CONTRACT EY-76-C-02-3409.A004

TWENTY-FOURTH ANNUAL PROGRESS REPORT OF THE PENNSYLVANIA STATE UNIVERSITY BREAZEALE NUCLEAR REACTOR

July 1, 1978 to June 30, 1979

Submitted to
United States
Department of Energy
and
The Pennsylvania State University

by

Samuel H. Levine, Director
Robert E. Totenbier (Editor),
Breazeale Nuclear Reactor
Department of Nuclear Engineering
The Pennsylvania State University
University Park, Pennsylvania

July 1979

PSBR 315-497992

ACKNOWLEDGEMENTS

The editor wishes to express his appreciation to all contributors for their timely research and project reports. Special thanks should be given to S. H. Levine for the Introduction, I. B. McMaster and J. R. McKee for the personnel section, J. L. Penkala for the Education and Training Utilization section and W. A. Jester for the Radionuclear Applications Laboratory summary. In addition, this report would not have been completed on time without the help of the nimble fingers of M. Beward and R. Fasick.

TABLE OF CONTENTS

TABLES

FIGURES

HIGHLIGHTS

HIGHLIGHTS

The PSBR provided contamination detection services and answers to questions from numerous concerned citizens in the aftermath of the Three Mile Island incident.

The reactor was used an average of 2.33 hours out of each 8 hour shift for educational purposes.

With no change in total hours of operation, more samples were irradiated for more sample hours than during the previous year.

Facility research involved 64 faculty and staff members and 42 graduate students in 29 departments or sections from 7 colleges of the University.

More than 2400 visitors were guided through the facility on over 125 tours.

27 high school science classes involving 312 students were involved in demonstration type experiments using the reactor and other facilities.

57 Nuclear Engineering Laboratory Classes involving 107 students used the facility for 341 hours.

The ninth four week Nuclear Concepts and Energy Resources Institute was held for 44 high school science teachers from 10 states.

Three unannounced Nuclear Regulatory Commission inspections revealed no items of non-compliance.

An Activation Analysis Workshop was attended by 17 researchers.

Two industrial training programs were conducted for 12 potential nuclear power plant operators.

Four other Universities used the reactor facilities under a DOE sponsored reactor sharing program.

The reactor staff has accumulated well over 125 man years of safe reliable reactor operating experience.

INTRODUCTION

I. INTRODUCTION

The Breazeale Reactor acted as a center of analysis and information during and after the accident at Three Mile Island. The local community was advised as to the potential hazards of this accident, and members of the staff helped in analyzing material and food for radiation contamination. In addition, concerned citizens, returning from the Harrisburg area, were survey-d for radiation contamination. Needless to say, no radiation contamination was found, but it served to allay their fears.

The Nuclear Engineering Laboratories, NucE. 440, NucE. 441, and NucE. 502, utilized the facilities to teach students practical applications and in some cases allowed them to operate the reactor. A special nuclear engineering course correlating reactor theory with practical situations involved operation of the reactor by students. Other nuclear engineering courses also provide opportunities for students to operate the reactor and gain practical experience related to their theoretical course work.

In addition to the educational and research benefits, there are related economic benefits provided by the facility to the University as well as to the residents of Pennsylvania. Continued education activities are conducted to provide students from high schools and other colleges and universities in Pennsylvania, the opportunity to use the Breazeale Reactor.

It is also important to recognize that the reactor provides experimental facilities that are necessary in the performance of some contracts; otherwise, faculty and students would either conduct their reactor experiments out of the state at additional costs to them or eliminate this portion of the work from their contracts. During the past year 64 Penn State University faculty and staff and 42 graduate students made use of the facility for research.

This year has seen increased utilization of the services provided by the Radionuclear Applications Laboratory, both by University research personnel and by industrial organizations. The majority of these projects involved either analytical services using neutron activation analysis or tracer services using nonradioactive but neutron activatable tracers. An exciting area of new research, which has been initiated for studying the

use of some of the water tracer techniques was pioneered by faculty in the Nuclear Engineering Department to evaluate sites for acceptability as shallow land radwaste burial sites.

Groups totaling more than 2,400 people visited the facility on guided tours during the year. This total does not include visitors for business purposes, small groups, and many casual visitors who are also guided through the facility.

The Reactor Staff and the Nuclear Reactor Safety Committee continue to review the operation of the facility in an effort to improve the safety and efficiency of its operation and to provide conditions conducive to its utilization. With the advent of TMI, and the increased public sensitivity to nuclear radiation activity, the NRC is imposing more and more restrictive rules and regulations on these facilities. These rules and proposed rules consume enormous amounts of staff time and restrict movement within the facility by people not on the permanent staff. It is anticipated that these conditions will continue into the future. The Nuclear Reactor Safety Committee met four times to confer with the staff on unusual experiments, review operational records, and consult on special operational problems. Three NRC inspections were conducted during the period covered by this report. These included compliance of activities conducted under the facility license and Special Nuclear Materials licenses, and physical protection and accountability of the materials held under these licenses.

The following sections of this report are intended to provide an outline of the various aspects of the operation of the facility. Personnel, operating and utilization, statistics and research are summarized in the various sections that follow.

152

PERSONNEL

[redacted]

[redacted]

153

II. PERSONNEL

After nearly 15 years of service to the facility, J. H. O'Brien terminated employment with the University to accept a position in industry. His duties have been temporarily absorbed by T. L. Flinchbaugh and R. C. Houtz with some duties distributed among the remainder of the staff. This vacant position has been accepted by J. B. Bonner who reported for duty in June 1979.

P. P. Carier has been added to the facility staff on a part-time basis as a reactor operator trainee. It is expected that he will be licensed to operate the reactor sometime this summer. He will then assist the regular staff in reactor operations on a part-time basis. J. K. Shillenn has been reassigned to the reactor staff to assist with tours and neutron activation research.

G. M. Faeth of the Mechanical Engineering Department continues as chairman of the Nuclear Reactor Safety Committee. No changes were made in committee membership during the year.

E. C. Augustine has been added to the university Health Physics staff as a full-time Health Physics Assistant.

Table 1, lists the personnel associated with the reactor facility. The organization chart, Figure 1, reflects the present area of responsibilities of the permanent staff.

Table 1

PERSONNEL

Faculty and Staff

J. B. Bonner	-Reactor Supervisor/Auxiliary Operations Specialist
** T. L. Flinchbaugh	-Reactor Supervisor/Nuclear Education Specialist
** R. C. Houtz	-Reactor Supervisor/Nuclear Education Specialist
W. A. Jester	-Associate Professor
** S. H. Levine	-Professor/Director
J. R. McKee	-Administrative Aide
** I. B. McMaster	-Research Assistant/Deputy Director
** J. H. O'Brien (Resigned 3/9/79)	-Reactor Supervisor/Auxiliary Operations Specialist
** J. L. Penkala	-Research Assistant
K. K. S. Pillay	-Associate Professor
** D. C. Raupach	-Reactor Supervisor/Reactor Utilization Specialist
* K. E. Rudy	-Senior Engineering Aide-Mechanical Service Supervisor
J. K. Shillenn	-Energy Education Specialist/ Technology Transfer
** R. E. Totenbier	-Research Assistant/Operations Supervisor
* D. S. Vonada	-Electronics Designer

Technical Service Staff

P. P. Carier	-Reactor Operator
W. A. Davy	-Custodian/Driver
F. G. LeWando	-Maintenance Worker
R. O. Lowrey	-Experimental and Maintenance Mechanic

Clerical

M. D. Beward	-Facility Secretary
R. M. Fasick	-Secretary and Receptionist

*Licensed Operator
**Licensed Senior Operator

1841 155

Table 1 (Continued)

Graduate Assistants

J. S. Brenizer	-Graduate Assistant
J. P. Colletti	-Graduate Assistant
G. M. Comparetto	-Graduate Assistant
R. K. Hanneman	-Graduate Assistant
R. F. Hoffman	-Graduate Assistant
H. Y. Huang	-Graduate Assistant
C. J. Jarvis	-Graduate Assistant
J. H. Wallace	-Graduate Assistant

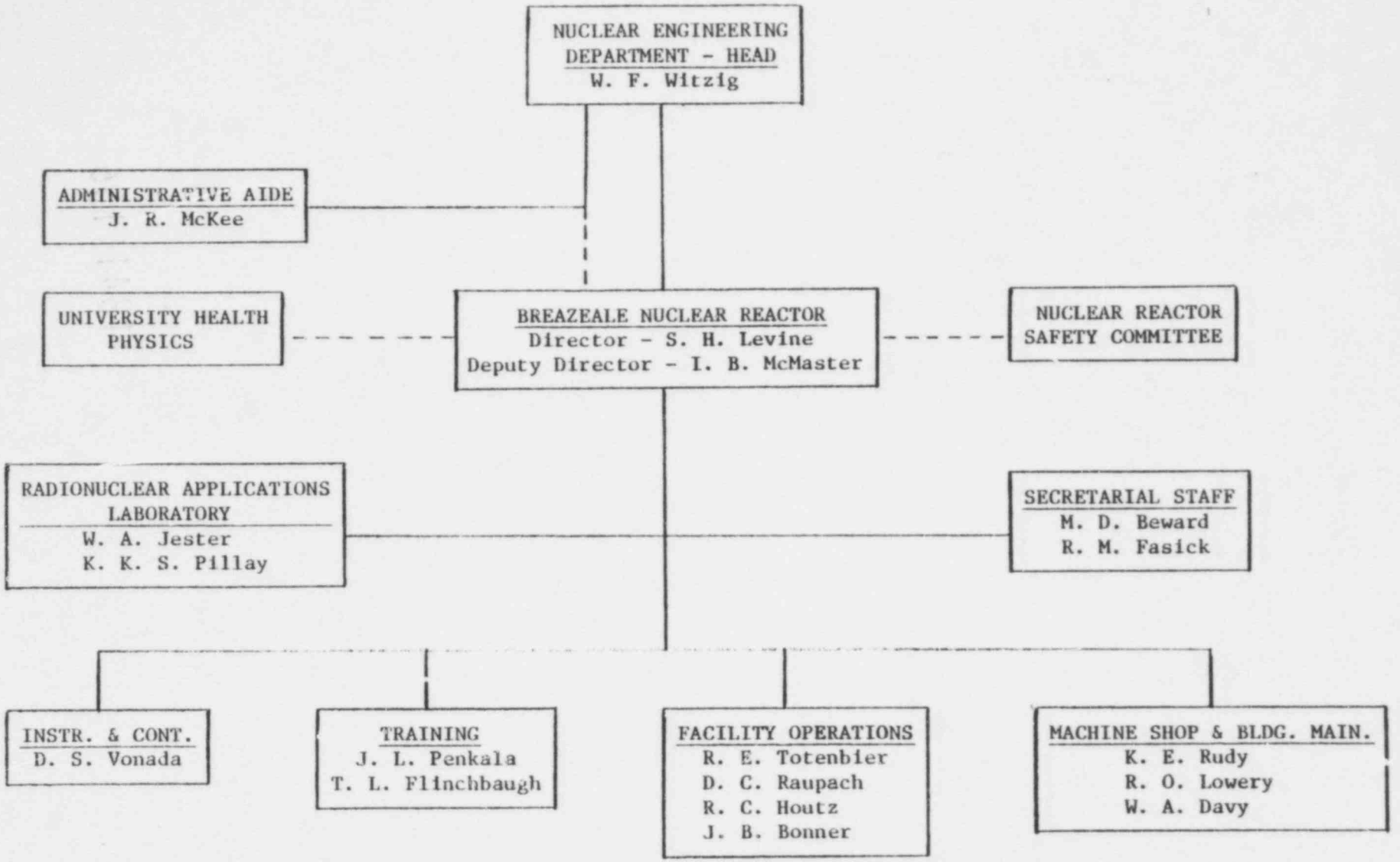
Health Physics

E. C. Augustine	-Health Physics Assistant
N. M. Dougherty	-Associate Health Physicist
R. W. Granlund	-University Health Physicist
D. H. Hollenbach	-Health Physics Assistant

Nuclear Reactor Safety Committee

P. Barton, Assistant Professor, Chemical Engineering
G. M. Faeth, Professor, Mechanical Engineering (Present Chairman)
R. W. Granlund, Health Physicist
R. E. Henderson, Associate Professor, Mechanical Engineering
E. H. Klevans, Professor, Nuclear Engineering
W. P. Kovacik, Westinghouse Research Laboratories
S. H. Levine, Professor and Director, Breazeale Nuclear Reactor
J. R. McKee (Secretary) Nuclear Engineering
I. B. McMaster, Research Assistant and Deputy Director, Breazeale Nuclear Reactor
W. M. Miller, Professor Emeritus of Chemistry
K. K. S. Pillay, Assistant Professor, Nuclear Engineering

1841 156



ORGANIZATION CHART

Figure 1

FACILITY OPERATION

1841 358

III FACILITY OPERATIONS

A comparison of the operation and utilization statistics for the past two years, as listed in Tables 2 and 3, indicates relatively small changes. There was a slight decrease in the hours critical which is also reflected in a lower energy release and a correspondingly lower figure of grams of U-235 consumed.

