909	44569		
	38380					46608	47582	48695	44098	.00215
F.E.: 61										
Poison R. Down	57430	56890	56870	57063	.0052	7591	7521	7487	7533	.0133
Poison R. Up		CRITICAL					CRITICAL			

TABLE 1

1/M MEASUREMENTS APPROACH TO CRITICAL - LOPRA

December 28, 1971

Condition	Counts at Console			Counts at BST		
	CPM	AVG.	1/M	CPM	AVG.	1/M
	READINGS AFTER SHUTDOWN					
F.E.: 61 Safety Rods Down Source in (A-1) Poison R. Down				1340 1269 1276 1280 1230		
Poison R. Up				6095/5 min 5945/5 min		

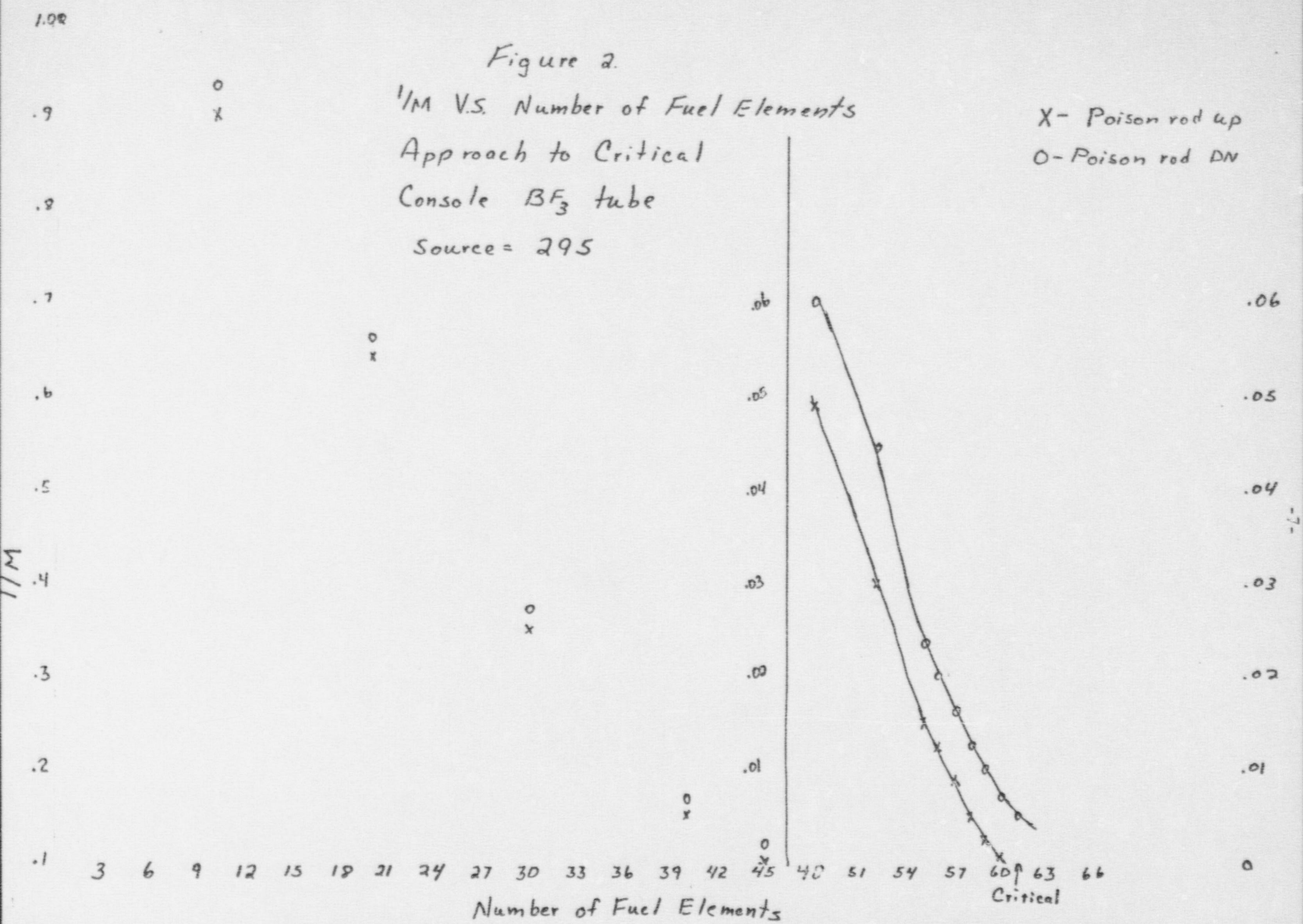


Figure 2.
1/M V.S. Number of Fuel Elements
Approach to Critical
Console BF3 tube
Source = 295
X- Poison rod up
O- Poison rod DN
1/M
Number of Fuel Elements
Critical

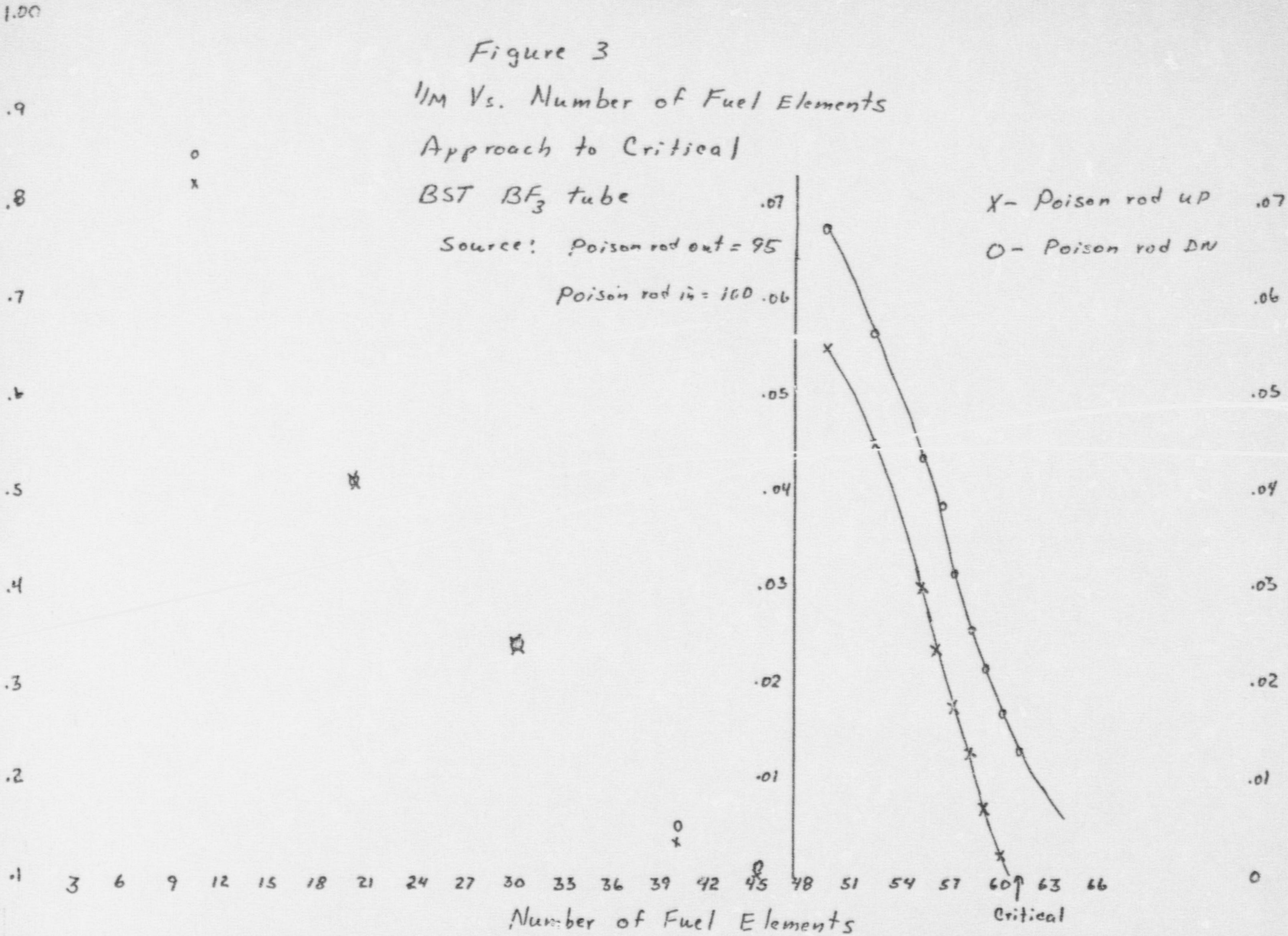


Figure 3
1/M Vs. Number of Fuel Elements
Approach to Critical
BST BF_3 tube
Source: Poison rod out = 95
Poison rod in = 100
X- Poison rod UP
O- Poison rod DN
1.00
.9
.8
.7
.6
.5
.4
.3
.2
.1
.07
.06
.05
.04
.03
.02
.01
0
3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66
Critical
Number of Fuel Elements

TABLE 2

REACTIVITY WORTH OF LAST ELEMENTS ADDED TO LOPRA

β = .0073

Fuel Element No.	1/M VALUES				Δ K				$			
	Console BF_3 Poison Rod		BST BF_3 Poison Rod		Console BF_3 Poison Rod		BST BF_3 Poison Rod		Console BF_3 Poison Rod		BST BF_3 Poinson Rod	
	Up	Dn	Up	Dn	Up	Dn	Up	Dn	Up	Dn	Up	Dn
55, 55 Al	.0157	.0235	.0294	.0434								
					.0035	.0036	.0053	.0051	0.48	0.49	0.73	0.70
56, 56 Al	.0122	.0199	.0236	.0383								
					.0001	-.0001	.0004	.0024	0.014	-0.014	0.055	0.33
56, 55 Al 1S	.0121	.0200	.0232	.0359								
					.00374	.0041	.0057	.0047	0.51	0.56	0.78	0.64
57, 55 Al 2S	.00836	.0159	.0175	.0312								
					.00286	.0035	.0050	.0051	0.39	0.48	0.68	0.70
58, 55 Al 3S	.0055	.0124	.0125	.0261								
					.00262	.00274	.0055	.00420	0.36	0.38	0.75	0.58
59, 55 Al 4S	.00288	.00966	.0070	.0219								
					.00210	.00286	.00485	.00490	0.29	0.39	0.66	0.67
60, 55 Al 5S	.00078	.0068	.00215	.0170								
						.0016		.0037		0.22		0.51
61, 56 Al 5S		.0052	.0133									

TABLE 3

POISON ROD REACTIVITY WORTHS DURING INITIAL LOADING

β = .0073

Fuel Elements No.	1/M VALUES				Δ K		$	
	Console BF_3 Poison Rod		BST BF_3 Poison Rod		Console	BST	Console	BST
	Up	Dn	Up	Dn				
55, 55 Al	.0157	.0235	.0294	.0434	.0078	.0140	1.07	1.92
56, 56 Al	.0122	.0199	.0236	.0383	.0077	.0147	1.05	2.01
56, 55 Al 1S	.0121	.0200	.0232	.0359	.0079	.0127	1.08	1.74
57, 55 Al 2S	.00836	.0159	.0175	.0312	.0075	.0137	1.04	1.88
58, 55 Al 3S	.0055	.0124	.0125	.0261	.0069	.0136	0.95	1.86
59, 55 Al 4S	.00288	.00966	.0070	0219	.0068	.0149	0.93	2.04
60, 55 Al 5S	.00078	.0068	.00215	.0170	.00602	.0149	0.82	2.03
61, 56 Al 5S		.0052		.0133	.0052*	.0133*	0.71*	1.82*

*Reactivity worth of poison rod below critical position. Total reactivity equals this plus 20.3¢.

