

**TWENTY-FOURTH PROGRESS REPORT
OF THE
TEXAS A&M UNIVERSITY
NUCLEAR SCIENCE CENTER
JANUARY 1, 1987-DECEMBER 31, 1987
CONTRACT DE-ACO5-76ER04207**



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

T W E N T Y - F O U R T H P R O G R E S S R E P O R T
of the
T E X A S A & M U N I V E R S I T Y
N U C L E A R S C I E N C E C E N T E R

January 1, 1987 - December 31, 1987

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and 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

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Table of Contents

	<u>Page</u>
I. Introduction	1
II. Reactor Utilization	3
A. Utilization Summary	3
B. Utilization by the Texas A&M University	3
C. Utilization by Other Educational Institutions	7
D. Utilization by Non-University Institutions	10
III. Facility Operations	13
A. Facility Safety and Operational Improvements	13
Front Gate Lighting	13
Cooling Tower Rewiring	13
B. Improvements to Reactor Systems and Experimental Facilities	13
Control Rod Travel Measurement	13
Heat Exchanger Cleaning	13
Self-Powered Neutron Detector	13
Console Monitor	13
D ₂ O Moderated Rotisserie Irradiation Device	14
C. Operational Problems	14
Control Rod Drive Controller Modifications	14
Transient Rod Drive Switching	16
Secondary Pump Shaft Coupling	16
D. Changes in Operating Procedures	
E. Unscheduled Shutdowns	17
F. Reactor Maintenance and Surveillance	17

	<u>Page</u>
IV. Facility Administration	19
A. Organization	19
B. Personnel	19
C. Reactor Safety Board	22
Appendix I	
Description of Projects Utilizing the NSCR	
Appendix II	
Publications, Theses and Papers Involving Use of NSC Facilities From 1978 to Date	
Appendix III	
Educational Institutions, Industrial, Government and Medical Organizations Served by the NSC	
Appendix IV	
Texas A&M University Departments Served by the NSC During Twenty Four Years of Operation	
Appendix V	
Environmental Survey Program, Effluent Release Summary and Personnel Exposure Summary	

List of Tables and Figures

		<u>Page</u>
Table I	Reactor Utilization Summary	5
Table II	Academic Use of the Reactor	8
<u>Figure</u>		
1	Yearly Reactor Operation	4
2	D ₂ O Irradiation Device	15
3	Nuclear Science Center Reactor Operations Organizational Chart	20

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 facility is available to the University, other educational institutions, government agencies, and private organizations and individuals. The facility operating license, R-83 issued by the U.S. Nuclear Regulatory Commission, was renewed in March, 1983 and 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 U.S. DOE Contract #DE-AC05-76ER04207 (formerly EY-76-C-05-4207) and of the U.S. NRC, under 10CFR50.59. The report covers the period from January 1, 1987 through December 31, 1987.

Utilization of the reactor during 1987 increased slightly over that in 1986. Although some parameters of reactor use, such as the number of irradiations and average irradiations per day decreased slightly, overall use of the reactor was greater than in 1986. The number of irradiation experiment hours decreased significantly in 1987 but there were large increases in the hours of beam port and irradiation cell usage. This reflects a shift in the NSC's main activity from isotope tracer production to testing and exposure irradiations. This trend is likely to continue in the future due to service irradiations for such companies as Poretics and TRW. In addition, the neutron activation analysis and radioassay areas saw increases in use and inquiries when compared to 1986. Part of this increase was due to the acquisition of a new gamma spectroscopy system which went on-line in late 1986. The software development program with the International Atomic Energy Agency continued during 1987 and the Nuclear Science Center again participated in the U.S. DOE Reactor Sharing Program.

Core VIII-A, which has been operational since March 1986, was used throughout 1987. Pulse operations were continued in 1987 and a total of 45 pulses (\$68.03 total pulse reactivity) were executed. The decrease in operation in the pulse mode reflects the current lack of interest in reactor experiments requiring pulsing operations. Pulsing operations for 1987 were due basically to calibration and maintenance requirements and engineering labs.

The new control rod drive and controller electronics continued to undergo troubleshooting modifications in 1987 but now appear to have reached their final form. The thermal column experiment was fully implemented during 1986 with production of film taking place. A new device, a heavy water filled "box" was constructed during 1987 for use in neutron transmutation doping and boron content determina-

tion experiments. And finally, two new high purity germanium detectors were obtained during the year to replace one of the older, Ge(Li) detectors that had been on loan to the NSC and to provide a new detector for use on the Lower Research Level. Beam Port 1 was revived during the past year and some neutron scattering work done. Plans are underway to develop a prompt gamma activation analysis capability using this beam port and one of the new detectors mentioned earlier.

Several operational problems occurred in 1987 but none resulted in significant losses of operating time. Work continued with the secondary water treatment system to attempt to improve performance, and equipment age continued to be the leading cause of reactor downtime. In the latter part of the year, the use of acid in the secondary treatment system was discontinued which is hoped to decrease system upkeep and danger to personnel.

During this reporting period there were no changes made to the site area. Spare equipment for possible future expansion and use was obtained from various sources.

In September 1987, Dr. Kevan Crawford was hired to fill the position of Manager of Reactor Operations and John Krohn was named Assistant Director while retaining his position as Manager of Technical Services. At the July Reactor Safety Board the NSC's plans to replace the Head of the Nuclear Engineering Department with the Director of Research Reactor Programs in the NSC organizational chart was approved by the Board. This change has been submitted to the NRC as a license amendment.

II. REACTOR UTILIZATION

A. Utilization Summary

Utilization of the NSCR during the reporting period is shown in Figure 1 and Table I. Figure 1 presents reactor operation from January 1975 through December 1986. During the present reporting period the NSCR was used by approximately 440 students (includes 407 involved in tours or lab work and 20 student researchers) and 24 faculty and staff members representing 13 departments at Texas A&M University. In addition, more than 220 faculty and students from 11 other educational institutions used the facilities, and 3,832 visitors were registered during 1987 including several public and private school groups. A total of 22 non-university organizations had programs that were dependent upon the NSCR.

A total of 45 visiting foreign officers undergoing training at Lackland Air Force Base visited the NSC during 1987. In addition 22 other officers from Fort Sam Houston and the Red River Army Base visited the NSC as part of training courses conducted by the University Radiation Safety Office.

During twenty four years of operation, the NSC has provided services to 41 departments at Texas A&M University, 111 other colleges and universities, 98 industrial organizations, and 23 federal and state agencies. (See Appendix III and IV for listing.)

B. Utilization by the Texas A&M University System

During 1987 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:	A. Lastovica	E. Rivera-Villareal
	K. Grigsby	S. Martin
	D. Poppi	D. McCarthy
	R. Worley	