Although there were twenty fewer eight hour shifts in the past year, by scheduling more simultaneous experiments, an increase in the number of users per shift was realized. For the same reason, there was an increase in both the number of samples and the number of sample hours. These increases were accomplished with no change in the total hours of operation.

A new item appearing in Table 3, Educational Usage, reflects the average per shift use of the reactor for academic instruction and other educational purposes such as demonstration type experiments for high school science classes. The better than two hours per shift usage shows the value of the reactor as an educational tool.

Because of delays in granting of funds by the Department of Energy (DOE), a computer program, TRICOM/SCRAM, was adapted to determine the amount of U-235 consumed in each fuel element in the reactor core and in storage racks. By reshuffling the fuel, using the less depleted elements near the center of the core, the core life was extended sufficiently to delay the need for additional fuel until the fall of 1979. This new core configuration was made in August 1978.

During the past year there were three unannounced inspections by Nuclear Regulatory Commission agents. These inspections covered physical security, accountability of Special Nuclear Material and compliance with the facility technical specifications and the numerous rules in the Code of Federal Regulations. In all inspections, no items of non-compliance were found.

Table 2

Breazeale Nuclear Reactor Operation Data

June 1, 1977 - May 31, 1979

		1977-1978	1978-1979
A.	Hours of Critical Time		
	1. Hours Critical	836.13	758.11
	2. Approaching Critical	172.05	165.30
	3. Adjusting Fuel	55.51	58.60
B.	Number of Pulses	239	183
C.	Number of Square Waves	45	62
D.	Energy Release (MWH)	586.30	513.61
E.	Grams U-235 Consumed	30.20	26.40
F.	Number of Scrams		
	1. Planned as part of experiments	99	108
	2. Unplanned - resulting from		
	a) Personnel action*	20	16
	b) Abnormal system operation	13	5

*The majority of these resulted from operation by trainees.

1841 160

Table 3

Breazeale Nuclear Reactor Utilization Data

(average per shift)

June 1, 1977 - May 31, 1979

		1977-1978	1978-1979
A.	Number of Users	1.97	2.38
B.	Samples or Experiments		
	1. Pneumatic transfer samples	11.75	11.96
	2. Total number of samples	14.00	16.36
	3. Sample hours	9.25	19.04
C.	Reactor Usage (hours)		
	1. Total operation	2.94	2.90
	2. Shutdown in stand-by condition	1.12	1.20
	3. Total usage	4.06	4.10
	4. Subtotals		
	a) Full power operation	1.98	1.62
	b) Educational usage	---	2.33
	c) Reactor operator training	1.80	1.35
	d) Calibration and maintenance	.87	.86
D.	Number of 8 hour shifts	284	262

1841 161

Cobalt-60 Utilization

Table 4 shows a significant increase in utilization of the Cobalt-60 facility. Most of the increased usage occurred since January of 1979, and is continuing into the summer. Again this past year, most of the exposures were for experimenters interested in biological effects. Although these exposures are usually of short duration, there were enough long term irradiations to roughly triple both the hours of facility use and the total sample hours.

Most of the long term irradiation periods extend overnight and over weekends which in effect makes the facility available for use 365 days a year even though it is not staffed during these times. Since the per day averages are based on 365 days they are artifically low.

There have been no recent changes in this facility partially due to a change over in supervisory personnel.

Table 4

Cobalt-60 Utilization Data
June 1, 1977 - May 31, 1979

		1977-1978	1978-1979
A.	Time involved (hours)		
	1. Set-up time	17	56
	2. Total facility use	457	1,141
	3. Total sample hours	858	2,586
B.	Numbers involved		
	1. Samples run	636	633
	2. Different experimenters	16	25
	3. Configurations used	4	3
C.	Per day averages		
	1. Experimenters	0.2	0.6
	2. Samples	1.8	1.9

EDUCATION AND TRAINING

1841 164

IV. EDUCATION AND TRAINING

The training and educational ability and adaptability of the Penn State Breazeale Reactor (PSBR) operating staff and the TRIGA Mark III reactor were manifest in the variety of formal laboratory courses, industrial training programs, inhouse training, and continuing education functions which were provided during this past reporting period.

Typical of the cooperative effort provided by the PSBR operating staff was the guidance and supervision given to the fourteen Nuclear Engineering Technology (NET) students as part of their Reactor Technology Laboratory course, Nuc.E. 814. Under the surveillance of senior operators I. B. McMaster, R. E. Totenbier, D. C. Raupach, R. C. Houtz, J. H. O'Brien, T. L. Flinchbaugh, and J. L. Penkala, each of the NET students logged in a minimum of twelve safe and informative operating hours at the controls of the PSBR where they participated in all the routine operations which the reactor is capable of performing. The experimentation portion of the NucE. 814 course was taught by J. L. Penkala, assisted by T. L. Flinchbaugh in the laboratory.

Rounding out the offerings of formal courses at the PSBR in the NET program, K. K. S. Pillay taught the Nuclear Technology Laboratory course, NucE. 812, in which the reactor was used to generate radioisotopes.

The inhouse training this past year consisted of a license requalification program that was completed in December of 1978 and a reactor operator licensing program which is currently in progress. The annual requalification program consisted of an oral examination on abnormal and emergency procedures which was conducted by R. E. Totenbier. As in past years, all nine members of the PSBR operating staff successfully requalified for their NRC operating licenses.

The inhouse reactor operator licensing program is currently being conducted for P. P. Carier who began in late Fall 1978. It is anticipated that Carier will take an NRC operator license examination during the Summer of 1979.

The Nuclear Concepts and Energy Resources Institute (NCERI) was offered as Nuclear Engineering 497 for the ninth consecutive year during the Summer of 1978. The NCERI, a four week institute, was attended by forty-four high school teachers from ten states, in addition to Pennsylvania. As a result

Table 5

High School Nuclear Science Program

1978-79

High School	Instructor	No. of Students
Altoona	Mr. Beach	14
Beattie Tech	Mr. Leseck	10
Bedford	Mr. Turner	5
Bellefonte	Mr. Young, Jr.	19
Blue Mountain	Mr. Miller	10
Chestnut Ridge	Mr. Popp	10
Council Rocks	Mr. Struble	11
Daniel Boone	Mr. Tobias	19
Delone Catholic	Sister Marie Aimee	11
Derry Area	Mr. Feeny	8
Exeter	Mr. Murray	8
Harbor Creek	Mr. Peterson	9
Hollidaysburg	Mr. Rhodes	10
Jersey Shore	Mr. Allen	8
Lower Dauphin	Mr. Lyter	19
Marion Center	Mr. Petrosky	10
Mt. Union	Mr. Shutawie	7
N. Schuylkill	Mr. Welker	6
Penn Crest	Mr. Good	10
Penns Valley Area	Mr. Fuller	11
Reading Central Catholic	Sister Marie Thomas	7
Ridgeway	Mr. Koos	17
Smethport Area	Mr. Fetter	7
Thomas Jefferson	Mr. Farrell	15
Union City Area	Mr. Obert	11
Warren Area	Mr. Szul	30
Wyomissing Area	Mr. Bell	10
Group Total 27	Participants Total	312

of their four weeks of intensive study, the participating teachers will return to their respective school districts and offer a senior elective course in Energy Alternatives. The major portion of the NCERI laboratory experiments was supervised by T. L. Flinchbaugh and J. J. Bonner. D. H. Hollenbach and J. L. Penkala assisted in two of the laboratory exercises.

As in previous institutes, the participants in the NCERI were encouraged to return with their high school classes for a one-day field trip to the PSBR. This past year, as a result of previous NCERI's, 27 groups totaling 312 students participated in a full day of experimentation, observation, and touring at the PSBR. J. K. Shillenn handled the scheduling and supervision of the high school tour groups with assistance from J. L. Penkala and T. L. Flinchbaugh. Table 5 summarizes the participation in the high school tour program.

The laboratory course NucE. 440 was taught in the Fall 1978 and Spring 1979 terms by M. A. Schultz with the valuable assistance of R. C. Houtz. Three of the more important experiments were conducted at the PSBR with major assistance from the reactor operating crew.

During the Fall 1978 and Winter 1979 terms, E. S. Kenney taught the NucE. 441 courses with the assistance of the reactor staff. Twenty-two students were registered for the NucE. 441 course.

The TRIGA reactor was used extensively when S. H. Levine taught NucE. 502B, a graduate laboratory course, for fifteen students the past Winter term. E. S. Kenney followed up with the NucE. 502C laboratory course during the Spring Term 1979 for eight students. Both NucE. 502 courses received extensive cooperation from the PSBR operating staff.

An elective nuclear engineering course which was designed to give the student an opportunity to correlate class room theory with actual reactor operation situations controlled by the student was offered a number of times this past year. The NucE. 444 course, Nuclear Reactor Operations Laboratory, was offered during Summer 1978, Fall 1978 and Spring 1979 Terms for 31 students by J. L. Penkala. Each student performed a minimum of ten reactor startups while logging approximately 30 hours of operating experience at the PSBR control console.

Two industrial training programs were provided for 12 reactor operator license candidates for the Pennsylvania Power and Light Company and

Cincinnati Gas and Electric Company. The entire senior reactor operating staff participated in these industrial training programs.

Through funding provided by DOE, the PSBR is cooperating with other colleges and universities in a reactor sharing program. This past reporting period, groups of students from Bucknell University, the University of Pittsburgh, Villanova University, Alliance College, and The Hazleton Campus of Penn State University were allowed to use the PSBR for experiments after appropriate background material was presented. Fifty-four students and their instructors were schooled in some of the basic reactor experiments in nuclear engineering. J. L. Penkala administered the reactor sharing program and executed the pedagogical duties with the four university groups this past year.