Section II

Poison Rod Calibration

The reactivity worth of the poison rod was measured according to the written procedures. The critical position was found and the remaining rod divided into five parts. The reactivity worth of the parts was then measured by use of positive periods. Negative periods were measured within the limits of the Inhour curve, which was used to find the reactivity worths for the various periods. All poison rod positions correspond to 0000 starting position. This measurement was done twice, with different excess reactivities in LOPRA. The change in excess reactivity came from the movement of the compensated ion chamber during power calibration. The results are summarized in Table 4 and 5. The rod worth curve is given in Figure 4.

The amount of reactivity worth that could be measured on the poison rod was 42¢ and accounted for only the upper part of the poison rod travel. Extrapolations of this reactivity worth to the total worth of the poison rod was done by comparison with the rod worth curves for the adjustable transient rod on the Illinois Advanced TRIGA. Four cases were examined:

- Case 1a. Worth curve of adjustable transient with fast transient rod up; Poison rod worth from 940-1480
- Case 1b. Worth curve of adjustable transient with fast transient rod down; Poison rod worth from 940-1480
- Case 2a. Worth curve of adjustable transient with fast transient rod up; Poison rod worth from 940-1380
- Case 2b. Worth curve of adjustable transient with fast transient rod down; Poison rod worth from 940-1380.

Cases 2a and 2b were examined because the poison rod position of 1380 corresponds to the full out position of the adjustable transient rod. Table 6 summarizes these cases. It is seen from these extrapolations that the poison rod reactivity worth, given by this method, is about $2.00.

TABLE 4

POISON CONTROL ROD REACTIVITY WORTH (Raw Data)

Rod Position	Increment	Period (sec)	Worth (¢)	Incremental Worth (¢)
		Previous to moving Chamber		
1089		∞		
	+80			+6.2
1169		174	+6.2	
	+80			+5.8
1249		77.8	+12.0	
	+80			+4.0
1329		51.8	+16.0	
	+80			+2.8
1409		40.7	+18.8	
	+71			+1.5
1480		36.2	+20.3	
1100		∞		
	-60			-5.5
1040		275	-5.5	
	-60			-8.5
980		140	-14.0	
	-40			-8.0
940		109.6	-22.0	
		After moving Ion Chamber		
1024		∞		
	+86			+8.74
1110		117	+8.74	
	+90			+7.44
1200		51.0	+16.18	
	+90			+5.41
1290		32.6	+21.59	
	+90			+3.59
1380		25.1	25.18	
	+100			+2.17
1480		21.55	27.35	

Table 5

Poison Control Rod Reactivity Worth Composite

Rod Position	Incremental Position	Reactivity Worth	Incremental Worth
940		0	
	40		8.0¢
980		8.0¢	
	44		8.0¢
1024		16.0¢	
	6		0.5¢
1040		16.5¢	
	50		5.5¢
1090		22.0¢	
	20		2.7¢
1110		24.7¢	
	40		3.5¢
1170		28.2¢	
	30		3.9¢
1200		32.1¢	
	50		1.9¢
1250		34.0¢	
	40		2.5¢
1290		36.5¢	
	40		1.5¢
1330		38.0¢	
	50		2.1¢
1380		40.1¢	
	30		0.7¢
1410		40.8¢	
	70		1.5¢
1480		42.3¢	

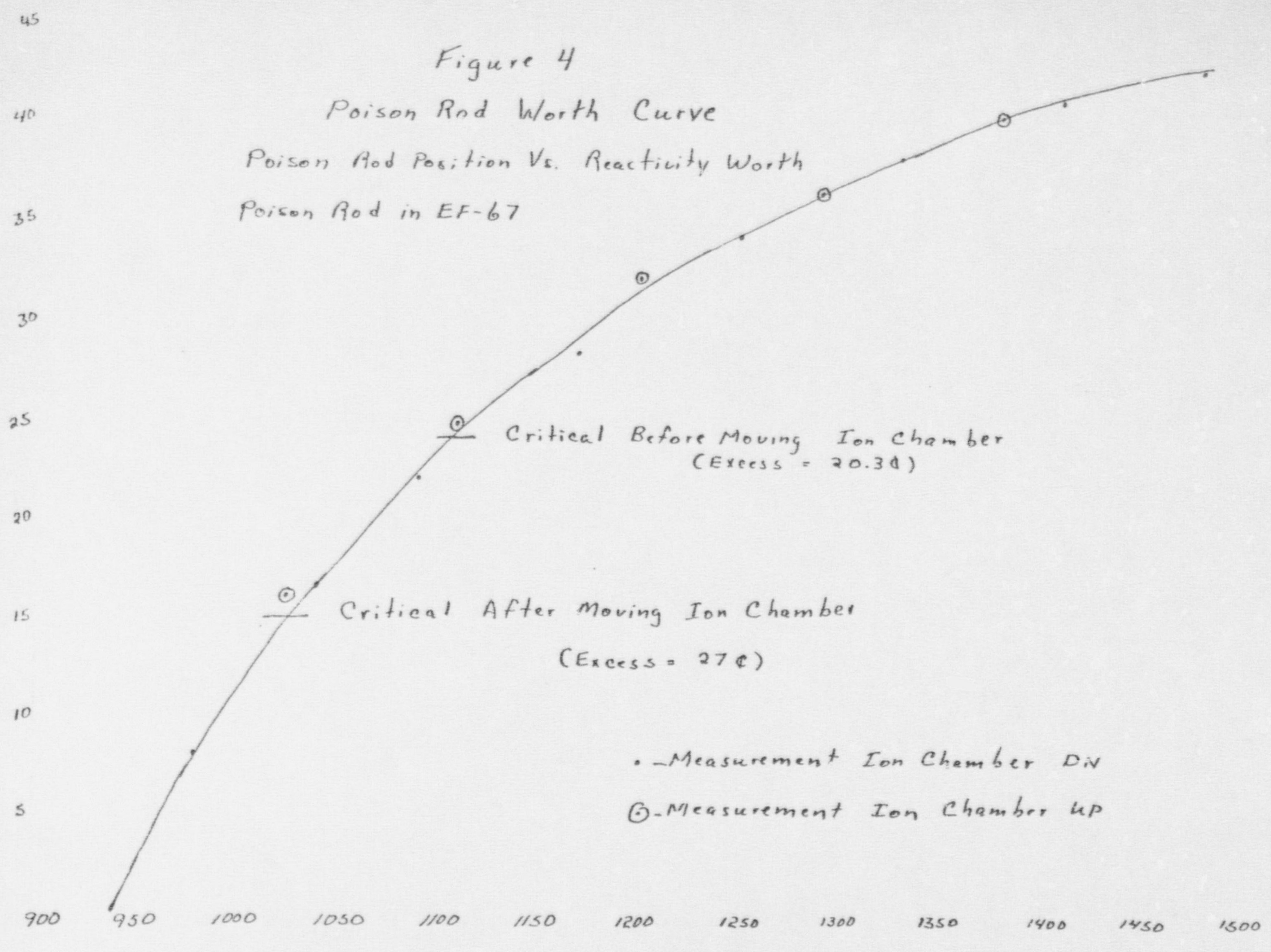


Figure 4
Poison Rod Worth Curve
Poison Rod Position Vs. Reactivity Worth
Poison Rod in EF-67
Critical Before Moving Ion Chamber
(Excess = 20.3¢)
Critical After Moving Ion Chamber
(Excess = 27¢)
• -Measurement Ion Chamber DN
⊙-Measurement Ion Chamber UP
45
40
35
30
25
20
15
10
5
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400
1450
1500

TABLE 6

EXTRAPOLATION OF POSION ROD REACTIVITY WORTH USING ADJUSTABLE TRANSIENT WORTH CURVE

Case 1	Poison rod worth in the interval 940-1480 = 42¢ Or 36% of upper portion of poison control rod = 42¢
	1a. Adjustable transient worth $2.35 Upper 36% equals worth from 626 to top or $1.93 to $2.35 Increment worth is 42¢ Extrapolation gives total poison rod worth of $2.35
	1b. Adjustable transient worth $2.02 Upper 36% equals worth from 626 to top or $1.63 to $2.02 Increment worth is 39¢ Extrapolation gives total poison rod worth of $2.18
Case 2	Poison rod worth in the interval 940-1380 = 40¢ Or 32% of upper portion of poison control rod = 40¢
	2a. Adjustable transient worth $2.35 Upper 32% equals worth from 662 to top or $2.03 to $2.35 Incremental worth is 32¢ Extrapolation gives total poison rod worth of $2.95
	2b. Adjustable transient worth $2.02 Upper 32% equals worth from 662 to top or $1.72 to $2.02 Incremental worth is 30¢ Extrapolation gives total poison rod worth of $2.71

Section III

Power Level Determination

Three methods of determining the power level for a given Keithley reading were used. The first method investigated was the power level of the subcritical multiplication of the source. Using the rod worth curve for the poison rod (Fig. 4) the LOPRA was made subcritical by various amounts. The Keithley reading was recorded. These values were then compared to the curve of the power level vs. subcritically of the Illinois Advanced TRIGA (Fig. 5). This curve was then used to calibrate the Keithley reading to Power level. The data is summarized in Table 7.

It was noted that the power increased linearly when LOPRA was just critical with a source, and from experience with the Advanced TRIGA, the rate of power increase was put at .03 Watt/min. The Keithley reading was increasing linearly at a rate of 1×10^{-8} amp/min. Thus, it was assumed that 1×10^{-8} amp equals .03 Watt. This compares with the value of 1.8×10^{-8} amp equal to .03 Watt found from the subcritical multiplication.

The compensated ion chamber was then reset so that 1×10^{-7} amp was equal to 1 Watt. The source multiplication numbers were used as the basis for this. It was noted that the compensated ion chamber had a reactivity worth of a -8¢ when it was completely down.

The γ - dose rate at the water surface was checked at a LOPRA power level of 20 Watts, as given by the final compensated ion chamber position. The rate was found to be 5 mr/hr, compared to 4.8 mr/hr. given in the LOPRA SAR. The γ - monitor read lmr/hr, compared to 2.4 mr/hr. given in the SAR.

