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ENGINEERING TEST REACTOR CRITICAL FACILITY
HAZARDS SUMMARY REPORT
SUPPLEMENT I

D. R. deBoisblanc, E. E. Burdick, T. K. DeBoer January 24, 1958

AEC RESEARCH AND DEVELOPMENT REPORT

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SUPPLEMENT I

by

D. R. deBoisblanc, E. E. Burdick, and T. K. DeBoer

ABSTRACT

This report is a supplement to IDO-16332, "The Engineering Test Reactor Critical Facility Hazards Summary Report", presenting information on the conduct in the Facility of certain experiments which are expected to be operated in the Engineering Test Reactor.

I. INTRODUCTION

The Engineering Test Reactor Critical Facility (ETRC) became critical on May 20, 1957. Since that time the reactor has been used in a study of the physics of the Engineering Test Reactor as a part of the startup program of the ETR. In addition, extensive investigations of the nuclear parameters of the ETRC have been made to verify the predictions of the nuclear design. The approval of the Atomic Energy Commission is being sought to operate this reactor for its second intended purpose--to study the hazards associated with proposed ETR experiments and to provide experiment designers with needed information.

The purpose of this report is to supply the responsible bodies in the Atomic Energy Commission with the information relating to the reactor and the experiments which will be conducted in this second phase. The form of presentation will be to discuss those measurements on the ETRC which have been made that bear upon the reactor safety and to discuss typical experiments in some detail.

This information is presented in fulfillment of the request from the Idaho Operations Office to Phillips dated June 19, 1957. A copy of this letter and its enclosure are included as an appendix.

II. OPERATING CHARACTERISTICS

One of the most effective safeguards against the occurrence of reactor incidents is the employment of highly trained operators to operate the reactor. The present ETRC staff is the same staff that performed the initial critical experiment and all of the experimental work to date. They are now familiar with the reactor characteristics, log count rate and log N recorder relationships, the control and safety systems, and all instruments, making it possible to recognize instrument and reactor trouble at an early moment.

The operating data accumulated during the first seven months of operation have demonstrated that the reactor is stable and possesses nuclear and safety characteristics showing close agreement with those presented in the Hazards Summary Report.

A. Void Coefficients

Measurements made in both the ETRC and ETR show that the void coefficient is negative for all void sizes in all fuel positions. Although the magnitude of the void coefficient has not yet been determined for each position, the coefficient appears to be proportional to the statistical weight for fuel in the corresponding fuel position. In the core experimental facilities where the change in macroscopic absorption cross section has a more pronounced effect than the moderating effect, the void coefficients were found to be everywhere positive as expected.

B. Temperature Coefficient

A measurement of the bulk temperature coefficient in the reactor for temperatures ranging from 70° F to 120° F has been completed, and the average coefficient over this range was found to be -3.1×10^{-5} $\Delta k/k$ per $^{\circ}F$. This compares favorably to the predicted value of -3.6×10^{-5} $\Delta k/k$ per $^{\circ}F$. *(1)

C. Control Rod Worth

The reactivity of the critical facility is controlled or adjusted with four black rods, twelve grey rods, and one regulating rod. The four black rods are fully withdrawn from the core at all times during reactor operation and reactor criticality is maintained somewhere on the one movable grey rod.

* Erroneously reported in IDO-16332 as -3.8×10^{-4} $\Delta k/k$ per $^{\circ}C$.

Rod worth experiments have shown that the average grey rod worth is approximately 1% $\Delta k/k$ as predicted, and the the worth of the black rods (ganged) is $\approx$ 7% $\Delta k/k$ or about one-half of the expected worth.

The drastic decrease in the black rod worth is not alarming, however. It does not increase the hazard potential of the facility, since, as discussed in Section VI-5 and Appendix D, IDO-16332, large reactivity insertions (rapidly rising power excursions) will cause the reactor to shut itself down to a safe operating level before the control system can operate and insert a sufficient amount of poison into the core. This self-regulation is attributed to the action of the negative temperature and void coefficients in the facility which resembles the SPERT I Reactor in many ways and can be expected to behave in a manner similar to that witnessed at SPERT and BORAX.

