NUCLEONICS WEEK 10-6-83

QUESTIONS REVOLVE AROUND DEATH IN ARGENTINE RESEARCH REACTOR

The obvious violation of fundamental safety procedures which resulted in a sudden criticality excursion and the ensuing death of a technician at an Argentine critical facility has left U.S. government and industry figures puzzled. The U.S. has offered directly and through the International Atomic Energy Agency to provide any help Argentina might need in investigating the incident and has requested a copy of the results of any evaluation or investigation which is conducted.

The incident occurred Sept. 23 when the technician, Osvaldo Rogoulich, 49, described as a qualified operator with 14 years' experience, was changing the core configuration of the RA-II reactor at the Constituyentes Atomic Center near Buenos Aires. The reactor is a zero-power, light water, tank-type reactor designed and built by the Comision Nacional de Energia Atomica which achieved criticality in 1966. The U.S. supplied the plate-type fuel. Standard approved safety procedure for changing fuel in the reactor is to drain the water from the tank, but according to IAEA and NRC information, the operator attempted to make the changes without draining the moderator water. In addition, according to the information, two cases of unloaded fuel were placed on the outside of the graphite reflector instead of being removed completely and an error was made in setting up the final configuration of the fuel.

Prompt criticality occurred in milliseconds at 10-15 megajoules, the equivalent of $3\text{-}4.5 \times 10^{17}$ fissions, and was stopped automatically by reduction of moderation (plate expansion, expulsion of water/steam) and because the safety systems opened the moderator dump valve, according to IAEA. The operator received an estimated dose of 1,400 rads of fast neutrons and 500 rads of gamma radiation, according to NRC figures. (IAEA estimates are 1,400 rads neutrons and 1,400 rads gamma.) He died two days later of radiation effects. Two other technicians were shielded from the radiation. No equipment damage resulted.

U.S. sources familiar with research reactors have expressed surprise that the operator would not have drained the water, even partially, out of the core, and that control rods apparently were not in place to prevent criticality. Procedures for fuel configuration changes are very clear, they said, and the first step is to shut down the reactor by inserting the rods. Before any fuel change is made, an estimate of excess shutdown capacity in the reactor is required – as fuel is removed, the excess capacity grows.

As more fuel is added, the excess capacity shrinks and more control rods are needed. Fuel can only be added one bundle at a time and a control rod or rods with more than enough shutdown capacity are usually held cocked out – with another operator at hand – ready to be dropped in if necessary, they said. In research reactors which produce any power (2 Mwth or above), some water must be left in the tank for cooling purposes, but in a zero-power reactor, there isn't enough heat to require the cooling and all of the water can be removed.

The fact that the unloaded fuel bundles were placed outside of the graphite reflector rather than removed completely would have had very little effect, although if the reactor was at the limit of criticality, it could have played a small part, the sources said. In any case, the bottom line, according to IAEA, is that removal of the water moderator from the tank would have been a 100% guarantee that the incident did not happen.

There have been deaths in the U.S. at critical facilities or defense or government research facilities, the most recent being at the SL-I reactor in Idaho Falls in 1961. That incident resulted in the release of 75-100 megajoules of energy and three deaths from the effects. But of the 100 privately licensed research reactors, there has never been a similar incident. – *Frances Seghers, Washington*

copy for Walt & Helmic! 10/18/83

SSINS No: 6835
IN 83-66, Supp 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, DC 20555

May 25, 1984

IE INFORMATION NOTICE NO. 83-66, SUPPLEMENT 1: FATALITY AT ARGENTINE CRITICAL FACILITY

Addressees:

All nuclear power reactor facilities holding an operating license (OL) or construction permit (CP) and nonpower reactor, critical facility, and fuel cycle licensees.

Purpose:

This information notice is a supplement to IE Information Notice No. 83-66, issued on October 7, 1983. It is expected that nonpower reactor, critical facility, and fuel cycle licensees will review the information for applicability to their facilities. No specific action or response is required.

Description of Circumstances:

The Argentine National Atomic Energy Commission [Comision Nacional de Energie Atomica, (CNEA)] provided the NRC Office of International Programs with the written report documenting the results of the Commissions investigation and evaluation of the September 23, 1983 RA-2 accident near Buenos Aries. A translated copy of the CNEA report is attached.

No response to this information notice is required. If you have any questions regarding this matter, please contact the Regional Administrator of the appropriate NRC Regional Office or this office.

Edward L. Jordan, Director
Division of Emergency Preparedness
and Engineering Response
Office of Inspection and Enforcement

Technical Contact: J. E. Wigginton
(301) 492-4967

Attachments:
1. CNEA Report
2. Figure 1 Fuel Element
3. Figure 2 RA-2 reactor facility
4. Figure 3B Modified core confirguration
5. List of Recently Issued IE Information Notices

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REPORT OF THE ACCIDENT THAT OCCURRED TO THE CRITICAL ASSEMBLY RA-2 REACTOR ON SEPTEMBER 23, 1984

1. Description of the Installation

The RA-2 is a critical assembly reactor operating at 0.1 watt of rated power. It has been in operation since 1966 and is used to conduct experiments with various core configurations. For experiments, the core assembly can be relocated and/or modified. The core consists of MTR-type fuel elements and control rods. The fuel elements are MTR-type, 90% enriched uranium and consist of 19 fuel plates (see Figure 1). The control rods consist of fuel elements in which four of the fuel plates are replaced with two cadmium plates. Demineralized water is the moderator; and demineralized water and graphite constitute the reflector.

The installation is shown in Figure 2.

2. The Accident

On Friday afternoon September 23, 1983, a modification of the core configuration had been scheduled so that an experiment using the pulsed source technique could be conducted. Figure 3A shows the initial core configuration and Figure 3B shows the configuration as it was to be modified. The operating procedure requires the complete removal of the moderator. However, this was only partially done. A short time afterwards, when the exchange operations were being carried out, a criticality excursion occurred.

The operator, who was the only person present in the containment, was fatally exposed; other persons, who were in the control room and other adjacent premises were exposed, but to a much lesser degree.

3. Analysis of the Accident

The President of the Comision Nacional de Energia Atomica (CNEA) (National Atomic Energy Commission, Argentine) appointed an ad hoc commission to investigate the accident. The conclusions of this commission indicate that the basic causes of the accident were as follows:

(a) The moderator was not completely removed from the core before the core configuration was modified.

(b) Two fuel elements, which should have been removed, were left inside the reactor in contact with the graphite reflector.

(c) Sequences were performed to change the positions of fuel elements; this decreased the subcriticality of the system.

(d) Two fuel elements of 15 plates were inserted without the corresponding cadmium control plates. The second fuel element was found to be only partially inserted, wherefore it is deemed that its insertion caused the accident.

(e) All of the operations were performed without the concurrence or presence of a safety official or the operations supervisor.

The evolution of the power and the magnitude of the released energy are still being investigated. Notwithstanding, it is estimated that the excursion was about 10 megajoules, which is equivalent to approximately 3×10^{17} fissions, which occurred during a few tens of milliseconds.

Also, the ad hoc commission identified shortcomings in the installation and operational procedures, as well as in the way approval was obtained and supervision of the experiments was carried out. Because the reactor had been operating for so many years without incident, an excessive degree of confidence had been fostered in regard to minor operations. In addition, other more urgent requirements of the nuclear program took precedence.

4. Dosimetric and Medical Evaluation

The dosimetric evaluations were based on (1) measurements of Na-24 to determine whole-body dose and of P-32 from samples of hair, (2) the gamma spectrometry analysis of the activated metal elements carried by the affected persons, and (3) the readings of the radiothermoluminescent and criticality dosimeters installed in the building.

The doses received by the exposed persons are as follows:

(a) The operator received a lethal, absorbed dose of about 2000 rads of gamma radiation and 1700 rads of neutrons, which precluded any effective therapeutic measures. The amount of P-32 (resulting from the sulfur activation) found in samples of body hair and the operator's woolen clothing, as well as the clinical manifestations, showed that the exposure had been very nonhomogeneous; the doses received on the upper right side of the body were higher than those elsewhere. Approximately 25 minutes after the accident, the operator showed signs and symptoms (vomiting, migraine headache, and diarrhea) of acute exposure over the entire body. His condition became worse the next day when he suffered gastrointestinal disorders. Then early on September 25, neurological and respiratory disorders (radiopneumonitis in the right lung) and edema of the right hand and forearm manifested themselves. Death occurred at 16:45 on the same day.