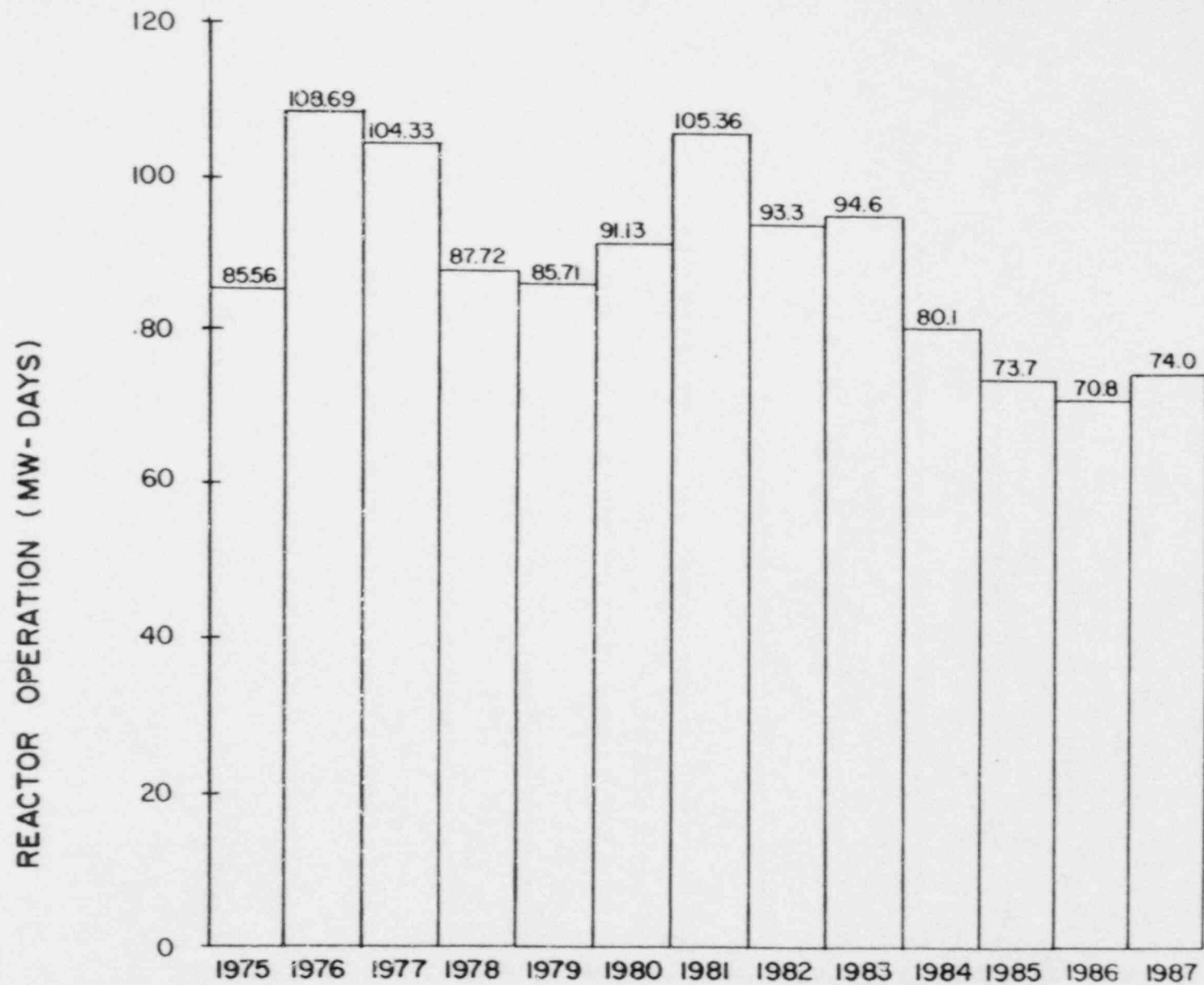


Figure 1. Yearly Reactor Operation

TABLE I
REACTOR UTILIZATION SUMMARY

	<u>1987 Annual Total</u>
*Number of Days Reactor Operated	243
Reactor Operation (MW-Days)	74.005
Number of Hours at Steady State	1947.647
Average Number of Operating Hours Per Week	38.95
Total Number of Pulses	45
Total Pulse Reactivity Insertion	\$68.03
Number of Irradiations	562
Number of Samples Irradiated	10,033
Sample Irradiation Hours	68,642.595
Average Number of Irradiations per Operating Day	2.313
Irradiation Experiment-Hours	4598.652
Beam Port Experiment-Hours	216.271
Irradiation Cell Experiment Hours	46.47
Total Experiment Hours	4861.393
Fraction of Utilization Attributable to Commercial Work	.31
Number of Visitors	3832

*Note: 50 Weeks of Operation Available

Center for Chemical Characterization and Analysis (CCCA)

Staff: Dr. D. James, Research Chemist
T. Woods, Technician

Chemistry Department

Faculty: Dr. M. W. Rowe, Associate Professor
Dr. R. Zingaro, Professor
Dr. A. Clearfield, Professor

Students: E. Campbell Y. Ortiz
 J. Perez H. Martin
 Z. Zhong R. Wang

Geophysics Department

Faculty: Dr. R. McCabe

Student: W. Morgan

Mechanical Engineering Department

Faculty: Dr. D. Bray, Associate Professor
Dr. G. Peterson, Assistant Professor

Students: P. Stevenson
 T. Salemanca

Nuclear Engineering Department

Faculty: Dr. R. G. Cochran, Professor Emeritus
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. W. Poston, Professor and
 Interim Head
Dr. J. A. Reuscher, Professor
Dr. G. A. Schlapper, Associate Professor

Students: T. Reinarts G. Shelton J. Simmons
 J. Alvis C. Guyot S. Na
 E. Bechler D. Deforest J. McWhirter
 E. Breiner

Nuclear Science Center

Staff: J. Krohn, Manager of Technical Services
 W. Davis, Research Associate
 N. Khalil, Research Associate
 D. McDonald, Student Technician
 G. Stasny, Reactor Supervisor
 D. Deere, Co-op Student

Oceanography Department

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

Students: M. Wells

Physics Department

Faculty: Dr. J. A. McIntyre, Professor

Students: R. Seidel
 W. Loewer

Radiological Safety Office

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

Students: S. Bateman
 P. Hoover
 M. Grimes

Veterinary Physiology and Pharmacology

Faculty: Dr. D. Hightower, Professor

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.

C. Utilization by Other Educational Institutions

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.

TABLE II
Academic Use of the Reactor

<u>Department</u>	<u>Course No.</u>	<u>Instructor</u>	<u>No. of Students and Purpose</u>
Chemistry	106	Kolar	137-Tour
Chemistry	116	Kolar	159-Tour
Chemistry	677	James	8-Tour
Industrial Engineering		Horath	18-Tour
Mechanical Engineering	148	Bray	12-Tour
Nuclear Engineering	102	Cochran	11-Tour
	402	James	8-Lab/Class
	405	Schlapper	23-Lab/Class
	606	Reuscher	12-Lab/Class
Oceanography	640	Presley	13-Tour
Safety Engineering	683	Konzen	6-Tour

Baylor University -- Waco, Texas

Faculty: Dr. Ken-Hsi Wang, Professor of Physics

Students: Physics Class

Louisiana State University -- Baton Rouge, Louisiana

Faculty: Dr. Ron Knaus

Students:	D. Von Gent	A. Showler
	M. Haik	F. Eftehher
	D. McKay	

Louisiana Tech University -- Ruston, Virginia

Faculty: Dr. R. Thompson

McLennan Community College -- Waco, Texas

Faculty: Mr. Don Tatum, Instructor of Physics

Students: Physics Class

New Mexico Tech -- Socorro, New Mexico

Faculty: Dr. F. Kuellmer

Sam Houston State University -- Huntsville, Texas

Faculty: Dr. B. Covington

Stephen F. Austin University -- Nacogdoches, Texas

Faculty: Dr. L. C. Hallman, Director, Energy Institute

Sul Ross State University -- Alpine, Texas

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

Students:	K. Nelson	B. Ward	K. Urbanzyek
	L. Yeu	L. Forsythe	K. Mohammed
	D. Yu	R. Miner	M. Leaveritt
	L. Baker	W. Wilson	M. Bloom
	D. Edwards		

Texas State Technical Institute -- Waco, Texas

Faculty: Mr. R. Wheet, Instructor

Students: Nuclear Technology Classes

University of Texas at El Paso -- El Paso, Texas

Faculty: Dr. J. Hoover

Students: V. Horder R. Schneider
 R. HoltPublic and Private School ToursNo. of Students

A&M Consolidated -- College Station, TX	347
Anderson High School -- Anderson, TX	8
ANS Teachers Tour -- Various	35
Bammel Middle School -- Houston, TX	30
Breckenridge High School -- Breckenridge, TX	12
Bryan High School, Bryan, TX	64
Buckholts High School -- Buckholts, TX	25
Career Day -- Various	75
Carver Elementary School -- Bryan, TX	54
Cy-Fair High School -- Houston, TX	80
Eisenhower High School -- Houston, TX	52
Ft. Sam Houston High School -- San Antonio, TX	8
Hardin Jefferson High School -- Sour Lake, TX	15
Iola High School -- Iola, TX	13
JETS -- Various	36
LaGrange High School -- LaGrange, TX	61
Lamar School -- Bryan, TX	125
Moody High School -- Moody, TX	10
North Zulch High School -- North Zulch, TX	9
Palestine High School -- Palestine, TX	12
Queen City High School -- Queen City, TX	24
Rockdale High School -- Rockdale, TX	14
Rogers High School -- Rogers, TX	30
Sharpstown High School -- Houston, TX	32
Taft High School -- San Antonio, TX	22
Twin Creek Middle School -- Spring, TX	76
Wells Middle School -- Houston, TX	41

D. Utilization by Non-University InstitutionsAAE/BCS Traders -- Globe, Arizona

Experimenter: D. Williams

Bell Helicopter - Textron -- Fort Worth, Texas

Experimenter: T. Reeves

Ebasco -- Austin, Texas

Experimenter: M. Buvinghausen

Gulf Nuclear -- Webster, Texas

Experimenters: C. Blackburn
R. Sallee
S. Petch

Houston Area Research Center -- Houston, Texas

Experimenter: G. Welch

Hughes Aircraft Company -- Carlsbad, California

Experimenters: D. Bell
Dr. R. Hart

International Rectifier -- El Segundo, California

Experimenter: J. Blattner

M. D. Anderson Hospital (University of Texas Medical Center)
Houston, Texas

Experimenter: Dr. J. Cundiff

Methodist Hospital -- Houston, TX

Experimenter: Dr. W. Cole

Poretics Corporation -- Livermore, California

Experimenters: G. Hubbard
S. Lukezic
J. Humphrey

Shell Development Company -- Houston, Texas

Experimenters: P. Filpus-Luyckx
T. Wheat

Santa Barbara Research Center -- Goleta, California

Experimenters: L. Luciano
J. Wells
P. Rose

Southwest Research Institute -- San Antonio, Texas

Experimenters: F. Iddings
J. Hageman

Teledyne Isotopes -- Westwood, New Jersey

Experimenters: J. Guenther
D. Schutz
A. Shaar

Texas Instruments -- Dallas, Texas

Experimenters: S. Halfacre
L. Blackburn

Tracerco, Inc. -- Houston, Texas

Experimenters: W. Ramage
B. White
R. Gilman
D. Bucior

Tru-Tec -- LaPorte, Texas

Experimenter: C. Winfield

III. FACILITY OPERATIONS

A. Facility Safety and Operational Improvements

Front Gate Lighting

The Nuclear Science Center front gate monitoring was enhanced by the change to a brighter and more durable high-pressure sodium lamp.

Cooling Tower Rewiring

Exposure to the elements had caused deterioration of the conduit and wiring for the cooling tower fan motor and controls. Replacement of these parts and a relocation of the remote fan control should increase safety and provide decreased maintenance.

B. Improvements to Reactor Systems and Experimental Facilities

Control Rod Travel Measurement

A metric scale was mounted on each rod drive housing to allow more accurate measurement of the 40 cm travel during calibrations.

Heat Exchanger Cleaning

The heat exchanger used for cooling of the reactor pool water had experienced reduced efficiency due to long term fouling of the primary and secondary loops. The exchanger was opened to provide access for cleaning of the tubing and housing. The primary side was cleaned with a high pressure spray. The secondary side was cleaned with a soap solution followed by a 10% sulfuric acid solution. Soda ash was used for final cleansing and neutralizing of the acid solution. Efficiency of heat transfer was greatly increased following this cleaning.

Self-Powered Neutron Detector

A self-powered neutron detector system is now used for spot monitoring of the flux levels at various experiment locations. This system allows for observation of potential changes due to different combinations of experiments.

Console Monitor

A 19" screen monitor was installed in the console replacing the previous 12" black and white monitor. A better picture with color capability has enhanced front gate monitoring. The monitor may also be used for observation of lower level work areas.

