1980 Annual Report

of

The University of Texas at Austin
Nuclear Engineering Teaching Laboratory

January 1, 1980 - December 31, 1980

D. E. Klein, Director
T. L. Bauer, Supervisor

Taylor Hall 104
512-471-5136

March 1981

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I. INTRODUCTION

This report has been prepared by the staff of the Nuclear Engineering Teaching Laboratory (NETL), The University of Texas at Austin, to satisfy the reporting requirements of the U.S. Department of Energy Contract Number At-(40-1)-3919 and 10 CFR 50.59. This report covers the period from January 1, 1980 to December 31, 1980.

The NETL is presently equipped with a 250 kW TRIGA Mark I nuclear reactor, a 1500 curie Cobalt-60 irradiator, two 150 kV Cockcroft-Walton 14 MeV neutron generators, three Californium-252 neutron sources, a subcritical assembly, and a neutron activation analysis laboratory, with various radiation detection systems. The nuclear reactor laboratory is shown in Figure 1 with adjacent areas of the Taylor Hall engineering building shown in Figure 2.

The major changes made to the laboratory during this period were:

1. The initial phase of work to improve laboratory physical security has begun with work to be completed in the fi t part of the 1981 year,
2. Staff changes at the positions of laboratory supervisor and technician,
3. Acquisition of a second 150 kV Cockcroft-Walton 14 MeV generator, and
4. Requests for license renewal of NRC R-92 and SNM-180 licenses were initiated, including a revision of the Technical Specification to current regulatory formats.

