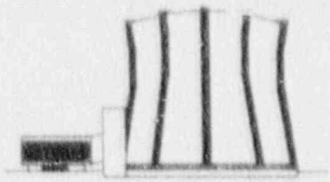
TEXAS ENGINEERING EXPERIMENT STATION

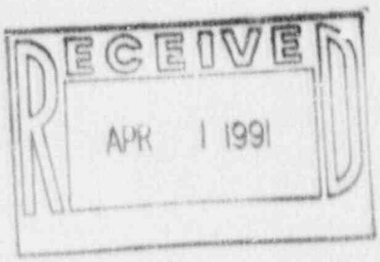
TEXAS A&M UNIVERSITY

COLLEGE STATION, TEXAS 77843-3575



NUCLEAR SCIENCE CENTER
409/845-7551

27 March 1991



Mr. A. Bill Beach, Director
Division of Radiation Safety and Safeguards
U.S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Reference: Docket No. 50-128
Facility License No. R-83

Subject: Submittal of the NSCR Annual Report for the Period January 1, 1990 - December 31, 1990

Dear Mr. Beach:

In accordance with the reporting requirements of Technical Specification 6.6.1 for the Nuclear Science Center Reactor, Texas Engineering Experiment Station, Texas A&M University System, I hereby submit three copies of our annual report for the period of January 1, 1990 - December 31, 1990.

Sincerely,

Donald E. Peltz
Director

DEF/ym

Enclosures

IE47
1/1

Form AEC-427
(6/70)
AECM 3201

U.S. ATOMIC ENERGY COMMISSION
UNIVERSITY-TYPE CONTRACTOR'S RECOMMENDATION FOR DISPOSITION OF SCIENTIFIC AND TECHNICAL DOCUMENT

(See Instructions on Reverse Side)

1. AEC REPORT NO.

ORO-4207-23

2. TITLE

Twenty-Seventh Progress Report of the Texas Engineering Experiment Station, Texas A&M University System, Nuclear Science Center

3. TYPE OF DOCUMENT (Check one):

- ☐ a. Scientific and technical report
- ☐ b. Conference paper not to be published in a journal:
  - Title of conference
  - Date of conference
  - Exact location of conference
  - Sponsoring organization
- ☒ c. Other (Specify) Facility Annual Progress Report (1990) USNRC License R-83, Docket No. 50-128

4. RECOMMENDED ANNOUNCEMENT AND DISTRIBUTION (Check one):

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- ☐ c. Make no announcement or distribution.

5. REASON FOR RECOMMENDED RESTRICTIONS:

6. SUBMITTED BY: NAME AND POSITION (Please print or type)

Donald E. Feltz, Director

Organization

Nuclear Science Center
Texas Engineering Experiment Station
Texas A&M University System

Signature Donald E Feltz

Date 3/27/91

FOR AEC USE ONLY

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- ☐ b. Report has been sent to responsible AEC patent group for clearance.
- ☐ c. Patent clearance not required.

INSTRUCTIONS

Who uses this Form: AEC contract administrators will designate the AEC contractors who are to use this Form. Generally speaking, it will be used by educational institutions and other "not for profit" institutions. AEC National Laboratories and other major contractors will generally use the longer Form AEC-426.

When to use this Form: AEC contractors are required under their contracts to transmit specified types of documents to the AEC. Some, but not all, of these are transmitted by AEC contract administrators to AEC's Division of Technical Information Extension (DTIE) and may be incorporated into AEC's technical information documentation system. Types of documents which will be transmitted to DTIE are identified in instructions which the contractor receives from his contract administrator. Each such document is to be accompanied by one copy of this transmittal Form recommending to DTIE appropriate announcement and distribution of the document. Documents which the contractor may be required to submit to the AEC under his contract but which are not of the type to be transmitted to DTIE, e.g., contract proposals, should not be accompanied by a copy of this transmittal Form.

Where to send this Form: Send the document and the attached Form AEC-427 to the AEC contract administrator for transmittal to DTIE unless the AEC contract administrator specifies otherwise.

Item instructions:

Item 1. The first element in the number shall be an AEC-approved code. This may be a code which is unique to the contractor, e.g. MIT, or it may be the code of the AEC operations office, i.e., NYO, COO, ORO, IDO, SRO, SAN, ALO, RLO, NVO. The contract administrator will specify the code which is to be used.

The code shall be followed by a sequential number, or by a contract number plus a sequential number, as follows: (a) Contractors with unique codes may complete the report number by adding a sequential number to the code, e.g., MIT-101, MIT-102, etc.; or they may add the identifying portion of the contract number and a sequential number, e.g., ABC-2105-1, ABC-2105-2, etc.; (b) Contractors using the operations office code shall complete the report number by adding the identifying portion of the contract number and a sequential number, e.g., NYO-2200-1, NYO-2200-2, etc. Subcontractor reports shall be identified with the code used by the prime contractor.

Item 2. Give title exactly as on the document itself.

Item 3. If box c is checked, indicate type of item being sent, e.g., thesis, translation, etc.

Item 4. The "normal announcement and distribution procedures" for unclassified documents may include abstracting in "Nuclear Science Abstracts" (NSA); and distribution to appropriate TID-4500 ("Standard Distribution for Unclassified Scientific and Technical Reports") addressees, to libraries which through purchase of microfiche maintain collections of AEC reports, and to the Clearinghouse for Federal Scientific and Technical Information for sale to the public. Check 4b or 4c if there is need for limiting announcement and distribution procedures described above. The normal expectation is that there should seldom be a necessity to check 4c.

Item 5. If 4b or 4c is checked, give reason for recommending announcement or distribution restrictions, e.g., "preliminary information", "prepared primarily for internal use", etc.

Item 6. Enter name of person to whom inquiries concerning the recommendations on this Form may be addressed.

Item 7. AEC contract administrators may use this space to show concurrence or nonconcurrence with the recommendation in item 4 and to make other recommendations.

Item 8. AEC contract administrator or patent group representative should check a, b, or c, and forward this Form and the document to:

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ORO-4207-23

TWENTY-SEVENTH PROGRESS REPORT
OF THE
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER
JANUARY 1, 1990-DECEMBER 31, 1990
CONTRACT DE-AC05-76ER04207

NUCLEAR SCIENCE CENTER
TEXAS ENGINEERING EXPERIMENT STATION
ENGINEERING PROGRAM
TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS

TWENTY-SEVENTH PROGRESS REPORT

of

TEXAS ENGINEERING EXPERIMENT STATION
TEXAS A&M UNIVERSITY SYSTEM
NUCLEAR SCIENCE CENTER

Facility License No. R-83
Docket No. 50-128

January 1, 1990 - December 31, 1990

Prepared by

The Nuclear Science Center Staff

Submitted to
U.S. Nuclear Regulatory Commission
and
U.S. Department of Energy
and
The Texas A&M University System

By

D. E. Feltz, Director
Nuclear Science Center
Texas Engineering Experiment Station
College Station, Texas

March, 1991

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List of Tables and Figures

I. INTRODUCTION

The Nuclear Science Center is operated by the Texas Engineering Experiment Station as a service to the Texas A&M University System and the State of Texas. The Nuclear Science Center provides services to researchers and/or faculty from Texas A&M University, other colleges and universities, government agencies and private industry. The Nuclear Science Center is recognized primarily for providing radioisotopes and other nuclear irradiation services for research, academic, medical and industrial applications and as a teaching and nuclear training facility. The facility operating license, R-83 issued by the U.S. Nuclear Regulatory Commission, currently extends through March, 2003.

This report has been prepared by the staff of the Nuclear Science Center of the Texas Engineering Experiment Station to satisfy the reporting requirements of Technical Specification 6.6.1 to the facility operating license R-83 and of U.S. DOE Contract #DE-AC05-76ER04207 (formerly EY-76-C-05-4207) and 10CFR50.59. The report covers the period from January 1, 1990 through December 31, 1990.

Total operating hours of the reactor increased over 1989 values. The total experiment hours were much higher than 1989 with an increase in sample irradiation hours. Irradiation experiments continued to increase and there was a decrease in irradiation cell and beam port experiment hours compared to 1989. Beam port utilization was down due to the unavailability of the beam ports during upgrades that were being performed. Commercial utilization and the number of tours decreased slightly.

Core VIII-A, which has been operational since March 1986, was used throughout 1990. Pulse operations were continued at a low level in 1990 with a total of 30 pulses ($43.15 total pulse reactivity) executed. As in the previous few years, pulsing operations were performed only for calibrations and laboratory demonstrations.

There were no changes made to the site area during this reporting period and no changes were made to the security or emergency plans.

A license change to R-83 was approved this year which modifies the NSCR line management structure. The NSC Radiation Protection Office now reports directly to the Deputy Director of TEES and works in cooperation with the NSC staff.

II. REACTOR UTILIZATION

A. Utilization Summary

Utilization of the NSCR for the 1990 calendar year is illustrated by Figure I and Table I. Figure I shows the annual totals for reactor operation for the years 1975 through 1990. During the present reporting period the NSCR was utilized by over 400 students (including 17 researchers) and 32 faculty and staff members representing 15 departments at Texas A&M University. In addition, more than 180 faculty and students from 15 other educational institutions used the facilities and 2,998 visitors were registered during 1990. A total of 17 non-educational organizations utilized the NSCR during the year for their commercial and research applications.

During twenty-nine years of operation, the NSC has provided services to 47 departments at Texas A&M University, 115 other colleges and universities, 107 industrial organizations, and 27 governmental and medical organizations (see Appendix III and IV for listings).

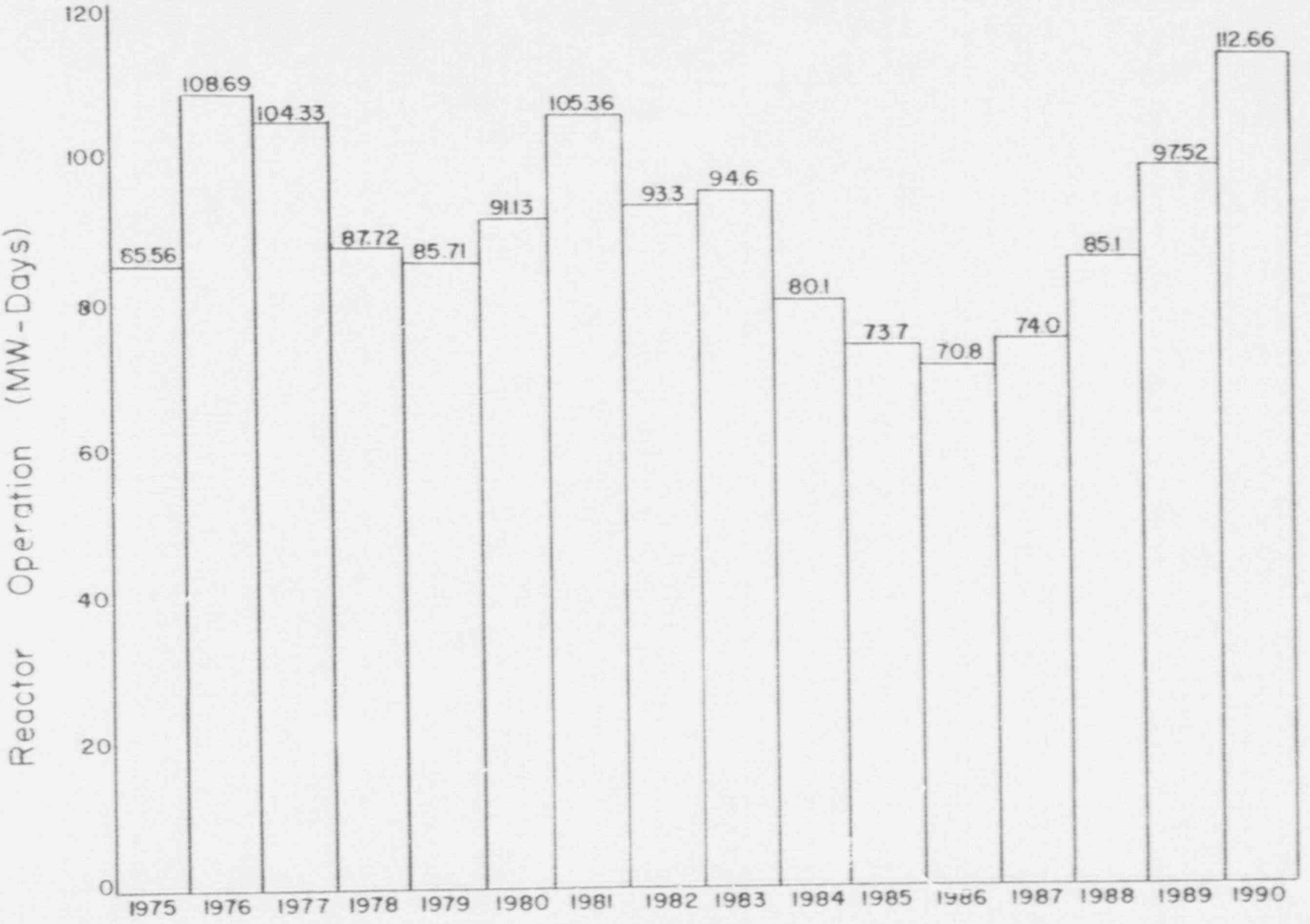

Figure 1. Yearly Reactor Operation

TABLE I

REACTOR UTILIZATION SUMMARY

	1990 Annual Total
*Number of Days Reactor Operated	253
Reactor Operation (MW-Days)	112.658
Number of Hours at Steady State	2812.451
Average Number of Operating Hours Per Week	56.249
Total Number of Pulses	30
Total Pulse Reactivity Insertion	$43.15
Number of Irradiations	652
Number of Samples Irradiated	9739
Sample Irradiation Hours	76,170.094
Average Number of Irradiations per Operating Day	2.577
Irradiation Experiment-Hours	9458.164
Beam Port Experiment-Hours	238.45
Irradiation Cell Experiment Hours	26.814
Total Experiment Hours	9723.428
Fraction of Utilization Attributable to Commercial Work	.34
Number of Visitors	2998

*Note: 50 Weeks of Operation Available

The NSCR was converted in August 1968 from the use of MTR plate fuel to TRIGA fuel with pulsing capability. Since the conversion both Standard TRIGA and FLIP TRIGA fuels have been used and at present the NSCR core has a full FLIP TRIGA loading. Since the initial use of TRIGA fuel the total energy produced by operations is 2,037.883 Mw-Days.

B. Utilization by the Texas A&M University System

During 1990 the following personnel from various departments at Texas A&M University used the NSCR for research. Appendix I describes some of the projects completed.

Animal Science

Faculty: Dr. W. C. Ellis, Professor

Students: L. Cabello
M. Hill
G. Stout

Anthropology

Faculty: Dr. D. B. Dickson

Student: G. Fox

Center for Chemical Characterization and Analysis (CCCA)

Staff: Dr. E. Schweikert, Professor
Dr. D. James, Research Chemist
M. Raulerson, Technician

Student: R. Betts

Chemistry Department

Faculty: Dr. M. W. Rowe, Professor
Dr. C. Martin

Student: C. Brumlik

Geology Department

Faculty: Dr. T. Tieh, Professor
V. Harder, Lecturer

Student: M. Denham

Geophysics Department

Faculty: Dr. N. Carter, Professor

Students: A. Huffman
T. Oldham

Horticulture Science Department

Faculty: C. Gonzalez

Student: M. Drew

Mechanical Engineering Department

Faculty: Dr. D. Bray, Associate Professor

Nuclear Engineering Department

Faculty: Dr. J. W. Poston, Professor and Head
Dr. R. R. Hart, Professor
Dr. D. W. James, Associate Professor
Dr. M. E. McLain, Associate Professor
Dr. T. A. Parish, Associate Professor
Dr. J. A. Reuscher, Professor

Students: NE 606 Class
NE 405 Class
S. Midgett
J. Wright
K. Seager

Nuclear Science Center

Staff: J. Reuscher, Director, Nuclear Research Reactor Programs
J. Krohn, Assistant Director and Manager of Technical Services
N. Khalil, Research Associate
G. Stasny, Reactor Supervisor
D. Deere, Research Associate
J. Petesch, Reactor Supervisor
B. Asher, Reactor Supervisor
C. Meyer, Health Physicist
M. Brown, Health Physicist

Oceanography Department

Faculty and Staff: Dr. B. J. Presley, Professor
Dr. P. Boothe, Asst. Research Scientist
Dr. R. J. Taylor, Research Associate

Physics Department

Faculty: Dr. J. A. McIntyre, Professor

Students: R. Seidel

Range Science

Faculty: Dr. R. Knight

Student: R. Lyons

Radiological Safety Office

Staff: Dr. M. E. McLain, Radiological Safety Officer
J. Simek, Assistant Radiological Safety Officer
C. Meyer, Senior Health Physicist

Veterinary Physiology and Pharmacology

Faculty: Dr. D. Hightower, Professor

Students: A. Komkov
P. Hulkovich

In addition to the research performed by the above personnel, the NSCR was used as an educational aid in numerous courses at Texas A&M. Table II lists the academic courses utilizing the reactor and their use.