A re-evaluation of the startup accident analyses described in the Hazards Summary Report has been made using experimentally determined rod worths and rod insertion speeds. It was found that, in the worst case analyzed, the power increases to 11.7 N_f (0.59 Mw) before a sufficient amount of poison is inserted into the core by the dropping of one grey and four black rods. This peak power is a factor of three above that reported previously but still is well below the steady state power level of 4.17 Mw at which the critical facility can be operated safely for extended periods.

III. EXPERIMENTAL PROGRAM

The in-pile experiments for the ETR are of three major types; water cooled, liquid-metal cooled, and air cooled.

The only ETRC experiment for which a design has been submitted is the air cooled ANPD experiment for the 9" x 9" space. It is believed that this experiment will present the greatest potential hazard to Critical Facility operation for two reasons: (1) The experiment contains more fuel than any other experiment and (2) a large positive reactivity effect would result should the experiment flood with water.

If it is proven that this experiment can be handled safely, the remainder of the experiments, being of a less hazardous nature, could also be handled safely.

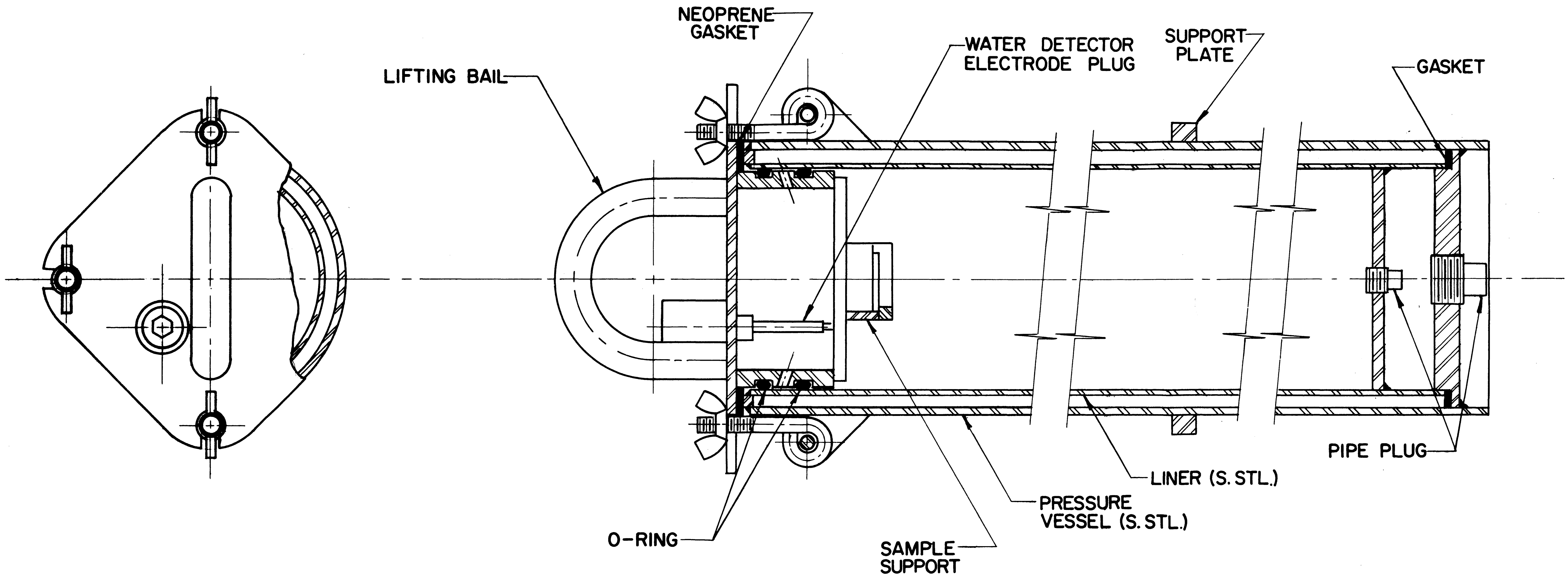
This section includes a description of the experiment and the procedures to be followed in the experimental program.

A. <u>ANPD-ETRC In-Pile Tube Design</u>(2)

In order to eliminate the shielding which would be required if the in-pile tube protruded above the ETRC pool surface, a fore-shortened tube design will be substituted. With the exception of slight filler piece modifications and elimination of the insulation between the pressure tube and liner, the ETRC design is identical to the ETR in-pile tube design. The overall length of the tube is sixty-seven (67) inches, permitting a twelve (12) inch air space above and below the core. This air space is necessary to insure that the neutron scattering and reflection properties will be identical to those produced by the ETR experimental loop. The in-pile tube assembly is shown in Figure 1.