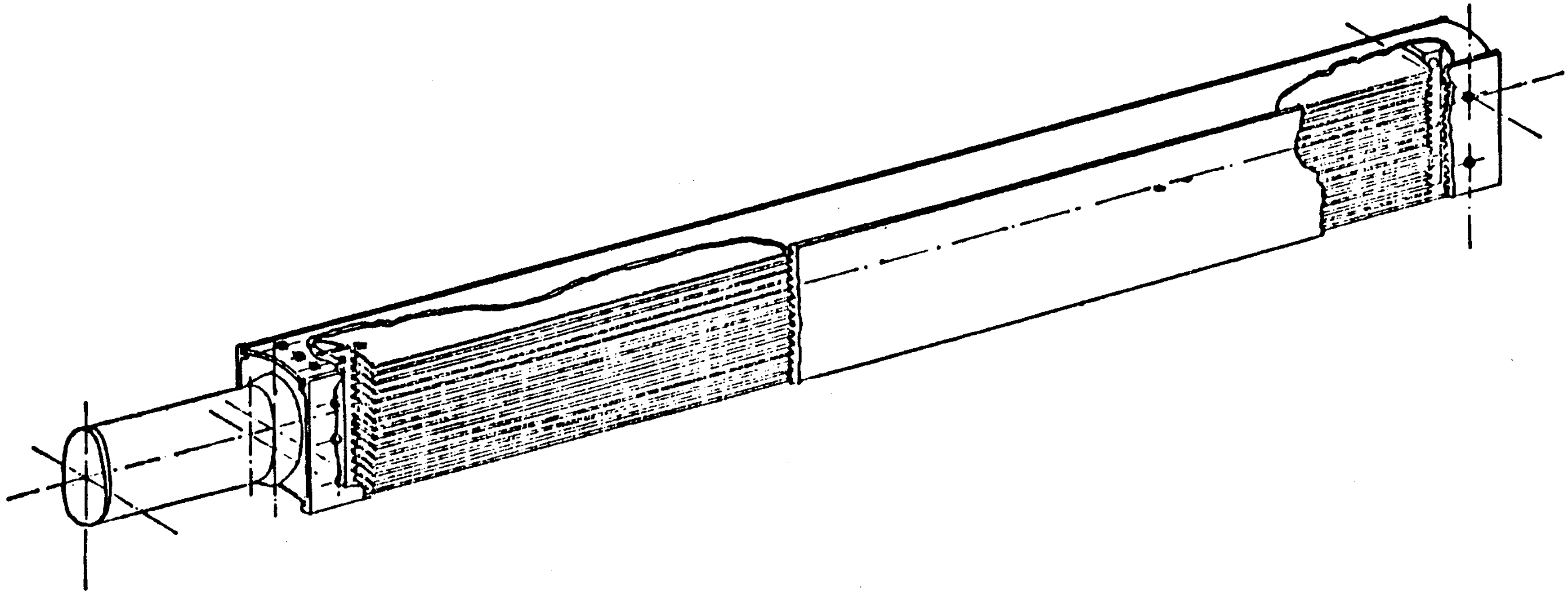
(b) Two persons in the control room at the time of the accident received doses of about 15 rads of neutrons and 20 rads of gamma. At present, they are under medical supervision and have not shown any clinical signs.

(c) Five persons received a dose ranging from 4 to 8 rads of neutrons and 7 to 10 rads of gamma. They also are under medical supervision.

(d) One person received a dose of about 1 rad of neutrons and 0.4 rad of gamma. Nine other persons received doses below 1 rad.

(e) The doses received by the affected personnel also are being measured by biological dosimetry techniques.

FUEL ELEMENT



ESC. 1:4

Figure 1 Fuel element

DIAGRAM OF THE INSTALLATION

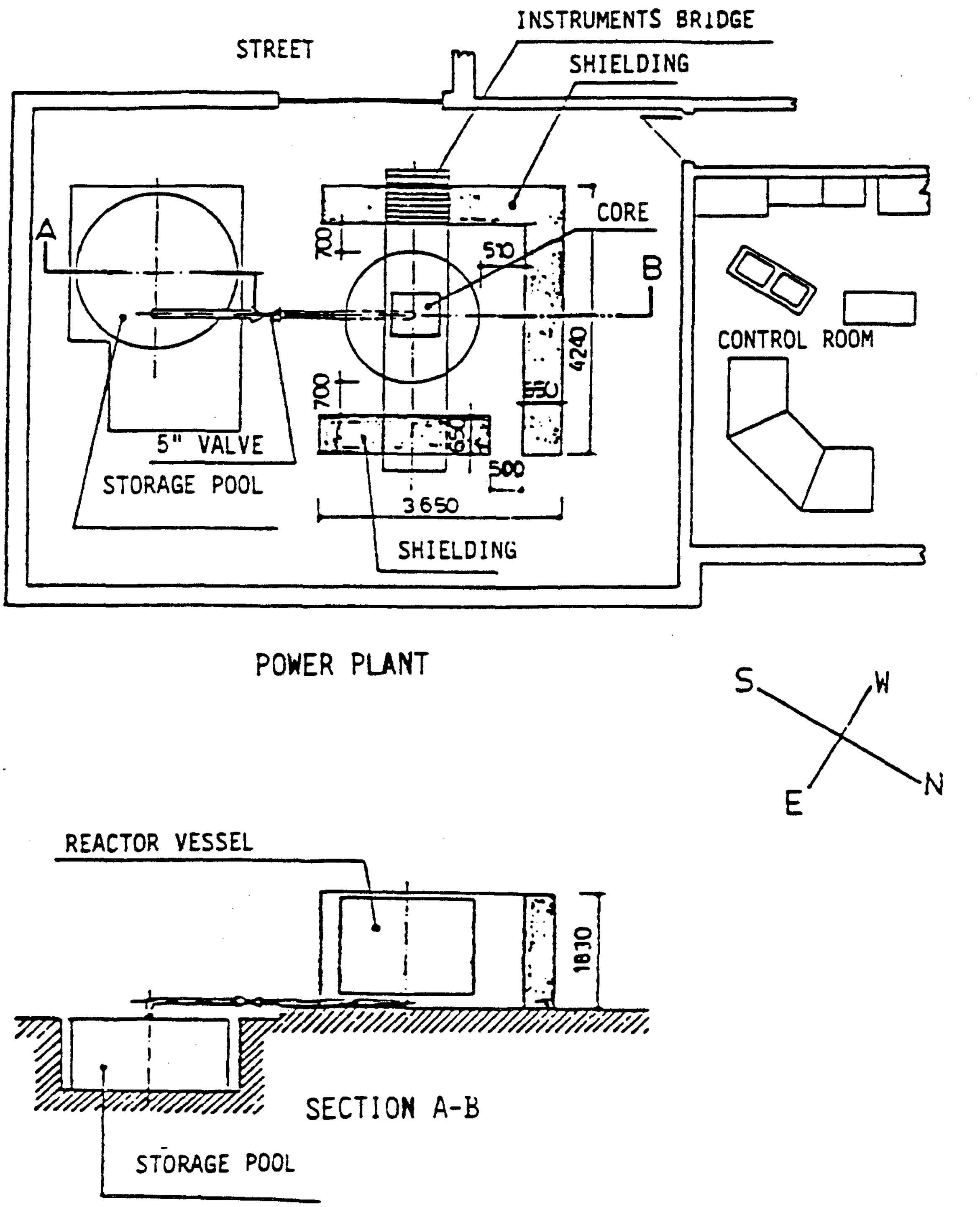


Figure 2 RA-2 reactor facility

CONFIGURATION A(Initial)

	G	G	G	G	G	G	G		
	G	C	C	BC	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	BC	C	C	G		
	G	G	G	G	G	G	G		

Figure 3A Initial core configuration

CONFIGURATION B(solicited)

	G	G	G	G	G	G	G		
	G	BC	C	C	C	BC	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	BC	C	C	C	BC	G		
	G	G	G	G	G	G	G		

C FUEL ELEMENT

G GRAPHITE

BC FUEL ELEMENT WITH CONTROL PLATES

Figure 3B Modified core configuration

Attachment 5
IN 83-66 Supp 1
May 25, 1984

LIST OF RECENTLY ISSUED
IE INFORMATION NOTICES

Information Notice No.	Subject	Date of Issue	Issued to
84-39	Inadvertent Isolation of Spray Systems	05/25/84	All power reactor facilities holding an OL or CP
84-38	Problems With Design, Maintenance, and Operation of Offsite Power Systems	05/17/84	All power reactor facilities holding an OL or CP
84-37	Use of Lifted Leads and Jumpers During Maintenance or Surveillance Testing	05/10/84	All power reactor facilities holding an OL or CP
84-36	Loosening of Locking Nut on Limitorque Operator	05/01/84	All power reactor facilities holding an OL or CP
84-35	BWR Post Scram Drywell Pressurization	04/23/84	All power reactor facilities holding an OL or CP
84-34	Respirator Users Warning: Defective Self-Contained Breathing Apparatus Air Cylinders	04/23/84	All power reactor facilities holding an OL or CP; research and test; fuel cycle; and Priority 1
84-33	Main Steam Safety Valve Failures Caused By Failed Cotter Pins	04/20/84	All power reactor facilities holding an OL or CP
84-32	Auxiliary Feedwater Sparger Pipe Hanger Damage	04/18/82	All power reactor facilities holding an OL or CP. for
84-31	Increased Stroking Time of Bettis Actuators Because of Swollen Ethylene-Propylene Seals and Seal Set	04/18/84	All power reactor facilities holding an OL or CP
84-30	Discrepancies in Record Keeping and Material Defects in Bahnson Heating, Ventilation, and Air Conditioning Units	04/18/84	All power reactor facilities holding an OL or CP

OL = Operating License
CP = Construction Permit

LA-TR -85-41

TITLE: REPORT OF THE ACCIDENT WHICH OCCURRED IN THE CRITICAL RA-2 UNIT ON SEPTEMBER 23, 1983
(RESENA DEL ACCIDENTE OCURRIDO EN EL CONJUNTO CRITICO RA-2 EL DIA 23 DE SEPTIEMBRE 1983.)