TABLE II

Academic Use of the Reactor

Department	Course No.	Instructor	No. of Students and Purpose
Animal Science	603	Ellis	9-Tour/Class
Chemistry	116	Kolar	88-Tour/Class
	491	Hogg	14-Tour
Industrial Engineering	683	Konzen	8-Tour/Class
Mechanical Engineering	461	Fletcher	9-Tour/Class
Nuclear Engineering	201	Bolch	10-Tour/Demo
	405	Schlapper	9-Lab/Class
	479	Schlapper	10-Tour
	606	Reuscher	9-Lab/Class
	679	Meyer	7-Tour/Class
	680	McLain	8-Tour/Class
Oceanography	640	Boothe	14-Tour
Physics	351	McIntyre	32-Tour
Plant Pathology and Microbiology	607	Lyda	10-Tour

C. Utilization by Other Educational Institutions (U.S. DOE Contract, #DE-FG07-80ER10732 - Reactor Sharing)

In addition to Texas A&M University, services were provided to the following educational institutions through the Department of Energy Reactor Sharing Program. A description of some of the projects utilizing the reactor is presented in Appendix I.

Baylor University -- Waco, Texas

Faculty: Dr. K. Wang, Professor of Physics

Students: Physics Class

Louisiana State University -- Baton Rouge, Louisiana

Faculty: Dr. R. M. Knaus
Dr. L. Foil
Dr. C. Issel

Students: D. Von Gent
K. Sweeney
B. Elkins

Louisiana Tech -- Ruston, Louisiana

Faculty: Dr. R. Thompson

Students: A. Bebahani
B. Griffis

McLennan Community College -- Waco, Texas

Faculty: Mr. D. Tatum, Instructor of Physics

Students: Physics Class

McNeese State -- Lake Charles, Louisiana

Faculty: Dr. J. Beck

Students: K. Stacks
K. Martin

Miami University -- Oxford, Ohio

Faculty: Dr. K. Crowley

Southern Methodist University -- Dallas, Texas

Faculty: Dr. S. Kelley
Dr. K. Damm

Students: K. Geving
L. Carter

Sul Ross State University -- Alpine, Texas

Faculty: Dr. D. Nelson
Dr. J. Richerson
Dr. M. McCurry

Lab Direct . L. Forsythe

Texas State Technical Institute -- Waco, Texas

Faculty: Mr. R. Wheet, Instructor
Ms. G. Martini
Ms. L. Morris

Students: Nuclear Technology Classes

University of Houston -- Houston, Texas

Faculty: J. Liu

University of Illinois --

Student: M. Flower

University of New Hampshire -- Durham, New Hampshire

Faculty: A. Conners
J. Macri

University of Okalahoma -- Norman, Oklahoma

Faculty: Dr. B. Weaver

Students: J. Aquilar
P. Anderson

University of Southwestern Louisiana -- Lafayette, Louisiana

Faculty: Dr. J. Meriwether

Student: K. Kie

University of Texas -- Austin, Texas

Faculty: Dr. F. Iskander
P. Schmidt
J. Corrigan
L. White

University of Texas -- El Paso, Texas

Faculty: E. Anthony

Public and Private School Tours	No. of Students
A&M Consolidated -- College Station, TX	79
Bammel High School -- Houston, TX	40
Baylor University -- Waco, TX	7
Bryan/College Station Science Teachers	58
Buckholts High School -- Buckholts, TX	18
Cameron Jr. High School -- Cameron, TX	14
Carver Middle School -- Bryan TX	30
Conroe Home School -- Conroe, TX	56
Centerville High School -- Centerville, TX	17
Coolidge High School -- Coolidge, TX	4
Cypress Creek High School -- Houston, TX	60
Cy Fair High School -- Houston, TX	21
Del Valle High School -- Austin, TX	38
East Texas State University -- Commerce, TX	13
Engineering Program for Minorities -- TAMU	36
Hardin Jefferson High School -- Sour Lake, TX	23
High School Teachers -- Various	26
Honors Program -- TAMU	24
Jane Long Jr. High -- Bryan, TX	36
Jeff Davis High School -- Houston, TX	26
Jersey Village High School -- Houston, TX	75
Jets Chapters -- Needville & San Antonio, TX	75
Keystone High School -- San Antonio, TX	20
Lamar School -- Bryan, TX	135
Lumberton High School -- Lumberton, TX	34
McCullough High School -- Woodlands, TX	37
McLennan County Community College -- Waco, TX	24
Moody High School -- Moody, TX	22
Pearsall High School -- Pearsall, TX	8
Queen City High School -- Queen City, TX	11

Public and Private School Tours (cont'd)	No. of Students
Rockdale High School -- Rockdale, TX	40
Sam Rayburn High School -- Pasadena, TX	35
Sharpstown High School -- Houston, TX	35
Stephen F. Austin University -- Nacogdoches, TX	36
Teague High School -- Houston, TX	36
Temple High School -- Temple, TX	15
Tyler Jr. College -- Tyler, TX	31
Wells Middle School -- Houston, TX	44
Woodville High School -- Livingston, TX	27
York Jr. High School -- Conroe, TX	48

D. Utilization by Non-University Institutions

AAE/BCS Traders -- Globe, Arizona

Experimenter: D. Williams

Ankha Nuclear Industries

Experimenter: J. Griedanus

Brown and Associates -- College Station, Texas

Experimenter: J. Fares

Gulf Nuclear -- Houston, TX

Experimenter: M. Skinnner

Kearfott Guidance and Navigation -- Little Falls, New Jersey

Experimenter: L. Breen

M. D. Anderson Hospital -- Houston, Texas

Experimenter: Dr. J. Cundiff

Methodist Hospital -- Houston, Texas

Experimenter: Dr. W. Cole

Poretics Corporation -- Bryan, Texas

Experimenters: E. Hubbard
G. Stasny

Racon -- Tyler, Texas

Experimenters: R. Heine
K. Munn

R/A Services -- Odessa, Texas

Experimenter: D. Hicks

Shell Development Company -- Houston, Texas

Experimenter: W. Stringfellow

Pro-Technics II, Inc. -- Houston, Texas

Experimenter: M. Brewer

Teledyne -- Westwood, New Jersey

Experimenter: A. Skaar

Texas Instruments -- Dallas, Texas

Experimenters: C. Blackburn

Tracerco, Inc. -- Houston, Texas

Experimenters: R. Gilman
D. Bucior

TRW-EDS -- Redondo Beach, California

Experimenters: D. Randall
T. Lunn

Tru-Tec -- LaPorte, Texas

Experimenters: C. Winfield
J. Landry

III. REACTOR AND FACILITY OPERATIONS

A. Changes Pursuant to the Requirements of 10CFR50.59

In accordance with the requirements of 10CFR50.59, changes to the facility and procedures and changes in the conduct of tests and experiments that occurred during the reporting period were reviewed and documented. It was concluded that these changes do not constitute a change in the Technical Specifications, do not present an unreviewed safety question, and do not increase the probability of an accident previously analyzed in the NSCR Safety Analysis Report. It was concluded that these changes do not increase the possibility that an accident or malfunction of a different type than any evaluated previously will be created, and do not reduce the margin of safety as defined in the bases for any Technical Specification.

1. Changes to the Reactor Systems

Shim Safety Potentiometer Replacement

The coarse incremental adjustment of the existing potentiometers that control the amount of current to the shim safety control rod electro-magnets made it difficult to set desired current levels. Also, a special purchase order had to be made anytime it was necessary to replace the potentiometers. Therefore, the potentiometers were replaced with locally available potentiometers that use a multi-turn adjustment and have the same milliamp adjustment range, ohm rating, and mounting structure as the old potentiometers.

2. Changes to Experimental Facilities

Real-Time Radiography Capabilities with Beam Port 4

Dr. Jon Reuscher, Professor, and Director, Nuclear Research Reactor Programs, designed and implemented a real-time radiography program for the facility. Changes were made to the Beam Port 4 cave to allow access for the handling of radiographed samples. The cave now has a movable shield block which covers an access opening on top of the cave. The Beam Port water shutter control circuitry provides an interlock to flood the shutter if the shield block is moved from its closed position during beam port operations. A "C-2" high radiation area personnel access monitoring system was installed at the shield block cave opening. This system is activated when the shield block is not in it closed position. Several different objects have been successfully radiographed in the cave with no adverse radiological consequences.

Changes to the Thermal Column Shielding

The Poretics take-up spool box is now shielded by a movable shield fabricated of steel plates and having a leaded glass window to allow viewing of the take-up roll. The existing shield blocks, Thermal Column Door, and fencing were extended to provide room for movement of the take-up spool box shield. Use of the movable shield has reduced personnel radiation exposures.

Beam Port 1 Safety Improvements

An interlock for the Beam Port 1 water shutter was added to the Beam Port 1 area entry gate. If the gate is opened during beam port operation, the water shutter will flood. Flooding of the water shutter provides additional protection against undue personnel radiation exposures.

3. Changes to the NSC Facility

Addition of a Volume Meter to the Liquid Waste Holdup Tanks

A volume meter has been added to the raw water supply line to the liquid holdup tanks. This was added to more accurately determine dilution to the radioactive liquid waste released to White Creek. Past reported radioactivity release concentration levels have been conservative without this information. The meter therefore enables the NSC to improve the accuracy of reporting liquid waste release concentrations.

4. Changes to Standard Operating Procedures (SOP's)

Changes to the following SOP's were reviewed and approved by the Reactor Safety Board during the reporting period:

SOP's

I-A	Definitions and Abbreviations
I-C	Administration
I-H	The Reactor Safety Board
II-A	General Organization and Responsibilities
II-J	Power Calibration
Figure II-J-1	NSC Form 591, Power Calibration
IV-F	Neutron Radiography Beam Port 4
Figure IV-H-4	Fission Product Filter System Valving Chart
Figure VI-C-1	NSC Form 582 - Electrical Power Failure Checklist

SOP's (cont'd)

VII-A	Health Physics Administration Procedures A1, A2, A4, A5
VII-B	Health Physics Maintenance and Surveillance Procedures B2, B3, B4, B5, B6, B7, B8, B9, B10, B11, B12, B13, B14, B15, B16
VII-C	Radioactive Materials Control Procedures C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C14, C15
VII-D	Health Physics Training - Radiation Safety Procedure D1
VIII-E	Personnel Dosimetry E1

B. Reactor Maintenance and Surveillance

1. The Technical Specification requirements for maintenance and surveillance were completed for all required channels as follows:

   Fuel Element Temperature Measuring Channel
   Linear Power Channel
   Log Power Channel
   High Power (Safety) Channels
   Facility Air Monitoring Channels
   Area Radiation Monitoring Channels

2. All control rods were calibrated during annual maintenance performed in January, 1990 with a total rod worth of $16.32 and a shutdown margin of $2.68.

3. The power level (linear) channel was calibrated by the calorimetric method on 1/8/90.

4. The rod scram time checks resulted in times less than the Technical Specification limit of 1.2 seconds.

5. Fuel elements requiring inspection were inspected by 8 January 1990.

6. The pulse measuring channel was calibrated on 2/1/90. Pulse operation parameters are verified semi-annually by pulsing the reactor for comparison of pulse energy and fuel temperature to previous pulse operation values.

   The maximum allowable pulse reactivity insertion is $2.09 for Core VIII-A as determined by a pulse test program. An administrative limit of $1.90 is imposed for pulse operations.

7. The reactivity worth for each experiment was measured or estimated as appropriate before performance of the experiment. The most reactive fixed experiment is the Thermal Column coupler with a value of $1.35.

8. The annual facility evacuation drill and staff emergency response was conducted on 4/9/90.

9. A review of the NSC security plan and emergency plan was conducted by the NSC staff prior to the Reactor Safety Board review conducted on 2/19/90.

10. A review of the NSC ALARA program was conducted by the NSC staff prior to the Reactor Safety Board review conducted on 2/19/90.

All other required maintenance as set forth in the Technical Specifications was performed annually, semi-annually, or weekly as required. This was in addition to completion of a pre-startup check-list done daily prior to reactor operation, and other daily checks.

C. Unscheduled Reactor Shutdowns

A total of thirteen unscheduled shutdowns occurred during 1990. The unscheduled shutdowns were caused by the following:

Six shutdowns caused by a complete power failure to the facility.

One shutdown when Shim Safety #4 inadvertantly dropped when approaching 1 MW power. No reactor scram signals were received.

One shutdown initiated due to Shim Safety #4 dropping when magnet current drifted low.

One shutdown due to a sample upon removal being passed near the Safety Channel #1 detector. The high gamma level of the sample produced a high reading on the Safety Channel #1 detector. The sample removal was performed following a reduction in reactor power of 40% as required.

One shutdown due to a short to ground in the Beam Port #4 cave door interlock circuitry. This occured during installation of the Beam Port Cave top shield door circuitry and with the reactor outside the beam port/thermal column rail stop.

One manual shutdown was initiated by action of the SRO when an object was accidently dropped into the pool near the reactor frame and having the potential to settle on top of the reactor core. The object did not strike the core and came to rest on the bottom of the pool.

One shutdown when a reinstalled indicator light switch on the reactor console short circuited resulting in a power loss to the Log-N measuring channel.

One shutdown due to Shim Safety #4 dropping while shim safety control rods were being banked at 1 MW. Suspected cause was an unclean armature.

D. Reportable Occurrence

Reportable Occurrence 90-01
Intermittent Loss of Signal to the Linear Power Channel

An intermittent loss of signal to the Linear Channel occurred on 2/28/90. Upon investigation, the apparent cause was a corroded connector. After replacing the connector, the detector channel was tested for operability and the reactor was delcared operational following the performance of a pool calorimetric reactor power calibration measurement.

IV. FACILITY ADMINISTRATION

A. Organization

The organization chart for reactor operations at the Nuclear Science Center is presented in Figure 2. During this reporting period Bill F. Asher joined the NSC staff filling the position of the Day Reactor Supervisor. James C. Luther terminated as a full-time Senior Reactor Opertor in December. James E. Petesch retired and later rehired on a part-time basis. It is anticipated that Mr. Petesch will return to full-time employment in 1991.

During the past year, Bill F. Asher and James C. Luther received Senior Reactor Operator licenses.

The organizational chart for administration of the NSCR is illustrated by Figure 3. This is the new administration structure defined by Ammendment 12 to USNRC License R-83. The new license structure provides for line management by the licensee of NSC health physics requirements. The newly created NSC Radiation Protection Office reports directly to the Deputy Director of TEES. Representatives of the University Office of Radiological Safety had previously been responsible for the health physics program at the NSC. Martha P. Brown was hired on June 1, 1990 to develop and implement a health physics program at the NSC under the new administrative structure.

B. Personnel

The following is a list of personnel at the Nuclear Science Center for the period of January 1, 1990 - December 31, 1990.