The PSBR and its operating staff continued to serve the nuclear engineering department in addition to other university departments and colleges in the following manner:

- Forty-seven of F. J. Remick's NucE 401 students were given a tour of the PSBR and a start-up and pulse demonstration.
- A number of G. E. Robinson's NucE 430 students were given the opportunity to schedule a 2 to 3 hour session on the console of the PSBR during which each student was supervised by a senior operator through a reactor start-up and pulse.
- The reactor was used for irradiation services and preparation of material for the eight students in K.K. S. Pillay's NucE 400/Chem 405 course.
- J. B. Nesbitt's C E 574 class used Mn-56 tracer material to determine the hydraulic characteristics of a model settling basin. Fourteen students were involved in this study.
- Three groups totaling approximately forty University Police Services personnel were given training/retraining sessions by R. C. Houtz at the PSBR to ensure familiarity with the facilities.
- A workshop (sponsored by Edinboro State College) was conducted for thirty-one high school students by J. L. Penkala.
- J. L. Penkala made the reactor and associated facilities available to twenty-four NucE 200 students during the Winter 1979 term.
- W. A. Jester conducted a workshop for twenty medical technicians from Harrisburg General Hospital at the PSBR.

With well over 125 man years of safe, reliable reactor operating experience, the staff of the PSBR is obviously fulfilling its obligation to "the general public" to disseminate information concerning the pros and cons, the do's and dont's, the how's and how not's of reactor operations, irradiation services, and understanding of nuclear energy in general and nuclear applications in particular through the spectrum of educational and training vehicles described in this report.

RADIONUCLEAR APPLICATIONS

LABORATORY

1841 170

V. RADIONUCLEAR APPLICATIONS LABORATORY

The staff of the Radionuclear Applications Laboratory during this year consisted of W. A. Jester, K. K. S. Pillay, and D. C. Raupach. Several of Jester's and Pillay's graduate students assisted in conducting one or more of the projects associated with the laboratory. The purpose of the laboratory is to provide consulting and technical assistance to University research personnel who wish to utilize some type of radionuclear technique in their work. While the bulk of these projects involve some type of neutron activation analysis procedure, the staff is prepared to provide services in such areas as nuclear medicine, radioactive tracer techniques, radiation gauging and radiation processing; in fact, they have provided services in these and other fields in the past.

This year has shown a considerable growth in the number of industrial customers who are now using the services of this laboratory or are considering future use of these services. One important industrial service was provided to the Hershey Food Corporation as a result of the Three Mile Island incident. The laboratory was asked to analyze many samples of their products, collected at various production stages, for the presence of any radioactive fission products.

The two-day annual activation analysis workshop held on March 1, 2, 1979 was organized by D. C. Raupach. The purpose of this workshop is to instruct University research personnel in the use of activation analysis and non-radioactive but neutron activatable tracers as research tools. S. H. Levine and W. A. Jester, of the Nuclear Engineering Department, and R. W. Granlund, University Health Physicist, assisted by D. C. Raupach, conducted the workshop. A total of 17 researchers were in attendance.

In terms of new facilities, advanced planning is underway to set up a laboratory for the detection of low levels of radioactivity in drinking water. When completed and certified by the Environmental Protection Agency (EPA), this will be one of only two or three throughout the State that will be able to provide these services, which are now required by all municipal water companies under the Safe Drinking Water Act (P 673-523). It is anticipated that the laboratory will be made operational and receive EPA certification during this coming year.

FACILITY RESEARCH UTILIZATION

173

VI. FACILITY RESEARCH UTILIZATION

Research continues to utilize the major portion of the available operation time of the reactor and the Cobalt-60 Facility. A wide variety of research projects are currently in progress as indicated on the following pages. For convenience, the University oriented research projects are arranged alphabetically by departments under the various colleges. Theses, publications and papers follow the research descriptions to which they pertain. In addition, a section is provided with examples of industrial research utilizing the facility.

The facility continues to serve as a research tool available to all faculty staff and graduate students of the various departments and colleges within the University. Sixty-four faculty and staff members and forty-two graduate students have used the facility in the past year for research. This represents a usage by twenty-nine different departments or sections in seven colleges of the University. Names of the individual users are arranged alphabetically under their departmental and college affiliations in Appendix A.

The following list of current research projects (arranged in alphabetical order using author's names) indicates the broad utilization enjoyed by the Breazeale Reactor Facility. The fifty projects described involve one batchelor's thesis, twenty master's theses, ten doctoral theses, fifteen publications and four papers. The examples cited are not to be construed as publications or announcements of research. The publication of research utilizing the facility is the prerogative of the researcher.

A. University Research Utilizing the Facilities of the Penn State Breazeale Nuclear Reactor

COLLEGE OF AGRICULTURE

Agronomy Department

Chemical and Microbiological Monitoring with Nutritional Bio Assay of Land Disposal of Sewage Sludge as it Affects Crop Production and Mineral Elements in the Food Chain

D. E. Baker
D. M. Jones

Activation Analysis was performed on sewage sludge samples to test validity of other methods for determining mercury. The determination was part of a thesis problem to test soils and soil-sludge mixtures for the availability of mercury.

Dairy and Animal Science Department

Rare Earth Markers for Animal Digestion Tracers

E. J. DePeters

This research involves rare earth markers such as samarium, lanthium, and dysprosium. There is presently an increasing interest in using these markers in animal research, particularly ruminant. These elements are not absorbed by the animal and appear to be strongly adsorbed onto feed particulate matter as it passes through the digestive tract of the animal. They have been used in rate of passage studies and digestion trials in the literature. Studies as these require much effort when using dairy or beef animals. Total collection of feces is difficult and time consuming, and there are presently few inert markers available which meet the criteria needed. The rare earth elements offer an alternative.

The object of this research is to determine the feasibility of using samarium to calculate the digestibility of various feeds for a future thesis research project. Thus far, the standard collection methods and calculations have been conducted and will be compared to the results obtained from the samarium data.

Food Science Department

Effects of Physical Treatment on Mirex and Kepone Residues in Brown Trout

M. Kroger
D. A. Cin

Brown trout taken from Spring Creek, Centre County, PA, are contaminated with two chlorinated hydrocarbon pesticides, Kepone ($\bar{x}$ = 0.116 ppm) and Mirex ($\bar{x}$ = 0.468 ppm). As part of the project, minced fish tissue was and will be exposed to gamma radiation (1,3 and 5 mrad). In previous work elsewhere it was shown that gamma radiation was capable of degrading some of the mirex in chicken eggs. In our preliminary experiments some of the mirex in the fish tissue has also been broken down by the Co-60 gamma radiation.

Food Science Department

Master's Paper

"Effects of Physical Treatment on Mirex and Kepone Residues in Brown Trout," D. A. Cin, 1979, M. Kroger, advisor.

Plant Pathology Department

Biology and Taxonomy of the Genue *Fusarium*

P. E. Nelson
N. L. Fisher

Fusarium species grow well in artificial culture on a medium consisting of 2% water agar and small pieces of carnation leaves (3-6 mm^2). In order to get the best possible growth of the fungi the carnation leaf pieces must be sterilized by a method that leaves the nutrients in the leaf intact. This can be done by cold sterilization with propylene oxide or with gamma radiation from Co-60. The latter method is by far the most satisfactory. Irradiated carnation leaf pieces serve as an important ingredient in the medium used in all of our research on *Fusarium* species.

Master's Theses

"Histopathology of Chrysanthemum, Cultivar Yellow Delaware, Infected with *Fusarium Oxysporum* f. sp. Chrysanthemi", G. Emberger, 1978, P. E. Nelson, advisor.

"Histopathology of the Tolerant Chrysanthemum, Cultivar Mandalay, Infected with *Fusarium Oxysporum* f. sp. Chrysanthemi", B. Steuhling, 1980, P. E. Nelson, advisor.

Veterinary Science Department

The Cells and Secretions of the Bovine Mammary Gland During the Early Dry Period and Their Relationship to Incidence of New Infection

R. J. Eberhart
G. J. Patronek

The phagocytic cells (neutrophils and macrophages) present in the bovine udder are an important part of the anti-bacterial defense mechanisms operating within the gland. Udder infections are collectively referred to as "Mastitis"; mastitis is a very serious problem for the dairy industry due to the deleterious effect on milk production and the general health of the animals. However, attempts to eliminate the condition in herds of dairy cattle have not been effective. Previous research has shown that phagocytic cells obtained from different cows vary in their ability to kill and ingest bacteria. It is the hypothesis of this study that observed differences in phagocytic ability of cells from different cows might be related to incidence of new infection.

Staphylococcus Aureus was used as a test particle for phagocytosis in this study. In order to use this bacteria, it was necessary to prevent the organisms from duplicating without destroying their structural integrity. This was accomplished using 2×10^5 rads of Co-60 radiation.

Veterinary Science Department

Master's Thesis

"The Cells and Secretions of the Bovine Mannary Gland During the Early Dry Period and Their Relationship to Incidence of New Infection," G. J. Patronek, 1979, R. J. Eberhart, advisor.

Maternal Immunocompetence: In Vitro and In Vivo Analysis

F. Ferguson
F. L. Confer
P. Gambel

During pregnancy reproducible alterations occur in the maternal lymphoid organs including thymic involution and splenic enlargement. Since the effect of naturally occurring pregnancy-induced thymic involution has not been fully examined, studies in this lab compare the functional activities of maternal lymphoid cells at specific times during gestation, lactation, and post-weaning. Changes in the maternal immunological network, particularly T cell function, may be important to the survival of the conceptus and may reflect maternal susceptibility to certain disease processes.

Assay systems include the mixed-leukocycle reaction (MLR) and cell-mediated lympholysis (CML) generated from MLR. These systems measure the proliferative and the effector phases of the immune response. In either case, lymphoid cells under investigation serve as responder cells which, in turn, are incubated with stimulator cells which have been irradiated (2000 rads). Irradiation serves to prevent DNA replication and retain the antigenicity of the stimulator cells thereby making the system undirectional. In addition, F1 hybrid mice are irradiated (900 rads) to provide an In Vivo system analogous to the MLR→CML assay.

Changes in Immunological Activity of Lymph Nodes During Pregnancy

F. Ferguson
C. Drozdowics

In outbred mammalian populations, a significant immunologic contradiction exists during pregnancy. A genetically dissimilar conceptus survives in the uterus of a mother, but almost invariably fails to invoke conventional immunologic rejection phenomenon.

Regional lymph nodes draining the uterus often are enlarged as a result of pregnancy. Although this is suggestive of an immune response, immune capabilities of the draining lymph nodes or peripheral lymph nodes have not been fully evaluated during gestation, lactation, or post-weaning.

In this research, gamma irradiation was used in a manner similar to that in the previous report for evaluation of lymph node cells.

Veterinary Science Department

Distribution of Cr-51 Labelled E. Coli Following Intratracheal Immunization

A. Zarkower
M. L. Eskew
W. J. Scheuchenzuber

Mice exposed to particulates (e.g. silica, fly ash) show a decreased antibody response following aerosol immunization with dried E. coli. In order to examine the distribution of E. coli following introduction into the lung, bacteria were labelled with Cr-51 and exposed to 2×10^5 rads from a Co-60 source to prevent replication. The bacteria were injected intra-tracheally and 5 days later organs were removed for gamma counting and evidence of antibody formation.

Immune Response of Swine During Pregnancy and Lactation

A. Zarkower
J. M. Ritchie

Pig white blood cells from a Duroc boar and a Yorkshire sow are mixed in culture. The immunological reaction of the sow's white blood cells to the foreign boar's cells is measured. In order to prevent the boar's reaction against the foreign sow's cells, the boar's cells are exposed to 3×10^3 rads from a Co-60 source so that the cells are living but can no longer proliferate.