The last method used to check power level was to increase the LOPRA power until temperature feedback became observable. The positive reactivity added, by the poison rod, to compensate for the negative temperature feedback was recorded for three LOPRA power levels above 1 kW. This was then compared to a similar curve for the Illinois Advance TRIGA and the Illinois Mark II TRIGA. (Fig. 6) The LOPRA power level was determined by using the γ-monitor value of 50 mr/hr per kW. The Keithley reading was also recorded but not used for power level determination. The results are given in table 8 and Fig. 6.

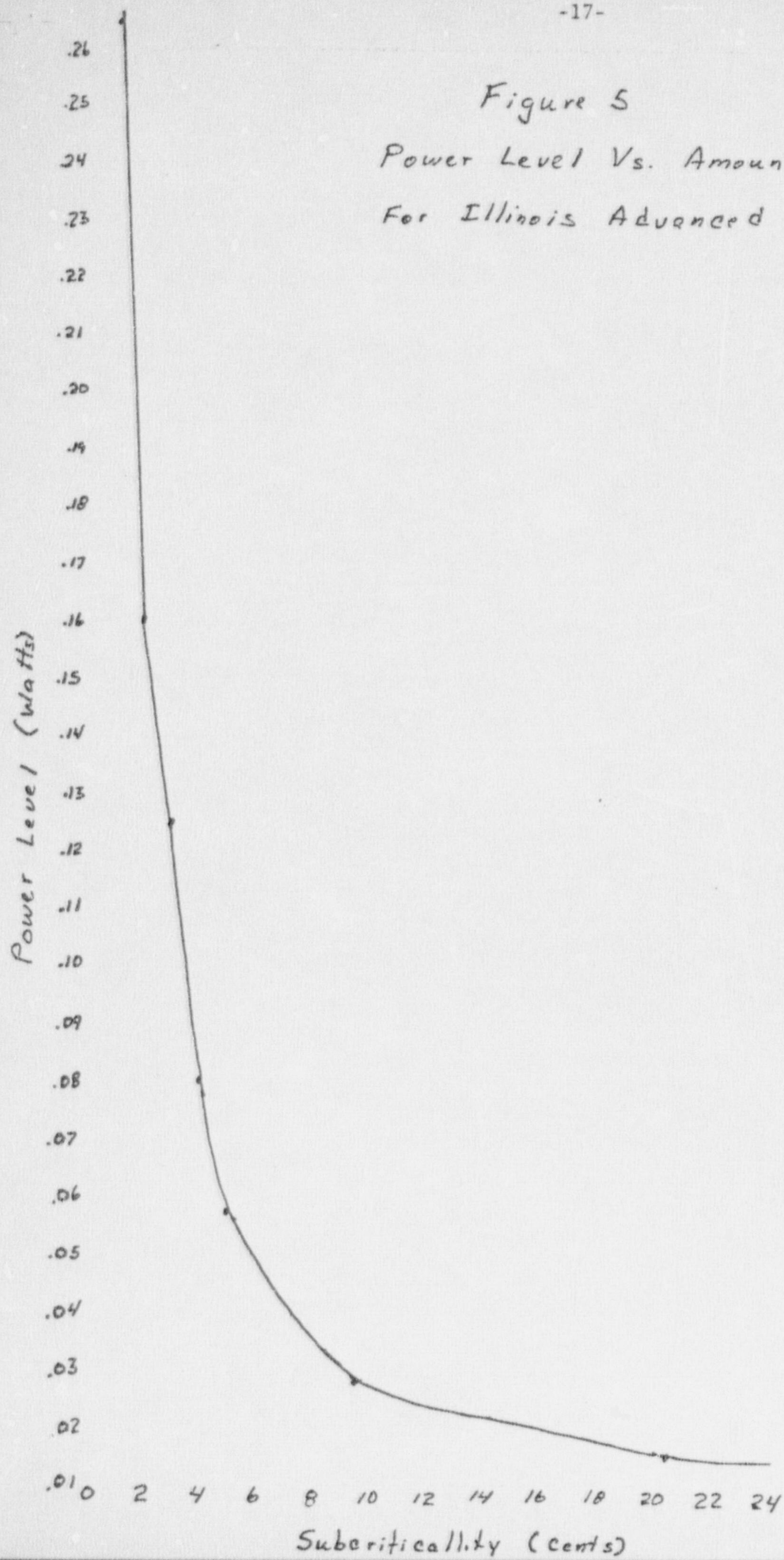


Figure 5
Power Level Vs. Amount Subcritical
For Illinois Advanced TRIGA
Power Level (Watts)
.26
.25
.24
.23
.22
.21
.20
.19
.18
.17
.16
.15
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
2
4
6
8
10
12
14
16
18
20
22
24
Subcriticallity (cents)

Table 7

LOPRA Power Level Due to Soure Multiplication

LOPRA Subcriticallity	Keithley Reading	Corresponding Advanced TRIGA power level (Fig.)
10 ¢	2.5×10^{-8} amp	.027 W
Source change		
20 ¢	1.18×10^{-8} amp	.005 W
10 ¢	1.8×10^{-8} amp	.027 W
4 ¢	4.1×10^{-8} amp	.08 W
2.8¢	6.9×10^{-8} amp	.12 W
Reset Compensated Ion Chamber		
3 ¢	2.2×10^{-9} amp	.105 W
1.5¢	3.6×10^{-9} amp	.2 W
Reset Compensated Ion Chamber		
10 ¢	3.0×10^{-10} amp	.027 W

TABLE 8

REACTIVITY LOSS Vs. POWER LEVEL

Reactivity Loss	Advanced TRIGA Power Level (Fig. 6)	MARK II TRIGA Power Level (Fig. 6)	LOPRA γ-Monitor Power Level	LOPRA Keithley Power Level
4.4¢	1.55kw	2.7kw	2kw	2kw
4.8¢	1.80kw	3.05kw	2kw	2kw
8.0¢	4.2kw	5.6kw	4kw	5kw
11.8¢	7.5kw	8.6kw	6kw	7.6kw

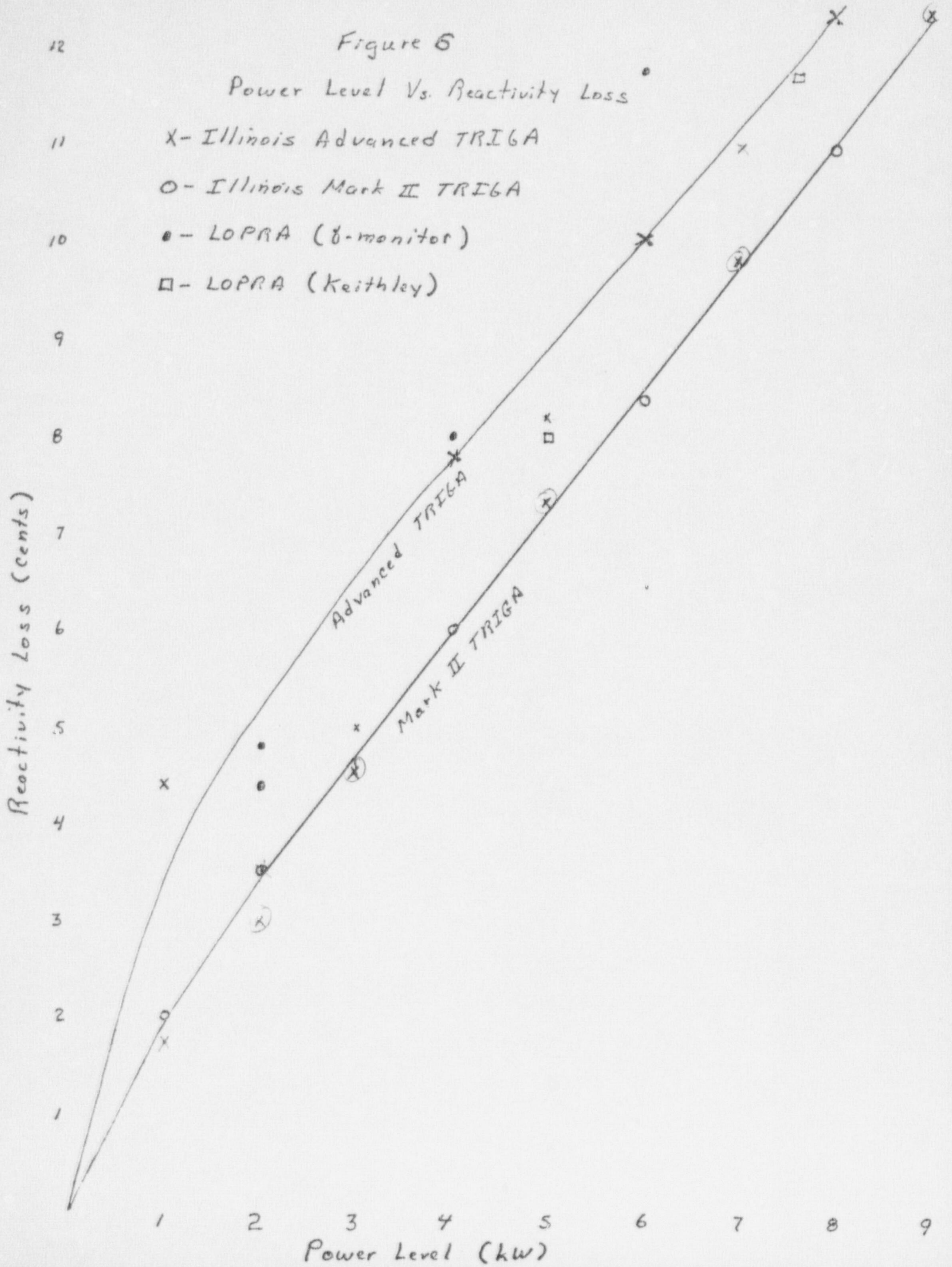


Figure 6
Power Level Vs. Reactivity Loss
X- Illinois Advanced TRIGA
O- Illinois Mark II TRIGA
•- LOPRA (γ-monitor)
□- LOPRA (Keithley)
Advanced TRIGA
Mark II TRIGA
Reactivity Loss (cents)
Power Level (kW)
1
2
3
4
5
6
7
8
9
10
11
12

Section IV

Rod Drop Measurement of Safety Rod Reactivity Worths.

The LOPRA was leveled off at a power level of 9W. A safety rod was then dropped into the core. The ratio of the power level 15 sec. after drop to the initial power level was found. This value was compared with the 18sec. curve of power ratios vs. reactivity insertion, generated on the Illinois Advanced TRIGA (Fig. 7). Comparing the 15 second ratios for LOPRA with the 18 second ratios for the Illinois Advanced TRIGA, it is seen that the safety rod reactivity worths, as measured by this method, are at least \$4.20 for safetry rod #1 and \$3.75 for safety rod #2. Table 9 gives the data collected in this measurement.