Facility Administration and Reactor Operations Staff

+Asher, B. F.	- Reactor Supervisor
+Brightwell, M. S.	- Reactor Operator
+Feltz, D. E.	- Director
+Ives, T. W.	- Manager of Reactor Opeations

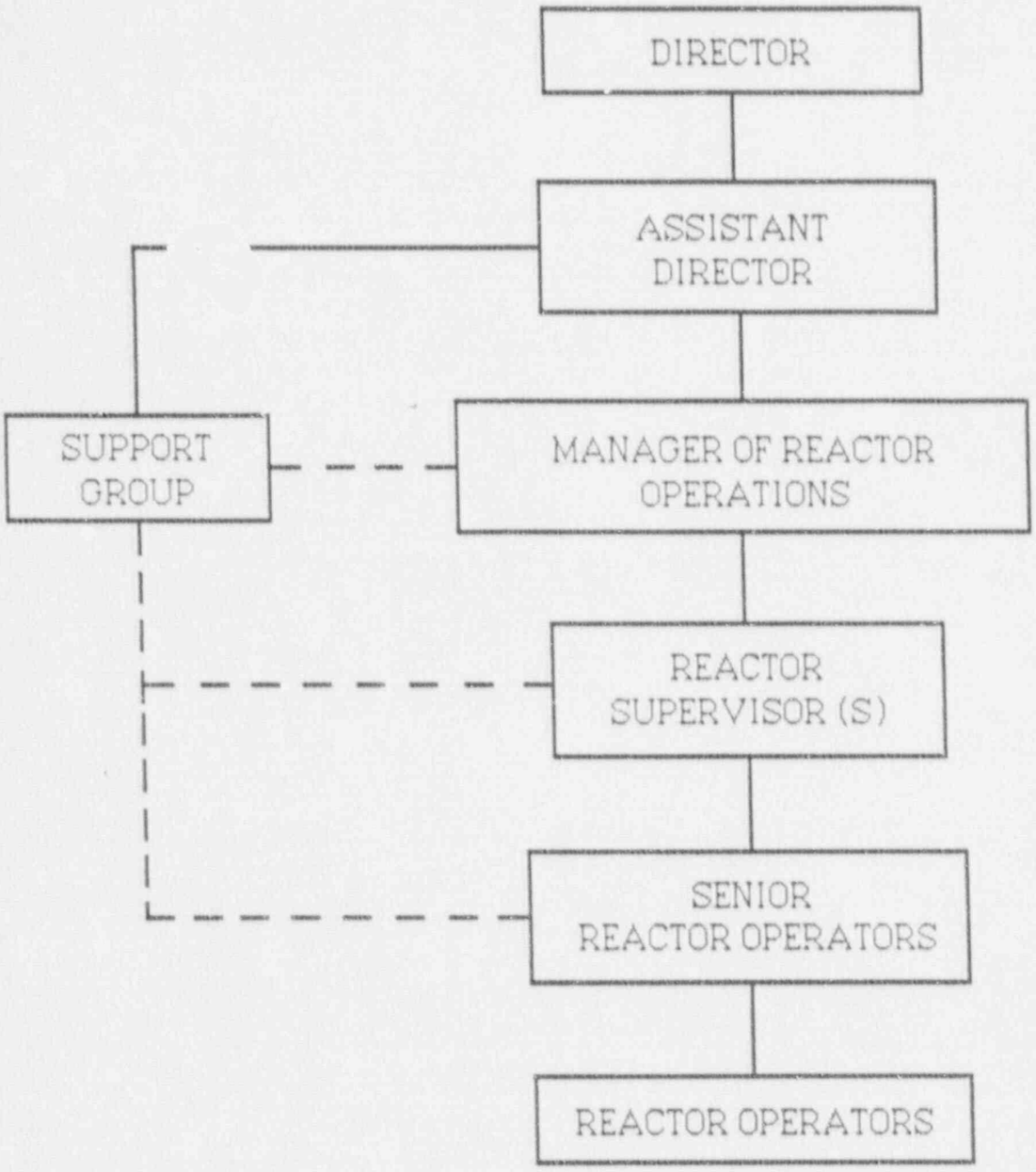

Figure 2 Nuclear Science Center
Reactor Operations Organization Chart

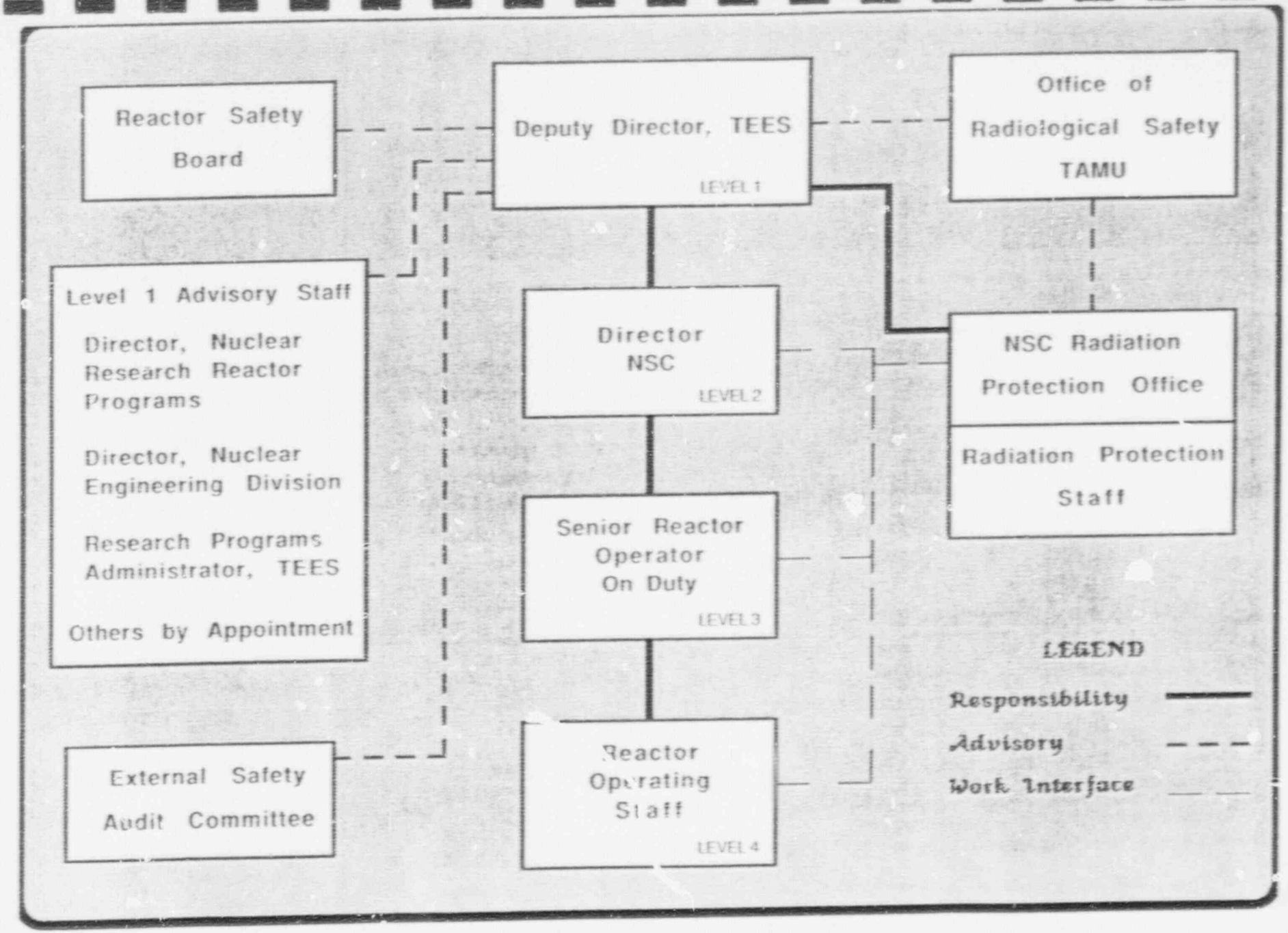

FIGURE 3 NSCR ADMINISTRATIVE ORGANIZATIONAL CHART

Facility Administration and Reactor Operations Staff (cont'd)

+Krohn, J. L.	- Assistant Director
+Luther, [illegible]. C.	- Reactor Supervisor (Terminated)
+O'Kelly, D. S.	- Senior Reactor Operator
+[illegible]esch, J. E.	- Reactor Supervisor
Reuscher, J. A.	- Professor, and Director, Nuclear Research Reactor Programs
+Stasny, G. S.	- Reactor Supervisor (Terminated)

Technical Service and Maintenance

Allen, R.	- Student Worker I (Terminated)
Baumbach, D.	- Student Worker I (Terminated)
Beeler, J.	- Student Technician (Terminated)
*Fisher, T. H.	- Scientific Instrument Maker II
Horn, C. R.	- Mechanical Equipment Foreman
Lively, T.	- Student Worker I (Terminated)
Oliver, C. M.	- Student Worker I
[illegible]estivo, A. L.	- Engineering Research Associate
Sanchez, A.	- Student Technician
Short, W.	- Student Technician (Terminated)
Steffek, R.	- Student Worker I
Tier, M.	- Draftsman (Terminated)

*Licensed Reactor Operator
+Licensed Senior Reactor Operator

Clerical

Killingsworth, S. B.	- Receptionist (Terminated)
Mitchell, Y.	- Secretary
Ribardo, J. E.	- Bookkeeper
Robins, G.	- Receptionist

Health Physics Staff

Brown, M. P.	- Senior Health Physicist
Cannell, B. K.	- Health Physics Technician

Visiting Scientist

Dr. R. M. Knaus	- Louisiana State University

C. Reactor Safety Board

Committee Composition

Chairman

F. Jennings, Director, Office of University Research
(January 1, 1990 - December 31, 1990)

Voting Members

T. Parish, Professor, Nuclear Engineering
(September 1, 1990 - December 31, 1990)
R. R. Hart, Professor, Nuclear Engineering
(January 1, 1990 - September 1, 1990) (Terminated)
R. Kenefick, Professor, Physics
(January 1, 1990 - December 31, 1990)
R. Koppa, Professor, Industrial Engineering
(January 1, 1990 - December 31, 1990)
E. L. Morris, Professor, Veterinary Medicine
(January 1, 1990 - December 31, 1990)
G. Schlapper, Associate Professor, Nuclear Engineering
(January 1, 1990 - December 31, 1990)
E. A. Schweikert, Professor, Chemistry
(January 1, 1990 - December 31, 1990)

Ex-Officio Members

D. E. Feltz, Director, Nuclear Science Center
(January 1, 1990 - December 31, 1990)
M. McLain, Professor and University Radiological Safety Officer
(January 1, 1990 - December 31, 1990)
J. W. Poston, Head, Nuclear Engineering
(January 1, 1990 - December 31, 1990)
M. P. Brown, Senior Health Physicist, Nuclear Science Center
(June 1, 1990 - December 31, 1990)

Meeting Frequency

The Reactor Safety Board (RSB) met on the following dates during the calendar year 1990: 2/19/90, 5/30/90, and 10/3/90.

RSB Audits

During the reporting period RSB audits of NSC activities were conducted on the following dates: 1/3/90, 4/19/90, 7/18/90, 7/24/90 and 10/29/90.

APPENDIX I

Description of Projects Utilizing the NSCR

DESCRIPTION OF PROJECTS UTILIZING THE NSCR

A. Texas A&M University

Nuclear Engineering

DAMAGE STUDIES OF INFRARED DETECTOR MATERIAL

Personnel

Dr. Ron R. Hart -- Professor
Kevin Seager -- Graduate Assistant

This study investigated damage caused to infrared detector materials by exposure to neutrons. The work included studies of charged particle channeling and the effects of neutron radiation on this channeling.

NUCLEAR ENGINEERING GRADUATE LAB IN REACTOR EXPERIMENTATION

Personnel

Dr. J. A. Reuscher -- Professor
NE 606 Graduate Students (16 students)

Several experiments were performed at the NSC during the lab course. Each student participated in a control rod calibration lab, a suboritical multiplication lab, a power calibration lab and a reactor pulsing lab. Other experiments performed included core flux mapping, neutron radiography, and neutron activation analysis.

REAL-TIME NEUTRON RADIOGRAPHY

Personnel

Dr. J. A. Reuscher -- Professor
John Wright -- Graduate Assistant
Scott Midgett -- Graduate Assistant

A real time neutron radiography system was developed and installed at Beam Port #4. This system uses a ZnS(LiF) scintillating screen to obtain images of samples placed in the neutron beam. The screen low-level light emission is intensified by a relay optics unit and collected by a monochrome CCD television camera. The TV image is digitized at a rate of 30 frames/second by an IBM PC/AT with image capture and processing boards. The neutron radiography image is displayed on a high resolution CRT. Numerous image enhancement options are available using digital filtering or false color displays.

The system shows good resolution for small holes (0.020-inch) in a cadmium plate or standard film quality indicators. The system is being used to image operating heat pipes, bubble flows in liquids, the melting of metallic samples, moisture measurements in zeolite and other research areas.

PROMPT GAMMA NEUTRON ACTIVATION ANALYSIS

Personnel

Dr. J. A. Reuscher -- Professor
John Krohn -- Graduate Student

Preliminary work was undertaken to establish a facility for Prompt Gamma Neutron Activation Analysis (PGNAA) utilizing Beam Port #1. Work conducted during this year included construction of a detector shield and determination of a background gamma spectrum.

NUCLEAR ENGINEERING UNDERGRADUATE LAB

Personnel

Dr. C. A. Schlapper -- Professor
NE 405 Students

Several experiments were performed at the NSC during the lab course. Each student performed a reactor startup and participated in a control rod calibration lab and a subcritical multiplication lab.

RADIOISOTOPE PRODUCTION FOR LABORATORY EXPERIMENTS

Personnel

Dr. Milton McLain -- Radiation Safety Officer
Dr. Dennis James -- Assistant Professor
Graduate and Undergraduate Students in various classes

Several laboratory classes took advantage of the NSC to produce short-lived radioisotopes for use in lab experiments ranging from half-life measurements to detector operation and calibration.

TOURS OF THE NSC

Personnel

Mr. F. Davis -- Lecturer
Dr. G. A. Schlapper -- Associate Professor
Graduate and Undergraduate Students in various classes

Various classes toured the NSC during the year as "field trips". The tours ranged from introductory views for freshman students to in depth studies of the facility air monitoring system for a graduate health physics class.

Animal Science

DYNAMICS OF RUMINANT DIGESTION AND NUTRITION

Personnel

Dr. W. C. Ellis -- Professor
L. Cabello -- Graduate Assistant
M. Hill -- Graduate Assistant

A continuation of investigations aimed at measuring the contributing dynamic processes in cattle fed a number of different roughage and roughage/chemical treatments. The results are to be integrated into models of the animal's intake and digestive system. The work involves activation analysis of elemental markers added to individual meals of the animals in the study.

Anthropology

METALLURGICAL ANALYSIS OF BRONZE ARTIFACTS

Personnel

Dr. D. Bruce Dickson -- Associate Professor
Georgia Fox -- Graduate Assistant

This NAA project involved analyzing small samples taken from bronze artifacts from an anthropological site in Tel Nami Isreal. The elemental composition and the copper-tin ratio of the bronze may help to determine the origin of the artifacts and possibly provide evidence for trade in this region during the late Bronze Age.

Oceanography

DISTRIBUTION OF BARIUM IN SEDIMENTS ON THE TEXAS-LOUISIANA CONTINENTAL SHELF AND SLOPE

Personnel

Dr. B. J. Presley -- Professor
Dr. P. N. Boothe -- Assistant Research Scientist
Dr. R. J. Taylor -- Research Associate
Three Graduate Students

This continuing project studied fine-grain sediment transport on the continental shelf using barium sulfate which is released during oil drilling operations. The determination of barium levels at various locations on the shelf and slope by activation analysis allows a model of the transport processes taking place to be formulated. These processes are important to understand in view of the increased off-shore drilling expected during the rest of this century.

Physics

CONSTRUCTION OF A POSITRON TOMOGRAPH

Personnel

Dr. J. A. McIntyre -- Professor
R. A. Seidel -- Graduate Student

Work continued on the construction and testing of a positron emission tomography system for clinical imaging. The NSC provided the positron sources, activated copper samples, for this system.