AUTHOR(S):

SOURCE: Comision Nacional de Energia Atomica, Argentina

TRANSLATED BY: Leo Kanner Assoc.
Redwood City, CA
1985

Los Alamos
Los Alamos National Laboratory
University of California

United States Department of Energy
Contract W-7405-Eng. 36

REPORT OF THE ACCIDENT WHICH OCCURRED IN THE CRITICAL RA-2 UNIT ON SEPTEMBER 23, 1983

1. Description of the Plant

The RA-2 is a critical unit of 0,1 watt nominal power which has been operating since 1966 and is used for experiments with different core configurations. Therefore it is possible to relocate it and/or modify the relative amount of the components of the core, which are as follows: fuel elements of the MTR type of 19 plates with 90% enriched uranium (Fig 1); control rod, formed by fuel elements in which four of the uranium plates are replaced by two of cadmium; ordinary demineralized water and moderator, water or graphite reflector.

Figure 2 shows schematically the plant.

2. The Accident

On the evening of Friday 23 September 1983 it had been planned to modify the configuration to carry out the experiment with a pulsed source technique. Figure 3A and B illustrate the starting configuration and the one which they wished to obtain.

According to the operating procedure, it was necessary to evacuate totally the moderator, but this was done partly. Soon after, during the period when the changing operations were being conducted, an excursion of criticality occurred.

Translated for Los Alamos National Laboratory from the original Spanish by LEO KANNER ASSOCIATES, P.O. Box 5187, Redwood City, California 94063, (145) 365-3046, August, 1985.

The operator, the only person present in the enclosure was highly irradiated and, to a much lesser extent other people who were in the control room and other adjacent areas.

3. Analysis of the Accident

The chairman of the CNEA appointed an "ad hoc" commission to investigate the accident. The conclusions of this commission indicate that the basic causes of this accident were:

a) The moderator was not totally removed before carrying out the change of configuration.

b) Two fuel elements which should have been removed were left inside the reactor, in contact with the graphite reflector.

c) The sequences in change position of the fuel cases were carried out decreasing the subcriticality of the system.

d) Two fuel boxes of 15 plates were inserted without the corresponding control cadmium plates. The latter was only partly introduced, so that it is considered that it was this insertion in which the sequence culminated which caused the accident.

e) All the operations were carried out without the presence of the security officer nor the auxiliary operating personnel.

The evolution of the power and the value of the energy released are still the object of detailed investigations. Nevertheless it is estimated that the excursion was about 10 MJ, which implies approximately 3×10^{17} fissions, which occurred in a few tens of milliseconds.

The "ad hoc" commission also identified defects for which there were prosed solutions, which may be attributed to the plant and to the operating procedures, and the organization of the approval and supervision of the experiment. These defects are partly due to the installation and its controls being very old, and partly to the excessive confidence arising through many years of operation, which inadvertently weakened the support for the minor plants in view of other more urgent requirements of the nuclear program.

4. Dosimetric and Medical Evaluations

The dosimetric evaluations were carried out by direct measurement of Na-24 on the entire body P-32 in samples of hair, analysis by gamma spectrometry of the activated metal elements which the persons involved carried and the readings of a thermoluminescent dosimeters and criticality existing in the person.

The doses received by the persons exposed are as follows:

a) The operator received a lethal absorbed dose of the order of 2,000 rad gamma rays and 1700 rad neutrons, which caused the situation to be beyond any possibility of effective therapy. The measurement of P-32 arising from the activation of sulfur contained in samples of the body's hair and wool of the clothes and also the clinical manifestations showed that the irradiation had been very inhomogeneous, the greatest doses being received in the upper right hand side of the body. Approximately 25 minutes after the accident, the operator showed signs of symptoms of nonstochastaic effect of acute irradiation in the entire body (vomiting, cephalea and diarrhea), His condition deteriorated the next day, showed gastrointestinal disorders. In the early hours of the 25 his condition was aggrevated with neurological and respiratory manifestations (radiopneumolitis in the right lung) and edema of the hand and forearm of the same side, then he died at 16 hours 45 minutes of the same day.

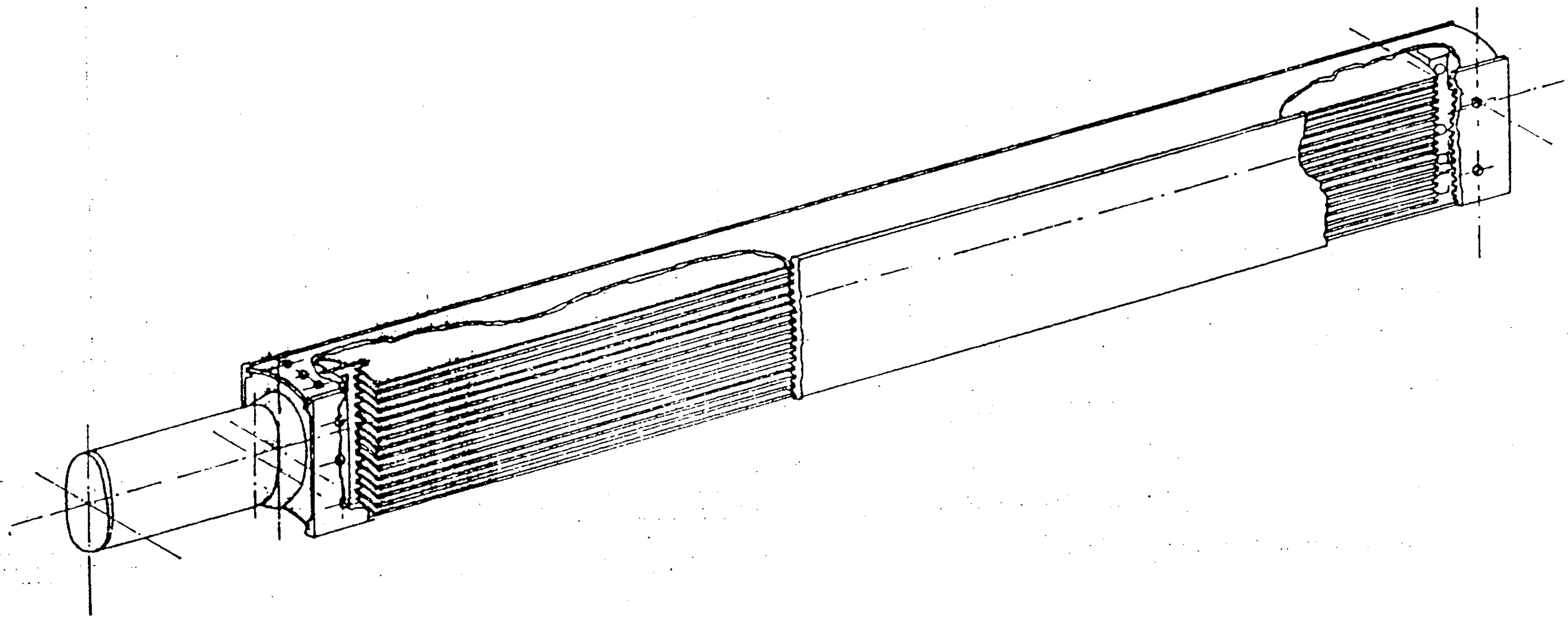
b) Two persons who were in the control room at the time of the accident received doses of 0-15 rads neutrons and 20 rads gamma radiation. They continue to be under medical care, without showing physical manifestations.

c) Five persons received a dose of between 4-8 rads neutrons and between 7 and 10 rads gamma radiation. In this case too, the suitable medical observation is being maintained.

d) One person received a dose on the order of 1 rad neutron and 0.4 gamma radiations and another 9 persons received total doses less than 1 rad.

