Rensselaer

Department of Environmental & Energy Engineering

November 30, 1995

DOE/ER/75923--T1

Director Region 1
Office of Inspection and Enforcement
US Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA

Dear Sir:

The RPI Reactor Critical Facility (RCF) operated successfully over the period fall 1994 - fall 1995. During this period, the RCF was used for Critical Reactor Laboratory spring 1995 (12 students); Reactor Operations Training fall 1994 (3 students); Reactor Operations Training spring 1995 (3 students); and Reactor Operations Training fall 1995 (3 students). Thirty-two Instrumentation and Measurements students used the RCF for one class for hands-on experiments with nuclear instruments. In addition, a total of nine credits of PhD thesis work were carried out at the RCF. This document constitutes the 1995 Report of the Rensselaer Polytechnic Institute's Reactor Critical Facility (RCF) to the USNRC, to the USDOE, and to RPI management.

Work proceeded on critical experiments with the 0.640 pitch lattice plates, the last of the three sets of lattice plates provided by USDOE contract. The results of experiments with SPERT(F1) fuel and with ABBCE fuel are being analyzed with the objective of publication. The RCF is now the only facility in the U.S. carrying out reactor physics critical experiments in support of the power reactor discipline. A recent paper (D.R. Harris and M.N. Galayda, "Secure Critical Experiments at a University Reactor," **Trans. Am. Nucl. Soc.** 71, 385, 1995) proposed the RCF for critical experiments for naval reactors and plutonium applications (Attachment A). Work continues on organizing files and records contained in the RCF. Work also continues on updating, correcting and verifying facility "as built" drawings and prints. Measurements are being conducted in support of research being done by Dr. Andrew Kalukin of RPI's Center for Integrated Electronics. This research involves experiments in neutron tomography.

The USDOE Reactor Sharing Program continued with a total of 198 individuals from participating organizations examining the RCF, operating it, and carrying out a reactor physics experiment. The visitors also learn about the radiological and nuclear safety of the reactor, its regulation by the USNRC, and its relation to civilian, naval and research power reactors. A cumulative list of RCF Sharing events is attached (Attachment B).

Training for Reactor Operating Licenses has been continuous, but has been intensified since 1994. On December 5, 1994, Warren Eresian of the USNRC administered an Operations SRO Examination to Dr. D.R. Harris (passed, now licensed). Also administered were written (three sections), oral, walk-through and operations SRO examinations to M. Leone (passed and licensed), B. Knight (failed one section of written) and J. Morton (failed two sections of

Jonsson Engineering Center (518) 276-6402 • Gaertner Laboratory (518) 276-6650
Materials Research Center (518) 276-6381
Rensselaer Polytechnic Institute • Troy, New York 12180-3590
Fax (518) 276-4832 (NES), 2055 (JEC) • Fax (518) 276-2080 (MRC)

DISCLAIMER

written and operations). On April 25, 1995, Mr. Eresian returned and administered one written section to B. Knight (passed, now licensed) and three sections of written, oral, walk-through and operations SRO examinations to A. Lemke (passed, now licensed), B. Craig (failed one section of written) and S. Mooradian (failed one section of written). B. Craig and S. Mooradian will retake the failed sections on the next scheduled examination. Three new applicants have been in training for the next scheduled SRO examination on January 16, 1996.

The technical specifications, App. A to USNRC License CX-22 require reporting the following operational items:

