PRNC 108 PUERTO RICO NUCLEAR CENTER Excess Reactivities Associated with Certain Core Configurations of the PRNC Research Reactor and the Proposed Pool Critical Facility Dr. Aviva E. Gileadi November 1967 'OPERATED BY UNIVERSITY OF PUERTO RICO UNDER CONTRACT [NO. AT (401-1833) FOR U.S. ATOMIC ENERGY COMMISSION ---Page Break--- PRNC REPORT 108 ---Page Break--- EXCESS REACTIVITIES ASSOCIATED WITH CERTAIN CORE CONFIGURATIONS OF THE PRNC RESEARCH REACTOR AND THE PROPOSED POOL CRITICAL FACILITY Dr. Aviva E. Gileadi +490. ---Page Break--- ACKNOWLEDGEMENTS The advice and assistance obtained from Mr. C. W. NESTOR of the Mathematics Division, ORNL, in running the TWENTY GRAND problems and from Dr. BAL RAJ SEHGAL of the Reactor Physics Division, BNL, in computing the few group cross sections is gratefully acknowledged herewith. The cooperation of the PRNC Reactor Division in performing the critical experiments is highly appreciated. ---Page Break--- EXCESS REACTIVITIES ASSOCIATED WITH CERTAIN CORE CONFIGURATIONS OF THE PRNC RESEARCH REACTOR AND THE PROPOSED POOL CRITICAL FACILITY Dr. Aviva E. Gileadi with certain core configurations of the Proposed PRNC Pool Critical Facility computed. The same computational method and the same input data, when used to compute the excess reactivity of a given core configuration of the PRNC HW Research Reactor, yield results that agree very well (within 2%) with those measured in critical loading experiments on the same configuration, thus establishing confidence in the validity of the computations reported herewith. (See p. 126 16) One of the objectives is to provide dependable reactor physics data to be used in the safety analysis of the proposed PRNC Pool Critical Facility. However, the usefulness of the data presented herewith is not limited to the solution of that problem; it is more general than that: The group constants may be used as input data to a variety of calculations concerning both the PRNC Research Reactor and the PRNC Pool Critical Facility, including calculations of...

flux distribution, depletion, perturbation, etc. The fuel elements to be used in the proposed PRNC-Pool Critical Facility are identical to those used in the PRNC Research Reactor. They are NTR-type, 18 plate fuel elements containing 10.67 g of 20% enriched U3O8 powder per plate. For the exact description of the geometry and the materials composition of these fuel elements, reference is made to the Final Hazards Summary Report PRNC-37. (see ref. 1) ---Page Break--- The results are presented in the following order: 1. Computed values of few group constants. 2. Computed values of effective multiplication factor (keff) for a set of configurations of the PRNC Pool Critical Facility. Comparison of measured and computed keff values for a given configuration of the PRNC Research Reactor. 1. Computed values of Few Group constants: Two, three, and four group constants were determined for the following regions: 1. Standard fuel element 2. Partial fuel element 3. Center wall 4. Pure water reflector The group constants were calculated at the Computing Center of Brookhaven National Laboratory, using the HAMMER code which was developed at BNL. HAMMER contains THERMOS library for thermal and MUFT library for fast microscopic cross sections; the rest of the necessary input data describe the materials composition and the geometry of the region. HAMMER-computed few group constants by regions and by energy groups are ---Page Break--- 1 MeV, ---Page Break--- ---Page Break--- ssisn suseoco om sey: | sett | _ sso" | w0so00 19 629° = HEM OL | Tee Tey wet | esesm* ° | 6mm oss: . | met €EzELO" L 'ész0z0" oss 190100 6€1100"1 600m 20000" Legees" 622601" £1000" uf NO1930 713K TOULNOD OWMd YOd SLWVASNOD snow 1G CaLN4WO> ua © nev ---Page Break--- 090941 0620610" 0 = 3 S29 we seo cro oy =a Se oom ce re 9 689265"! offz20" 061000" AM ESS ~ HOW OL om cas . mae 1 €tSses~ Lesh 910100" *8 S29" ~ now E55 [Beste wo tir seve =o | omsco-z 6ut901° 09¢000" 20M 128° = 50H OF sdnos6 ase) sesus YGLVA Suna WOs SLMVLSHOD aNQYD AZ a3LNEHOO-¥IMACH ome ---Page Break--- 2 of Eff