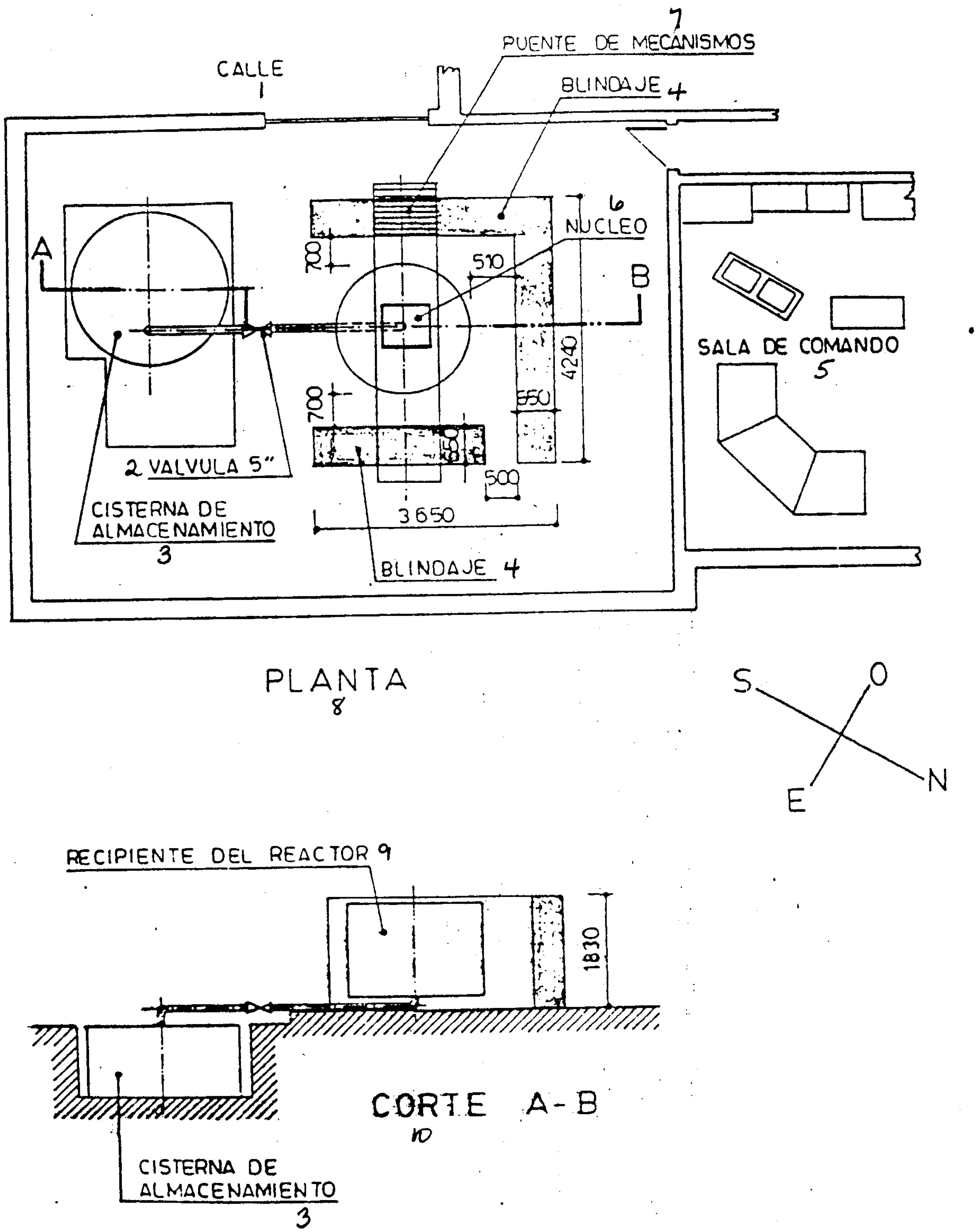
On the other hand the evaluations of the doses received by this personnel are being supplemented by techniques of biological dosimetry.

Figure 1 Scale 1:4 FUEL ELEMENTS



Scheme of the Plant

Key: 1) Street; 2) Valve; 3) Storage Tank; 4) Shields; 5) Control room; 6) Core; 7) Bridge of mechanisms; 8) Plant; 9) The after vessel; 10) A-B Cross-section.



CONFIGURATION A (Initial)

	G	G	G	G	G	G	G		
	G	C	C	BC	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	BC	C	C	G		
	G	G	G	G	G	G	G		

CONFIGURATION B (Required)

	G	G	G	G	G	G	G		
	G	BC	C	C	C	BC	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	BC	C	C	C	BC	G		
	G	G	G	G	G	G	G		

C: Fuel element G: Graphite BC: Elements combined with control plates

Comisión Nacional de Energía Atómica
DEPENDIENTE DE LA PRESIDENCIA DE LA NACION

BUENOS AIRES, [illegible] JUL. 1985

Mr. David R. Smith
Criticality Safety
Los Alamos
National Laboratory
Los Alamos, New Mexico 87545
U.S.A.

Dear Mr. Smith:

Please find enclosed a copy of the summary of the report dealing with the accident at the RA-2 installation.

Best Regards.

D. Beninson

D. Beninson

RESEÑA DEL ACCIDENTE OCURRIDO EN EL
CONJUNTO CRITICO RA-2 EL DIA
23 DE SEPTIEMBRE DE 1983

1. Descripción de la instalación

El RA-2 es un conjunto crítico de 0.1 watt de potencia nominal que funciona desde 1966 y es utilizado para experimentar con diferentes configuraciones de núcleo. Para ello pueden reubicarse y/o modificarse en cantidad relativa los componentes del núcleo, que son los siguientes: elementos combustibles tipo MTR de 19 placas con uranio enriquecido al 90% (fig.1); barras de control, formadas por elementos combustibles en los cuales 4 de las placas de uranio están sustituidas por 2 de cadmio; moderador de agua común desmineralizada; reflector de agua o de grafito.

La figura 2 muestra esquemáticamente la instalación.

2. El accidente

En la tarde del día viernes 23 de septiembre de 1983 se había planeado una modificación de configuración para realizar una experiencia con la técnica de fuente pulsada. La figura 3 A y B ilustra la configuración de partida y la que se deseaba obtener.

De acuerdo con el procedimiento de operación, éste demandaba evacuar totalmente el moderador, pero esto se realizó en forma parcial. Poco después, en momentos en que se efectuaban las operaciones de cambio, se produjo una excursión de criticidad.

El operador, única persona presente en el recinto, resultó fuertemente irradiado y, en proporción mucho menor, otras personas que se encontraban en la sala de control y otras dependencias contiguas.

3. Análisis del accidente

El Presidente de la CNEA designó una Comisión 'ad-hoc' para investigar el accidente. Las conclusiones de esta Comisión indican que las causas básicas que originaron el mismo fueron:

a) No desagotar totalmente el moderador antes de efectuar el cambio de configuración.

b) Dejar en el interior del reactor, en contacto con el reflector de grafito, dos elementos combustibles que debían ser retirados.

c) Realizar secuencias de cambio de posición de cajas combustibles que disminuyeron la subcriticidad del sistema.

d) Insertar dos cajas combustibles de 15 placas sin las placas de cadmio de control correspondientes. La segunda se encontró sólo parcialmente introducida, por lo que se considera que su inserción fue la que culminó la secuencia que provocó el accidente.

e) Todas las operaciones se realizaron sin la presencia del oficial de seguridad ni del auxiliar de operación.

La evolución de la potencia y el valor de la energía liberada son todavía objeto de investigaciones detalladas. No obstante, se estima que la excursión fue de unos 10 MJ, lo cual implica aproximadamente 3×10^{17} fisiones, las que ocurrieron en pocas decenas de milisegundos.

Asimismo, la Comisión 'ad-hoc' ha identificado fallas, para las cuales propone soluciones, atribuibles a la instalación y a los procedimientos operativos, así como a la organización de la aprobación y supervisión de las experiencias. Esas fallas se deben en parte a la antigüedad de la instalación y sus controles y, en parte, a confianza excesiva originada en muchos años de operación, que ha ido debilitando inadvertidamente el apoyo a instalaciones menores frente a otras exigencias más urgentes del programa nuclear.

4. Evaluaciones dosimétricas y médicas

Las evaluaciones dosimétricas fueron realizadas por medición directa de Na-24 en todo el cuerpo, de P-32 en muestras de pelo, del análisis por espectrometría gamma de los elementos metálicos activados que portaban las personas involucradas y de las lecturas de los dosímetros termoluminiscentes y de criticidad existentes en el edificio.

Las dosis recibidas por las personas expuestas son las siguientes:

a) El operador recibió una dosis absorbida letal del orden de 2000 rad de radiación gamma y 1700 rad de neutrones, lo cual colocó la situación fuera de toda posibilidad terapéutica efectiva. La medición de P-32 proveniente de la activación del azufre contenido en muestras de pelo corporal y de lana de su vestimenta, como así también sus manifestaciones clínicas, mostraron que la irradiación había sido muy inhomogénea, recibiendo dosis mayores en el lado superior derecho del cuerpo. Aproximadamente 25 minutos después del accidente, el operador presentó signos y síntomas de efectos no estocásticos de irradiación aguda en todo el cuerpo (vómitos, cefalea y diarrea). Su estado empeoró al día siguiente, manifestando trastornos gastrointestinales. En las primeras horas del día 25 su cuadro se agravó con manifestaciones neurológicas y respiratorias (radioneumonitis en el pulmón derecho) y edema de mano y antebrazo del mismo lado, falleciendo a las 16:45 hs del mismo día.

b) Dos personas que se encontraban en la sala de control en el momento del accidente recibieron dosis del orden de 15 rad de neutrones y 20 rad de gamma. En la actualidad continuan bajo vigilancia médica, sin evidenciar manifestaciones clínicas.

c) Cinco personas recibieron una dosis comprendida entre los 4 y 8 rad de neutrones y entre 7 y 10 rad de gamma. También en este caso se mantiene la vigilancia médica correspondiente.

d) Una persona recibió una dosis del orden de 1 rad de neutrones y 0,4 de gamma y otras 9 personas recibieron dosis totales menores que 1 rad.

Por otra parte, se están complementando las evaluaciones de las dosis recibidas por dicho personal mediante técnicas de dosimetría biológica.