D₂O Moderated Rotisserie Irradiation Device

The D₂O moderated rotisserie irradiation device is designed to provide sample exposure to thermal neutrons with a very small fast neutron component. There are three irradiation positions which provide increasing thermal to fast neutron ratios with increasing distance from the reactor. The D₂O irradiation device and installation is shown in Figure 2.

The irradiation device consists of an aluminum stand which is positioned on centerline of the pool floor, a sealed aluminum inner box containing D₂O, a water tight outer aluminum box, an electric motor and drive unit, the rotisserie irradiation tubes, and graphite or air filled plugs for placement into the irradiation positions when not in use. The inner aluminum box is anodized to protect against Al-D₂O interactions and has reinforcement ribbing to increase strength and act as a spacer when placed inside the outer box. Both the inner and outer boxes were leak tested before being put into service. The double container design will prevent contamination of the D₂O by pool water in the event of leakage of the outer container and prevent the loss of D₂O into the pool due to leakage from the inner tank. The space between the inner and outer box is helium filled. The outer box also has external ribbing for strength and the end away from the reactor is flanged. The large flange has two small service/maintenance flanges to provide access to the stainless steel bellows valves on the inner box to be used for D₂O transfers. Under normal conditions the valves will be shut off and capped. The gasket material used to seal the flanges is "Grafoil" (pure graphite) which will resist radiation damage and has been used successfully at the NSCR for other in-pool/high radiation level applications. Sampling fittings are located on each of the service flanges to provide for sampling of gases inside the outer box. All nuts, bolts, and washers used in the device are stainless steel.

The device is monitored for temperature, pressure, and water leakage. A pressure transducer and thermocouple have been placed inside the inner box to monitor the temperature and pressure of the D₂O. A conductivity circuit is also inside the outer box to monitor for D₂O or pool water leaks. The monitors are connected to a poolside monitoring station through poly tubing containing two wire pairs which enters the device near the back flange.

C. Operational Problems

Control Rod Drive Controller Modifications

The control rod drive controller units experienced occasional problems in erroneous rod position indication due to electronic noise interference. The controller main circuit board was replaced with a new version that incorporated both previous modifications and new circuitry. Circuit interlock additions and increased motor direction monitoring have decreased the possibility of noise signal interference.

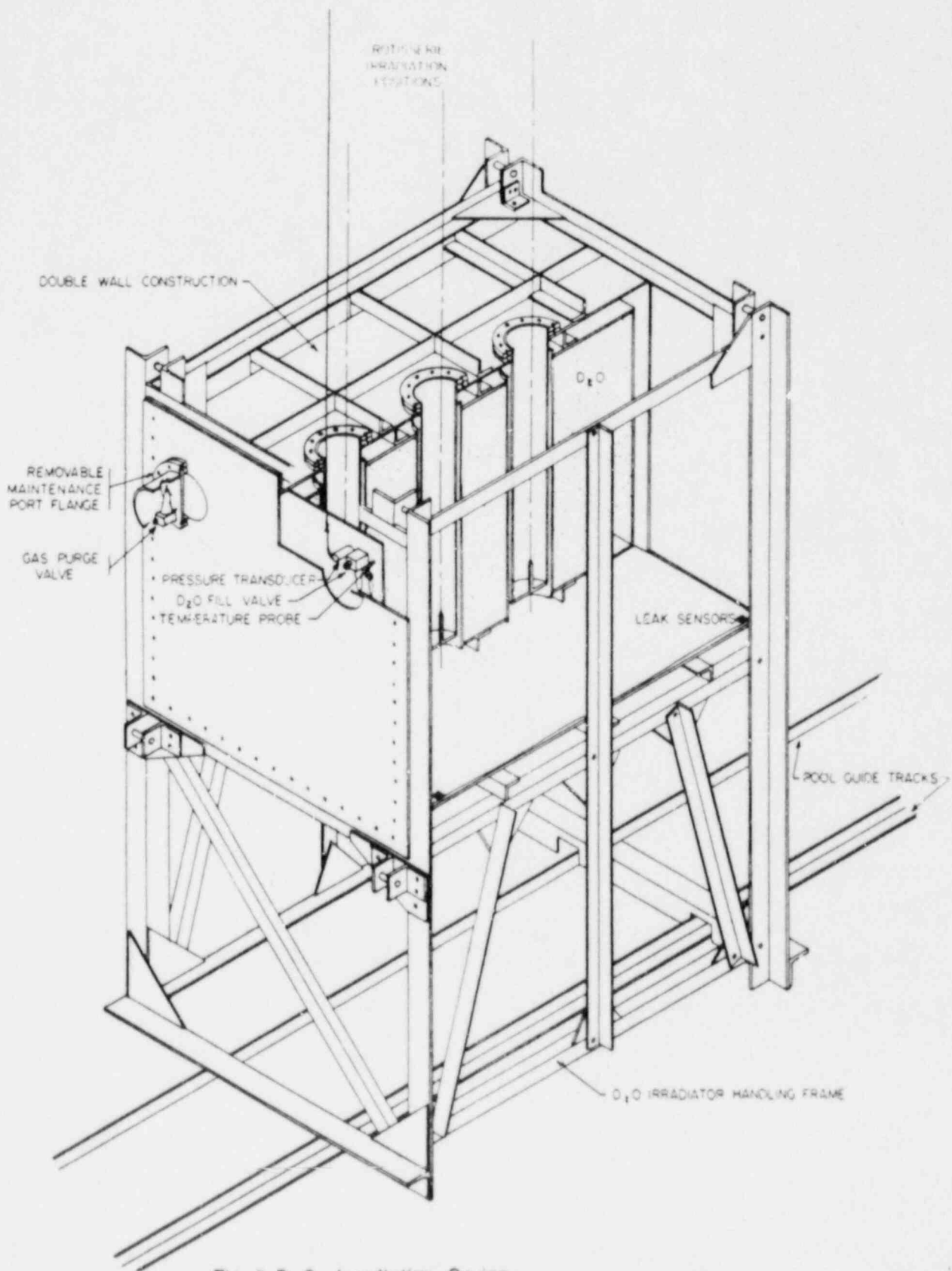


Fig. 2 D_2O Irradiation Device

Transient Rod Drive Switching

The transient rod drive utilizes solid state switching for motor control. A failure of the "down" control module prevented the carriage from withdrawing. Unusual line power surges and loss of building power was determined as the cause of failure. The module was replaced with no further problems.

Secondary Pump Shaft Coupling

The secondary pump shaft coupler broke during cooling system operation. Metal fatigue and corrosion was the apparent cause of failure. A complete overhaul was performed with new bearings installed, the motor was rewound, and a new strainer was installed. A new parallel pump system is planned for installation in 1988.

D. Changes in Operating Procedures

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

SOP's

- I-A Definitions and Abbreviations
- II-A General Organization and Responsibilities
- II-C Prestartup Checklist - Reactor Startup
- II-D Steady State Operation
- II-G Movement of Reactor Bridge
- III-I Scram Circuit Surveillance
- III-L Control Rod Drive Maintenance
- IV-A Experiment Approval
- IV-D Beam Port Experiments
- IV-H Thermal Column Film Irradiator
- VII-A Health Physics Administration
- VII-B Health Physics Maintenance and Surveillance
- X-A Annual Operator Console Manipulations

E. Unscheduled Shutdowns

A total of eleven unscheduled shutdowns occurred during 1987. The unscheduled shutdowns can be arranged in the following categories:

<u>Cause of Shutdowns</u>	<u>Number of Shutdowns</u>
Building power loss	5
Operations error	1
Electronics	
a) Channel failure	1
b) Rod drops	4

F. Reactor Maintenance and Surveillance

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

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

All control rods were calibrated on January 26, 1987 with a total rod worth of \$15.31 and a shutdown margin of \$2.69.

The power level (linear) channel was calibrated by the calorimetric method on 1/8/87.

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

Fuel elements requiring inspection were inspected on 7 January 1987.

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.

2. A pulse test program for Core VIII-A was conducted on 7 August 1986 to determine the maximum allowable reactivity insertion for Core VIII-A as required by Tech Spec 3.1.2. The test program produced an insertion limit of \$2.09 and an administrative limit of \$1.90 was imposed by memo on 28 August 1986.

The pulse mode is calibrated annually by comparison of flux foils. Operability is verified semi-annually by pulsing for comparison of pulse energy and temperature.

3. The reactivity worth for each experiment was measured as appropriate before reactor operation with the experiment. The most reactive experiment irradiated was the Thermal Column coupler with a value of \$1.35.
4. Emergency evacuation drills were conducted on March 4 and August 13, 1987.
5. A review of the NSC security plan and emergency plan was conducted by the NSC staff and the Reactor Safety Board on 1/30/87.
6. A review of the NSC ALARA program was conducted by the NSC staff and the Reactor Safety Board on 1/30/87.

IV. FACILITY ADMINISTRATION

A. Organization

The organization chart for reactor operations at the Nuclear Science Center is presented in Figure 3. During this reporting period Dr. Kevan Crawford was hired as Manager of Reactor Operations and John Krohn was moved to Assistant Director. Tom Blanchat resigned from his position of Senior Reactor Operator to work for the Nuclear Engineering Department and Doug McDonald was moved from Technical Services to the vacant operator position. Mark Stowers and Doug McDonald received operator licenses during the year and Nazir Khalil received a SRO License. The NSC continued to experience problems in personnel turnover among the student workers, and expects to continue to see these problems in the future.

B. Personnel

The following is a list of personnel at the Nuclear Science Center for the period of January 1, 1987 - December 31, 1987.