1. Pressure Tube

The pressure tube will have a welded cap sealing the bottom and a double gasket design sealing the top. One gasket is located on the ring seal between the pressure tube and liner while the other, two O-ring seals, is within the liner. The cap assembly will be held in place by swivel bolts and wing nuts.



ANPD — ETRC
EXPERIMENT

2. Liner

The liner extends the full length of the pressure tube and is sealed at the bottom by a welded cap. The upper end is sealed by the O-rings mentioned in the preceding paragraph.

3. Spacer Ring

A metal spacer ring is welded between the liner and pressure tube to provide proper positioning for the liner. The ring also serves as a tube seal.

4. Grid Support Plate

The grid plate supports the assembly weight by means of a grid support plate welded on the pressure tube. This support plate fits into the grid plate grooves.

5. Sample Support

The sample is suspended from the sample support plate of the cap assembly.

6. Leak Detection Device

The cap assembly has been fitted with two O-rings. Water that leaks past the first O-ring will flow into a chamber inside the cap and actuate a leak detection device.

When water leaks into the top cover the resistance across the electrodes will decrease and the current flow will actuate a signal. It may be necessary to add metallic salt crystals to the chamber in the cap to increase the conductivity of the water. The detection system will be tested prior to inserting the tube in the ETRC.

B. Procedures

1. Reactivity Measurements

The general procedures to be followed when inserting a large experiment of this nature are discussed in Section IV-D of the Hazards Summary Report. For this particular experiment the following procedure will be used:

a. Several fuel elements will be removed from the core to produce a negative reactivity effect which is known to be greater than the positive effect of inserting the experiment. In addition the control rods will be in the scrammed position.

b. The pressure vessel with the experiment in place will be filled with water and lowered into the experimental position with the overhead crane. (As will be seen later, the purpose of filling the vessel with water is to measure the reactivity effect that would result if the vessel were to rupture and fill with water. The water-filled measurement will be made before the air-filled measurement, because the former will produce the greater reactivity effect.)

c. The reactor will then be made critical by replacing the fuel elements one at a time after each rod withdrawal and after multiplication has been determined.

d. The vessel will be removed from the reactor, drained of its water, and dried out. It will be resealed and pressure tested. The leak detector and its associated instrumentation will be checked.

e. The experiment will be replaced in the reactor, which will then be made critical. The rod positions will be compared with the previous condition to determine the reactivity effect of flooding the experiment with water.

2. Flux Measurements

Measurements of the neutron and gamma flux distributions will be made on this experiment. These distributions will be made with and without the experiment in the pressure vessel. Uranium foils together with catcher foils will be used for the neutron flux measurements, and gamma sensitive film will be used for the gamma flux measurements.

The only part of these measurements that presents a hazard is the insertion of the experiment into the reactor. The reactivity effect and the procedures to be followed when inserting the experiment will follow critical loading procedures as outlined in the previous section.

C. Insertion Approval

The insertion of all experiments of this nature must be approved by the MTR-ETR Reactor Safeguard Committee. This Committee is composed of engineers and physicists who were selected because of their various fields of study and background so that all phases of reactor operation and safety are covered. The detailed design of the experiment and the proposed procedures for reactor operation are reviewed by this Committee before an insertion approval is granted.

IV. USE OF IRRADIATED FUEL ELEMENTS

A. Handling Procedures

The hazards associated with these experiments are mainly those of handling the fuel elements. As mentioned in the Hazards Summary Report, the fuel elements will be transported from the ETR to the ETRC in a suitable shielding cask. The cask will be lowered by the overhead crane into the tank between the storage area and the reactor core (Figure 3, IDO-16332), and the fuel elements will be removed from the cask and placed in the reactor core by the use of remote handling tools. The depth of the tank and the length of the fuel element are such that in transferring the spent fuel element into the reactor grid, the minimum water depth will be approximately seven feet. With the element at this depth the maximum radiation at the surface of the water will be about 700 mr/hr for approximately ten seconds (time required to place fuel element in grid).

It is conceivable that while both irradiated and unirradiated elements are in the tank an operator might inadvertently raise an irradiated element to the surface, thinking he is raising an unirradiated element. To prevent such an occurrence the top of the tank is constantly monitored by a radiation instrument which has an audible alarm. The trip level of the alarm is set at 20 mr/hr.