ELEMENTO COMBUSTIBLE

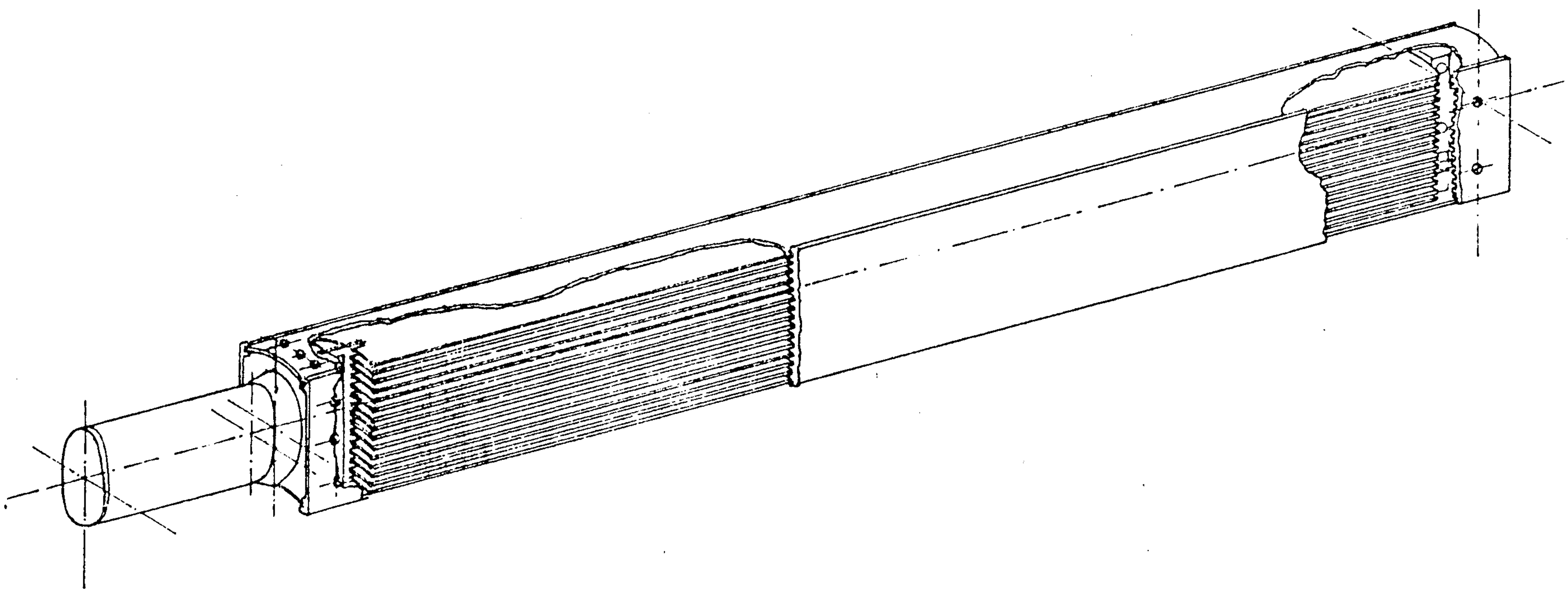
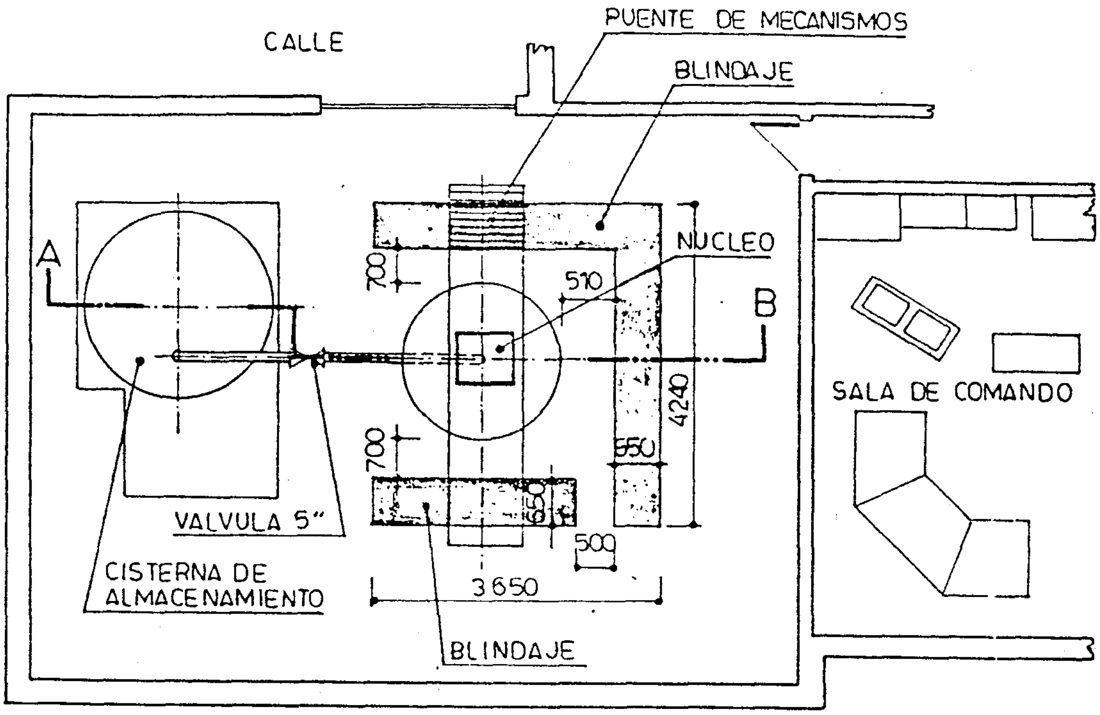


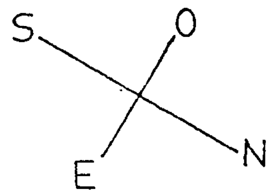
Fig. N°1

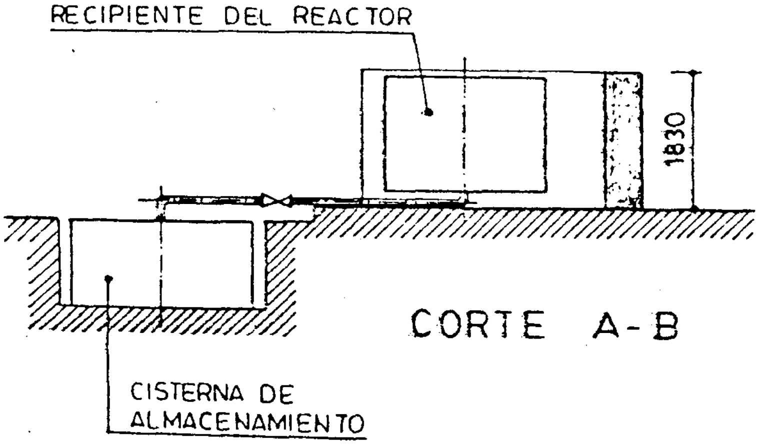
ESC: 1:4

ESQUEMA DE LA INSTALACION



PLANTA





CORTE A-B

CONFIGURACION A (INICIAL)

	G	G	G	G	G	G	G		
	G	C	C	BC	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	BC	C	C	G		
	G	G	G	G	G	G	G		

CONFIGURACION B (SOLICITADA)

	G	G	G	G	G	G	G		
	G	BC	C	C	C	BC	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	BC	C	C	C	BC	G		
	G	G	G	G	G	G	G		

- C — Elemento combustible.
- G — Grafito.
- BC — Elem. comb. con placas de control.

RESEÑA DEL ACCIDENTE OCURRIDO EN EL CONJUNTO CRITICO RA-2 EL DIA 23 DE SEPTIEMBRE DE 1983

1. Descripción de la instalación

El RA-2 es un conjunto crítico de 0.1 watt de potencia nominal que funciona desde 1966 y es utilizado para experimentar con diferentes configuraciones de núcleo. Para ello pueden reubicarse y/o modificarse en cantidad relativa los componentes del núcleo, que son los siguientes: elementos combustibles tipo MTR de 19 placas con uranio enriquecido al 90% (fig.1); barras de control, formadas por elementos combustibles en los cuales 4 de las placas de uranio están sustituidas por 2 de cadmio; moderador de agua común desmineralizada; reflector de agua o de grafito.

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3. Análisis del accidente

El Presidente de la CNEA designó una Comisión 'ad-hoc' para investigar el accidente. Las conclusiones de esta Comisión indican que las causas básicas que originaron el mismo fueron:

a) No desagotar totalmente el moderador antes de efectuar el cambio de configuración.

b) Dejar en el interior del reactor, en contacto con el reflector de grafito, dos elementos combustibles que debían ser retirados.

c) Realizar secuencias de cambio de posición de cajas combustibles que disminuyeron la subcriticidad del sistema.

d) Insertar dos cajas combustibles de 15 placas sin las placas de cadmio de control correspondientes. La segunda se encontró sólo parcialmente introducida, por lo que se considera que su inserción fue la que culminó la secuencia que provocó el accidente.

e) Todas las operaciones se realizaron sin la presencia del oficial de seguridad ni del auxiliar de operación.

La evolución de la potencia y el valor de la energía liberada son todavía objeto de investigaciones detalladas. No obstante, se estima que la excursión fue de unos 10 MJ, lo cual implica aproximadamente 3×10^{17} fisiones, las que ocurrieron en pocas decenas de milisegundos.

Asimismo, la Comisión 'ad-hoc' ha identificado fallas, para las cuales propone soluciones, atribuibles a la instalación y a los procedimientos operativos, así como a la organización de la aprobación y supervisión de las experiencias. Esas fallas se deben en parte a la antigüedad de la instalación y sus controles y, en parte, a confianza excesiva originada en muchos años de operación, que ha ido debilitando inadvertidamente el apoyo a instalaciones menores frente a otras exigencias más urgentes del programa nuclear.

4. Evaluaciones dosimétricas y médicas

Las evaluaciones dosimétricas fueron realizadas por medición directa de Na-24 en todo el cuerpo, de P-32 en muestras de pelo, del análisis por espectrometría gamma de los elementos metálicos activados que portaban las personas involucradas y de las lecturas de los dosímetros termoluminiscentes y de criticidad existentes en el edificio.