Veterinary Physiology and Pharmacology

SM-153 EDTMP BONE THERAPY AGENT

Personnel

Dr. Dan Hightower, D.V.M. -- Professor
Mark Chambers -- Graduate Assistant
Andrea Komkov -- Graduate Assistant

Initial irradiations of samarium oxide were performed to study the feasibility of producing EDTMP Bone Therapy sources. The initial studies included calibrations and preliminary studies with animals.

Geology

OCCURRENCE OF URANIUM IN HYDROCARBON RESERVOIR ROCKS

Personnel

Dr. T. Tieh -- Professor
M. Denham -- Graduate Assistant

Fission tracks were induced using neutrons to investigate occurrence of uranium to determine if uranium concentrates in certain phases during diagenesis and hydrocarbon migration.

FISSION TRACK AGE DETERMINATIONS FROM FLOURITE

Personnel

Dr. V. Harder -- Lecturer

This work is aimed at determining the burial depth of sediments by finding the flourite fission track ages of these sediments.

Geophysics

TRACE ELEMENT GEOCHEMISTRY ACROSS THE CRETACEAUS/TERTIARY BOUNDARY

Personnel

Dr. N. Carte. -- Professor
A. Huffman -- Graduate Assistant
T. Oldham -- Graduate Assistant

Neutron activation analysis was performed on deep sea and volcanic rock samples to study trace-element signatures across the Cretacious-Tertiary boundary and determine the cause for a major extinction 66 million years ago.

Chemistry

CHEMICAL PROPERTIES OF ETCHED NUCLEAR TRACKS IN MICA

Personnel

Dr. Charles Martin -- Professor
Charles Brumlik -- Graduate Assistant

Small fission plates were used to produce nuclear tracks in mica samples. The samples were then etched and the tracks studied under light microscopes for reactions to various chemical treatments.

B. Other Universities

Louisiana State University

FIRE ANT TERRITORIALITY

Personnel

Dr. Ron Knaus -- Professor, LSU Nuclear Science Center
Dr. Lane Foil -- Professor, Entomology
Kevin Sweeney -- Graduate Assistant
Beth Elkins -- Graduate Assistant
Daniel Van Gent -- Graduate Assistant

This continued study investigated fire ant territoriality in a producing sugar cane field as determined by NAA performed at the NSC on the ants which had been tagged with Dy and Sm.

TRANSMISSION OF EQUINE DISEASES

Personnel

Dr. R. M. Knaus -- Professor, Nuclear Science
Dr. Charles Issel -- Professor, Veterinary Science

Animals were injected with Na-24 produced at the Texas A&M Nuclear Science Center, to study mechanical transmission of equine infectious diseases.

Sul Ross State University

ANALYSIS OF GEOLOGIC SAMPLES FROM VARIOUS SITES IN TEXAS

Personnel

Mr. Lance Forsythe -- Interim Lab Director
Dr. Michael McCurry -- Lecturer
Five Graduate and Undergraduate Students

These continued studies include the determination of trace element contents of various rock and mineral samples from a variety of sites in Texas. The samples are irradiated at the NSC and the analysis performed at Sul Ross. Several projects are ongoing at any one time with various combinations of faculty, graduate and undergraduate students. Many of the results from these studies are incorporated into theses, papers and presentations at geologic society meetings.

Texas State Technical Institute

Personnel

Richard Wheet -- Chairman, Nuclear Technology, Waco
Linda Morris -- Lecturer
Georgia Martini -- Lecturer

During 1990, approximately 35 students participated in health physics training which included items from shipping and release regulations to an introduction to reactor physics and neutron activation analysis. The training provided the students with hands-on experience to supplement their classroom instructions in the Health Physics Technician program.

Southern Methodist University

FISSION-TRACK ETCH STUDIES

Personnel

Dr. S. Kelley -- Assistant Professor, Geology
Dr. K. Damm -- Visiting Lecturer
Rhonda Geving -- Graduate Assistant
Larry Carter -- Graduate Assistant

Fission-track etching was performed for a variety of projects. All of the projects are aimed at dating samples and in some cases to determine the cooling history of the geological site.

McNeese State University, University of Southwestern Louisiana, Louisiana Tech University

DISTRIBUTION OF TRACE METALS IN LOUISIANA STATE SEDIMENTS

Personnel, McNeese State

Dr. J. Beck -- Professor, Chemistry
K. Stacks -- Graduate Assistant
K. Martin -- Graduate Assistant

Personnel, Southwestern Louisiana

Dr. John Meriwether -- Professor, Physics
K. Kie -- Graduate Assistant

Personnel, Louisiana Tech

Dr. R. H. Thompson, Director, Nuclear Center
A. Bebahani -- Graduate Assistant
B. Griffis -- Undergraduate

Neutron activation analyses were carried out on lake sediment samples to study the presence of pollution by heavy metal concentration.

Miami University (Ohio)

FISSION-TRACK ANALYSIS OF GEOLOGICAL MATERIALS

Personnel

Dr. K. Crowley -- Professor

Fission-track age by induced U-238 fissions was determined to study annealing processes.

University of Houston

RADIATION EFFECTS ON HIGH TEMPERATURE SUPERCONDUCTORS

Personnel

Dr. J. Lui -- Scientist
Dr. W. Chu -- Director, TCSUH

Samples of superconductor material were irradiated to study the possibility of raising the temperature at which the materials became super conducting.

University of Oklahoma

RARE EARTH CONCENTRATIONS IN IGNEOUS ROCKS AND SHALES

Personnel

Dr. B. Weaver -- Professor, Geology
P. Anderson -- Graduate Assistant

Rare earth concentrations were determined by neutron activation analysis to study the geochemistry of igneous rocks and shales.

University of Texas - Austin

FISSION TRACT ANALYSIS OF GEOLOGICAL MATERIALS

Personnel

Dr. Mark Cloos -- Professor, Geological Sciences
Jeff Corrigan -- Graduate Assistant
Richard Ketchum -- Graduate Assistant
Leslie White -- Graduate Assistant

Fission track aging was used in several geologic studies to determine the age of samples

University of Texas - Austin

MEASUREMENT OF TOXIC ELEMENTS IN FISH

Personnel

Dr. F. Iskander -- Research Associate, Mechanical Engineering

In a cooperative project with the Texas Parks and Wildlife Department, tissue from fish taken from several Texas lakes are analyzed by NAA for several toxic elements.

TOURS AND NEUTRON ACTIVATION ANALYSIS DEMONSTRATIONS

Groups from various institutions toured the Texas A&M Nuclear Science Center facilities and saw neutron activation analysis demonstrations. Some of the associated group chaperones and their institutions are listed below.

D. Tatum, McLennan Community College
K. H. Wang, Physics, Baylor University

C. Non-University Institutions

M. D. Anderson Hospital

PRODUCTION OF RADIOISOTOPES FOR RESEARCH AND TREATMENT

Personnel

Jack Cundiff -- M. D. Anderson

The NSC produces radioisotopes for use in medical research and treatment at the M. D. Anderson Hospital and Tumor Center in Houston. Several different isotopes and forms have been produced for various types of uses at the hospital.

K. W. Brown and Associates

NEUTRON ACTIVATION ANALYSIS OF AIR FILTERS

Personnel

Dr. J. Fares -- K. W. Brown
Dr. C. Magneson -- K. W. Brown
J. Krohn -- Nuclear Science Center

Air filter samples taken in industrial environments were analyzed by NAA to investigate possible releases of toxic or other undesirable elements.

Texas Instruments

NEUTRON ACTIVATION ANALYSIS OF SEMICONDUCTOR MATERIALS

Personnel

Bruce Gnade -- Texas Instruments
Cheryl Blackburn -- Texas Instruments

This long-term project involves the irradiation of semiconductor materials supplied by Texas Instruments at the Nuclear Science Center and subsequent analysis by TI personnel. The analysis results are used in quality assurance and product development.

TRW-EDS

RADIATION HARDNESS TESTING OF ELECTRONIC COMPONENTS

Personnel

Terry Lunn -- TRW
Don Randall -- TRW
John Krohn -- Nuclear Science Center

The NSC provided a fast neutron environment for exposure of electronic components for radiation hardness testing. This project includes characterization of the radiation environment and monitoring of each irradiation for dose received.

RADIOISOTOPE PRODUCTION

The NSC produced a wide variety of radioisotopes for a number of commercial users. These isotopes were produced for a variety of projects including well logging, gamma radiography, and tracer studies. Some of the more commonly produced isotopes were: Sb-124, Sc-46, Ir-192, Br-82, Ar-41, and Na-24. Some of the companies supplied were: Racon, Spectratek, Inc., R/A Services, Inc., Tracerco, Inc. and Tru-Tec.

APPENDIX II

Publications, Theses and Papers Involving Use of NSC Facilities From 1976 to Date

Publications, Theses and Papers Involving the Use of NSC Facilities From 1978 to Date

1. R. R. Hart and L. D. Albert, "Measurement of P-31 Concentrations Produced by Neutron Transmutation Doping of Silicon", International Conference on Neutron Transmutation Doping, University of Missouri, April 1978.

2. D. Wootan, "Measurement of Neutron Flux in Thermal Rotisserie", M.S. Thesis in Nuclear Engineering, Texas A&M University, 1978.

3. W. Huang and J. Catham, "Uranium in Lignite: I. Geological Occurrence in Texas", Tenth International Congress on Sedimentology, Volume 1, 1978.

4. W. Huang and S. Parks, "Uranium Resources in Some Tertiary Sediments of Texas Gulf Coastal Plain: I Geologic Occurrence in the Lower Miocene Sediments", Tenth International Congress on Sedimentology, Volume 1, 1978.

5. W. Huang and K. Pickett, "Factors Controlling In-Situ Leaching of Uranium from Sandstone and Lignite Deposits in South Texas", Proceedings of Uranium Mining Technology, Update 78, Reno, Nevada, November 1978.

6. B. J. Presley, R. Pflaum and J. Trefry, "Fallout and Natural Radionuclides in Mississippi Delta Sediments", Environmental Oceanographic Science, Vol. 59, No. 4, April 1978.

7. P. H. Fishman, "Minerological Analysis and Uranium Distribution of the Sediments from the Upper Jackson Formation, Karnes County, Texas", M. S. Thesis in Geology, Texas A&M University, 1978.

8. E. M. Prasse, "Uranium and Its Relationship to Host Rock Minerology in an Unoxidized Roll Front in the Jackson Group, South Texas", M. S. Thesis in Geology, Texas A&M University, 1978.

9. W. C. Ellis, J. H. Mathis and C. E. Lescano, "Quantitating Ruminal Turnover", Fed. Proc., Vol. 38, 1979.

10. C. E. Lescano and W. C. Ellis, "An Evaluation of Lanthanides as Particulate Matter Markers", American Society of Animal Science (abstract), Tucson, Arizona, 1979.

11. S. W. Bachinski and R. B. Scott, "Rare-Earth and Other Trace Elements Contents and the Origin of Mineetes", Geochim. Cosmochim. Acta, Vol. 43, 93, 1979.

12. R. B. Scott, D. G. Temple and P. Peron, "Nature of Hydrothermal Exchange Between Oceanic Crust and Seawater at 26°N Lat., Mid-Atlantic Ridge", Benthic Boundary Layer Processes, IOGC Symposium on the Benthic Boundary Layer, 1979.

13. L. J. Tiezzi and R. B. Scott, "Crystal Fractionation in a Cumulate Gabbro, Mid-Atlantic Ridge, 26°N Lat.", J. of Geophys. Research, 1979.

14. P. J. McGoldrick, R. R. Keays and R. B. Scott, "Thallium: A Sensitive Indicator of Rock/Seawater Interaction of Sulfur Saturation of Silicate Melts" Geochim. Cosmochim. Acta, 1979.

15. G. Zakoriadze, R. B. Scott and D. H. Lilly, "Petrology and Geochemistry of the Palao-Kyushu Remnant Arc, Site 448, DSDP Leg 59", Trans. Amer. Geophys. Union, Vol. 50, 94, 1979.

16. R. B. Scott, "Petrology and Geochemistry of Ocean Plateaus", TAMU Symposium on Ocean Plateaus, 1979.

17. A. Clearfield and L. Kullberg, "On the Mechanism of Ion-Exchange in Zirconium Phosphates: An Equilibrium Study of Sodium-Potassium-Hydrogen Exchange on Crystallizing Zirconium Phosphates", J. of Inorganic and Nucl. Chem., 1979.

18. O. F. Zeck, R. A. Ferrieri, C. A. Copp, G. P. Gennaro and Y. N. Tang, "Gas Phase Recoil Phosphorous Reactions IV - Effect of Moderators on Abstraction Reactions", J. of Inorganic and Nucl. Chem., 41, 1979.

19. J. R. Catham, "A Study of Uranium Distribution in an Upper Jackson Lignite - Sandstone Ore Body, South Texas", M. S. Thesis in Geology, Texas A&M University, 1979.

20. S. L. Parks, "Distribution and Possible Mechanism of Uranium Accumulation in the Catahoula Tuff, Live Oak County, Texas", M. S. Thesis in Geology, Texas A&M University, 1979.

21. M. E. Miller, "Uranium Roll Front Study in the Upper Jackson Group, Alascosa County, Texas", M. S. Thesis in Geology, Texas A&M University, 1979.

22. W. C. Ellis, J. H. Matis and C. E. Lescano, "A Method for Determining In-Vivo Rates of Particle Size Degradation, Genesis, and Passage from the Rumen", Proc. of 15th Conference on Rumen Function, 1979.

23. W. C. Ellis, J. H. Matis and C. E. Lescano, "Sites Contributing to Compartmental Flow for Forage Residues", Ann. Res. Vet., 1979.

24. C. E. Lescano, "Determir 'on of Grazed Forage Voluntary Intake", Ph.D. Dissertatio n Animal Nutrition, Texas A&M University, 1979.

25. K. Pond, "Effect of Monensin on Intake Digestibility, Gastrointestinal Fill and Flow in Cattle Grazing Coastal Bermuda Pasture", M. S. Thesis in Animal Nutrition, Texas A&M University, 1979.

6. H. Loza, "Effect of Protein Deficiency on Forage Intake and Digestibility", M. S. Thesis in Animal Nutrition, Texas A&M University, 1979.

27. V. L. Tenhet, "Penetration Mechanism and Distribution Gradients of Sodium-Tripoly-Phosphate in Peeled and Deveined Shrimp", M. S. Thesis in Animal Science, Texas A&M Univer ity, 1979.

28. W. C. Ellis and H. Lippke, "A Continuous Infusion and Pulse Dose Marker Method for Determining Fecal Output", Proceeding of Southern Pasture and Forage Crop Improvement Conference, Nashville, Tennessee, May 1980.

29. D. S. Delaney, "Effects of Monensin on Intake, Digestibility, and Turnover of Organic Matter and Bacterial Protein in Grazing Cattle", M. S. Thesis in Animal Science, Texas A&M University, 1980.

30. J. P. Telford, "Factors Affecting Intake and Digestibility of Grazed Forages", Ph.D. Dissertation in Animal Science, Texas A&M University, 1980.

31. E. E. Siefert, K. L. Loh, R. A. Ferrieri and Y. N. Tang, "Formation of 1-Silacyclopenta-2,4-diene Through Recoil Silicon Atom Reactions", J. Amer. Chem. Soc., 102, 1980.

32. M. W. Rowe, E. W. Filberth and H. J. Shaeffer, "Uranium in Huero and Guadalupe Mountain Indian Ceramics", Archaeometry, Great Britian, 1980.

33. E. B. Ledger, T. T. Tieh and M. W. Rowe, "Delayed Neutron Activation Determination of Uranium in Thirteen French Rock Reference Samples", Geostandards Newsletter, 1980.

34. T. T. Tieh, E. B. Ledger and M. W. Rowe, "Release of Uranium from Granitic Rocks During In Situ Weathering and Initial Erosion (Central Texas)", Chemical Geology, 1980.

35. J. P. Taft, J. D. Randall and K. Walker, "Core Modification of the Texas A&M Nuclear Science Center Reactor for Improved Commercial Utilization", presented at the Seventh TRIGA User's Conference, San Diego, California, March 1980.