TABLE 9

DATA FOR ROD DROP MEASUREMENT OF SAFETY ROD REACTIVITY WORTHS

Safety Rod Number	Initial Power	Power 15 sec. After Drop	Ratio	Reactivity Worth on 18 sec. TRIGA Curve
1	9W	.38W	.0425	$4.20
2	9W	.42W	.0494	$3.75

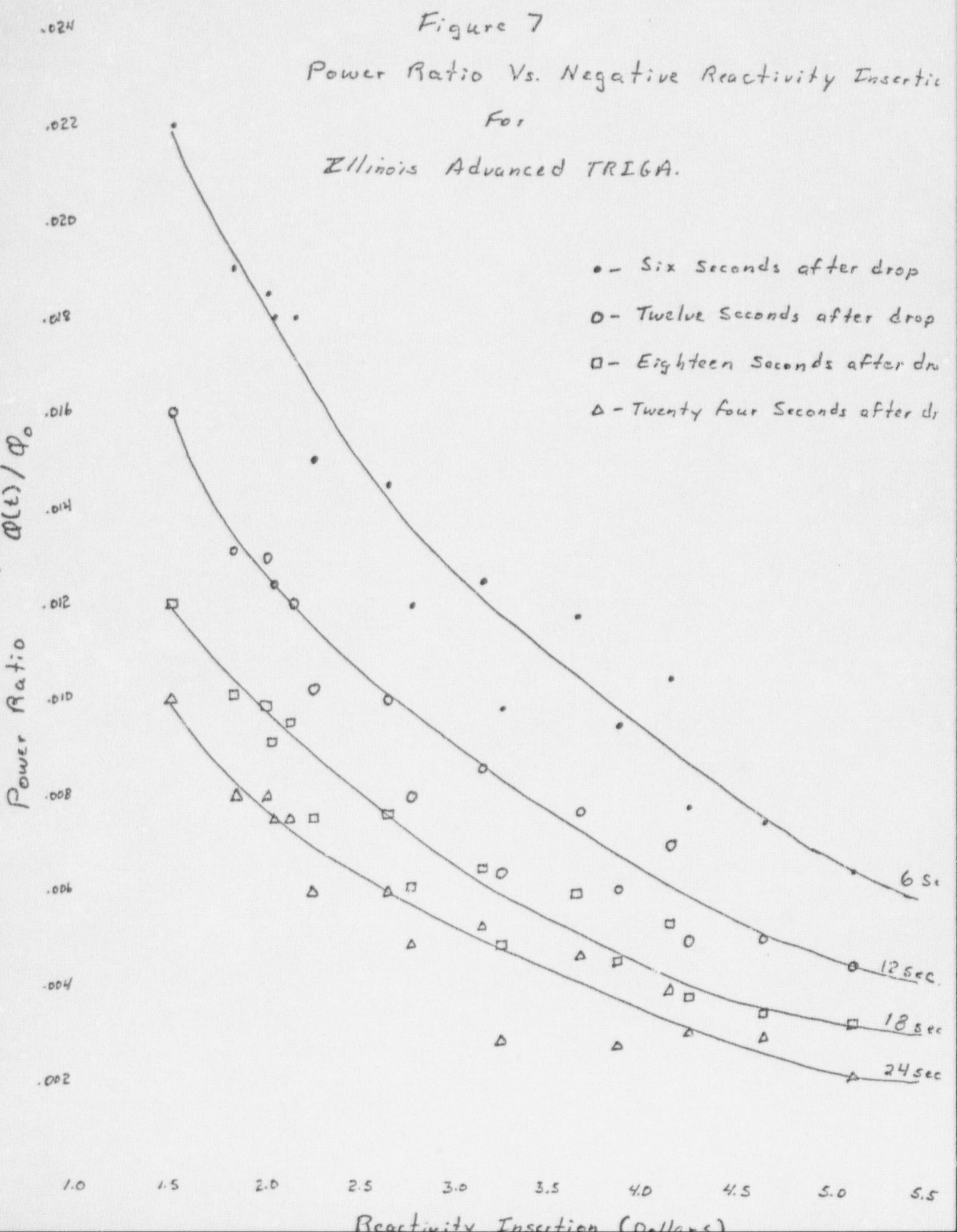


Figure 7
Power Ratio Vs. Negative Reactivity Insertic
For
Illinois Advanced TRIGA.
• - Six Seconds after drop
o - Twelve Seconds after drop
□ - Eighteen Seconds after dr
Δ - Twenty four Seconds after d
6 S
12 sec.
18 sec
24 sec
Power Ratio $\Phi(t)/\Phi_0$
.024
.022
.020
.018
.016
.014
.012
.010
.008
.006
.004
.002
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
Reactivity Insertion (Dollars)

Section V

1/M MEASUREMENTS OF POISON ROD AND SAFETY RODS REACTIVITY WORTHS

1/M measurements in LOPRA were used to determine the reactivity worth of the poison rod and the safety rods. The value of the source used in the initial loading was the source value for these measurements. The various configurations measured and the 1/M values are given in Table 12. The reactivity worths calculated from the above measurements are given in Table 11. The total worth of the poison rod with the safety rods up is found by adding the excess reactivity in the assembly to the negative reactivity worth found from the 1/M measurements.

Another value for the source was found using the data collected from the power calibration. The source was found by extrapolation of the data where power level vs. small negative reactivities in LOPRA was measured. This source value gave rod reactivity worths about 40% higher than the worths reported here.

TABLE 10

CONFIGURATIONS AND 1/M VALUES FOR POISON ROD AND SAFETY ROD REACTIVITY WORTHS

β = .0073

Source = 295 Counts/min.

Configuration	Counts/min.	1/M	Subcriticallity of LOPRA
All rods in	4617	.06389	$8.75
Safety Rod #1 Up	10360	.02847	$3.90
Safety Rod #2 Up	9160	.03220	$4.41
Poison Rod Up	5198	.0568	$7.78
Safety Rod #1 and #2 Up	52560	.005612	$0.77

TABLE 11

ROD REACTIVITY WORTHS

β = .0073

Source = 295 counts/min

Rod	Reactivity Worth
Negative portion of poison rod Safety Rods out	$0.77
Total poison rod Safety rods out	$0.97
Total poison rod Safety rods in	$0.97
Safety rod #1 Safety rod #2 and poison rod in	$4.85
Safety rod #2 Safety rod #1 and poison rod in	$4.34
Safety rod #1 and #2 Poison rod in	$7.78
All rods added separately	$10.16
Total negative worth of all rods in	$8.75

Section VI

COUPLING OF LOPRA WITH THE ILLINOIS ADVANCED TRIGA

The critical rod position, at power level of 0.1 W, for the LOPRA was determined with the TRIGA shutdown. The poison rod of the LOPRA was inserted and the TRIGA was brought to a power level of 15 W. A power indication of 0.002 W was noted in the LOPRA under these conditions. The LOPRA was then brought to a power level of 1.0 W, at which time a possible slight increase in the TRIGA power was noted. For the level LOPRA power of 1.0 W the same LOPRA poison rod position occurred as the previous position of 0.1 W.

The TRIGA power was increased to 1 kW and a nearly linear increase in power was noted in the LOPRA. The LOPRA poison rod was then inserted until the LOPRA was approximately 5¢ subcritical. The resulting power level in the LOPRA was noted and the power then increased to 10 kW. Because of the long time necessary for the LOPRA power level to come to equilibrium at 5¢ subcritical, the poison rod was inserted so that LOPRA was 19¢ subcritical and the experiment continued. The results are given in Table 12. The LOPRA power levels are approximate since time was not allowed for the LOPRA power to level off and the asympotic LOPRA power level was estimated.

The value of .016¢ for the coupling coefficient found from these measurements (Table 12), compares with a value of 0.10¢ used in the calculation for the graphs on page 14 of the LOPRA SAR. Thus the SAR graph will over estimate the LOPRA power levels from TRIGA operation, by a factor of approximately 6. The graph on page 15 of the LOPRA SAR for peak pulsed power in LOPRA will also be a factor of 6 high. Also, there is a finite time (seconds) needed for LOPRA to come to equilibrium which was not accounted for in the SAR, which would lower the peak power in LOPRA during a pulse. Thus the pulse characteristics of LOPRA should be conservatively estimated in the LOPRA SAR.

TABLE 12

COUPLING BETWEEN THE ILLINOIS ADVANCED TRIGA AND LOPRA

LOPRA Subcriticallity	TRIGA Power	LORPA Power	Coupling Coef.
0	15 W	1W	-----
0	1 kW	Rising linearly	-----
5¢	1 kW	4W	.02¢
5¢	10 kW	30W	.015¢
19¢	100 kW	85W	.016¢
19¢	200 kW	165W	.016¢
19¢	300 kW	250W	.016¢
19¢	400 kW	310W	.015¢

UNIVERSITY OF ILLINOIS

REPORT OF THE COMPTROLLER

YEAR ENDED JUNE 30, 1988

CRAIG S. BAZZANI, COMPTROLLER

UNIVERSITY OF ILLINOIS

REPORT OF THE COMPTROLLER

YEAR ENDED JUNE 30, 1988

CRAIG S. BAZZANI, COMPTROLLER

PUBLISHED BY THE UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS 1988

UNIVERSITY OF ILLINOIS
OFFICE OF
Vice President for Business and Finance, Comptroller

CHICAGO URBANA - CHAMPAIGN

349 Administration Building · 506 South Wright Street · Urbana, Illinois 61801

President Stanley O. Ikenberry
and
The Board of Trustees
University of Illinois

I am pleased to transmit the Annual Report of the Comptroller of the University of Illinois for the fiscal year ended June 30, 1988. This report is supplemented by the Annual Report of the University of Illinois Auxiliary Facilities System, the Annual Report of the Construction Engineering Research Laboratory, and the Annual Report of the Willard Airport Facility, which are issued under separate cover.

The year 1987-88 marks the 120th year of the operation of the University. Prior to 1911, statements of the financial operations appeared only in the proceedings of The Board of Trustees which since 1909 have contained the annual and biennial budgets. Since July 1, 1911, separate reports have been published showing the financial operations of each year. These reports are intended to form a comprehensive and permanent record of the finances of the University for the periods covered for the information and reference of all persons concerned or interested.

The financial statements of the University for the past year have been examined by Grant Thornton, Certified Public Accountants, and their report follows. Grant Thornton has also prepared a report for the year ended June 30, 1988 containing special data requested by the Auditor General of the State of Illinois and another report covering their audit of the compliance of the University with applicable state and federal laws and regulations for the two years ended June 30, 1988. These reports are not contained herein and are primarily for the use of the State Auditor General and federal agencies.

Respectfully submitted,

Craig S. Bazzani

Craig S. Bazzani
Vice President for
Business and Finance,
Comptroller

TABLE OF CONTENTS

600 One Prudential Plaza
130 E. Randolph Drive
Chicago, IL 60601-6145
312 856-0200

REPORT OF INDEPENDENT CERTIFIED PUBLIC ACCOUNTANTS

Grant Thornton

Accountants and
Management Consultants

The U.S. Member Firm of
Grant Thornton International

The Honorable Robert G. Cronson
Auditor General, State of Illinois
and
The Board of Trustees
University of Illinois

As Special Assistant Auditors for the Auditor General, State of Illinois, we have audited the accompanying balance sheets of the University of Illinois (University) as of June 30, 1988 and 1987, and the related statement of changes in fund balances (deficit) and the statement of current funds revenues, expenditures and other changes for the year ended June 30, 1988. These financial statements are the responsibility of the University's management. Our responsibility is to express an opinion on these financial statements based on our audits.

