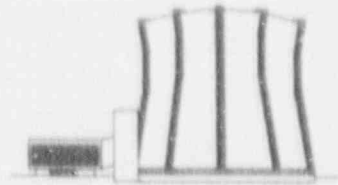


TEXAS ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77643-3575

27 March 1991



NUCLEAR SCIENCE CENTER
409/845-7551

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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

Gentlemen:

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, we hereby submit three copies of our annual report for the period of January 1, 1990 - December 31, 1990.

Sincerely,

Donald E. Feltz
Director

DEF/ym

Enclosures

9104020062 901231
PDR ADOCK 05000128
R PDR

RESEARCH AND DEVELOPMENT FOR MANKIND

IE 47
1/3

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

(See Instructions on Reverse Side)

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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☐ b. Conference paper not to be published in a journal: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

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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

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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.

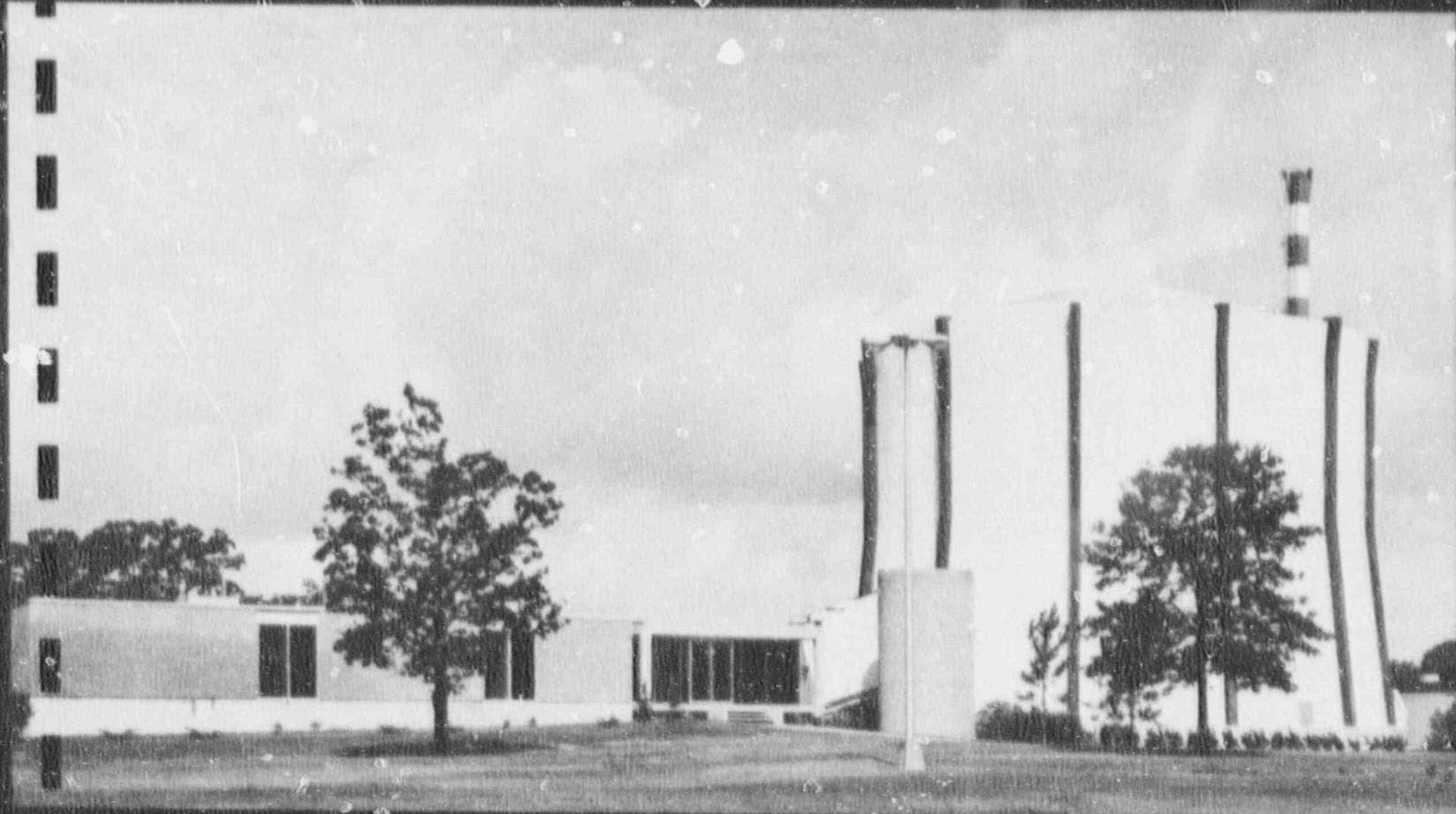
Item 6. Enter name of person to whom inquiries concerning the recommendations on this Form may be addressed.