Facility Administration and Reactor Operations Staff

+Blanchat, T. K.	- Reactor Operator (Terminated)
Crawford, K. C.	- Manager, Reactor Operations
+Feltz, D. E.	- Director
+Krohn, J. L.	- Assistant Director
+Petesch, J. E.	- Reactor Supervisor
Reuscher, J. A.	- Director, Nuclear Research Reactor Programs (TEES)
*Stagg, F. B.	- Reactor Operator
+Stasny, G. S.	- Reactor Supervisor
*Stowers, M. W.	- Reactor Operator

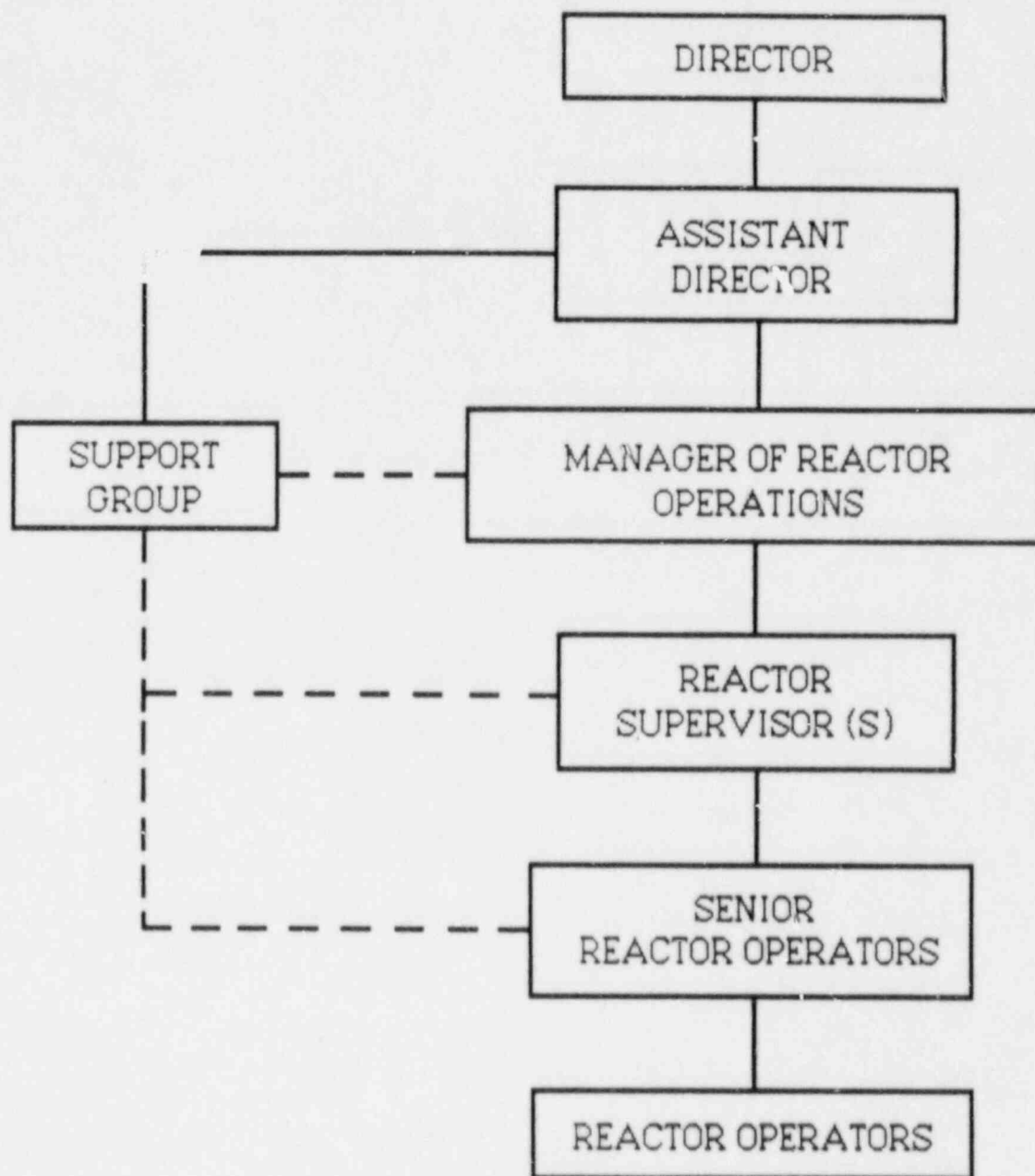


Figure 3. Nuclear Science Center
Reactor Operations Organization Chart

Technical Service and Maintenance

*Davis, J. W.	- Engineering Research Associate
Deere, D. C.	- Co-Op Research Aide
*Fisher, T. H.	- Scientific Instrument Maker II
Hobdy, M.	- Draftsman
Horn, C. R.	- Mechanical Equipment Foreman
Jordan, T.	- Student Worker I
+Khalil, N. S.	- Research Assistant
MacCallum, T.	- Student Worker I (Terminated)
*McDonald, D. B.	- Student Worker III
Restivo, A. L.	- Engineering Research Associate
Thacker, M.	- Draftsman (Terminated)
Twomey, T. C.	- Student Worker I

*Licensed Reactor Operator

+Licensed Senior Reactor Operator

Clerical

Mitchell, Y.	- Secretary
Ribardo, J.	- Bookkeeper
Snowden, C.	- Receptionist (Terminated)
Werner, M.	- Receptionist

Health Physics Staff

Hoover, P.	- Health Physicist (Terminated)
Meyer, C. M.	- Senior Health Physicist
Oxley, C.	- Student Technician (Terminated)
Rodriguez, L.	- Health Physicist

C. Reactor Safety Board

Committee Composition

Chairman

F. Jennings, Director, Office of University Research
(January 1, 1987 - December 31, 1987)

Voting Members

R. Green, Assistant Professor, Small Animal Clinic
(January 1, 19867 - December 31, 1987)

R. R. Hart, Professor, Nuclear Engineering
(January 1, 1987 - December 31, 1987)

J. Hiebert, Professor, Physics
(January 1, 1987 - December 31, 1987)

E. A. Schweikert, Professor, Chemistry
(January 1, 1987 - December 31, 1987)

R. Koppa, Professor, Industrial Engineering
(January 1, 1987 - December 31, 1987)

Ex-Officio Members

G. S. Schlapper, Professor, Nuclear Engineering
(January 1, 1987 - December 31, 1987)

D. E. Feltz, Director, Nuclear Science Center
(January 1, 1987 - December 31, 1987)

M. McLain, Professor and University Radiological Safety Officer
(January 1, 1987 - December 31, 1987)

Meeting Frequency

The Reactor Safety Board (RSB) met on the following dates during the calendar year 1987: 1/30/87 and 7/22/87.

RSB Audits

During the reporting period RSB audits of NSC activities were conducted on the following dates: 4/6/87, 7/15/87, 9/29/87, and 12/17/87.

APPENDIX I

Description of Projects Utilizing the NSCR

DESCRIPTION OF PROJECTS UTILIZING THE NSCR

A. Texas A&M UniversityNuclear Engineering

NEUTRON TRANSMUTATION DOPING OF SEMICONDUCTOR MATERIALS

Personnel

Dr. Ron R. Hart -- Professor
Kevin Seager -- Graduate Assistant
William Kennamore -- Student

Further work was performed into neutron transmutation doping of semiconductor materials for several uses including infra-red detectors. Such effects as self-annealing and different impurity levels in materials such as indium and GaAs were investigated. Some work was done in conjunction with Hughes Research Labs. In addition, a D₂O irradiation device was designed and constructed to provide further capabilities in this research area.

LiD FUSION PLATE

Personnel

Dr. T. A. Parish -- Associate Professor
Seong Ho Na -- Graduate Assistant

Preliminary studies were carried out on developing a simulated fusion neutron source in the irradiation cell for materials shielding studies.

NUCLEAR ENGINEERING GRADUATE LAB IN REACTOR EXPERIMENTATION

Personnel

Dr. J. A. Reuscher -- Professor
NE 606 Graduate Students (9 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 an approach to critical lab. Other experiments performed included core flux mapping, neutron radiography, and neutron activation analysis.

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

Dr. R. G. Cochran -- Professor
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
Roger Worley -- Graduate Assistant
Abban Lastovica -- Student
D. Poppi -- Graduate Student
S. Martin -- Graduate Student
K. Grisby -- Graduate Student

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.

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
 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

This product involved 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.

Radiological Safety OfficeCALIBRATION OF A RADIOACTIVE EFFLUENT MONITOR FOR A NUCLEAR POWER
PLANT

Personnel

Dr. Bill Bartlett -- Research Concepts, Inc.
 John Krohn -- Nuclear Science Center
 John Simek -- Radiological Safety Office
 Phil Sandel -- Radiological Safety Office
 Dr. Milton McLain -- Radiological Safety Office
 Penny Shamblin -- Radiological Safety Office

This project involved the calibration of a gaseous effluent monitor for the Brown's Ferry Nuclear Power Plant. The calibration work included cross-calibration to the NSC's counting system and to Analytics Incorporated in Atlanta, Georgia using Xe-133 gas.

Veterinary Physiology and Pharmacology

VETERINARY NUCLEAR MEDICINE

Personnel

Dr. Dan Hightower, D.V.M. -- Professor
Dianne Tveter -- Graduate Assistant
Brian Poteet -- Graduate Assistant
Sara Bateman -- Graduate Assistant
Suzanne Helfinstine -- Graduate Student

Various studies were carried out on the uses of radio-pharmaceuticals in veterinary care. The NSC was used to generate radioisotopes for some of these studies.

B. Other UniversitiesLouisiana State University

FIRE ANT TERRITORIALITY

Personnel

Dr. Ron Knaus -- Professor, LSU Nuclear Science Center
Dr. T. E. Reagan -- Professor, Entomology
Allen Showler -- Graduate Student

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.

Sam Houston State University

NEUTRON TRANSMUTATION DOPING OF SILICON AND GaAs SAMPLES

Personnel

Dr. B. Covington -- Professor, Division of Physics and Chemistry

This continued study was performed to identify shallow impurities and to observe the effects of annealing on the centers created by fast neutrons in Si and GaAs.