1. Changes to the facility design are as follows:
   On June 14, 1995, changes were made to the RCF Main Control Panel (CP1) which allow ganged operation of any combination of the control rods now in use. This involved installation of one gang shim switch and four single/gang selector switches, one each for each control rod. Also installed was a relay which energizes the control rod drive mechanisms in the "In" direction when actuated by a switch on the Main Control Panel. This is to allow shutting down the reactor at normal control rod speeds without actuating the shim switches. These changes and the test procedure to verify their operation have been reviewed by the NSRB and have resulted in no unreviewed safety questions as defined in 10CFR50.59 (Environmental and Energy Engineering Memorandum from M. Galayda to Dr. D. Steiner, June 14, 1995).
2. Significant maintenance, repairs and other work performed on RCF systems as follows:
   a. February 8, 1995, repaired broken ground connection on PP2 detector.
   b. May 3, 1995, installed new remote security alarm system.
   c. June 14, 1995, rewired Main Control Panel.
   d. June-July 1995, drilled additional holes in the 0.640 inch pitch lattice plates to support experiments.
   e. July 5, 1995-August 8, 1995, removed 0.613 inch pitch lattice plates and installed 0.640 inch pitch lattice plates.
   f. August 14, 1995, replaced faulty PP2 detector.
   g. October 1995, acquired new gears for control rod coarse position indication.
   h. October 1995, repaired amplifier in counting room fuel pin counting equipment.
3. There have been no changes in Operating Procedures which relate to the safety of RCF operations.
4. Surveillance checks, tests, and calibrations were conducted and logged as required. The results were satisfactory. On August 2, 1995 an emergency drill was conducted at the RCF. Agencies that took part in the drill were RPI Radiation Safety Office, RPI Department of Public Safety, Schenectady Fire Department, Schenectady Police Department and Mohawk Ambulance Inc. The drill scenario involved a small electrical fire in the reactor room with two injured personnel.
5. There were no changes, tests or experiments requiring authorization from the NRC under 10CFR50.59 a or b.
6. In January 1995, Robert Ryan retired and was replaced as Radiation Safety Officer by Dr. Xie (George) Xu. On March 18, 1995, the Nuclear Engineering & Engineering Physics Department merged with Environmental Engineering and became the Environmental & Energy Engineering Department. Dr. Don Steiner replaced Dr. Michael Podowski as Department Chairman and Chairman of the Nuclear Safety Review Board.
7. Calculation of integrated thermal power in progress.
8. Unplanned scrams are as follows:
   December 2, 1994, failure to change scales on LP1.

December 2, 1994, failure to change scales on LP2.
December 7, 1994, PP2 Period Low, spurious at 0845.
December 7, 1994, PP2 Period Low, spurious at 0925.
February 1, 1995, 4 spurious scrams on PP2 Period.
March 1, 1995, failure to change scales on LP1.
October 4, 1995, failure to change scales on LP1.

9. Maintenance operations were carried out and logged with satisfactory results.
10. The environmental monitoring program yielded the following summary of TLD doses taken at the exclusion area boundary and the site boundary for this report period

Station		Dose mRem
1	Exclusion Area Boundary	0
2	Exclusion Area Boundary	22
3	Exclusion Area Boundary	30
4	Exclusion Area Boundary	0
5	Site Boundary	20
6	Site Boundary	13
7	Control (Public Safety Office)	0

11. Facility personnel exposures were all less than 282 mRem for the report period.

Sincerely,

Donald R. Harris

Dr. Donald R. Harris, Director
RPI Reactor Critical Facility

/mas
attachment

cc: NSRB Members
R.C. Block
G. Judd, Dean of Faculty
R.T. Lahey, Jr., Dean, School of Engineering
Anthony Vanolla, Idaho National Eng. Lab.
Paul J. Lawler, Vice President of Finance

A

Secure Critical Experiments at a University Reactor

D. R. Harris and M. N. Galayda

Rennselaer Polytechnic Institute
Troy, N. Y. 12181

The Reactor Critical Facility (RCF) of Rennselaer Polytechnic Institute (RPI) is the only remaining U. S. facility for carrying out critical experiments in support of the nation's light water reactor(LWR) power programs, civilian and naval (1-3). The RCF can accommodate fuel rod or fuel plate cores up to four feet high and up to several feet in lateral dimensions, generally with "infinite" lateral water reflectors. Unless control rod properties are specifically required in the cores, the control rods are in reflectors and are fully withdrawn when "clean" cores are required. The RCF is the only U.S. university reactor designed and built (in the 1950's) as a critical facility, and for the last ten years improved methods and equipment have been under development and reported . This work considers cores, measurements, safety, security, radiological matters, and licensing as required for mixed oxide rod cores or naval reactor plate cores at the RCF.

Two cores are considered: (1) an ABBCE 16x16 fuel assembly of 42 inch long pins of mixed oxide surrounded by a 4.81 w/o enriched UO2 matching driver lattice of 42 inch long SPERT(F1) fuel pins, all in 1/8 core symmetry,and (2) a naval core of comparable height and appropriate symmetry. In both cases the fuel contains weapons grade Pu or U, so the RCF must be upgraded to Category I for the duration of the measurements, in accord with 10CFR73.60. Round-the-clock armed guards (two or more) are required, with adequate training, clearance, and drills. Required modifications to plant include (a) three-strand wire on the top of the security fence, (b) enhanced motion sensors, (c) bullet resistant glass on the guard building, and (d) restricted access structures.