This procedure is to be done during the sow's estrus cycle, pregnancy, and the beginning of lactation. We are currently studying the sow's cell reactions during her estrus cycle.

Studies to Determine the Toxicity of Olivine Inhalation

A. Zarkower
W. J. Scheuchenzuber
M. L. Eskew

Olivine sand is proposed as a low toxicity substitute for the silica sand used in foundry operations. This project measures the effect of the inhalation of olivine and silica dusts on immunological functions using a murine model. A variety of tests are used which measure effects on both antibody producing and cellular immune responses. One of the tests used is the mixed lymphocyte reaction, in which lymphocytes from experimental animals are combined in culture with inactivated lymphocytes from allogeneic animals. The procedure corresponds somewhat to an <u>in vitro</u> test of graft rejection. The inactivated lymphocytes are produced by irradiation at the Co-60 facility.

COLLEGE OF EARTH AND MINERAL SCIENCES

Ceramic Science Department

NSF A15 Growth DMR78-10054 NSF Grant

K. E. Spear
C. F. Wan

Neutron activation analysis was utilized for qualitative and quantitative analysis of chemical vapor deposited (CVD) samples as part of the characterization of their superconducting properties as well as analysis of the CVD process itself.

Doctoral Thesis

"Chemical Vapor Deposition of Nb_3Ge," C. F. Wan, 1979, Metallurgy, Material Sciences Department, K. E. Spear, advisor.

Geosciences Department

Geochemical Exploration for Sandstone-Type Uranium Deposits

A. W. Rose
M. L. Keith
L. J. Pilione
C. Bell
P. M. Tole

We are testing for the existence and nature of weak uranium and thorium anomalies in sedimentary rock in the region near uranium deposits, using analyses of the rocks and of small amounts of the mineral zircon separated from the rocks. The delayed neutron activation equipment is used to carry out the analyses for the U and Th.

Doctoral Thesis

"Uranium and Other Elements in the Catskill Formation of East-Central Pennsylvania," S. Pirc, 1979, Geochemistry Graduate Program, A. W. Rose, advisor.

Master's Theses

"Geology and Geochemistry of Uranium Deposits near Beaver Lake, Sullivan County, Pennsylvania," D. L. Mahar, 1978, Geochemistry Graduate Program, A. W. Rose, advisor.

"Uranium and Other Elements in Shales and Sandstones from Pennsylvania and Colorado," C. Bell, 1979, Geochemistry, A. W. Rose, advisor.

"Uranium and Thorium in Zircon from Pennsylvania as a Guide to Uranium Provinces," P. M. Tole, 1979, Geochemistry, A. W. Rose, advisor.

"Regional Geochemical Anomolies Associated with Sedimentry Uranium Deposits," C. Bell, 1979, A. W. Rose, advisor.

Geosciences Department

Radium and Other Uranium Decay Products as a Guide to Uranium Ore

A. W. Rose
L. J. Pilione
E. R. Karasevich

The natural movement of radium, radon, and other uranium decay products away from uranium ore is poorly understood, but it appears that iron oxides formed by weathering may immobilize many of the decay products. Iron oxides from a variety of localities are being analyzed to determine which elements are concentrated in them and whether they are a guide to uranium ore. Solutions are being analyzed for uranium by counting fission tracks in plastic film after irradiation with thermal neutrons.

Master's Thesis

"Radium and Other Uranium Decay Products in Limonite as a Guide to Uranium Ore," E. R. Karasevich, 1979, Geology Graduate Program, A. W. Rose, advisor.

Coal

W. Spackman
N. H. Suhr

The reactor is being used as an aide in determining the amount of uranium in various coal samples from throughout the U.S.

The coal samples are packed into polyethylene vials which are then loaded into polyethylene capsules ("rabbits") and sent into the reactor's D_2O tank by a pneumatic system. The D_2O tank acts to slow down the fast and epithermal neutrons in the reactor so that only thermal neutrons are radiating the sample. The neutron flux is about 1.3×10^{11} neutron/cm^2-sec.

After a minute, the rabbit is returned from the D_2O tank and positioned in a BF_3 detector where, after a 5 second delay time, the neutron decay is measured. By comparing the amount of neutrons from the sample to the quantity given off by known standards, it is possible to obtain a U concentration for the sample.

Materials Science and Engineering Department

The Effect of Mass Perturbations on the Longitudinal Accoustical Mode of Polymers.

I. R. Harrison
J. P. Runt

Polyethylene (PE) single crystals possess a lamallae-like, chain-folded structure. These lamallae contain two phases: a central crystalline core sandwiched between top and bottom amorphous surfaces. The surface layers are thought to consist of chain folds (primarily) and cilia. The longitudinal accoustic (LA) mode found in Raman spectra of these crystals can potentially provide structural information. The LA peak frequency can be related to the crystalline core thickness and, if coupled with knowledge of the

total lamalla thickness, one can obtain an estimate of the size of the amorphous layers. However, it has been postulated that mass perturbations (i.e., the presence of surface groups) can significantly effect the observed LA mode frequency. In order to check this, various amounts of bromine were chemically attached to the folds. The bromine concentration was determined by neutron activation analysis. The LA mode of each of the reacted samples was obtained and compared to that of the unreacted crystals. Peak shifts were indeed observed, especially at high bromine concentration. These experiments therefore qualitatively confirm the theoretical predictions. Further work on the effect of surface modification on LA mode of PE single crystals is presently being conducted.

Doctoral Thesis

"On the structure of Polyethylene Single Crystals," J. P. Runt, 1979, I. R. Harrison, advisor.

Publications

"The Effect of Mass Perturbations on the LA mode in Polymers: Surface Bromination of Polyethylene Crystals," J. Macromol. Sci.,: Physics, submitted for publication, 1979, J. Runt, W. Varnell, J. T. Wang, and I. R. Harrison.

"The Effect of Surface Modification on the LA Mode of Polyethylene Crystals," presented at the Chicago Meeting of the American Physics Society, March 1979, J. Runt.

Mineral Engineering Department

The Influence of Point Defects on Flotation Systems

F. F. Aplan
G. Simkovich
E. Y. Spearin

Gamma radiation is known to change the color of florite (CaF_2) from white to purple by the creation of F centers (an electron occupying an anionic site). We have also found that such radiation and color change controls the point-of-zero charge (PZC) of fluorite in solution and the flotation properties of the mineral.

White fluorite has a PZC at pCa $\sim$ 4, i.e., it is positively charged in solutions of 10^{-4} M/L or greater and negative in solutions more dilute. Fluorite irradiated several hours with a strong γ source (Co-60) not only becomes purple but is positively charged at all pCa levels.

Doctoral Thesis

"The Influence of Point Defects on Flotation Systems," E. Y. Spearin, 1979, F. F. Aplan and G. Simkovich, co-advisors.

Mineral Processing Department

A Study of the Breakage of Coals in the Hardgrove Machine

L. G. Austin
P. T. Luckie
J. Shah

In studies of the breakage rates of material in grinding mills a major problem is to investigate the breakage of a small size in the mixture of sizes in the mill. It is not possible to distinguish between particles of a given size which were present in the mill feed from particles of that size produced by breakage of larger sizes. This problem was overcome by making a fraction of a given size in the feed radioactive. After grinding, a radiation count on each size fraction enables the rate of breakage and the primary daughter fragment distribution of the irradiated size to be calculated. By irradiating fine material (minus 10μm), grinding, and counting larger size fractions it was shown that fine particles do not agglomerate or pelletize into larger pieces.

This work was, of course, only a small part of a large program investigating grinding in laboratory and pilot plant mills.

Master's Thesis

"A Study of the Breakage of Coals in the Hardgrove Machine," J. Shah, 1979, L. G. Austin, advisor.

COLLEGE OF ENGINEERING

Chemical Engineering Department

The Behavior of Carbon-Supported Metals as CO Hydrogenation Catalysts

M. A. Vannice
H. J. Jung

The catalytic properties of carbon-supported iron are being determined in the CO-H_2 synthesis reaction. The reactor was used to measure Fe metal loadings by neutron activation analysis.

Doctoral Thesis

"The Behavior of Carbon-Supported Metals as CO Hydrogenation Catalysts," H. J. Jung, 1980, M. A. Vannice, advisor.

The Effect of Preparation Variables on the Dispersion of Supported Platinum Catalysts

M. A. Vannice
M. B. Palmer, Jr.

This research involved the use of chemisorption and x-ray techniques to determine platinum crystallite sizes in different catalysts. The reactor was used to measure platinum metal loading via neutron activation analysis.

Master's Thesis

"The Effect of Preparation Variables on the Dispersion of Supported Platinum Catalysts", M. B. Palmer, Jr., 1979, M. A. Vannice, advisor.

Nuclear Engineering Department

Development of 7-Channel Dynamic Radiograph Guidance System

A. M. Jacobs
D. Atkinson

The directional and positional control systems for the third generation dynamic radiograph system for cardiac performance interrogation are currently under development. The new 7-channel device should prove to be clincally useful for studying ischemic heart disease.

Master's Thesis

"Guidance System for Dynamic Radiograph System," D. Atkinson, 1980, Bioengineering Program, A. M. Jacobs, advisor.

Transit Time Transaxial Tomography

A. M. Jacobs
S. A. Dansky

The general new dynamic imaging technique of transit time transaxial tomography can be used as a non intrusive method for obtaining a self calibrated measurement of fluid flow velocity profiles in an enclosed channel. The technique can be adapted to the coolant flow loop of a PWR using N-16 as the flow information carrier. In this proof-of-principle

effort an external flow loop using reactor coolant N-16 was designed, constructed and used to verify the 4T idea.

Master's Paper

"Fluid Velocity Profile Measurement by Transit Time Transaxial Tomography," S. A. Dansky, 1978, A. M. Jacobs, advisor.

Paper

"Non Intrusive Transaxial Tomography Technique for Velocity Profile Measurement," SPIE Technical Symposium, 1979, A. M. Jacobs.

Fast Mechanical X-Ray Scanner

A. M. Jacobs
G. McGruer

X-ray backscatter imaging of moving internals of opague objects is greatly facilitated by a fast mechanical scanning capability. This project resulted in the development of a fast x-ray line scanner which when coupled to a multichannel detection system could yield 1 cm^2 resolution at about 1 cycle per second.

Batchelor's Thesis

"Mechanical Scanning Backscatter X-Ray System," G. McGruer, 1979, Engineering Science and Mechanics Department, A. M. Jacobs, advisor.

X-Ray Backscatter Radiography

A. M. Jacobs
B. C. Towe

X-ray backscatter radiography employs the field of radiation scattered by the internals of an object to obtain an image of the internal configurations. A beam of desired image resolution diameter is raster scanned over the object and the maximum possible fraction of the scattered field is sensed. Scanning is accomplished either by mechanical movement of the object or by electronically steering an electron beam in the x-ray generator. Varying x-ray energy allows tomographic capabilities.

Doctoral Thesis

"X-Ray Backscatter Imaging," B. C. Towe, 1979, Bioengineering Program, A. M. Jacobs, advisor.