We conducted our audits in accordance with generally accepted auditing standards and the "Standards for Audits of Governmental Organizations, Programs, Activities and Functions" issued by the Comptroller General of the United States. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion. We previously audited the financial statements of the University as of June 30, 1987 and for the year then ended, from which the accompanying comparative totals for 1987 were derived.

In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of the University at June 30, 1988 and 1987, and the changes in fund balances (deficit) and current funds revenues, expenditures and other changes for the year ended June 30, 1988, in conformity with generally accepted accounting principles.

Grant Thornton

Chicago, Illinois
November 3, 1988

UNIVERSITY OF ILLINOIS
BALANCE SHEETS
JUNE 30, 1988 AND 1987

ASSETS

	1988	1987
Current funds:		
Unrestricted -		
Assets held by State Treasurer - University Income Fund	$ 17,893,340	$ 15,341,462
Claim on cash and pooled investments	17,643,927	15,889,847
Investments	30,537,525	16,129,694
Accrued investment income	540,410	386,063
Receivable from State of Illinois General Revenue Fund	9,402,778	10,075,801
Accounts receivable (less allowance for doubtful accounts of $110,256,000 in 1988 and $107,900,000 in 1987)	65,179,617	57,617,654
Inventories and deferred charges	22,541,011	22,739,643
Total unrestricted	163,738,608	138,180,164
Restricted -		
Claim on cash and pooled investments	31,678,240	23,172,024
Investments	13,634,543	17,897,739
Accrued investment income	586,215	829,667
Accounts receivable (less allowance for doubtful accounts of $14,832,000 in 1988 and $16,850,000 in 1987)	39,838,157	39,137,035
Inventories	350,247	12,171
Total restricted	86,087,402	81,048,636
Total current funds	$ 249,826,010	$ 219,228,800
Loan funds:		
Claim on cash and pooled investments	$ 4,421,844	$ 5,142,766
Investments	193,031	469,846
Accrued investment income	33,788	31,739
Notes receivable (less allowance for doubtful notes of $5,332,000 in 1988 and $5,640,000 in 1987)	29,364,681	26,578,085
Other assets	69,100	69,100
Total loan funds	$ 34,082,444	$ 32,291,536
Endowment and similar funds:		
Claim on cash	$ 51,412	$ 245,231
Investments	34,609,142	29,979,713
Real estate and farm properties	5,724,267	5,723,562
Accrued investment income	993	
United States land grant fund assumed by State of Illinois	649,013	649,013
Total endowment and similar funds	$ 41,034,827	$ 36,597,519
Plant funds:		
Claim on cash and pooled investments	$ 17,735,075	$ 17,448,633
Investments	49,160,899	84,632,126
Accounts receivable	1,009,376	
Accrued investment income	890,439	1,605,608
Prepaid expense	13,320,000	14,800,000
Investment in plant -		
Land	37,170,699	32,728,325
Buildings	802,976,931	777,207,759
Improvements other than buildings	80,547,234	78,094,982
Equipment	711,502,985	643,785,269
Construction in progress	93,242,933	41,106,840
Total plant funds	$1,807,556,571	$1,691,409,542
Agency funds:		
Claim on cash and pooled investments	$ 1,955,486	$ 3,854,989

See accompanying notes to financial statements.

LIABILITIES AND FUND BALANCES (Deficit)

	1988	1987
Current funds:		
Unrestricted -		
Accounts payable	$ 29,682,873	$ 28,085,881
Accrued payroll	35,613,987	35,778,837
Accrued compensated absences	63,958,759	55,665,044
Deferred revenue and student deposits	14,206,034	13,610,337
Accrual self insurance	40,652,836	24,704,347
Fund deficits	(20,375,881)	(19,664,282)
Total unrestricted	163,738,608	138,180,164
Restricted -		
Accounts payable	5,497,730	5,378,153
Accrued payroll	4,446,157	4,623,440
Accrued compensated absences	3,252,880	2,718,882
Fund balances	72,890,635	68,328,161
Total restricted	86,087,402	81,048,636
Total current funds	$ 249,826,010	$ 219,228,800
Loan funds:		
Accounts payable	$ 48,367	$ 198,236
Fund balances -		
Refundable Federal loan funds - restricted	23,665,610	22,459,061
Private gifts and other - restricted	7,720,893	7,145,303
State matching funds	2,647,574	2,488,936
Total fund balances	34,034,077	32,093,300
Total loan funds	$ 34,082,444	$ 32,291,536
Endowment and similar funds:		
Fund balances -		
Endowments - restricted	$ 18,093,415	$ 16,669,247
Quasi-endowments - restricted	22,156,332	19,143,251
Living trusts - restricted	136,067	136,008
United States land grant - unrestricted	649,013	649,013
Total endowment and similar funds	$ 41,034,827	$ 36,597,519
Plant funds:		
Accounts payable	$ 8,986,625	$ 7,226,793
Accrued interest	733,821	792,767
Bonds payable	138,608,082	133,276,357
Leaseholds payable	60,772,687	60,932,768
Fund balances -		
Unexpended - restricted	12,918,128	38,995,550
Renewals and replacements - restricted	10,862,872	11,974,894
Retirement of indebtedness - restricted	21,359,316	20,242,066
Net investment in plant	1,553,315,040	1,417,968,347
Total plant funds	$1,807,556,571	$1,691,409,542
Agency funds:		
Assets held in custody for others	$ 1,955,486	$ 3,854,989

UNIVERSITY OF ILLINOIS
STATEMENT OF CHANGES IN FUND BALANCES (DEFICIT)
YEAR ENDED JUNE 30, 1988 WITH COMPARATIVE TOTALS FOR 1987

	CURRENT FUNDS		LOAN FUNDS
	UNRESTRICTED	RESTRICTED	
Revenues and other additions:			
Unrestricted current funds revenues	$921,759,846	$	$
Federal appropriations		15,481,884	
Medical service plan		33,419,598	
Restricted gifts, grants and contracts -			
Private		77,853,225	596,633
Federal		180,211,354	603,215
State of Illinois		27,657,107	
Investment income - restricted		5,777,242	695,171
Net realized gains on investments - restricted			
State appropriations, restricted			
Interest and service charges on student loans			680,743
Decrease in allowance for uncollectable notes			307,796
Additions to plant facilities -			
From current funds expenditures			
From plant funds expenditures			
From other State of Illinois agencies, principally Capital Development Board			
Acquired through capital leases			
Retirement of indebtedness -			
Bonds defeased			
Bond principal payments			
Bond proceeds net of underwriters' fees ($0 in 1988 and $1,072,619 in 1987)			
Increase of equity in capitalized leased assets -			
Adjustment in equity in capitalized leased assets			
Lease principal payments			
Other		1,457,066	476
Total revenues and other additions	921,759,846	341,857,476	2,884,034
Expenditures and other deductions:			
Educational and general expenditures	668,676,821	278,610,128	
Auxiliary enterprises expenditures	99,307,669	2,208	
Hospital expenditures	120,357,231	57,384	
Independent operations expenditures	4,580,976	22,950	
Indirect costs recovered		48,472,078	
Educational and administrative allowances recovered		590,201	
Refunds to grantors		518,415	230,478
Student notes receivable assigned to U. S. Government			107,413
Cancellation of loans under terms of gifts and grants			81,752
Increase in leaseholds payable			
Expended for plant facilities -			
Capitalized expenditures -			
Land			
Buildings			
Improvements other than buildings			
Equipment			
Noncapitalized expenditures			
Deposit to advance refunding escrow			
Retirement of indebtedness			
Interest on indebtedness			
Bonds issued			
Capital appreciation on bonds payable			
Trade-ins, disposals and property adjustments			
Payments to beneficiaries of life income trusts			
Amortization of prepaid expense			
Other deductions			
Total expenditures and other deductions	892,922,697	328,273,364	419,643

Continued on following page.

	PLANT FUNDS					
ENDOWMENT AND SIMILAR FUNDS	UNEXPENDED	RENEWALS AND REPLACEMENTS	RETIREMENT OF INDEBTEDNESS	INVESTMENT IN PLANT	COMBINED TOTALS 1988	COMBINED TOTALS 1987 (MEMO ONLY)
$	$	$	$	$	$ 921,759,846	$ 905,311,786
					15,481,884	14,136,400
					33,419,598	31,826,822
182,060	3,283,009	65,000		9,508,170	91,488,097	118,112,618
	3,466,636			2,113,379	186,394,584	168,859,740
	32,380				27,689,487	26,399,714
	3,161,874	657,988	814,103		11,106,378	11,[illegible]12,261
2,768,044					2,768,044	1,667,449
	1,043,526				1,043,526	8,747,178
					680,743	900,546
					307,796	1,050,789
				64,397,527	64,397,527	77,655,032
				56,864,534	56,864,534	41,706,639
		16,547,528		15,442,255	31,989,783	11,346,796
				13,424,176	13,424,176	53,265,487
						28,576,662
				10,335,000	10,335,000	10,014,000
	6,907,500		793,528		7,701,028	45,582,979
				56,500	56,500	6,742,764
				13,527,757	13,527,757	14,384,400
705			291,567		1,749,814	1,067,547
2,950,809	17,894,925	17.270,516	1,899,198	185,669,298	1,492,186,102	1,579,147,609
					947,286,949	920,585,948
					99,309,877	92,308,172
					120,414,615	118,669,329
					4,603,926	4,336,139
					48,472,078	43,935,946
					590,201	277,299
	12,071				760,964	646,664
					107,413	1,403,600
					81,752	44,201
				13,424,176	13,424,176	57,465,487
	1,621,249				1,621,249	3,824,403
	50,512,284	1,444,742			51,957,026	35,069,437
	2,160,303	(3,366)			2,156,937	1,333,097
	724,977	404,345			1,129,322	1,479,702
	1,564,174	20,489,621			22,053,795	7,158,518
			293,175		293,175	39,913,064
			23,862,757		23,862,757	24,398,400
			8,158,266		8,158,266	5,619,625
	6,907,500			767,500	7,675,000	46,635,598
				7,991,725	7,991,725	7,310,468
				9,232,434	9,232,434	46,462,061
18,719					18,719	20,191
				1,480,000	1,480,000	
287					287	703
19,006	63,502,558	22,335,342	32,314,198	32,895,835	1,372,682,643	1,458,898,052

UNIVERSITY OF ILLINOIS
STATEMENT OF CHANGES IN FUND BALANCES (DEFICIT) (Continued)
YEAR ENDED JUNE 30, 1988 WITH COMPARATIVE TOTALS FOR 1987

	CURRENT FUNDS		LOAN FUNDS
	UNRESTRICTED	RESTRICTED	
Transfers - additions (deductions):			
Mandatory -			
Renewals and replacements	$ (3,589,170)	$	$
Retirement of indebtedness	(24,299,338)	(5,760,517)	
Student loan matching	(50,000)		50,000
Investment income utilized for bond and interest sinking fund			
Bond principal utilized for bond and interest sinking fund			
Non-mandatory -			
Bond principal utilized for capitalized and noncapitalized expenditures			
Renewals and replacements	(367,367)		
Other, net	(1,242,873)	(3,261,121)	(573,614)
Total transfers	(29,548,748)	(9,021,638)	(523,614)
Increase (decrease) in fund balances	(711,599)	4,562,474	1,940,777
Fund balances (deficit) at beginning of year	(19,664,282)	68,328,161	32,093,300
Fund balances (deficit) at end of year	$(20,375,881)	$ 72,890,635	$34,034,077

See accompanying notes to financial statements.