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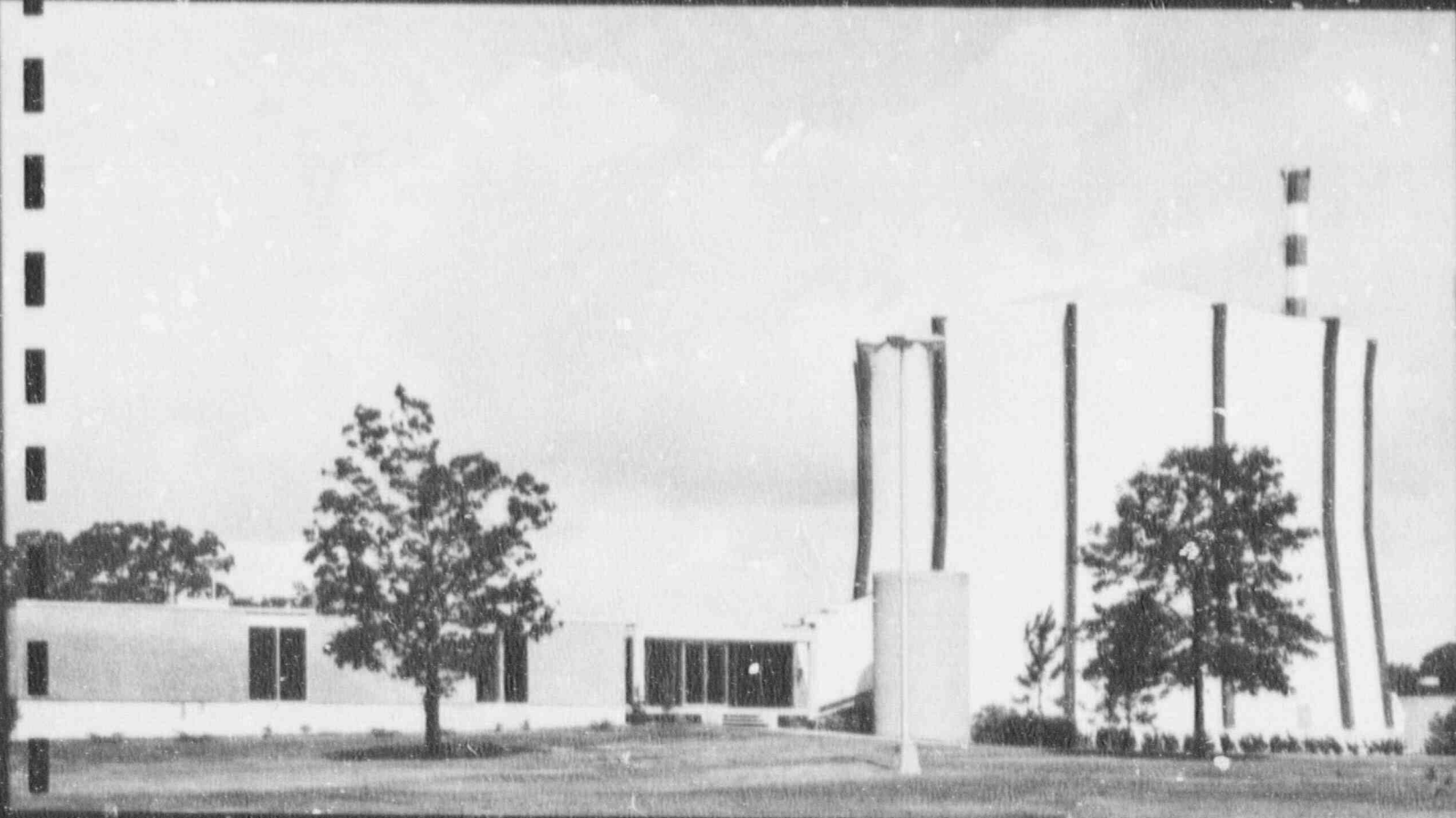
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TWENTY-SEVENTH PROGRESS REPORT
OF THE
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER
JANUARY 1, 1990-DECEMBER 31, 1990
CONTRACT DE-ACO5-76ER04207