Las dosis recibidas por las personas expuestas son las siguientes:

a) El operador recibió una dosis absorbida letal del orden de 2000 rad de radiación gamma y 1700 rad de neutrones, lo cual colocó la situación fuera de toda posibilidad terapéutica efectiva. La medición de P-32 proveniente de la activación del azufre contenido en muestras de pelo corporal y de lana de su vestimenta, como así también sus manifestaciones clínicas, mostraron que la irradiación había sido muy inhomogénea, recibiendo dosis mayores en el lado superior derecho del cuerpo. Aproximadamente 25 minutos después del accidente, el operador presentó signos y síntomas de efectos no estocásticos de irradiación aguda en todo el cuerpo (vómitos, cefalea y diarrea). Su estado empeoró al día siguiente, manifestando trastornos gastrointestinales. En las primeras horas del día 25 su cuadro se agravó con manifestaciones neurológicas y respiratorias (radioneumonitis en el pulmón derecho) y edema de mano y antebrazo del mismo lado, falleciendo a las 16:45 hs del mismo día.

b) Dos personas que se encontraban en la sala de control en el momento del accidente recibieron dosis del orden de 15 rad de neutrones y 20 rad de gamma. En la actualidad continuan bajo vigilancia médica, sin evidenciar manifestaciones clínicas.

c) Cinco personas recibieron una dosis comprendida entre los 4 y 8 rad de neutrones y entre 7 y 10 rad de gamma. También en este caso se mantiene la vigilancia médica correspondiente.

d) Una persona recibió una dosis del orden de 1 rad de neutrones y 0,4 de gamma y otras 9 personas recibieron dosis totales menores que 1 rad.

Por otra parte, se están complementando las evaluaciones de las dosis recibidas por dicho personal mediante técnicas de dosimetría biológica.

ELEMENTO COMBUSTIBLE

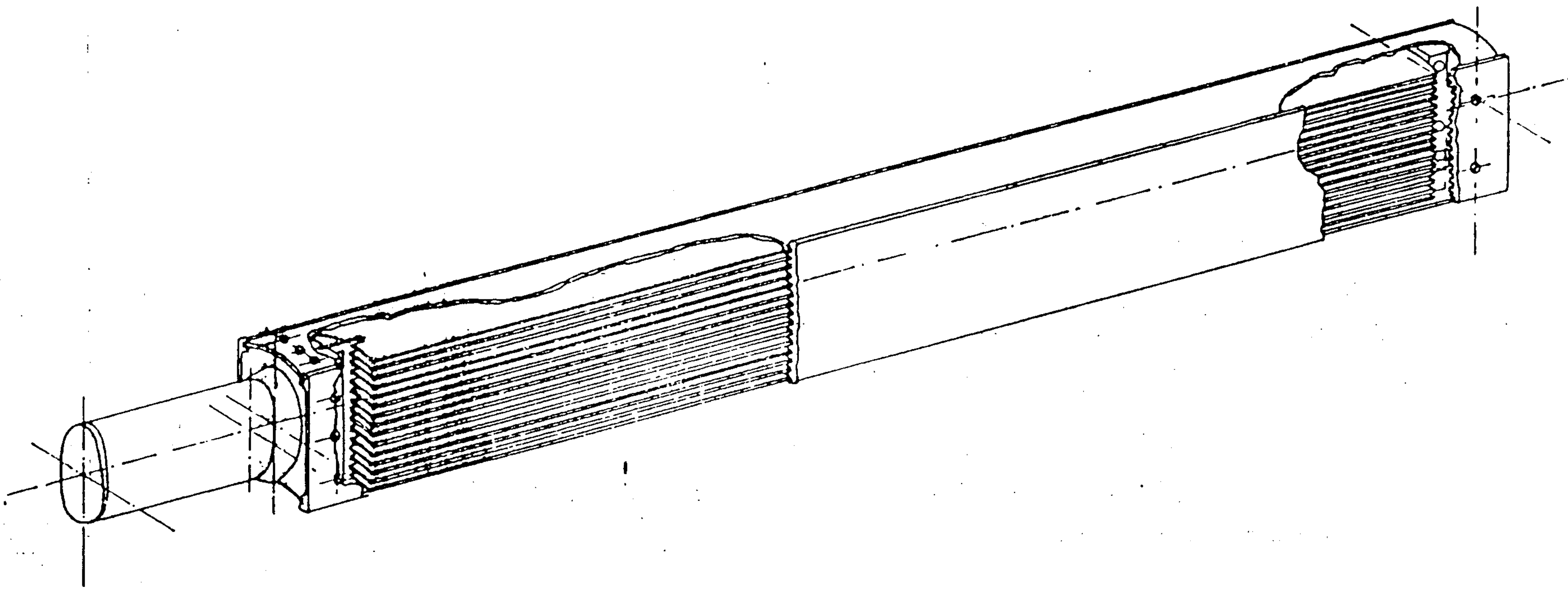
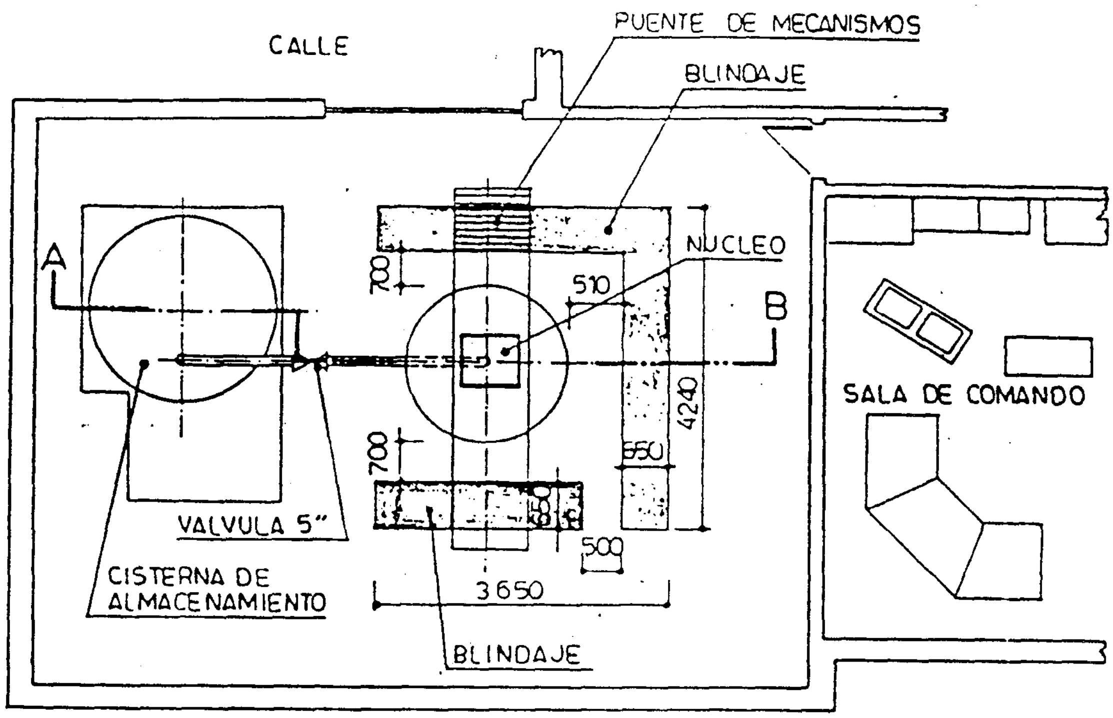


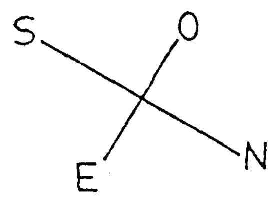
Fig. N° 1

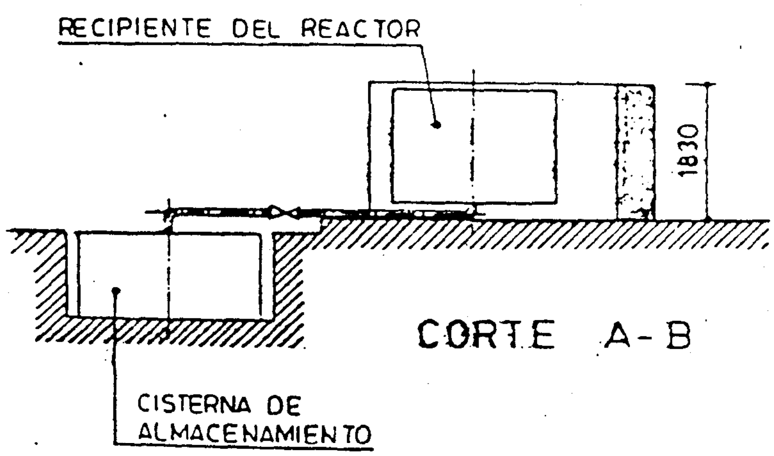
ESC. 1:4

ESQUEMA DE LA INSTALACION



PLANTA





CORTE A-B

CONFIGURACION A (INICIAL)

	G	G	G	G	G	G	G		
	G	C	C	BC	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	BC	C	C	G		
	G	G	G	G	G	G	G		

CONFIGURACION B (SOLICITADA)

	G	G	G	G	G	G	G		
	G	BC	C	C	C	BC	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	BC	C	C	C	BC	G		
	G	G	G	G	G	G	G		

C	Elemento combustible.
G	Grafito.
BC	Elem. comb. con placas de control

NUCLEONICS WEEK 10-6-83

QUESTIONS REVOLVE AROUND DEATH IN ARGENTINE RESEARCH REACTOR

The obvious violation of fundamental safety procedures which resulted in a sudden criticality excursion and the ensuing death of a technician at an Argentine critical facility has left U.S. government and industry figures puzzled. The U.S. has offered directly and through the International Atomic Energy Agency to provide any help Argentina might need in investigating the incident and has requested a copy of the results of any evaluation or investigation which is conducted.