	PLANT FUNDS					
ENDOWMENT AND SIMILAR FUNDS	UNEXPENDED	RENEWALS AND REPLACEMENTS	RETIREMENT OF INDEBTEDNESS	INVESTMENT IN PLANT	COMBINED TOTALS 1988	COMBINED TOTALS 1987 (MEMO ONLY)
$	$	$ 3,589,170	$	$	$	$
	(527,762)		30,587,617			
	(841,013)		841,013			
	(3,620)		3,620			
	17,426,770			(17,426,770)		
		367,367				
1,505,505	3,575,836	(3,733)				
1,505,505	19,530,211	3,852,804	31,532,250	(17,426,770)		
4,437,308	(26,077,422)	(1,112,022)	1,117,250	135,346,693	119,503,459	120,249,557
36,597,519	38,995,550	11,974,894	20,242,066	1,417,968,347	1,606,535,555	1,486,285,998
$41,034,827	$ 12,918,128	$10,862,872	$21,359,316	$1,553,315,040	$1,726,039,014	$1,606,535,555

UNIVERSITY OF ILLINOIS
STATEMENT OF CURRENT FUNDS REVENUES, EXPENDITURES AND OTHER CHANGES
YEAR ENDED JUNE 30, 1988 WITH COMPARATIVE TOTALS FOR 1987

	UNRESTRICTED				COMBINED
	STATE APPROPRIATIONS	OTHER	RESTRICTED	TOTAL 1988	TOTAL 1987 (MEMO ONLY)
Revenues:					
Educational and general -					
tudent tuition and fees	$128,689,005	$	$	$ 128,689,005	$ 112,596,902
tate appropriations	464,953,333			464,953,333	486,042,142
ederal appropriations			15,099,236	15,099,236	15,801,149
ederal grants and contracts		42,609,879	137,515,249	180,125,128	168,449,087
State of Illinois grants and contracts		1,379,710	26,010,485	27,390,195	26,387,863
Private gifts, grants and contracts		5,503,345	65,765,911	71,269,256	66,563,690
Endowment income	32,451		2,984,518	3,016,969	3,212,886
Other sources	4,047,867	45,491,760	37,077,788	86,617,415	70,080,243
Total educational and general revenue	597,722,656	94,984,694	284,453,187	977,160,537	949,133,962
Sales and services of auxiliary enterprises		118,904,356		118,904,356	113,790,654
Sales and services of hospital		105,465,415		105,465,415	105,266,978
Independent operations		4,682,725		4,682,725	4,148,169
Total revenues	597,722,656	324,037,190	284,453,187	1,206,213,033	1,172,339,763
Expenditures and mandatory transfers:					
Educational and general -					
Instruction	249,807,327	7,971,168	44,752,246	302,530,741	298,506,264
Research	32,472,012	21,793,566	157,045,692	211,311,270	199,647,690
Public service	33,851,695	20,525,063	47,686,007	102,062,765	93,851,174
Academic support	87,529,179	11,536,636	2,341,246	101,407,061	105,844,996
Student services	15,059,011	477,620	735,524	16,272,155	15,743,193
Institutional support	54,071,078	10,715,790	2,094,845	66,881,713	67,867,281
Operation and maintenance of plant	72,439,959	13,792,922	307,532	86,540,413	85,009,218
Scholarships and fellowships	34,682,699	1,951,096	23,647,036	60,280,831	54,116,132
Total educational and general expenditures	579,912,960	88,763,861	278,610,128	947,286,949	920,585,946
Mandatory transfers for -					
Retirement of indebtedness	3,213,462	7,762,754	5,760,517	16,736,733	14,921,489
Student loan matching grant	50,000			50,000	15,158
Total educational and general	583,176,422	96,526,615	284,370,645	964,073,682	935,522,595
Auxiliary enterprises -					
Expenditures		99,307,669	2,208	99,309,877	92,308,172
Mandatory transfers for -					
Renewals and replacements		3,589,170		3,589,170	3,429,450
Retirement of indebtedness		12,040,692		12,040,692	9,001,634
Total auxiliary enterprises		114,937,531	2,208	114,939,739	104,739,256
Hospital -					
Expenditures	15,509,933	104,847,298	57,384	120,414,615	118,669,329
Mandatory transfers for retirement of indebtedness		1,192,244		1,192,244	1,531,934
Total hospital	15,509,933	106,039,542	57,384	121,606,859	120,201,263
Independent operations -					
Expenditures	402,822	4,178,154	22,950	4,603,926	4,336,139
Mandatory transfers for retirement of indebtedness		90,186		90,186	62,360
Total independent operations	402,822	4,268,340	22,950	4,694,112	4,398,499
Total expenditures and mandatory transfers	599,089,177	321,772,028	284,453,187	1,205,314,392	1,164,861,613

UNIVERSITY OF ILLINOIS
STATEMENT OF CURRENT FUNDS REVENUES, EXPENDITURES AND OTHER CHANGES (Continued)
YEAR ENDED JUNE 30, 1988 WITH COMPARATIVE TOTALS FOR 1987

	UNRESTRICTED				COMBINED
	STATE APPROPRIATIONS	OTHER	RESTRICTED	TOTAL 1988	TOTAL 1987 (MEMO ONLY)
Other transfers and additions (deductions):					
Excess of restricted receipts over transfers to revenues	$	$	$ 8,342,010	$ 8,342,010	$ 7,723,690
Refunds to grantors			(518,415)	(518,415)	(196,029)
Inter-fund transfers -					
Current funds	(1,370,699)	2,542,877	(1,172,178)		
Loan funds		653,975	(80,658)	573,317	280,356
Endowment and similar funds			(1,505,207)	(1,505,207)	(105,011)
Plant funds -					
Unexpended		(3,072,759)	(503,078)	(3,575,837)	(2,425,002)
Renewals and replacements		(363,634)		(363,634)	(2,283,196)
Total other transfers and additions (deductions)	(1,370,699)	(239,541)	4,562,474	2,952,234	2,994,808
Total increase (decrease) in fund balances	$ (2,737,220)	$ 2,025,621	$ 4,562,474	$ 3,850,875	$ 10,472,958

See accompanying notes to financial statements.

1 - Summary of Significant Accounting Policies

The University of Illinois (University), a federal land grant institution and an agency of the State of Illinois, conducts education, research and public service and related activities principally at its two campuses in Urbana-Champaign and Chicago which includes the University of Illinois Hospital (Hospital) and other health care facilities. The governing body of the University is The Board of Trustees of the University of Illinois (Board). The accompanying financial statements present the combined financial position and financial activities of the University's various operations, including certain activities and expenditures funded by other State agencies on behalf of the University or its employees. The accounts of the University of Illinois Foundation, The Athletic Association of the University of Illinois at Urbana-Champaign and The University of Illinois Alumni Association, related organizations which conduct principally fund raising activities and collegiate athletics on behalf of the University, are not included in the accompanying financial statements (Note 7).

Basis of presentation

The financial statements of the University are prepared on the accrual basis of accounting, except for depreciation accounting as explained below.

The accounts of the University are maintained in accordance with the principles of fund accounting. Under fund accounting, resources are classified for accounting and reporting purposes into funds according to specified activities or objectives. Separate accounts are maintained for each fund; however, funds with similar characteristics are combined into fund groups in the accompanying financial statements.

Within each fund group, fund balances restricted by outside sources are so indicated and are distinguished from unrestricted funds. Restricted resources may only be used for the purposes established by the source of such funds. Included in Current Unrestricted Funds is the University of Illinois Income Fund (University Income Fund) which consists of student tuition and fees that, by law, are deposited with the State Treasurer. These funds must be appropriated by the State Legislature before they can be expended.

The Statement of Current Funds Revenues, Expenditures and Other Changes is a statement of financial activities of the Current Funds. It does not purport to present the overall results of operations of the University as would a statement of revenues and expenses. In the accompanying financial statements, the use of Current Funds to acquire or finance assets of the Plant Funds is accounted for as (a) expenditures in the case of the normal replacement of equipment and ordinary repairs and maintenance and (b) mandatory and other transfers when providing for debt service, repair and replacement reserves and all other cases.

Claim on cash and pooled investments

Various University funds have cash and certain investments which are pooled for the purpose of securing a greater return on investment and providing an equitable distribution of investment return. Pooled investments, which consist principally of U. S. Government and government agency securities, time deposits, corporate commercial paper, and short to intermediate term mutual fund investments, are stated at cost which approximates market. Income is distributed based upon average quarterly balances invested in the pool. Total claim on cash and pooled investments included net cash overdraft book balances of $8,479,115 and net cash balances of $3,158,340 at June 30, 1988 and 1987, respectively. Total bank balance at June 30, 1988 was $2,858,754 of which $1,166,755 was covered by federal depository insurance or collateral held by a third party, $187,779 was covered by collateral held in the pledging bank's trust department in the University's name, and $1,504,220 was uninsured and uncollateralized.

Investments

Investments, including real estate and farm properties, are stated at cost or, when donated, at the fair market value at the date of donation. Investment income, including gains and losses resulting from the sale or other disposition of investments, is recognized in the fund which owned such investments, except for income derived from investments of the Endowment and Similar funds which is recognized in the funds to which the income is restricted.

Illinois Statutes and Board of Trustee's policy authorize the University to invest in obligations of the U. S. Treasury, agencies, and instrumentalities, bank and savings and loan time deposits, corporate bonds, stock and commercial paper, repurchase agreements, and mutual funds. The University did not enter into any repurchase agreements for the year ended June 30, 1988.

The University's investments, including pooled investments but excluding real estate and farm properties, are categorized below to give an indication of the level of risk assumed by the University at June 30, 1988. Category 1 includes investments that are insured or registered or for which the securities are held by the University or its agent in the University's name. Category 2 includes uninsured and unregistered investments for which the securities (or collateral) are held by the broker's or dealer's trust department or agent in the University's name. Category 3 includes uninsured and unregistered investments for which the securities are held by the broker or dealer, or by its trust department or agent but not in the University's name.