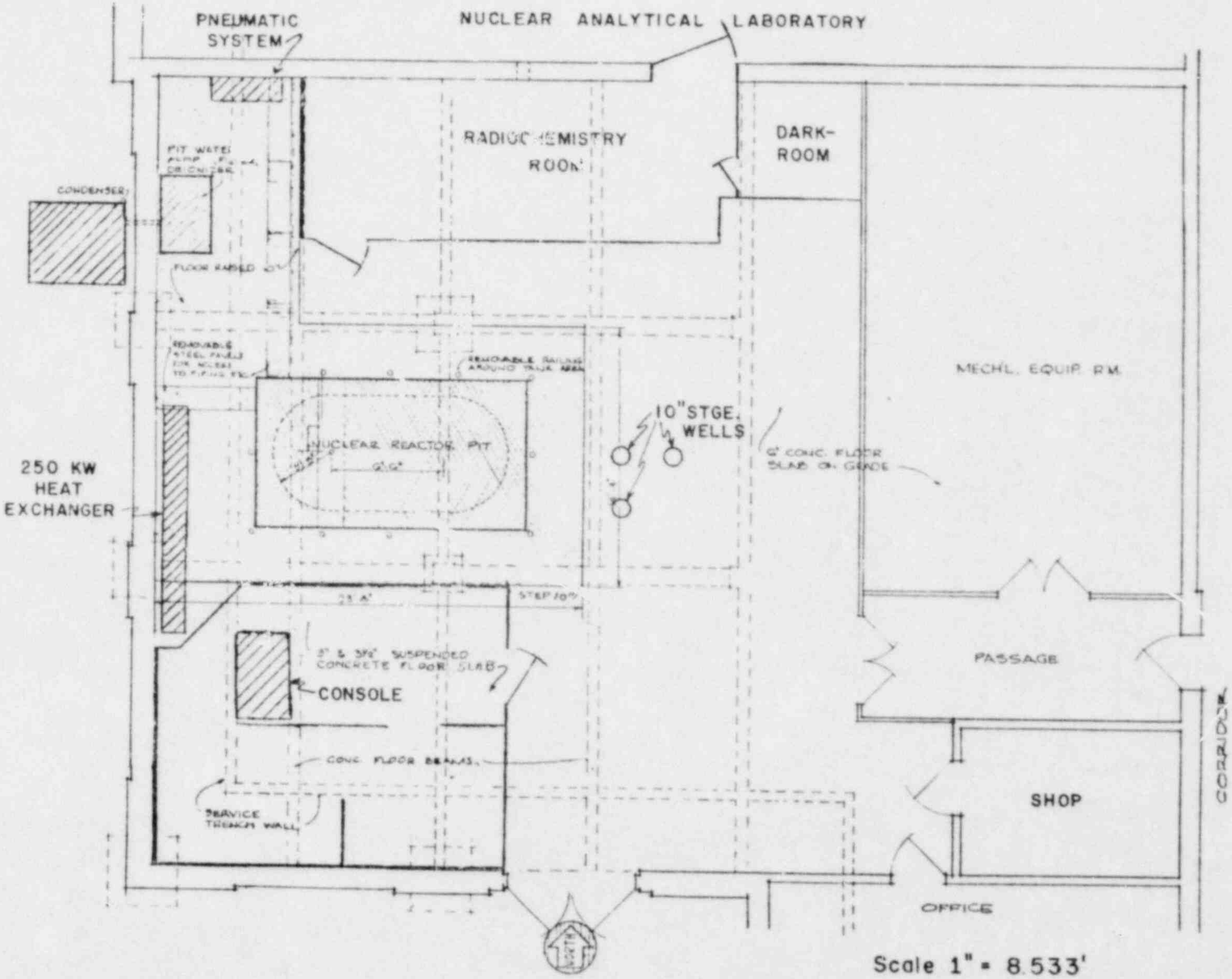

Fig. 1 TAYLOR HALL 131 FLOOR PLAN

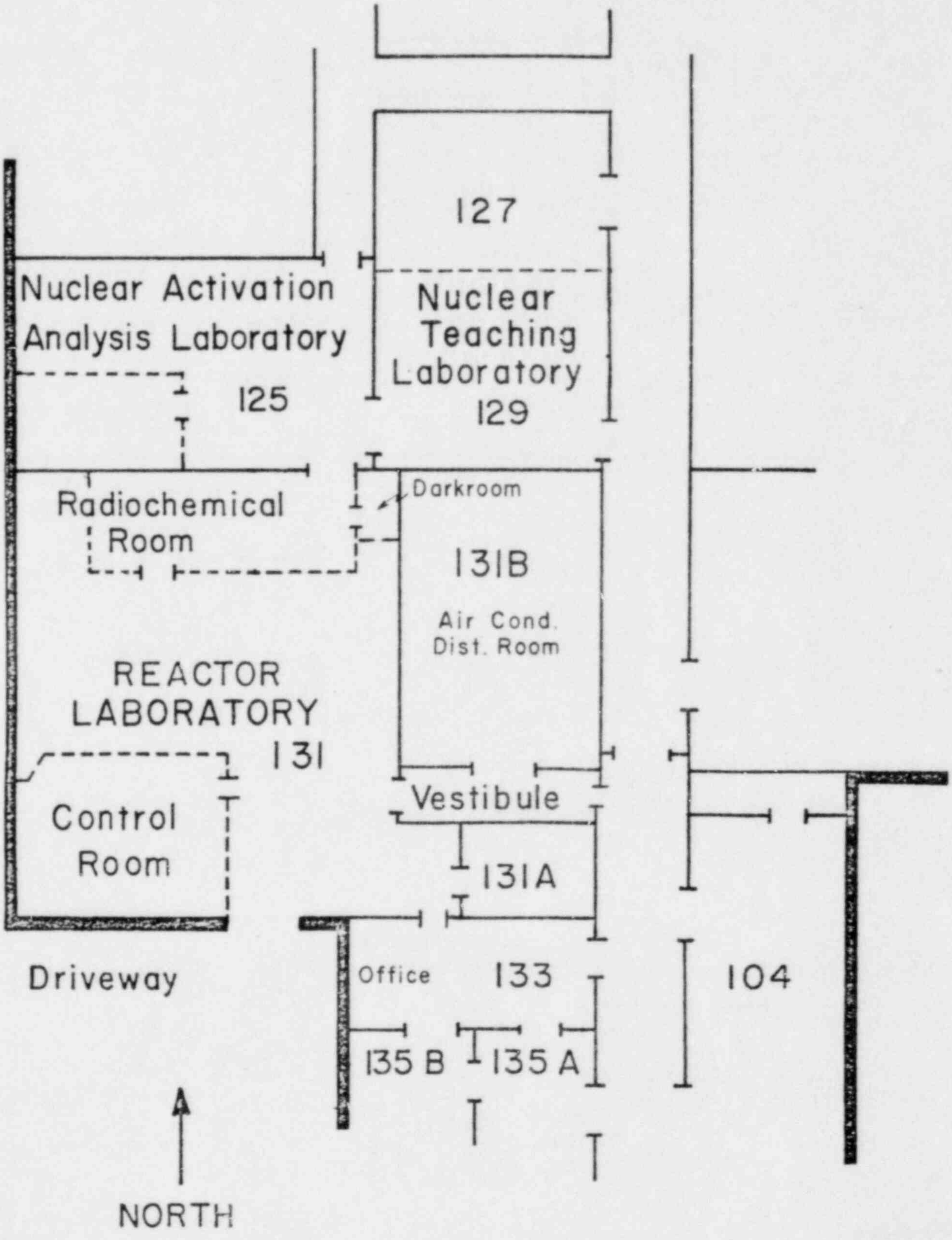

Fig. 2 TAYLOR HALL FLOOR PLAN
ADJACENT ROOMS TO 131

II. LABORATORY ADMINISTRATION

A. Organization

The present organizational chart of the Nuclear Engineering Teaching Laboratory is presented in Figure 3.

B. Personnel

The following is a list of personnel of the Nuclear Engineering Teaching Laboratory for the period January 1, 1980 to December 31, 1980.

Laboratory Administration and Staff

Klein, D.E., Director
+Bauer, T.L., Supervisor (researcher)
+Burack, J.A., Supervisor (terminated)
Povio, N., Nuclear Technical Specialist
*Krause, M., Nuclear Technical Specialist
Pradzynski, A.H., Radiochemist
Garcia-Morrison, M., Administrative Secretary
Garvel, L., Parker, T., Smith, R., Secretary (temporary)
Dao, T., and Anaya, P., Laboratory Assistants
Hertel, N.E., Researcher
Davidson, J.W., Researcher

Graduate Assistants

Ally, M.
*Ganthner, S.
Gantt, B.
Hamann, J.
*Krause, M.
Kunimoto, Y.
Laucius, R.
Murphie, B.
Razzaque, M.
+Sanders, T.
+Smith, D.
Yang, S.