Sul Ross State University

ANALYSIS OF GEOLOGIC SAMPLES FROM VARIOUS SITES IN TEXAS

Personnel

Dr. Dennis Nelson -- Associate Professor and Chairman, Geology
Dr. G. David Mattison -- Associate Professor, Geology
Dr. David Rohs -- Assistant Professor, Geology
Eight Graduate and Five 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

William Kester -- Chairman, Nuclear Technology, Waco
Gary Wiechering -- Instructor, Waco
Richard Wheet -- Chairman, Nuclear Technology, Waco

During 1987, 10 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.

University of Texas at El Paso

Personnel

Dr. James D. Hoover

The studies performed include the determination of trace element contents of various rock and mineral samples from a variety of sites. The samples are irradiated at the NSC and the analysis is performed at UTEP.

C. Non-University InstitutionsHouston Area Research Center

DIODE PERFORMANCE EVALUATION AFTER FAST NEUTRON IRRADIATION

Personnel

John Zeigler -- Texas Accelerator Center

This continued project involved the fast neutron irradiation of several types of diodes under cryogenic conditions in order to evaluate their performance and reliability. The purpose of the project is to identify a diode which can survive in the associated radiation environment of super conducting magnets of a large accelerator.

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.

The Methodist Hospital of Houston

DEVELOPMENT OF A TREATMENT FOR RHUMETOID ARTHRITIS

Personnel

Dr. Bill Cole -- Nuclear Medicine, Methodist Hospital
John Krohn -- Nuclear Science Center

This continuing project was aimed at developing an alternative to surgery as treatment for rhumetoid arthritis. The work was based on similar work done at Harvard Medical School and involves the injection of radioisotopes to destroy the affected cells instead of the usual surgical removal. The efforts conducted in 1987 included continued patient treatments at Methodist Hospital in Houston.

Shell Development Company

Personnel

Paul Filpus-Luyckx -- Shell Development
Tom Wheat -- Shell Development

This ongoing project involves activation analysis of various oil, petrochemical and related materials by Shell Development personnel. The analysis is usually aimed at identifying one or more trace elements in the products and serves to aid all divisions of Shell Oil Company in quality assurance and product development.

Texas Instruments

NEUTRON ACTIVATION ANALYSIS OF SEMICONDUCTOR MATERIALS

Personnel

Bruce Gnade -- Texas Instruments
Sandra Halfacre -- 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.

RADIOISOTOPE PRODUCTION

During 1987, 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: Co-60, Ir-192, Fe-59, Br-82, Ar-41, and Na-24. Some of the companies supplied were: Gulf Nuclear Corp., Tracerco, Inc., Teledyne Isotopes, R/A Services, Inc., and Tru-Tec.

APPENDIX II

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

Publications, Theses and Papers Involving the Use of NSC
Facilities From 1976 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, TAMU, 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, "Mineralogical Analysis and Uranium Distribution of the Sediments from the Upper Jackson Formation, Karnes County, Texas", M. S. Thesis in Geology, TAMU, 1978.
8. E. M. Prasse, "Uranium and Its Relationship to Host Rock Mineralogy in an Unoxidized Roll Front in the Jackson Group, South Texas", M. S. Thesis in Geology, TAMU, 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 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, TAMU, 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, TAMU, 1979.
21. M. E. Miller, "Uranium Roll Front Study in the Upper Jackson Group, Alascosa County, Texas", M. S. Thesis in Geology, TAMU, 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, TAMU, 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, TAMU, 1979.
26. H. Loza, "Effect of Protein Deficiency on Forage Intake and Digestibility", M. S. Thesis in Animal Nutrition, TAMU, 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, TAMU, 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, TAMU, 1980.
30. J. P. Telford, "Factors Affecting Intake and Digestibility of Grazed Forages", Ph.D. Dissertation in Animal Science, TAMU, 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-Difluoroethyl 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 Output 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 Difluorosilylene 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, TAMU, 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 Carboxylase 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, TAMU, 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. Dervoan, "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 Oatman 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, TAMU, 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, Gaithersburg, 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, TAMU, 1983.
79. L. Pgzoniski, A. N. Hanna and O. Suschny, "Report on Inter-comparisons 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, "Orea 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, TAMU, 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, TAMU, 1983.

97. D. S. Followill, "Determination of Exchangeable Potassium in the Canine by Means of Whole-Body Counting", M. S. Thesis in Nuclear Engineering, TAMU, 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, TAMU, 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. Lescano 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 Turn-over", M. S. Thesis in Animal Science, TAMU, 1984.
105. L. R. Roth, "Effects of Grazing Upon Sward Attributes and Utilization of Coastal Bermudagrass by Cattle", M. S. Thesis in Animal Science, TAMU, 1984.
106. M. Whiteacre, "Experimental Determination of Elemental Recovery from Natural Seawater Achieved by Ion Exchange Resins", Master of Engineering project report, TAMU, 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.

109. M. Charles, "The Application of a Scintillation Flask Technique for the Measurement of Radon Emanation", M. S. Thesis in Nuclear Engineering, TAMU, 1984.
110. Y. C. Gonzalez, "Aerosol Dilution and Dispersion at the Nuclear Science Center Confinement Building", M. S. Thesis in Health Physics, TAMU, 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, TAMU, 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 Composition 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 1985.
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, TAMU, 1985.
121. K. D. Seager, "Acceptor and Donor Production in $Hg_{1-x}Cd_xTe$ by NTD", M. S. Thesis in Nuclear Engineering, TAMU, 1985.
122. M. Schuller, "An Investigation of Aqueous Slurries as Fusion Reactor Blankets", Ph.D. Dissertation in Nuclear Engineering, TAMU, 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, TAMU, 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. Ogugbuaaja, 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, TAMU, 1985.
133. J. H. Kleck, "Determination of Radiation Absorbed Dose to the Kidneys of Rhesus Monkeys from Radiolabelled Orthiodohippuran", M. S. Thesis in Nuclear Engineering, TAMU, 1985.
134. D. L. Mayfield, "A Calibration and Evaluation of Eberline Instrument Corporation's SPIN-4 Radiological Air Monitor", M. S. Thesis in Nuclear Engineering, TAMU, 1985.
135. R. Yupari, "Three-dimensional Neutronics Calculations for the Texas A&M TRIGA Reactor", M. S. Thesis in Nuclear Engineering, TAMU, 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, TAMU, 1985.
137. H. C. Cheung and A. Clearfield, "The Oxidative Dehydrogenation of Cyclohexene Catalyzed by $\text{ZrCu}(\text{PO}_4)_2$ ", 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, TAMU, 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. . . 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. 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.
150. 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.
151. 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.
152. 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.

153. M. J. Wylic, 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.
154. E. Rovera-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.
155. E. Rovera-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.
156. M. C. Wells, P. N. Boothe and B. J. Presley, "Iridium in Marine Biota", AGU Meeting, 1987.
157. 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.
158. 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.
159. 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.

APPENDIX III

Educational Institutions, Industrial, Government and
Medical Organizations Served by 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
California State College	Longwood College
California State Poly. College	Louisiana State University
Catholic College for Women	Louisiana Tech University
Chadron State College	Mary Hardin Baylor College
Cheyney State College	Massachusetts Institute of Tech.
Clarion State College	McLennan Community College
Columbus College	McNesse State University
Community College of the Finger Lakes	Milwaukee Institute of Technology
Defiance College	Moody College
Denison University	Nebraska Wesleyan University
Eastern Kentucky University	New Mexico State University
East Texas 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 New Hampshire
State College of Arkansas	University of Oklahoma
State University College, N.Y.	University of Pittsburgh
State University of Ohio	University of Southern Louisiana
Stephen F. Austin College	University of Texas - Austin
Sue Bennett College	University of Texas - Dallas
Sul Ross State University	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.	Exxon Research and Development
Ardrychuk Gemstones	General Electric Company
American Hoechst Corporation	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.
Catalytic, Inc.	Hughes Aircraft Company
Celanese Company	Hughes Research Labs
Chemtrol, Inc.	Independent Exploration Company
Comfacco	Institute of Research and Instrumentation
Core Laboratories	Isotex
Diamond Alkali Company	Jet Research Center, Inc.
Dow Chemical Company	Kansas Gas and Electric Company
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	Mission Engineering
Engineers/Designers, Inc.	Mobil Oil Company
Estrada, Inc.	Monsanto, Inc.
E-Systems, Inc.	Morris Engineering Company
Exxon Oil & Refining	

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.
Radian Corporation	Texas Nuclear Corp.
Radiation Consultants, Inc.	Texas Romec
Ranger Engineering	Todd Shipyards Corp.
R/A Services, Inc.	Traceco Services, Inc.
Raytheon Corporation	Tracerco, Inc.
Research Concepts	Tracer Labs of Midland
Resource Engineering	TRACO, Inc.
Rivera Foods	TRIAD
Santa Barbara Research Center	Tru-Tec Corporation
Shell Chemical Company	Turbine Lab
Shell Development Co. - Houston	Universal Technology Corp.
Shell Development Co. - Oakland	Westinghouse Electric Co.
Southwest Research Institute	Xomox
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
 M. D. Anderson Tumor Center and Hospital
 The Methodist Hospital of Houston
 National Aeronautics and Space Administration
 North East Radiological Health Lab
 Oklahoma Medical Examiner
 Orange Police Department
 Osage County Oklahoma District Attorney
 United States Air Force
 United States Army
 United States Geologic Survey
 Wichita Falls District Attorney