B. Neutron Flux Measurements

The effect of fuel burnup and fission products on the neutron flux distribution will be studied. The same handling problems are involved as mentioned in the previous section. An additional problem is that of placing the flux detector in the element; this will be done one of two ways:

1. If cobalt detectors are used, they will be inserted and removed from the element with electromagnets.
2. If gold foils are used, they will be placed on lucite strips and lowered into the element with a handling tool.

In both cases the elements will be left in the core. A further discussion of these techniques can be found in section IV-D-1 of the Hazards Report.

C. Full-Core Loading of Irradiated Elements

It is possible that a full-core loading of spent fuel elements will be placed in the ETRC for the purpose of studying the neutron flux distribution. The fuel handling problems are the same as those discussed in Section A. The hazards, resulting from a power excursion when the reactor is loaded with the elements, is discussed in the Hazards Summary Report. However, the validity of the conclusions in that report are now more certain in view of the measured void and temperature coefficients.

REFERENCES

1. Kaiser Engineers and General Electric Company, ETR Engineering Design and Safeguards Report, IDO-24020, July, 1956.

2. AEC Classified Report, XDC 57-10-721, October, 1957.

APPENDIX

COPY

UNITED STATES
ATOMIC ENERGY COMMISSION
P. O. BOX 1221
IDAHO FALLS, IDAHO

In Reply Refer to:
O:JBP

June 19, 1957

Dr. R. L. Doan, Manager
Phillips Petroleum Company
Atomic Energy Division
Idaho Falls, Idaho

Dear Dick:

On May 2, 1957 the Director of Reactor Development approved the startup and operation of the ETR Critical Facility with some reservations. This approval was transmitted to you in my letter dated May 2. We have now received the attached communication setting forth in some more detail the questions raised by the Reactor Hazards Evaluation Staff. In order to resolve these questions and to secure approval for the operation of the reactor for its original purpose, will you please prepare a report describing the types of experiments to be inserted in the reactor and the procedure for their insertion in more detail than that included in IDO-16332, particularly with reference to the possible loading of irradiated fuel from the ETR.

This report, together with your report on the characteristics of the facility on the basis of recent operation, should be sufficient to satisfy the Reactor Hazards Evaluation Staff as to the safety of operation of the reactor for its designed purpose. These responses should be prepared with adequate lead time for reconsideration in advance of the date for loading of the experimental equipment into the ETR.

Very truly yours,

/s/

J. Bion Philipson, Director
Division of Operations
Idaho Operations Office

Enclosure:
Memo Price to Davis dated 5/10/57

cc: R. L. Doan

C O P Y

W. K. Davis, Director
Division of Reactor Development

H. L. Price, Director
Division of Civilian Application

ENGINEERING TEST REACTOR CRITICAL FACILITY (ETRC)

The Hazards Evaluation Staff has reviewed the hazards associated with the facility as described in IDO-16332 in accordance with your request of April 22, 1957.

The facility will be operated at unusually high powers for a critical facility and will have an unusual degree of flexibility. On the other hand, the remoteness of the site and the experience of the Phillips organization favor the safe operation of such a facility and it may thus be concluded that operation of the reactor for the normal purposes of a critical experiment facility will not constitute an undue risk to the health and safety of the public.

There are a few matters, however, on which we do not have adequate details available and upon which we wish to reserve judgement at this time. These matters relate generally to the use of the facility as a low power testing reactor rather than as a conventional critical facility.

1. A description of the types of experiments to be inserted in the experimental holes in the core and on the methods of handling these experiments will be required before a complete evaluation of the hazards involved in the anticipated experimental program can be made.

2. The experimental program to be conducted using spent ETR fuel elements and the hazards associated with such operation have not been adequately described. These hazards may be more adequately reviewed and judged after experience has been gained through operation of the facility with clean fuel elements.

It is therefore concluded that:

1. The reactor may be operated as a critical facility without undue risk to the health and safety of the public.

2. Review and judgment on the proposed operation of the facility with inserted experiments or spent fuel elements will be deferred pending:

    a. The receipt of a description of experiments to be inserted.

    b. The accumulation of operating experience with the facility, using clean fuel elements.

Phillips
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