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

TWENTY-SEVENTH PROGRESS REPORT
OF THE
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER
JANUARY 1, 1990-DECEMBER 31, 1990
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**NUCLEAR SCIENCE CENTER
TEXAS ENGINEERING EXPERIMENT STATION
ENGINEERING PROGRAM
TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS**

T W E N T Y - S E V E N T H P R O G R E S S R E P O R T

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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Reportable Occurrence No. 90-01
Intermittent Loss of Signal to the Linear Power
Channel

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Appendix I

Description of Projects Utilizing the NSCR

Appendix II

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

Appendix III

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

Appendix IV

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

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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 radio-isotopes 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 mostly 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).

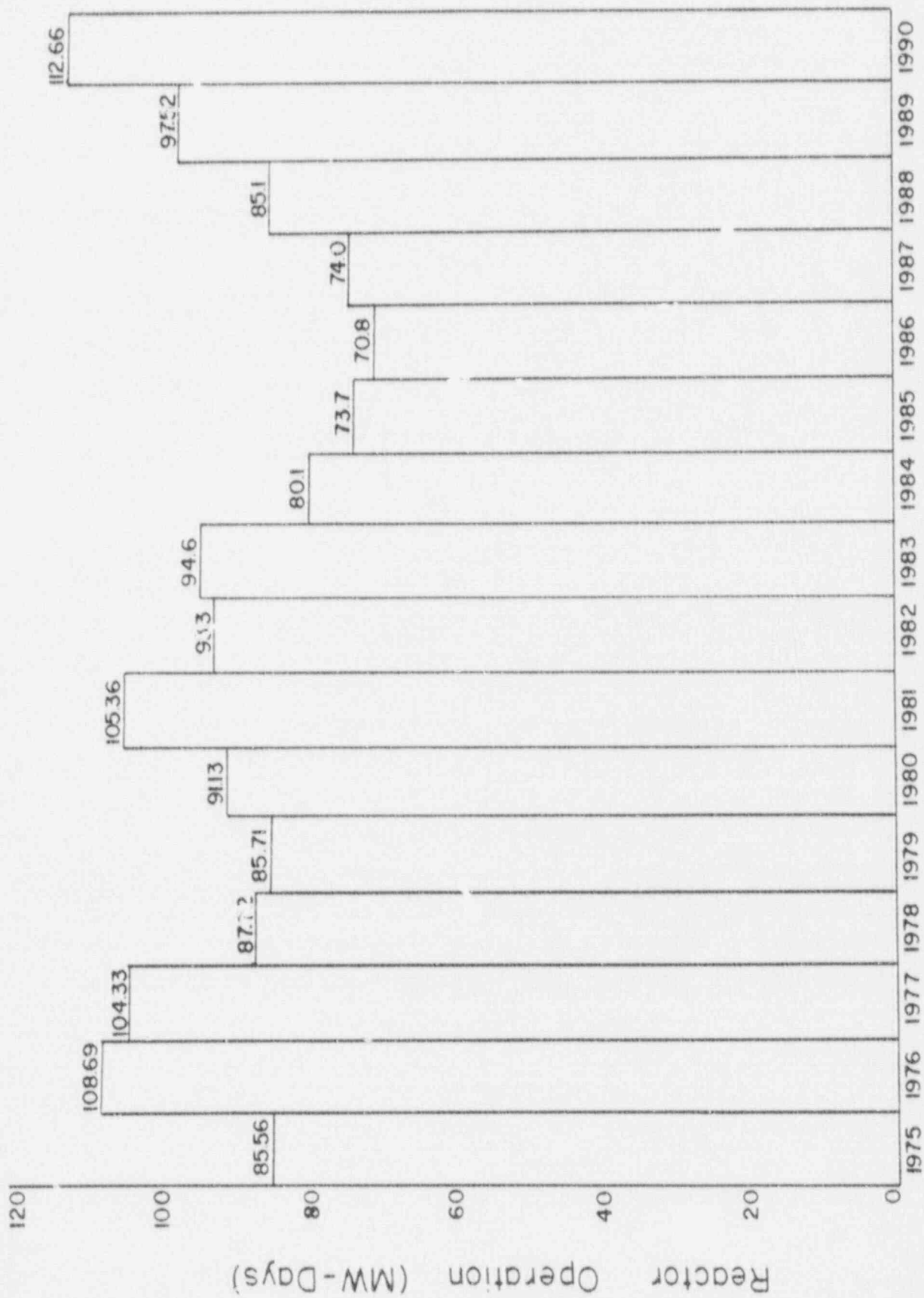


Figure 1. Yearly Reactor Operation

TABLE I
REACTOR UTILIZATION SUMMARY

	<u>1990 Annual Total</u>
*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	\$4,15
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

<u>Department</u>	<u>Course No.</u>	<u>Instructor</u>	<u>No. of Students and Purpose</u>
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, TexasFaculty: Dr. S. Kelley
Dr. K. DammStudents: K. Geving
L. CarterSul Ross State University -- Alpine, TexasFaculty: Dr. D. Nelson
Dr. J. Richerson
Dr. M. McCurry

Lab Director: L. Forsythe

Texas State Technical Institute -- Waco, TexasFaculty: 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 HampshireFaculty: A. Conners
J. MacriUniversity of Oklahoma -- 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 ToursNo. 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 InstitutionsAAE/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. Skinner

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, TexasExperimenters: 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 its 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 "1"

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 checklist 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 occurred 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 declared 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 Operator 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 Amendment 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 Operations