36. E. F. Bates, R. D. Neff and J. D. Randall, "Organization and Management of Health Physics Support for a Research Reactor", presented at the Seventh TRIGA User's Conference, San Diego, California, March 1980.

37. K. L. Walker, "Analysis of Uranium in Ore Samples by Delayed Neutron Activation Analysis", Radiochemical and Radioanalytical Letters, October 1980.

38. E. E. Siefert, K. L. Loh, R. A. Ferrieri and Y. N. Tang, "Fluoride Atom Shift in 1,2-Diflouroethyl Radicals", J.C.S. Chem. Comm., 814, 1980.

39. E. B. Ledger, T. T. Tieh and M. W. Rowe, "Delayed Neutron Activation Determination of Uranium in Twelve Rock Reference Standards", Geostandards Newsletter, 4, 1980.

40. K. R. Pond and W. C. Ellis, "Effects of Monensin on Fecal Out-out and Voluntary Intake of Grazed Coastal Bermudagrass", Beef Cattle Research in Texas, 1981.

41. W. C. Ellis, J. H. Matis and K. R. Pond, "Effect of Monensin on Gastrointestinal Fill and Turnover of Undigested Forage Residues in Animals Grazing Coastal Bermuda", Beef Cattle Research in Texas, 1981.

42. D. S. Delaney, K. R. Pond, C. E. Lescano and W. C. Ellis, "Comparison of Fecal Output as Estimated by Two Marker Methods", Beef Cattle Research in Texas, 1981.

43. D. S. Delaney and W. C. Ellis, "Effect of Monensin on Rumen Microbial Turnover", Beef Cattle Research in Texas, 1981.

44. D. Hightower, "Whole Body Counting", Southwest Chapter of Society of Nuclear Medicine, 1981.

45. J. Watson and B. Covington, "Neutron Transmutation Doped Silicon", American Association of Physics Teachers, 1981.

46. L. Kullberg and A. Clearfield, "Mechanism of Ion Exchange in Zirconium Phosphates - 32: Thermodynamics of Alkali Metal Ion Exchange on Amorphous ZrP", J. Phys. Chem., 1981.

47. L. Kullberg and A. Clearfield, "Mechanism of Ion Exchange in Zirconium Phosphates - 32: Thermodynamics of Alkali Metal Ion Exchange on Crystalline ZrP", J. Phys. Chem., 1981.

48. D. Nelson, W. McDonough and D. Mattison, "Trace Element Geochemistry of the Sawtooth Mountain Syenites, Transpecos Magmatic Belt of West Texas", Trans Pecos Volcanism Symposium, 1981.

49. E. E. Siefert, S. D. Witt and Y. N. Tang, "Reactions of Monomeric Diflourosilylene with Ethylene", J.C.S. Chem. Comm., 1981.

50. Y. N. Tang, "Unusual Compounds Synthesized via Nuclear Recoil Methods", Advances in Chemistry Series, No. 197, 1981.

51. E. J. Parma, "Gamma Abundance of Silicon-31", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1981.

52. L. R. Theriot and L. Daley, "Matrix Effect in Atomic Absorption Determination of Copper in Fraction I Protein: Possible Role of Copper in Light Sensitive Control of Ribulose Biphosphate Carboxyglase Activity", Texas Journal of Science, December 1981.

53. W. C. Ellis, C. E. Lescano, R. Teeter and F. N. Owne, "Solute and Particulate Flow Markers", Proceedings of Symposium on Ruminant Protein Nutrition, Oklahoma State University, 1982.

54. J. P. Telford and W. C. Ellis, "Duration of Grazing Effects on Gastrointestinal Fill, Turnover, Digestibility and Voluntary Intake of Grazed Oak Pasture", Beef Cattle Research in Texas, 1982.

55. K. R. Pond, "The Fragmentation and Flow of Forage Residues Through the Gastrointestinal Tract of Cattle", Ph.D. Dissertation in Animal Science, Texas A&M University, 1982.

56. K. R. Pond, A. G. Deswyen, J. H. Matis and W. C. Ellis, "Chromium-mordanted and Rare Earth Marker Fiber for Particulate Flow Measurement", Beef Cattle Research in Texas, 1982.

57. K. R. Pond, A. G. Deswyen, J. H. Matis and W. C. Ellis, "Rate of Passage Measurements as Affected by Dosing at Beginning or End of a Meal", Beef Cattle Research in Texas, 1982.

58. K. R. Pond, A. G. Deswyen, J. H. Matis and W. C. Ellis, "Marker Technique - A Two Marker, Two Dose Method for Estimating Fecal Output, Fill and Flow", Beef Cattle Research in Texas, 1982.

59. M. S. Mohan, R. A. Zingaro, R. D. Macfarlane and K. J. Irgolic, "Characterization of Uranium-Rich Organic Material Obtained from a South Texas Lignite", Pittsburgh Energy Technology Center, May 1982.

60. D. Casserly, M. Vecchiono, R. Maples, R. Ilg, D. Gaston, D. Weston and L. Dervoen, "Biological Attributes of the West Hackberry Brine Disposal Site", Oceans 82, 4, 1982.

61. G. L. Grout and C. L. Webre, "Quick Separation of Manganese from Brine Solutions", Radiochemical and Radioanalytical Letters, 51, 1982.

62. J. Watson and B. Covington, "Annealing Studies of Transmutation Doped Silicon", presented at Texas Academy of Science Meeting in San Angelo, Texas, March 1982.

63. J. Watson and B. Covington, "Annealing Study of Transmutation Doped Silicon: Boron", Proceedings of the Fourth International NTD Conference, Washington, D. C., 1982.

64. R. K. Dokka, "Implications of Fission Track Ages from the Kaplan Geothermal Geopressure Zone, Vermilion Parish, Louisiana", Transactions of Gulf Coast Association of Geological Societies, Vol. 32, 1982.

65. W. F. McDonough, D. O. Nelson and G. D. Mattison, "Major and Trace Element Variation in a Dynamically Evolving Silicon Magma Chamber", Trans-Pecos Volcanism, March 1982.

66. J. H. Schieffer, G. D. Mattison and D. O. Nelson, "The Mineralogy and Geochemistry of the Igneous Rocks of the Terlingua District, Brewster County, Texas", Trans-Pecos Volcanism, March 1982.

67. J. H. Schieffer and G. D. Mattison, "Nature and Origin of Alkalic and Calcic Veinlets in Xenoliths from the Terlingua District, West Texas", Geological Society of America, 1982.

68. C. Conrad, "Uranium in the Catman Creek Granite and Its Economic Impact", M. S. Thesis in Geology, Sul Ross State, 1982.

69. W. Schaftenaar, "Uranium in Igneous Rock of the Central Davis Mountains of West Texas", M. S. Thesis in Geology, Sul Ross State, 1982.

70. H. Deigl and D. E. Feltz, "Antiquity, Man and Machine", presented at the Eighth TRIGA User's Conference, Idaho Falls, Idaho, March 1982.

71. R. D. Rogers and J. D. Randall, "In-Pool Neutron Radiography of Damaged FLIP Fuel", presented at the Eighth TRIGA User's Conference, Idaho Falls, Idaho, March 1982.

72. C. W. Beasley, "Perfusion Measurement with Rubidium-81 to Krypton-81m Ratio", Ph.D. Dissertation in Veterinary Physiology and Pharmacology, TAMU, 1982.

73. M. C. Brady, "Radiation Field Measurements in the TAMU Nuclear Science Center Irradiation Cell", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1982.

74. E. J. Parma and R. R. Hart, "Measurements of the Gamma Abundance of Si-31", Proceedings of the Fourth International Conference on Neutron Transmutation Doping of Semiconductors, Gaithersburg, Maryland, June 1982.

75. M. H. Young and R. R. Hart, "Neutron Transmutation Doping of p-Type Czochralski-Grown GaAs", Proceedings of the Fourth International Conference on Neutron Transmutation Doping of Semiconductors, Gaithersburgh, Maryland, June 1982.

76. K. R. Pond, W. C. Ellis and J. H. Matis, "Digesta Flow Through the Ruminant's Digestive Tract", Beef Cattle Research in Texas, 1983.

77. K. R. Pond, W. C. Ellis, W. D. James and M. G. Otte, "Analysis of Multiple Markers Used in Nutrition Research", Beef Cattle Research in Texas, 1983.

78. K. L. Welch, "Fluence Monitor Calibration of the Multiple Rotisserie Irradiation Device for Neutron Transmutation Doping", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1983.

79. L. Pgzoniski, A. N. Hanna and O. Suschny, "Report on Intercomparisons S-14, S-15, S-16 of the Determination of Uranium and Thorium in Thorium Ores", IAEA Report IAEA/RL/101, 1983.

80. J. H. Schieffer, and D. O. Nelson, "Petrology and Geochemistry of Megacrysts, Xenoliths and Their Host Basalts from the Terlingua Mercury District of West Texas", Geological Soc. of America, Abstracts with Program, Vol. 13, 1983.

81. D. O. Nelson, K. L. Ott and R. D. Tolley, "Geochemistry of Cibolo Creek I: Evaluation of Element Distribution in Stream Sediments", Earth Sciences, 1983.

82. R. L. Rudnick, "Geochemistry and Tectonic Affinities of a Proterozoic Bimodal Igneous Suite, West Texas", Geology, 1983.

83. W. G. McDonough, "The Geochemistry and Petrology of a Trachyte Comendite Suite from the Oligocene Paisano Volcano, West Texas", M. S. Thesis in Geology, Sul Ross State, 1983.

84. M. C. Kennicutt II, W. L. Kenny-Kennicutt, B. J. Presley and F. Fenner, "The Use of Pyrolysis and Barium Distributions to Assess the Areal Extent of Drilling Fluids in Surficial Marine Sediments", Environ. Geol., 4, 1983.

85. B. J. Presley and D. D. Sheu, "Orca Basin: Recent Deep-Sea Black Mud", Annual Meeting of the Geological Society of America, Indianapolis, Indiana, 1983.

86. M. Whiteacre, "Sorber Performance Data on the Recovery of Strategic Elements from Seawater", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1983.

87. F. R. Best and M. Whiteacre, "Sorber Performance Data on the Recovery of Strategic Elements from Seawater", International Meeting on Recovery of Uranium from Seawater, Tokyo, Japan, 1983.

88. F. R. Best, "Interpretation and Analysis of Sorber Performance Data on Recovery of Uranium from Seawater - II", International Meeting on Recovery of Uranium from Seawater, Tokyo, Japan, 1983.

89. W. D. James, "Multiple Stable Isotope Markers Used in Nutrition Research", Annual American Nuclear Society Meeting, Detroit, Michigan, 1983.

90. M.S. Akanni, V. O. Ogugbuaja and W. D. James, "Trace Element Content of Magnetohydrodynamic Coal Combustion Effluents", J. of Radioanalytical Chem., Vol. 79, No. 2, 1983.

91. R. L. Budnick, "Petrology and Geochemistry of the Carrizo Mountain Group", Geology, Spring 1983.

92. T. H. Simpkins, "The Geology and Geochemistry of the Aguachili Mountain Fluorspar-Beryllium District", presented at The Geologic Society of America Meeting, Fall 1983.

93. G. A. Schlapper, R. D. Neff, D. R. Davis and P. S. Sandel, "Measurement of Routinely Encountered Neutron Doses in Research Facilities", Radiation Protection Management, 1983.

94. N. Khalil, "A Test of the Efficiency of the Raw Water Stirring System Installed in Liquid Waste Holdup Tank 1", NSC Technical Report No. 44, 1983.

95. D. G. Goodman, "Motor Driven Flux Wire Counter", NSC Technical Report No. 45, 1983.

96. J. O'Donnell, "Determination of the Neutron Flux in the TAMU Nuclear Science Center Reactor During Pulse and Steady-State Operation", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1983.

97. D. S. Followill, "Determination of Exchangeable Potassium in the Canine by Means of Whole-Body Counting", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1983.

98. M. S. Mohan and R. A. Zingaro, "Trace Element Characterization of Deep Basin Lignites of Texas", Final Report to Texas Energy and Natural Resources Advisory Council, 1983.

99. W. A. Ilger, "A Study of Uranium in South Texas Lignite", M. S. Thesis in Chemistry, Texas A&M University, 1983.

100. L. S. Daley, "ESR of Transition Metal 'Chromophores' in RuBP Case Supporting Neutron Activation and Optical Data Concepts of UV Light Activation Through Transition Metal Chromophores", Blue Light Syndrome, Springer-Verlag, 1984.

101. J. D. Ilger, W. A. Ilger, M. S. Mohan and R. A. Zingaro, "Characterization of Uranium in a South Texas Lignite", Eleventh Annual Meeting of Federation of Analytical Chemistry and Spectroscopy Societies, Philadelphia, September 1984.

102. W. C. Ellis, J. H. Matis, K. R. Pond, C. E. Lascano and J. P. Telford, "Dietary Influences on Flow Rate and Digestive Capacity", Proceedings of Symposium on Herbivore Nutrition in the Sub-Tropics and Tropics, Johannesburg, South Africa, 1984.

103. L. D. Roth, W. C. Ellis and F. M. Rouquette, Jr., "Sward Attributes and Nutritive Value of Coastal Bermudagrass as Influenced by Grazing Pressure", Proceedings of Forage and Grasslands Conference, Houston, Texas, 1984.

104. R. V. Machem, "Effects of Physiological Status, Supplementation and Monensin on Forage Intake, Digestibility and Digesta Turnover", M. S. Thesis in Animal Science, Texas A&M University, 1984.

105. L. R. Roth, "Effects of Grazing Upon Sward Attributes and Utilization of Coastal Bermudagrass by Cattle", M. S. Thesis in Animal Science, Texas A&M University, 1984.

106. M. Whiteacre, "Experimental Determination of Elemental Recovery from Natural Seawater Achieved by Ion Exchange Resins", Master of Engineering project report, Texas A&M University, 1984.

107. M. H. Tobey, H. J. Shafer and M. W. Rowe, "Trace Element Investigations of Mayan Chert from Belize", International Symposium on Archaeometry, May, 1984.

108. M. H. Tobey, E. O. Nielsen and M. W. Rowe, "Elemental Analysis of Etruscan Ceramics from Murlo, Italy", International Symposium on Archaeometry, May 1984.

09. M. Charles, "The Application of a Scintillation Flask Technique for the Measurement of Radon Emanation", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1984.

110. Y. C. Gonzalez, "Aerosol Dilution and Dispersion at the Nuclear Science Center Confinement Building", M. S. Thesis in Health Physics, Texas A&M University, 1984.

111. C. H. Poynton, R. S. Tilbury, J. G. Head, S. Tindle, K. A. Dicke, L. Peters and C. L. Reading, "Boron Slow Neutron Capture with Colloidal Cobalt Boride Conjugated to Monoclonal Antibody", Conference on Advances in the Application of Mono-Clonal Antibodies in Clinical Oncology, London, U.K., June 1984.

112. V. O. Ogugbuaja, "Bioaccumulation of Trace Elements from Coal Fly Ash in Rats", Ph.D. Dissertation in Chemistry, Texas A&M University, 1984.

113. T. E. Clevenger, E. J. Hinderberger, D. A. Yates and W. D. James, "Analysis for Trace Elements in Magnetohydrodynamic (MHD) Pilot Plant Effluents", Environmental Science and Technology, 18, 1984.

114. W. D. James, F. F. Arnold, K. R. Pond, M. D. Glascock and T. G. Spalding, "Application of Prompt Gamma Activation Analysis and Neutron Activation Analysis to the Use of Samarium as an Intestinal Marker", J. of Radioanalytical Chem., 83, 1984.

115. W. F. McDonough and D. O. Nelson, "Geochemical Constraints on Magma Processes in a Peralkaline System: The Paisano Volcano, West Texas", Geochem. Cosmochim. Acta, Vol. 48, 1984.

116. D. O. Nelson, K. L. Nelson and G. D. Mattison, "Reconnaissance Geochemistry of Rocks of the Trans-Pecos Magmatic Belt", Geological Soc. of America Abstracts, Vol. 16, No. 2, 1984.