For security and other reasons it is necessary to limit the duration of the measurements. A campaign of measurements can be accomplished (2) in about one month , assuming that at least one additional experimenter is supplied by the sponsoring organization. The campaign requires (a) approach to critical, (b) control rod worths, (c) isothermal temperature coefficient of reactivity, (d) fuel pin worth, (e) void coefficient of reactivity, (f) relative spatial power shape, (g) absolute power calibration, all at various boric acid levels in the water up to about 300ppm. Measurements after (b) are carried out with all control rods fully withdrawn, thus on rising periods to about one watt core power. The measurements (a) through (g) are required by the Tech Specs, but experience has shown that only (c), (d), and (f) are of great interest for reactor physics benchmarking. Relative spatial power is measured to about 1%, while reactivities and reactivity changes are measured to about 1/3 cent. About 100 periods constitute a campaign, so the total energy production in a campaign is about 25 ws per fuel pin or plate. Thus there is negligible

fission product activity after a short time, and the customer's fuel pins can be returned to the fuel fabrication facility, cut open, and the fuel pellets recovered.

Weapons grade fuel shipments must be by DOE armed carrier (SST) using licensed shipping casks. While the fuel is at the RCF it is either in the core or in the shipping cask, which thus must remain for the duration of the campaign. The radiological safety requirements at RPI meet or exceeed the requirements of 10CFR20, although better alpha monitoring sensors should be on hand. The Emergency Procedures should be modified to include ruptured PuO2 fuel pins or fuel plates. Document submittals include (a) Amendments to License CX-22 and Tech Specs, (b) Amendments to Security Plan and Procedures (10CFR73 App C), (c) Modifications to the Safety Analysis Report to reflect the presence of Pu and HEU, (d) Modified Emergency Plan and Emergency Procedures. No changes in the Design Basis Accident, Safety Limits, or Scram Settings are required. No changes in instrumentation, core support, water treatment or control are required.

In summary, secure critical experiments at the RCF appear to be feasible with proper planning and the use of offsite support, particularly for security and measurements. The measurements would be of appropriate quality and at relatively little cost, a small fraction of the their cost elsewhere.

References:

1. D. R. Harris, K. J. Connor, R. C. Rohr, and S. W. Bucher, " Operating Experience at a University Based Reactor Critical Facility", Proc. Sixteenth Reactor Operations International Topical Meeting, August 15-18, 1993, Long Island, N. Y. , Am. Nucl. Soc. Publishers, La Grange Park, Illinois, 1993, pp367-374.
2. D. R. Harris, R. C. Rohr, D. K. Hayes, A. Jonsson, J. Y. Jung, and R. Y. Chang , "Critical Experiments for ABB Fuel With Erbium Burnable Poison", Trans. A. Nuc. Soc. 65, 415(1992).
3. D. R. Harris, "Critical Experiments With Mixed Oxide Fuel", Proc. of Fourth Nuclear Criticality Technology Safety Project Workshop, Williamsburg, Va., May 9-11,1994, USDOE, Los Alamos National Laboratory, 1994, pp94-97.

ATTACHMENT B

REACTOR SHARING EVENTS UNDER US DOE PROGRAM

September 1990 - November 1995

Date	Visitor	# of students
9/29/90	Troy High School	30
3/6/91	U.S. Navy	6
4/16/92	West Point	11
5/1/91	USMA	13
5/8/91	Amsterdam High	21
5/21/91	Troy High School	7
5/28/91	Burnt Hills High School	16
8/2/91	Oneonta	25
2/28/92	Adirondack Community College	9
3/4/92	Fulton Montgomery Com. College	11
3/27/92	Amsterdam High School	15
5/12/92	Stillwater High School	14
5/12/92	Williams College	3
5/18/92	Guilderland High School	45
5/19/92	Guilderland High School	45
5/20/92	Guilderland High School	60
8/4/92	Oneonta	26
3/27/93	ANS North Eastern Student Conf.	28
5/6/93	Vermont Tech	6
12/3/93	Adirondack Community College	28
5/6/93	Boy Scouts of America	25
5/3/94	Vermont Tech	9
5/5/94	State University of NY at Delhi	9
10/29/94	ANS Secondary School Teachers	35
3/2/95	Duanesburg Central School	45
3/3/95	Duanesburg Central School	38
5/5/95	Bethlehem Central High School	23
5/9/95	Vermont Technical College	7
11/6/95	U.S. Military Academy	32