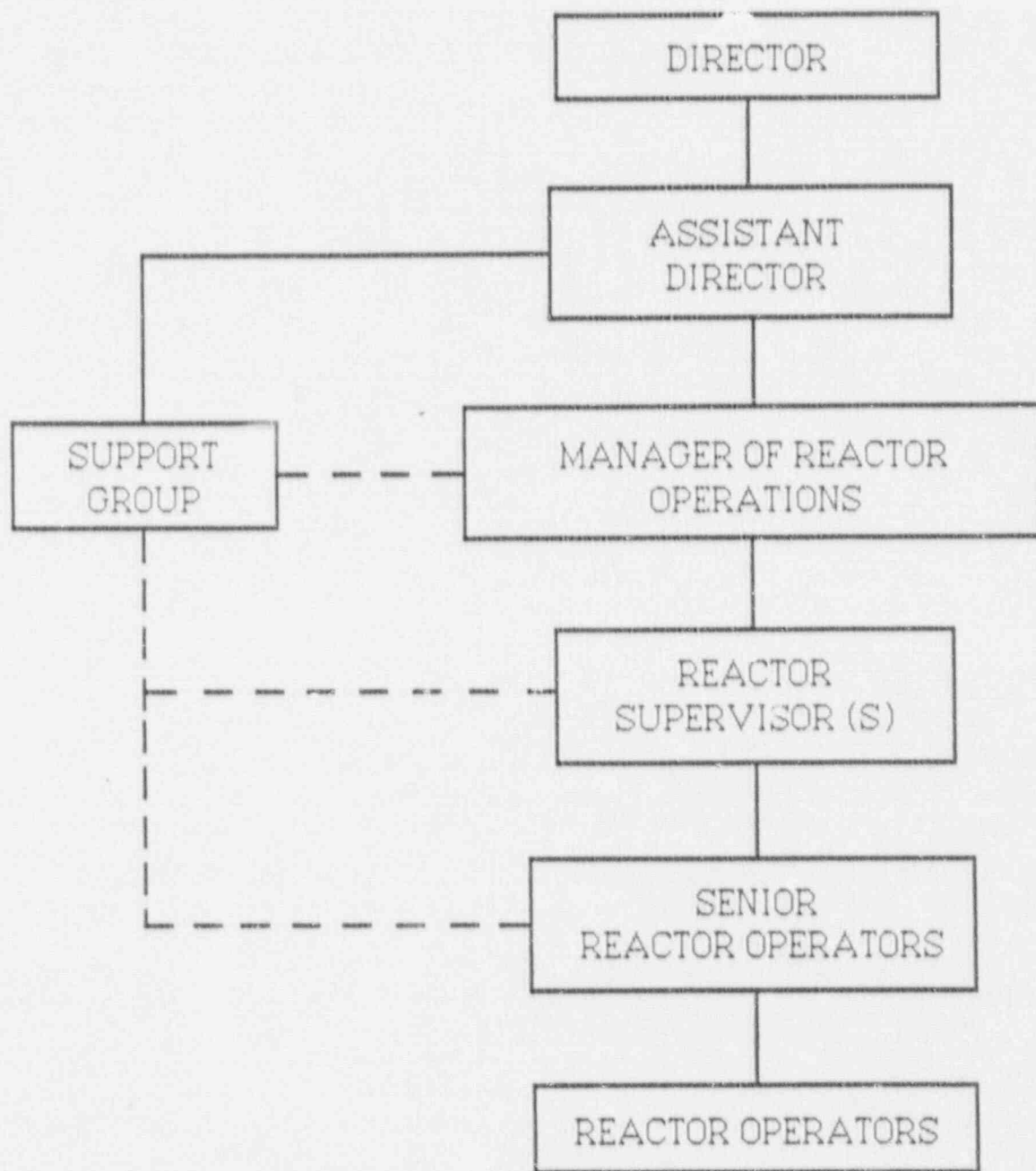


Figure 2 Nuclear Science Center
Reactor Operations Organization Chart

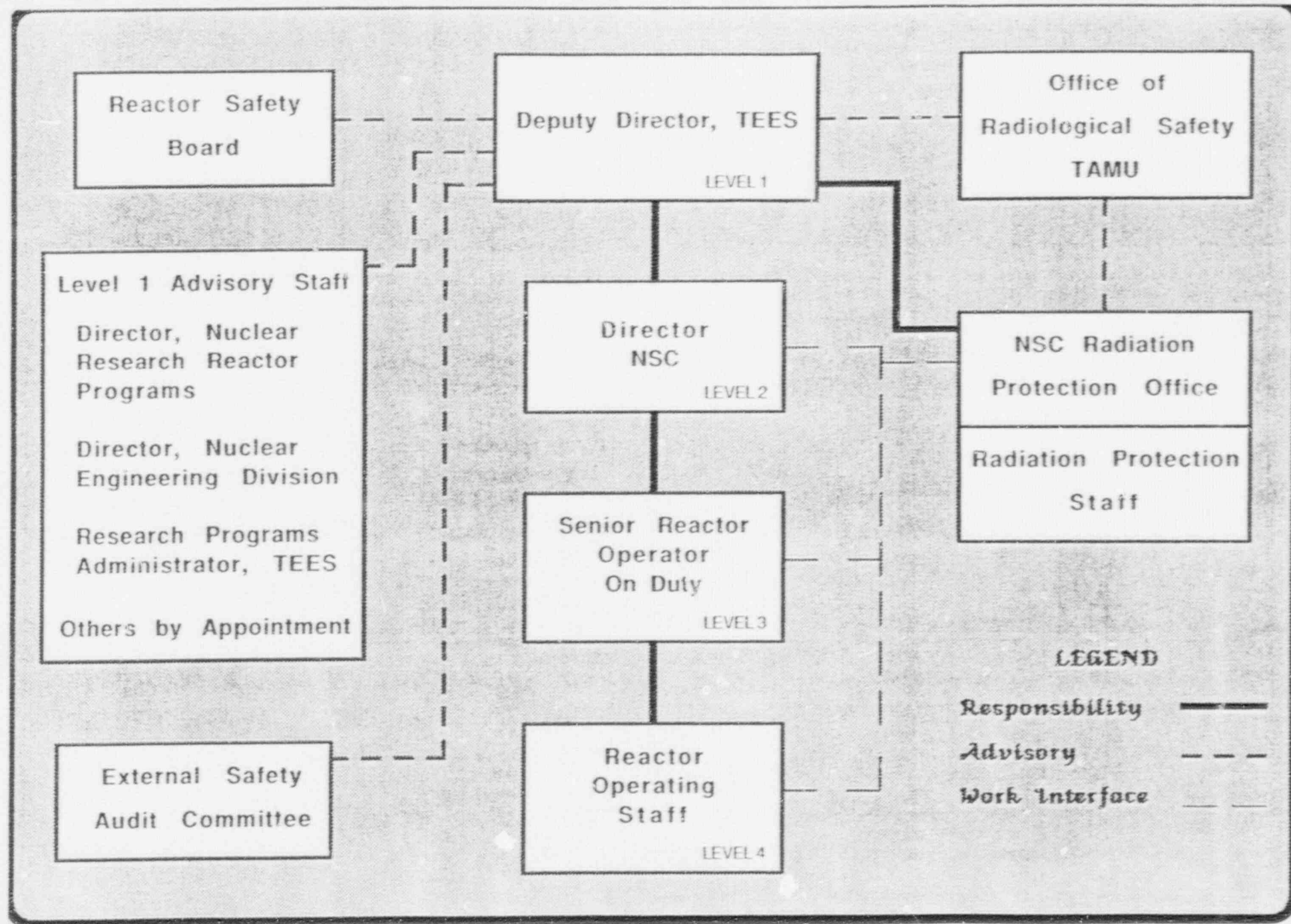


FIGURE 3

NSCR ADMINISTRATIVE ORGANIZATIONAL CHART

Facility Administration and Reactor Operations Staff (cont'd)

+Krohn, J. L.	- Assistant Director
+Luther, J. C.	- Reactor Supervisor (Terminated)
+O'Kelly, D. S.	- Senior Reactor Operator
+Petesch, 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
Restivo, 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
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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

J. Feltz, Director, Nuclear Science Center
(January 1, 1990 - December 31, 1990)

J. L. Poston, Professor and University Radiological Safety Officer
(January 1, 1990 - December 31, 1990)

J. L. 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 UniversityNuclear Engineering

DAMAGE STUDIES OF INFRARED DETECTOR MATERIAL

Personnel

Dr. Ron R. Hart -- Professor
Kevin Seeger -- 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 subcritical 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. G. 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.