117. D. O. Nelson, K. L. Nelson and G. D. Mattison, "Implications of Trace Element and Isotopic Compostion for the Origins of Silicic Rocks of the East-Central Trans-Pecos Magmatic Belt of West Texas", Geological Soc. of America Abstracts, Vol. 16, No. 4, 1984.

118. R. T. Perry., W. B. Wilson and T. A. Parish, "A 14-MeV Neutron Source", Sixth Topical Meeting on the Technology of Fusion Energy, San Francisco, California, March 1984.

119. G. A. Schlapper, D. C. Kay, R. D. Neff and P. S. Sandel, "Dose Equivalent Measurements in an Area of Reduced Shielding at the Texas A&M Variable Energy Cyclotron", Radiation Protection Management, July 1984.

120. J. G. Pina-Jordan, "Measurement and Modeling of Uranium and Strategic Element Sorption by Amidoxime Resins in Natural Seawater", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

121. K. D. Seager, "Acceptor and Donor Production in Hg Cd Te by NTD", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

122. M. Schuller, "An Investigation of Aqueous Slurries as Fusion Reactor Blankets", Ph.D. Dissertation in Nuclear Engineering, Texas A&M University, 1985.

123. Y. R. Contreras and G. A. Schlapper, "Aerosol Dilution and Dispersion in a Nuclear Research Facility", Radiation Protection Management, July 1985.

124. K. L. Nelson, "Combined Elemental and Isotopic Evaluation of a Deep-Water Carbonate: Implications for a Dynamic Diagenetic Model", Geological Soc. of America Abstracts, Vol. 17, No. 7, September 1985.

125. K. L. Nelson, "Combined Elemental and Isotopic Evaluation of a Deep-Water Carbonate: Implications for a Dynamic Diagenetic Model", M. S. Thesis in Geology, Sul Ross State, 1985.

126. G. D. Mattison, "Mineralogy and Petrology of the Sheep Canyon Basalts, Trans-Pecos Volcanic Field, West Texas", Geological Soc. of America Abstracts, Vol. 17, No. 3, 1985.

127. D. O. Nelson and K. L. Nelson, "Geochemical Comparison of Alkaline Volcanism in Oceanic and Continental Settings: Clarion Island Versus the Eastern Trans-Pecos Magmatic Province", Geological Soc. of America Abstracts, Vol. 17, No. 3, 1985.

128. G. M. Vasquez, P. S. Sandel and G. A. Schlapper, "Development of the Scintillation Flask Technique for the Measurement of Indoor Radon-222 Concentrations", presented at the Mid-Year Symposium of the Health Physics Soc., Colorado Springs, Colorado, January, 1985.

129. G. M. Vasquez, "Development of the Scintillation Flask Technique for the Measurement of Indoor Radon-222 Concentrations", M. S. Thesis in Health Physics, Texas A&M University, 1985.

130. P. N. Boothe and W. D. James, "Neutron Activation Analysis of Barium in Marine Sediments from the North Central Gulf of Mexico", J. Trace and Microprobe Techniques, 3, 1985.

131. W. D. James, V. O. Ogugbuaja, M. D. Glascock and R. C. Attig, "Partitioning of Trace Elements in MHD Coal Combustion Effluents", Proceedings of the Fifth International Conf. on Nuclear Methods in Environ. and Energy Research, 1985.

132. C. M. Meyer, "Improved Assessment of Population Doses and Risk Factors for a Nuclear Power Plant Under Accident Conditions", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

133. J. H. Kleck, "Determination of Radiation Absorbed Dose to the Kidneys of Rhesus Monkeys from Radiolabelled Orthoiodohippuran", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

134. D. L. Mayfield, "A Calibration and Evaluation of Eberline Instrument Corporation's SPING-4 Radiological Air Monitor", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

135. R. Yupari, "Three-dimensional Neutronics Calculations for the Texas A&M TRIGA Reactor", M. S. Thesis in Nuclear Engineering, Texas A&M University, 1985.

136. R. D. Rogers, "Modification and Verification of the "SPOOFA" Computer Code for use at the Texas A&M University Nuclear Science Center", M. E. Project in Nuclear Engineering, Texas A&M University, 1985.

137. H. C. Cheung and A. Clearfield, "The Oxidative Dehydrogenation of Cyclohexene Catalyzed by $ZrCu(PO_4)_2$", Journal of Catalysis, Vol. 98, 1986.

138. T. Feeley and E. Morris, "Petrologic Similarities of Eocene Quartz-Olivine Basaltic Andesites, Oregon and Montana", Geological Soc. of America Abstracts, Vol. 18, No. 6, 1986.

139. E. Morris and G. Nelson, "Petrologic and Age Relations in Granite Mountain Syenite", Geological Soc. of America Abstracts, Vol. 18, No. 3, 1986.

140. D. O. Nelson and D. Gerlach, "Sr, Nd, and Pb Isotopic Compositions of Rocks of Clarion Island, East-Central Pacific Ocean", Geological Soc. of America Abstracts, Vol. 18, No. 6, 1986.

141. B. Sanza, "Measurement of Neutron Spectra for Determining Dose Equivalent Rates at the Texas A&M University Nuclear Science Center", M.S. Thesis in Nuclear Engineering, Texas A&M University, 1986.

142. C. Meyer and G. Schlapper, "A Comparison of Dose Calculation Methodologies for Airborne Releases from Nuclear Power Plants", Radiation Protection Management, April 1986.

143. J. Randall, "Development of a Generic Job Task List for Research Reactor Operators and Senior Reactor Operators", presented at the Tenth TRIGA User's Conference, College Station, Texas, April 1986.

144. R. Yupari, R. Perry and T. Parish, "Three Dimensional Neutronics Calculation for the TAMU Nuclear Science Center TRIGA Reactor Using Bold Venture", presented at the Tenth TRIGA User's Conference, College Station, Texas, April 1986.

145. J. L. Krohn, D. E. Feltz and N. Khalil, "Software Development for Research Reactors", presented at the Tenth TRIGA User's Conference, College Station, Texas, April 1986.

146. S. Na, R. Perry and T. Parish, "Spectroscopy System for Use With a Fusion Plate Installed on the TAMU Reactor", presented at the Tenth TRIGA User's Conference, College Station, Texas, April 1986.

147. P. N. Boothe, B. J. Presley, "Long-term Fate of Drilling Mud Barite on the Texas-Louisiana Continental Shelf and Slope", AGU/ASLO Meeting, New Orleans, Louisiana, January 1986.

148. K. L. Nelson, D. O. Nelson, D. Shucker and B. Brister, "Physical Evidence for Open-System Evolution of the Trans-Pecos Magmatic Province", Geological Society of America Abstracts, Vol. 18, No. 6, 1986.

149. D. E. Feltz, "The Conversion of TRIGA Research Reactors from High-Enriched Uranium to Low-Enriched Uranium Fuel: Owner/Operator View", Trans. American Nuclear Society, Vol. 52, June 1986.

150. R. Knaus, "Neutron Activation Analysis of Very Recent Accumulations in Wetlands Bordering the Northern Gulf of Mexico", presented at the Annual American Chemical Society Meeting, New Orleans, Louisiana, September 1987.

151. W. D. James, P. N. Boothe, "Ocean Sediment Analysis by NAA", Proceedings of ANS Topical Conference on Methods and Application of Radioanalytical Chemistry, Kona, Hawaii, April 1987.

152. D. B. McCarthy, W. C. Ellis, and R. Worley, "Digestion of Fiber in Segments of the Bovine Gastrointestinal Tract", Journal of Animal Science, Vol. 65, Supplement 1, 1987.

153. K. N. Grigsby, F. M. Rouquette, Jr., W. C. Ellis, D. P. Hutcheson and G. T. King, "Source and Level of Protein Supplement on Performance of Calves Grazing Bermuda Grass Pastures", Journal of Animal Science", Vol. 65, Supplement 1, 1987.

154. M. J. Wylie, M. C. Calhoun, A. Lastovica, W. C. Ellis and J. H. Matis, "Turnover of Dietary Residues Through Successive Anatomical Segments of the Lamb's Gastrointestinal Tract", Journal of Animal Science, Vol. 65, Supplement 1, 1987.

155. E. Rivera-Villarreal, W. C. Ellis and J. H. Matis, "Flow of Masticated Particles From the Rumen Upper Digesta Struta of Cattle", Journal of Animal Science, Vol. 65, Supplement 1, 1987.

156. E. Rivera-Villarreal and W. C. Ellis, "Effects of Ammoniation of Bermuda Hays on Particle Size Reduction and Outflow in Cattle", Journal of Animal Science, Vol. 65, Supplement 1, 1987.

157. M. C. Wells, P. N. Boothe and B. J. Presley, "Iridium in Marine Biota", AGU Meeting, 1987.

158. D. O. Nelson, K. L. Nelson and R. S. Miner, "Geochemistry of Plutons in the Eastern Trans-Pecos Magmatic Province", Geological Society of American Abstracts, Vol. 19, No. 3, 1987.

159. R. L. Ward, D. O. Nelson and K. L. Nelson, "Trace Element and Oxygen Isotope Evidence for the Origin of Quartz-Trachytes and Rhyolite, Northern Davis Mountains, West Texas", Geological Society of America Abstracts, Vol. 19, No. 5, 1987.

160. J. L. Krohn, "Radiation Effects Testing Capabilities of the Texas A&M Nuclear Science Center", presented at 4th Symposium on Space Nuclear Power Systems, Albuquerque, New Mexico, January, 1987.

161. M. C. Wells, P. N. Boothe and B. J. Presley, "Iridium in Marine Biota", AGU Fall Meeting Transactions 1988.

162. W. D. James and P. N. Boothe, "Evaluation of Gamma Lines for NAA", American Nuclear Society Annual Meeting, San Diego Transactions 1988.

163. W. D. James and P. N. Boothe, "Ocean-Sediment Analysis by NAA", Journal of Radioanalytical and Nuclear Chemistry 123/1, 295 1988.

164. W. C. Ellis, J. H. Matis and D. Popp , "Use of Age-Dependent Compartmental Models to Estimate Particulate Flow in Ruminants", Journal of Animal Science, 66/1, 479 1988.

165. M. E. Denham and T. T. Tieh, "Distribution and Occurrence of Uranium in Reservoir Rocks", American Association of Petroleum Geologists, 72/2 1988.

166. E. Rivera-Villareal, "Forage and Animal Response to Ammoniations of Coastal Bermuda-grass Hays of Different Maturities", Ph.D. Dissertation, Texas A&M University, 1988.

167. P. Lee, "Dosimetry of Noble Fission Gas Products", Ph.D. Dissertation, Texas A&M University, 1988.

168. K. Crowley and S. Kuhlman, "Apatite Thermochemistry of the Western Canadian Shield: Implications for the Origin of the Williston Basin", Geophysical Research Letters, 15/3, 221 1988.

169. B. C. Covington and M. O. Manasreh, "Fourier-Transform Infra-Red Absorption Studies of Intracenter Transitions in the EL2 Level in Semi-Insulating Bulk GaAs grown with the Liquid-Encapsulated Czochpalski Technique", Physical Review, 35/5, 2524 1988.

170. B. C. Covington, et al., "Electron Paramagnetic Resonance of Isolated As Antisite Defect in Neutron-Transmutation Doped GaAs", Solid State Comm., 65, 1267 1988.

171. J. L. Krohn, T. H. Fisher, "Modification of the NSCR Control Rod System Utilizing Optically Sensed Rod Position Indication", Eleventh TRIGA Owner/User Conference, AFRRI, Bethesda, Maryland, April, 1988.

17 D. E. Feltz, "Installation and Operation of a D O Moderated Rotisserie Irradiation Device for the NSCR", Eleventh TRIGA Owner/User Conference, AFRRI, Bethesda, Maryland, April, 1988.

173. J. W. Davis, "Two-Dimensional Neutronics Analysis of the TAMU Nuclear Science Center Reactor Using Transport and Diffusion Theory Based Codes, M.S. Thesis in Nuclear Engineering, Texas A&M University, 1988.

174. M. E. Denham and T. T. Tieh, "Uranium as an Indicator of Fluid Migration During Late-Stage Diagenesis", Geological Society of America, Vol. 20, No. 7, 1988.

175. A. R. Tripp, "Geochemistry of Arsenic and Antimony in Galveston Bay, Texas", M. S. Thesis in Oceanography, Texas A&M University, 1988.

176. A. T. Showler, R. M. Knaus amd T. E. Reagan, "Foraging Territoriality of the Imported Fire Ant, Solenopsis Invicta Buren, in Sugarcane as Determined by Neutron Activation Analysis", Insectes Sociaux, Paris, Vol. 36, No. 3, 1989.

177. R. M. Knaus and D. L. Van Gent, "Accretion and Canal Impacts in a Rapidly Subsiding Wetland III A New Soil Horizon Marker Method for Measuring Recent Accretion", Estuaries, Vol. 12, No. 4, 1989.

178. P. N. Boothe and B. J. Presley, "Trends in Sediment Trace Element Concentrations Around Six Petroleum Drilling Platforms in the Northwestern Gulf at Mexico", in Drilling Wastes, Engelhardt, Ray & Gillon eds., Elgevier Science Publishers, London, 1989.

179. J. D. Corrigan and K. D. Crowley, "Thermal History of Sites 717 and 718, ODP Log 116, Central Indian Ocean: Constraints from Numerical Simulations and Apatite Fission-Track Data", Geological Society of America Annual Meeting, 1989.

180. K. D. Crowley, "Phanerozoic Thermal History of Michigan Basin and Southern Canadian Shield from Apatite Fission-Track Analysis", Journal of Geophysical Research, 1989.

181. J. D. Corrigan and K. D. Crowley, "Fission-Track Analysis of Detrital Apatites from Holes 717 and 718, ODP Log 116, Central Indian Ocean", Proceeding of the Ocean Drilling Program, 1989.

182. N. S. Khalil, "Design, Installation and Implementation of a Neutron Depth Profiling Facility at the Texas A&M Nuclear Science Center", M.S. Thesis in Nuclear Engineering, Texas A&M University, 1989.

183. T. L. Salamanca, "Ultrasonic Measurement of Residual Stress in Steels Using Critically Refracted Longitudinal Waves", Ph.D., Dissertation in Mechanical Engineering, Texas A&M University, 1989.

184. G. R. Shelton, "Neutronics Evaluation of the Replacement Fuel for the Nuclear Science Center TRIGA Reactor", M.S. Thesis in Nuclear Engineering, Texas A&M University, May, 1989.

185. J. M. Vukovics, "Stress Analysis on NSC BeO-UO_2 Fuel Element Using ANSYS, M.E. in Nuclear Engineering, Texas A&M University, December, 1989.

186. R. Parthasarathy, "Reduced Enrichment Neutronics Evaluation for Texas A&M Nuclear Science Center Reactor", M.S. Thesis in Nuclear Engineering, Texas A&M University, August, 1989.

187. M. E. Denham and T. T. Tieh, "Stylolites in the Upper Smackover Formation of North Louisiana", American Association of Petroleum Geologists Annual Meeting, 1990.

188. R. M. Knaus, "Instrumental Neutron Activation Analysis to Measure Short-term Accretion and Erosion in Wetlands Using Rare Earth Element Soil Horizon Markers", International Conference on Activation Analysis and Applications, Beijing, China, 1990.

189. M. Mallett, "Calibration and Assessment of a Unique Standup Moving Detector Whole Body Counter", M.S. Thesis, Nuclear Engineering, Texas A&M University, 990.

190. J. A. Reuscher, "The Real-Time Neutron Radiography System at Texas A&M University", Twelfth TRIGA Owner/User Conference, University of Texas, March 1990.

191. J. L. Krohn, J. A. Reuscher and N. S. Khalil, "Multiple Experiment Applications with a Beam Port", Twelfth TRIGA Owner/User Conference, University of Texas, March 1990.

192. J. A. Reuscher, S. P. Midgett and J. W. Wright, "Real-Time Neutron Radiography at Texas A&M University", Abstracts of Seventh Symposium on Radiation Measurements and Applications, Ann Arbor, Michigan, May, 1990.