+--Licensed Senior Operator
*--Licensed Operator

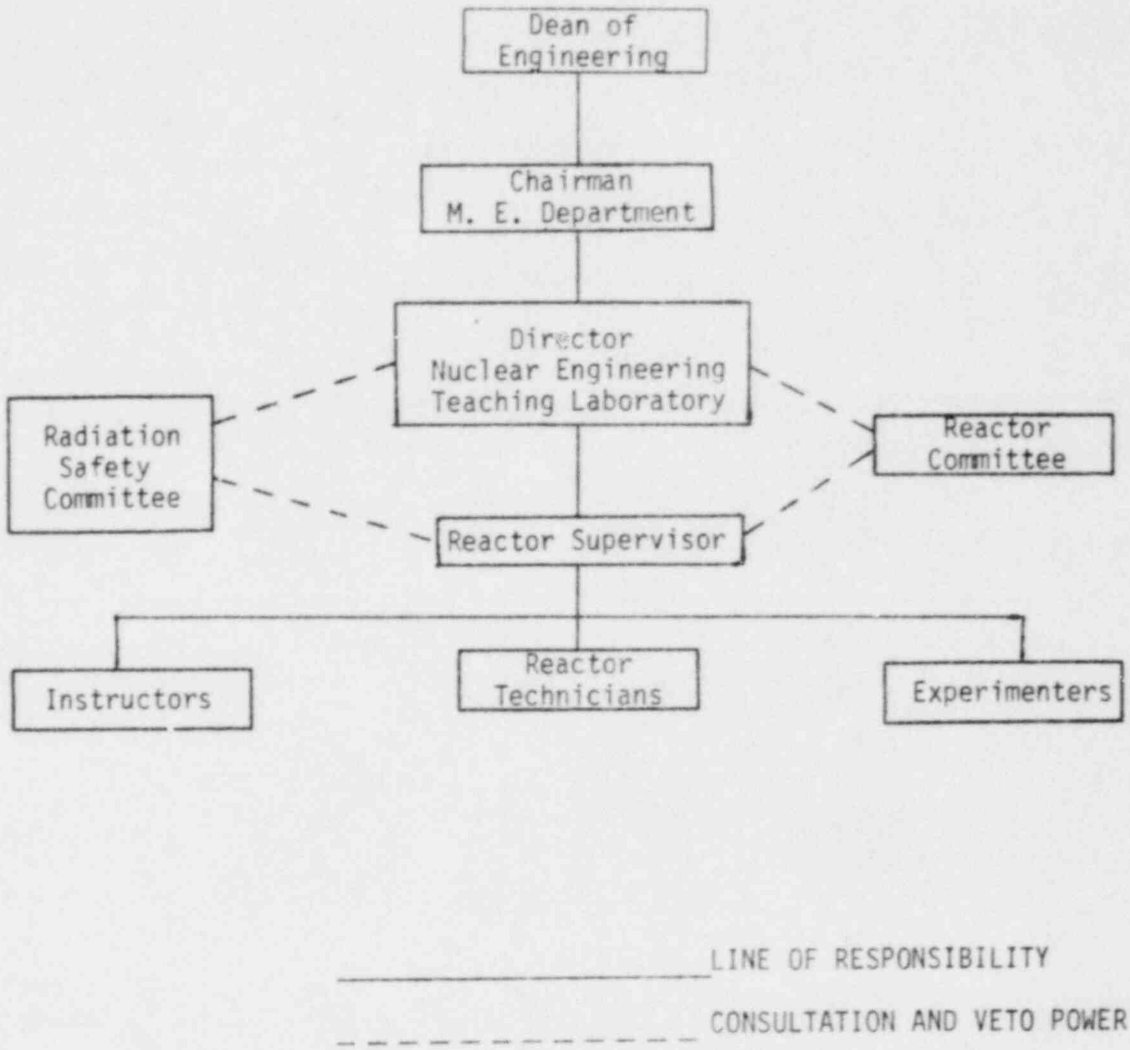

FIGURE 3 - ORGANIZATIONAL CHART

C. Reactor Committee

1. Committee Composition

Regular Members: (9/1/80)

Dr. Dale Klein
Dr. Joe Ledbetter
Dr. Harris Marcus (Chairman)
Dr. Dale Klein
Dr. Nolan E. Hertel
Mr. Michael Krause (Student)

Ex Officio Members:

Dr. H. G. Rylander, Chairman, Department of Mechanical Engineering
Mr. H. W. Bryant, University Radiation Safety Officer
Dr. T. L. Bauer, Supervisor, Nuclear Engineering Teaching Laboratory

2. Meeting Frequency

The Reactor Committee met four times during the calendar year of 1980.

3. The Nuclear Reactor Committee Annual Report for September 1979 to August 1980 as presented to the Dean of the College of Engineering is included in the following paragraphs.

Function, Activities, and Membership

The Nuclear Reactor Laboratory staff and facility are administered through the Department of Mechanical Engineering of the College of Engineering at The University of Texas at Austin. The Nuclear Reactor Committee is a requirement of the Nuclear Regulatory Commission and its function is to ensure that the nuclear reactor and its associated facilities are operated in a professional and safe manner.

This objective is met primarily be regularly scheduled quarterly meetings of the Nuclear Reactor Committee. These meetings include a review of the activities of the reactor staff, faculty, and associated graduate students; a tour of the laboratory facilities by a member or members of the committee; and a reporting of the minutes which includes any unusual occurrences. The committee also reviews and accepts or rejects any special experiments or requested changes in the reactor technical specifications and/or operating procedures. Minutes of the committee meetings are recorded and reviewed. The committee does not involve itself with the day-to-day activities of the reactor facility, as these responsibilities lie with the associated faculty and professional staff of the Nuclear Reactor Laboratory.

Membership on the committee consists of two categories: members and ex officio members. The committee members are appointed by the Dean of the College of Engineering, usually after conferring with the Director of the Nuclear Reactor Laboratory and the Chairman of the Department of Mechanical Engineering. The members include faculty members having some knowledge of nuclear engineering and reactor operation, but with no direct involvement in the operation of the reactor facility. In recent year one or two students have been added to the committee. The members of the committee as of June 1980 are: Professors H. L. Marcus (Committee Chairman and on the Mechanical Engineering faculty), Joseph Ledbetter (Civil Engineering), Nolan Hertel (Mechanical Engineering), and M. Krause (student in Mechanical Engineering). The ex officio members are: the Chairman of the Mechanical Engineering Department (H.G. Rylander), the Director of the Nuclear Reactor Laboratory (Dale Klein), the Reactor Supervisor (T. Bauer), and the University Radiation Safety (W. Bryant).

Activities and Comments

The recorded activities of the Nuclear Reactor Committee and those items of business pertinent to the committee are included in the minutes of the quarterly meetings, copies of which are attached. These include minutes for the meetings of July 30, 1979; October 30, 1979; January 30, 1980; and May 2, 1980. An additional meeting will be held this summer.

Specific items of interest include:

(1) The reactor has had its maximum usage during the reporting period. A wide range of applications have been identified and vigorously pursued to increase the activity.

(2) A large number of personnel have received their reactor operator licenses. This has assisted in the increased usage of the reactor.

(3) The last NRC inspection showed no items of noncompliance.

(4) Separate funding for the facility has been approved and a request for facility improvement funds is being processed.

(5) The operating organization has been modified and seems to be operating in a smooth, enthusiastic manner.

(6) The remodeling for security has started and should be vigorously pushed to completion.

In general we feel that this year has been the second consecutive strong year for the activities of the Nuclear Reactor Facility.

D. Radiation Safety Committee

1. Committee Composition

Dr. P. Riley, Chairman (9/79 - 12/80)
Dr. L. O. Morgan (4/75 - 12/80)
Dr. Joanne Ravel (- 8/79)
Dr. C. Desjardins (10/79 - 12/80)
Mr. H. W. Bryant, Ex Officio

2. Meeting Frequency

The Radiation Sa-. y Committee met twice during the calendar year of 1980 (/,ri 10 and November 12).

III. LABORATORY DEVELOPMENT

A. Organization

Dr. Dale E. Klein continued as the Director during the past year. Several changes of personnel classification and job requirements of the university personnel classification system have altered job descriptions with a goal to increase job position effectiveness. Positions effected were the Reactor Supervisor, Radiochemist, and Technicians. Combined with the changes of job classification, several personnel changes occurred during the 1980 year. The responsibilities of reactor supervisor were assumed by Dr. T. L. Bauer and N. Povio accepted the position of Nuclear/Electronic Technical Specialist III. A graduate student M. Krause accepted as position as Nuclear Technical Specialist II to supplement the reactor operation staff.

B. Nuclear Engineering Teaching Laboratory

The Nuclear Engineering Teaching Laboratory is an important part of the Nuclear Engineering program at The University of Texas.

The Nuclear Engineering Teaching Laboratory's central feature is a Mark I TRIGA thermal fission reactor. Originally licensed by the Atomic Energy Commission to operate at 10 KW in 1963, the nuclear reactor and the associated laboratory equipment have been updated over the past few years and the research capabilities of the Laboratory are now quite diverse.

In 1968, the facility license was amended to allow the TRIGA reactor to operate at a steady state power level of 250 KW and pulsed power of 250 MW which increased experimental capabilities tremendously. The acquisition of lithium drifted silicon and germanium solid state radiation detectors with a data acquisition system composed of dual Nuclear Data 1024 channel multichannel analyzers linked to a Data General Nova 800 minicomputer provided facilities for analysis of large quantities of data.

Other experimental devices available at the Laboratory are a subcritical assembly, a neutron beam irradiation facility, a curie cobalt-60 irradiator, a Nuclear Chicago sodium iodide coincidence counting system, an α - β detection system, and numerous other proportional and Geiger-Mueller detection and counting systems for radiation.