A Comparison of Three Groundwater Tracers: the Use of Bromide, Iodide, and Chloride Ions in Soil and Fracture-Rich Systems with Post-Sampling Neutron Activation Analysis

W. A. Jester
W. R. Heald
J. B. Urban
F. G. Haaser

Three different segments of the groundwater system of the Mahantango Creek watershed, located near Klingerstown, Pennsylvania, have been studied

using one or more nonradioactive but neutron activatable tracers. These systems include the deep groundwater system, the deep perched groundwater system, and a shallow soil system. Tracer breakthrough curves have been generated for 20 different sampling wells located at the study site. These curves have been used to determine groundwater velocities and hydraulic conductivities in these three systems. These results have been compared with the values obtained by the Auger Hole method employed at each well site.

Master's Thesis

"A Comparison of Three Groundwater Tracers in Soil and Fractured Rock Systems," F. G. Haaser, June 1979, W. A. Jester, advisor.

Publication

"Tracing Underground Water Movements Using Three NAA Detected Halogen Tracers," Transactions of the American Nuclear Society, Vol. 30, pp. 114-115 (1978), F. G. Haaser, W. A. Jester and W. R. Heald.

Evaluating Soil Macro-Pore Systems From Tracer Breakthrough Curves

W. A. Jester
A. R. Jarrett
J. S. Brenizer

Several low level radioactive waste disposal sites have had problems with movement of radionuclides into environmental monitoring wells. The velocities observed were much faster than predicted by theoretical models based on laboratory determined parameters. The faster unpredicted velocities may be due to errors in the experimental procedures used to determine the site characteristic parameters. However, in many cases, field data obtained when tracers were utilized indicates that groundwater movement may be a factor of ten times more rapid than predicted. This implies that pathways exist which allow very rapid movement of the subsurface water and corresponding transported radionuclides.

Several of the recent papers in the soils literature have concluded that, in many cases, there exists a dual-pored system in the soil. The first system is comprised of interped voids which promote flow according to classical Darcy theory. The other is comprised of cracks and fissures which are not included in most steady-state uniform flow models.

Thus, the major problem in predicting subsurface water movement appears to be not the flow through a homogeneous porous media but the channeling of this water through imperfections in the soil such as cracks, fissures, sand lenses, etc., which allow the water to flow more easily through the soil and reach the water table much more quickly than would otherwise be possible.

Over the last eleven years, Dr. W. A. Jester and his colleagues have been developing techniques for using nonradioactive but neutron activatable tracers for studying the movement of surface and groundwaters. When using neutron activatable tracers to follow subsurface water flow through a fractured media, breakthrough curves with detailed structure are obtained. The structure of the breakthrough curve seems to indicate various pathways available in the media for subsurface water flow. Unfortunately, to this

date no extensive studies have been made on the various factors which affect the shape of breakthrough curves and the modeling based on this technique is still quite crude.

In order to better determine the relation between the structure observed with the activatable tracer breakthrough curves and the pathways available for subsurface water flow, a laboratory experiment has been initiated. The experiment will involve a large soil column (0.91 meters in diameter by 1.524 meters high) through which groundwater tagged with a radioactive tracer (bromine-82 with a 35.34 hr. half-life) flows. Water will be pumped from the bottom of the column and the tracer activity of the outflow measured to determine the breakthrough curves. By examining the resulting breakthrough curves and analyzing their structure, an attempt will be made to correlate the various types of structure with the non-homogeneities introduced into the system. In addition, an overall effective permeability for each of the various sand distributions will be calculated and, when used with several computer flow models, predictions of tracer arrival times will be made.

The reactor facility will be used both in the making of the bromine-82 tracer and in the counting of the activity breakthrough curves.

Doctoral Thesis

"Evaluating Soil Macro-Pore Systems From Tracer Breakthrough Curves," J. S. Brenizer, 1980, W. A. Jester, advisor.

An Investigation of Simultaneous Bromide and Chloride Ion Movement Through Soils

W. A. Jester
A. R. Jarrett
J. S. Brenizer
S. Morrison

Techniques have been developed for using nonradioactive but neutron activatable tracers for studying the movement of surface and groundwaters. During the course of these studies, the best water tracers have been found to be the halogen ions, with the best of these being the bromide and chloride ions. In a U.S. Geological study at the Amaragosa tracer study site, the bromide ion and tritium tracers gave the same breakthrough curves.

Dr. Jester's work to date has indicated that both the chloride and bromide ions move with the groundwater. However, a recent paper* indicated that while the chloride ion moved with the groundwater, the bromide ion was sorbed. Thus, the object of this study is to investigate the simultaneous movement of the bromide and chloride ions through several soils, using the procedures described in this paper. A soil column was constructed in the reactor machine shop and set-up in a laboratory room in the reactor facility. The short half-life of the chlorine necessitated the use of activatable tracers. The soil column effluent samples were irradiated us-

*"Use of Baker's Yeast to Trace Microbial Movement in Groundwater", Groundwater, Vol. 16, No. 6, pp. 398-403, 1978, W. W. Wood and G. G. Ehrlich.

ing the reactor pneumatic transfer system. The gamma spectrums were then analyzed to determine the concentrations of the bromide and chloride ions.

The results thus far show that under simulated field conditions (i.e., using groundwater and untreated soils), the bromide and chloride ions move simultaneously through soils with the groundwater over the pH range expected to be encountered under natural conditions.

Minimization of Groundwater Contamination in Surface Mine Backfills

W. A. Jester
D. C. Raupach
L. B. Phelps
J. S. Brenizer

The object of this project is to develop backfill methods for strip mining which will cause minimum contamination to reconstructed groundwater systems after mining. The laboratory phase of the study will examine the permeability of certain strip mining spoil materials which might be used as acquicludes and therefore be selectively placed to encompass toxic spoiled materials.

The bromide ion water tracer technique developed by Dr. Jester will be employed to evaluate the success of these materials in preventing the toxic materials from coming in contact with groundwater.

Doctoral Thesis

"Minimization of Groundwater Contamination in Surface Mine Backfills," L. B. Phelps, 1981, Department of Mineral Engineering, L. W. Saperstein, advisor.

Determination of Arsenic Content in Fresh Water Fish Samples

W. A. Jester
D. R. Raupach
K. K. S. Pillay
G. M. Comparetto

Penn State University was contracted by Pennsylvania Power and Light Company to determine the arsenic content in 29 fish samples. The method used was that one developed by K. K. S. Pillay involving a radiochemical separation and distillation procedures. We are now in the process of researching new and different methods which may either be quicker or yield a greater amount of information in toxic elements on fish and aquatic vegetation.

Master's Thesis

"Activation Analysis for Toxic Elements in Fish and Aquatic Vegetation," G. M. Comparetto, 1980, W. A. Jester, advisor.

Report

"Neutron Analysis for Arsenic in 29 Biological Samples" Final Report Submitted to PP&L by W. A. Jester, D. C. Raupach, and G. M. Comparetto.

Nuclear Engineering Department

Analysis of Food Samples for Fission Products

W. A. Jester
K. K. S. Pillay
D. C. Raupach
C. Y. Wong

As a result of the Three Mile Island incident, Hershey Foods Corporation sent a series of food samples collected at various processing stages of their products to be analyzed for the presence of fission products. Liquid scintillation counting was performed on about 100 milk samples while gamma ray spectroscopy was performed on 20 composite food samples. No significant amount of fission products were detected in any of these samples above background conditions.

Establishment of a Radiological Laboratory for the Monitoring of Drinking Water for Low Level Radioactivity

W. A. Jester
D. C. Raupach
S. Trivellas

The safe drinking water act (P.L. 93-523) requires that all municipal water supply companies have their water monitored quarterly for radioactivity as well as for other potentially toxic constituents. For the last year work has been undertaken to establish a radiological laboratory as part of the radionuclear applications laboratory which could provide these services to Pennsylvania water utilities. This laboratory will be one of only two or three in the state which will have the ability to perform these analyses. Work has proceeded in the setting up and calibration of a low background alpha-beta detection instrument. The laboratory furniture has been purchased and will be installed shortly. It is anticipated that within the next year EPA certification will be obtained so that the water monitoring services can be offered to Pennsylvania water utilities.

Fast Neutron Oxygen Analysis of Silicon Carbide and Silicon Nitride

W. A. Jester
D. C. Raupach
R. E. Tressler
K. McHenry
J. Wallace
A. R. Kahveci

An oxygen analysis capability was established using the pool side fast pneumatic transfer system. Oxygen is analyzed by the O-16(n,p)N-16 reaction. Calibration was accomplished using chemical compounds having known oxygen content. A technique was developed to analyze for oxygen down to the 1% level. A series of silicon carbide and silicon nitride samples were then analyzed for their oxygen content. Work is continuing to improve the sensitivity and accuracy of this technique.

Nuclear Engineering Department

Evaluation of Eberline PING-2 Iodine Monitor

W. A. Jester
J. Wallace

The ability of commercial airborne radio iodine detectors varies with the chemical form of the iodine and the hunidity of the air being sampled. Iodine-128 labeled I_2 and CH_3I were prepared from reactor-irradiated ammonium iodide crystals. Amounts of I-128 were determined by counting as a point source in a calibrated Ge(Li) multichannel analyzer system. The I_2 or CH_3I thus prepared was introduced into a controlled humidity air sample stream of the commercial detector. Variations in detector efficiency and filter breakthrough were then determined as a function of chemical form and air humidity.

Master's Thesis

"A Method of Evaluation of Commercial Airborne Radioiodine Detectors," J. H. Wallace, 1979, W. A. Jester, advisor.

Multipoint Thermometry Using "Johnson Noise"

E. S. Kenney
C. Charlier

With a view towards reactor application, a multipoint Johnson Noise thermometer has been designed and constructed based upon a tuned RLC circuit sensor system. The concept examined allows bandpass selection of a given sensor's temperature by measuring the noise in frequency increments characteristic of the pre-tuned resonant ranges of the sensors. Aside from the expected advantage of reading several sensors with a single amplifier, two other advantages were determined in the research. Specifically, the resistor ohmic value could be substantially reduced by proper impedance matching in the input sensor circuit. Also, the resistor value changes normally associated with temperature variation and aging were nearly eliminated in their effect on output noise values.

The reactor facility provided the base from which the idea was evolved. That is, examining temperature measuring requirements in reactors led to the development of this concept. The ideal temperature system would be able to scan down each fuel element and record temperature continuously with a minimum number of sensor leads going to the core.

Master's Thesis

"Multipoint Thermometry Using Bandpass Selected Johnson Noise," C. Charlier, 1979, E. S. Kenney, advisor.

Application of High Speed Plastic Phosphors to the Development of a Beta-Gamma Imaging Camera

E. S. Kenney
S. Pandey

A scintillation camera using fast plastic scintillators has been built as a high-speed, two-dimensional, position-sensitive detector for both weakly and strongly ionizing radiation. The experimental model is similar to an

[redacted]

Anger camera but capable of achieving counting rates of more than 1 MHz. This increase in speed was achieved through the use of plastic scintillators, instead of the conventional sodium-iodide crystals, and high-speed electronic circuitry.

Two detectors were examined. In the first, a single thick plastic scintillator, loaded with lead to increase the photon detection efficiency, was employed for photon imaging, as in an Anger camera. In the second, a beta/alpha scintillation camera using a pure plastic phosphor was employed as a test device for possible extension to a converter screen. In the converter screen, a weakly ionizing radiation like a neutron or a photon is first converted to a strongly ionizing radiation such as a beta or an alpha particle. The resulting radiation is then detected in the beta/alpha scintillation camera. The advantage of the converter screen is that it can be used for both neutron and photon imaging. The converter screen thereby overcomes the low detection efficiency of plastic scintillators in such imaging work.