APPENDIX IV

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

TAMU Departments and Agencies

Department of Biochemistry and Biophysics
Department of Nuclear Engineering
Department of Oceanography
Department of Physics
Department of Petroleum Engineering
Department of Animal Science
Department of Range Science
Department of Mechanical Engineering
Department of Wildlife and Fisheries Sciences
Department of Chemistry
Department of Large Animal Veterinary Medicine and Surgery
Radiological Safety Office
Cyclotron Institute
Department of Plant Sciences
Department of Veterinary Physiology and Pharmacology
Department of Radiation Biology
Center for Chemical Characterization and Analysis
Bioengineering Program, College of Engineering
Texas Engineering Extension Service, Electronic Training
Department of Geology
Department of Forest Science
Department of Soil and Crop Sciences
College of Medicine
Department of Health and Physical Education
Department of Architecture
Department of Building Construction
Department of Industrial Engineering
Department of Industrial Education
Department of Aerospace Engineering

TAMU Departments (Cont'd)

Department of Engineering Technology
Department of Civil Engineering
Fireman's Training School
Department of Archaeology
Department of Entomology
Department of Recreation and Parks
Department of Engineering Design Graphics
College of Architecture and Environmental Design
Center for Energy and Mineral Resources
Department of Horticulture Sciences
Department of Chemical Engineering

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
1987

- _____ Provided health physics monitoring support for processing 628 irradiations containing over 10,033 samples.
- _____ Certified 251 shipments of radioactive materials to off-site industry.
- _____ Certified 84 shipments of radioactive materials to other campus laboratories.
- _____ Provided monitoring support for processing and handling over 3,800 experimental samples retained at the Nuclear Science Center laboratories.
- _____ Conducted environmental survey program in cooperation with the Texas State Department of Health. This program consists of in-situ TLD monitors and the collection, analyses and evaluation of soil, water, vegetation, and milk samples.
- _____ Provided personnel monitoring support for 24 persons on a daily basis and 3,745 visitors as required.
- _____ Performed radionuclide identification and determined radioactivity concentrations for 24 releases of radioactive liquid effluents totaling 288,000 gallons (1.09 E+09 ml) including fresh water diluent.
- _____ Performed surveys of the Nuclear Science Center facilities for radiation levels and radioactive contamination including the collection, analyses, and evaluation of approximately 250 smear samples on a monthly basis.
- _____ Conducted radiation safety training for 25 NSC employees and experimental personnel using NSC facilities.

EFFLUENT RELEASE SUMMARY

Introduction

Summaries of radioactive effluents released from the Nuclear Science Center for 1987 are included in this Appendix. These data are presented in tabular form and include atmospheric, liquid and solid waste releases.

Particulate Releases

Radioactive particulates are monitored at the base of the central exhaust stack and summarized on a monthly basis. The annual average release rate was $1.27 \text{ E-11 } \mu\text{Ci/cc}$. Total radioactivity released for the year was 9.43 E-04 curies. These data, presented in Table 1, represent output of the Nuclear Science Center Facility Air Monitoring System. The individual particulate monitors in this system detect gross beta and gamma radiations emitted from filtered particulate material without regard to the origin or half-life of the radioactive materials. Other than naturally-occurring Radon/Thoron progeny, particulates with half-lives exceeding eight days were identified only once. In May, 1987, Cerium-139 was identified on filter paper removed from the stack exhaust particulate monitor (Channel 1). Less than 1% of the activity released in May 1987 was identified as Ce-139 resulting in a release totaling $0.25 \mu\text{Ci}$ resulting in an average site boundary concentration of $2.0 \text{ E-16 } \mu\text{Ci/cc}$ or 0.0002% of the Unrestricted Area Maximum Permissible Concentration (MPC) for Cerium-139.

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-41 released during 1987 was 8.28 curies. This results in an annual average release rate of $1.11 \text{ E-07 } \mu\text{Ci/cc}$ as measured in the central exhaust stack with no dilution factors applied. Applying the dilution factor of 5.0 E-03 allowed at the site boundary (as determined, SAR, pages 116-119, June 1980) results in radioactivity concentrations of <1.4% of the limits specified in 10CFR20, Appendix B, Table II, Column 1. These data are summarized on a monthly basis and presented in Table 2.

Solid Radioactive Waste

There was a total of 38 ft^3 of uncompacted dry solid waste material packaged in plastic bags for disposal during 1987. These materials are transferred to the Radiological Safety Office, Texas License 6-448, for disposal. This material consisted of laboratory glassware, irradiation containers, decontamination materials, and expendable protective clothing and equipment, e.g., paper, shoe covers, plastic bags and gloves. This material contained Co-60,

Ir-192, Zn-65, and Mn-54 with the total radioactivity being 2.5 E-04 Ci . These data are in Table 3.

Liquid Waste Releases

Radioactive liquid effluents are collected in liquid waste holdup tanks prior to release from the confines of the Nuclear Science Center. Sample analyses for radioisotope identification and radioactivity concentrations were determined for each release. There were 24 liquid waste releases totaling 1.09 E+09 ml including diluents from the Nuclear Science Center during 1987. The total radioactivity released for 1987 was 1.48 E-02 Ci with an average concentration of $1.35 \text{ E-05 } \mu\text{Ci/ml}$. Summaries of the radioisotope data are presented in Table 4 through 16. Radioactivity concentrations for each isotope were below the limits specified in 10CFR20, Appendix B, Table II, Column 2.

TABLE 1
 Particulate Effluent Releases
 Annual Summary
 1987

Month	Exhaust Volume(cc)	Average Concentration* ($\mu\text{Ci/cc}$)	Radioactivity Released (Ci)
January	6.31 E12	1.86 E-11	1.17 E-04
February	5.91 E12	1.69 E-12	9.99 E-06
March	6.31 E12	7.87 E-12	4.97 E-05
April	6.12 E12	3.15 E-11	1.93 E-04
May	6.31 E12	3.94 E-12	2.49 E-05
June	6.12 E12	$\leq 1.00 \text{ E-12}$	$\leq 6.12 \text{ E-06}$
July	6.31 E12	2.08 E-11	1.31 E-04
August	6.31 E12	1.12 E-12	7.07 E-06
September	6.12 E12	$\leq 1.00 \text{ E-12}$	$\leq 6.12 \text{ E-06}$
October	6.31 E12	$\leq 1.00 \text{ E-12}$	$\leq 6.31 \text{ E-06}$
November	6.12 E12	3.04 E-11	1.86 E-04
December	6.31 E12	3.27 E-11	2.06 E-04

Total Volume: 7.45 E13 (cc)

Annual Average Release Rate*: 1.27 E-11 $\mu\text{Ci/cc}$

Total Radioactivity Released: 9.43 E-04 Ci

*As measured in the central exhaust stack without applying the allowed 200/1 dilution factor between the release point and the approximate boundary of the exclusion area (SAR, pp. 117-119, June 1979).

TABLE 2
Gaseous Effluent Releases
Argon-41
Annual Summary
1987

Month	Exhaust Volume(cc)	Average Concentration* (μ Ci/cc)	Average Concentration** (μ Ci/cc)	Ratio MPC	Total Radioactivity (Ci)*
January	6.31 E12	9.19 E-08	4.60 E-10	1.15 E-02	5.8 E-01
February	5.91 E12	\leq 4.55 E-08	\leq 2.27 E-10	\leq 5.68 E-03	\leq 2.7 E-01
March	6.31 E12	4.75 E-08	2.38 E-10	5.94 E-03	3.0 E-01
April	6.12 E12	\leq 4.42 E-08	\leq 2.21 E-10	\leq 5.52 E-03	\leq 2.7 E-01
May	6.31 E12	\leq 4.28 E-08	\leq 2.14 E-10	\leq 5.35 E-03	\leq 2.7 E-01
June	6.12 E12	9.15 E-08	4.58 E-10	1.14 E-02	5.6 E-01
July	6.31 E12	2.58 E-07	1.29 E-9	3.23 E-02	1.63 E+00
August	6.31 E12	2.60 E-07	1.30 E-9	3.25 E-02	1.64 E+00
September	6.12 E12	2.40 E-07	1.20 E-9	3.00 E-02	1.47 E+00
October	6.31 E12	8.08 E-08	4.04 E-10	1.01 E-02	5.1 E-01
November	6.12 E12	7.03 E-08	3.51 E-10	8.78 E-03	4.3 E-01
December	6.31 E12	5.55 E-08	2.77 E-10	6.93 E-03	3.5 E-01

Total Volume: 7.45 E+13 cc

Annual Average Release*: 1.11 E-07 μ Ci/cc

Total Ar-41 Radioactivity Released*: 8.28 E+00 Ci

*As measured in the central exhaust stack.

**As determined at 100 meters, approximate boundary of exclusion area, with 200/1 dilution factor (SAR, pp. 117-119, June 1979).