	Category			Carrying Amount	Market Value
	1	2	3		
Certificate of Deposits	$400,000	$ 3,000,000		$ 3,400,000	$ 3,400,000
U. S. Government Securities		69,139,304	$ 1,063,767	70,203,071	70,098,909
Commercial Paper			33,438,631	33,438,631	33,476,250
Corporate Bonds			1,700	1,700	85
Corporate Stock		179,250	9,135	188,385	279,343
	$400,000	$72,318,554	$34,513,233	107,231,787	107,254,587
Mutual Funds - Bonds				21,461,410	21,943,625
Mutual Funds - Stocks				20,588,958	17,943,833
Mutual Funds - Money Market				60,127,314	60,127,314
Equity in UI HMO				390,770	390,770
Equity in MedCare HMO				300,000	300,000
Total Investments				$210,100,239	$207,960,129

Inventories

Inventories are stated at the lower of cost or market.

Investment in plant

Investment in plant is carried at cost or, when donated, at the fair market value at the date of donation. In accordance with generally accepted accounting principles for colleges and universities, the University does not record depreciation on these assets.

Additions to the University's investment in plant financed by the State of Illinois Capital Development Board (CDB) are recorded by the University as the funds are expended by the CDB. Expenditures of the CDB for University-related repair and maintenance projects are recorded as expenditures from and additions to the University's Plant Funds.

Accrued self insurance

Accrued self insurance of $40,652,836 and $24,704,347 for the years ended June 30, 1988 and 1987, respectively, covers hospital patient liability; hospital and medical professional liability; estimated general and contract liability; and workers' compensation liability relative to employees paid from local funds. Amounts increasing the self-insurance liability are charged to Current Funds expenditures based upon estimates made by actuaries. Workers' compensation self insurance of $3,900,000 and $4,800,000 at June 30, 1988 and 1987, respectively, for the estimated liability related to employees who are paid from State appropriations are included in Accounts Payable. These claims will be paid from State appropriations in the year in which the claims are finalized, rather than from the current unrestricted funds at June 30, 1988 and 1987.

Accrued self insurance includes $30,091,899 and $16,868,754 at June 30, 1988 and 1987, respectively, for the most probable and reasonably estimable ultimate cost of uninsured medical malpractice liabilities recorded in accordance with the American Institute of Certified Public Accountants Statement of Position 87-1, "Accounting for Asserted and Unasserted Material Malpractice Claims of Health Care Providers and Related Issues". Ultimate cost consists of amounts determined by actuaries, using relevant industry data and hospital specific data to cover asserted claims, reported unasserted claims, projected losses for claims incurred but not reported, and estimated litigation expenses. The University has contracted with several commercial carriers to provide varying levels and upper limits of excess indemnity coverage. These coverages have been considered by the actuaries in determining the required self-insurance liability balances.

As of June 30, 1988, the self-insurance liability of $40,652,836 has been fully funded. This amount has been discounted to account for future expected earnings on invested assets. The undiscounted carrying amount of the self-insurance liability is $51,588,717 and $33,041,711 at June 30, 1988 and 1987, respectively.

Revenue recognition

Appropriations made from the State of Illinois General Revenue Fund for the benefit of the University are recognized as revenues to the extent expended, limited to available appropriations.

Tuition and fees, except for the Summer Session, are recognized as revenues as they are assessed. The portion of Summer Session tuition and fees applicable to the following fiscal year is deferred. The value of tuition and fee exemptions awarded to graduate assistants, staff members and others is included in both revenues from student tuition and fees and in expenditures for scholarships and fellowships. These exemptions amounted to $32,868,680 and $27,741,101 in 1988 and 1987, respectively.

Current Restricted Funds which are received or receivable from external sources are recognized as revenues to the extent of related expenditures on the accrual basis and as additions to fund balance (excess of restricted receipts over transfers to revenues) to the extent funds are received in excess of expenditures.

Expenditure recognition

Employment contracts for certain academic personnel provide for twelve monthly salary payments, although the contracted services are rendered during a nine month period. The liability for those employees who have completed their contracted services, but have not yet received final payment, was approximately $18,900,000 and $18,600,000 at June 30, 1988 and 1987, respectively, and is recorded in the accompanying financial statements. These amounts were subsequently paid from amounts specifically included in State of Illinois General Revenue Fund appropriations to the University for fiscal years 1989 and 1988, respectively, rather than from the Current Unrestricted Funds at June 30, 1988 and 1987.

Substantially all employees participate in group health insurance plans administered by the State of Illinois. The employer contributions to these plans on behalf of University employees paid by State appropriations and auxiliary enterprises are funded from separate State appropriations to another State agency and are not reflected in the accompanying financial statements. The amount of such contributions cannot be determined. The employer contributions to these plans on behalf of employees paid from other University-held funds are paid by the University.

Accrued compensated absences for University personnel are charged to Current Funds based on earned but unused vacation and sick leave days. At June 30, 1988 and 1987, the University estimates that $34,000,000 and $39,000,000, respectively, of the accrued compensated absences liability will be paid out of State of Illinois General Revenue Fund appropriations to the University in years subsequent to June 30, 1988 and 1987, respectively, rather than from Current Unrestricted Funds available at June 30, 1988 and 1987.

2 - Investments

Investments of the Current, Loan and Plant Funds consist principally of United States Government and government agency securities, certificates of deposit and similar short-term investments. The carrying value of these investments approximates market value.

The carrying value and approximate market value of investments of Endowment and Similar Funds at June 30, 1988 and 1987 were as follows:

	1988		1987	
	Carrying Value	Market	Carrying Value	Market
Certificates of Deposit and Money Market funds	$ 3,501,013	$ 3,501,013		
United States Government and government agency securities			$14,289,339	$14,794,933
Corporate bonds and commercial paper	10,340,671	11,038,904	7,657,836	7,550,756
Common and preferred stocks	20,767,458	18,219,873	8,032,538	10,892,115
Total	$34,609,142	$32,759,790	$29,979,713	$33,237,804

Endowment and Similar Funds also include real estate and farm properties, the income from which is included in endowment income.

3 - Funds Held in Trust by Others

The University is an income beneficiary of several irrevocable trusts which are held and administered by outside fiscal agents. The University has no control over these funds as to either investment decisions or income distributions, thus the principal is not recorded in the accompanying financial statements. The market value of these funds at June 30, 1988 and 1987 and the amount of income received from their trustees during the years then ended were as follows:

	1988	1987
Market value of funds held in trust by others	$11,107,128	$10,753,352
Income received from funds held in trust by others	460,216	554,839

4 - Bonds Payable

At June 30, 1988, bonds payable consist of University of Illinois Auxiliary Facilities System (System) Revenue Bonds, Series 1984, Series 1985, and Series 1986 (Series 1984, 1985, and 1986 Bonds) University of Illinois Revenue Bonds, Series 1985A and Series 1985B (Series 1985A and 1985B Bonds) and University of Illinois Revenue Bonds, Series 1987 (Series 1987 Bonds).

Series 1984 Bonds -

On September 27, 1984, the Series 1984 Bonds were issued in the principal amount of $55,267,602. The Series 1984 Bonds are capital appreciation bonds which do not require current interest payments. They mature semi-annually, commencing October 1, 1990, at amounts sufficient to produce yields ranging from 8.75% to 11.40%. The University records the annual increase in the principal amount of the bonds as capital appreciation on bonds payable.

Proceeds from the sale of the Series 1984 Bonds, together with other available funds from the System, were used to advance refund the University of Illinois Auxiliary Facilities System Revenue Bonds, Series M and N (Series M and N Bonds), to fund a debt service reserve, to pay all costs incidental to the issuance of the Series 1984 Bonds and advance refunding, and to finance certain expenditures related to the planning and development of various proposed additions to the System.

Series 1985 Bonds -

On July 25, 1985 the Series 1985 Bonds were issued in the principal amount of $56,750,000. The Series 1985 Bonds were issued as parity bonds pursuant to the Bond Resolution authorizing the issuance of the Series 1984 Bonds. They bear interest at rates ranging from 5.0% to 8.0% per annum, payable semi-annually, commencing October 1, 1985. The Series 1985 Bonds mature semi-annually, beginning October 1, 1985 through April 1, 2009.

Proceeds from the sale of the Series 1985 Bonds are being used (a) for remodeling, repair, equipment replacement and improvement of certain existing facilities of the System; (b) for construction of facilities which will become part of the System including construction of a residence hall and new parking facilities on the Chicago campus, renovation of an ice arena, construction of a recreation structure and improvements and additions to athletic facilities at the Urbana-Champaign campus; (c) to fund the Debt Service Reserve in an amount equal to the difference between the Maximum Annual Net Debt Service and the balance in such account at the time of delivery of the Series 1985 Bonds; and (d) to pay certain expenses relating to the issuance of the Series 1985 Bonds.

Series 1985A and 1985B Bonds -

On June 12, 1985, the Series 1985A Bonds were issued in the principal amount of $2,700,000. On July 25, 1985, the Board issued the Series 1985B Bonds in the principal amount of $2,025,000. The Series 1985A Bonds bear interest at 9.70%, per annum, and the Series 1985B Bonds bear interest at rates ranging from 6.25% to 8.90%, per annum, both payable semi-annually, commencing October 1, 1985. The 1985A Bonds mature semi-annually, beginning October 1, 1996 through April 1, 2003 and the Series 1985B Bonds mature semi-annually, beginning October 1, 1986 through April 1, 1996.

The Series 1985A and 1985B Bonds were issued in connection with the advance refunding of debt relating to the Construction Engineering Research Laboratory (CERL) and to fund future additions to CERL.

Series 1986 Bonds -

On August 14, 1986, the Series 1986 Bonds were issued in the principal amount of $46,635,598. The Series 1986 Bonds are capital appreciation bonds which do not require current interest payments. They mature semi-annually, commencing October 1, 1996 through April 1, 2009, at amounts sufficient to produce yields ranging from 7.2% to 8.125%.

Proceeds from the sale of the Series 1986 Bonds were used (a) to advance refund the Series 1984 Bonds due October 1, 1996 through April 1, 2009; (b) to finance various additions and enhancements to the System; and (c) to pay all costs incidental to the issuance of the Series 1986 Bonds and the advance refunding. The annual net Debt Service was not changed by the refunding.

Series 1987 Bonds -

On September 17, 1987, the Series 1987 Bonds were issued in the principal amount of $7,675,000. The Series 1987 Bonds bear interest at rates ranging from 7.30% to 8.40% per annum, payable semi-annually, commencing April 1, 1988. They mature annually, beginning April 1, 1990 through April 1, 2009.

Proceeds from the sale of the Series 1987 Bonds are being used (a) for Willard Airport expansion project costs; (b) to fund a Debt Service Reserve; (c) to purchase bond insurance; and (d) to pay certain expenses relating to the issuance of the Series 1987 Bonds.