Conventional electronic amplifiers were not suitable for highspeed work in the MHz frequency range. It was therefore necessary to design the preamplifier and amplifier circuits used in this research. The design of the amplifiers was based on the use of operational amplifiers because of their low cost and the ease of their use in circuit design. Flat frequency response up to 3 MHz and good linearity of gain were achieved by proper selection of wide-band operational amplifiers and their associated components.

The results obtained with the beta/alpha scintillation camera were found very encouraging. Inherent resolution of better than 7 mm for P-32 sources (average beta energy of 694 kev) has been demonstrated. This resolution is comparable to presently available scintillation cameras. The detection sensitivity for P-32 beta particles was ~13% with a 5.38 mg/cm^2 detector window. However, the resolution in the Anger camera mode for gamma photons was not as good as expected.

In this scintillation camera work, the reactor provided radioisotope sources by direct irradiation and from the stock of calibration sources. Electronic shop facilities as well as machine shop work and other logistical support was provided.

Doctoral Thesis

"A Study of Plastic Phosphors in the Development of a High Speed Scintillation Camera" S. Pandey, 1978, E. S. Kenney, advisor.

Publication

"A High-Speed Scintillation Camera Using Plastic Phosphors," ANS Transactions, Vol. 30, pp. 145-146, November 1978, S. Pandey and E. S. Kenney.

Nuclear Engineering Department

Fuel Management of the PSBR

S. H. Levine
R. E. Totenbier
A. T. Ali

The simple analytical program TRICOM/SCRAM, has been slightly modified and used to study the depletion of fuel elements and the core performance characteristics, i.e., k_{eff} and normalized power, as a function of core operation. The results provide, among other useful data, a complete listing of the burnup and position of each TRIGA fuel element.

Gamma Dose Measurements in the TRIGA Core by Plastic Detectors

L. J. Pilione
K. K. S. Pillay
R. C. Houtz

Gamma dose measurements are of great significance to many applications and research work involving radiation-induced processes. Gamma irradiation facilities at The Pennsylvania State University are routinely used for research work in Biological Sciences, Medical Science and Radiation Process Chemistry. While intense sources of Co-60 are generally used as gamma sources, there are many applications in which a research reactor in the shut-down mode could be readily used for providing high gamma doses. The need for a more reliable means of gamma dose measurements has prompted us to utilize a technique employing optical density changes in plastic film, recently developed at the National Bureau of Standards for the measurement of gamma doses in the range of 1-25 M Rads.

The technique uses "Cronar" graphic film 7 mil (0.1778mm) thick as the detector. One of the advantages of this technique is that it allows the use of detectors cut into various sizes and shapes and can be isolated from the environment by proper packaging.

Paper

"Gamma Dose Measurements in the TRIGA Core by Plastic Detectors," (To be presented), 1979 ANS Conference on Reactor Operating Experience, Arlington, Texas, August 6-8, R. C. Houtz.

Examination of the Coagulation of Boron in a Fuel Storage Pool at a Reactor Facility

K. K. S. Pillay

At the request of a manufacturer of fuel storage racks this problem was examined using neutron activation analysis. The cause of the problem was identified as due to the inadvertant incorporation of a cleaning agent used in metal surface preparation. It is recognized that this problem can be eliminated by better quality control and good housekeeping practices. This recommendation was given to the manufacturer.

Nuclear Engineering Department

Examination of Milk and Milk Products for I-131

K. K. S. Pillay

After the Three Mile Island incident various food processors approached Penn State for radioanalytical services. Where possible these services were provided. One such large effort was to examine about sixty five milk samples for Iodine-131. A few samples of milk found to contain traces of Iodine-131 was used as the basis for action to prevent contaminated milk from reaching the consumers. As part of this effort, milk collected from the University's cattle herds and a variety of farms in Centre County were continually examined during the emergency.

An Overview of DOE's Technology Development Programs for Nuclear Waste Management

K. K. S. Pillay

The U.S. Department of Energy has in recent years placed nuclear waste management programs in prominent status by the organization of an office of nuclear waste management. The division of waste products under this office is assigned the task of developing alternate technologies for the long-term management of various types of nuclear wastes generated both during defense production activities and in the commercial sector. As part of this effort, the present status of the technology development programs for the management of nuclear wastes were reviewed and a report was submitted to the Department of Energy. The report covers technology development activities for the low-level, high-level, airborne and transuranic wastes.

Publications

"An Analysis of DOE's Technology Development Programs for Nuclear Waste Management" (NE/ET-78-01), pp. 16, 1978, K. K. S. Pillay.

"Development of Alternate Waste Forms for the Long-Term Management of Commercial High-Level Nuclear Waste," A contribution to the GEIS for the long-term Management of Nuclear Waste, U.S. Department of Energy (1979), K. K. S. Pillay, Greg McCarthy, et. al.

The Establishment of Baseline Levels of Radioactive and Nonradioactive Wastes Associated with Uranium Mill Tailings

K. K. S. Pillay
R. C. Baldwin
J. Shillenn

Neutron activation analysis of tree rings from plants grown near a large uranium mill tailing dump in Salt Lake City, Utah are being examined for leachable materials migrating from these dumps. This program is now analyzing a variety of environmental samples collected from Utah.

Development of Electrochemical Methods for the Preconcentration of Low Level Water-borne Fission Products

K. K. S. Pillay
C. Jarvis

Nuclear Engineering Department

This is a continuation of the program to develop practical methods to quickly monitor low level radioactivities that are likely to be present in secondary effluents from nuclear power plants. During earlier investigations, it was demonstrated that although methods such as ion exchange and liquid-liquid extractions had greater efficiencies in extracting radionuclides from aqueous media, in the case of secondary cooling water containing very high concentrations of Ca and Mg salts, these methods had serious limitations. Various modifications of electrochemical methods were examined during this investigation. It seems that among these methods, an anodic dissolution and precipitation method showed considerable potentials. Various parameters are being optimized to maximize the recovery of various fission products and fuel residues in extremely low concentrations.

Neutron Activation and Dendrochronological Analysis of California Redwoods

K. K. S. Pillay
H. D. Knoble
J. Jempson

Earlier investigations at Penn State have demonstrated that certain tree specimens are capable of revealing pollution history around the tree via neutron activation analysis of trace elements within its tree rings. This concept was applied to some unique specimens of California redwood trees to determine the environmental levels of trace elements over the past 12 centuries. Through the courtesy of the California Parks and Recreation Department, we received three samples of freshly cut cross sections of redwood trees ranging in age from 500 to about 1250 years. These specimens were carefully dated via dendrochronological measurements. Samples from about one hundred carefully selected tree ring segments were extracted and subjected to multiple neutron activation and multiple counting using high resolution γ-ray spectrometry.

The results of these analyses are still being interpreted. It is however recognized that redwood trees are capable of keeping a pollution almanac and these results are being carefully analyzed and interpreted.

Master's Thesis

"Neutron Activation Analysis and Dendrochronological Measurements on California Redwoods," J. Jempson, 1979.

Investigations of the Trace Element Profiles in the Hair of Cancer Patients

K. K. S. Pillay
D. Lawrence
A. Lipton
S. P. Moo

In recent years, there has been considerable interest in the potential use of trace element data from human tissues for the detection and diagnosis of health problems. Because of the extensive investigations done at Penn State over the past several years on human hair, we undertook to

examine the trace element profiles of some of the cancer patients from the Hershey Medical Center of The Pennsylvania State University. At the present time, the results of these investigations are being carefully compared with data from normal population to determine whether there is a potential for using human hair trace element data for the early detection or diagnosis of cancer in humans.

Examination of the Physical Chemical and Radiochemical Characteristics of Boron Carbide Polymeric Composite Used in Fuel Storage

K. K. S. Pillay
M. H. MacMillan

Some of the characterization of a composite of boron carbide and phenolic resin used in lining fuel storage racks was undertaken in association with the Materials Research Laboratory of the PSU. This work is part of a major effort to study the long-term changes in this neutron absorber material by the manufacturer, Carbonundum, Inc. of Niagara Falls, New York.

K-Infinity Measurement Meter

M. A. Schultz
S. H. Levine
W. F. Witzig
H. O'Campo

The purpose of the project is to develop a method for measuring the k_∞ of spent fuel elements prior to placing them in a high density fuel element storage pool. Two objectives are being studied:

1) analytical development of a computer program to relate count rates in a subcritical configuration (k(eff) < .95) to the k_∞ of the fuel assembly and
2) verification of the analytical techniques by performing similar multiplication experiments with the Penn State TRIGA reactor.

The k_∞ measurements are based on the well known subcritical multiplication formula

$$CR = \frac{\alpha S}{1-k(eff)}$$

where

Cr = count rate from the detector output
S = neutron source emission rate
k(eff) = effective multiplication factor
α = factor which may depend on geometry, packing array, etc.

Some of the parameters in the above formula vary as a function of k_∞. Thus, it is necessary to establish a set of relations between the dependent parameters and k_∞. To prove the validity of these relationships, two subcritical experiments have been performed utilizing the Breazeale Nuclear Reactor.

The changes in k_∞ were achieved by interchanging 12 wt% and 8.5 wt% TRIGA fuel elements in the inner rings of the fuel arrays. Several arrays were arranged to simulate a typical power plant fuel array. The subcritical multiplication of a Cf-252 neutron source (located in the central

thimble) was measured at different positions at the periphery of the configuration. By this means the variation in k_∞, in a subcritical assembly similar to the one to be used in the spent fuel storage rack, with change in detector count rate can be measured and compared with the analytical techniques.

At the present the data obtained are being analyzed by using computer codes to emulate the physical behavior of neutrons in the given fuel configurations.

Master's Thesis

"Determination of the Shape of the Fission Neutron Flux Near a Reactor Core Through the Use of a Radiation Leakage Pipe and an External Detector," S. P. Meyer, 1978, M. A. Schultz, advisor.

Publications

"Obsidian Sources in Guatemala: A Regional Approach," American Antiquity, 43(3) 424-435 (1978) L. H. deMendoza and W. A. Jester.

"Neutron Activation Analysis of Contemporary Pottery and Pottery Materials from the Valley of Guatemala," The Ceramics of Kaminaljuyu, P.S.U. Press Monograph Series, 543-590 (1978), D. E. Arnold, P. M. Rice, and W. A. Jester, et. al.

"Tracing Underground Water Movements Using Three NAA Detected Halogen Tracers," Transactions of the American Nuclear Society, 30, 114-115 (1978), F. G. Haaser, W. A. Jester, and W. R. Heald.

"Physical Migration of Radioactive Material in Soil," Transactions of the American Nuclear Society, 31 (1979), A. R. Jarrett, W. A. Jester, and J. S. Brenizer.

"Activation Analysis of Tungsten in Al_2O_3 Using a D_2O Thermal Column," Transactions of the American Nuclear Society, 31 (1979), W. A. Jester, D. C. Raupach, I. B. McMaster, and D. Dube.

"Migration of Radioactive Material in Soil" (tutorial) American Nuclear Society Education Division Tutorial Publication-2 (ANS/ED/TP-2), 90 (1979) W. A. Jester (editor).

"Optimum Design of Subcritical Neutron Multipliers Using Cf-252 Neutron Sources," Accepted for publication in Nuclear Technology, B. Lee, S. H. Levine and W. A. Jester.