OceanographyDISTRIBUTION 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 CRETACEOUS/TERTIARY BOUNDARY

Personnel

Dr. N. Carter -- 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 Cretaceous-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 UniversitiesLouisiana 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 TRACK 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 InstitutionsM. 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. Magnuson -- 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 Ruminant 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 F. 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, PSDP 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, Alameda 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, "Determination of Grazed Forage Voluntary Intake", Ph.D. Dissertation in 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.
26. 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 University, 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.
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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.
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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-Difluoroethyl Radicals", J.C.S. Chem. Comm., 814, 1980.
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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.
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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.
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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	Fort Valley State College
Alfred State College	Galveston College
Arapahoe Junior College	Grayson County College
Arkansas State University	Grove City College
Arkansas Tech University	Hastings College
Auburn University	Henderson County Junior College
Austin College	Hill Junior College
Ball State Teachers College	Howard Payne College
Baylor School of Medicine	Iowa State University
Baylor University	Kent State University
Bemidji State College	Lamar University
Blinn College	Laredo Junior College
Bluefield College	Lock Haven State College
Bryan High School	Longwood College
California State College	Louisiana State University
California State Poly. College	Louisiana Tech University
Catholic College for Women	Mary Hardin Baylor College
Chadron State College	Massachusetts Institute of Tech.
Cheyney State College	McCullough High School
Clarion State College	McLennan Community College
Columbus College	McNeese State University
Community College of the Finger Lakes	Miami University (Ohio)
Defiance College	Milwaukee Institute of Technology
Denison University	Moody College
Eastern Kentucky University	Nebraska Wesleyan University
East Texas University	New Mexico State University
	New Mexico Institute of Mining and Technology

Educational Institutions (Cont'd)

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

Educational Institutions (Cont'd)

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

Industrial Organizations

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

Industrial Organizations (Cont'd)

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

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 $1.47 \text{ E}+6$ liters excluding dilutents from the Nuclear Science Center. The total radioactivity released for 1990 was $1.28 \text{ E}-2 \text{ Ci}$ with an average concentration of $2.96 \text{ E}-5 \text{ uCi/cc}$. 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 Radioactivity	Exhaust Volume (cc)	Average Concentration (uCi/cc)	Releases (Ci)
January	6.31 E12	3.7 E-11	2.33 E-4
February	5.70 E12	$\leq 6.6 \text{ E-12}$	3.76 E-5
March	6.31 E12	$\leq 6.6 \text{ E-12}$	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	$\leq 6.6 \text{ E-12}$	4.03 E-5
October	6.31 E12	5.1 E-15	3.21 E-8
November	6.12 E12	$\leq 1.6 \text{ E-15}$	1.00 E-8
December	6.31 E12	$\leq 1.6 \text{ E-15}$	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

<u>Isotope</u>	<u>Activity (uCi)</u>
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

<u>Isotope</u>	<u>Activity(uCi)</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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	4E-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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
Co-60	2	4.98E-7	3E-5	1.88E-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
Br-92	1	7.60E-7	7E-5	2.38E-
Nb-97	1	3.00E-6	9E-4	1.14E-

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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
Mn-54	2	1.26E-6	1E-4	7.27E-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	3.33E-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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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

<u>Isotope</u>	<u>No of Releases</u>	<u>Conc. uCi/cc</u>	<u>MPC uCi/cc</u>	<u>Activity Curies</u>
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 fluoride 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)

<u>Site #</u>	<u>Location</u>	<u>Measured Average Exposure Rate (mR/182 days)</u>	<u>Projected Annual Exposure 1990 (mR)</u>
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

<u>Tr</u>	<u>Location</u>	<u>Total Activity</u> <u>(UCi/gal)</u>	<u>Activity</u> <u>(UCi/gal)</u>
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

<u>Our</u>	<u>Location</u>	<u>Total Activity</u> <u>(uCi/ml)</u>	<u>Activity</u> <u>(uCi/ml)</u>
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

<u>Qtr</u>	<u>Location</u>	<u>Total Activity</u> <u>(uCi/ml)</u>	<u>Activity</u> <u>(uCi/ml)</u>
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 cm². The 250 dpm/100 cm² is an administrative limit. Standard Operating Procedures call for decontamination of any items with levels in excess of 1000 dpm/100 cm².

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	180	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	1290	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	80	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	100	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