Advance refunded bonds -

Certain revenue bonds of the Board have been defeased through advance refundings and, accordingly, have been accounted for as if they were retired. The principal amount of advance refunded bonds outstanding at June 30, 1988 is $143,741,484.

Debt service requirements and security -

Future debt service requirements for all bonds outstanding are as follow:

	Principal	Interest and Capital Appreciation
1989	$ 11,000,000	$ 2,655,723
1990	12,115,000	1,846,573
1991	10,410,859	3,548,561
1992	9,545,674	4,416,277
1993	8,703,171	5,247,062
1994-2009	86,833,378	127,566,684
Total	$138,608,082	$145,280,880

The Maximum Annual Net Debt Service, as defined, for all outstanding debt is $12,939,215.

None of the bonds described above constitute obligations of the State of Illinois or of the Board. Series 1984, 1985 and 1986 Bonds are payable solely by the Board from net revenues of the System, student tuition and fees and certain restricted plant funds. Series 1985A and Series 1985B Bonds are payable solely from the net revenues of CERL and, under certain circumstances, the net revenues of the System, student tuition and fees and certain restricted plant funds. Series 1987 Bonds are payable solely from the net revenues of the airport facilities and related restricted plant funds.

5 - Leases

The University leases various plant facilities and equipment under capital leases. Assets held under capital leases are included in investment in plant as follows:

	1988	1987
Land	$ 744,716	$ 703,642
Equipment	53,985,876	51,830,526
Telecommunications System	34,870,000	34,870,000
Total	$89,600,592	$87,404,168

As of June 30, 1988, future minimum lease payments under capital leases are as follows:

1989	$16,664,722
1990	13,822,236
1991	11,760,087
1992	9,730,820
1993	6,843,235
Later years	19,538,266
Total minimum lease payments	78,359,366
Amount representing interest	17,586,679
Net present value	$60,772,687

6 - State Universities Retirement System

The University participates in the State Universities Retirement System of Illinois (SURS), a cost-sharing multiple employer public employee retirement system.

Eligible employees must participate upon initial employment. Employees are ineligible to participate if a) employed after having attained age 68; b) employed less than 50 percent of full-time; or c) employed less than full-time and attending classes with an employer. Of those University employees ineligible to participate, the majority are students at the University. For the year ended June 30, 1988, total University payroll was $701,516,000; of this amount, $568,338,000 represented earnings for covered employees and was reported to SURS.

Participants are required by statute to contribute 8% of their gross earnings to SURS. For the year ended June 30, 1988, this amounted to $45,451,000. The University contributes annually an amount determined by the State Legislature from State appropriations and amounts from other current funds based on actuarially determined rates. Contributions by the University to SURS for the year ended June 30, 1988 were $38,784,000 which consisted of $32,237,000 from State appropriations and $6,547,000 from other current funds; these contributions represented 6.8% of covered payroll. The University contributes 14.5% of the actuarially determined contributions required from all participating employers. Contributions by the University to SURS for the year ended June 30, 1987 were $45,876,000 which consisted of $37,276,000 from State appropriations and $8,600,000 from other current funds.

SURS provides retirement, disability and death benefits. Members are eligible for normal retirement at any age after 35 years of service, at age 60 after 8 years of service or at age 62 after 5 years of service. There are also provisions for early retirement. Retirement benefits are based on certain formulas that generally are a function of years of service and the average salary based on the highest earnings of any four consecutive years. Disability benefits are paid to disabled members with two years of covered service, generally at 50 percent of basic compensation until the total benefits paid equal 50 percent of the total earnings in covered service. Death benefits are payable to survivors of an active member with one and one half years of covered service or of a former member with ten years of covered service. These benefits are payable until children attain the age of 18, to a spouse after age 50 and to a dependent parent after age 55. Benefits are equal to the retirement contributions and interest, a lump sum payment of $1,000, and a monthly annuity equal to a portion of the accrued normal retirement benefit based on specified formulas.

The pension benefit obligation shown below for SURS as a whole is a standardized disclosure measure of the present value of pension benefits, adjusted for the effects of projected salary increases, estimated to be payable in the future as a result of employee service to date. The measure is the actuarial present value of credited projected benefits and is intended to help users assess SURS' funding status on a going concern basis, assess progress made in accumulating sufficient assets to pay benefits when due, and make comparisons among public employee retirement systems. The SURS does not make separate measurements of assets and pension benefits obligations for individual employees. This information is based on the most recent information available from the SURS Component Unit Financial Report for the year ended June 30, 1987.

Total pension benefit obligation	$4,234,900,000
Net assets available for benefits	2,470,500,000
Unfunded pension obligation	$1,764,400,000

Ten-year historical trend information is available in the above-mentioned SURS report.

University employees are exempt from contributing to Social Security.

Employees of the University may also elect to participate in certain tax-sheltered retirement plans under Section 403(b) of the Internal Revenue Code. These voluntary plans permit employees to designate a part of their earnings into tax-sheltered investments and thus defer federal and state income taxes on their contributions and the accumulated earnings under the plans. Participation and the level of employee contributions are voluntary. The University is not required to make contributions to these plans.

7 - Transactions with Related Organizations

The University of Illinois Alumni Association (Alumni Association), The Athletic Association of the University of Illinois at Urbana-Champaign (Athletic Association), and the University of Illinois Foundation (Foundation) are related organizations formed to support in various ways the University's instructional, research and public service missions.

The University provides these organizations with office space, facilities use, and various goods and services at charges approximating the University's cost and has also provided other items at no charge. These transactions are not material to the University's financial statements.

The University leases various properties from the Foundation under capital lease obligations amounting to $745,000 and $704,000 at June 30, 1988 and 1987, respectively. There were no principal payments made under these leases in 1988 and in 1987.

The following financial information is summarized from the audited financial statements of the Foundation, Athletic Association and Alumni Association:

	Foundation	Athletic Association	Alumni Association
At June 30, 1988 -			
Total Assets (primarily cash and investments)	$136,313,000	$ 5,799,000	$ 6,937,000
Liabilities	$ 5,060,000	$ 6,000,000	$ 179,000
Fund balances:			
Current -			
Unrestricted	144,000	(2,833,000)	46,000
Restricted	11,670,000		6,494,000
Endowment and similar funds	106,211,000		
Annuity and life income funds	9,128,000		
Plant funds	4,100,000	2,632,000	218,000
Total fund balances	131,253,000	(201,000)	6,758,000
Total liabilities and fund balances	$136,313,000	$5,799,000	$6,937,000
At June 30, 1987 -			
Total Assets (primarily cash and investments)	$128,916,000	$6,954,000	$6,387,000
Liabilities	$ 4,720,000	$5,159,000	$ 161,000
Fund balances:			
Current -			
Unrestricted	178,000	(683,000)	13,000
Restricted	9,979,000		6,027,000
Endowment and similar funds	94,341,000		
Annuity and life income funds	8,153,000		
Plant funds	11,545,000	2,478,000	186,000
Total fund balances	124,196,000	1,795,000	6,226,000
Total liabilities and fund balances	$128,916,000	$6,954,000	$6,387,000
For the year ended June 30, 1988 -			
Revenues and other additions -			
From the University	$ 1,516,000	$ 1,636,000	$ 60,000
Others	37,669,000	11,764,000	2,196,000
Total revenues and other additions	39,185,000	13,400,000	2,256,000
Expenditures and other deductions -			
Gifts to the University -			
Restricted	28,916,000		
Unrestricted	486,000		
Rental and other payments to the University	117,000	1,839,000	63,000
Others	2,609,000	13,557,000	1,661,000
Total expenditures and other deductions	32,128,000	15,396,000	1,724,000
Increase (decrease) in fund balances	$ 7,057,000	$(1,996,000)	$ 532,000

	Foundation	Athletic Association	Alumni Association
For the year ended June 30, 1987 -			
Revenues and other additions -			
From the University	$ 1,435,000	$ 1,806,000	$ 83,000
Others	68,492,000	13,331,000	2,317,000
Total revenues and other additions	69,927,000	15,137,000	2,400,000
Expenditures and other deductions -			
Gifts to the University -			
Restricted	61,940,000		
Unrestricted	769,000		
Rental and other payments to the University	65,000	1,826,000	62,000
Others	2,840,000	13,700,000	1,646,000
Total expenditures and other deductions	65,614,000	15,526,000	1,708,000
Increase (decrease) in fund balances	$ 4,313,000	$ (389,000)	$ 692,000

Revenues of the Foundation consist primarily of restricted and unrestricted gifts for the benefit of the University. Revenues of the Athletic Association are related to athletic activities, principally intercollegiate. Revenues of the Alumni Association relate principally to alumni memberships.

For the Athletic Association certain account classifications were changed in 1987 to agree with 1988 classification.

Subsequent event

The University formed a task force in July 1988 for the intercollegiate athletic programs of the Urbana-Champaign campus. The objective of the task force is to bring the governance of intercollegiate athletics from its current stand-alone structure to a position within the structure of the University.

8 - Commitments and Contingencies

Encumbrances

Encumbrances which represent goods or services that have been ordered for which delivery has not been made or the services have not been rendered at June 30, 1988 are not recorded in the accompanying financial statements. Encumbrances of the Current Funds were approximately $17,910,000 at June 30, 1988.

Contracts and grants

The University receives monies from Federal and State government agencies under grants and contracts for research and other activities, including medical service reimbursements. The costs, both direct and indirect, charged to these grants and contracts are subject to audit and disallowance by the granting agency. The University administration believes that any disallowances or adjustments would not have a material effect on the University's financial position.

Legal actions

The University is a defendant in a number of legal actions primarily related to medical malpractice. These legal actions have been considered in estimating and funding the University's self-insurance liability program. The total of amounts claimed under these legal actions, plus potential settlements and amounts relating to losses incurred but not reported, could materially exceed the amount of the self-insurance liability accrual. In the opinion of the University's legal counsel and its administrative officers, the University's self-insurance liability fund and limited excess indemnity insurance coverage from commercial carriers are adequate to cover the ultimate liability of these legal actions, in all material respects.

Currently, the financial stability is uncertain for one of the commercial carriers providing excess indemnity coverage to the University. Also, a second carrier is in liquidation and a third is experiencing financial difficulty and is currently being supported by the Irish government. The University's self-insurance liability accrual has been reduced by $12.7 million and $7.5 million for anticipated recoveries from these commercial carriers for the years ended June 30, 1988 and 1987, respectively. However, because of the potential insolvency of the carriers and certain instances in which commercial carriers have sought to impose limits or reservations on their coverage, the University is unable to determine the eventual collectibility of these anticipated recoveries.

Excess funds

The University is required by legislation to deposit funds in excess of current requirements (excess funds) with the State Treasurer into the University Income Fund or in certain circumstances into the State of Illinois General Revenue Fund. No such deposits were made for the year ended June 30, 1988.

In November 1982 the Legislative Audit Commission of the State of Illinois approved the "University Guidelines - 1982" (Guidelines) which contain criteria for computing certain excess funds. The Guidelines were adopted by the University effective June 30, 1983.