COLLEGE OF THE LIBERAL ARTS

Anthropology Department

Measuring Nutritional Stress in a Prehistoric American Population

J. W. Hatch
R. Geidel

Positions of status in societies organized according to ranked kinship groupings are known to be either ascribed by birthright or achieved during one's lifetime. Certain cultural anthropologists (notably Sahlins, 1972) have argued that the economic redistribution characteristics of such societies involves altruistic behavior among chiefs since, due to their lack of institutionalized power, they retain their positions at the discretion of the populace. Hatch and Willey (1974) have suggested that the relationship between tall adult stature and high status in the prehistoric Dallas society of eastern Tennessee is a function of better nutritional histories derived from the self-serving manipulation of food exchanges by chiefs.

In an archaeological setting, Hatch (1976) has shown that tangible symbols of status often accompany the deceased (in the form of elaborate tombs or rich grave offerings) and that a population of graves will manifest the network of status relationships once operating in the community. Traditionally, however, researchers have not investigated attributes of the skeletons themselves for clues to the fine structure of the social system and the impact of status on an individual's health and nutrition. This research proposes a three-pronged study of skeletal attributes known to be sensitive indicators of nutritional and disease histories in humans. With the previously researched social structural framework as a backdrop, it will outline the impact of social structure on individual relationships in Dallas society and test the notion of the altruistic chief.

The quantification of trace elements known to be sensitive indicators or either meat rich (Zn and Sr) or vegetable rich (Mg, Mn, and Cu) diets can be used to assess nutritional history (Brown, 1973; Gilbert, 1975). The levels of all elements except strontium should be positively correlated with the rank of the individual, reflecting as they do either protein or total caloric mal- or undernutrition. A high relative percentage of Zn or Sr will also be expected to vary with high rank, since meat rich diets are known to traditionally characterize elite households.

Samples of bone from 200 Dallas Culture burials are being analyzed to determine the relative percentage of each of these elements. Preliminary results indicate a fluctuation in meat and vegetables rich elements in conjunction with episodes of social change and political consolidation.

Master's Paper

"Measuring Nutritional Stress in a Prehistoric American Population" R. Geidel, Fall 1979, J. W. Hatch, advisor.

Paper

"Status-Specific Nutritional Variation in a Mississippian Chiefdom," presented at 44th Annual Meeting of the Society for American Archaeology, April 23, 1979, Vancouver, B.C., J. W. Hatch.

COLLEGE OF SCIENCE

Biology Department

Role of the Skin in Sodium and Water Exchange of Aquatic Snakes Placed in Seawater

W. A. Dunson

The skins of marine snakes are impermeable to Na, but show varying degrees of water permeability. Fasting marine and estuarine snakes placed in seawater undergo gradual dehydration due to a net water loss, and an increase in plasma and body Na content. Freshwater snakes, in contrast, typically lose weight and gain Na much more rapidly. This apparently leads to drinking, followed by catastrophic weight loss and death characterized by extremely high plasma Na concentrations and body Na content. Initial water influx and efflux (largely dermal) in freshwater snakes prior to seawater drinking are within the range measured in marine snakes. Na influx is much higher in the freshwater snakes, even immediately after being placed in seawater. It appears that essentially all of the measurable but minute Na influx in marine forms is due to leakage into the mouth. The skin is virtually impermeable to Na in both in vivo and in vitro tests. Skins of freshwater snakes show a low but significant degree of permeability to Na. However dermal Na influx is a small fraction of the total influx (less than 5% in Natrix sipedon). Thus a slight oral uptake of seawater (Na influx bebween 100 and 200 μmol/g·h) may be the proximate factor leading to death in these freshwater snakes. The unreliability of the standard Ussing cell for measurement of epithelial membrane Na fluxes has been confirmed. Na influx across freshwater snakes skins was considerably reduced by use of a glass cell sealed by silicone grease instead of pressure exerted by a clamp.

Doctoral Thesis

"Permeability of Native and Reconstituted Keratin to Water and Electrolytes," G. Stokes, 1979, W. A. Dunson, advisor.

Publications

"Role of the Skin in Sodium and Water Exchange of Aquatic Snakes Placed in Seawater," Am. J. Physiol. 235, R151-9, 1978, W. A. Dunson.

"Control Mechanisms in Reptiles in: Mechanism of Osmoregulation in Animals, R. Gilles (ed.). Wiley-Interscience, N. Y., p. 273-322, 1979 W. A. Dunson.

The Permeability of Reptilian Keratin to Water and Electrolytes

W. A. Dunson
G. Stokes

This research involves the relative permeability of keratin sheets to water, oxygen, sodium, potassium, and bromine. One purpose of these studies is to further our understanding of mechanisms of osmoregulation, especially in marine reptiles. An additional goal is to evaluate the practical use of keratin membranes in reverse osmosis applications. The reactor has been used to activate samples of sodium, potassium, and bromine needed to measure the permeability of membranes.

Microbiology and Cell Biology Department

Mechanism of Action of Clostridium Perfringens Enterotoxin

J. L. McDonel

This research involves studying the mechanism of action of Clostridium Perfringens enterotoxin which is responsible for one of the most common types of food poisoning in the United States today. Studies were conducted on how this enterotoxin affects the intestine to cause the characteristic symptoms of the disease, namely, diarrhea. To do this, intestinal tissue was isolated to perform transport studies. The reactor has been utilized by providing Na-24 which was used to trace the transport of sodium by the enterotoxin-treated intestinal tissue. These studies will help to understand what the toxin does to the intestine to cause the disease symptoms that have been noted.

Physics Department

Energy Levels in Y-86

W. W. Pratt

Energy levels in the yttrium isotopes involve states of unusually high spin due to the possibility of different coupling modes of the g 9/2 protons and neutrons. Various nuclear reactions can be used to produce these states, and the study of these reactions has the potential to give a great deal of information about the properties of these states. States in Y-88 have been studied previously in the reactions: Sr-87(Ge-3,d), Sr-88(He-3,t), Y-89(p,d), Y-89(d,t), Y-89(He-3,α) and Zr-90(d,α). States in Y-87 have previously been studied in the reactions: Y-89(p,t), Zr-90(p,α), Sr-86(He-3,d), Sr-86(p,γ) and Sr-86(d,n) as well as the radioactive decay of Zr-87. The energy level structure of Y-86, on the other hand, is almost completely unknown except for a few states found in the radioactive decay of Zr-86. We are carrying out measurements in another laboratory using the reactions: Sr-86(p,nγ), Rb-85(α,3nγ) and Sr-86(d,n) as well as in the radioactive decay of Zr-87. The Breazeale Nuclear Reactor is being used for auxiliary calibration experiments in connection with these studies.

B. Industrial Research Utilizing the Facilities of the Penn State Breazeale Nuclear Reactor

The facilities of the Penn State Breazeale Nuclear Reactor (PSBR) are made available to state, federal, and industrial organizations for use in their research and development programs. Some typical examples follow:

The Charles Stark Draper Laboratory, Inc.

Robert B. Miller

In the past year, the Draper Laboratory has used the Breazeale nuclear reactor facility to investigate how neutron environments effect the functional and parametric characteristics of transistors and integrated circuits. The results of this research have provided greater insight in understanding neutron sensitive damage mechanisms in semiconductor circuits. In addition, the studies undertaken have provided data to determine damage coefficients which will be useful for predicting circuit responses to neutron environments.

The cooperation and performance of the reactor staff over the past five years has contributed substantially to the success of our test programs. We expect that our relationship with the reactor facility will continue in the future.

E. I. DuPont De Nemours and Company

Norman W. Henry, III, Research Chemist

Aquatic Waste Water Facility Monitoring. The purpose of this project is to investigate the feasibility of monitoring ground water well samples for bromide anion by neutron activation analysis in order to determine leakage in our aquatic waste water lagoon. Currently, background well water samples are being collected monthly and analyzed quarterly by neutron activation analysis for bromide anion concentrations by the Radionuclear Applications Laboratory of the Penn State Breazeale Nuclear Reactor. The monitoring program is scheduled until October, 1979. At that time background bromide anion levels will be evaluated in order to determine the amount of bromide to be added to the lagoon as a tracer. Results of this program hopefully will provide us with a waste lagoon leak monitoring technique and also satisfy regulatory requirements for insuring lagoon liner integrity.

Raytheon Company

Robert N. Diette

The services provided by the staff of the Penn State Breazeale Nuclear Reactor Facility have been utilized in assessing neutron damage to electronic components. The facility is favored by the Raytheon Survivability and Vulnerability personnel because the reactor spectrum is well characterized and reliable exposure to specified fluence levels has been consistently demonstrated. Electrical tests, pre and post neutron exposure, of devices provides data required for analysis of the nuclear vulnerability of electronic systems. Raytheon has applied this analytical approach to various systems destined for applications ranging from land based communications to strategic missile systems. The use of the reactor facility

has been frequent during the past year and Raytheon's projected contractual requirements indicate continued use of irradiation services provided by its staff.

GTE Sylvania, Inc.

Robert A. Long, Manufacturing Superintendent

Determination of Low Levels of Tungsten in Calcium Hydrogen Phosphate

The host material for producing calcium halophosphate lamp phosphors for fluorescent lighting is calcium hydrogen phosphate. As such this material has very tight specifications on impurity levels. Recently we have been using a phosphate source resulting from a pollution recovery system which is contaminated to a slight extent by tungsten. We have utilized neutron activation analyses at the Breazeale Reactor Facility to precisely measure the tungsten level in this material. Through improvements in the pollution recovery system we were able to lower the level of the tungsten impurity. The neutron activation analysis is the only method known for determining such low levels of tungsten in a cost effective way.

Westinghouse Electric Corporation

John Bartko, Radiation and Nucleonics

Between May 1978 and May 1979 neutron irradiation experiments were conducted on semiconductor power devices, principally thyristors. We were interested in determining the effects of fission neutrons on parameters, such as, forward voltage drop, switching speed, reverse recovery charge and blocking voltages of devices with different power ratings. Also of interest was the effect of elevated temperatures on these parameters during the experiments. In some of the experiments, we heated the devices to 250°C in a specially fabricated cannister during the irradiation. We found, as expected, that considerable annealing occurred. Unexpected was the fact that the switching speed and reverse recovery charge annealed more rapidly than the forward voltage drop. This investigation is being continued with the help of deep level transient spectroscopy (DLTS). The overall purpose of the experiments is to identify the devices which might be suitable for certain specialized applications.

APPENDIX A

APPENDIX A

Faculty, staff and students utilizing the facilities of the Penn State Breazeale Reactor.