TABLE 3

Solid Radioactive Waste Disposal
Annual Summary
1987

Radioisotope	Radioactivity (μ Ci)
Co-60	126
Zn-65	76
Ir-192	25
Mn-54	25

Total Volume: ~ 38 ft³ contained in plastic bags (uncompacted)

Total Radioactivity: 2.5 E-04 Ci

TABLE 4
Radioactive Liquid Effluent Releases
Summary
1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Ar-41	1	7.74E+05	3.78 E-06	--	--	2.93 E-06
As-76	1	5.31E+07	2.65 E-07	2E-05	1.3	1.41 E-05
Ce-141	1	5.31E+07	1.99 E-07	9E-05	.22	1.06 E-05
Cs-137	1	1.16E+08	1.10 E-07	2E-05	.55	1.28 E-05
Cr-51	4	3.49E+08	5.62 E-06	2E-03	.281	1.96 E-03
Cd-109	1	4.83E+07	1.60 E-05	2E-04	8.0	7.73 E-04
Co-57	4	1.76E+08	1.59 E-07	4E-04	.04	2.81 E-05
Co-58	8	5.15E+08	4.58 E-07	9E-05	.50	2.36 E-04
Co-60	16	9.43E+08	1.32 E-06	3E-05	4.4	1.25 E-03
Ir-192	1	4.83E+07	1.34 E-06	4E-05	3.3	6.48 E-05
Mn-54	17	9.96E+08	4.54 E-06	1E-04	4.5	4.53 E-03
Mn-56	1	7.74E+05	8.25 E-07	1E-04	.82	6.39 E-07
Rb-86	1	5.31E+07	1.29 E-06	2E-05	6.4	6.9 E-05
Na-22	2	1.01E+08	1.09 E-06	3E-05	3.6	1.10 E-04
Na-24	4	2.93E+08	1.85 E-06	3E-05	6.1	5.44 E-04
Zn-65	7	4.72E+08	1.52 E-06	1E-04	1.5	7.20 E-04
K-40	4	1.42E+08	8.16 E-07	3E-06	27.	1.16 E-04

Total Number of Releases: 24

Total Volume Including Dilution: 1.09E+09 mL

Total Activity: 1.47E-02 Curies

Average Concentration Including Dilution: 1.35E-05 $\mu\text{Ci/cc}$

TABLE 5

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
January 1987

Isotope	No. of Releases	Volume mL	Conc. μ Ci/cc	MPC μ Ci/cc	MPC Percent	Activity Curies
Cd-109	1	4.83E+07	1.60 E-05	2E-04	8.0	7.73 E-04
Co-58	1	4.26E+07	2.23 E-07	9E-05	.24	9.51 E-06
Co-60	2	9.09E+07	1.15 E-06	3E-05	3.8	1.05 E-04
Ir-192	1	4.83E+07	1.34 E-06	4E-05	3.3	6.48 E-05
Mn-54	2	9.09E+07	1.95 E-06	1E-04	1.9	1.781 E-04
Na-22	1	4.83E+07	2.13 E-06	3E-05	7.1	1.03 E-04

Total Number of Releases: 2

Total Volume Released (with dilution): 9.09E+07 mL

Average Concentration (with dilution): 1.35E-05 μ Ci/cc

Total Radioactivity: 1.23E-03 Curies

TABLE 6

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
February 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Ar-41	1	7.74E+05	3.78 E-06	--	--	2.93 E-06
Co-58	1	5.31E+07	2.09 E-07	9E-05	.23	1.11 E-05
Co-60	1	5.31E+07	8.88 E-07	3E-05	2.9	4.72 E-05
Mn-54	1	5.31E+07	2.29 E-06	1E-04	2.2	1.22 E-04
Mn-56	1	7.74E+05	8.25 E-07	1E-04	.82	6.39 E-07
Na-22	1	5.31E+07	1.49 E-07	3E-05	.49	7.96 E-06
Na-24	1	7.74E+05	1.96 E-05	3E-05	65.	1.52 E-05
Zn-65	1	5.31E+07	7.19 E-07	1E-04	.71	3.82 E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 5.38E+07 mL

Average Concentration: 4.56E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 2.45E-04 Curies

TABLE 7

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
March 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	1	5.31E+07	1.31 E-07	4E-04	.03	7 E-06
Co-58	1	5.31E+07	3.52 E-07	9E-05	.39	1.87 E-05
Co-60	1	5.31E+07	7.53 E-07	3E-05	2.5	4 E-05
Mn-54	1	5.31E+07	3.12 E-06	1E-04	3.1	1.66 E-04
K-40	1	5.31E+07	8.70 E-07	3E-06	29.	4.62 E-05

Total Number of Releases: 1

Total Volume Released (with dilution): 5.31E+07 mL

Average Concentration (with dilution): 5.21E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 2.77E-04 Curies

TABLE 8

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
April 1987

Isotope	No. of Releases	Volume mL	Conc. μ Ci/cc	MPC μ Ci/cc	MPC Percent	Activity Curies
	0	0.0	0	0	0	0.0

Total Number of Releases: 0

Total Volume Released (with dilution): 0 mL

Average Concentration (with dilution): 0 μ Ci/cc

Total Radioactivity: 0 Curies

TABLE 9

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
May 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-57	2	7.05E+07	2.19 E-07	4E-04	.05	1.54 E-05
Co-58	2	7.05E+07	3.51 E-07	9E-05	.39	2.48 E-05
Co-60	2	7.05E+07	9.61 E-07	3E-05	3.2	6.78 E-05
Mn-54	2	7.05E+07	3.4 E-06	1E-04	3.4	2.39 E-04
Na-24	1	5.0E+07	6.34 E-06	3E-05	21.	3.17 E-04
Zn-65	2	7.05E+07	1.33 E-06	1E-04	1.3	9.44 E-05
K-40	1	2.05E+07	9.60 E-07	3E-06	32.	1.97 E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 7.05E+07 mL

Average Concentration (with dilution): 1.10E-05 $\mu\text{Ci/cc}$

Total Radioactivity: 7.78E-04 Curies

TABLE 10
Radioactive Liquid Effluent Releases
Monthly Summary
June 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
As-76	1	5.31E+07	2.65 E-07	2E-05	1.3	1.41 E-05
Ce-141	1	5.31E+07	1.99 E-07	9E-05	.22	1.06 E-05
Cs-137	1	1.16E+08	1.10 E-07	2E-05	.55	1.28 E-05
Cr-51	1	5.31E+07	1.29 E-06	2E-03	.06	6.9 E-05
Co-57	1	5.31E+07	1.07 E-07	4E-04	.02	5.73 E-06
Co-58	1	5.31E+07	1.59 E-07	9E-05	.17	8.49 E-06
Co-60	2	1.69E+08	5.18 E-07	3E-05	1.7	8.77 E-05
Mn-54	2	1.69E+08	7.29 E-07	1E-04	.72	1.23 E-04
Rb-86	1	5.31E+07	1.29 E-06	2E-05	6.4	6.9 E-05
Zn-65	1	5.31E+07	3.69 E-07	1E-04	.36	1.96 E-05

Total Number of Releases: 6

Total Volume Released (with dilution): 2.96E+08 mL

Average Concentration (with dilution): 1.41E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 4.20E-04 Curies

TABLE 11

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
July 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Mn-54	1	5.31E+07	1.06 E-07	1E-04	.10	5.68 E-06
K-40	1	5.31E+07	8.43 E-07	3E-06	28.	4.48 E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 9.1E+07 mL

Average Concentration (with dilution): 5.54E-07 $\mu\text{Ci/cc}$

Total Radioactivity: 5.05E-05 Curies

TABLE 12

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
August 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Cr-51	1	5.31E+07	1.57 E-06	2E-03	.07	8.38 E-05
Co-60	2	1.06E+08	3.29 E-07	3E-05	1.0	3.5 E-05
Mn-54	2	1.06E+08	1.22 E-06	1E-04	1.2	1.30 E-04
Zn-65	1	5.31E+07	4.65 E-07	1E-04	.46	2.47 E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 1.06E+08 mL

Average Concentration (with dilution): 2.57E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 2.73E-04 Curies

TABLE 13

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
September 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Cr-51	1	5.31E+07	1.93 E-06	2E-03	.6	1.03 E-04
Co-60	1	5.31E+07	6.40 E-07	3E-05	2.1	3.4 E-05
Mn-54	1	5.31E+07	2.80 E-06	1E-04	2.8	1.49 E-04
Na-24	1	5.31E+07	3.08 E-06	3E-05	10.	1.64 E-04

Total Number of Releases: 1

Total Volume Released (with dilution): 5.31E+07 mL

Average Concentration (with dilution): 8.47E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 4.5E-04 Curies

TABLE 14

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
October 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-58	1	5.31E+07	6.70 E-08	9E-05	.07	3.56 E-06
Co-60	2	1.062E+08	2.21 E-07	3E-05	.73	2.35 E-05
Mn-54	2	1.062E+08	8.03 E-07	1E-04	.80	8.53 E-05
Zn-65	1	5.31E+07	2.99 E-07	1E-04	.29	1.59 E-05

Total Number of Releases: 2

Total Volume Released (with dilution): 1.06E+08 mL

Average Concentration (with dilution): 1.20E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 1.28E-04 Curies

TABLE 15

Nuclear Science Center
Radioactive Liquid Effluent Releases
Monthly Summary
November 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Cr-51	1	1.9E+08	9 E-06	2E-03	.45	1.71 E-03
Co-58	1	1.9E+08	8.42 E-07	9E-05	.93	1.6 E-04
Co-60	2	2.05E+08	3.89 E-06	3E-05	12.	8.01 E-04
Mn-54	2	2.05E+08	1.60 E-05	1E-04	16.	3.30 E-03
Na-24	1	1.9E+08	2.51 E-07	3E-05	.83	4.78 E-05
Zn-65	1	1.9E+08	2.77 E-06	1E-04	2.7	5.28 E-04
K-40	1	1.58E+07	3.59 E-07	3E-06	11.	5.68 E-06

Total Number of Releases: 2

Total Volume Released (with dilution): 2.05E+08 mL

Average Concentration (with dilution): 3.18E-05 $\mu\text{Ci/cc}$

Total Radioactivity: 6.55E-03 Curies

TABLE 16

Radioactive Liquid Effluent Releases
Monthly Summary
December 1987

Isotope	No. of Releases	Volume mL	Conc. $\mu\text{Ci/cc}$	MPC $\mu\text{Ci/cc}$	MPC Percent	Activity Curies
Co-60	1	3.64E+07	2.80 E-07	3E-05	.93	1.02 E-05
Mn-54	1	3.64E+07	9.09 E-07	1E-04	.90	3.31 E-05

Total Number of Releases: 1

Total Volume Released (with dilution): 3.64E+07 mL

Average Concentration (with dilution): 1.18E-06 $\mu\text{Ci/cc}$

Total Radioactivity: 4.33E-05 Curies

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 commercially available thermoluminescent dosimeters (TLD's) of lithium 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 #3 (261.4 mR/yr) which is on the NSC Site Boundary fence west by south-west of the reactor 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 1987 are presented in Tables 18-22 for total (sum) gamma or total beta activity as reported to the NSC (or determined by the NSC in the case of the fourth quarter 1987).