The nuclear reactor and the associated laboratory equipment are also used to teach the fundamentals of reactor operation. Students from all over the state as well as other organizations and groups have toured the Nuclear Engineering Teaching Laboratory. Approximately 1000 persons tour the Laboratory each year.

The use, operation, regulation, security, and monitoring of the Nuclear Engineering Teaching Laboratory is controlled by the United States Nuclear Regulatory Commission, the Nuclear Reactor Committee of The University of Texas, the Director of the Nuclear Engineering Teaching Laboratory, the Radiation Safety Committee and the Radiation Control Board of the State of Texas.

The use, operation, security and radiation monitoring of the Nuclear Radiation Laboratory is controlled by the Director of the Nuclear Engineering Teaching Laboratory and the Radiation Safety Officer of The University of Texas at Austin.

C. Nuclear Radiation Laboratory

The Nuclear Radiation Laboratory at Balcones Research Center has been utilized by the students and staff of the Nuclear Engineering Program at The University of Texas at Austin for the past several years.

The primary use of the building was to house and operate a 14 MeV Texas Nuclear neutron generator. To facilitate experiments utilizing the neutron generator, a large quantity of graphite was obtained, machined and formed into a 8 ft. cube into which was inserted the drift tube of the neutron generator. This device is a very flexible one for investigating neutron migration in matter. When the Nuclear Engineering Teaching Laboratory acquired three (3) Californium-252 sources from Louisiana State University in 1973, the Nuclear Radiation Laboratory became the logical place for their storage and use due to the space and availability of the already installed neutron shielding around the neutron generator. Thus, with the acquisition of Cf^{252}, students and staff can perform experiments utilizing not only the high energy neutrons from the neutron generator but fission spectrum neutrons from Cf^{252}. In addition to the neutron generator and the Californium sources, other smaller radioactive sources are also used within the confines of the Nuclear Radiation Laboratory.

Large amounts of neutron shielding material have been installed in and around the neutron generator cavity and at selected spots on the exterior of the building to protect other experimentalists and the environment from abnormal radiation levels. Because of the possibility of high radiation doses within the confines of the neutron generator cavity, the Nuclear Radiation Laboratory is a limited access building and all generator cavity doors are wired into the controls of the generator so that any unwarranted entry automatically shuts down the machine.

D. Subcritical Facility

In association with the undergraduate nuclear engineering laboratory course (ME 361F) and the graduate nuclear engineering course (ME 389R), the subcritical assembly has continued to provide a facility with which the student can perform measurements that are related to fundamental reactor parameters. Such concepts as age, diffusion, and buckling are demonstrated in individual experiments performed by each student.

E. Neutron Activation Analysis Facilities

The Nuclear Analytical Laboratory has provided support for more than twenty separate projects ranging from student laboratory support for advanced classes in chemistry, zoology, physics, and engineering to investigative projects in environmental monitoring. Scientific articles based upon the results of sponsored and unsponsored research by this laboratory have been published or accepted for publication in several journals and proceedings, and have been presented at conferences of the state, national and international level.

IV. Laboratory Operation and Utilization

A. Reactor

1. Operation

During this reporting period the reactor operated for a total of 184.1 hours while supporting numerous nuclear engineering and operation courses, research, and other related activities.

2. Maintenance

During 1980 most maintenance was limited to routine repair and adjustments.

3. Inadvertant Reactor Scrams

During 1980 there were 17 inadvertant shutdowns as compared with 11 in 1979. Tables 1 and 2 itemize the "SCRAMS" and compare this year's data to previous years' data.

4. Utilization

Tables 3 and 4 and Figures 4 and 5 show the utilization of the reactor for the year and compares this data with that of previous years.

5. Courses Offered Using the Reactor

Table 5 lists the courses offered at The University of Texas at Austin which utilized the reactor and associated facilities.

B. Facility Changes

1. Physical Security

Several improvements of the physical boundaries of the laboratory have been made or will be done in early 1981.

TABLE 1

REACTOR SCRAMS

Intentional	-- 0
Operator Error	-- 4
Instrument Error	-- 3
Power Outage	-- 0
Safety	-- 0
Total	-- 7

TABLE 2

COMPARISON OF YEARLY INADVERTANT SCRAMS

'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73
10	9	3	4	3	31	15	11	13	6	10

'74	'75	'76	'77	'78	'79	'80
4	7	5	9	14	11	7

TABLE 3

NUCLEAR ENGINEERING TEACHING LABORATORY

PERFORMANCE DATA, 1980

	Total Hours Reactor In Operation*	Total Burn-up (kW-hrs)	Number of Samples Irradiated
First Quarter 1980	57	4,781.1	26
Second Quarter 1980	42.8	2,374.6	60
Third Quarter 1980	13.5	54.2	6
Fourth Quarter 1980	70.8	4,613.5	58
TOTAL	184.1	11,760.4	150

*Includes experimental setup time, maintenance, etc.

TABLE 4

COMPARISON OF PREVIOUS UTILIZATION DATA

Year	Total Hours Reactor In Operation*	Total Burn-up (kW-hrs)	Number of Samples Irradiated
1965-66**	104.5	251	63
1966-67	150.0	595	202
1967-68***	342.6	28,168	2449
1968-69	260.8	49,985	1452
1969-70	222.0	36,477	1640
1970-71	262.5	53,912	2990
1971-72	222.8	38,624	1946
1973	318.6	45,794	1347
1974	226.1	27,641	778
1975	206.905	20,450	363
1976	135.74	11,312	468
1977	139.29	7,509	164
1978	171.9	26,870	178
1979	311.61	72,616	1568
1980	184.1	11,760.4	150

* Includes experimental setup time, maintenance, etc.