The incident occurred Sept. 23 when the technician, Osvaldo Rogoulich, 49, described as a qualified operator with 14 years' experience, was changing the core configuration of the RA-II reactor at the Constituyentes Atomic Center near Buenos Aires. The reactor is a zero-power, light water, tank-type reactor designed and built by the Comision Nacional de Energia Atomica which achieved criticality in 1966. The U.S. supplied the plate-type fuel. Standard approved safety procedure for changing fuel in the reactor is to drain the water from the tank, but according to IAEA and NRC information, the operator attempted to make the changes without draining the moderator water. In addition, according to the information, two cases of unloaded fuel were placed on the outside of the graphite reflector instead of being removed completely and an error was made in setting up the final configuration of the fuel.

Prompt criticality occurred in milliseconds at 10-15 megajoules, the equivalent of $3\text{-}4.5 \times 10^{17}$ fissions, and was stopped automatically by reduction of moderation (plate expansion, expulsion of water/steam) and because the safety system's opened the moderator dump valve, according to IAEA. The operator received an estimated dose of 1,400 rads of fast neutrons and 500 rads of gamma radiation, according to NRC figures. (IAEA estimates are 1,400 rads neutrons and 1,400 rads gamma.) He died two days later of radiation effects. Two other technicians were shielded from the radiation. No equipment damage resulted.

U.S. sources familiar with research reactors have expressed surprise that the operator would not have drained the water, even partially, out of the core, and that control rods apparently were not in place to prevent criticality. Procedures for fuel configuration changes are very clear, they said, and the first step is to shut down the reactor by inserting the rods. Before any fuel change is made, an estimate of excess shutdown capacity in the reactor is required – as fuel is removed, the excess capacity grows.

As more fuel is added, the excess capacity shrinks and more control rods are needed. Fuel can only be added one bundle at a time and a control rod or rods with more than enough shutdown capacity are usually held cocked out – with another operator at hand – ready to be dropped in if necessary, they said. In research reactors which produce any power (2 Mwth or above), some water must be left in the tank for cooling purposes, but in a zero-power reactor, there isn't enough heat to require the cooling and all of the water can be removed.

The fact that the unloaded fuel bundles were placed outside of the graphite reflector rather than removed completely would have had very little effect, although if the reactor was at the limit of criticality, it could have played a small part, the sources said. In any case, the bottom line, according to IAEA, is that removal of the water moderator from the tank would have been a 100% guarantee that the incident did not happen.

There have been deaths in the U.S. at critical facilities or defense or government research facilities, the most recent being at the SL-I reactor in Idaho Falls in 1961. That incident resulted in the release of 75-100 megajoules of energy and three deaths from the effects. But of the 100 privately licensed research reactors, there has never been a similar incident. – *Frances Seghers, Washington*

Copy for Walt & Helmi

SSINS No: 6835
IN 83-66, Supp 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF INSPECTION AND ENFORCEMENT
WASHINGTON, DC 20555

May 25, 1984

IE INFORMATION NOTICE NO. 83-66, SUPPLEMENT 1: FATALITY AT ARGENTINE CRITICAL FACILITY

Addressees:

All nuclear power reactor facilities holding an operating license (OL) or construction permit (CP) and nonpower reactor, critical facility, and fuel cycle licensees.

Purpose:

This information notice is a supplement to IE Information Notice No. 83-66, issued on October 7, 1983. It is expected that nonpower reactor, critical facility, and fuel cycle licensees will review the information for applicability to their facilities. No specific action or response is required.

Description of Circumstances:

The Argentine National Atomic Energy Commission [Comision Nacional de Energie Atomica, (CNEA)] provided the NRC Office of International Programs with the written report documenting the results of the Commissions investigation and evaluation of the September 23, 1983 RA-2 accident near Buenos Aries. A translated copy of the CNEA report is attached.

No response to this information notice is required. If you have any questions regarding this matter, please contact the Regional Administrator of the appropriate NRC Regional Office or this office.

Edward L. Jordan, Director
Division of Emergency Preparedness
and Engineering Response
Office of Inspection and Enforcement

Technical Contact: J. E. Wigginton
(301) 492-4967

Attachments:
1. CNEA Report
2. Figure 1 Fuel Element
3. Figure 2 RA-2 reactor facility
4. Figure 3B Modified core confirguration
5. List of Recently Issued IE Information Notices

8405240317

REPORT OF THE ACCIDENT THAT OCCURRED TO THE CRITICAL ASSEMBLY RA-2 REACTOR ON SEPTEMBER 23, 1984

1. Description of the Installation

The RA-2 is a critical assembly reactor operating at 0.1 watt of rated power. It has been in operation since 1966 and is used to conduct experiments with various core configurations. For experiments, the core assembly can be relocated and/or modified. The core consists of MTR-type fuel elements and control rods. The fuel elements are MTR-type, 90% enriched uranium and consist of 19 fuel plates (see Figure 1). The control rods consist of fuel elements in which four of the fuel plates are replaced with two cadmium plates. Demineralized water is the moderator; and demineralized water and graphite constitute the reflector.

The installation is shown in Figure 2.

2. The Accident

On Friday afternoon September 23, 1983, a modification of the core configuration had been scheduled so that an experiment using the pulsed source technique could be conducted. Figure 3A shows the initial core configuration and Figure 3B shows the configuration as it was to be modified. The operating procedure requires the complete removal of the moderator. However, this was only partially done. A short time afterwards, when the exchange operations were being carried out, a criticality excursion occurred.

The operator, who was the only person present in the containment, was fatally exposed; other persons, who were in the control room and other adjacent premises were exposed, but to a much lesser degree.

3. Analysis of the Accident

The President of the Comision Nacional de Energia Atomica (CNEA) (National Atomic Energy Commission, Argentine) appointed an ad hoc commission to investigate the accident. The conclusions of this commission indicate that the basic causes of the accident were as follows:

(a) The moderator was not completely removed from the core before the core configuration was modified.

(b) Two fuel elements, which should have been removed, were left inside the reactor in contact with the graphite reflector.

(c) Sequences were performed to change the positions of fuel elements; this decreased the subcriticality of the system.

(d) Two fuel elements of 15 plates were inserted without the corresponding cadmium control plates. The second fuel element was found to be only partially inserted, wherefore it is deemed that its insertion caused the accident.

(e) All of the operations were performed without the concurrence or presence of a safety official or the operations supervisor.

The evolution of the power and the magnitude of the released energy are still being investigated. Notwithstanding, it is estimated that the excursion was about 10 megajoules, which is equivalent to approximately 3×10^{17} fissions, which occurred during a few tens of milliseconds.

Also, the ad hoc commission identified shortcomings in the installation and operational procedures, as well as in the way approval was obtained and supervision of the experiments was carried out. Because the reactor had been operating for so many years without incident, an excessive degree of confidence had been fostered in regard to minor operations. In addition, other more urgent requirements of the nuclear program took precedence.

4. Dosimetric and Medical Evaluation

The dosimetric evaluations were based on (1) measurements of Na-24 to determine whole-body dose and of P-32 from samples of hair, (2) the gamma spectrometry analysis of the activated metal elements carried by the affected persons, and (3) the readings of the radiothermoluminescent and criticality dosimeters installed in the building.

The doses received by the exposed persons are as follows:

(a) The operator received a lethal, absorbed dose of about 2000 rads of gamma radiation and 1700 rads of neutrons, which precluded any effective therapeutic measures. The amount of P-32 (resulting from the sulfur activation) found in samples of body hair and the operator's woolen clothing, as well as the clinical manifestations, showed that the exposure had been very nonhomogeneous; the doses received on the upper right side of the body were higher than those elsewhere. Approximately 25 minutes after the accident, the operator showed signs and symptoms (vomiting, migraine headache, and diarrhea) of acute exposure over the entire body. His condition became worse the next day when he suffered gastrointestinal disorders. Then early on September 25, neurological and respiratory disorders (radiopneumonitis in the right lung) and edema of the right hand and forearm manifested themselves. Death occurred at 16:45 on the same day.

(b) Two persons in the control room at the time of the accident received doses of about 15 rads of neutrons and 20 rads of gamma. At present, they are under medical supervision and have not shown any clinical signs.

(c) Five persons received a dose ranging from 4 to 8 rads of neutrons and 7 to 10 rads of gamma. They also are under medical supervision.

(d) One person received a dose of about 1 rad of neutrons and 0.4 rad of gamma. Nine other persons received doses below 1 rad.

(e) The doses received by the affected personnel also are being measured by biological dosimetry techniques.