TABLE 17

Environmental Radiation Monitoring Program
Integrated Radiation Exposure
18 November 1986 to 4 February 1988

<u>Site #</u>	<u>Location</u>	<u>Average Dose Rate (μR/hr)</u>	<u>Calculated Dose Rate (mh/yr)</u>
2	104 yd W of reactor building, on SW chain link fence, 1.6 yd SE of W corner	5.2*	45.8*
3	86 yd WSW of reactor building, on SW chain link fence, 45 yd SE of W corner	29.8*	261.4*
4	68 yd NW of reactor building, on NE chain link fence, 67 yd NE of W corner, near junction of calibration range fence and NE chain link fence	3.6*	31.2*
5	75 yd NE of reactor building, 8.3 yd NW of main gate, on NE chain link fence	3.5*	31.0*
6	99 yd NNE of reactor building, on NE chain link fence, 1.6 yd SE of N corner	22.1*	193.4*
10	63 yd SE of reactor building, on SE chain link fence, 78 yd SW of E corner	2.7*	23.4*
11	99 yd E of reactor building, on NE chain link fence, 1.6 yd NW of E corner	1.5*	12.8*
14A	5.25 miles WSW of reactor building, at FM 60 bridge over Brazos River, at SW side of bridge, on fence brace of wooden fence at end of access road - back- ground (as of 3/26/87)	6.7	59

*Background subtracted from these values.

TABLE 18
Environmental Survey Programs
Fourth Quarter 1986

V E G E T A T I O N

Location	Number Samples	Total Activity* (pCi/g)	Activity** (pCi/g)
TAMU Dairy	1	20	≤ MDA

W A T E R

Location	Number Samples	(pCi/ml)	(pCi/ml)
White Creek	1	≤ MDA	≤ MDA

M I L K

Location	Number Samples	(pCi/ml)	(pCi/ml)
TAMU Dairy	1	1.4	0.002

S O I L

Location	Number Samples	(pCi/g)	(pCi/g)
NSC Creek	1	17.0	8.4

*Total gamma activity including naturally occurring radionuclides

**Excluding naturally occurring radionuclides

TABLE 19
Environmental Survey Program
First Quarter 1987

V E G E T A T I O N

Location	Number Samples	Total activity* (pCi/g)	Activity** (pCi/g)
TAMU Dairy	1	8.6	0.01

W A T E R

Location	Number Samples	(pCi/ml)	(pCi/ml)
Brazos River	1	≤ MDA	≤ MDA
White Creek	1	≤ MDA	≤ MDA

M I L K

Location	Number Samples	(pCi/ml)	(pCi/ml)
TAMU Dairy	1	≤ MDA	≤ MDA

S O I L

Location	Number Samples	(pCi/g)	(pCi/g)
NSC Creek	1	24.3	7.7

*Total gamma activity

**Excluding naturally occurring radionuclides

TABLE 20
Environmental Survey Program
Second Quarter 1987

V E G E T A T I O N

Location	Number Samples	Total Activity* (pCi/g)	Activity** (pCi/g)
TAMU Dairy	1	7.6	≤ MDA

W A T E R

Location	Number Samples	(pCi/ml)	(pCi/ml)
White Creek	1	≤ MDA	≤ MDA
Brazos River	1	≤ MDA	≤ MDA

M I L K

Location	Number Samples	(pCi/g)	(pCi/g)
TAMU Dairy	1	1.3	≤ MDA

S O I L

Location	Number Samples	(pCi/g)	(pCi/g)
NSC Creek	1	45.2	37.3

*Total gamma activity

**Excluding naturally occurring radionuclides

TABLE 21
Environmental Survey Program
Third Quarter 1987

VEGETATION

Location	Number Samples	Total Activity* (pCi/g)	Activity** (pCi/g)
TAMU Dairy	1	6.9	≤ MDA

WATER

Location	Number Samples	(pCi/ml)	(pCi/ml)
White Creek	1	≤ MDA	≤ MDA

MILK

Location	Number Samples	(pCi/ml)	(pCi/ml)
A&M Dairy	1	≤ MDA	≤ MDA

SOIL

Location	Number Samples	(pCi/g)	(pCi/g)
NSC Creek	1	16.7	6.6

*Total gamma activity

**Excluding naturally occurring radionuclides

TABLE 22
Environmental Survey Program
Fourth Quarter 1987***

V E G E T A T I O N

Location	Number Samples	Total Activity* (pCi/g)	Activity** (pCi/g)
TAMU Dairy	1	≤ MDA	≤ MDA

W A T E R

Location	Number Samples	(pCi/ml)	(pCi/ml)
Brazos River	1	≤ MDA	≤ MDA
White Creek	1	0.5	≤ MDA

M I L K

Location	Number Samples	(pCi/ml)	(pCi/ml)
TAMU Dairy	1	1.9	≤ MDA

S O I L

Location	Number Samples	(pCi/g)	(pCi/g)
NSC Creek	1	43.2	16.8

*Total gamma activity

**Excluding naturally occurring radionuclides

***All activities taken from Nuclear Science Center analyses since Texas Department of Health, Bureau of Radiation Control reports were not available by the reporting deadline.

PERSONNEL EXPOSURES

Radiation exposures to personnel at the Nuclear Science Center in 1987 were below the limits set forth in 10CFR20.101 with one exception. The exception concerns a potential overexposure for one individual which was documented in a Radiation Safety Office Memorandum sent to the Texas Department of Health, Bureau of Radiation Control and a similar Nuclear Science Center Memorandum sent to the U.S. Nuclear Regulatory Commission's Region IV Office.

The reported overexposure occurred during a period between mid-September and November 12, 1987 as a result of experimental beam port work. The individual wore a Landauer-supplied thermoluminescent dosimetry (TLD) in a mixed gamma and neutron field. The total reported exposure for the period mentioned was 6.86 rem, whole body dose, and 6.96 rem for all of 1987. The investigation into the exposure at the beam port facility is still in progress. When completed, a full report including recommendations for proper adjustment of the recorded dose will be submitted to the NRC.

With the exception of the potential overexposure, the maximum exposure received by any individual for the year was 280 mrem. A total of 3.24 MANREM was received for 1987 (10.2 MANREM including the overexposure as reported).

The access control procedures for visiting personnel were effective in preventing measurable exposures to radiation. During 1987, 3745 persons visited the Nuclear Science Center. The maximum exposure to any visitor as determined by film badges was less than the minimum measurable quantities: 10 millirem for X or gamma, 40 millirem for hard beta, 20 millirem for fast neutrons, and 10 millirem for thermal neutron radiations.

TABLE 23
Summary of Whole Body Exposures
1987

Whole Body Exposure Range (Rem)	Number of Persons In Range
No Measurable Exposure	4
Less than 0.100	29
0.100 - 0.249	12
0.250 - 0.499	0
0.500 - 0.749	0
0.750 - 0.999	0
1.000 - 1.999	0
2.000 - 2.999	0
3.000 - 3.999	0
4.000 - 4.999	0
5.000	0
Greater than 5.000	1
Total Number of Individuals Reported:	46

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 to radiation.

Radiation Survey

The Nuclear Science Center uses an area radiation monitoring system consisting of nine (9) 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 impending 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, no unexpected radiation levels were detected in 1987. Within the NSC facility, radiation areas and high radiation areas were identified and posted in accordance with state and federal regulations and NSC procedural requirements.

Contamination Survey

The Nuclear Science Center is routinely surveyed for radioactive contamination every month. This program includes the collection, analysis and evaluation of approximately 250 smear samples and the decontamination of areas and materials with removable beta-gamma radioactivities of greater than 1000 dpm/100 cm².

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-4207-20

2. TITLE

"Twenty-Fourth Progress Report of the Texas
A&M University Nuclear Science Center

3. TYPE OF DOCUMENT (Check one):

☐ a. Scientific and technical report

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

Docket 50-128

License R-83

Title of conference _____

Date of conference _____

Exact location of conference _____

Sponsoring organization _____

☒ c. Other (Specify) Facility Progress Report

4. RECOMMENDED ANNOUNCEMENT AND DISTRIBUTION (Check one):

☒ a. AEC's normal announcement and distribution procedures may be followed.

☐ b. Make available only within AEC and to AEC contractors and other U.S. Government agencies and their contractors.

☐ 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 A&M University

Signature

Donald E. Feltz

Date

3/31/98

FOR AEC USE ONLY

7. AEC CONTRACT ADMINISTRATOR'S COMMENTS, IF ANY, ON ABOVE ANNOUNCEMENT AND DISTRIBUTION RECOMMENDATION:

8. PATENT CLEARANCE:

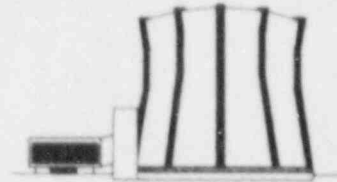
☐ a. AEC patent clearance has been granted by responsible AEC patent group.

☐ b. Report has been sent to responsible AEC patent group for clearance.

☐ c. Patent clearance not required.

TEXAS ENGINEERING EXPERIMENT STATION

TEXAS A&M UNIVERSITY
COLLEGE STATION, TEXAS 77843-3575



31 March 1988

NUCLEAR SCIENCE CENTER
409/845-7551

Mr. L. S. Rubenstein, Director
Standardization and Non-Power Reactor
Project Directorate
Division of Reactor Projects III, IV,
V and Special Projects
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Rubenstein:

In accordance with the reporting requirements of Technical Specification 6.6.1 for the Texas A&M University Nuclear Science Center Reactor we hereby submit three copies of our annual report for the period of January 1, 1987 - December 31, 1987.

Sincerely,

John L. Krohn
Assistant Director

JLK/ym

Enclosures

A020
1/1