** 1965 was the first year the utilization data were maintained.

*** Reactor upgraded from 10 to 250 kW during this academic year.

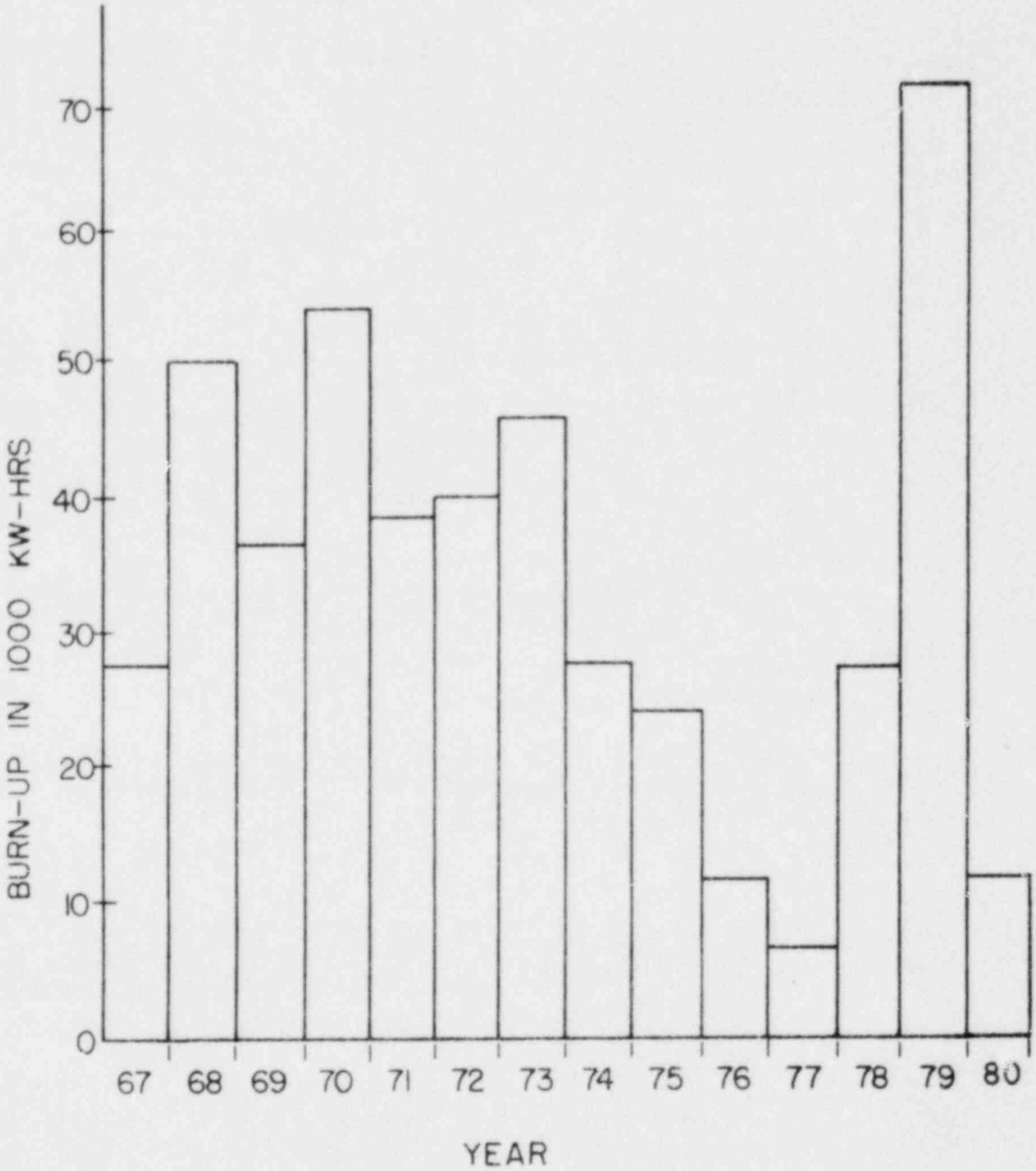

FIGURE 4 - TOTAL BURN UP PER YEAR

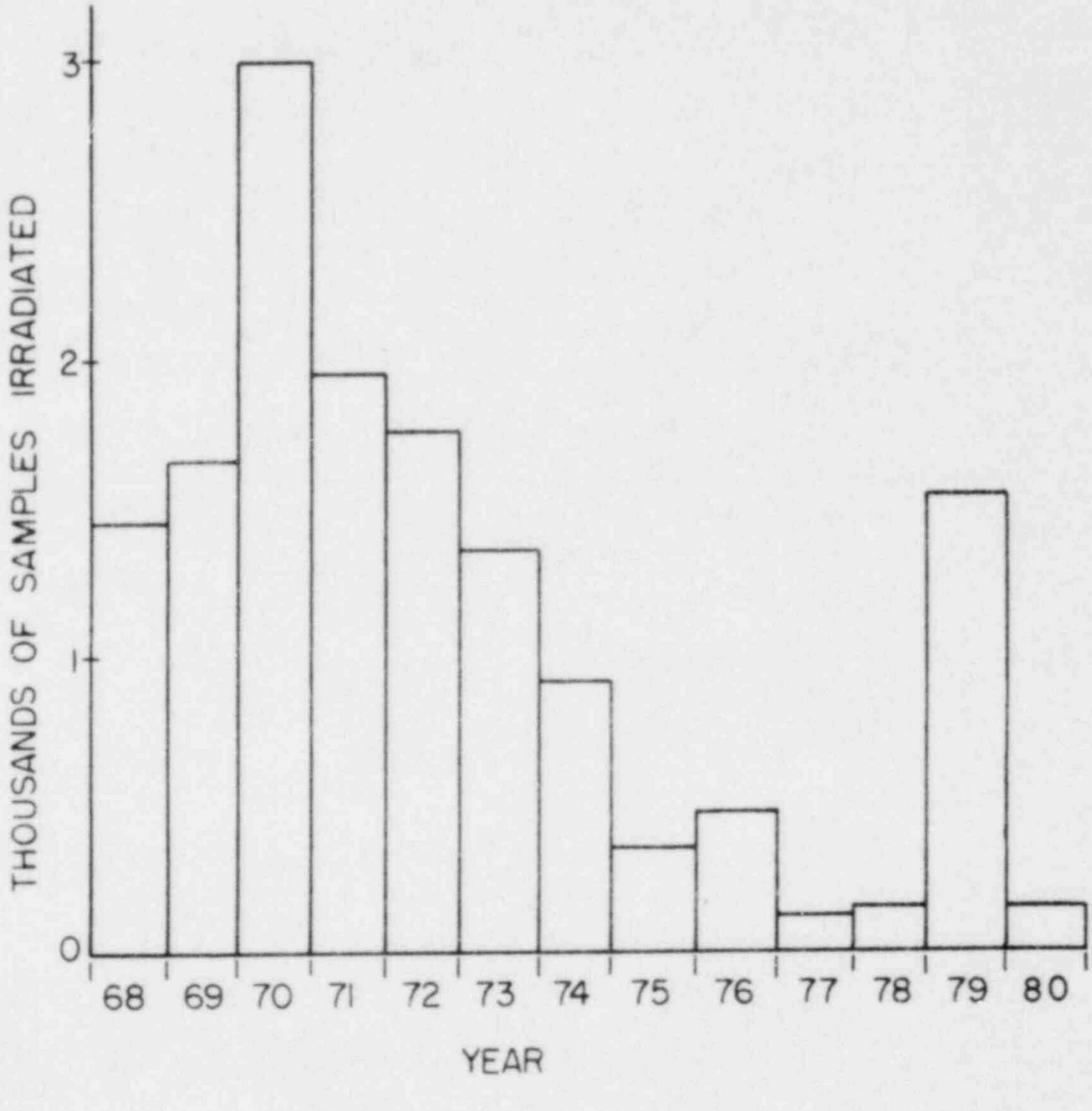

FIGURE 5 - NUMBER OF SAMPLES IRRADIATED PER YEAR

TABLE 5

COURSES UTILIZING THE REACTOR AND ASSOCIATED FACILITIES

Course Number	Course Description
ME 397	This course was a project course in which the experiments for ME 379M were documented for use as an aid to the students.
ME 361F	Introductory Nuclear Laboratory Designed as an introduction to radio-active decay, activation, and radiation measurement.
ME S389R	A special projects laboratory course for foreign nuclear engineers.
ME 379M	A reactor operations course, open to all students. Designed to allow students with an interest in nuclear power to learn basic reactor theory and participate in actually operating a nuclear reactor.
ME 377K	A special projects course whereby students can pursue special topics.
ME 389R	A required laboratory course for students pursuing a Master of Science in the Nuclear Program.
CH 376K	A senior level course in instrumental analytical methods which utilizes the Nuclear Engineering Teaching Laboratory Facilities to study Neutron Activation Analysis.
CE 390L	This is a graduate course in environmental analysis for environmental health engineers. Students use neutron activation analysis and energy dispersive X-ray emission spectrometry to analyze samples for toxic contaminants.

The major items are the replacement of windows on two sides of the laboratory with concrete block and brick construction.

2. Ventilation System

An exhaust has been partially installed to increase control of room and air pressure and air leakage rates. A pre-filter, high efficiency particulate filter, and pneumatically controlled damper have been installed. The damper was installed in the closed position until license modifications allow operation of the exhaust system. The fan, exhaust stack, and control system are to be installed in 1981.

V. LABORATORY INSPECTION

A. An inspection by a member of the Nuclear Regulatory Commission of the activities authorized by NRC Operating License R-92 occurred during April 16-18, 1980 in which no items of non-compliance were found.

B. A visit by a member of the NRC regarding the renewal of NRC Operating License R-92 occurred during July 9, 1980 to gather information on the facility and license renewal.

C. A visit by members of the NRC regarding activities authorized by NRC Special Nuclear Material License SNM-180 occurred during December 3, 1980 in which information regarding the license renewal and use of licensed material was obtained.

VI. PUBLIC SERVICE ACTIVITIES

These activities include those other than research projects or assistance provided in the pursuit of research which are covered in Section VII of this report. In this section the subjects are symposiums, lectures, presentations, and tours.

A. Summer High School Science Teachers Symposium

Funded by the Electric Utility Companies of Texas, this program was designed to familiarize high school science teachers with the theory and technology of energy resources. During the summer of 1980, teachers participated in the program.

B. Lectures and Presentations

On numerous occasions during 1980 the NETL staff gave talks on subjects including: "Nuclear Reactor Safety," "Nuclear Engineering and Society," "Research and Development of Energy Resources," "Energy and the Environment," and "What Happened at Three Mile Island."

C. Tours and Radiation Monitoring