COLLEGE OF AGRICULTURE

Agronomy

Baker, Dale E., BS, MS, PhD
Professor of Soil Chemistry

Heald, Walter R., BSc, MS, PhD
Adjunct Professor of Soil Science

Jones, Donna M.
Graduate Student

Centralized Biological Laboratory

Confer, Florence L.
Research Aide

Gamble, Phillip
Graduate Student

Dairy and Animal Science

DePeters, Edward J.
Graduate Assistant

Food Science

Cin, David A.
Graduate Student

Kroger, Manfred, BS, MS, PhD
Professor of Food Science

Plant Pathology

Emberger, Gary
Graduate Student

Fisher, Nancy L.
Graduate Student

Klotz, Lois
Research Assistant

Nelson, Paul E., BS, PhD
Professor of Plant Pathology

Steuhling, Barbara
Graduate Student

Switkin, Connie
Research Assistant

Toussoun, T. A., BS, PhD
Professor of Plant Pathology

School of Forest Resources

Baldwin, Robert C., BS, MS, PhD
Assistant Professor of Wood Science and Technology

Veterinary Science

Drozelowics, Carla
Graduate Student

Eberhart, Robert J., AB, VMD, MS, PhD
Associate Professor of Veterinary Science

Ferguson, Frederick G., BS, MPH, DVM, PhD
Associate Professor of Veterinary Science

Patronek, Gary J.
Research Assistant

Ritchie, Joan M.
Graduate Student

Zarkower, Arian, DVM, MS, PhD
Professor of Veterinary Science

COLLEGE OF EARTH AND MINERAL SCIENCES

Ceramic Sciences Section

McHenry, Kelly
Graduate Student

Spear, Karl E., BSc, PhD
Associate Professor of Ceramic Science

Tressler, Richard E., BS, MS, PhD
Associate Professor of Ceramic Science

Coal Research Section

Spackman, William, Jr., BS, MS, PhD
Professor of Paleobotony

Geochemistry Section

Bell, Christy
Graduate Student

Keith, MacKenzie L., BSc, MSc, PhD
Professor Emeritus of Geochemistry

Mahar, D. L.
Graduate Student

Pirc, Simon
Graduate Student

Tole, Peter M.
Graduate Student

Geosciences

Karasevich, Ellen R.
Graduate Student

Geosciences

Rose, Arthur W., BS, MS, PhD
Professor of Geochemistry

Materials Science

Harrison, Ian R., BSc, MS, PhD
Associate Professor of Polymer Science

Simkovich, George, BS, MS, PhD
Professor of Metallurgy

Metallurgy Section

MacMillan, Norman H., BA, MA, PhD
Assistant Professor of Metallurgy

Wan, Chang-Feng
Research Assistant

Mineral Constitution Laboratories

Gong, Henry
Project Associate

Suhr, Norman H., AB, MS
Professor of Geochemistry

Mineral Engineering

Aplan, Frank F., BS, MS, ScD
Professor of Metallurgy and Mineral Processing

Phelps, L. Barry
Graduate Student

Saperstein, Lee W., BS, DPhil, PE
Associate Professor of Mining Engineering

Spearin, Elliott Y.
Graduate Student

Mineral Processing Section

Austin, Leonard G., BSc, PhD
Professor of Fuels and Mineral Engineering

Luckie, Peter T., BS, MS, PhD
Professor of Mineral Engineering

Shah, Jyotrinda
Graduate Student

Solid State Science Section

Runt, John P.
Graduate Student

Varnell, William D.
Graduate Student

COLLEGE OF ENGINEERING

Agricultural Engineering

Jarrett, Albert R., BS, MS, PhD
Assistant Professor of Agricultural Engineering

Bioengineering

Atkinson, Dennis
Graduate Student

Towe, Bruce C.
Graduate Assistant

Chemical Engineering

Jung, Hyun-Jong
Graduate Assistant

Palmer, Malcolm B., Jr.
Graduate Student

Vannice, M. Albert, BS, MS, PhD
Associate Professor of Chemical Engineering

Civil Engineering

Nesbitt, John B., BS, SM, ScD
Professor of Civil Engineering

Engineering Science and Mechanics

McGruer, Greg
Graduate Student

Nuclear Engineering

Ali, Ahmad T.
Malaysia Atomic Energy Department

Brenizer, Jack S., Jr.
Graduate Assistant

Comparetto, Gary M.
Graduate Assistant

Charlier, Christian
Graduate Student

Diethorn, Ward S., BS, MS, PhD
Professor of Nuclear Engineering

Dansky, Steven A.
Graduate Assistant

Foderaro, Anthony, BS, PhD
Professor of Nuclear Engineering

Flinchbaugh, Terry L.
Nuclear Education Specialist

Haaser, Frederic L.
Graduate Assistant

Nuclear Engineering (Cont'd)

Houtz, Robert C.
Nuclear Education Specialist

Jacobs, Alan M., BS, MS, PhD
Professor of Nuclear Engineering

Jarvis, Christopher
Graduate Assistant

Jempson, James R.
Graduate Student

Jester, William A., BS, MS, PhD
Associate Professor of Nuclear Engineering

Kahveci, Ali R.
Graduate Student

Kenney, Edward S., BS, PhD
Professor of Nuclear Engineering

Klevans, Edward H., BS, MS, PhD
Professor of Nuclear Engineering

Levine, Samuel H., BS, MS, PhD
Professor of Nuclear Engineering

McKee, John R., BS
Coordinator, Energy Education Programs

McMaster, Ira B., BS
Research Assistant

Meyer, S. P.
Graduate Student

Moo, Siew Pheng
Malaysia Atomic Energy Department

Morrison, Steve
Undergraduate Student

Pandy, Sudhakar
Graduate Assistant

Penkala, John L., BS
Research Assistant

Pillay, K. K. Sivasankara, BSc, MSc, PhD
Associate Professor of Nuclear Engineering

Raupach, Dale C., BS
Reactor Utilization Specialist

Remick, Forrest J., BS, MS, PhD
Professor of Nuclear Engineering

Robinson, Gordon E., BS, MS, PhD
Associate Professor of Nuclear Engineering

Nuclear Engineering (Cont'd)

Schultz, Mortimer A., BS
Professor of Nuclear Engineering

Shillenn, James K.
Energy Education Specialist

Sulcoski, Mark
Graduate Student

Totenbier, Robert E., BS
Research Assistant

Trivellas, Sotirios
Graduate Student

Wallace, Jonathan
Graduate Assistant

Witzig, Warren F., BS, MS, PhD, PE
Professor of Nuclear Engineering

COLLEGE OF THE LIBERAL ARTS

Anthropology

Geidel, Richard
Graduate Student

Hatch, James W., BA, MA, PhD
Assistant Professor of Anthropology

COLLEGE OF SCIENCE

Biology

Dunson, William A., BS, MS, PhD
Professor of Biology

Stokes, Glenn
Graduate Student

Microbiology and Cell Biology

McDonel, James L., BSEd, PhD
Assistant Professor of Microbiology and Cell Biology

Physics

Pilione, Lawrence J., BS, MS, PhD
Associate Professor of Physics - Altoona

Pratt, William W., BS, PhD
Professor of Physics

INTERCOLLEGE RESEARCH PROGRAMS AND FACILITIES

Center for Air Environmental Studies

Eskew, Mary Lou
Junior Laboratory Assistant

Center for Air Environmental Studies

Scheuchenzuber, W. J.
Research Aide

Computation Center

Knoble, Herman D., BS,
Research Associate

Health Physics Office

Granlund, Rodger W., BS
University Health Physicist

Hollenbach, Donald H.
Health Physics Assistant

Materials Research Laboratory

Krishnaswamy, S. V.
Research Associate

THE MILTON S. HERSHEY MEDICAL CENTER

Oncology

Lipton, Allen, MD
Professor of Medicine & Microbiology

APPENDIX B

APPENDIX B

Formal Group Tours

1978			Participants
May	27	Nuclear Engineering Graduation Reception	75
June	23	Reactor Facility Open House	106
	26	Westinghouse - Explorer Scouts	7
	28	4 H Group	6
July	5	Conservation Leadership Camp	34
	10	Conservation Leadership Camp	29
	11	Argonne University Association	30
	12	Edinboro State College Workshop	31
	13	Harrisburg Hospital Medical Technicians	20
	19	Conservation Leadership Camp	34
	19	Pittsburgh Explorer Scouts	7
	21	Nuclear Concepts Institute	44
	24	Conservation Leadership Camp	32
Aug.	7	Nuclear Concepts Sponsors	19
	15	Soil Conservation Service	12
	21	Visitors from Texas	6
	31	Police Services	5
Sept.	7	Nuclear Engineering 440	29
	7	Nuclear Engineering 405	15
	21	Bio Engineering 401	13
	27	Environmental Resources 413	28
	29	Environmental Resources 413	46
	29	Altoona Nuclear Technology Class	4
Oct.	9	Physics 100	14
	10	Physics 100	38
	10	Higher Education 101	13
	11	Food Science 521	7
	12	Geological Sciences 303	17
	11	Physics 100	10
	13	Power Systems Engineers	42
	17	Society of Physics Students	8
	19	Science Technology and Society	19

Formal Group Tours (Continued)

1978			Participants
Oct.	19	Industrial Professional Advisory Council	6
	25	Hazleton Campus	8
	24	Metallurgy 412	19
	26	Geological Sciences 303	11
	31	Engineering 5	24
Nov.	2	Happy Valley C. B. Club	15
	3	International Fellows	10
	7	Franklin and Marshall College	11
	7	Biological Sciences 3	26
	9	Recreation Department	12
	13	Delone High School	11
	15	Wyomissing High School	10
	15	Altoona High School	6
	16	Alternative Program - State College High School	6
	29	Lower Dauphin High School	19
Dec.	11	Police Services	28
	21	Smethport High School	7
1979			
Jan.	3	Nuclear Engineering 200	24
	5	Bucknell University	7
	8	Pennsylvania Power and Light Company	9
	18	Police Services	5
	22	Nuclear Engineering 200	26
	25	Life Science Interest House	11
	31	Engineering 5	106
Feb.	1	Geological Sciences 303	30
	7	Society of American Military Engineers	16
	16	Tyrone Cub Scouts	5
	21	Cub Scouts	6
	17	Entomology Class	19
	14	Jersey Shore High School	8
	20	Westerly Parkway Jr. High School	7
	21	Westerly Parkway Jr. High School	8

Formal Group Tours (Continued)

1979			Participants
Feb.	26	Daniel Boone High School	19
Mar.	2	Activation Analysis Workshop	17
	2	Cub Scouts	4
	3	Cub Scouts	6
	8	Penn Crest High School	10
	8	Council Rocks High School	11
	8	Cub Scouts	7
	9	Beatty Technical High School	10
	15	Penns Valley High School	11
	20	Nuclear Engineering 440	14
	20	Ligonier Valley High School	27
	22	Hollidaysburg High School	10
	23	Villanova University	22
	23	Junior Reserve Officers Training Corps	25
	29	Physics 597	14
April	2	Pittsburgh Explorers	9
	3	Selingsgrove High School	54
	4	English 117	5
	6	Penn Cambria High School	15
	9	Physics 101	18
	10	Physics 101	40
	11	Ridgway High School	17
	11	Physics 101	14
	12	Physics 101	14
	12	Bellefonte High School	19
	16	Biological Sciences 3	22
	17	Mercyhurst College	8
	18	Environmental Health 420	15
	18	Scouts	13
	19	BlueMount High School	10
	19	Geological Sciences 303	38
	20	Exeter Township High School	8
	20	Environmental Health 420	26

Formal Group Tours (Continued)

1979			Participants
April	23	Pittsburgh Explorer Scouts	9
	24	Higher Education 101	23
	25	Alliance College	9
	27	Robb School - Lock Haven	47
May	1	Plant Breeding - Horticulture 444	10
	2	Plant Breeding - Horticulture 444	10
	2	High Education 101	8
	3	Warren Area High School	30
	3	Harbor Creek High School	9
	4	Union City High School	11
	8	Nuclear Engineering 440	11
	9	Thomas Jefferson High School	15
	9	Physics 406	10
	10	Marion Center High School	10
	10	Central Cambria Middle School	51
	11	Bedford High School	5
	14	Nuclear Engineering 401	31
	14	Reading Central Catholic High School	7
	14	Nittany 24	10
	14	Engineering 5	2
	15	Sinclair High School	10
	16	Mount Union High School	7
	17	Derry Area High School	8
	17	North Schulykill High School	6
	18	Mercyhurst College	7
	22	Chestnut Ridge	10
	25	Tyrone Elementary School	90
	26	Nuclear Engineering Graduation Reception	94
		TOTAL	2,413