193. J. A. Reuscher, S. P. Midgett and J. W. Wright, "Real-Time Neutron Radiography at Texas A&M University", Nuclear Instruments and Methods in Physics Research, A299, 1990.

194. J. W. Wright, "Design and Implementation of a Dynamic Neutron Radiographic Imaging System", M. S. Thesis in Nuclear Engineering, Texas A&M University, May, 1990.

195. S. P. Midgett, "Design, Development and Applications of a Low-cost, Dynamic Neutron Radiography System Utilizing the TAMU NSC TRIGA Reactor", M. S. Thesis in Nuclear Engineering, Texas A&M University, May, 1990.

APPENDIX III

A Listing of Educational Institutions, Industrial, Government and Medical Organizations That Have Utilized the Facilities and Services of the NSC

Educational Institutions

Abraham Baldwin College
Alfred State College
Arapahoe Junior College
Arkansas State University
Arkansas Tech University
Auburn University
Austin College
Ball State Teachers College
Baylor School of Medicine
Baylor University
Bemidgi State College
Blinn College
Bluefield College
Bryan High School
California State College
California State Poly. College
Catholic College for Women
Chadran State College
Cheyney State College
Clarion State College
Columbus College
Community College of the Finger Lakes
Defiance College
Denison University
Eastern Kentucky University
East Texas University
Fort Valley State College
Galveston College
Grayson County College
Grove City College
Hastings College
Henderson County Junior College
Hill Junior College
Howard Payne College
Iowa State University
Kent State University
Lamar University
Laredo Junior College
Lock Haven State College
Longwood College
Louisiana State University
Louisiana Tech University
Mary Hardin Baylor College
Massachusetts Institute of Tech.
McCullough High School
McLennan Community College
McNeese State University
Miami University (Ohio)
Milwaukee Institute of Technology
Moody College
Nebraska Weslyan University
New Mexico State Unviersity
New Mexico Institute of Mining and Technology

Educational Institutions (Cont'd)

North Park College and Theological Seminary
North Shore Community College
North Texas State University
Oregon State University
Pan American University
Potomac State College
Prairie View A&M University
Rice University
Sam Houston State University
San Antonio College
San Bernadino Valley College
Somerset Community College
South Dakota School of Mines
South Dakota State University
Southeast Missouri State College
Southern Methodist University
Southwestern State College
Southwest Texas State College
Southwest Theological Seminary
State College of Arkansas
State University College, N.Y.
State University of Ohio
Stephen F. Austin College
Sue Bennett College
Sul Ross State University
Taft College
Tarleton State College
Temple University
Thames Valley State Tech. College
Tennessee Tech University
Texas Eastern University
Texas Southmost College
Texas State Tech. Institute - Harlingen
Texas State Tech. Institute - Waco
Texas Tech University
Texas Women's University
University of Alaska
University of Arizona
University of Arkansas
University of Calif. at Los Angeles
University of Corpus Christi
University of Genova
University of Houston
University of Illinois (Chicago)
University of New Hampshire
University of Oklahoma
University of Pittsburgh
University of Southern Louisiana
University of Texas - Arlington
University of Texas - Austin
University of Texas - Dallas
University of Texas - El Paso

Educational Institutions (Cont'd)

UT Medical School - San Antonio
UT System Cancer Center
University of Texas - Tyler
University of Washington
University of Wisconsin
Victoria College
West Virginia Institute of Tech.
Wharton County Junior College
Winona State College
Wisconsin State University
Xavier University

Industrial Organizations

AAE/BCS Traders, Inc.
Ankha Nuclear
Amber Engineering
American Hoechst Corporation
Andrychuk Gemstones
Atomic Energy Industrial
Avery Oil Company
Babcock and Wilcox Company
Balcones Research
Bell Helicopter
Bendix Corporation
Bio Assay Lab - Bio Nuclear
Broz Labs
Cardinal Survey
Celanese Company
Chemtrol, Inc.
Comfaco
Core Laboratories
Diamond Alkali Company
Dow Chemical Company
D. W. Mueller, Consultant
Eastern Whipstock
Ebasco
E.I. DuPont DeNemours and Co.
Electric Reliability Council Texas
Engineers/Designers, Inc.
Estrada, Inc.
E-Systems, Inc.
Exxon Oil & Refining
Exxon Production Research
Exxon Research and Development
General Electric Company
General Nuclear Corporation
Gulf Nuclear, Inc.
Gulf Research
Gulf Science and Technology
Gulf States Utilities Company
Halliburton Services, Inc.
Hastings Radiochemical Works
Houston Area Research Center
Houston Lighting and Power Co.
Hughes Aircraft Company
Hughes Research Labs
Independent Exploration Company
Institute of Research and Instrumentation
Isotex
Jet Research Center, Inc.
Kansas Gas and Electric Company
Kearfott Guidance
K. W. Brown & Associates
Lane Well Company
LGL, Ltd.
Lloyd Barber and Associates
Medical Arts
Mission Engineering
Mobil Oil Company
Monsanto, Inc.
Morris Engineering Company

Industrial Organizations (Cont'd)

NAPKO Corporation
North American Aviation
Nuclear Environmental Eng. Corp.
Nuclear Laboratory Services
Nuclear Sources and Services, Inc.
Pacific Gas and Electric Co.
Petro-Tex Chemical Corp.
Poretics, Inc.
Pro-Tag Services, Inc.
Racon
Radian Corporation
Radiation Consultants, Inc.
Ranger Engineering
R/A Services, Inc.
Raytheon Corporation
Research Concepts
Resource Engineering
Rivera Foods
Santa Barbara Research Center
Shell Chemical Company
Shell Development Co. - Houston
Shell Development Co. - Oakland
Southwest Research Institute
Spectratek, Inc.
Spectronics, Inc.
States Marine Lines
Stoneworks
Technology for Energy Corp.
Tech-Sil Corporation
Teledyne Isotopes, Inc.
Temple Industries
Tennessee Gas Transmission Co.
Texaco, Inc.
Texas Instruments, Inc.
Texas Nuclear Corp.
Texas Romec
Todd Shipyards Corp.
Traceco Services, Inc.
Tracerco, Inc.
Tracer Labs of Midland
TRACO, Inc.
TRIAD
Tru-Tec Corporation
TRW-EDS
Turbine Lab
Universal Technology Corp.
Westinghouse Electric Co.
Xomax

Government and Medical Organizations

Amarillo District Attorney
Austin Police Department
Brooks Medical Center
Bureau of Economic Geology
Corpus Christi District Attorney
Dallas County District Attorney
Denton County District Attorney
Fort Worth Police Department
Houston District Attorney
Houston Police Department
International Atomic Energy Agency
Jefferson County District Attorney
Lawrence Livermore Labs
M. D. Anderson Tumor Center and Hospital
National Aeronautics and Space Administration
North East Radiological Health Lab
Oklahoma Medical Examiner
Orange Police Department
Osage County Oklahoma District Attorney
Scurlock Orthopedic
TAES Office of State Chemistry
The Methodist Hospital of Houston
United States Air Force
United States Army
United States Bureau of Mines
United States Geologic Survey
Wichita Falls District Attorney

APPENDIX IV

Texas A&M University Departments Served by the NSC During Twenty Eight Years of Operation

TAMU Departments and Agencies

Bioengineering Program, College of Engineering
Center for Chemical Characterization and Analysis
Center for Energy and Mineral Resources
College of Architecture and Environmental Design
College of Medicine
Cyclotron Institute
Department of Aerospace Engineering
Department of Animal Science
Department of Archaeology
Department of Architecture
Department of Biochemistry and Biophysics
Department of Building Construction
Department of Chemical Engineering
Department of Chemistry
Department of Civil Engineering
Department of Electrical Engineering
Department of Engineering Design Graphics
Department of Engineering Technology
Department of Entomology
Department of Forest Science
Department of Geology
Department of Geophysics
Department of Health and Physical Education
Department of Horticulture Sciences
Department of Industrial Education
Department of Industrial Engineering
Department of Large Animal Veterinary Medicine and Surgery
Department of Mechanical Engineering
Department of Nuclear Engineering
Department of Oceanography
Department of Petroleum Engineering

TAMU Departments and Agencies (Cont'd)

Department of Physics
Department of Plant Pathology and Microbiology
Department of Plant Sciences
Department of Radiation Biology
Department of Range Science
Department of Recreation and Parks
Department of Soil and Crop Sciences
Department of Veterinary Physiology and Pharmacology
Department of "Vet" Public Health
Department of Wildlife and Fisheries Sciences
Fireman's Training School
Radiological Safety Office
Texas Agriculture Experiment Station
Texas Engineering Extension Service, Electronic Training

APPENDIX V

Environmental Survey Program, Effluent
Release Summary and Personnel Exposure Summary

Summary of Health Physics Support for the Operation of the Nuclear Science Center Reactor

* Provided Health Physics monitoring support for processing 697 irradiations.

* Prepared 369 shipments of radioactive material for shipment to locations off-site (industry, other universities, etc.).

* Prepared 93 shipments of radioactive material for shipment to other locations on the Texas A&M campus.

* In conjunction with representatives of the State of Texas Department of Health conducted a quarterly environmental survey program. This program consists of TLD monitors located around the NSC site and the collection, analysis and evaluation of soil, water, vegetation and milk samples.

* Provided personnel monitoring support for 32 persons on a daily basis and 2,998 visitors as required.

* Performed radionuclide identification and determined radioactivity concentrations for 41 releases of radioactive liquid effluents totaling 1.47 E+6 liters (3.88 E+5 gallons).

* Performed surveys of the Nuclear Science Center facilities for radiation levels and radioactive contamination including the collection, analysis and evaluation of approximately 200 smear samples on a monthly basis.

* Conducted radiation safety training for 75 NSC employees and experimental personnel using the NSC facilities.

* Generated a report to the Nuclear Regulatory Commission identifying mishandling of radioactive material and the records associated with the mishandled material.

* Prepared for disposal over 300 sources of radioactive material stored at the Nuclear Science Center between 1977 and 1989.

* Transferred to the Office of Radiological Safety six barrels of resins and assorted waste for disposal.

* Revised all the Health Physics procedures to reflect changes made in the organization.

Effluent Release Summary

Introduction

Summaries of the radioactive effluents releases from the Nuclear Science Center for 1990 are included in this Appendix. These data are presented in tabular form and includes atmospheric, liquid and solid waste releases.

Particulate Releases

Radioactive particulate are monitored at the base of the central exhaust stack and are summarized on a monthly basis. The annual average release rate was 8.46 E-11 uCi/cc. Total activity release for 1990 was 6.26 E-3 Ci.

Gaseous Releases

Argon-41 is the major gaseous effluent produced and released at the Nuclear Science Center. This effluent is measured by counting the Argon-41 photopeak in the gaseous discharges of the central exhaust stack. Total Argon release during 1990 was 7.11 Curies. This figure yields an annual release rate of 9.62 E-8 uCi/cc as measured in the central exhaust stack with no dilution factors applied. These data are summarized in Table 2.

Solid Radioactive Waste

Approximately 104.2 kg of uncompacted dry solid waste material was packaged in plastic bags for disposal during 1990. These materials were transferred to the Texas A&M University Office of Radiological Safety, Texas License No. 6-448 for disposal. These plastic bags contained laboratory glassware, irradiation containers, decontamination materials, and expendible protective clothing (shoe covers, gloves). The total radioactivity in all these bags summed was 4.7 E-2 Ci. This data is shown in Table 3.

The Radiation Protection Staff also transferred several barrels of waste resins to the Texas A&M University Office of Radiological Safety. The total activity in these barrels of waste resins was 1.33 E-2 Ci. This data is shown in Table 3A.

Liquid Waste Releases

Radioactive liquid effluents are collected in liquid holdup waste tanks prior to release from the confines of the Nuclear Science Center. Sample activity concentrations and isotope identification was performed for each release. There were 41 releases in 1990 totaling 1.47 E+6 liters excluding dilutents from the Nuclear Science Center. The total radioactivity released for 1990 was 1.28 E-2 Ci with an average concentration of 2.96 E-5 uCi/cc. Summaries of the radioisotopic data are presented in Tables 4 through 16. Radioactivity concentrations for each isotope were below the limits specified in 10 CFR20, Appendix B Table II, Column 2.

TABLE 1
Particulate Effluent Releases
Annual Summary
1990

Month	Exhaust Volume (cc)	Average Concentration (uCi/cc)	Releases (Ci)
Radioactivity			
January	6.31 E12	3.7 E-11	2.33 E-4
February	5.70 E12	≤ 6.6 E-12	3.76 E-5
March	6.31 E12	≤ 6.6 E-12	4.16 E-5
April	6.12 E12	9.2 E-10	5.63 E-3
May	6.31 E12	1.4 E-11	8.96 E-5
June	6.12 E12	7.6 E-12	4.65 E-5
July	6.31 E12	4.6 E-12	2.90 E-5
August	6.31 E12	1.3 E-11	7.88 E-5
September	6.12 E12	≤ 6.6 E-12	4.03 E-5
October	6.31 E12	5.1 E-15	3.21 E-8
November	6.12 E12	≤ 1.6 E-15	1.00 E-8
December	6.31 E12	≤ 1.6 E-15	1.03 E-8

Total Volume : 7.43 E13 (cc)

Annual Average Release Concentration* : 8.46 E-11 uCi/cc

Total Activity Released : 6.26 E-3 Ci

* as measured in the central exhaust stack

TABLE 2
Gaseous Effluent Releases
Argon-41
Annual Summary
1990

Month	Exhaust Volume (cc)	Average Concentration (uCi/cc)*	Average Concentration (uCi/cc)+	Total Activity (Ci)*
JANUARY	6.31 E12	5.14 E-9	2.52 E-11	3.18 E-2
FEBRUARY	5.70 E12	8.23 E-8	4.11 E-10	4.69 E-1
MARCH	6.31 E12	1.17 E-7	5.85 E-10	7.38 E-1
APRIL	6.12 E12	3.36 E-8	1.68 E-10	2.05 E-1
MAY	6.31 E12	8.7 E-08	4.35 E-10	5.49 E-1
JUNE	6.12 E12	1.68 E-7	8.4 E-10	1.03 E-1
JULY	6.31 E12	1.2 E-7	6.0 E-10	7.5 E-1
AUGUST	6.31 E12	1.85 E-08	9.25 E-11	1.16 E-1
SEPTEMBER	6.12 E12	$\leq$ 2.02 E-7	1.01 E-9	1.23 E-1
OCTOBER	6.31 E12	1.38 E-7	6.9 E-10	8.7 E-1
NOVEMBER	6.12 E12	1.29 E-7	6.45 E-10	7.7 E-1
DECEMBER	6.31 E12	5.54 E-8	2.77 E-10	3.49 E-1

Total Volume : 7.44 E+13 cc

Annual Average Release Concentration* : $\leq$ 9.62 E-8 uCi/cc

Total Argon-41 Activity Released : 7.11 Ci

* As measure in the central exhaust stack
+ As determined using the dilution factor from pgs 117-119 of the SAR

TABLE 3
Solid Waste Disposal Summary
1990

Isotope	Activity (uCi)
Co-60	773.459
Co-57	100.620
Co-58	0.260
Mn-54	291.784
Zr-95	80.120
Eu-152	180.624
Eu-154	340.749
Tm-170	801.560
Nb-97	0.259
Sc-46	52.125
Ir-192	55.437
Ru-103	5.896
Cs-137	50.541
Ce-144	415.236
Sb-124	11.276
I-124	11.079
Fe-59	3.016
Zn-65	1040.875
Sm-153	27.500
Nb-95	161.031
Cd-109	362.900

Total Activity: 4766.347 uCi (4.7 E-2 Ci)

Total Weight: 104.200 kg

TABLE 3A
Solid Waste Disposal Summary
Resin Waste
1990

Isotope	Activity(uCi)
Mn-54	20.58
Co-60	121.66
Eu-152	86.83
Eu-154	112.23
Co-57	78.14
Cd-109	260.19
Tn-228	650.54
Sm-153	0.70
Cs-137	1.60