During the calendar year of 1980 over 1,000 persons visited the lab. Most of these persons represented educational, civic, or industrial organizations, while others were part of formal engineering laboratory groups. All persons working in or around the laboratory are provided with personal radiation monitoring devices while tour group members are randomly monitored. Measurable exposure to tour group members was in the non-measurable exposure range as indicated by pocket dosimeters. Persons employed by or working in the laboratory are issued film badges. The annual statistical summary of those badges is found in Table 6.

TABLE 6

STATISTICAL SUMMARY OF RADIATION EXPOSURE

1980

Range of Exposure in REM	Number of Individuals
Non-measurable exposure	20
0.0 0.1	30
0.1 - 0.25	0
0.25 - 0.5	0
0.5 - 0.75	0
0.75 - 1.0	0
1.0 - 2.0	0
2.0 - 3.0	0

VII. RESEARCH ACTIVITIES

The Nuclear Engineering Teaching Laboratory is pursuing research in numerous areas which are sponsored by the organizations listed below. Major research funding is shown in Table 7.

A. The U.S. Department of Energy has provided research support by providing reactor fuel for the operation of the University of Texas at Austin TRIGA reactor.

B. The Electric Utility Companies of Texas has sponsored Summer High School Science Teachers Symposium, a program designed to familiarize these teachers with the theory and technology of energy resources.

C. "Determination of Vanadium and Barium in Marine Sediments and Biota."

Personnel: A. H. Pradzynski, NETL
T. L. Bauer, NETL
M. Ally, NETL

Sponsored by: Southwest Research Institute (SWRI)

Description:

The Southwest Research Institute (SWRI) in San Antonio subcontracted to the Nuclear Engineering Teaching Laboratory a part of a project on "Ecological Investigations of Petroleum Production Platforms in the Central Gulf of Mexico." The project was performed under SWRI's contract with the Bureau of Land Development, Department of the Interior No. AA550-RP8-2. Most experimental work for SWRI was performed in 1979 with some of the project concluded in and submitted to SWRI in 1980.

D. Development of a Preconcentration Method for Field Sampling of Uranium

Personnel: Dale Klein, NETL
Mohammed Ally, NETL

Sponsored by: Nuclear Engineering Teaching Laboratory

TABLE 7

RESEARCH FUNDING

Texas Atomic Energy Research Foundation (5/1/79 - 4/30/81)	$35,000
Department of Energy -- Fuel Program	----
Center for Energy Studies (9/1/80 - 8/31/81)	27,500
National Science Foundation (5/15/80 - 10/31/82)	39,975
Department of Energy (3/30 - 4/81)	14,000
Institute of Nuclear Power Operations (9/1/80 - 8/31/81)	8,000
TOTAL	$124,475

Description:

Two basic techniques are used presently at the Nuclear Engineering Teaching Laboratory at The University of Texas at Austin for the determination of trace elements (e.g. uranium). These include neutron activation analysis and x-ray fluorescence. When the elements to be examined are present in trace quantities, either a large sample must be measured or the sample must be preconcentrated. There are several advantages of a preconcentration method and the objective of this project is to develop a suitable method for the analysis of trace elements, including uranium, in water. In previous years a method was developed for transition elements in water. Experiments were extended to Cr, Mn, Th and U.

E. Preconcentration of Trace Elements in water for X-Ray Fluorescence Analysis

Personnel: A. H. Pradzynski, NETL

Sponsored by: Nuclear Engineering Teaching Laboratory

Description:

In cooperation with the University of Monterey, Mexico, samples of water spiked with trace elements were prepared for analysis by X-Ray Fluorescence Spectrometry for several trace elements. Experiments were performed by a group of students from the University of Monterey.