iplicatl 1 Effective multiplication factors were computed on the Control Data e 16OK-A computer of the ORNL Mathematics Division, using "TWENTY GRAND", a few group, few region diffusion code developed at ORNL. Four groups were used. The core configurations chosen include the proposed basic configuration of the Pool Critical Facility as well as certain other configurations of the same facility obtained by adding one, two, three, or four standard fuel elements to the basic configuration, into the corner positions. Some of these configurations were instrumental in determining the excess reactivity associated with the accident, agreed upon in the case of the PRNC-Pool Critical Facility as inadvertently dropping a standard fuel element into a corner position when the core is already critical in its basic configuration. The configuration labeled "CONTROL CASE" refers to the actual configuration of the PRNC Research Reactor used in a critical loading experiment. TWENTY GRAND calculated effective multiplication constants, together with the configuration diagrams, are given in figures 1-5. ---Page Break--- Pecos LEGEND BBB sre.0mo rue. [wate nersscron ¢ EEE cowmo. ve. . E1gue 1 CORE CONFIGURATION A, COMPUTED K = 1.0143652 ---Page Break--- LEGEND BBB srmonen ree [J wien nessccton EER conraon ven EguRE 2. CORE CONFIGURATION B, COMPUTED K = 1.0212336 ---Page Break--- % OPS eS BBB stavonwo ruer [J wares nervecron ---Page Break--- Leceno BBQ seo rue (te rercecron FEES) common wer EIGURE 4. CORE CONFIGURATION D, COMPUTED K = 1.0341291 ---Page Break--- LEGEND + BRP samo ruet conrnot weue: PARTIAL FUEL (1 saves aercecroa FIGURE 5. CONFIGURATION "CONTROL CASE" computed K = 1.0209783 ROSES Reve 22 ---Page Break--- 3. Comparison of Measured and Computed Data for the "CONTROL CASE": In order to check the overall validity of these computations, a comparison was made with experimentally determined results. A set of critical loading experiments were performed in the PRNC-Research Reactor Core in the open pool position and the

Excess activities were determined with the aid of a calibrated regulating rod and one calibrated shim rod. The regulating rod was calibrated by the stable period method and the shim rod by the trading method. Integral calibration curves of the regulating rod and of the shim rod are shown in Figures 6 and 7 respectively. Figures 8 through 11 show the core configurations for which critical loading has been performed. ---Page Break--- "The 20304 ROD POSITION (% OUT) REGULATING ROD CALIBRATION CURVE INTEGRAL RODWORTH VS ROD POSITION 80-30-100 Figure 6 ---Page Break--- 20 30 30-80 60-70 ROD POSITION (%) PARTIAL ROD CALIBRATION CURVE OF SHIM ROD #3 INTEGRAL RODWORTH VS ROD POSITION ---Page Break--- CONTROL CASE ~ MEASURED ---Page Break--- Figure 10: CONFIGURATION H SH-1 SH-2 SH-3 SH-4 RR 100. 100. 100. 100. 36.49 Conditions of one standard fuel element in lattice position 50 of the "CONTROL CASE" core results in 33 excess reactivity - as it can be read off from the calibration curves. Rod positions at criticality: SH-1 SH-2 SH-3 SH-4 RR 100. 100. 23.9 100. 100. Addition of the last fuel element amounts to an addition of $1.75 Ry of reactivity - as can be read off the calibration curves of the regulating rod and shim rod #3. ---Page Break--- The discrepancy between measured and computed kerf values in the "CONTROL CASE" is .0029, which is very satisfactory, especially if one takes into account that the computations refer to a clean core and the measurements were performed on a core that has had an operating history of approximately 80 megawatt days. Conclusions: 1. From the close agreement obtained between measured and computed values, we conclude that using the BNL-HAMMER code for generating few group constants and the ORNL-IVENTY GRAND code for determining the effective multiplication factor leads to valid computed results. In an attempt to corroborate this conclusion, further calculations are being made on. 2. We have seen that for configuration A of the proposed PRNC Pool Critical Facility we...

obtain a computed kye = 1.014 corresponding to clean cold excess reactivity of this value by substituting partial fuel elements for some of the standard elements preferably in the center of the core. 3. The excess reactivity associated with the postulated maximum credible accident is computed as the difference between the ky's of cases A and B. OK * 0.0068684 ~ 90g ---Page Break--- aise

References

1. Hazards Summary Report for the Puerto Rico Nuclear Center, Research Reactor, 1965, PRNC 37.

2. TWENTY-GRAND Program for the Numerical Solution of Few Group Neutron Diffusion Equations in Two Dimensions by K. L. Tobias & B. Fowler Feb, 1962, ORNL 3200 ---Page Break---