Total Volume: 257.50 gallons

Total Activity: 1332.47 uCi (1.30 E-2 Ci)
1.30 E-2 Ci

TABLE 4
Radioactive Liquid Effluent Releases
Summary
1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	21	9.5E-6	3E-5	4.2E-4
Cr-51	13	4.4E-5	2E-3	1.8E-3
Cs-137	1	1.3E-7	2E-5	9.9E-7
K-40	4	2.6E-6	3E-4	9.1E-5
Mn-54	30	3.2E-5	1E-4	1.2E-3
Na-24	6	7.5E-6	1E-4	3.4E-4
Nb-97	5	4.5E-6	9E-4	1.6E-4
Sb-124	2	9.9E-7	2E-5	5.6E-5
Sc-46	24	2.0E-4	4E-5	7.1E-3
Sr-95	2	9.0E-7	7E-5	3.2E-5
Zn-65	5	2.4E-5	1E-4	1.3E-3

Total Number of Releases : 41

Total Volume : 1.47 E+9 ml (3.51 E+5 gallons)

Total Activity : 1.28 E-2 Curies

Avg. Concentration : 2.96E-5 uCi/cc

TABLE 5
Radioactive Liquid Effluent Releases
January 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	4	4.5E-6	3E-5	2.68E-4
Mn-54	4	2.5E-6	1E-4	1.37E-4
K-40	1	2.8E-7	3E-4	1.16E-5
Sb-124	2	9.8E-7	2E-5	5.62E-5
Na-24	1	7.5E-7	1E-4	4.24E-5
Zn-65	1	6.3E-6	1E-4	3.58E-4

Total Number of Releases: 4

Total Volume: 2.0 E+8 ml

Total Activity: 8.732 E-4 Ci

Avg. Concentration: 3.83 E-6 uCi/cc

TABLE 6
Radioactive Liquid Effluent Releases
February 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	2	7.35E-7	3E-5	1.15E-5
Mn-54	2	1.61E-6	1E-4	2.55E-5
Zn-65	1	7.74E-7	1E-4	1.17E-5

Total Number of Releases: 2

Total Volume: 3.23 E+7 ml

Total Activity: 4.87 E-5 Ci

Avg. Concentration: 1.04 E-6 uCi/cc

TABLE 7
Radioactive Liquid Effluent Releases
March 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	3	8.49E-7	3E-5	1.94E-5
Mn-54	3	4.17E-6	1E-4	8.58E-5
Cr-51	1	2.90E-6	2E-3	4.95E-5

Total Number of Releases: 3

Total Volume: 7.92 E+7 ml

Total Activity: 1.55 E-4 Ci

Avg. Concentration: 2.64 E-6 uCi/cc

TABLE 8
Radioactive Liquid Effluent Releases
April 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	1	1.82E-7	3E-5	6.63E-6
Mn-54	1	3.21E-7	1E-4	1.16E-5

Total Number of Releases: 1

Total Volume: 3.64 E+7 ml

Total Activity: 1.82 E-5 Ci

Avg. Concentration: 2.52 E-7 uCi/cc

TABLE 9
Radioactive Liquid Effluent Releases
May 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	2	2.87E-7	3E-5	1.21E-5
Mn-54	5	3.69E-6	1E-4	1.47E-4
Na-24	2	2.66E-6	1E-4	1.15E-5
Cr-51	2	6.07E-6	2E-3	3.03E-4

Total Number of Releases: 5

Total Volume: 2.04 E+8 ml

Total Activity: 4.74 E-4 Ci

Avg. Concentration: 3.17 E-6 uCi/cc

TABLE 10
Radioactive Liquid Effluent Releases
June 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	3	7.40E-7	3E-5	2.78E-5
Mn-54	2	1.19E-6	1E-4	4.79E-5
K-40	1	1.14E-6	3E-4	5.62E-5
Zn-65	1	4.72E-7	1E-4	1.34E-5
Cr-51	2	5.77E-6	2E-3	2.46E-4
Sc-46	4	6.46E-6	4E-5	2.38E-4

Total Number of Releases: 5

Total Volume: 1.84 E+8 ml

Total Activity: 6.29 E-4 Ci

Avg. Concentration: 2.63 E-6 uCi/cc

TABLE 11
Radioactive Liquid Effluent Releases
July 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	1	4.03E-7	3E-5	1.91E-5
Mn-54	2	2.75E-6	1E-4	1.12E-4
K-40	1	6.75E-7	3E-4	1.02E-5
Na-24	1	1.81E-6	1E-4	8.56E-5
Cr-51	2	5.52E-6	2E-3	2.24E-4
Sc-46	6	9.24E-5	3E-5	2.91E-3

Total Number of Releases: 6

Total Volume: 1.72 E+8 ml

Total Activity: 3.36 E-3 Ci

Avg. Concentration: 1.73 E-5 uCi/cc

TABLE 12
Radioactive Liquid Effluent Releases
August 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	1	4.12E-7	3E-5	1.87E-5
Mn-54	1	7.26E-7	1E-4	3.30E-5
Sc-46	1	2.59E-6	4E-5	1.18E-4

Total Number of Releases: 1

Total Volume: 4.55 E+7 ml

Total Activity: 1.69 E-4 Ci

Avg. Concentration: 1.24 E-6 uCi/cc

TABLE 13
Radioactive Liquid Effluent Releases
September 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	2	4.98E-7	3E-5	1.85E-5
Mn-54	3	5.21E-6	1E-4	2.11E-4
Na-24	1	6.62E-7	1E-4	3.01E-5
Zn-65	1	5.60E-6	1E-4	3.18E-4
Cr-51	2	1.06E-5	2E-3	4.27E-4
Sc-46	4	4.16E-5	4E-5	1.62E-3
Sr-92	1	7.60E-7	7E-5	2 88E-5
Nb-97	1	3.00E-6	9E-4	1.14E-4

Total Number of Releases: 5

Total Volume: 2.01 E+8 ml

Total Activity: 2.77 E-3 Ci

Avg. Concentration: 8.49 E-6 uCi/cc

TABLE 14
Radioactive Liquid Effluent Releases
October 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Mn-54	2	1.26E-6	1E-4	7.22E-5
K-40	1	3.12E-7	3E-4	1.30E-5
Na-24	1	1.65E-6	1E-4	6.88E-5
Cr-51	1	2.96E-6	2E-3	1.79E-4
Sc-46	4	1.33E-5	4E-5	6.62E-4
Nb-97	3	7.61E-7	9E-4	3.21E-5
Cs-137	1	1.31E-7	2E-5	9.93E-7

Total Number of Releases: 4

Total Volume: 1.52 E+8 ml

Total Activity: 1.03 E-3 Ci

Avg. Concentration: 2.91 E-6 uCi/cc

TABLE 15
Radioactive Liquid Effluent Releases
November 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Co-60	2	5.70E-7	3E-5	1.55E-5
Mn-54	3	4.60E-6	1E-4	1.31E-4
Cr-51	2	7.40E-6	2E-3	2.29E-4
Sc-46	3	2.54E-5	4E-5	6.87E-4
Sr-95	1	1.39E-7	7E-5	3.16E-6
Nb-97	1	7.52E-7	9E-4	1.71E-5

Total Number of Releases: 3

Total Volume: 7.77 E+7 ml

Total Activity: 1.08 E-3 Ci

Avg. Concentration: 6.47 E-6 uCi/cc

TABLE 16
Radioactive Liquid Effluent Releases
December 1990

Isotope	No of Releases	Conc. uCi/cc	MPC uCi/cc	Activity Curies
Mn-54	2	3.87E-6	1E-4	1.67E-4
Zn-65	1	1.11E-5	1E-4	6.14E-4
Cr-51	1	2.74E-6	2E-3	1.52E-4
Sc-46	2	2.54E-5	4E-5	7.91E-4

Total Number of Releases: 2

Total Volume: 9.32 E+7 ml

Total Activity: 1.72 E-3 Ci

Avg. Concentration: 1.07 E-5 uCi/cc

ENVIRONMENTAL SURVEY PROGRAM

Introduction

The environmental survey samples were collected in accordance with the schedules of the cooperative surveillance program between the Texas State Department of Health and the Texas A&M University. These samples were analyzed for gross gamma and beta activities and isotope identification. Data from these samples reflect the continued use of retention facilities and sample analysis for laboratory effluents prior to their release.

The environmental survey program includes the in-situ measurement of integrated radiation exposures at the site boundaries. These measurements are made for a period of approximately 90 days using flouride chips in glass encapsulated bulbs. The dosimeters are provided and processed by Texas Department of Health, Bureau of Radiation Control, Division of Environmental Programs. The state utilizes a background monitor located at a point 5.25 miles west-southwest of the NSC facility. This site for the background measurement is generally at right angles to the prevailing southeasterly winds.

Table 17 lists the average exposure rate above ambient background for a number of locations at the site boundary. The highest exposure point was determined to be at Site #12 (349 mR/yr) which is on the NSC Site Boundary fence northeast of the reactor building near the calibration range source building.

The closest offsite point of extended occupancy is located just beyond the Site Boundary fence directly behind the Site #10 monitoring location. From the data in Table 17, it can be easily shown that those occupants received much less than twice the average local off-site background exposure.

Summaries of the environmental survey program for 1990 are presented in Tables 18-21 for total (sum) gamma or total beta activity as reported to the NSC or as determined by the NSC when data from the state was unavailable.

TABLE 17
Environmental Radiation Monitoring Program
Radiation Exposures, 1990
(including background)

Site #	Location	Measured Average Exposure Rate (mR/182 days)	Projected Annual Exposure 1990 (mR)
2	300 ft. W of reactor building, near fence corner	41.4	83
3	250 ft WSW of reactor building, on SW chain link fence	124.2	250
4	200 ft NW of reactor building, on chain link fence, near butane tank	51.3	103
5	225 ft NE of reactor building, on fence N of driveway	45.9	92
6	300 ft NNE reactor building, near fence corner	102.6	206
10	190 ft SE of reactor building, on SE chain link fence	31.3	63
11	300 ft E of reactor building, near fence corner	31.9	64
12	375 ft. NE of reactor building, near source building	87.0+	349
13	320 ft. NE of reactor building, near waste storage shed	76.8	154
14A*	5.25 miles WSW of reactor building, at FM 60 bridge over Brazos River	15.3+	64

Measured Values: 1st & 2nd quarter results from Bureau of Radiation Control, Texas Department of Health (2/12/90 through 8/6/90)
* Background values.
+ information provided for 91 days only

TABLE 18
Environmental Survey Program
Vegetation
1990

Qtr	Location	Total Activity (UCi/gal)	Activity (UCi/gal)
1st	TAMU dairy	< MDA	< MDA
2nd	TAMU dairy	1.40 E-3	8.16 E-5
3rd	N/A	N/A	N/A
4th	TAMU dairy	< MDA	< MDA

TABLE 19
Environmental Survey Program
Water
1990

Qtr	Location	Total Activity (uCi/ml)	Activity (uCi/ml)
1st	Brazos River	< MDA	< MDA
1st	White Creek	< MDA	< MDA
2nd	NSC Creek	5.87 E-4	7.73 E-7
2nd	White Creek	< MDA	< MDA
2nd	Brazos River	7.99 E-4	7.99 E-4
3rd	White Creek	< MDA	< MDA
3rd	Brazos River	1.737 E-7	< MDA
3rd	NSC Creek	3.658 E-5	2.27 E-5
4th	White Creek	5.35 E-7	< MDA

TABLE 20
Environmental Survey Program
Milk
1990

Qtr	Location	Total Activity (uCi/ml)	Activity (uCi/ml)
1st	TAMU dairy	1.002 E-6	< MDA
2nd	TAMU dairy	1.192 E-6	1.84 E-7
3rd	TAMU dairy	7.406 E-7	< MDA
4th	TAMU dairy	< MDA	< MDA
4th	TAMU dairy	8.137 E-5	8.137 E-5

RADIATION AND CONTAMINATION CONTROL PROGRAM

Introduction

The detection and elimination or control of radiation hazards is an integral part of the Radiation Safety Program at the Nuclear Science Center. The radiation and smear survey programs contribute to the control and elimination of these health hazards. This program is effective in preventing the spread of radioactive contamination, improper storage of radioactive materials, and unwarranted exposures.

Radiation Survey

The Nuclear Science Center uses an area radiation monitoring system consisting of ten (10) detector channels located throughout the Reactor and Laboratory Buildings. This system is equipped with alarm settings and remote readouts in the control and reception rooms. Radiation levels and operational checks are recorded on a daily basis. This system functions as a radiation safety monitor for the early detection of radiation hazards. The Nuclear Science Center facilities and site boundaries are surveyed monthly with beta-gamma sensitive instruments. These measurements are taken to determine proper storage and identification of radioactive materials and that visitor and routine work areas are free of radiation hazards. Additionally, radiation monitoring support is provided for the reactor operations and experimenter groups to insure the safe handling of radioactive materials and control of personnel exposures. At the perimeter of the NSC site, radiation levels did not exceed the 500 mrem dose limit during 1990.

Contamination Survey

The Nuclear Science Center is routinely surveyed for radioactive contamination every month. This program includes the collection, analysis and evaluation of approximately 200 smear samples and the decontamination of areas and materials with removable beta-gamma radioactivities of greater than 250 dpm/100 cm^2. The 250 dpm/100 cm^2 is an administrative limit, Standard Operating Procedures call for decontamination of any items with levels in excess of 1000 dpm/100 cm^2.

PERSONNEL EXPOSURES

Radiation exposures to personnel at the Nuclear Science Center in 1990 were below the limits set forth in 10CFR20.101. The maximum exposure received by any individual for the year was 460 mrem. A total of 3.6 MANREM was received for 1990. These data are summarized in Table 22.

All employees at the Nuclear Science Center were changed to neutron badges as an evaluation of the potential for exposure to neutrons indicated that the majority of NSC employees have the potential for exposure.

During 1990, 2,998 persons visited the Nuclear Science Center. The maximum exposure to any visitor as determined by issued film badges did not exceed minimum measurable quantities. Dosimetry results were provided by a NVLAP accredited supplier.

TABLE 22

1990 NSC DOSE REPORT

EMPLOYEE NUMBER	TOTAL (mRem)			QTR. WHOLE BODY (mRem)			
	BODY	*RT HD*	*LT HD*	*FIRST*	*SECOND*	*THIRD*	*FOURTH*
1	160	1180	720	70	20	30	40
2	70	570	500	10	60	0	0
3	130	N/A	N/A	30	20	50	30
4	50	N/A	N/A	10	10	30	0
5	40	N/A	N/A	0	10	30	0
6	450	1530	1990	40	170	120	120
7	40	N/A	N/A	10	0	30	0
8	150	90	110	40	60	40	10
9	30	N/A	N/A	0	0	30	0
10	0	0	0	0	0	0	0
11	140	100	130	30	40	40	30
12	40	N/A	N/A	0	10	30	0
13	30	N/A	N/A	0	0	30	0
14	40	N/A	N/A	0	10	30	0
15	150	1270	1200	60	10	20	60
16	200	270	240	0	10	110	80
17	120	100	140	60	0	20	40
18	160	970	570	70	30	20	40
19	460	940	490	220	90	110	40
20	150	360	310	60	20	10	40
21	40	N/A	N/A	0	10	30	0
22	60	N/A	N/A	10	20	30	0
23	0	N/A	N/A	0	0	0	0
24	0	N/A	N/A	0	0	0	0
25	60	70	110	50	10	0	0
26	0	90	60	0	0	0	0
27	40	140	220	10	0	30	0
28	0	200	130	0	0	0	0
29	50	190	190	0	0	50	0
30	20	220	140	20	0	0	0
31	160	440	420	30	100	30	0
32	340	2940	3260	150	90	30	70
33	190	430	370	100	0	0	0
34	0	N/A	N/A	0	0	0	0
35	30	N/A	N/A	0	0	30	0
36	30	150	170	20	0	10	0
37	0	N/A	N/A	0	0	0	0
38	0	N/A	N/A	0	0	0	0
39	0	N/A	N/A	0	0	0	0
40	50	N/A	N/A	0	20	30	0
41	60	N/A	N/A	20	10	30	0
MANREM:	3.65	12.25	11.49	1.14	0.83	1.08	0.6