F. Preconcentration of Water Samples for X-Ray Fluorescence Spectrometric Analysis and Neutron Activation Analysis

Personnel: A. H. Pradzynski, NETL

Sponsored by: Nuclear Engineering Teaching Laboratory

Description:

Previous work on determination of trace elements in water by XRF and NAA was continued. Investigation of a preconcentration method comprising APDC coprecipitation and pressure filtration was performed. The investigation was extended to samples of waste water and industrial effluent.

G. Advanced Analytical Chemistry - CH 376K

Personnel: J. Holcomb, Chemistry
A. H. Pradzynski, NETL

Sponsored by: Nuclear Engineering Teaching Laboratory

Description:

Undergraduate students in chemistry performed qualitative and quantitative determinations of several elements in samples by neutron activation analysis. The program of the class included: (a) sample preparation and encapsulation, (b) two irradiations in the TRIGA reactor, one for long half-life and another for short half-life radioisotopes, (c) measurements using a Ge-Li detector gamma spectrometer, (d) data processing using an on-line computer and (e) data evaluation and discussion of practical applications of NAA in analytical chemistry.

H. Determination of Selenium in Fish

Personnel: Elsie Sorensen, Memphis State University
A. H. Pradzynski, NETL
Thomas L. Bauer, NETL

Sponsored by: Nuclear Engineering Teaching Laboratory

Description:

During experiments on As accumulation in fish from a contaminated lake, another toxic element, Se has been found in the samples. Determinations of Se were done by Neutron Activation Analysis and Gamma

Spectrometry. Results were prepared for publication. Further experiments will be performed.

I. Analysis of Corrosion Material Accumulations on Structural Steel

Personnel: A. H. Pradzynski, NETL

Sponsored by: School of Architecture (Professor W.H. Hilbertz)

Description:

A steel grid samples showing accummulations of white corrosion products was examined by neutron activation analysis. Mg was determined quantitatively. Qualitatively Cl, Na, Mn and Cu were shown.

J. Determination of Br in RNA

Personnel: A. H. Pradzynski, NETL
Dr. B. Hardesty (Department of Chemistry)

Sponsored by: Department of Chemistry

Description:

Bromine in samples of RNA combined with cosine was determined by neutron activation analysis.

K. Determination of Sb in Styrene

Personnel: A. H. Pradzynski, NETL

Sponsored by: Department of Chemistry

Description:

Sb was determined in styrene samples by neutron activation analysis. Gamma photons of Sb^{122} and Sb^{124} were used for quantitative determinations. This was a fesibility study.

L. Construction of a Large Benjamin Counter

Personnel: Nolan E. Hertel, NETL
Richard Savage, NETL

Sponsored by: Texas Atomic Energy Research Foundation

Description:

A large spherical proton-recoil proportional counter is being constructed for use in measuring neutron energy spectra below 2 MeV. By differentiating proton-recoil spectra obtained with the detector filling gas (methane or hydrogen) at various pressures, an unknown neutron energy spectrum can be reconstructed. This detector will be used with an existing NE-213 spectrometry system to make possible neutron spectral measurements from 20 MeV down to approximately 10 keV. The two detection systems will then be employed in fusion energy related neutronics studies.

M. Measured Neutron and Gamma-Ray Spectra in a Tissue-Equivalent Medium

Personnel: Nolan E. Hertel, NETL
William E. Murphie, NETL

Sponsored by: Texas Atomic Energy Research Founation
Bureau of Engineering Research

Description:

An experimental fusion-neutron irradiation facility at Balcones Research Center was used to measure neutron and gamma-ray fields in a tank of tissue-equivalent liquid. A neutron generator was used to produce 14-MeV neutrons which impinge on one face of the tank. An NE-213 spectrometer was used to measure neutron and gamma-ray fluxes at various locations in the tank as a function of incident neutron flux. The project was useful in assessing the neutron-induced gamma-ray spectrum in tissue as well as the quality of the neutron and gamma-ray doses. The results provided information of relevance in cancer radiotherapy as well as in the determination of dose equivalent indices due to fusion neutrons.

N. Measurement of Gamma-Ray Spectra Resulting in Tissue from Bombardment with Neutron Radiotherapy Beams

<u>Personnel</u>: Nolan E. Hertel, NETL
James B. Smathers, UCLA
Robert G. Graves, University of Rochester

<u>Sponsored by</u>: National Institutes of Health: Public Health Service Grant CA12542 from the National Cancer Institute

Mechanical Engineering Department

<u>Description</u>:

Measurements of gamma-ray spectra produced in tissue-equivalent liquid when bombarded by 50-MeV d^+-Be and 42 MeV p^+-Be neutron beams have been performed. These measurements were done at the Texas A&M University Variable Energy Cyclotron using an NE-213 spectrometer. Analysis of the measurements will help to determine gamma-ray spectral distribution in tissue during radiotherapy treatment. These spectral distributions are currently being used to calculate the average gamma-ray energy as well as the average gamma-ray mass-energy-absorption coefficient.

O. High-Energy Neutron Transport Studies

<u>Personnel</u>: Nolan E. Hertel, NETL
Regina Laucius, NETL

<u>Sponsored by</u>: National Science Foundation

<u>Description</u>:

The principal thrust of this project is to develop the capability to routinely and accurately measure high-energy neutron spectra from 1 to 50 million electron volts (MeV). An effective means of performing such measurements is to utilize the recoil pulse-height data from an organic scintillation detector. The reconstruction of the unknown neutron spectrum from the recoil data requires the use of a matrix describing the detector's response to monoenergetic neutrons over the energy range of interest. To meet this need, a neutron response matrix from 1 to 50 MeV is being constructed from recent neutron time-of-flight data. The resulting unnormalized experimental pulse-height distribution data will be used in conjunction with various computer codes to form the matrix. This matrix can then be applied with existing unfolding codes to reconstruct unknown energy spectra. High-energy spectral measurements could be made using this technique at neutron radiotherapy facilities and intense neutron source facilities such as fusion materials radiation damage facilities.

P. An Analysis of the High-Level Waste Streams from Fuel Cycles Using Fissile-Fuel Producing Fusion Reactors

Personnel: N.E. Hertel, NETL
J.W. Davidson, NETL

Sponsored by: Texas Atomic Energy Research Foundation

Description:

Fissile fuel may be produced or bred in fusion reactors by surrounding the fusion neutron source with a blanket containing a fertile material such as ^{232}Th. The end product of neutron absorption in this material is the fissile nuclide ^{233}U which may be used to fuel fission power reactors. A by-product of breeding this fuel is the accompanying fission of the fertile and fissile materials. Both neutron capture and fission reactions produce radionuclides which would constitute a high-level waste stream similar to that from fission reactors. The fission level can be maximized by appropriate blanket designs to increase the power of the fusion reactor; such a device is called a fusion-fission hybrid. The fission level could be minimized to reduce fission product waste; this type of device would be a symbiotic fusion reactor. The fuel bred in either of these devices could be used to fuel existing fission reactors. The high-level waste streams from fuel cycles incorporating a fissile-fuel producing fusion reactor and its client fission reactors are being investigated for the ^{232}Th - ^{233}U fuel cycle.