FUEL ELEMENT

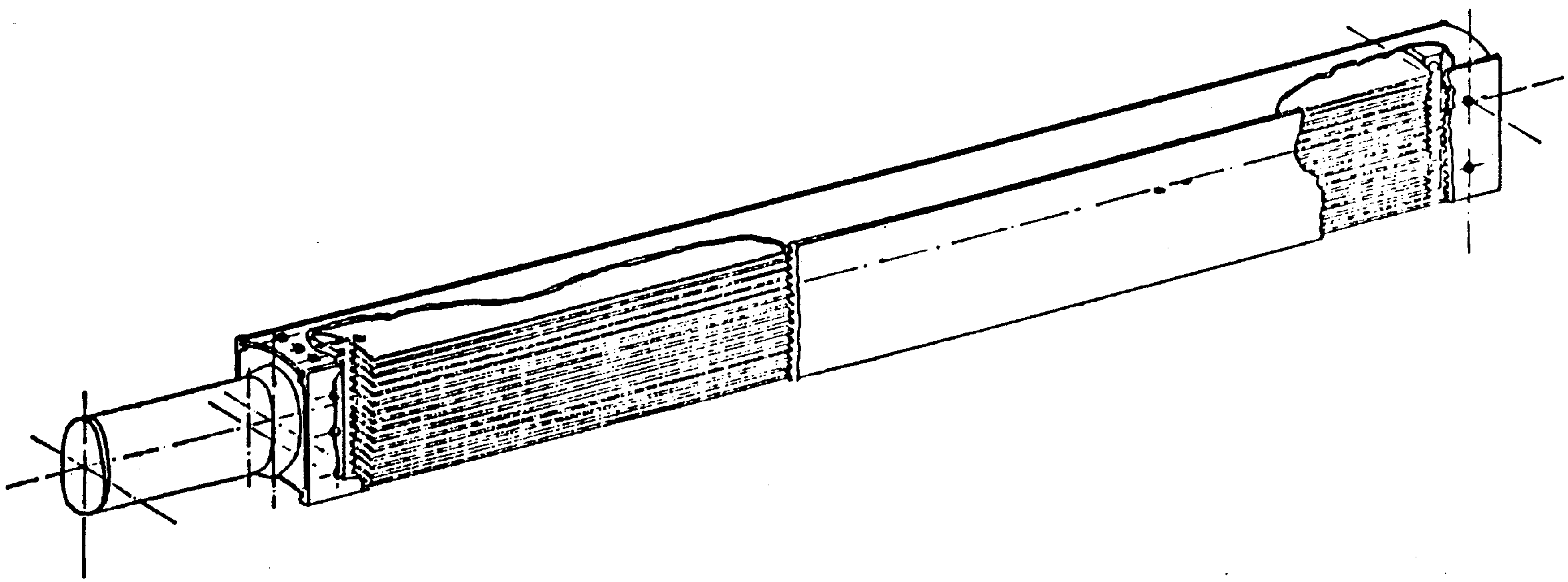


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Figure 1 Fuel element

DIAGRAM OF THE INSTALLATION

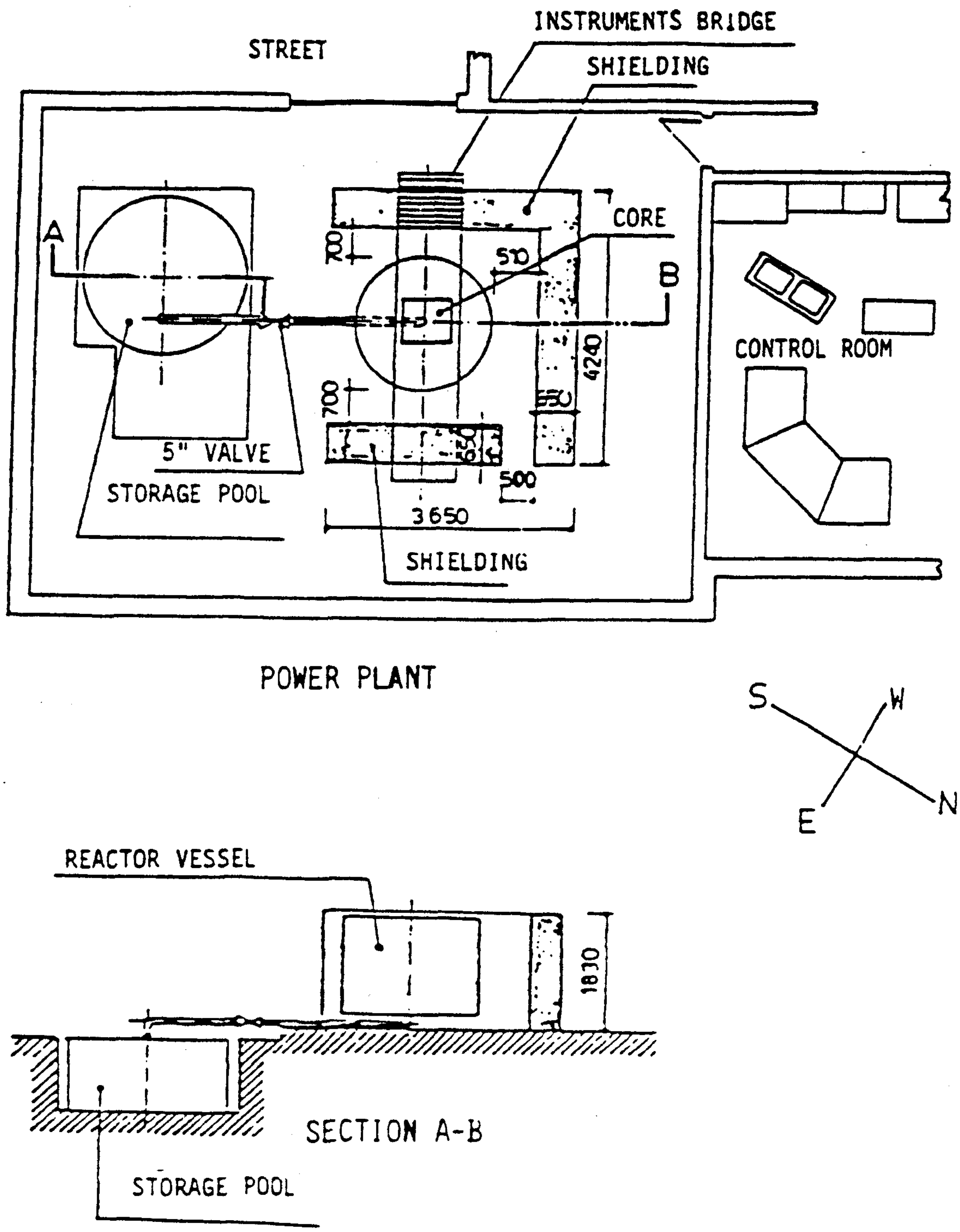

Figure 2 RA-2 reactor facility

CONFIGURATION A(Initial)

	G	G	G	G	G	G	G		
	G	C	C	BC	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	C	C	BC	C	C	G		
	G	G	G	G	G	G	G		

Figure 3A Initial core configuration

CONFIGURATION B(solicited)

	G	G	G	G	G	G	G		
	G	BC	C	C	C	BC	G		
	G	C	C	C	C	C	G		
	G	C	C	C	C	C	G		
	G	BC	C	C	C	BC	G		
	G	G	G	G	G	G	G		

C FUEL ELEMENT
G GRAPHITE
BC FUEL ELEMENT WITH CONTROL PLATES

Figure 3B Modified core configuration

Attachment 5
IN 83-66 Supp 1
May 25, 1984

LIST OF RECENTLY ISSUED IE INFORMATION NOTICES

Information Notice No.	Subject	Date of Issue	Issued to
84-39	Inadvertent Isolation of Spray Systems	05/25/84	All power reactor facilities holding an OL or CP
84-38	Problems With Design, Maintenance, and Operation of Offsite Power Systems	05/17/84	All power reactor facilities holding an OL or CP
84-37	Use of Lifted Leads and Jumpers During Maintenance or Surveillance Testing	05/10/84	All power reactor facilities holding an OL or CP
84-36	Loosening of Locking Nut on Limitorque Operator	05/01/84	All power reactor facilities holding an OL or CP
84-35	BWR Post Scram Drywell Pressurization	04/23/84	All power reactor facilities holding an OL or CP
84-34	Respirator Users Warning: Defective Self-Contained Breathing Apparatus Air Cylinders	04/23/84	All power reactor facilities holding an OL or CP; research and test; fuel cycle; and Priority 1
84-33	Main Steam Safety Valve Failures Caused By Failed Cotter Pins	04/20/84	All power reactor facilities holding an OL or CP
84-32	Auxiliary Feedwater Sparger Pipe Hanger Damage	04/18/82	All power reactor facilities holding an OL or CP. for
84-31	Increased Stroking Time of Bettis Actuators Because of Swollen Ethylene-Propylene Seals and Seal Set	04/18/84	All power reactor facilities holding an OL or CP
84-30	Discrepancies in Record Keeping and Material Defects in Bahnson Heating, Ventilation, and Air Conditioning Units	04/18/84	All power reactor facilities holding an OL or CP

OL = Operating License
CP = Construction Permit

[illegible]

^{235}U 8 mm 9/30/87

H_2O .5 mm

Reflector (cm)		K-eff	
Water			
0.0		.81	
2.0		.89	
4.0		.95	
6.0		.99	
7.0		1.00	1.0006
8.0		1.01	1.0068
10.0		1.01	1.0077
Plex (cm)			
6	water in core	1.01	
Poly (cm)			
4		.98	
6		1.02	1.0153
6	no water in core	.99	