Q. Modification of COBRA-4

Personnel: Dale Klein, NETL
Tom Sanders, NETL

Sponsored by: General Atomic Company
Center for Energy Studies

Description:

The transient version of the thermal-hydraulic computer code COBRA-4 is being modified. Considerable modifications have been made to COBRA-4 to enhance its application for analyzing Gas Cooled Fast Breeder Reactor (GCFR) transients. This includes new numerical techniques to speed up calculations. Further analysis of the model is needed prior to the examination of long transient GCFR applications. This is the second year of a three-year project.

R. Thermal Analysis of a Spent Fuel Shipping Cask in an Engulfing Fire

Personnel: Dale Klein, NETL
James E. Hamann, NETL

Sponsored by: Sandia Laboratories

Description:

A thermal analysis using the computer code HEATING5 is underway to predict the temperature distribution in a nuclear fuel shipping cask. Results from this detailed model will be compared with data from a full scale thermal test conducted by Sandia. The Sandia test involved a full-scale shipping container in an engulfing fire for more than 120 minutes. The HEATING5 model enables thermal analysis for a 3-dimensional transient system where a change in phase occurs. Although this project is directly applicable for a spent-fuel shipping cask, other heat transfer systems can be examined. This is the second year of a two year study.

S. Heat Transfer through Random Packed Beds by Using the Monte Carlo Method

Personnel: Dale Klein, NETL
John R. Howell, Mechanical Engineering
Sam Yang, NETL

Sponsored by: Center for Energy Studies

Description:

This study examines the constricted heat flow in packed beds of spherical particles. The packing pattern is obtained by a numerical simulation that provides the bulk solid fraction, the contact-number frequency function and the angular distribution of contacting spheres. The contact resistance is calculated by the Holm formula based on the packing simulation. The effective conductivity can be determined by statistical methods. Results from this investigation will be applied to a thermal analysis of a pebble bed nuclear reactor core.

T. Heat Transfer and Friction Factor Analysis for Artifically Roughened Surfaces

Personnel: Dale Klein, NETL
J. Parker Lamb, Mechanical Engineering
Mike Krause, NETL
Gary Polansky, Mechanical Engineering

Sponsored by: Center for Energy Studies
National Science Foundation

Description:

The proposed research is to determine the heat transfer and friction characteristics for surfaces with discrete roughness geometry. Two major aspects are to be examined in that this is both an experimental and an analytical investigation. Values of $R(h^+)$ and $G(h^+)$ in the universal velocity and temperature profiles will be examined. New experimental techniques have been developed at The University of Texas at Austin to measure local heat transfer values surrounding discrete roughness elements. A test assembly to examine artifically roughened surfaces is being designed. In addition, a new analytical method has also been developed to determine $R(h^+)$ and $G(h^+)$ values without making detailed velocity and temperature profile measurements. Analytical predictions will be made utilizing fundamental parameters in boundary layer theory coupled with the latest information on rough surfaces using integral techniques. Results from the experimental and analytical methods will be compared in order to gain insight as to the dominant mechanism involved for the use of discrete rough surfaces. This research has fundamental application for heat transfer augmentation. Primary application includes heat exchangers and the Gas Cooled Fast Breeder Reactor (GCFR). The modeling will be directed towards the GCFR design conditions. This is the fourth year of a seven year study.

U. Structural Activation in Fusion Devices

Personnel: Dale Klein, NETL
Danny Smith, NETL

Sponsored by: Texas Atomic Research Foundation

Description:

The primary thrust of the current work in the area of structure activation in fusion devices involves the development of capabilities for characterizing the neutron flux in the various regions of the devices to be examined. Computer codes are available for one-dimensional neutron transport calculations and other codes are being adapted to The University of Texas computer system which will allow two-dimensional transport analysis. Other aspects of this work include the selection of the specific devices to be investigated, formulation of better methods for characterizing the potential hazard of the radioisotopes generated and examination of techniques for minimizing the total hazard of the radioisotopes generated.

V. Finite Elements in Radiative Heat Transfer in Asborbing/Emitting Medium

Personnel: Dale Klein, NETL
Muhammad Razzaque, NETL

Sponsored by: Texas Atomic Energy Research Foundation

Description:

The transfer of heat through materials that attenuate radiation is mathematically difficult to model. The finite element method is being used in an effort to solve such problems as heat transfer by radiation through hot gases in gas-cooled reactors, industrial furnaces or a fusion plasma. Successful application may allow design of more efficient devices of their associated heat transfer components.

W. Pebble Bed Breeding Blanket for a D-T Fusion Reactor

Personnel: J.W. Davidson, NETL
Dale Klein, NETL
Brian Gantt, NETL

Sponsored by: Texas Atomic Energy Research Foundation

Description:

An analysis is underway to examine the feasibility of incorporating an advanced fuel handling scheme to the blanket region of a hybrid fusion reactor. The fuel is that used in a Pebble Bed Reactor (PBR) and both initial enrichment and regeneration of the fuel is being considered. The Th-232/U-233 fuel cycle used in the PBR would require a fresh or spent thorium feed to the hybrid blanket. The fertile material would be circulated through the blanket, removed, and returned to a position determined by both the current U-233 concentration and the available neutron spectra and flux levels in the blanket. Problems involve integrating a pebble bed blanket to currently envisioned fusion reactor designs and determination of optimum recirculation schemes. Detailed neutronic analysis for the various blanket concepts will be made using computer codes presently available in the Nuclear Engineering Teaching Laboratory.

X. Neutronic and Heating Analysis of Accelerator Targets and Blankets

Personnel: J.W. Davidson, NETL

Sponsored by: Texas Atomic Energy Research Foundation
Center for Energy Studies

Description:

Both the breeding of fissile material and the transmuation of high-level nuclear waste appear to be attractive uses for neutrons produced with accelerators. Neutrons produced through spallation reactions in an accelerator target offer potentially high source strengths at a modest energy input. Recent advances in accelerator technology should allow construction of smaller, lower cost accelerators with increased beam currents. Calculation of the neutron transport in the target and surrounding blanket for incident particle energies of several hundred GeV require a complex computational ability. This research involves the development of a computational package with which neutron and charged particle transport in targets and neutron transport in blankets may be accurately determined in a coupled mode along with heat deposition rates in both regions.

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